Where's the Air?
Study Guide

Wisconsin and the world are facing a huge challenge to protect and preserve the earth's fragile atmosphere. This Where's the Air? study guide is a series of activities and supplemental information designed to assist educators and students in learning and understanding complex air quality issues. It also contains activities that will help people understand the important role they play in solving or avoiding air quality problems in their community. The activities complement classroom use of the poster that is enclosed.

Educators can order up to 10 additional posters by writing the Department of Natural Resources, 2421 Darwin Rd., Madison, WI 53704. The posters are free. Donations to help cover the cost of printing, handling and mailing are appreciated.

We encourage you to share your comments and ideas with us on these materials. Drop us a note c/o EE news, DNR, CE/6, P.O. Box 7921, Madison, WI 53707.

What's Inside

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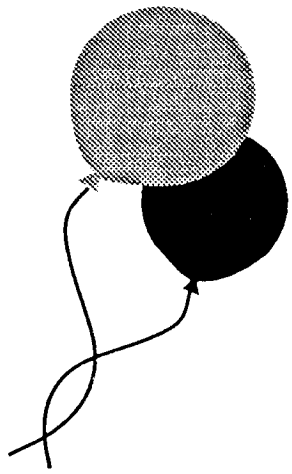
Introduction to Air
Grades: K–3

Background:

Because air is seemingly invisible, it is difficult for us to think of air as very important. It's particularly difficult to recognize that the air might be less than clean when we can't see or smell anything unusual. The following activities demonstrate and encourage younger students to observe and consider that air has weight, that it moves from one place to another, and that when it is polluted we may not necessarily see the pollution. Students will also observe that pollution can damage things made of rubber, such as tires and rubber bands.

Air Has Weight



Science

Objective:

- Visually demonstrate that air has weight.

Materials:

- wood dowel—15"
- 3 pieces of string—6"-7" each
- 2 balloons
- pin

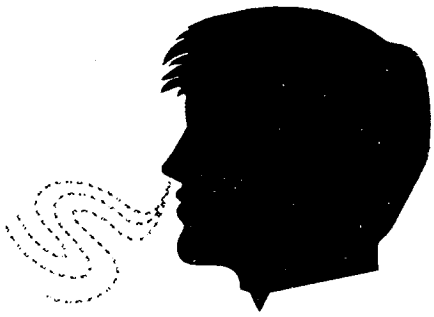
Procedure:

Tie one string tightly to the middle of the dowel. Using the other end of the string, hang up the stick so that it does not touch anything. Slide the string along the stick until the stick is balanced. Blow up a balloon. Tie the balloon tightly with a second piece of string. Do the same with another balloon and piece of string. Tie a balloon to one end of the stick. Tie the other balloon to the other end of the stick. Slide the strings back and forth until the stick is balanced. Let the air out of one of the balloons by carefully puncturing it with the pin (it should not burst). What happens? Ask the students what this tells us about air.

(Adapted from *More Science in Action: Earth and Space* by Laura Buller and Ron Taylor. New York: The Marshall Lavendish Guide to Projects and Experiments)

What Do You Smell?

Science



Objectives:

- Use creative imagery and writing to think about the effects of air pollution.
- Demonstrate the concept of air pollution transport from one region to another.

Materials:

- diced up onions
- fan
- *Where's the Air* poster

Procedure:

A. Use a fan to blow over a freshly sliced onion in the front of class. Have students raise their hand when they can smell the onion. Record who smells it first, second, etc. How much time does it take to reach each student? Did any students cry? What conclusions can you make about the effect of wind on air pollution? Try other items that emit a scent that can reach the students.

B. Have students pick a spot or a person on the poster, close their eyes, and imagine what the air in that spot smells like. What does the air smell like for the people on the bike trail? what about the highway? what about the children at the school? the person burning garbage? the people mowing their lawns and cooking out? the people at the beach? Have the children write about what they imagined.

Burning Causes Air Pollution

Science

Objectives:

- Discover various sources of particulate air pollution and think of solutions.
- Demonstrate that particulate air pollution can be invisible to the eye.

Materials:

- candle
- matches
- white or clear pyrex dish cover or other heat-resistant glass
- *Where's the Air* poster

Procedure:

A. Ask the children if they think that air pollution can ever be invisible. Discuss their answers and then tell them that they'll be watching a demonstration that shows you can't always see air pollution. Place the candle where everyone can see it and light it. Ask the children if they can see any pollution coming from the burning flame (no). Next lower the glass cover over the candle until it touches the flame for a few seconds. Then take away the glass but leave the candle burning.

Have the children look at the soot that has collected on the glass. Explain that as the candle burned, it released gases and very small particles of the burned wax into the air, making air pollution. The polluting particles, however, weren't visible until they were collected on the glass.

Have the children find different things on the poster that they think might release similar, very small particles into the air, like the candle did. They might identify the cars, trucks, and busses on the highway, the forest fire, open burning barrel, leaf pile near the residential homes, or the grill. Then ask them to find alternatives that don't release these particles, such as, the bicycles, the solar heated houses, the electric cars, the natural gas car, the electric lawn mower, etc. Have them draw a picture of one of the particulate-releasing items from the poster on one side of their paper and a less polluting alternative on the other. Their alternative could be something from the poster, from a magazine or newspaper, or something they made up themselves. It could even be something from home!

(Adapted from Ranger Rick's *NatureScope* Magazine, 1990)

Air Pollution Does Damage

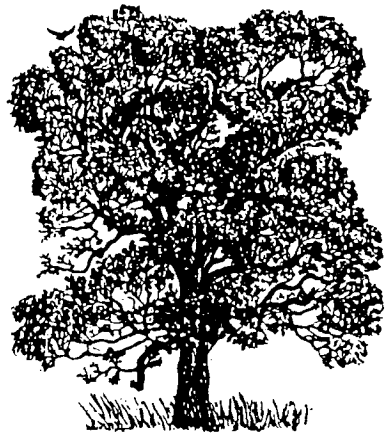
Science

Objectives:

- Demonstrate the use of a "control" in scientific experiments.
- Demonstrate that **ozone** air pollution can cause rubber to deteriorate.

Materials:

- 4 natural rubber bands
- two coat hangers
- plastic bag
- magnifying glass

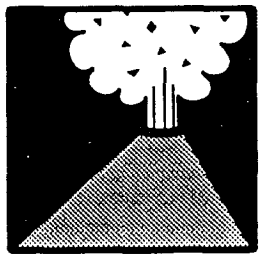


Procedure:

Bend each coat hanger into a rectangle. Slide two rubber bands onto each coat hanger, making sure they're stretched tight. If they're not tight at first, bend the coat hangers out until they are. Hang one up outside in a shady place so it's *out of the sun* (important). Put the other coat hanger in a plastic bag and seal it tightly. Keep it indoors in a drawer.

Wait a week. When a week is up, check on the rubber bands hanging outside. Are they cracked and broken? Use the magnifying glass to look them over carefully. Compare the outside rubber bands with the ones you kept in the bag by stretching each group the same distance. Do you notice any difference? If the rubber bands from outdoors are still in good shape, hang them back up and keep them there for a few more weeks. See what happens to them over a longer period of time.

Sources and Solutions to Air Pollution



Grades: 4-12

Science, Social Studies

Objectives:

- Identify sources of air pollution.
- Identify solutions to air pollution.
- Distinguish between natural and human sources of air pollution.

Materials:

- laminated *Where's the Air?* poster
- washable markers

Background:

The thin layer of gases that surround the earth is changing. Today, the current composition of the earth's atmosphere is mostly nitrogen and oxygen. It also contains water droplets, fine particles, and very small amounts of carbon dioxide, nitrous oxides, methane, and other gases. Some of these substances have been present in the atmosphere for millions of years and come from natural sources like volcanoes and forest fires. Today, human sources are major contributors to air pollution. We can see some of the results of human sources in smog over our cities. Many other air pollutants are totally invisible.

The *Where's the Air?* poster lists both natural and human sources of air pollution. It is important to understand the similarities and differences.

Natural Air Pollutants

Volcanoes release tremendous amounts of gases and particles into the air with each eruption. Forest fires can release tons of particles into the air. Decaying organic materials in oceans, swamps, and bogs release greenhouse gases like methane and carbon dioxide. The piney scent from pine trees and the easily recognized smell of a skunk are caused from the release of **volatile organic compounds (VOCs)**. Other trees and plants release VOCs in varying amounts during the process of photosynthesis. These sources are called "biogenic."

Trees and other growing plants perform a variety of tasks to give us a better environment. We are grateful for the process of photosynthesis which gives us oxygen. However, all plants also emit a variety of other gases including hydrocarbons (VOCs). These "biogenic" sources release hydrocarbons that are part of the natural chemistry of the earth and its atmosphere.

These natural sources have always been a part of the earth's changing atmosphere. Some of these sources could have dramatically changed the earth's atmosphere at different times in the past. Volcanoes have been known to change weather patterns for years. Since little can be done to control natural pollution, the focus is on controlling human sources of air pollution.

Human Sources Of Air Pollution

Air pollution from human sources is the result of our increased use of fossil fuels. These sources tend to concentrate in urban areas where people live and work. Many of these pollutants come from the burning of coal, wood, oil and other fuels we use to run our cars, factories and power plants.

A few common air pollutants can be found throughout the United States. The Environmental Protection Agency (EPA) calls these pollutants "criteria air pollutants." EPA has established health-based standards for these pollutants. The table lists the criteria pollutants and gives a brief overview of each one. A geographic area in which the level of air pollution is higher than the level allowed by federal standards is called a **nonattainment** area.

Both natural and human sources of pollution can be transported almost anywhere in the world on global winds. The regional air transport diagram on the poster shows the type of weather system associated with high levels of air pollution in Wisconsin. Air pollution is more than just a local concern. Perhaps no natural resource better represents the need for a "global action program" than clean air.

Procedure:

A. Students work in small groups and circle as many of the sources of air pollution that they can find pictured on the poster. They should develop a list of these sources, name the process that produces the pollution, and then write the reason for the process. An example would be:

Source:	Process:	Reason:
Car	Burning gasoline	Transportation

Some answers are listed on the back of the poster. These lists include both natural and human sources. How many sources did the students find? How many additional sources did they find on the poster that are not on their list? One way to measure how the groups did would be to give one point for each source they find. If a group finds a source that no other group found they get 2 points.

Students should expand the list to include other sources that add to air pollution that are not shown or listed on the poster. Some additional sources are listed in the box below.

Air Pollution Sources Or Problems

Natural sources:	Human sources:
volcanoes	buses
geysers	tractors
wetlands/swamps	gas stations
plants	sewage treatment plants
skunks/animals	bakeries
chemical/gas refineries	

B. Groups should identify and list the solutions to pollution shown on the poster. Students should identify the action involved and who is doing the action. An example would be:

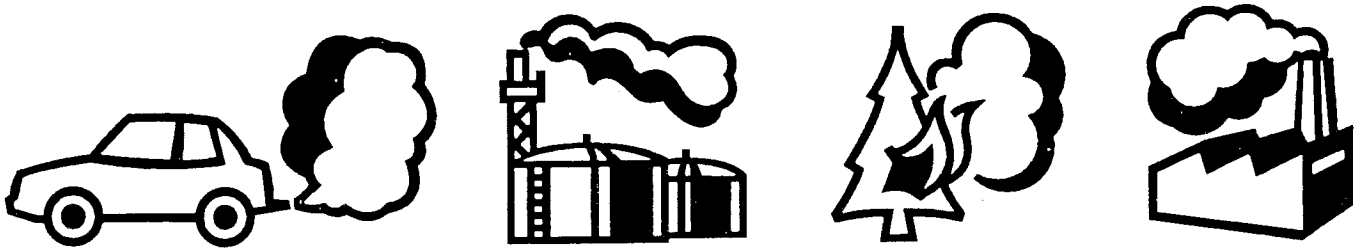
Source:	Process:	Reason:
Biking	Reduce car use	Commuters

Some answers are listed on the back of the poster. How many additional solutions can they find in the poster that are not on the list? Use a similar point system from part A.

Students should expand the list to include any other solutions that they feel would reduce air pollution. Here are some examples: education, working at home, trees/plants, landscaping, combining trips, reduced, travel, cleaner fuels, etc.

Extension:

Wisconsin residents are being urged to take voluntary actions during hot summer days to avoid unhealthy levels of ozone. The program is called "Ozone Action Days" and is being coordinated with similar programs in Illinois, Indiana, and Michigan. Citizens will be notified through the media that ozone levels have been predicted to be high for the next day. This prediction will be based on weather patterns and pollution levels. Review the Taking Action list on the back of the poster. Highlight an "Ozone Action Day" with your class and list the types of actions students, teachers, and parents can take to prevent adding pollutants to the air.



The Common Air Pollutants (Criteria Air Pollutants)

Name	Source	Health Effects	Environmental Effects	Property Damage
Ozone (ground level ozone is the principal component of smog)	chemical reaction of pollutants; VOCs and NO_x	breathing problems, reduced lung function, asthma, irritated eyes, stuffy nose, reduced resistance to colds and other infections, may speed up aging of lung tissue	ozone can damage plants and trees; smog can cause reduced visibility	damages rubber, fabrics, etc.
VOCs* (volatile organic compounds); smog-formers	VOCs are released from burning fuel (gasoline, oil, wood, coal, natural gas, etc.), solvents, paints, and glues. Cars are an important source of VOCs. VOCs include chemicals such as benzene, and toluene.	In addition to ozone (smog) effects, many VOCs can cause serious health problems such as cancer.	In addition to ozone (smog) effects, some VOCs such as formaldehyde and ethylene, may harm plants.	
Nitrogen Dioxide (NO_2)	burning of gasoline, natural gas, coal, oil, etc. Cars are an important source of NO_2	lung damage, illnesses of breathing passages and lungs (respiratory system)	NO_2 is an Ingredient of acid rain which can damage trees and lakes.	acid aerosols can eat away stone used in 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 tissues. Carbon monoxide may be particularly hazardous to people who have heart, circulatory or respiratory problems.		
Particulate Matter (PM-10); (dust, smoke, soot)	burning of wood, diesel and other fuels; industrial plants; agriculture (plowing, burning off fields); unpaved roads	nose and throat irritation, lung damage, bronchitis, early death	particulates are the main source of haze that reduces visibility	ashes, soots, smokes, and dusts can dirty and discolor structures and other property, including clothes and furniture
Sulfur Dioxide (SO_2)	burning of coal and oil, especially high-sulfur coal from the Eastern United States; industrial processes.	breathing problems, may cause permanent damage to lungs	SO_2 is an ingredient in acid rain which can damage trees and lakes.	acid rain can eat away stone used in buildings, statues, monuments, etc.
Lead	leaded gasoline (being phased out), paint (houses, cars), smelters (metal refineries); manufacture of lead storage batteries	brain and other nervous system damage; children are at special risk. Some lead-containing chemicals cause cancer in animals.	Lead can harm wildlife.	

*All VOCs contain carbon (C), the basic chemical element found in living beings. Carbon-containing chemicals are called organic. Volatile chemicals escape into the air easily. Many VOCs, such as the chemicals listed in the table, are also hazardous air pollutants, which can cause very serious illnesses. EPA does not list VOCs as criteria air pollutants, but they are included in this list of pollutants because efforts to control smog target VOCs for reduction.

What is pollution?

Grades: 7-12

Environmental Studies, Social Studies, Ecology, Science

Objectives:

- Students will become familiar with a variety of sources of air pollution.
- Students will form an opinion about what makes pollution, pollution.

Materials:

- *Where's the air?* poster

Procedure:

A. What makes it "pollution?"

Working in groups, students will identify from the poster three sources of pollution. With each item they should list the characteristics of each source that make it "pollution."

The characteristics could include:

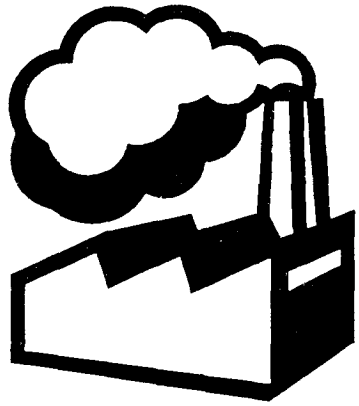
- not biodegradable
- human-made
- negatively affects the quality of life, ie.:
  - ✓ creates noise
  - ✓ prevents you from hearing other things or experiencing silence
  - ✓ causes physical discomfort
  - ✓ ugly
  - ✓ smells bad
- human-beings have control over it
- contrasts with the natural landscape
- consumes an unreasonable amount of non-renewable energy
- occurs in quantities harmful to human health, i.e, damages respiratory system
- occurs in quantities harmful to animal and plant health
- occurs in quantities harmful to ecosystem health, i.e.:
  - ✓ may cause changes in climate or other natural phenomena
  - ✓ contributes to an unsustainable situation

From the list of characteristics, each group should develop a set of criteria that forms their definition of an air "pollutant."

B. Refining the Criteria

1. Assign each group one of the human-produced sources of air pollution and one of the naturally produced sources of air pollution from the poster. Have students apply their criteria to each. Would the item be a pollutant or source of pollution according to the students' criteria? Get the students to think about the part that human control plays in this question. Would they want to focus their pollution reduction on a natural source of pollution or a human source?
2. After they apply their criteria and decide whether the item is a pollutant or not, give them the option to revise their criteria. Students may feel that the biggest need is to defend their criteria! Impress on them that changing their minds after careful consideration is perfectly acceptable and to be expected in the process of critical thinking.

C. Reducing Pollution



For the sources selected in "B" (or others), answer these questions:

1. Who is responsible for releasing this pollutant into the environment?
2. Would it still be a pollution problem if released in smaller amounts?
3. What is currently being done to control this pollutant. Who is doing it? What role does government play? industry? you?

Trees and Air Quality

Grades: 4-10

Math, Science

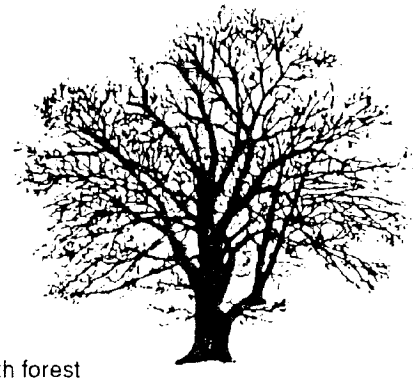
Objectives:

- Describe the ways in which trees benefit air quality.
- Design a home using trees to decrease energy use.

Materials:

- Drawing of students' residences.

Background:



Trees are much more than something pretty in your yard. They are important for a number of reasons, including:

- Reduce run-off of water
- Provide habitat for wildlife
- Provide people with forest products
- Provide a recreation site
- Economic value
- Aesthetic value

In addition, trees and plants have a great impact on our air quality. Trees act like filters. The leaves capture particulates like dust, soot, and pollen and remove them from the air. They also remove and store carbon and reduce our need for energy.

Trees act like a carbon warehouse. In the process of photosynthesis plants remove carbon dioxide (CO_2) from the air and release oxygen (O_2). A healthy tree uses over 20 lbs. of CO_2 each year. The carbon is stored in the tree (wood is about 45% carbon) and the O_2 is released back into the atmosphere. The storage of carbon is important to reduce the amount of CO_2 in the atmosphere. CO_2 is the most common greenhouse gas. Other greenhouse gases include a variety of nitrogen oxides or NO_x, methane, and chlorofluorcarbons(CFCs).

Trees are outdoor air conditioners. They provide a natural way to shade and cool your house in summer and can shield your home from the cold winds of winter. A person can save energy by landscaping with trees. Deciduous trees planted on the south, west, and east will protect your home from the direct rays of the sun in summer. In winter, without their leaves, they allow most of the sun's energy to reach the house. Conifers to the north and west can block the cold winter winds. This reduces consumption of energy to heat your home. The energy savings from trees reduces air pollution because it reduces electricity generation at power plants. This reduces power plant emissions of sulfur dioxide (SO_2), NO_x, and a large amount of CO_2.

A successful urban tree program can also impact whole communities. Cities are often 10 degrees warmer than suburbs, partially due to the "heat island effect" caused by concrete, steel, and asphalt. The planting and care of trees can minimize this phenomenon and greatly reduce energy consumption.

Procedure:

1. Testing for particulate removal. Students should draw a map to scale of their yard or school site and locate any trees on the map. Using a damp white cloth they should carefully wipe a leaf from each tree. Is the cloth dirty? Can you tell what material is on the cloth? Using your map, record which tree had the most dirt on the cloth. What was the source of the material? What will happen to the particulates that became trapped on the leaf in a week? or month?
2. Using the same map of their yard/school and trees determine which trees assist in saving energy. Estimate the height of the trees. Students should make several observations on sunny or windy days. Which trees provide shade in the summer? Students should consider the changing angle of the sun's rays during the seasons? Which trees block winter wind?
3. Draw in locations where you would plant trees to save energy. What types of trees would you plant? Students should consider a variety of factors when planting new trees, including distance to buildings, soil, drainage, and power lines.

For Your Information

For more information on trees and tree planting check out the following:

The Simple Act of Planting a Tree—Healing Your Neighborhood, Your City and Your World. 1990. Andy and Katie Lipkis. Publisher: Jeremy P. Tarcher, Inc.

Tree City USA Bulletins. For a complete list, contact: The National Arbor Day Foundation, 211 North 12th St., Lincoln, NE 68508.

Windbreaks that Work! (Publ. # FR-070), **Forest Trees of Wisconsin** (Publ. # FR-053), **Arbor Day Poster** (Publ. # FR-055). All are available from the Wisconsin Department of Natural Resources, Bureau of Forestry, P.O. Box 7921, Madison, WI 53707. (Classroom sets of **Forest Trees of Wisconsin** are available upon request, contact Genny Fannucchi, Forest Resource Educator, 608-267-3120.)

Graphs

Grades 4-10

Math, Environmental Studies

Objectives:

- Become familiar with the different sources of air pollution and their relative contributions to air pollution.
- Practice reading graphs and using percentages.

Material:

- *Where's the air?* poster

Background Information:

On the back of the poster you will find two pie graphs. These graphs show the categories of sources of nitrogen oxides (NO_x) and volatile organic compounds (VOCs) as defined by the Environmental Protection Agency (EPA). They also show the amounts each category contributes to the total NO_x and VOCs emitted in southeastern Wisconsin. Many people believe that industry is primarily responsible for air pollution. Others think that cars are the main source. The graphs on the poster show amounts from nonattainment counties in southeastern Wisconsin on a summer weekday in 1993.

Volatile organic compounds are a category of chemicals which all contain the element carbon and readily produce vapors at room temperature and normal atmospheric pressure. Some, but not all, of these can be hazardous. Paint solvents and gasoline are two important sources of VOCs.

Nitrogen oxides are another category of chemicals. They all contain some nitrogen atoms and some oxygen atoms. Nitrogen dioxide, for example, contains one nitrogen atom and two oxygen atoms.

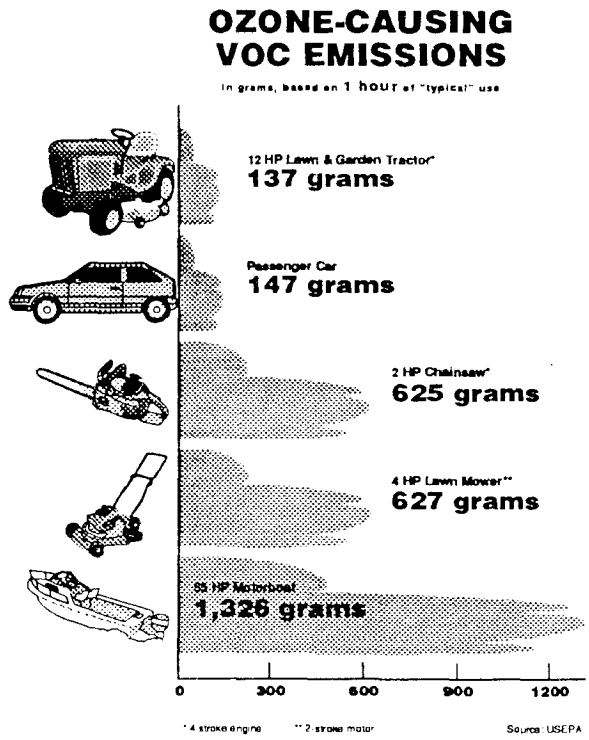
When chemicals in these two categories combine in sunlight, they "cook" and form tropospheric ozone. Ozone can accumulate away from the original source of the NO_x and VOC's because the chemical reaction takes place in the sky over time. Meanwhile, the chemicals are being blown by wind patterns away from their source.

Area sources form a significant portion of the sources of both VOCs and NO_x. These include small industry, commercial businesses like dry cleaners, bakeries, auto body painting shops, print shops, and asphalt paving. They also include gas-fired engines like lawn mowers and motor boats. Other products include charcoal lighter fluid, oil-based paints, solvents, and even nail polish.

Not all sources are equal. The figure to the right shows that operating a passenger car for 1 hour produces 147 grams of VOCs. A 2 hp chainsaw produces almost 5 times that amount for the same time period. Manufacturers are currently researching how to reduce the pollution from these smaller engines.

Procedure:

A. Before referring to the pie graphs on the back of the poster, have students estimate the percentages that each of the following sources contribute to air pollution in southeastern Wisconsin: mobile, non-highway mobile, area, and industrial. For definitions of these sources, see the back of the poster. The students should compare their estimates with the graphs.



B. These graphs show percent contributions from various sources. But how much pollution is that exactly? Have students answer the questions and fill in the table. We have filled in one of the amounts in tons to get you started.

1. According to the graph, how many tons of VOCs are emitted by: a) industrial, b) mobile, c) non-highway, d) area sources on a summer day in Wisconsin nonattainment counties?

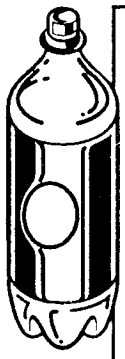
2. According to the graph, how many tons of NO_x are emitted by: a) industrial, b) mobile, c) non-highway, d) area sources on a summer day in Wisconsin nonattainment counties?

	Percentages	Number of Tons
1. VOCs		
Total	100%	409.52
a. Industrial	29%	
b. Mobile	39%	
c. Non-highway mobile	11%	
d. Area	21%	
2. NO_x		
Total	100%	419.43
a. Industrial	51%	
b. Mobile	34%	
c. Non-highway mobile	13%	
d. Area	2%	

Answers:

1a.	118.76 tons (237520 lbs)	2a.	213.9 tons (172000 lbs)
B.	159.71 tons (319420 lbs)	B.	142.60 tons (285200 lbs)
C.	45.05 tons (90100 lbs)	C.	54.53 tons (109060 lbs)
D.	86 tons (171998.4 lbs)	D.	8.39 tons (16780 lbs)

Pounds of Pollution



Grades 9-12.

Chemistry, Math, Environmental Studies

Objectives:

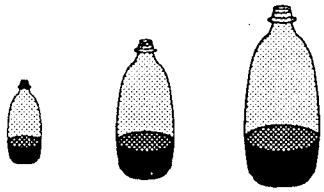
- To calculate the weight of various pollutants.
- To visualize the amount of air pollution emitted by a car each year.

Background Information:

Air pollution is a difficult concept to grasp. We often can't see it! Yet, cars emit many different air pollutants. (See box.) Air pollution is often referred to in terms of pounds. You know that air has weight, but how much of a gas is a pound? By displaying the soda bottles and attaching a label that informs passers-by that the bottles represent 1 pound of carbon dioxide (CO_2), the awareness of a good part of the whole school and community can be significantly raised.

Material:

- many 2-liter soda bottles



Procedure:

A. Calculate the volume of 1 pound of whatever air pollutant you are interested in by using the following equation:

$$\frac{454\ g}{1\ lb} \times \frac{1\ mole}{\text{"X" g}} \times \frac{22.4\ L}{1\ mole} = \text{liters of gas/pound}$$

Explanation:

There are 454 grams in a pound. The next step is to find out how many grams of your pollutant are in a mole. This number can be calculated using values from the Periodic Table of Elements. Add the grams per mole for each compound. For example, one atom of oxygen is 16 grams per mole and carbon is 12 grams per mole. This totals 44 grams per mole of carbon dioxide molecule. (CO_2 is 2 oxygen atoms plus 1 carbon atom.) For your convenience, we have listed the weights of carbon dioxide, carbon monoxide, and nitrogen dioxide, three pollutants given off by cars. Insert these values for "X" depending on the pollutant:

CO_2 = 44 g
CO = 28 g
NO_2 = 46 g

There are 22.4 liters in a mole. Multiply by this number of liters and you have converted the pound of gas into an equivalent number of liters.

B. Calculate how many 2-liter bottles are needed for the display. Use the following equation:

$$\frac{\text{volume of 1 lb. of the pollutant}}{2\ \text{liters}} = \text{total bottles}$$

For example, if you are dealing with CO_2, which you have calculated to be 231 liters per pound, divide 231 by 2. This tells you that you need 115.5 bottles to represent one pound of CO_2.

A Car Does What?

A car which travels an 18-mile round trip commute, 5 days a week, 48 weeks a year, spews into the air we breathe:

- 4,500 lbs. of carbon dioxide (CO_2)
- 160 lbs. of carbon monoxide (CO)
- 16 lbs. of volatile organic compounds (VOCs)
- 16 lbs. of nitrogen oxide (NO_x)
- smaller amounts of benzene, formaldehyde, particulate matter and other toxic materials

Note: Cars emit several different **nitrogen oxides.** If you want to demonstrate how much of a particular nitrogen oxide weighs per pound, you would have to make a separate calculation for each kind of nitrogen oxide using their different atomic masses.

Answer Key

Number of 2-liter bottles:

CO_2 = 115.5 bottles
CO = 181.3 bottles
NO_2 = 110.5 5 bottles

Student Questions:

1. How many bottles would be needed to represent the hypothetical car's (see box) yearly CO_2 and CO emissions?
2. Calculate how many bottles would be needed to represent the amount of CO_2 and CO your class members contribute to the atmosphere during one school week. Use the hypothetical car amounts, above.
3. The number of tons of NO_x emitted on a hot summer day in southeastern Wisconsin is 419.43 (see graph on the back of the poster and the graph exercise page 7.) If this amount were made up entirely of NO_2, how many soda bottles would this be?

Student Answers:

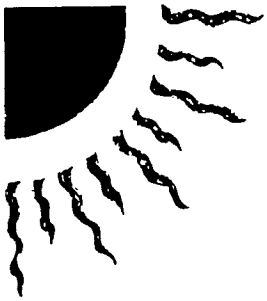
1. There are 363 liters per pound of CO, multiplied by 160 lbs. emitted by the average car per year equals 58,080 liters.

   There are 231 liters per pound of CO_2, multiplied by 4500 lbs. emitted by the average car per year equals 1,039,500 liters.

   CO_2 = 1,039,500 liters
   CO = 58,080 liters

2. Answers will vary.
3. Multiply the 419.43 tons of NO_x emitted, by 2000 lbs. in a ton, you have 838,860 lbs. of NO_x. There are 221 liters per pound of NO_2. Multiply this by 838,860 lbs. and you have 185,388,060 liters. This is 92,694,030 soda bottles worth emitted on one summer day in southeastern Wisconsin.

Adapted from Tammie Niffenegger, Port Washington High School.



Ozone: Good & Bad

Grades 7-12

Reading, Science, Social Studies

Objective:

- Identify differences between **stratospheric** and **tropospheric ozone**.

Background Information:

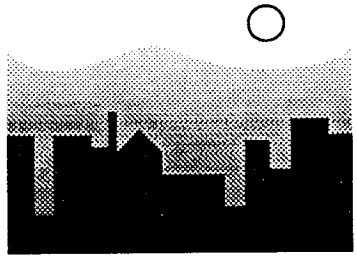
Many people get confused when they read about ozone. Is it good or is bad? Do we want to protect it or get rid of it? Does it make me cough or does it give me a sunburn? Yes to all of the above! It all depends on where you find it. This activity will show the differences between stratospheric and tropospheric ozone.

Material:

- enough posters for students to share
- copies of the student chart

Procedure:

Copy the chart for your students. Have them read the section on the back of the poster called, "Ozone: good and bad." After reading the section, they should fill in the worksheet with answers to the questions below.



Answers:
Stratospheric Ozone

A. Three oxygen molecules.

B. Naturally.

C. 9 to 30 miles above the earth's surface.

D. It protects us from ultraviolet rays that can cause skin cancer, eye problems (cataracts), and can weaken our immune system.

E. We are just beginning to discover how it affects animal and plant life, such as phytoplankton, frogs, and crops.

F. We've passed laws to eliminate the production of CFCs and other substances which harm the ozone layer and have developed chemical substitutes for them in manufacturing. We try to avoid harmful effects by wearing sunscreen, sunglasses, and staying out of the sun.

Tropospheric Ozone

A. Three oxygen molecules.

B. It forms when VOC's and nitrogen oxides combine and react in sunlight.

C. From the earth's surface up to 8 miles above the surface.

D. It can cause irritated eyes, coughing, shortness of breath and may weaken the immune system.

E. It can damage crops and buildings.

F. We've passed laws and developed technology to reduce the amount of VOC's and nitrogen oxides we put into the air. We make voluntary efforts to drive less and find alternative ways of getting around.

Extension:

There are several ways to deal with problems of pollution. Have students make a list of several pollution strategies. These might include: ignore the problem, develop and use technology to control the problem, reduce, reuse, recycle, alleviate the effects, enact regulations and laws, and educate the public. Which of these have been used to deal with the problem of stratospheric and tropospheric ozone?

Worksheet

	Stratospheric Ozone	Tropospheric Ozone
A. What is it made of?		
B. How does it form?		
C. Where is it found?		
D. How does it affect human health?		
E. What other affects are there?		
F. What have we done to deal with this problem?		

Good Ozone, Bad Ozone Word Search

Grades 4-8

Materials:

- poster
- copies of student pages

Objective:

- Distinguish the difference between good and bad ozone

Find these words which are related to ground level ozone. Words may be found forward, backward, up, down, and diagonally.

regulations
transportation
nonattainment
vapors
solvents
reactive
sunlight
atmosphere
ground level (no space)
asthma
immune system
volatile
smog
VOC
ozone
pollution
troposphere
bad
gasoline powered (no space)

Smog? No Thanks! (Answers)

```
D E R E W O P E N I L O S A G
  V       O   T H G I L N U S
  I O     L   R           M   S
  T   C   L   A           E   N
  C       U   N         T T   O
  A       T   S         N S   I
  E       I   P       S E Y   T
E R E H P S O P O R T R   M S   A
  R       N   R V O     N E M   L
S   E   A     T P O     I N   O U
  T   H S       A     L   A U   G
    N T P     V T       A T M   E
    H E   S     I   E     T M   R
  M     V   O   O G       A I
A       L   M N           N   L
    E N O Z O A T         O     E
          H S   A         N
B A D     C   L E V E L D N U O R G
```

Background Information:

The issues associated with good versus bad ozone continue to confuse people. Ozone in the stratosphere is good ozone that protects us from ultraviolet light rays. It's depletion is resulting in a hole in the layer of protective ozone over Antarctica and a reduction in the ozone layer all over the earth. Bad ozone, on the other hand, forms right here in the troposphere whenever volatile organic compounds—or VOCs—and nitrogen oxides combine in sunlight. It is a principle component of smog and can be irritating to respiratory systems, particularly for people with asthma, the elderly, and those who exercise heavily outdoors. See the back of the poster and page 9 for more information.

Procedure:

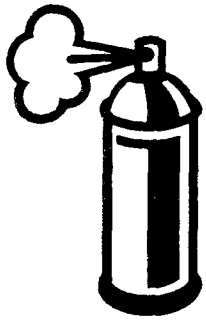
- Make copies of the word search and have students complete the search.

Extension:

Have students make their own word searches using vocabulary they choose from the front and back of the poster. These can be duplicated and distributed for classmates to solve.

Smog? No Thanks!

D	E	R	E	W	O	P	E	N	I	L	O	S	A	G	G	A	S
T	V	K	R	L	I	O	P	T	H	G	I	L	N	U	S	C	B
Q	I	O	J	F	E	L	O	R	I	U	L	B	O	M	I	U	S
R	T	H	C	D	E	L	C	A	B	L	A	G	M	E	N	I	N
M	C	P	S	A	H	U	O	N	N	R	I	H	T	T	F	K	O
N	A	R	H	L	M	T	N	S	F	A	D	L	N	S	J	L	I
W	E	S	A	H	E	I	Z	P	A	M	H	S	E	Y	F	S	T
E	R	E	H	P	S	O	P	O	R	T	R	E	M	S	E	U	A
H	R	M	T	E	J	N	A	R	V	O	L	I	N	E	M	T	L
S	D	E	Q	R	A	M	I	T	P	O	A	S	I	N	I	O	U
P	T	I	H	S	L	O	P	A	U	Y	L	P	A	U	L	T	G
O	D	N	T	P	I	T	V	T	D	A	O	A	T	M	P	R	E
R	A	H	E	Z	S	Z	M	I	V	E	G	J	T	M	T	K	R
C	M	O	G	V	E	O	U	O	G	O	H	E	A	I	C	O	W
A	X	N	A	Z	L	Z	M	N	Z	R	R	W	N	U	L	S	I
M	H	E	N	O	Z	O	A	T	O	W	T	O	O	D	A	E	O
S	G	J	I	P	K	H	S	H	A	Y	I	M	N	N	G	D	P
B	A	D	T	U	C	H	L	E	V	E	L	D	N	U	O	R	G



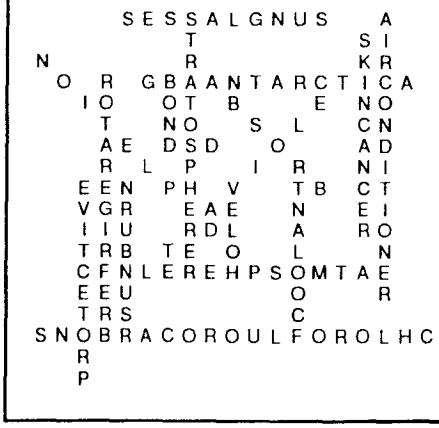
Try to find the stratospheric ozone related words listed below.

chlorofluorocarbons
stratosphere
atmosphere
ultraviolet
sunburn
good
sunglasses
bond
hole
skin cancer
protective
depletion
air conditioner
antarctica
absorb
coolant
refrigerator

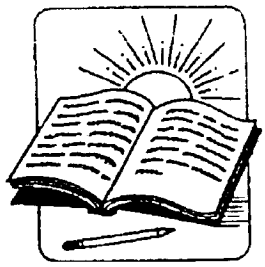
Protecting the Ozone Layer

A T M O S E S S A L G N U S P H A T S
L V Z Z I M O T N O R O P T R S I R N
N Z M S R N A R T G O W I O D K R O E
T O F R I G B A A N T A R C T I C A B
K A I O G L O T R B E B J E G N O F M
F D U T E I N O C T S E L K S C N I A
O O L A E N D S D T M O S P H A D V E
C A N R O L U P R A I Y R A E N I L A
V I E E N O P H X V T O T B R C T P M
A T V G R B M E A E P V N Z A E I G N
S T I I U O A R D L A N A O H R O E S
U L T R B S T E F O R O L H C X N R O
N H C F N L E R E H P S O M T A E A K
G S E E U W R Z H P L M O S P H R T I
L O T R S K I B O N R E C N A K S O M
S N O B R A C O R O U L F O R O L H C
W D R E F R I G T N A L P E D T H M O
S T P H E R A R B O N S G O O D L U C

Protecting The Ozone Layer (Answers)



Air Pollution Education Resources



The following selected resources provide additional information and activities on air quality resources.

Books

Air Pollution. 1990. Grades K-3. Darlene R. Stille. Discusses the benefits of air, its pollution, and the harmful effects of and ways of avoiding air pollution. Cost: $4.95., Order from: Children's Press, Chicago, IL.

Ozone Hole. Grades K-3. Darlene R. Stille. Studies the important role of atmospheric ozone in protecting the earth, tells how human-made chemicals are causing worrisome holes in the polar ozone layers. Order from: Children's Press, Chicago, IL.

Ozone. 1989. Kathlyn Gay. 1989. Grades 5 and up. Discusses the dual problem of too much ozone in the troposphere creating smog and the depletion of the ozone layer in the stratosphere which shield harmful rays.

Growing Greener Cities. Gary Moll and Stanley Young. This 126-page handbook explains benefits of and how to plant trees in urban areas. Available from Global ReLeaf, PO Box 2000, Dept. GGC, Washington, DC 20013.

Curriculums And Activity Guides

Growing Greener Cities. This environmental education guide accompanies the resource listed above. It contains 13 activities for children emphasizing the value of trees and how to plant them. Available from Global ReLeaf, PO Box 2000, Dept. GGC, Washington, DC 20013.

Project A.I.R.E.: Air Information resources for Education (K-12), A guide for instructors. 1994. This activity guide contains 21 activities regarding air and air quality issues. Excellent source of current air quality information. 267 pages. Available from Renee Kuruc, Region 5, US-EPA, 77 West Jackson Blvd., Chicago, IL 60604-3507. 312-353-5574.

Air. Ava Deutsch Drutman. Grades 1-3. This activity book contains 40 reproducible pages to use with kids. Covers topics related to acid rain, smog, global warming, the ozone layer and others. A Good Apple Environmental Education Activity Book. 1204 Buchanan St., Box 299, Carthage, IL 62321-0299. About $8.00.

Air. Robyn Freedman Spizman and Mariane Daniels Garber. Grades 4-7. This activity book contains 46 reproducible pages to use with kids. Covers topics related to acid rain, smog, global warming, the ozone layer and others. A Good Apple Environmental Education Activity Book. 1204 Buchanan St., Box 299, Carthage, IL 62321-0299. About $8.00.

Videos

"Keeping the Lid on Air Pollution" and **"The Inside Story on Air Pollution."** 20 minutes. Each for grades 4-6.Color. 1989. From the Healthy Environment Healthy Me series, Environmental and Occupational Health Sciences Institute, Public Education and Risk Communication Division, 45 Knightsbridge Road, Brookwood II, Piscataway, NJ 08854-3923. 908-463-5353. Cost: $85 each.

"Fueling the Future: Running on Empty" and "Fueling the Future: No Place Like Home" High school to adult. 58 min. each. 1988. This series, produced for national PBS broadcast, is a very comprehensive series on energy use in the USA. Viewers are taken on a historical journey that illuminates how our values and dreams shaped current energy usage without regard for future costs. Produced by KBDI-TV, Denver. Available from the Video Project, 5332 College Avenue, Suite 101, Oakland, CA, 94618. 1-800-4-PLANET. Cost: $85 or $45 each for individuals or low income groups, $25 rental.

"Moving Beyond Auto America." High School to adult. 29 min. 1991. Questions America's dependence on the car and presents alternative transportation systems already in use around the globe. This fast-paced video features consumer advocate Ralph Nader and 17 of the nation's foremost transportation experts, who critically analyze our "love affair" with the auto and question how much longer we can rely so heavily on our sacred cars. A wide variety of alternatives are illustrated and discussed, including electric cars, magnetic trains, light rail systems, several highly futuristic approaches, and even some traditional low-tech alternatives. Study guide included. Available from the Video Project, 5332 College Avenue, Suite 101, Oakland, CA, 94618, 1-800-4-PLANET. Cost: $59.95 institutions, individual and low income groups $35, and $20 rental.

Monitoring Methods

ECO Badge by Vistanomics. These are hand-sized ozone level indicators. Hung outside in the shade, the ozone sensitive filter paper darkens showing relative levels of ozone. Very easy to use. Available in standard kit size including 8"x10" color chart and 30-day supply of filter paper, as well as the badge itself. Smog Patrol Kit is a miniature of the standard kit. It includes a 4.5"x7" color chart and fewer filter papers plus badge. Order from: Gary Short at Vistanomics, Inc, 230 N. Maryland Ave., Suite 310, Glendale, CA 91206, or call 881-409-9157. Cost: Smog Patrol Kits are $10.95 each plus $2.00 shipping and handling. Standard Kits are $24.95 each plus $3.00 shipping and handling.

Ozonometer. A gadget that measures ozone using a rubber band that you string up. Ozone makes the rubber deteriorate, causing the needle indicator to change position on the dial. Order by calling or writing Stephan Bannasch and Bart Wise 617-547-0430. Mailing address is TERC, 2067 Massachusettes Ave., Cambridge, MA, 02140. Or email stephen_bannasch@terc.edu or bart_wise@terc.edu. Cost: $15 each plus $3.00 s/h for the first and .50 s/h every one after that.

Milkweed Monitoring. This summer, join the network of volunteers who evaluate ozone damage to common milkweed plants *(Asclepias syriaca)* found near your school, nature center, or home. In June plants are randomly tagged to be evaluated in August. Ozone damage appears as small blackish or dark purple dots on the upper surface of the leaves. To receive a participant packet, contact: Jennifer Morgan, Wisconsin Department of Natural Resources, I&E/6, P.O. Box 7921, Madison, WI, 53707, 608-264-6298.

Others

Air Matters is a quarterly newsletter from the DNR's Bureau of Air Management. Back issues available. Free. Great resource for Grades 6-12. Contact Anne Urbanski, DNR Bureau of Air Management, P.O. Box 7921, AM/10, Madison, WI 53707-7921, 608-267-0573.

Gas-ette is a newsletter for high school teachers who are interested in Global Systems Science Education. Includes information on global warming and classroom activities. Order from: Climate Protection Institute, 5833 Balmoral Dr., Oakland, CA 94619, 510-531-0100.

20 Ways to Fight Ozone Pollution. Pamphlet explaining ways kids and other people can help reduce ozone. Free from the Department of Natural Resources. Available by ordering from the Educ'ade order form. Contact: DNR, 2421 Darwin Road, Madison, WI 53704.

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