UNIT 1

Wanted For Polluting Our Air

An Introduction to the Six Major Air Pollutants

ACTIVITY DESCRIPTION

This activity provides an overview of the common air pollutants. Students work in teams to research the six major air pollutants (ozone, nitrogen dioxide, carbon monoxide, particulate matter, sulfur dioxide and lead). Students are provided with background readings and websites for information. Each team first completes a study guide about its assigned pollutant which includes pollutant description (what it is and where it comes from); major sources; effects of their type of pollution (on visibility, property, and health of humans and the environment); laws pertaining to their pollutant; and control measures. Using the information obtained, teams next complete a "wanted poster" of their pollutant. The wanted posters include all the pertinent information as well as a collage of images such as student drawings, magazine cut-outs, or Internet prints. Each student team then presents its poster to the rest of the class. Posters are displayed on the classroom wall for the duration of the program.

curricular ties

See page viii for the list of this lesson's curricular ties to District of the Columbia, Maryland, and Virginia education standards. All Education Standards are articulated in the Appendices.

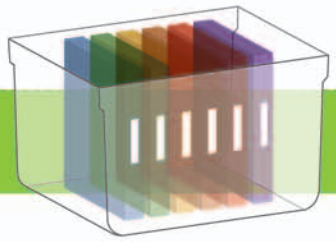
time needed

Two, 45 minute class periods (plus ~20 minutes up front for the introduction video)

LEARNING OBJECTIVES

Upon completion of this Unit, students will be able to:

- List the six common, "criteria" air pollutants.
- Describe the major sources of at least one pollutant.
- List and describe the effects that pollution has on human health.
- Explain how pollution affects the environment.
- Name the primary governing body (EPA) and law (Clean Air Act) that regulate air quality at the National Level.
- Name at least one local governing body (e.g., Virginia DEQ) that regulates air quality.
- Locate information about air pollution using a variety of resources including the Internet, newspapers, and EPA publications.
- Propose strategies for reducing pollution.



MATERIALS

Background:

Video (on CD ROM): *Forecast Earth: Air Aware*
Teacher Background Reading: *A Brief History of Air Pollution Control*
Medical Poster: *Effects of Common Air Pollutants*

Student Handouts:

Student Study Guide—Wanted for Polluting Our Air
Wanted for Polluting Our Air—Poster Presentations Worksheet

Team Packets (Six total, one for each pollutant):

Student Teams Task List
Wanted for Polluting Our Air—Poster Guidelines
Technology Connections for Student Research
Background Reading (Reproduced from the Internet):

- *Clean Air Partners—Clean Air Facts*
- *The Clean Air Act and Criteria Air Pollutants*
- *Air Pollution, What's the Solution?—Major Air Pollutants*

Background Reading (EPA Pamphlets and Brochures):

- *Ozone Good Up High, Bad Nearby*
- *Smog—Who Does it Hurt?*
- *What You Can Do to Reduce Air Pollution*
- *Particle Pollution and Your Health*
- *Air Quality Index—A Guide to Air Quality and Your Health*

Not Included in Kit:

Six large pieces of poster board for student posters

TEACHER PREPARATION

- Read the Teacher's Background Information—*A Brief History of Air Pollution Control.*
- Preview the video—*Forecast Earth: Air Aware.* Make preparations to view the video as a class.
- Review all the steps in the procedures before conducting the activity.
- Make copies of the Student Handouts, *Student Study Guide—Wanted for Polluting Our Air* and Wanted for Polluting Our Air—Poster Presentations Worksheet, 1 per student.
- If necessary, make arrangements with your school's technology coordinator for students to access the computer lab and conduct research online.
- Display the medical poster: *Effects of Common Air Pollutants.*
- Acquire and have ready a variety of magazines which would have photographs depicting pollution sources. Consider asking students to bring in magazines.

technology connections

http://www.epa.gov/air/urbanair/6poll.html
This link on the EPA's website provides descriptions of the six common pollutants.

http://www.airnow.gov/index.cfm?action=airnow.main
AIRNow is a cross-agency government website on our nation's air quality. Under the link "Air Quality Basics" there are descriptions of Ozone and Particle Pollution.

http://www.k12science.org/curriculum/airproj/docs/major_air_pollutants.pdf
Air Pollution What's the Solution? is an online, air pollution curriculum. On this link, they provide a concise matrix description of the major air pollutants.

http://www.greenfacts.org/air-pollution/index.htm
Green Facts provides clear summaries of scientific studies. This link provides information on ozone, particulate matter, and nitrogen dioxide.

http://www.cleanairpartners.net/
Students can investigate ozone, AQI and link to additional data at the Clean Air Partners website.

http://www.scorecard.org/env-releases/cap/pollutant-desc.tcl#7439-92-1
Scorecard is a pollution information site with specific facts about the six common (or criteria) air pollutants.

http://www.epa.gov/ttn/naaqs/
This EPA (Environmental Protection Agency) website describes the laws and standards regulating the six common (criteria) pollutants.

http://www.deq.virginia.gov/air/homepage.html
This is the home page for the Virginia Department of Environmental Quality's Air Quality Program. Links to the state's ozone and Particulate Matter monitoring programs are available through this site as are links to the Clean Air Act and state regulations.

ACTIVITY PROCEDURES

1. We strongly recommend that before beginning this or any other activity in this kit, students should view the CD-ROM video—*Forecast Earth: Air Aware* as an introduction to air pollution.
2. Conduct an introductory discussion on air pollution reviewing key points made in the video—Forecast Earth: Air Aware. Use the following questions to guide your discussion:
   - What are some sources of air pollution? *(Automobile exhaust, fumes from factories, power plants, and other industries, trucks, wildfires, fireplaces, etc.)*
   - What is one of the main human health issues aggravated by air pollution? *(Asthma)*
   - What are the two kinds of ozone and how are they different? *(Stratospheric ozone is "good ozone." It surrounds the earth's atmosphere and protects us from the harmful UV rays of the sun. Ground level ozone is "bad ozone" and is unhealthy for humans and the environment.)*
   - How can we tell when the air is dangerous to breathe? *(The Air Quality Index (AQI) color code indicates the quality of the air.)*
   - Besides ozone, what is another kind of air pollution mentioned in the video? *(Particle pollution)*
3. Point out that two main types of pollution, ozone and particle pollution, were discussed in the video. However, scientists recognize six different types of common air pollutants, called "criterion" air pollutants. In this activity, the class will work in teams to research those six common air pollutants, with each team focusing on one particular type. Teams will create "Wanted Posters" which will serve to educate others about the common air pollutants.
4. Divide students into six teams. Give each team a *Team Packet*. Remind students to be careful with the materials and to return them to their packets when finished.
5. Hand out the *Student Study Guide—Wanted for Polluting Our Air*. Allow time for teams to complete their *Student Study Guides* using the provided readings, resources, and references. Finding time for Internet research is strongly recommended.
6. Give students time to develop their wanted posters. They should use the information from their study guides to develop their wanted posters. Encourage the use of graphics, drawings, and pictures cut out from magazines or printed from the Internet.
7. Hand out the *Wanted for Polluting Our Air—Poster Presentations Worksheet*. Explain that students should complete the worksheet during each team's poster presentation.
8. Have student teams present their wanted posters to the rest of the class. They should be sure to cover all the key points as presented in their study guides. They should refer to their *Student Study Guides* as a presentation checklist.
9. Display all the *Wanted for Polluting Our Air* posters in the classroom.

Teacher Background Reading

A BRIEF HISTORY OF AIR POLLUTION CONTROL

Look at the picture of the Earth below. From space we can see how fragile it is, and how all the parts of the Earth are a part of what has been called "The Big Blue Marble." For thousands of years we did not understand how our activities were polluting our air. In fact, it was not until the middle of the 20th century that we started to realize that air pollution was a global problem. Until then, we treated air pollution as a local problem and did not make the connection that when we pollute the air where we live, that "dirty" air is carried to other parts of the Earth.

When you look at the earth from space it is hard to tell that air pollution is a real problem. From space, the earth looks fresh and clean. Nevertheless, ask yourself these questions: Have you ever seen:

- A volcano erupting
- Dark smoke coming from a factory smokestack
- An exhaust cloud from a bus
- A traffic jam

If you have, then you know what air pollution looks like.

Air pollution has been around for millions of years. Our early ancestors created small amounts of air pollution when they made fire in their caves. However, as the population of the earth has increased and as we became more reliant on the use of coal and other fossil fuels, we have increased tremendously the amount of **pollutants** we are spewing into our atmosphere.

The federal government made some attempts to control air pollution in the early 20th century, but it was not until a deadly air pollution episode killed 20 people in Donora, Pennsylvania in October 1948 that the federal government started to seriously look at the problems of air pollution in the United States. Even then, air pollution was still viewed and treated as strictly a local problem.

It was not until the time that John Kennedy was President that we began to recognize air pollutions as a national problem. Because of President Kennedy's efforts, the 1963 Clean Air Act was passed. It is believed that Kennedy was motivated, in part, by killer smog episodes in London and New York. While the 1963 Act recognized air pollution as a national problem, it did little to establish or enforce national air quality standards.

The Environmental Protection Agency (EPA) was established by Executive Order on December 2, 1970. President Nixon signed the Clean Air Act of 1970 into law on December 31, 1970. Under this authority, EPA has set national air quality standards for **ground level ozone (smog)**, **particulate matter (soot)**, **carbon monoxide**, **lead**, **sulfur dioxide**, and **nitrogen dioxide**. The Act also directs the EPA to review the standards for each of these pollutants every five years. In simple terms this means that the federal government, in cooperation with the States, sets air quality standards that are supposed to help reduce air pollution and clean the air for all of our citizens. This is important because we now know that bad air can make us sick.

The United States Congress has made changes to the Clean Air Act over the years in an effort to make air pollution control activities by the States and the federal government more effective. Concerns were raised in the 1980s about **acid rain**, **smog**, and air borne **pollutants**, and this resulted in passage of the Clean Air Act of 1990. The 1990 act is now the major controlling legislation affecting clean air issues in the United States.

In other lessons on air pollution, you will learn more about smog, acid rain, ozone, and other air pollutants. The purpose of this lesson was to give you some brief history of air pollution and to let you know what your government is doing to help make sure you have air that is clean and healthy to breathe.

If we all do our part, both by making sure the anti-pollution laws of our local governments and the United States are enforced and taking actions as individuals to make sure we are not contributing to pollution—instead of having air that looks like this:

We can have air that looks like this:

Local Government

In every state, there is the Department of the Environment and many other agencies that work to ensure that the air is healthy to breathe and that local potential sources of pollution are being controlled. There are state programs to control tailpipe **emissions** from mobile sources (automobiles and trucks) and smokestack emissions from factories, power plants, and small businesses (dry cleaners and some restaurants).

The Departments of the Environment also monitor the outdoor air by measuring how much and what type of pollution is in the air. Our region meets the health standards for all but one of the six **criteria pollutants**. The pollutant that is a serious problem in much of our area is ground level ozone and occurs during the warmer months of the year when the sunlight is more intense. When ozone is expected to reach unhealthy levels, local environmental agencies issue messages to the affected communities and advise people to take action to protect their health.

Businesses

Many businesses are required to control pollution and use two approaches to prevent air pollution. One approach is to use devices, or add-on controls, that capture pollution before

it gets into the air. Another approach is to prevent pollution without **add-on controls**.

Add-on controls capture gases and solids in the air stream of a heating or industrial process before the air is emitted through the stack. Add-on controls either collect and deposit the pollutant as waste material or send it back into the fuel stream to completely **combust**.

Preventing pollution without add-ons can include a process or fuel change, improved operating practices, shutting off equipment, or shutting down the plant. An example of a process change might be the conversion from a power source using fossil fuel to a power source using **hydroelectric**. An example of a fuel change would be to use coal with a low sulfur content rather than coal with a high sulfur content.

Individuals

Factories and power plants are tightly regulated to prevent pollution and as a result, are often not the major source of air pollution in a particular region. Often the major contributors to air pollution are common human activities—driving our vehicles, heating and cooling our homes, and using household appliances. There are things households and individuals can do to prevent pollution.

Many household appliances require electricity to operate. Houses require fuel to heat them. A significant amount of electricity is generated by burning fossil fuel resources such as coal, oil, or natural gas. When fossil fuels are burned, by-products are produced such as soot, nitrogen oxides, sulfur oxides, and carbon dioxide. These by-products pollute the air. A way to prevent pollution is to conserve and use less of these resources. Turn off appliances like televisions, lamps, and computers when you are not using them. Houses that are properly insulated retain heat and use less fuel.

Tailpipe emissions from passenger vehicles are a significant source of air pollutants. There are many ways for people to control the amount of pollution from vehicles. When people ride together or use public transportation, fewer vehicles are driven and less emissions are produced. Well-maintained vehicles use less fuel. Have your family consider buying a low emissions vehicle when it is time to replace the family car. When you only have to travel a short distance, consider riding a bicycle or walking.

Student Handout

Student Study Guide—Wanted For Polluting Our Air

Name_____

Name of your pollutant.

_____

Pollutant description. (What is your pollutant and how is it formed?)

_____

_____

_____

_____

Major sources. (What are some of the main sources—such as cars or factories, etc.—that cause your pollutant?)

_____

_____

_____

_____

Why is your pollutant a problem? (Describe the effects your pollutant has on visibility, property, human health, and the environment, including plants and animals.)

_____

_____

_____

_____

Laws and agencies that regulate your pollutant. (Name and describe the National Act and the primary national and state agencies that regulate your pollutant.)

_____

_____

_____

_____

Control measures. (What can be done and is being done to control your pollutant?)

_____

_____

_____

_____

How can you help? (What actions can you and other citizens do to help control your pollutant?)

_____

_____

_____

_____

Student Handout

Wanted for Polluting Our Air—Poster Presentations Worksheet

	Description / How Formed	Major Sources	Effects on Human Health	Effects on Environment	Control Measures	How One Can Help
Particulate Matter						
Carbon Monoxide						
Sulfur Dioxide						

Student Handout

Wanted for Polluting Our Air—Poster Presentations Worksheet

	Description / How Formed	Major Sources	Effects on Human Health	Effects on Environment	Control Measures	How One Can Help
Nitrogen Dioxide						
Ozone						
Lead						

TEAM PACKET
Student Teams Tasks List

1. Review the contents of this packet. Be sure you have the following items:
   - Student Teams Task List (this paper)
   - Wanted for Polluting Our Air—Poster Guidelines
   - Technology Connections for Student Research
   - Background Reading (Reproduced from the Internet):
     - Clean Air Partners—Clean Air Facts
     - The Clean Air Act and Criteria Air Pollutants
     - Air Pollution, What's the Solution?—Major Air Pollutants
   - Background Reading (EPA Pamphlets and Brochures):
     - Ozone Good Up High, Bad Nearby
     - Smog—Who Does it Hurt?
     - What You Can Do to Reduce Air Pollution
     - Particle Pollution and Your Health
     - Air Quality Index—A Guide to Air Quality and Your Health
2. Read this entire task list first to see the different tasks your team needs to complete this project.
3. Working as a team, decide how you will complete your *Student Study Guides*. You may each take a specific question then share information or each complete all the questions then compare answers. Remember, you are working as a team and everyone should have an equal role.
4. Complete your *Student Study Guides*. You will need to research your assigned pollutant to answer the questions. You should find all the answers you need in the reading material provided in your Team Packets and/or you may go online and visit the websites listed in *Technology Connections for Student Research*. Be sure everyone on your team completes their own copy of the Student Study Guide.
5. Create a "Wanted for Polluting Our Air" poster. Use a large piece of poster board. Refer to your *Wanted for Polluting Our Air Poster Guidelines* for what to include on your poster. You should have all the information you need on your Student Study Guide. Be sure to include photos from magazines or the Internet, drawings, or other graphics to enhance your poster. Your goal is to create an attractive, eye-catching "wanted" poster to educate others about your pollutant.
6. Present your poster and information about your pollutant to the rest of the class. Be sure to cover all of the information as listed on your *Student Study Guide*. Decide as a team who will present what information to ensure everyone takes part in the presentation.
7. Display your poster in the classroom with the other "Wanted for Polluting Our Air" posters.

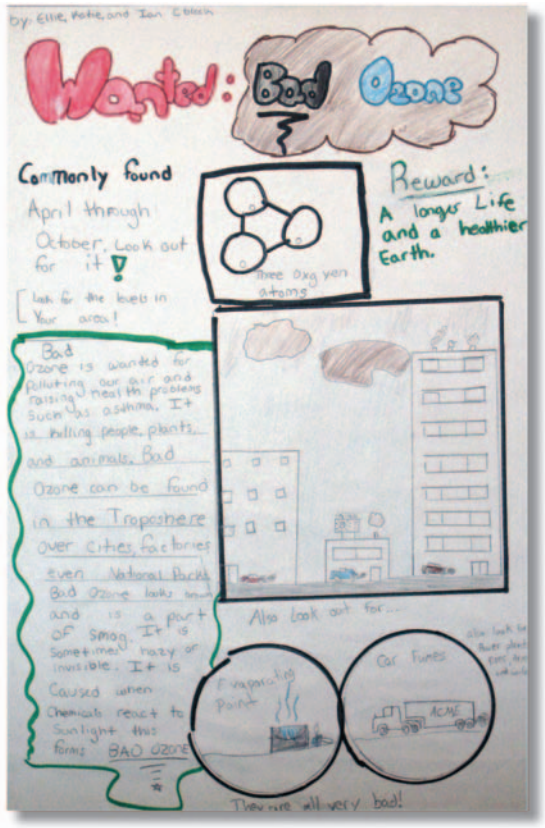
TEAM PACKET

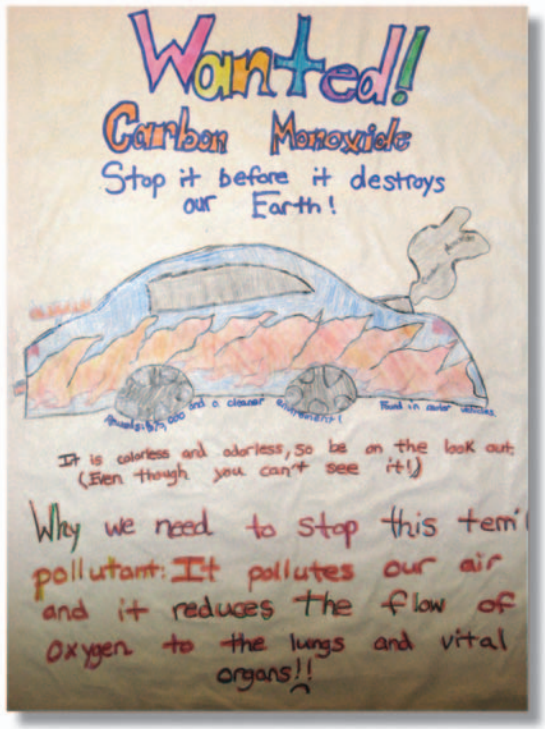
Wanted For Polluting Our Air Poster Guidelines

A wanted poster is a public notice typically used to educate people about criminals that are wanted by the authorities. A wanted poster usually describes the person (or thing) that is wanted, why it is wanted, and what to look for when searching for the wanted person or thing.

On your ***Wanted for Polluting Our Air*** poster, you should include the following:

- Name of your pollutant
- Why, in general, your pollutant is "wanted"
- A picture or other graphic depicting your pollutant (the chemical structure, sources, etc.)
- Where your pollutant could be found
- Time your pollutant might be more common (e.g., the time of day or year)
- What your pollutant looks like (e.g., invisible, hazy, a brown cloud, black smoke, etc.)
- Sources of your pollutant (cars, factories, etc.)
- Problems your pollutant causes to humans and the environment
- Is there a reward (other than money) for your pollutant?





http://www.epa.gov/air/urbanair/6poll.html
This is the Environment Protection Agency's (EPA) information page which provides descriptions of the six common pollutants. For each of the six pollutants, information is provided on the sources, causes for concern, health and environmental impacts and efforts to reduce each specific pollutant.

http://www.airnow.gov/index.cfm?action=airnow.main
This website, presented by AIRNow, presents information on our nation's air quality. There are several very useful links at this site, most of which you will find in the greenish column on the left side of the page. Under "Air Quality Basics" there are links for information on Ozone and Particle Pollution. Under "Resources" there is a link for "Publications." You will find several downloadable booklets and brochures under the "Publications" link.

http://www.k12science.org/curriculum/airproj/docs/major_air_pollutants.pdf
This link is from Air Pollution What's the Solution?, an online, air pollution curriculum. At this specific link, a table is presented which includes descriptions, sources, and effects of the six major air pollutants.

http://www.greenfacts.org/air-pollution/index.htm
Green Facts provides clear summaries of scientific studies on air pollution. This link provides very thorough information on ozone, particulate matter, and nitrogen dioxide.

http://www.cleanairpartners.net/
This is the Clean Air Partners website. Under the link "Air Quality Facts" there are links to information on ozone, including health and economic impacts.

http://www.scorecard.org/env-releases/cap/pollutant-desc.tcl#7439-92-1
Scorecard is a pollution information site with specific facts about the six common (or criteria) air pollutants. This link provides descriptions of the air pollutants including details about their chemical makeup, hazards, and how they are regulated.

http://www.epa.gov/ttn/naaqs/
This EPA (Environmental Protection Agency) website describes the laws and standards regulating the six common (criteria) pollutants.

Ozone—Good Up High, Bad Nearby

The word "ozone" has prompted confusion and debate over the past few years. This confusion persists in part because ozone conjures up both good and bad images. In fact, both perceptions are correct.

This invisible gas can be found in both the upper and lower atmospheres. The ozone layer in the upper atmosphere exists naturally and is essential to life because it filters harmful ultraviolet radiation from the sun, reducing the amount reaching the earth's surface. High concentrations of ozone near ground level, however, can be harmful to people, animals, crops, and other materials.

Ground Level Ozone

Ground level ozone is the main ingredient in urban and regional smog. Common air pollutants, such as Volatile Organic Compounds (VOCs) and Nitrogen Oxides (NO_x), are released from the exhaust of cars, paint, and aerosol products. These pollutants react with heat and sunlight, producing ground level ozone. Unhealthy levels of ground level ozone occur during the summer months, typically May through September.

Each year cars and trucks travel more than 38 billion miles on the roads, accounting for 30-40% of the ozone-causing pollutants. However, motor vehicles are not the only sources of ozone pollution; emissions from gas powered lawnmowers, boats, many household products, power plants, and industrial facilities contribute to the formation of ozone.

Health Effects of Ozone

If you are a typical adult, you'll breathe in close to 3,500 gallons of air in a single day. If your atmosphere is ground level ozone-polluted, you may see your lung function reduced by as much as 20 percent.

High concentrations of ozone can cause shortness of breath, coughing, wheezing, fatigue, headaches, nausea, chest pain, and eye and throat irritation. The most common symptom that people have when exposed to ozone while exercising is pain when taking a deep breath.

The EPA estimates that 5 to 20% of the total U.S. population is especially susceptible to the harmful effects of ozone pollution.

The following groups are most vulnerable:

- Children, because their respiratory systems are still developing. They're more active and spend more time outdoors, inhaling more air pollution per pound of body weight than do adults.
- People with pre-existing respiratory problems.
- Athletes and individuals who exercise outdoors.
- Older adults, because their respiratory and immune systems lose some of their resilience. Damage caused by ground level ozone pollution can aggravate existing conditions or irritate tissues that make them susceptible to infection.

Ozone Sources:

- Motor vehicles
- Gas powered lawn and garden equipment
- Household aerosol products
- Oils based paints
- Power plants and industrial facilities

Ozone Facts:

- Ozone is an invisible gas.
- Ozone is not emitted directly into the air; it forms in the atmosphere through chemical reactions.
- Ozone needs heat and sunlight to form.
- Ozone doesn't linger long; it quickly reacts with its surroundings.
- Ozone usually dissipates after sunset.

How Ozone Is Formed

The main ozone-causing pollutants are volatile organic compounds (VOCs) and nitrogen oxides (NO_x). Ground level ozone results when VOCs and NO_x come together in the hot, still weather of summer. Sources of VOC are evaporative emissions from household products such as cleaning fluids and oil-based paints. Consumer products contribute about 13% of the total non-vehicular VOC emissions in the Baltimore-Washington region.

Nitrogen monoxide (NO) and nitrogen dioxide (NO_2) are the two forms of nitrogen oxide found in the atmosphere. Nitrogen oxides contribute to the formation of ozone, production of particulate matter pollution, and acid deposition. The presence of nitrogen oxides gives smog its brown appearance.

Factories, motor vehicles and power plants that burn fossil fuels produce nitrogen oxides. Diesel engines produce a disproportionately large amount of NO_x compared to gasoline engines because of their high temperature combustion process. Other sources include gas stations, outboard motors, and lawn and construction equipment.

Items such as deodorants, air fresheners, household cleaners, engine degreasers, windshield washer fluids, and non-aerosol, brush-on house paints contain smog contributors. Hair spray, cleaning products, and insecticides are other examples. Solvents, used to enhance cleaning qualities or to dissolve ingredients in products, are also smog contributors.

Activities that we take for granted can have a major impact on the air we breathe, releasing more than 1800 tons of VOCs and NO_x into the region's air each day. By better understanding how ground level ozone forms, we can develop everyday strategies to control it.

Activity	VOCs Produced	NOx Produced
Refueling Your Car	YES	NO
Auto—Idling	YES	YES
Auto—Highway Driving	YES	YES
Operating gas lawn mower	Many Times Output of Auto	YES
Operating Motor Boat	Many Times Output of Auto	YES
Staining Fence	YES	NO
Painting Fingernails	YES	NO
Aerosol Hair Spray	YES	NO
Spray Paint	YES	NO
Barbecue Lighter	YES	NO

Source: Clean Air Partners—**http://www.cleanairpartners.net/ozoneinfo.cfm**

Background Reading: The Clean Air Act and Criteria Air Pollutants

What is the Clean Air Act?

The Clean Air Act is a federal law that provides for the protection of human health and the environment. The original Clean Air Act was passed in 1963, and the 1970 version of the law resulted in the creation of the U.S. Environmental Protection Agency (EPA), which was charged with setting and enforcing ambient air quality standards. The law was amended in 1977, and most recently in 1990. Most of the activities of the Virginia Department of Environmental Quality's Air Division come from mandates of the Clean Air Act, and are overseen by the EPA. More information on the 1990 amendments to the Clean Air Act can be found at: **http://www.epa.gov/air/oaq_caa.html**.

What is a Criteria Air Pollutant?

The Clean Air Act names six air pollutants that are commonly found in the air throughout the United States, and that can injure humans by causing respiratory and cardiovascular problems, and harm the environment by impairing visibility, and causing damage to animals, crops, vegetation and buildings. EPA has developed health-based criteria for these pollutants through scientific studies, and has established regulations setting permissible levels of these pollutants in the air. The "criteria" pollutants are: carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, particulate matter, and lead, and the limits that have been set for them are the National Ambient Air Quality Standards (NAAQS).

Particulate Matter

PM2.5 is particulate matter (PM) that is less than or equal to 2.5 micrometers (a micrometer is one millionth of a meter) in aerometric diameter. These particles are often called "fine particles" because of their small size. Fine particles originate from a variety of man-made stationary and mobile sources, such as factory smoke stacks and diesel engines, as well as from natural sources, such as forest fires. These particles may be emitted directly into the air, or they may be formed by chemical reactions in the atmosphere from gaseous emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and volatile organic compounds (VOCs).

Scientific research has linked fine particle pollution to human health problems. The particles are easily inhaled deep into the lungs, and can actually enter the bloodstream. Particle pollution is of particular concern to people with heart or lung disease, such as coronary artery disease, congestive heart failure, asthma, or chronic obstructive pulmonary disease (COPD). Older adults are at risk because they may have underlying, undiagnosed heart or lung problems. Young children are also at risk because their lungs are still developing, they are more likely to have asthma or acute respiratory disease, and they tend to spend longer periods of time at high activity levels, causing them to inhale more particles than someone at rest. Even otherwise healthy people may suffer short-term symptoms such as eye, nose, throat irritation, coughing, and shortness of breath during episodes of high particulate levels.

PM2.5 air quality standards were implemented by EPA in 1997 to protect against

the health effects of fine particle pollution. In addition to health problems, fine particle pollution contributes to haze that causes deterioration of visibility in scenic areas, and also deposits harmful compounds on the soil and water. Unlike ozone, which is a seasonal pollutant in most areas of the country, particle pollution can occur year-round, and is monitored throughout the year in Virginia. The Virginia DEQ PM2.5 monitoring network uses three different types of samplers to monitor fine particulate in the state.

Carbon Monoxide

Carbon monoxide (CO) is a colorless, odorless gas that is produced by incomplete burning of carbon compounds in fossil fuels (gasoline, natural gas, coal, oil, etc.). Over half of the CO emissions in the country come from motor vehicle exhaust. Other sources include construction equipment, boats, lawnmowers, woodstoves, forest fires, and industrial manufacturing processes.

CO concentrations are higher in the vicinity of heavily traveled highways, and drop rapidly the further the distance from the road. Ambient levels of carbon monoxide tend to be higher in the colder months due to "thermal inversions" that trap pollutants close to the ground. A thermal inversion occurs when the temperature of the air next to the ground is colder than air above it. When this happens, the air resists vertical mixing that can help the pollutants to disperse, forming a layer of smog close to the ground.

Carbon monoxide is harmful because it reacts in the bloodstream, reducing the amount of oxygen that is supplied to the heart and brain. CO can be harmful at lower levels to people who suffer from cardiovascular disease, like angina, arteriosclerosis, or congestive heart failure. At high levels, CO can impair brain function, causing vision problems, reduced manual dexterity, and reduced ability to perform complicated tasks. At very high levels, carbon monoxide can be deadly.

Sulfur Dioxide

Sulfur Dioxide (SO_2) is a colorless gas that has a strong odor. It results from burning of fuels containing sulfur (such as coal and oil), petroleum refining, and smelting (extracting metals from ore), and it also occurs naturally from volcanic eruptions. SO_2 can dissolve in water vapor to produce sulfuric acid, and it can also interact with other gases and particles in the air to produce sulfate aerosols that are capable of traveling long distances in the atmosphere.

EPA has developed primary and secondary air quality standards for SO_2. The primary standards are designed to protect people from the health effects of sulfur dioxide gas, which include respiratory problems for people with asthma and for those who are active outdoors. Long-term exposure to high concentrations of sulfur dioxide gas can cause respiratory illness and aggravate existing heart conditions. Sulfate particles that are formed from SO_2 gas can be inhaled, and are associated with increased respiratory symptoms and disease.

Secondary standards for sulfur dioxide protect against damage to vegetation and buildings, and against decreased visibility. The acids that can form from SO_2 and water vapor contribute to acid deposition (commonly called "acid rain") which causes damage to the leaves of plants and trees, making them vulnerable to disease, and can

increase the acidity of lakes and streams, making them unsuitable for aquatic life. Acid deposition also causes deterioration of materials on buildings, monuments, and sculptures. Finally, small sulfate particles, formed when SO_2 gas reacts with other gases and particles in the air, contribute to haze that causes decreased visibility in many areas of the country.

Nitrogen Dioxide

Nitrogen dioxide (NO_2) is one in a group of gases referred to as oxides of nitrogen (NO_X). Nitrogen dioxide, which is characterized by a reddish-brown color and pungent odor, along with the other NO_X gases, results from high-temperature burning of fossil fuels in automobiles, power plants, and other industrial, commercial, and residential sources. NO_X can occur naturally from lightning, forest fires, and bacterial processes that take place in soil.

NO_X pollution contributes to a wide range of problems in the environment. Ground-level ozone, a major component of "smog", forms when NO_X and volatile organic compounds (VOCs) react in the presence of sunlight. NO_X also reacts with other gases and particles in the air to form acids that contribute to acid deposition, and to form small particles that can be inhaled into the lungs. NO_X contributes to water quality deterioration by depositing nitrogen into water bodies, upsetting the nutrient balance and causing oxygen depletion in the water so that fish and other aquatic life cannot survive. Nitrate particles and nitrogen dioxide also contribute to visibility impairment by blocking light transmission.

EPA has established primary and secondary air quality standards for NO_2 because it can cause lung irritation and respiratory problems in humans. Small particles formed from reaction of NO_X gases with other compounds can be inhaled deep into the lungs and cause or worsen respiratory conditions such as emphysema and bronchitis, and can aggravate existing heart conditions.

Ozone

Ozone (O_3) is a gas comprised of three oxygen atoms. It is unstable, and a strong oxidizing agent, and will react readily with other compounds to decay to the more stable diatomic oxygen (O_2).

Ozone can be good or bad, depending on its location in the atmosphere. "Good" ozone occurs naturally in the stratosphere, about 10-30 miles above the earth's surface, where it forms a layer that filters the sun's ultraviolet rays before they reach the surface where they can cause harm to animals and plants. "Bad" ozone, or ground-level ozone, occurs when chemicals found in the atmosphere at earth's surface react in the presence of intense sunlight. Ozone at ground level is harmful because it can cause a variety of health problems, as well as damage to plants and materials. Since ground-level ozone is not emitted directly, it is called a "secondary" pollutant. The chemicals needed to form ozone, NO_X and hydrocarbons (also called volatile organic compounds, or VOCs), can come from motor vehicle exhaust, power plants, industrial emissions, gasoline vapors, chemical solvents, as well as natural sources such as lightning, forest fires, and plant decomposition. Ozone, and the chemicals that produce ozone, can travel hundreds of miles from their sources, so that even rural areas with few pollutant emissions can occasionally experience high ozone levels.

Efforts to control ground-level ozone involve limiting emissions of NO_X and VOCs, or "ozone precursors," that are necessary for ozone production.

Ground-level ozone is a seasonal pollutant, and the length of the ozone season varies across the country. In some areas, the season may last most of the year, but in Virginia it is usually only a problem during the late spring to summer months when the sunlight is most intense. Virginia is only required to operate its ozone monitors from the months of April to October, although a few sites operate year-round. In addition to the seasonal pattern, ozone also has a strong diurnal (daily) pattern at low altitudes, so that it is usually depressed at night, but begins to build during the day after the sun rises.

EPA has created primary and secondary air quality standards for ground-level ozone because of its adverse affects on public life and welfare. In humans, ozone can irritate lung airways, causing sunburn-like inflammation, and can induce symptoms such as wheezing, coughing, and pain when taking a deep breath. Although people with existing respiratory problems, such as asthma and emphysema, are most vulnerable, young children and otherwise healthy people can also suffer respiratory problems from ozone exposure. Scientific studies have shown that even at low levels, ozone can trigger breathing problems for sensitive individuals. In addition to human health problems, ozone can damage the leaves of plants and trees, making them susceptible to disease, insects, and harsh weather. Ozone can also cause rubber to harden and crack, and some painted surfaces to fade more quickly.

Lead

Lead is a metal found naturally in the environment as well as in manufactured products. The major sources of lead emissions have historically been motor vehicles (such as cars and trucks) and industrial sources. Due to the phase out of leaded gasoline, metals processing is the major source of lead emissions to the air today. The highest levels of lead in air are generally found near lead smelters. Other stationary sources are waste incinerators, utilities, and lead-acid battery manufacturers.

Lead particularly affects young children and infants. It is still found at high levels in urban and industrial areas. Lead deposits on soil and water and harms animals and fish. Although overall blood lead levels have decreased since 1976, infants and young children still have the highest blood lead levels. Children and others can be exposed to lead not only through the air, but also through accidentally or intentionally eating soil or paint chips, as well as food or water contaminated with lead.

High levels of lead are still of concern in localized areas. Urban areas with high levels of traffic, trash incinerators, or other industry, as well as areas near lead smelters, battery plants, or industrial facilities that burn fuel, may still have high lead levels in air. People, animals, and fish are mainly exposed to lead by breathing and ingesting it in food, water, soil, or dust. Lead accumulates in the blood, bones, muscles, and fat. Infants and young children are especially sensitive to even low levels of lead. Lead causes damage to the kidneys, liver, brain and nerves, and other organs. Exposure to lead may also lead to osteoporosis (brittle bone disease) and reproductive disorders.

Excessive exposure to lead causes seizures, mental retardation, behavioral disorders, memory problems, and mood changes. Low levels of lead damage the brain and nerves in fetuses and young children, resulting in learning deficits and lowered IQ. Lead exposure causes high blood pressure and increases heart disease, especially in men. Lead exposure may also lead to anemia, or weak blood. Wild and domestic animals can ingest lead while grazing. They experience the same kind of effects as people who are exposed to lead. Low concentrations of lead can slow down vegetation growth near industrial facilities. Lead can enter water systems through runoff and from sewage and industrial waste streams. Elevated levels of lead in the water can cause reproductive damage in some aquatic life and cause blood and neurological changes in fish and other animals that live there.

EPA set identical health-protection (primary) and welfare-protection (secondary) national air quality standards for lead in 1978. Across the nation, there are monitoring stations that measure the levels of lead and other pollutants in the air. These measurements are compared to the national standards. Areas that have lead levels that are too high must develop and implement a plan to reduce the levels.

Thirty years ago, cars and trucks were the major contributors of lead emissions to the air. In the early 1970s, EPA set national regulations to gradually reduce the lead content in gasoline. In 1975, unleaded gasoline was introduced for motor vehicles equipped with catalytic converters. EPA banned the use of leaded gasoline in highway vehicles in December 1995.

As a result of EPA's regulatory efforts to remove lead from gasoline, emissions of lead from the transportation sector have dramatically declined (95 percent between 1980 and 1999), and levels of lead in the air have decreased by 94 percent between 1980 and 1999. Transportation sources, primarily airplanes, now contribute only 13 percent of lead emissions. A recent National Health and Nutrition Examination Survey reported a 78 percent decrease in the levels of lead in people's blood between 1976 and 1991. This dramatic decline can be attributed to the move from leaded to unleaded gasoline (as well as the removal of lead from soldered cans).

The large reductions in lead emissions from motor vehicles have changed the nature of the air quality lead problem in the United States. Industrial processes, particularly primary and secondary lead smelters and battery manufacturers, are now responsible for most of lead emissions and all violations of the lead air quality standards. Emissions from industrial processes have decreased by only 6 percent since 1988. EPA's lead air quality monitoring strategy now focuses on areas surrounding these industrial sources.

Sources:

Virginia Ambient Air Monitoring: 2005 Data Report—**http://www.deq.state.va.us/airmon/documents/AnnualReport05_001.pdf**

U.S. EPA—What are the Six Common Air Pollutants?—**http://www.epa.gov/air/urbanair**

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Background Reading: Air Pollution, What's the Solution?–Major Air Pollutants

Major Air Pollutants				
Pollutant	Description	Sources	Effects	Release
Carbon Monoxide (CO)	CO is an odorless, colorless, and poisonous gas produced by the incomplete burning of fossil fuels (gasoline, oil, natural gas).	Cars, trucks, buses, small engines, and some industrial processes are major sources. Wood stoves, cigarette smoke, and forest fires are also sources of CO.	CO interferes with the blood's ability to carry oxygen, slowing reflexes and causing drowsiness. In high concentrations, CO can cause death. Headaches and stress on the heart can result from exposure to CO.	Direct
Nitrogen Oxides (NO_x)	Nitrogen and oxygen combine during combustion (burning) to form nitrogen oxides. Many nitrogen oxides are colorless and odorless gases.	NO_x come from burning fuels in motor vehicles, power plants, industrial boilers and other industrial, commercial, and residential sources that burn fuels.	NO_x can make the body vulnerable to respiratory infections, lung disease, and possibly cancer. NO_x contributes to the brownish haze seen over congested areas and to acid rain. NO_x easily dissolves in water and forms acids which can cause metal corrosion and fading/deterioration of fabrics.	Direct
Sulfur Dioxide (SO_2)	SO_2 is a gas produced by chemical interactions between sulfur and oxygen.	SO_2 comes largely from burning fossil fuels (gasoline, oil, natural gas). It is released from petroleum refineries, paper mills, chemical and coal burning power plants.	SO_2 easily dissolves in water and forms an acid which contributes to acid rain. Lakes, forests, metals,and stone can be damaged by acid rain.	Direct

Source: Air Pollution, What's the Solutions?–http://www.k12science.org/curriculum/airproj/docs/major_air_pollutants.pdf

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Background Reading: Air Pollution, What's the Solution?–Major Air Pollutants

Major Air Pollutants				
Pollutant	Description	Sources	Effects	Release
Particulate Matter (PM)	Particulate matter is a term used to describe very small solids. Smoke, ash, soot, dust, lead, and other particles from burning fuels are examples of some of the compounds that make up particulate matter.	Some particles are directly emitted from cars, trucks, buses, factories, construction sites, tilled fields, unpaved roads, and burning wood. Other particles are indirectly formed when gases from burning fuels react with sunlight and water vapor.	Particulate matter can reduce visibility and cause a variety of respiratory problems. Particulate matter has also been linked to cancer. It can corrode metal, erode buildings and sculptures, and soil fabrics.	Direct and formed in the air
Lead (Pb)	Lead is a metal found naturally in the environment as well as in manufactured products. Small solid particles of lead can become suspended in the air. Lead can then be deposited on soil and in water.	The major source of lead is metal processing with the highest levels of lead generally found near land smelters. Other sources include waste incinerators, utilities, and lead acid battery manufacturers.	Exposure to lead can cause blood, organ and neurological damage in humans and animals. Lead can also slow down the growth rate in plants.	Direct
Ozone (O_3)	Ozone (O_3) is a gas not usually emitted directly into the air. Ground level ozone is created by a chemical reaction between NO_x and VOCs in the presence of heat and sunlight.	Motor vehicle exhaust, industrial emissions, gasoline vapors, and chemical solvents are some of the major sources of NO_x and VOCs.	Ozone can irritate lung airways and cause wheezing and coughing. Repeated exposure can cause permanent lung damage. Ozone damages leaves of trees and other plants. It decreases the ability of plants to produce and store food, and reduces crop yield.	Formed in the air

Source: Air Pollution, What's the Solutions? http://www.k12science.org/curriculum/airproj/docs/major_air_pollutants.pdf