

AIR POLLUTION CURRICULUM RESOURCE GUIDE

Traffic Exposure Study

This teacher resource guide is designed to provide teachers with a background and suggestions for classroom activities related to air pollution, particularly as it relates to the “Traffic Study” by Columbia University’s Mailman School of Public Health, South Bronx Clean Air Coalition, and West Harlem Environmental Action (WE ACT). The guide is divided into five sections by content; however, these are not in necessary order of presentation.

Section 1: Introduction to Air Pollution	2
1.1 Air pollution: definition and sources	2
1.2 Health and ecological effects of pollution	5
1.3 Ways to detect air pollution using senses	182
1.4 Vocabulary	124
1.7 Some Suggested Activities	124
Section 2: Regulatory Approaches to Air Pollution	16
2.1 Overview	16
2.2 History of air pollution and regulatory strategies	16
2.3 Why monitor?	19
2.4 Flaws in the system	19
2.5 Alternative regulatory strategies	22
2.6 Sampling & Analysis Vocabulary	24
Section 3: Particulate Matter & Diesel	27
3.1 Particulate Matter CHECK THIS TITLE	28
3.2 Why diesel is a problem for communities of color	28
3.3 Health effects	30
3.4 Vocabulary	31
3.5 Some Suggested Activities	32
Section 4: The Aethalometer	33
4.1 What Does It Measure?	33
4.2 How Does It Work?	34
4.3 Useful User Features	34
4.4 Suggested Activities	34
Section 6: Presenting and Taking Action	37
6.1 Overview	38
6.2 Vocabulary	39
6.3 Some Suggested Activities	40

Section 1: Introduction to Air Pollution

Objectives

The student will be able to.....

- ✓ Identify sources of pollution in their communities
- ✓ Identify major sources of air pollution
- ✓ Name some health and ecological effects of air pollution
- ✓ Learn some specific forms of air pollution

Technology Resources

http://www.tnrcc.state.tx.us/air/monops/lessons/lesson_plans.html

<http://www.smogcity.com/welcome.htm>

<http://www.scorecard.org/>

Materials

- Student Handout: Finding sources of Air Pollution
- Risk Assessment of Toxic Air Pollutants: A Citizen's Guide (EPA)

1.1 Air pollution: definition and sources

Objectives

The student will be able to.....

- ✓ Identify sources of pollution in their communities
- ✓ Identify major sources of air pollution
- ✓ Learn some specific forms of air pollution

Motivation

Let students look outside... What do they see? Have students name some local sources of air pollution.

1.1.1 What is Air Pollution?

Air is the gaseous atmosphere around us. Air supplies us with oxygen, which is essential for the life of almost all plants and animals, including humans. Air is about 80% nitrogen, 18% oxygen, and the rest water vapor, inert gases and air pollutants. Human activities can release substances into the air which cause problems for humans and the environment.

Air pollution comes from many different sources such as factories, power plants, dry cleaners, cars, buses, trucks and even windblown dust and wildfires. Air pollution threatens the health of human beings, trees, lakes, crops, and animals, as well as damages the ozone layer and buildings. Air pollution also causes haze, reducing visibility in national parks and wilderness areas as well as in our cities.

Although air pollution can be caused by natural sources, the vast majority of air pollution in most areas comes from anthropogenic (human-made) sources. Air pollution can occur indoors or

outdoors. Outdoor sources may be mobile (e.g. cars, trucks, buses, trains, airplanes, boats) or stationary (e.g. factories, refineries, power plants, bus garages).

1. How pollution is formed (Primary vs. Secondary)

Primary pollutants are emitted directly from a source. Secondary pollutants are formed in the atmosphere as a result of interaction between two or more existing chemicals in the air. For example, sulfur dioxide emitted from power plant smokestacks is a primary pollutant. Ozone is a secondary pollutant, because it is formed in the atmosphere as a result of an interaction between nitrogen oxides and volatile organic chemicals (VOCs) in the presence of sunlight. Particulate matter can be both primary (when it is emitted directly from combustion sources) and secondary (when particles form in the atmosphere as the result of gas-phase molecules aggregating).

2. Sources of pollutants (i.e. Stationary, Mobile, or Area)

Area sources and stationary sources are sometimes referred to as “point sources” of pollution, since pollution originates from a fixed point in space.

A) Stationary sources: are larger sources of pollution that are always in the same place; for example, oil or chemical refineries, power plants, incinerators.

- Stationary sources can be major sources of air pollution because the emissions from them are released not only in the local area but they are also blown to distant cities and states.
- Some of our air pollution in NY comes from the power plants and stationary sources that are located in the Midwest. The quantity of pollutants blown from the Midwest is so serious that the Attorney General of New York State, along with the Attorneys General of most other Northeastern states, has sued the federal government to enforce stronger pollution controls on these plants.
- Air pollution does not respect geographical boundaries such as city limits, state lines, and national borders. Rather, the pollution emitted here in the US affects not only our own communities but also communities as far away as South America, Asia and the North Pole.
- Some details about specific examples of stationary sources are as follows:
 - Power plants: usually burn coal, oil, or natural gas, with emissions greatest for coal, less for oil, and lowest for natural gas. Emissions may contain nitrogen oxides, particulate matter, sulfur dioxide, and trace quantities of other substances.
 - Waste incinerators: produce different pollutants because of the diversity of the waste. Such chemicals as NO_x, CO, heavy metals e.g. lead, nickel, cadmium, copper and mercury, are routinely emitted, and highly toxic organic chemicals such as dioxin and furan are released when chlorinated compounds, including many plastics, are burned. This pollution goes into the air from the smokestacks and fugitive emissions as well as into soil and water from the ash

B). Area sources: are smaller sources of pollution that are always in the same place, e.g. dry cleaners, nail salons, auto body shops, and other small businesses that use chemicals.

- Indoor air pollution sources in the home or school include chemicals from building materials, synthetic carpets, cleaning and cosmetic products, pesticides, hobby, art or science supplies, as well as breathable biological sources such as molds, pet dander, vermin, etc.

- Home heating: Buildings often have boilers that burn oil or natural gas for space heating. Emissions are of similar types to those from power plants, but the quantity depends on how much fuel is burned in a given time.
- In the workplace, indoor air pollution may come from sources as diverse as copy machines, solvents or the air ventilation system itself.
- Some air pollutants are also released from natural sources such as volcanic eruptions and forest fires. Nature is able to cope with its own pollution by different means. However, the pollution produced by humans is simply too much, and or too complex, for nature to safely eliminate.

C). Mobile sources: travel from one place to another; e.g., cars, buses, trucks, etc.

- Some details on specific mobile sources are as follows:

D). Diesel Emissions: most buses and trucks burn diesel, emitting particulate matter, nitrogen oxides and some toxic organic compounds.

E). Gasoline emissions: cars usually use gasoline as fuel, emitting carbon monoxide, nitrogen oxides, ozone, and toxic organic materials, such as benzene, formaldehyde.

1.1.2 Characterizing Air Pollution

1. Physical characteristics of pollutants (Gaseous vs. particulate)

Air pollutants can be categorized according to their different physical phases: gas and particulate. Particulates are primarily small solid fragments light enough to be suspended in the air. Some particles may also contain, or be, a liquid mist. Their chemical composition can vary. Particulates are classified primarily by their size. The finer the particulate, the deeper it can penetrate into the small branches of the respiratory system, and the more harm it can do. Gases are chemicals in their low-density, elastic, aeriform state. Both particulates and gases are created for example when fossil fuels are burned, such as when vehicles are driven.

2. Regulatory Categories

Air pollutants can also be categorized according to the ways in which the federal government regulates them. These categories include: Criteria Pollutants, Hazardous Air Pollutants (HAPs), and Particulate matter (PM). Other gaseous pollutants are regulated individually by chemical.¹

A). Criteria air pollutants include the six most common air pollutants in the U.S.: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide. Congress has focused regulatory attention on these six pollutants because they endanger public health and the environment, are widespread throughout the U.S., and come from a variety of sources.

- Criteria air pollutants are responsible for many adverse effects on human health, causing thousands of cases of premature mortality and tens of thousands of emergency room visits annually, especially asthma. They also cause [acid rain](#) and can significantly harm ecosystems and the built environment.
- Criteria pollutants are the only air pollutants with national [air quality standards](#) that define allowable concentrations of these substances in ambient air. In 1997, EPA concluded that several of our current national air quality standards do not provide

¹ The following information is from the Environmental Defense Fund (EDF).

sufficient public health protection. New, [more stringent](#) air quality standards were adopted for ozone and particulate matter. Implementation of these standards has been slowed by legal challenges, but the U.S. Supreme Court upheld most of EPA's air quality rules in February 2001. The Court approved EPA's new standard for particulates, which expanded regulation of fine pollution particles down to 2.5 microns. The Court approved EPA's new ozone standard as well, but ordered EPA to develop a new plan that sets out a schedule for when state and local air districts must be in compliance.

B). Hazardous air pollutants (HAPs) are chemicals which can cause adverse effects to human health or the environment. Almost 200 of these chemicals have been identified, including chemicals that can cause cancer or birth defects. Very little is known about the potential health risks from this type of air pollution because fewer than 50 locations in the U.S. regularly measure the concentrations of HAPs in ambient air.

1.2 Health and ecological effects of pollution

Objective

The student will be able to.....

- ✓ Identify some health and ecological effects of pollution

Motivation

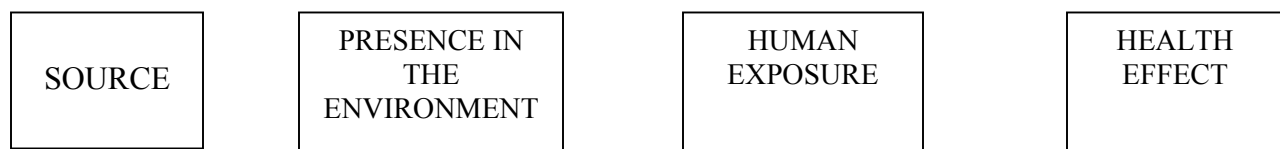
How many of you suffer from respiratory problems? How many of you know someone who does?

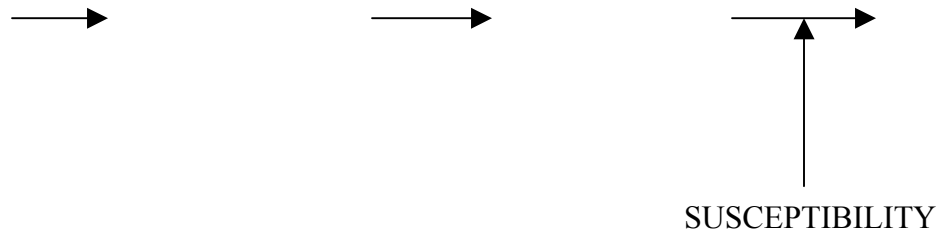
1.2.1 Risk and health effects of air pollutants

EPA's air quality [monitoring network](#) indicates that over 130 million people live in counties with unhealthy air due to one or more criteria air pollutants. People exposed to harmful air pollutants at excessive concentrations and durations may have an increased chance of getting cancer or experiencing other serious health effects. These health effects can include respiratory problems, damage to the immune system, as well as neurological, reproductive (e.g., reduced fertility or genetic damage that can cause birth defects), developmental and other health problems.

Because the lungs are the first place that air pollution lands in our bodies, adverse effects in our lungs are especially important. In addition to exposure from breathing air toxics, risks also are associated with the deposition of toxic pollutants onto soils or surface waters, where they are taken up by plants and ingested by animals and eventually magnified up through the food chain. Like humans, animals may experience health problems if exposed to sufficient quantities of air toxics over time. Some of these pollutants can be stored in the body and be passed on to a baby during pregnancy or breast-feeding.

The following schematic illustrates the way that pollution typically impacts human health.





Pollution is generated at a source and dispersed into the environment. Humans are exposed to pollution through a variety of routes, including inhalation, ingestion, and dermal absorption. The “dose” of pollutant any given individual is exposed to is a function of how much pollution that person is exposed to, and how much of that pollution makes it past the body’s primary defenses. Exposure can be modified by individual susceptibility to a given pollutant (or combination of pollutants) and this can lead to adverse health effects.

1.2.2 Types of Exposures

1. Acute exposures occur over a short time frame, such as a few minutes to a few days. In general, acute exposures lead to relatively short-lived health effects, such as respiratory or eye irritation, and are frequently considered “reversible” by risk managers and regulators. In general, the level of pollution that must be encountered by most people to lead to acute health effects is relatively high, compared to the dose that can cause health effects over a long period of time. This is because the body is equipped with defenses to clear pollutants out of the body and to fix some of the damage caused by short-term exposures.

2. Chronic exposures occur over the period of months to years, and can lead to long-term, irreversible health effects. In general, the level of pollution that must be encountered by most people to lead to chronic health effects is lower than that required for acute health effects. This is because over time, even low-level exposures can wear down a body’s defenses, or can accumulate in the body.

- There are important exceptions to these rules of thumb.
 - Very high-level acute exposures may lead to “overloading” of the body’s defenses, resulting in permanent damage or longer-term health effects.
 - Other types of acute exposures can just accumulate in the body without ever being effectively eliminated. One example of this is bioaccumulative toxins, which accumulate in the fat of human beings (including breast milk) and can serve as constant, low-level “internal exposure” to human beings over the course of years.
 - Lead is another example of this, although it is not considered a bioaccumulative toxin. Rather, lead (which the body treats like calcium) accumulates in people’s bones, where it may remain immobilized over the course of a person’s life. However, later in life, or during pregnancy for women, bones can be slowly broken down to provide calcium to the body, releasing lead into the body at the same time.

1.2.3 Possible health effects of various air pollutants

Possible biological effects of air pollution include:

1. Carcinogenic – can cause cancer, these compounds are present in indoor and polluted outdoor urban air; e.g. dioxin.
2. Respiratory – impacts lungs and breathing, e.g. occupational exposures to substances with high concentrations of sulfur dioxide, and particulates.
3. Neurological – impacts nerve and brain development and function, including learning and behavior; e.g. lead and carbon monoxide.
4. Immunological – affects the body's immune system. Allergies are a function of the immune system, so pollutants with an immunological effect can also impact allergic diseases such as asthma. Studies in animals suggest that ozone may reduce the immune system's ability to fight off bacteria infections in the respiratory system.
5. Reproductive – affects people's ability to produce healthy offspring, e.g. DDT.
6. Developmental – affects the proper (physical and mental) development, e.g. lead.
7. Endocrine – interfere with production of people's hormones, e.g. dioxins, PCB's, arsenic and phtalates.
8. Circulatory system – affects the circulation of blood, mainly heart function. Certain emissions, particularly carbon monoxide (which come from the use of fossil fuels in transportation) can exacerbate heart disease.

1.2.4 Focus: Respiratory Effects

1. Hyper reactive airways: This is when the airways constrict much more readily in response to foreign matter. Some constrictions of the airways are a normal defense mechanism to prevent inhaling noxious substances. However, people with asthma respond to levels that do not bother most people. The symptoms are, shortness of breath, coughing, and wheezing. The pollutants that stimulate airway reactivity are sulfur dioxide, particulate matter, ozone, and nitrogen oxides.
2. Asthma attacks: asthma is a disease of lungs and airways, the most common symptoms are wheezing, cough and difficulty breathing. The lungs become clogged up by mucus and the airways narrowed.
 - Causes of asthma include infection, genetic predisposition, allergies, exposure to dust, cockroaches, pollen, cats, and changes in the weather, increase air level of particulate matter, ozone, sulfur dioxide and sulfate. There is some

evidence that air pollution not only triggers asthma but also perhaps is a cause of it. This disease is diagnosed clinically with evidence based on lung function tests.

- Complications of asthma include simple exhaustion up to respiratory failure and death.
 - In the U.S. 5,000 people die each year because of asthma. Every year, asthma is responsible for 470,000 hospital admissions in this country.
3. Respiratory infections: common colds, influenza and sore throats, are associated with sulfates, sulfur dioxide and particulate matter. Influenza is related to the seasons of the year like winter or spring, and is sometimes associated with poultry slaughter.
 4. Reversible changes in lung function: temporarily, less air is inhaled when there is an elevated pollutant concentration. When the exposure ceases, lung function returns to normal.
 5. Lung cancer: causes 25% of cancer deaths. Some experts contend that air pollution causes only a few percent of all cases, while others argue that it's 20% or more². Although smoking is the major cause of lung cancer, burning by-products such as polycyclic aromatic hydrocarbons (PAHs), dioxins, fibers like asbestos, and metals such as arsenic and cadmium, can also cause lung cancer.
 6. Chronic obstructive pulmonary disease (COPD): a group of diseases that share the symptom, breathlessness. They include chronic bronchitis, emphysema and small airway disease. The main causes of COPD are smoking, occupational exposures to such substances as sulfur dioxide and particulates, and genetic factors. Regardless of how they contracted it, copious evidence shows that COPD sufferers suffer more on high pollution days.

1.2.5 Ecological effects

Several main types and effects of pollution include: smog, acid rain, the greenhouse effect, and "holes" in the ozone layer. Each of these problems has serious implications for our health and well being as well as for the whole environment

A. Acid rain is caused when fossil fuel emissions of sulfur and nitrogen oxides combined with water in the atmosphere. Acid rain is defined as any form of wet precipitation, which has a pH less than 5.6 (on a scale of 0 to 14, with 7 being neutral). The "rain" becomes acidic when water molecules (H₂O) react with gases in the air; these gases are primarily sulfur dioxide and various nitrogen oxides, forming sulfuric acid and nitric acid. When the environment cannot neutralize the acid being deposited, damage occurs.

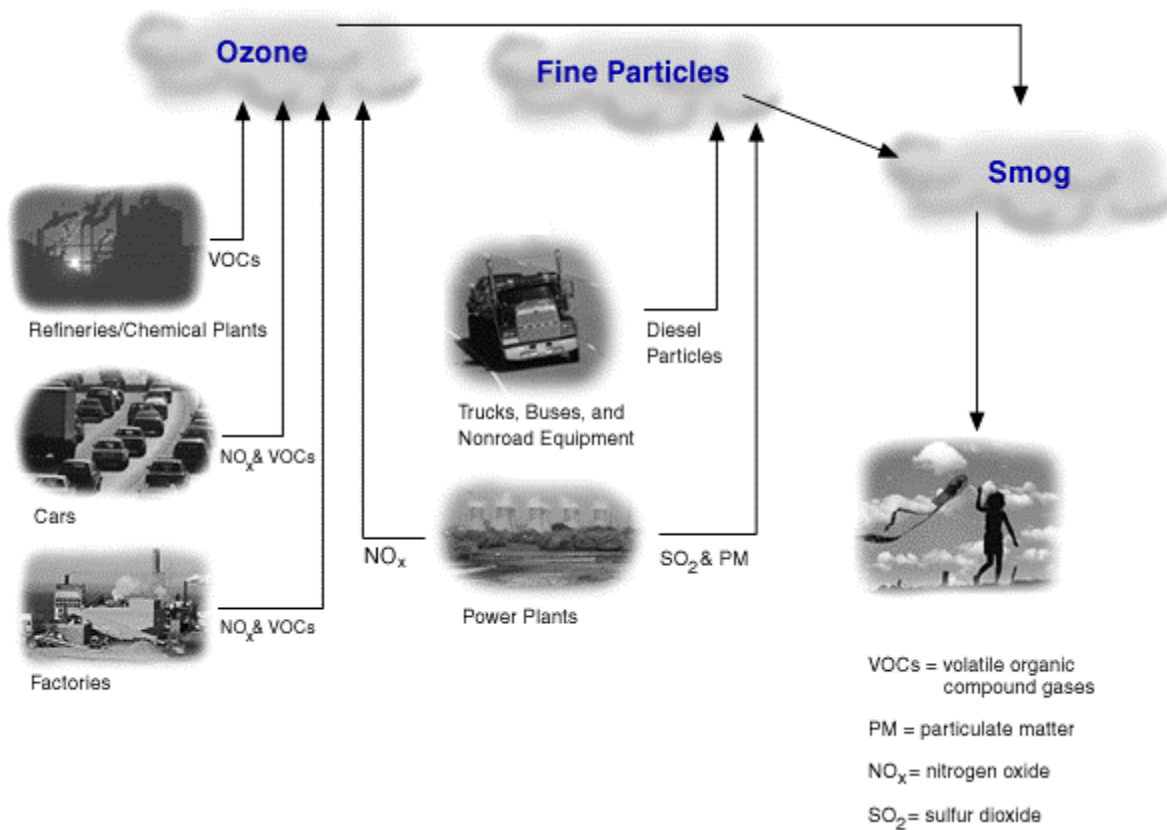
² Harte, John; Holdren, Ch.; Richard S.; Shirley, C.; "*Toxics A to Z, a guide to everyday pollution hazards*", University of California Press, California, U.S.A. 1991 page. 49

- Acid rain accelerates the decay of building materials and paints, including irreplaceable buildings, statues and sculptures that are part of our nation's cultural history. Most of the acid rain effect can be seen in the aquatic environments, such as streams, lakes, and marshes. In addition to falling directly on aquatic habitats, additional acid rain enters these habitats from run-off from forests, fields, buildings and roads. Aquatic ecosystems that have been acidified cannot support the same variety of life. As they become more acidic, fish and clam populations are the first to disappear, and then plankton (minute organisms that form the basis of the aquatic food chain) is also affected. Even the birds that feed on the fish can die.
- Acid rain also affects forests. Prolonged exposure to acid rain causes forest soils to lose valuable nutrients; it also increases the concentration of aluminum in the soil, which interferes with the uptake of nutrients by the trees. More visible damage, such as defoliation, may show up later.

B. Global warming is the increase in the average temperature of the earth's atmosphere. During the Industrial Revolution, more than 200 years ago, we began altering our climate and environment through agricultural and industrial practices that released many gases into the atmosphere. So far, in the last 200 years the global average surface temperature has risen 0.5 – 1.1 degrees Fahrenheit. In the next century, scientists are expecting an increase in temperature of 5 – 6 degrees Fahrenheit, which might not sound like much, but it could change the climate of our planet as never before. At the peak of the last ice age, 18,000 years ago, the temperature was only 7 degrees colder than it is today, and glaciers covered much of North America. A small increase in temperature over a long time can change the climate; this could alter forest, crop yields, and waters supplies, raise sea level and change precipitation and other local climate conditions. Most of the United States is expected to warm, although sulfates may limit warming in some areas.

Global warming is also an environmental justice issue, or it is an issue that will affect communities of color and poor communities sooner and more severely than other communities (for more information see Sections 2 and 3).

C. Ozone depletion is another result of pollution. Chemicals released by our activities affect the stratosphere, one of the atmospheric layers surrounding earth. The ozone layer in the stratosphere protects the earth from harmful ultraviolet radiation from the sun. Release of chlorofluorocarbons (CFC's) from aerosol cans, cooling systems and refrigeration equipment breaks down some of the ozone, causing "holes"; to open up in this layer and allowing the radiation to reach the earth. Ultraviolet radiation is known to cause skin cancer and has damaging effects on plants and wildlife.



D. Smog this term comes from the combination of the terms *smoke* and *fog*. Today it describes a mixture of air pollutants including gases and fine particles, which can often be seen as a brownish-yellow or grayish-white **haze** in the air, primarily over urban areas and especially in the summer. It impairs visibility by scattering of light. Smog is formed in the Earth's lower atmosphere, just above the surface, when pollutants emitted by cars, industrial boilers, refineries, chemical plants, power plants, and other sources react chemically in the presence of sunlight. Components of smog include ground level ozone, nitrogen oxides (NO_x), volatile organic

compounds (VOCs), sulfur dioxide (SO₂), and and particulate matter. Ground level ozone is a colorless and highly irritating gas that forms just Earth's surface. This is a *secondary* pollutant, because it is produced when two primary pollutants (NO_x and VOC) react in sunlight and stagnant air. Unlike the ozone that forms naturally in the stratosphere, **ground-level ozone** not provide any significant protection from the harmful UV rays, nor does it find its way to the atmosphere. Not only is ozone a problem for humans, it is also known to damage vegetation decrease the productivity of some crops. It can also injure flowers and shrubs and may contribute to forest decline. It can also damage synthetic materials, causes cracks in rubber,



gases,
above
does
sun's
upper
and

accelerate fading of dyes, speed deterioration of some paints and coatings. As well, it damages cotton, acetate, nylon, polyester and other textiles. Ozone is a contributor to smog found in urban areas.

1.2.5 Pollutants, some sources and health effects

The following table contains pollutants and some of their health effects, this only occur in very high concentrations, associated with some occupational exposure.

POLLUTANT	DESCRIPTION	SOURCES	HEALTH EFFECT
Benzene	colorless liquid, sweet odor	Refinery emissions, gasoline motor vehicle exhaust	Drowsiness, dizziness, and unconsciousness, long term exposure may cause anemia, leukemia
Carbon monoxide	colorless, odorless gas	Emissions from motor vehicles, coal and oil furnaces, smelters, steel plants.	Headaches, reduced mental alertness, heart damage, death.
Formaldehyde	colorless, pungent-smelling gas	Emissions from motor vehicles, chemical plants, pressed wood products	Irritates eyes, nose and throat; wheezing and coughing; fatigue; skin rash; may be a factor in causing cancer
Nitrogen dioxide	gaseous compounds made up of nitrogen and oxygen	Emissions from motor vehicles, power plants, coal and oil furnaces	Bronchitis, emphysema, lowers resistance to influenza
Ozone	bluish gas	Vehicle exhaust, formed from hydrocarbons and nitrogen oxides in the presence of sunlight	Lung disorders, eye irritation, respiratory tract problems, aggravates asthma
Particulate matter	particles of soot, dust or other matter, including small droplets of liquids	Diesel engines, power plants, industries, windblown dust, wood coal or oil stoves/heaters.	Lung disorders, eye irritation, respiratory tract problems
Sulfur dioxide	colorless gas, smells like burnt matches	Emissions from coal and oil furnaces, smelters, diesel	obstructs breathing, irritates eyes, lung damage
Lead	metallic element	Vehicle burning leaded gasoline, smelters	Brain and kidney damage; high blood pressure, impairs growth

1.3 Ways to detect air pollution using senses

Objective:

The student will be able to.....

- ✓ Detect air pollution using senses

Motivation: Have you notice the difference between the smells that come from trucks than those that come from cars?

A. Smell the sense of smell sometimes can tell you when there is something wrong with the air you are breathing. Some chemicals can be identified by their smell, such as benzene, ammonia, chlorine (bleach), hydrogen sulfide (which smells like rotten eggs).

B. Sight the sense of sight can indicate that there is too much smog in the atmosphere, because when you look towards the horizon it is hard to see buildings.

C. Taste the sense of taste can also be used to detect air pollution, because pollutants like sulfur can be actually detected with the tongue, it tastes metallic.

Of course not all pollutants can be detected by the senses but as you can see, some can be.

1.4 Vocabulary

1. Air pollution: the soiling of the atmosphere by contaminants to the point that may injure health, property, plant or animal life, or prevent the use and enjoyment of the outdoors.
2. Atmosphere: the whole mass of air surrounding the earth.
3. Carbon dioxide: a colorless, odorless gas formed during breathing, combustion, and decaying which adds to the greenhouse effect.
4. Carbon monoxide: a colorless, odorless, poisonous gas produced when carbon-containing substances such as coal, oil, gasoline, wood, or natural gas do not burn completely.
5. Combustion: burning or the production of heat and light energy through a chemical process; rapid oxidation.
6. Contaminant: an element or pollutant that soils the air.
7. Emission: a discharge or release of pollutants into the air, such as from a smokestack or automobile engine.
8. Formaldehyde: colorless gas with a pungent and irritating odor.
9. Haze: fine dust, smoke, or light vapor causing lack of transparency of the air.
10. Hydrocarbon: organic compounds that contain carbon and hydrogen in their molecules.
11. Inversion: occurs when a dense layer of cold air is trap under the layer of warm air and acts much like a lid, trapping pollutants within the cold air near the floor.
12. Ozone: a colorless gas that is formed when pollutants react with sunlight and that is a major part of smog.
13. Pollution: impurities in air, water and land that create an unclean environment.
14. Smog: the ground level haze resulting from the sun's effect on air pollutants.
15. PH scale: measures how acidic or basic a substance is. Ranging from 0 – 14, considering 7 as neutral.
16. Solvent: substance capable of dissolving or dispersing another.
17. Vapor: a substance in gaseous state.

1.5 Some Suggested Activities

- 1) Go online to <http://www.epa.gov/ozone/science/misoz/index.html> and read the comic “On the trail of the missing ozone.”

- 2) True and False Air Pollution handout- see attached
- 3) Go online to scorecard.org and have students put in their zip codes and identify who and what is polluting their neighborhood.
- 4) Guest Speaker: one of the scientists and/community organization representatives involved in the high school study would explain the purpose of study and some of its preliminary findings.
- 5) Have students fill in the table on page 12.

1.5.1 Laboratory Activity: “Acid rain: An air pollutant”

Objective

The student will be able to....

- ✓ Explore the effects of acid rain.

Materials:

Picture of a defaced statue; chalk, vinegar and glasses for each group

Background:

Acid rain is more acidic than normal rain and forms through a complex process of chemical reactions involving air pollution. The two most important pollutants that contribute to the formation of acid rain are oxides of nitrogen and sulfur dioxide, which react with moisture in the atmosphere to form nitric and sulfuric acid. The sulfur and nitrogen compounds that contribute to acid rain primarily come from manmade sources, such as industries and utilities. Emissions also come from automobiles and other forms of transportation and industrial processes, such as smelting.

Acid rain can harm forests and crops, damage bodies of water, and contribute to the damage of statues and buildings. Researchers are considering the possible effects of acid rain on human health. These acidic pollutants can be deposited through rain, snow, fog, dew, or sleet. Large quantities can also be deposited in a dry form through dust.

Pollutants that contribute to acid rain may be carried hundreds of miles before being deposited on the earth. Because of this, it is sometimes difficult to determine the specific sources of these acid rain pollutants.

Procedure:

1. Explain that acids react chemically with limestone.
2. Explain that the vinegar is an acid and chalk is limestone.
3. Fill a glass 1/3 full with vinegar for each group.
4. Add a piece of chalk to the glass.
5. Have the students write what they see happening.
6. Discuss their observations and inferences.
7. Add corrected notes to notebook.

Discuss the slow deterioration of statues and buildings due to the weak acid rain that falls on some statues and buildings. If the stone is limestone or has limestone in it, the deterioration is more rapid.

Extensions:

- See the Acid Rain "[Information, Activities and Data](#)" page for suggested activities using acid rain data collected by the Texas Natural Resource Conservation Commission.
- Gather pictures of examples of acid rain (chemical weathering).
- Research effects of acid rain on great art works.
- Research causes of acid rain.
- Suggest solutions to the problem of acid rain.

Acknowledgment:

Lois Richardson, Stephen F. Austin University Nacogdoches TES Course, 1994

Section 2: Regulatory Approaches to Air Pollution

Objectives

The student will be able to.....

- ✓ Identify key moments in the history of air pollution awareness
- ✓ Understand the history of air pollution regulation and air quality standards
- ✓ Understand the importance of establishing regulations and monitoring them
- ✓ Understand the politics behind air pollution standards and management
- ✓ Understand NAAQS in more detail, including pro's and con's in the process
- ✓ Understand the "prove harm" approach to environmental regulation
- ✓ Understand sampling and analysis concepts/vocabulary
- ✓ Be introduced to the inequalities of air pollution protection
- ✓ Learn about alternative regulatory strategies
- ✓ Understand the main meaning of, and concepts behind the Precautionary Principle

Motivation: With all of the dangers of air pollution, how can people protect themselves? What role does/should the government play in regulating air pollution?

2.1 Overview

The creation, implementation and enforcement of environmental regulations are good and clear examples of how differing social, economic and political forces may operate in the governmental arena to influence policy. Although regulations may appear to be set on the basis of scientific information, in reality they are decided upon after a variety of "stakeholders," make their views known.

Stakeholders may include corporate lobbyists (and scientists and financial analysts hired by them), public health and environmental advocates, public interest organizations, industry and union representatives, and the general public. Government agencies usually then make a *political* decision, weighing competing interests including forces the political and economic interests of the officials and/or the party in power.

Thus the limits of "permissible pollution" are set as the social (both financial and quality of life) costs of human illness and environmental harm balanced against the economic drive of industry to reduce costs and maximize profits. Often, government supports the industry position, particularly in the absence of very strong public pressure to the contrary.

Indeed, it is only due to the struggles of communities and advocates across the U.S. that we have environmental regulations at all. In other words, whatever improvements have resulted in the protection of the environment and the health of human beings and other living organisms has been obtained due to the work of many generations of community and other activists. More advances are needed to protect the environment, especially our air.

2.2 History of Air Pollution Awareness & Regulation

Objective:

The student will be able to.....

- ✓ Identify key moments in the history of air pollution awareness.
- ✓ Evaluate key moments in the history of Air Pollution regulation in the U.S.
- ✓ Understand NAAQS in more detail, including pro's and con's in the process
- ✓ Understand sampling and analysis concepts/vocabulary

Motivation: Air pollution is not something you can necessarily see or hear – how did people first become aware that it was a problem? How might politics play a role in setting air quality standards?

2.2.1 Timeline of Selected Air Pollution Awareness Events

Industrial Revolution (late 1800 to early 1900s):

- The problems of atmospheric pollution began during Industrial Revolution, when people living near the industries had to breathe intolerable amounts of smoke, which spread to the whole city, but at that time, the eagerness for industrial development counteracted the annoyance and complaints. In 1912 England and the United States developed some smoke emissions regulations, but did not enforce them.

Mid 20th Century:

- 1930: A temperature inversion trapped the pollutants produced in the Valley of the River Meuse, in eastern Belgium for a week causing sudden respiratory problems to 6,000 inhabitants. 60 died during that incident. In that same year, one hundred persons were killed by pollution emitted by the industries.
- Early 1940's: An irritating fog formed over Los Angeles giving birth to the word, "smog."
- 1948: Six hundred inhabitants suffered respiratory problems, and 20 died during a pollutant fog that stopped several days over a small town in Donora, Pennsylvania. The fog resulted from the combined emissions of the town's steel and zinc melting industries and a sulfuric acid plant.
- 1952: In what is considered the worst pollution catastrophe in England, acid smog in London covered the city, forming a dense fog, affecting the Thames River Valley, and provoking widespread respiratory and circulatory system symptoms. The death toll climbed to an estimated 3,500. The smog resulted from the combination of sulfur dioxide emitted by industries, the massive burn of carbons used in heating, and the combustion of oils used in industrial plants. As a prevention measure, the authorities closed the domestic coal burners and ordered their replacement by natural gas or electricity.

Late 20th Century

- 1984: Bhopal, India, the gas leak of a pesticide plant owned by Union Carbide (now Dow) killed 8000 persons and injured about ½ million, with many more sick and dying. The pollution, which initially was in the air, settled in the soil and water of the nearby community. Thus, the poisoning continues today, as no one has accepted responsibility for the waste, and the chemical company still refuses to clean up the site. Today, the

death toll stands at 20,000 and is rising every day. Children born to survivors are suffering health problems and 150,000 people are in urgent need of medical attention. Look for more information on this continuing crisis at www.greenpeace.org.

2.2.2 Timeline of Existing Regulations and some of their Pro's and Con's

1963 - 1967 Initial clean air legislation

- States were given primary responsibility for setting standards
- Problems: lack of state expertise; states were concerned that too-strict regulations would hamper about their ability to stay financially competitive

1970 Creation of EPA by Nixon Administration/Clean Air Act amendments

- Goal was to achieve clean air by 1975
- Federal government took responsibility for setting standards; states would implement them
- Regulations now managed air quality and controlled emissions
- National Ambient Air Quality Standards set for six major air pollutants, known as criteria pollutants: sulfur dioxide, particulate matter, nitrogen oxides, ozone, lead, and carbon monoxide. (See Section 2.4 for more information)

1977 Clean Air Act amendments

- Postponed the original schedule for compliance with the regulations set in 1970
- Preserved air quality in pristine areas, but allowed degradation in other areas that were already below the standards

1980s Reagan Era of Government Decontrol

- Reagan administration did little to promote environmental quality while also greatly reducing government involvement in corporate affairs

1990 Clean Air Act amendments

- Bush I reinstated environmental regulation
- New Sulfur Dioxide emissions reduction plan was established to reduce acid precipitation
- EPA was now required to establish emissions controls for a set of 189 Hazardous Air Pollutants (HAPs)

2002 Clear Skies proposal

- Proposal set forth by Bush II administration and currently still under debate
- Reduces cuts in power plants' sulfur, nitrogen and mercury pollution required by the Clean Air Act
- Expands "cap and trade" program. In this program, the government caps emissions at certain levels. Each polluter is then given permits to pollute up to a certain amount. Those that are able to reduce emissions at a low cost can sell their extra permits to companies facing high costs (which will generally prefer to buy permits rather than make costly reductions themselves)

- BUT, this allows certain places that may already be polluted to become even more polluted³

2.2.3 Current Regulatory Challenges

New generations of community air pollution activists face many challenges including:

- The alarming rate of asthma and other respiratory diseases that are affecting communities of color and poor communities across the USA.
- Modifications to New Source Review. This provision of the Clean Air Act compels industries, when expanding or significantly modifying plants, to bring them up to current codes, instead of allowing them to be “grandfathered” to lower standards. The Bush Administration is attempting to exempt certain kinds of industries from the rule, including coal producers. This particularly affects New York because prevailing wind patterns blow asthma-causing emissions from the Midwest into New York.
- The attempt by oil interests to rollback the modest gain in the phase-in of “cleaner” diesel fuel until 2010. The use of truly clean fuels in trucks and buses (including school buses) would have a major impact on air pollution in our communities.
- Current permitting forces communities to prove harm, rather than polluters needing to prove safety. Permitting “acceptable” pollution levels is done one company at a time, and does not take into account the cumulative impacts (be they synergistic or additive), of a concentration of industries and/or mobile sources (concentration of vehicles for example on crowded highways or bus routes).

2.2.4 National Ambient Air Quality Standards – Evaluation & Reassessment

- Standards follow 5-year revision for reevaluation
- Each revision takes ~3 years to complete
- Revisions start with an exhaustive literature review that forms the basis of a 'criteria document'
- Next, a synthesis document summarizes the science and recommends ranges of possible standards. This is called a “staff paper.”
- The EPA includes extensive opportunities for public comment at every step of the revision process
- The EPA administrator decides on the new standard
- States then must develop implementation plans to achieve the standard.

³ Despite the support of emissions trading by several mainstream environmental organizations, many grass-root environmental organizations visualize emissions trading and pollutions credits as a new tool for corporations and government to perpetuate environmental injustice. A study conducted in California by scientists Richard Toshiyuki Drury, Michael E. Belliveau, J. Scottkuhn and Shipra Bansal concluded:

“Evidence indicates that pollution trading programs in Los Angeles are plagued with problems. Although the programs have succeeded in saving money for industry, they have not effectively reduced emissions and have not promoted technology innovation or public participation. Instead, they have further concentrated the region's pollution in lower income communities and given industry a "free ride" from otherwise obligatory emissions reduction schedules.

- States must monitor air quality to assess compliance. Penalties may be imposed if compliance does not occur; but in practice, the deadlines for compliance are usually extended as long as some progress towards compliance is being made.

2.3 Why monitor?

Objective:

The student will be able to.....

- ✓ Understand the importance of monitoring air quality and emissions

Motivation: Why is it important to keep track of air pollution?

Regulations are one thing, but continuous monitoring of emissions and air quality is also important for several reasons:

- The first, most obvious reason for monitoring is to evaluate compliance with National Ambient Air Quality Standards for criteria pollutants.
- Each standard has factors which determine the kind of monitoring that is carried out. These factors include evaluating contaminant concentrations, averaging times of exposures, and establishing a reference period.
- Because of this regulatory need, criteria pollutants have the most extensive monitoring data.

Other specific monitoring objectives include:

- To measure population exposures related to a particular source
- To measure long-term trends
- To measure worst case “hot-spots”
- To support epidemiologic studies

2.4 Flaws in the System

Objectives:

The student will be able to.....

- ✓ Understand the politics behind the Clean Air Act’s initial passage
- ✓ Understand the concept of “Prove Harm”, and the politics behind it
- ✓ Be introduced to inequalities in air pollution protection

Motivation: Thresholds for permissible levels of air pollution change frequently – why does the government not set one standard and stick to it? What kinds of interests are involved in setting these standards? How might they change over time?

2.4.1 Politics and the Passage of the Clean Air Act

The groundbreaking passage of the Clean Air Act and the Clean Water legislation of the 1970’s came about under tremendously contentious political circumstances. Former Maine senator and presidential candidate Edmund S. Muskie, in a paper published originally in The Environmental Forum in 1990, clearly described the politics behind Act’s passage:

“In 1970, the members of the Senate Subcommittee on Air and Water Pollution were ready to launch a tough new approach to clean up the nation's air. Earth Day occurred during the hearings. Members were overwhelmed by mail from across the nation. We used every ounce of political leverage the Earth Day constituency created to prod a reluctant President and an equally reluctant House of Representatives to accept landmark clean air legislation. Passage of the Act was a success against tremendous odds. We overcame political adversity and the business community's inertia....”(The Environmental Forum, 1990).

Clearly the passage of clean air regulations was more a political decision than a decision based on changing the heart of government and corporations about the need of protecting the health of people and the environment, or new scientific understandings.

2.4.2 Politics & “Prove Harm”

Partly as a result of the contentious environment under which it was passed, the Clean Air Act, and other major US environmental regulations, is based on what Peter Montague calls the **“prove harm regulatory system.”** Montague argues that this system hinders the meaningful protection of the environment and of humans from environmental toxins. In his magazine, *RACHEL'S ENVIRONMENT & HEALTH NEWS*, Montague offers a partial list of reasons that a “prove harm” system fails:

1. The "prove harm" system of regulation requires that harm must occur before action can be taken. This means that many millions of people had to become sick (with childhood cancers, lymphomas, reproductive cancers [breast, prostate], Parkinson's disease, chronic fatigue syndrome, diabetes, endometriosis, asthma, and a host of other environment-related diseases) before regulators could pay attention. Thus regulators were put in the futile and frustrating position of trying to close the barn door long after the horse had left.

As a result, the entire planet is now contaminated with potent, long-lived industrial poisons that were released (and, in most cases, are still being released) on the assumption that they are "safe" because no one has proven otherwise. By the time scientific proof of harm accumulates it is too late to prevent harm. Thus true prevention is generally not an option under the "prove harm" system.

2. Science often cannot define "harm" very clearly; much less prove that it has occurred. Take the case of the toxic metal, lead. In 1975, 39 micrograms of lead in a 10th of a liter of human blood was declared harmless (40 was the "action level"). We now know that 39 can cause severe brain damage in children. As science improved, 29 micrograms was declared harmless, then 14 micrograms, and now 9. Today -- 30 years and tens of millions of brain-damaged children later -- many scientists acknowledge that ANY amount of lead in your blood can damage your central nervous system and reduce your IQ. However scientists hired by the lead industry dispute these conclusions, pointing to uncertainties in some of the data, and so the scientific debate continues while the "safe" level of lead remains at 9 micrograms, which most knowledgeable scientists consider damaging to children.

3. As in the case of harm from lead, there is always some uncertainty in any scientific conclusion. Under the "prove harm" regulatory system, scientific uncertainty provides a green light for business as usual. But, when scientific uncertainty is allowed to create a green light for business as usual, scientists can always be found who will cast doubt on any study, any set of data, thus creating scientific uncertainty.

4. The "prove harm" system focuses its attention on the "most exposed individual" and sets regulations intended to protect that hypothetical person. If "risk assessment," concludes that the "most exposed individual" will probably not be harmed by the industrial discharge of chemical X, Y, or Z, that discharge is approved. What the system fails to take into account -- because science has no means for doing so -- is the cumulative effects of thousands upon thousands of "safe" discharges, which add up too contaminated neighborhoods and a contaminated planet. By focusing on individuals and by requiring science to "prove harm," the system has sacrificed ecosystems and communities.

5. The "prove harm" system has no way to account for the fact that all people (and these days, all plants and animals as well) are subject to multiple exposures -- from the soot from power plants and garbage incinerators; from pharmaceutical drugs; from diesel exhausts; from excessive ultraviolet light streaming in through the Earth's damaged ozone layer; from pesticides in air, rain, fog, food and water; from industrial poisons discharged into sewage treatment plants and then into rivers; from radioactive fallout left over from the era of A-bomb tests, from artificial growth hormones widely used in agriculture, etc. etc.

Scientists have no agreed-upon methods for evaluating the combined effects of multiple exposures to toxicants, and so they ignore multiple exposures, pretending that the world is much simpler than it really is. As a consequence, none of the regulatory system's "scientific" determinations of "safety" actually has any scientific validity. They represent seat of the pants estimates, gut feelings, best professional judgments, and plain guesses, all laced with a strong measure of hope that everything will turn out OK.

6. The "prove harm system underlies risk based analysis, which is premised on the rationale that there is a social acceptable impact on the environment or the health of a human being. Thus one sees such statements as "the risk to human health of the use of X chemical is *only* X cases of cancer per million of population," in an effort to make insignificant its effect.

7. Moreover, by the concentration of toxic industries in particular areas characterized by their racial and income demographics, one finds that not only are some lives disposable, but that through disproportionate burdens that some lives are more disposable than others. So we find that the regulatory system is neutral neither in its development nor in its practice.

2.4.3 Air Pollution Protection Inequalities

As mentioned above, when we evaluate the results of the Clean Air Act Protection to individuals in our society we find that generally speaking not all are protected equally by the federal, states and local regulations.

In a study published in October of 2002 by the Georgia Coalition for the Peoples, titled “Air of Injustice,” the authors concluded that:

- 71 % of African Americans live in counties that violate federal air pollution standards, compared to 58% of the white population.
- Asthma attacks send African Americans to the emergency room at three times the rate (174.3 visits per 10,000 populations) of whites (59.4 per 10,000 populations).
- African Americans are hospitalized for asthma at more that three times the rate of whites (35.6 admissions per 10,000 populations versus 10.6 admissions per 10,000 populations).
- The death rate from asthma for African Americans is twice that of whites (38.7 deaths per million populations versus 14.2 deaths per million populations).

More information about environmental justice and what you can do about it is included in Sections 3 and 5.

2.5 Alternative regulatory strategies

Objective:

The student will be able to.....

- ✓ Understand alternative approaches to environmental regulation
- ✓ Understand the main meaning of, and concepts behind the Precautionary Principle

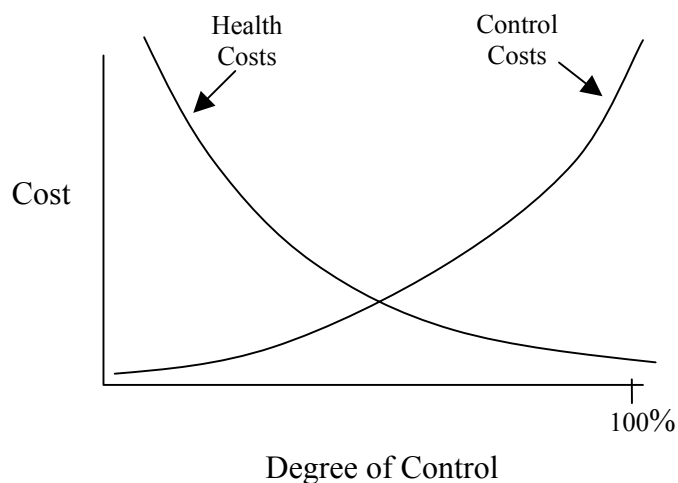
Motivation: What kinds of things do other countries do to regulate air pollution? How could we correct some of the problems we’ve discussed? How could we move beyond the “prove harm” ideology?

1. Cost-Benefit Analysis

- See figure
- optimal societal strategy is to minimize total costs

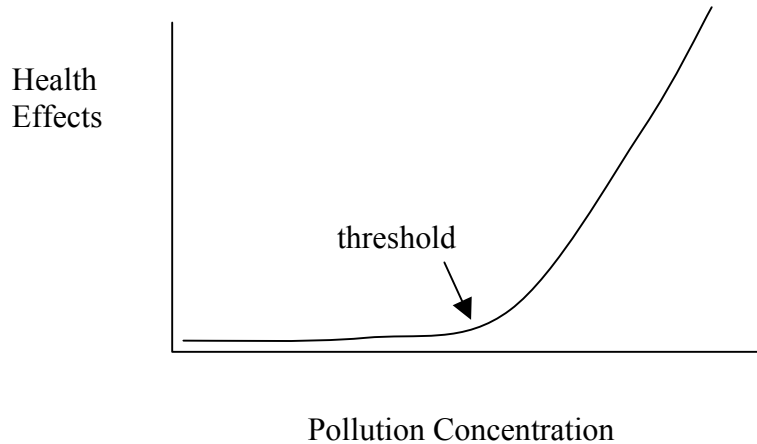
but...

- health costs are hard to identify and quantify
- equity issues are ignored
- definition of costs is political



2. Air Quality Management

- Assumes we can determine a safe level of air pollution, below which no adverse effects occur. This puts a high demand on scientific evidence, and implies the existence of a health 'threshold', e.g.:



- This is the approach used in the US Clean Air Act to regulate the criteria pollutants. The CAA legislation says the National Ambient Air Quality Standards (NAAQS) should protect against "adverse health effects" among "sensitive population subgroups" with an "adequate margin of safety."
 - But all three phrases are open to interpretation
 - Once an air quality standard is established, we need a mechanism for achieving it (emissions control plan), for evaluating success in achieving it (i.e., air monitoring), and for enforcing it (penalties or incentives).
- (3) Emissions Standards
- A simple strategy that is based on what current control technology is capable of doing
 - Results in uniform emissions goals within a class of emitters (e.g., power plants of a certain size)
 - Tends to result in gradual improvements in air quality as control technology improves
 - This is the main policy approach used in the UK and other European countries to regulate air quality.
 - In the U.S., the emissions standards approach is used for controlling hazardous air pollutants (HAPs) and for SO₂ emissions that produce acid precipitation.
 - A good strategy to use when there's not enough scientific data, or political will, to set an air standard for a particular pollutant
- (4) Other Economic Strategies
- Pollution taxes
 - Pollution credits and trading
 - First used for SO₂ emissions in the 1990 Clean Air Act amendments

- Power plant is given allowance to emit x amount of SO₂. If emissions are less than x , plant can sell the credits; if emissions are greater than x , plant can buy credits from somebody else
- Results in equity concerns, e.g., if emissions are higher in some neighborhoods than others (see also footnote 3, this section)

2.5.1 Precautionary Principles

- The precautionary principle is simple: when there is reasonable suspicion that harm is occurring or about to occur, we all have a duty to take action to prevent harm even if some cause-and-effect relationships have not been proven to a scientific certainty, a “First do no Harm” approach.
- The precautionary principle is best summed up as "better safe than sorry." As simple as it may seem, precautionary action represents a completely different approach to the protection of human and environmental health (Montague, 2002).
- This approach was used, much to the consternation of the tobacco industry, in the Surgeon General’s warnings on smoking in the 1960’s at a time when there was only preliminary evidence linking smoking and lung cancer. Today a similar level of evidence exists on the harms of many toxic chemicals, yet a struggle is still on going to have them better regulated or banned.
- To summarize:
 - The first difference between the cost/benefit ratio risk analysis approach or the precautionary approach is that under the former, some lives are expendable and some harms are acceptable.
 - The second difference regards the burden of proof. Under our current approach the stakeholders with the least resources; community, public health and environmental advocates have to prove “unacceptable, irrefutable harm,” whereas under the precautionary approach a manufacturer or a user of a process or chemical first has to prove its safety.

2.6 Sampling and Analysis Vocabulary

1. **Sampling**: You can’t measure every place all the time. Rather, you must choose places and times to monitor that are representative of the places and times you really want to know about.
2. **Averaging time**: Over what period should concentrations be averaged? Usually averaging times are set to correspond to those defined by air quality standards. For example, ozone is usually recorded in one-hour averages since the air quality standard is for one hour. However, for an epidemiology study, one may want to characterize long-term exposures, which implies a longer averaging time.
3. **Accuracy**: How close a measurement is to the true value. Generally assessed using calibration, i.e., delivering a known “standard” quantity of the pollutant to the monitor and seeing how well it measures it.
4. **Precision**: How scattered are measurements around the mean value? Can be assessed by looking at the repeatability of measurements of a standard, or by replicate sampling.

5. Quality control (QC): Routine procedures used during the monitoring process to ensure accurate and precise data.
6. Quality assurance (QA): A system for ensuring and documenting data quality, encompassing QC procedures, maintenance of records, audits.
7. Calibrations: Periodic testing of instrument response using known, standard levels of the pollutant of interest. Standards may be ‘primary’ or ‘secondary.’ Either is okay.
8. Audits: Periodic testing by an independent body of instrument response or overall measurement systems, procedures, and documentation.
9. Sensitivity: Given that the pollutant of interest is present, how well is it measured? Degradation of collected sample, through evaporation or chemical transformation, reduces sensitivity.
10. Specificity: Is the measurement method specific to the compound of interest, or do other compounds influence the result?
11. Limit of detection: The lowest concentration that can be measured with a specific level of confidence. How is this determined?
12. Four basic approaches to air monitoring: grab, static, integrated, and continuous:
 - a. Grab: vacuum containers or bags can be used to “grab” some air, which can then be brought back to the lab for analysis. E.g., VOCs, tracer gas experiments.
 - b. Static: a device is left exposed to air for a period of time. Air pollution is collected passively. The collector is taken to a lab for analysis. E.g., diffusion sampling for VOCs onto activated carbon, ozone, NO₂.
 - c. Integrated/(or Intermittent): This refers to active collection (i.e., with a pump) of a sample of air onto some sort of collector. Collector is taken to lab for subsequent analysis. E.g., bubblers for gasses like SO₂, adsorption of VOCs onto activated carbon, collection of particles on filters.
 - d. Continuous/(or Real-time): Since the mid-1970’s, all criteria gases are collected with automated continuous analyzers that have internal pumps, which draw air through a detector. The detector sends an electronic signal (voltage) that is proportional to gas concentration. This signal is recorded on chart paper and also on a digital recorder, which can later be downloaded and processed on a computer.

2.10 Some Suggested Activities

- 1) Have students choose one criteria pollutant and trace its standards and compliance in a particular state.
- 2) For environmental injustice activities, see those suggested in Section 5.
- 3) MORE??

Section 3: Particulate Matter & Diesel

Objectives:

The student will be able to....

- ✓ Identify sources of fine particle matter and diesel
- ✓ Identify health and ecological effects of air pollution
- ✓ Identify how the government regulates air pollution
- ✓ Students will understand the following concepts about fine particulate matter (fine PM) and diesel exhaust:
 - Sources (including local sources)
 - Fate & transport in the environment
 - How and where people are exposed
 - Health Effects
 - How the government regulates these pollutants

Materials:

- Risk Assessment of Toxic Air Pollutants: A Citizen's Guide (EPA)
- Diesel Article
- PowerPoint presentation on "Diesel Exhaust" by WE ACT

Technology Resources:

<http://www.tnrcc.state.tx.us/exec/sbea/education/air/lessons/partinfo.html>

<http://www.epa.gov>

<http://www.nrdc.org/air/transportation/schoolbus/sbusinx.asp>

<http://www.mindfully.org/Air/SchoolBus-Diesel-Asthma7feb02.htm>

3.1 Particulate Matter & Diesel Exhaust Defined

Objectives

The student will be able to....

- ✓ Define and identify sources of fine particle matter
- ✓ Develop a comprehensive definition of diesel exhaust
- ✓ Why diesel is a problem for their community in particular
- ✓ Identify the health effects of diesel exhaust

Motivation: What are some of the worst air pollution problems facing our community? Where do they come from?

3.1.1 What is particulate matter?

Particulate matter is made up of tiny particles in the atmosphere that can be solid or liquid (except for water or ice). It is produced by a wide variety of natural and manmade sources. Particulate matter includes dust, dirt, soot, smoke and tiny particles of pollutants. Some particles attract and combine with amounts of water so small that they do not fall to the ground as rain. Major sources of particulate pollution are factories, power plants, trash incinerators, motor

vehicles, construction activity, fires, and natural windblown dust. Particles below 2.5 microns (micrometer, or a millionth of a meter) in size (about seven times smaller than the width of a human hair) are more likely to travel deep in the respiratory system, and be deposited deep in the lungs where they can be trapped on membranes. If trapped, they can cause excessive growth of fibrous lung tissue, which leads to permanent injury. Children, the elderly, and people suffering from heart or lung disease are especially at risk. Particles of 2.5 microns or less are also referred to as PM_{2.5}.

Large amounts of pollution particles in the air cause haze and can lower visibility. Vehicles also emit particulate matter, which can cause higher pollution levels in more densely populated areas. Highs or lows may also be caused by area-wide weather conditions such as dust storms or rain. Some areas within a city may be worse than others if they are located closer to major pollution sources such as industry or highways.

3.1.2 What is Diesel Exhaust?

The characteristic clouds of black smoke emitted by diesel engines are comprised of thousands of substances, including gaseous pollutants and solid particulate matter. The gaseous pollutants include carbon monoxide, carbon dioxide, sulfur dioxide, nitrogen oxides, and organic chemicals or hydrocarbons. Of these, nitrogen oxides (NO_x) are especially problematic because they are precursors to ozone. In fact, the EPA estimates that diesel trucks are responsible for one-third of the smog-forming NO_x emissions coming from all vehicles in the United States. Diesel exhaust contains over 40 organic chemicals identified by the EPA as Hazardous Air Pollutants (HAPs), also called air toxics, which are either suspected to cause cancer or create other serious health risks.

Ground-level ozone, also known as smog, is formed when nitrogen oxides from motor vehicles reacts with volatile organic chemicals (VOC's) in the presence of sunlight. This highly oxidizing pollutant irritates the respiratory system and can cause wheezing and coughing, and trigger asthma attacks. Long-term exposure to ozone can cause lung damage, and one recent study showed that children in Los Angeles who played three or more sports were at higher risk of developing asthma later in life, possibly as a result of their ozone exposure (McConnell *et al*, 2002). Ozone also increases susceptibility to respiratory illnesses and can reduce lung capacity in both the long run and the short-run.

Diesel exhaust is also made up of millions of tiny solid particles, ranging in size from 5 nanometers (a billionth of a meter) to slightly larger than 10 micrometers (µm, also known as or microns, which are a millionth of a meter.). The period at the end of this sentence is about 200 µm in diameter. Most particles are smaller than 2.5 µm, and most are smaller than 1 µm. These particles are made up of an inorganic carbon core, to which organic compounds can adhere. Inorganic carbon is also referred to as black carbon or elemental carbon.

It is this elemental carbon core that distinguishes diesel exhaust particles from other types of fine particles in ambient air. Elemental carbon serves as a great surface for other types of chemical

pollutants to cling to⁴. For example, volatile organic chemicals, allergens, and other elements in the air adhere to the surface of diesel exhaust particles. These are pollutants that could not normally get deep into our lungs because they would be “caught” by the body’s natural defenses. However, since fine diesel particulate matter can bypass these defenses, these pollutants are essentially able to hitch a ride into the lungs where they would not otherwise get access. Furthermore, because diesel exhaust particles are so small, they collectively have a lot of surface area to which other substances can adhere.

Diesel particulate matter also contributes to ambient levels of fine particulate matter, or PM_{2.5}, which is defined by the EPA as particles with a diameter of 2.5 μm or less. PM_{2.5} are tiny particles in the air that are of special concern because they are so small that they are able to bypass our respiratory defense systems and penetrate deep into the lungs. In a typical city, diesel particulate matter contributes between 10% and 30% of the fine PM in the air of the city. The other PM in the air is comprised of sulfates, which come from sulfur dioxide emissions, and nitrates, from nitrogen oxide emissions. Sulfur dioxide primarily comes from coal-burning power plants, while nitrogen oxides come from both power plants and motor vehicles.

The haze that characterizes many urban skies is largely a result of fine particulate, or PM_{2.5} pollution. Fine particulate matter is well known to be associated with early mortality, largely from cardiac effects, hastening at least 30,000 deaths annually. Additionally, recent studies have shown that fine PM pollution is also associated with lung cancer, and that living in the most polluted cities in the U.S. can increase a nonsmoker’s risk of dying of lung cancer by 20% -- about the same increase in lung cancer risk faced by a nonsmoker living with a smoker (Pope *et al.* 2002). PM_{2.5} also exerts other chronic respiratory, immunological, and neurological effects.⁵

Because diesel exhaust is composed of thousands of different substances in varying proportions, exposure to this combination of multiple substances exemplifies the kind of poorly understood risk associated with exposure to multiple substances, a common phenomenon in many communities of color. Each of these substances exerts its own potential health effect and may interact with each other substance in ways that remain poorly understood.

3.2 Why diesel is a problem for communities of color

Objectives

The student will be able to....

- ✓ Understand the links between asthma and diesel emissions
- ✓ Identify some of the reasons why communities of color have higher asthma rates than the rest of the country

Motivation: What kinds of diesel sources do you see around you everyday? Is there a difference between your neighborhood and other neighborhoods in the city?

⁴ For example, water filters and other pollution-trapping devices are frequently made out of charcoal or “activated carbon,” which traps pollution by making it stick to a carbon bed.

⁵ In 1997 the Environmental Protection Agency, recognizing the severe health problems created by fine PM, promulgated a National Ambient Air Quality Standard for PM_{2.5} of 15 μg/m³ annually averaged.

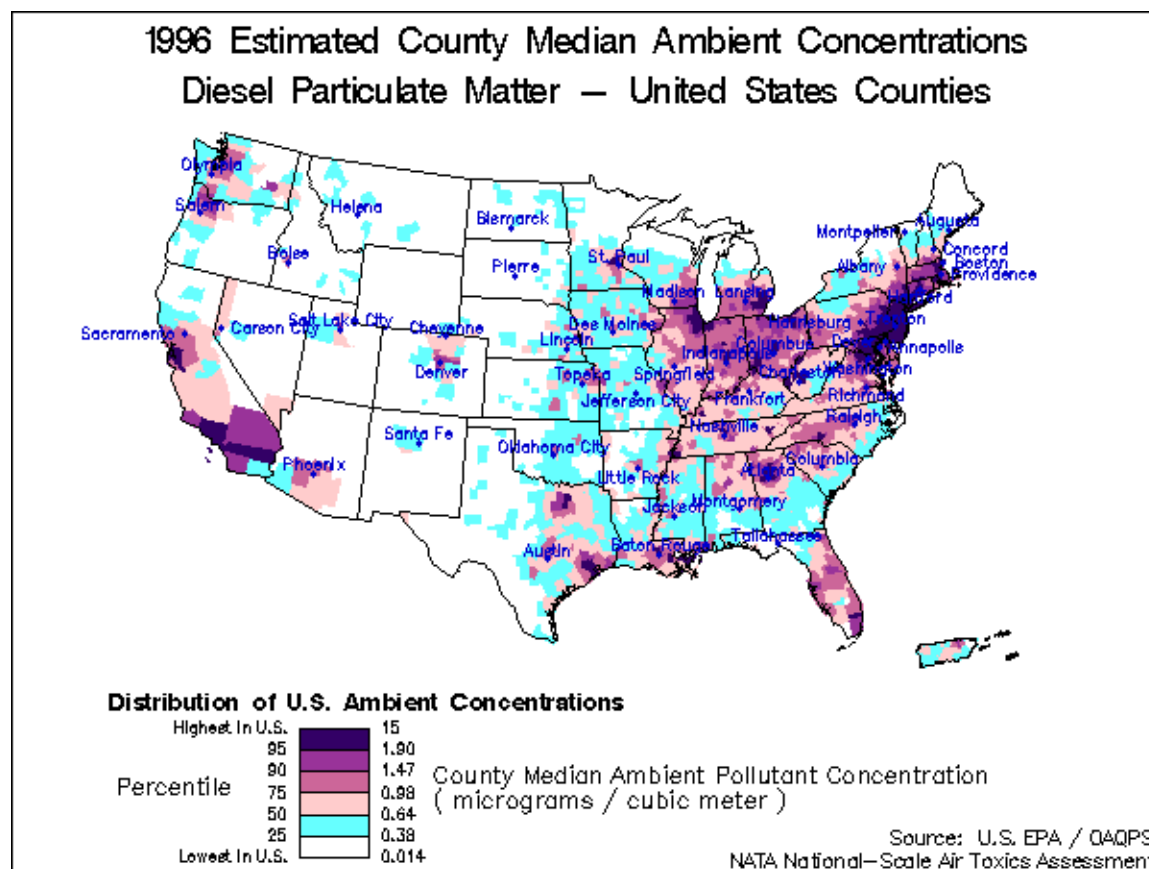
Overview:

Asthma, one of the health problems associated with diesel exposure, has increased tremendously over the past 20 years, hitting low-income communities and communities of color the hardest. While other types of ambient air pollution have decreased in the past 20-30 years, mobile source pollution and diesel exhaust in particular have remained constant or increased. Farming, shipping, construction and other non-road sources, as well as major highway sources of diesel ensure that *all* communities --even rural or suburban -- are subject to diesel exposures.

However, urban areas are home to high concentrations of diesel sources, and large populations. As well, these areas have the most rapid increase in asthma rates and morbidity. The racial/ethnic and socioeconomic groups that have the greatest prevalence of asthma also have the highest exposures to diesel exhaust.

The burden of asthma is borne disproportionately by African-Americans and persons under the age of 18:

- In 2000 the rates of asthma hospitalizations for African-Americans were 35.5 per 10,000, compared to 10.4 for whites (American Lung Association 2002).
- In 1996 the estimated prevalence of asthma among African-Americans was 69.6 per 1000, compared to 53.5 per 1000 for whites, and 55.2 for the general population.
- Similarly, among all the age groups asthma prevalence is highest in those under age 18, 62 per 1000.
- The greatest increase in the prevalence and severity of asthma has been among children and young adults living in poor inner-city neighborhoods (Eggleston *et al.*, 1999).
- In New York City the communities with the highest rates of childhood asthma hospitalization are all low-income communities of color. East Harlem heads the list at 170.2 hospitalizations per 10,000 for children aged 0-14 in the year 2000, compared to a citywide average of 64 and a national average of 31.5 childhood asthma hospitalizations per 10,000 people in 1999. (NYC Department of Health 2000).
- Not coincidentally bus depots and other concentrated sources of diesel exhaust are frequently found in low-income communities.
 - In New York City six out of eight of the Metropolitan Transit Authority's diesel bus depots in Manhattan are located in Northern Manhattan, a low-income community of color, while citywide twelve of twenty depots are in communities of color.
 - In addition, five of the depots in Northern Manhattan are in residential communities, within 200 feet of people's homes.
- Another vulnerable population facing high exposures to diesel exhaust is schoolchildren who ride yellow school buses, which are among the dirtiest vehicles on the road today.
 - A recent NRDC study found that children on school buses are exposed to levels of diesel exhaust up to 4 times higher than a child riding a car besides that school bus, with on-bus exposures averaging 19 micrograms (μg) per cubic meter (m^3), (Solomon *et al.*, 2001).
- Another highly exposed group is people who encounter diesel on the job on a daily basis, including bus and truck drivers, railroad workers, and airport workers who work on the tarmac, many of whom are people of color.



3.3 Health Effects

Objectives:

The student will be able to....

- ✓ Identify the health effects of diesel exhaust

Motivation: Why should *you* be concerned about particulate matter, especially diesel?

3.3.1 Asthma

The two major health effects associated with diesel exhaust particles (DEP) that are independent of its contribution to ambient PM_{2.5} and smog production are asthma attacks and lung cancer. Diesel exacerbates asthma and contributes to respiratory symptoms. Recent epidemiological studies also show an association between experiencing respiratory symptoms and living near major highways and other sources of truck traffic.⁶ The study being conducted in this school by the Columbia researchers is in line with these types of studies.

⁶ A few researchers have conducted cross-sectional studies examining the relationship between children's acute and chronic experiences of respiratory distress and their proximity to motor vehicles from highways. Wjst et al (1993). Showed a small but significant decrease in peak expiratory flow (PEF) among 10-year old children in school districts in Munich with higher flow of car traffic, as well as increased self-reports of respiratory symptoms. Other analyses found that decreases in lung function and parental report of chronic respiratory symptoms were associated with truck traffic density and with concentration of black smoke measured in schools in the Netherlands (Van Vliet et al., 1997; Brunekreef et al., 1997). One case-control study found a linear trend between hospital admissions for

Little is known about the potential impact that diesel exhaust might have on the development or onset of asthma. There have been cases of newly developed asthma reported in workers exposed to very high levels of diesel exhaust (CARB ES-16). Considering that diesel does impact the immune system, and the onset of asthma is essentially governed by alterations in immune function, it is plausible that exposure to diesel in early childhood, especially for fetuses and very young children, could contribute to development of asthma. This is a research question that needs to be further explored.

3.3.2 Cancer and other health effects

Diesel exhaust is known to exert a genotoxic effect, meaning that it can damage DNA, a necessary (but not sufficient) step in the development of cancer. There is a substantial body of evidence associating long-term exposure to high levels of diesel exhaust (generally at the level of occupational exposure,) and increased risk of developing lung cancer. (US EPA c, HEI). A study by the South Coast Air Quality Management District (AQMD) estimates that exposure to diesel exhaust in the Los Angeles basin is responsible for 71% of the cancer risk from all sources of air pollution in that region. Another study conducted by state and local air pollution officials concluded that nationwide, based on lifetime risk, diesel particulate matter contributes to 125,000 cancers in the United States, (STAPPA / ALAPCO).

The Environmental Protection Agency has concluded that “long-term inhalation exposure is likely to pose a lung cancer hazard to humans, as well as damage the lung in other ways.” The EPA’s health assessment document is by far the most comprehensive review of the available literature on the overall health effects of diesel exhaust. Unlike the state of California, the EPA has not developed a benchmark number that is used to determine acceptable levels of exposure. (US EPA c).

3.3 Vocabulary

1. Particulate Matter: Small objects of solid, liquid matter, or both including dust, smoke, fumes, spray and mist.
2. Diesel Exhaust: Diesel exhaust is a pervasive airborne contaminant in workplaces where diesel-powered equipment is used.
3. Asthma: A chronic respiratory disease, often arising from allergies that is characterized by sudden recurring attacks of labored breathing, chest constriction, and coughing.
4. Fine Particulate Matter, (or PM_{2.5}): Particles with a diameter of 2.5 µm or less.
5. Hazardous Air Pollutants (HAPs): Also called air toxics, are either suspected to cause cancer or create other serious health risks.
6. VOCs: Volatile Organic Compound, these come mainly from the evaporation of liquid fuels, solvents and organic chemicals (nail polish remover, barbecue starter, paints, cleaners) and from burning gasoline.
7. Genotoxic effect: Effects of contaminants that can damage DNA, a necessary (but not sufficient) step in the development of cancer.

asthma and traffic flow (Edwards et al., 1994), while another found a positive association between wheezing and symptoms of allergic rhinitis and self-reported frequency of truck traffic (Duhme et al., 1996).

3.4 Some Suggested Activities

1. Read article on diesel and have discussion -- See attachment.
2. Student pollutant worksheet -- See attachment.
3. Experiment -- See attachment.
4. Guest speaker on local action against Diesel exposures.
5. Students can create a “poster” or other visual summary of sources of fine particle matter and diesel, health effects of these pollutants, measured levels, potential solutions.

Section 4: The Aethalometer

It is strongly recommended that this section be taught in conjunction with a live demonstration of the Aethalometer by WE ACT staff.

Condensed Simplified Summary; for more information see <http://www.mageesci.com>

Objective: The student will be able to....

- ✓ Understand the purpose and use of an Aethalometer

Motivation:

What can I do to measure the air pollution that I take in?

Technology Resources:

<http://www.lbl.gov/Education/ELSI/Frames/pollution-measure-BC-f.html>

<http://www.lbl.gov/Education/ELSI/Frames/pollution-measure-carbon-f.html>

4.1 What Does It Measure?

The Aethalometer is an instrument that provides a real-time readout of the concentration of 'Black' or 'Elemental' carbon aerosol particles (BC or EC). These particles ("soot") are emitted from all types of combustion, most notably from diesel exhaust. 'BC' is defined by blackness, an optical measurement. The Aethalometer uses an optical measurement, and gives a continuous readout. The 'EC' definition is more common. It is based on a thermal-chemical measurement, an analysis of material collected on a filter sample for several hours and then sent to a laboratory. Research at Harvard University showed that the Aethalometer BC measurement is directly related and equivalent to the filter-based EC measurement. In fact, an option in the software allows it to read out in EC units. The Aethalometer performs the optical analysis and data readout immediately. The results are available immediately to the user, without waiting for analysis of a sample at a laboratory.

4.2 How Does It Work?

The Aethalometer is a self-contained, automatic instrument. It requires no consumable materials, no special gas cylinders, and no operator attention. It is fully automatic: plug it in, turn it on and walk away. It requires no calibration other than checking the air flow meter response once per year.

The Aethalometer draws a sample through its 'Aerosol Inlet' port, typically at a flow rate of a few LPM. It can have the vacuum pump installed internally (completely self-contained instrument), or it can be ordered for use with an external pump. There is a flow control valve on the rear panel: an electronic flow controller is optional.

The Aethalometer collects the sample on a quartz fiber filter tape, and performs a continuous optical analysis, while the sample is collecting. During this process, the tape does not move. The tape only moves forward when the spot has reached a certain density. In a city, it may use 3 or 4 spots per day. In a rural location, it will use maybe 1 spot per day. The roll of tape contains 1500 spots.

The analysis gives one new reading every time base period. The user sets the time base to reflect how rapidly they want data. The Aethalometer can go from 1 measurement per second, to 1 per hour. Faster time base gives more rapid response, but more instrument noise. Slower time base gives less noise, but you 'lose' the time details and also lose more data when the tape advances. For typical urban monitoring the recommended time base is 5 minutes. At the end of a time base period the data are written to diskette; transmitted by the COM port; and produced as an analog

voltage. The saved data include internal diagnostic signals that confirm that the instrument is working correctly.

4.3 Useful User Features

The software will automatically run the Aethalometer if it is simply plugged in and turned on. If the power fails, it will automatically re-start when the power resumes.

The front control panel has colored lights that indicate the following:

1. SOLID GREEN, the instrument is running and everything is OK.
2. FLASHING GREEN, re-initialization after tape advances.
3. YELLOW, the instruments needs attention, but instrument still running, data still OK.
4. RED, Problem, the instrument stopped running.

One diskette typically holds months of data. Diskette can be changed without stopping the instrument.

The only attention that the instrument needs is:

1. Once per day, look at it. Green light, OK.
2. Once per week, check to see how much diskette space is left.
3. Once per month, replace the diskette.
4. Once per year, replace the tape roll.

In addition:

- The front door can be locked, and the keypad requires a password to stop measurements or change parameters. This provides security against tampering.
- The operating system software can be upgraded by inserting a diskette: as new features become available, it's not necessary to send the instrument back to the factory for upgrading.
- An automatic 'Optical Test Strip' procedure provides a QC/QA assurance routine.
- In extremely polluted locations, invoking the 'Tape Saver' feature can reduce tape usage.

4.4 Suggested Activities

4.4.1 Take a Black Carbon Air Pollution Sample Using a Vacuum Cleaner

Materials:

- vacuum cleaner with hose attachment
- two paper cups
- cardboard filler
- screen mesh
- tissue paper for filter
- paper for mask

- large plastic bag (e.g., 30-gallon lawn trash bag)

Instructions for Assembly:

1. **Bore** a 1-inch diameter hole through the bottom of each cup. Make sure that the holes are aligned. This will produce a spot with an area of approximately 5 square centimeters.
2. Next, **cut** a ring of cardboard with a centered, 1-inch diameter hole. This will act as a filler. Invert one cup, and put it on top of the hole.
3. Select a suitable mesh screen to support the filter, and **cut** it into a disk that will fit into the bottom of a cup. Put it on top of the cardboard filler.
4. Put the second cup on top of the first one.
5. Assemble as illustrated.
6. Position this sampler onto the hose of the vacuum cleaner. A *tight seal* should be produced when the vacuum is turned on. Put the tissue over the open end-hole; the suction will hold it on.
7. Run the vacuum cleaner for approximately 20 minutes with the sampler in place.
8. Remove the tissue filter after the sample has been run.

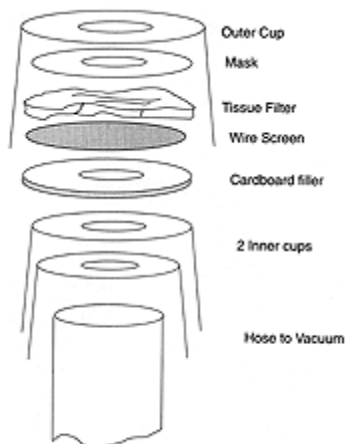
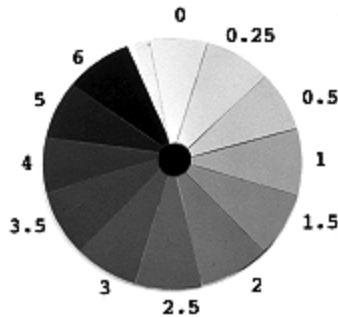


Figure 2. Air sampler.

Instructions for Measuring Black Carbon:

1. Airborne particles will appear as a spot on the tissue filter. Spots are generally either brown or gray in color. Brown spots are normally caused by *dust particles*. The dust has a minimal affect on the analysis. The gray is caused by *soot* (suspended carbon particles). Because carbon is intensely black, it may be detected in small amounts.
2. Compare the sample to the visual scale shown here.

Reflection Density Guide
 Approximate surface amount of
 Aerosol Black Carbon
 Micrograms per square centimeter



Using the 'Attenuation' scale:

1. Note that '**Attenuation**' = $100 \ln ([\text{blank}] / [\text{spot}])$,
 where [blank] = milliamper reading of the white area of the filter and
 [spot] = milliamper reading of the pollution spot collected. Use natural logarithm (ln).
2. Black Carbon Density = Attenuation / 12
The units of this are micrograms per square centimeter.
3. Total micrograms of black carbon
 in the spot sample = Density x Area of the original collection spot (cm²)
4. Total sampled volume of air = Flow Rate x Sample Duration
5. Concentration of Black Carbon in the Air
 (in micrograms per cubic meter of air) = Total Micrograms / Total Volume

4.4.2 Analyze Data from the Aethalometer

Materials:

- Aethalometer
- Spreadsheet software
- Chart paper

Suggested Activities:

- Students may take a subsection of the data, enter the data by hand into 2 columns, and then graph the data by hand.
- Students may enter data into Excel spreadsheets
- Students may create graphs and charts of a specified portion of the data.
- Students may analyze time trends in the data and draw conclusions about factors affecting ambient air quality, specifically focusing on:
 - 24-hour trends
 - weekly trends
 - trends as impacted by weather
 - trends as impacted by other factors

- Students may access information to compare their measurements to information about regulatory thresholds for each pollutant, and ambient data collected elsewhere in New York City.

Section 5: Presenting and Taking Action

Objectives:

The student will be able to....

- ✓ Develop an understanding of the environmental justice movement.
- ✓ Discuss the data collected in the school study and what will be done with this data.
- ✓ Brainstorm action steps and how they can present data to others.
- ✓ Develop a strategy for reducing a local source of pollution
- ✓ Name and plan how they can get involved in protecting their communities

Motivation:

How can *you* get involved in protecting their communities from air pollution and/or environmental racism?

Materials:

- Environmental Justice timeline-milestones
- Forward and Chapter one of *Confronting Environmental Racism: Voices from the Grassroots* Edited by Robert Bullard and Forward by Benjamin Chavis, Jr.
- Read “Clearing the Air” and “Victory in the South Bronx” from the website <http://www.southbronxcac.org/history/> or download them as handouts.
- Download or read on line the environmental justice bill of rights: <http://www.swop.net/ejbillorights.htm>
- Download http://WE.ACT.org/ej_principles.html or read on line the Principles of Environmental Justice.

Technology Resources:

<http://www.WE.ACT.org>

<http://www.scorecard.org>

<http://www.southbronxcac.org>

6.1 Overview

Environmental Justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. (www.epa.com). It is the pursuits of equal justice and equal protection under the law for all environmental statutes and regulations without discrimination.

For more than a century the environmental movement in the United States has been rooted in wilderness, wildlife preservation, and resource conservation. The decade of the sixties ushered in a new era of activism with the civil rights and antiwar movements. The environmental justice movement began in the 1980s in a low income, predominately African-American community in the South. While there had always been an awareness of disproportionate burden borne by people of color and low-income communities, events did not give rise to a movement, until 1982 in Warren County, North Carolina. A landfill was created in this poor, Predominately African-American area, to be used for the disposal of PCB contaminated soil. Many civil rights activists collaborated to stage numerous demonstrations, which resulted not only in the arrest of more

than 500 people, but in the creation of rallying center for those eager to focus on the necessity of communities empowered to effect usage of community lands. This is the first act that started the environmental justice movement. This "new" movement redefined environmentalism to address issues of equity, disparate impact, and unequal protection.

In other parts of the United States, environmental justice activists were inspired by other struggles for human and civil rights. Native Americans have fought for hundreds of years for sovereignty and an end to the ecological destruction of their lands and water. Chicano (Mexican American) activists in the Southwest participated in the struggle for land and water rights and in the struggle of farm workers against the spraying of pesticides on fields in which they were working. Puerto Ricans have been inspired by the decades-long effort in Puerto Rico to stop the destruction by the United States military of Puerto Rican lands and marine life on the island municipalities of Vieques and Culebra, and an end to the export of polluting industries and practices from the mainland of the US to Puerto Rico. Many urban activists have spent years fighting for community control of education, health care, and community development.

People of color and the poor are exposed to greater environmental hazards in their homes, on their jobs, in their neighborhoods, and in their schools and the playgrounds. Environmental inequities result from a host of industry and government practices such as discriminatory land use and zoning; discriminatory facility siting and clean-up strategies; exclusionary practices that limit participation of governmental agencies charged with protecting public health and the environment, and faulty assumptions in calculating health risks. Also critical is that communities are not informed (especially in languages other than English) about new projects proposed for their neighborhoods, as well as the frequent unwillingness of government agencies to include low-income and people of color communities in environmental and planning decisions that effect their health and quality of life.

Colleges and universities play a tremendous role in shaping public policy debate on natural resources, economic development, environmental protection, and public health. For many years, few college courses and their professors tackled the thorny question of "who gets what, when, why, and how much?" Only recently have we begun to see environmental policy and environmental studies courses explore the link between class, race, gender, social equity, land use, pollution, exposure, and environmental decision-making. Indeed, historically, many professors have served as industry-friendly witnesses, testifying as to the safety of polluting facilities, and have used community residents as pollution study subjects, rather than as research partners.

6.2 Vocabulary

1. Environmental racism: "Racial discrimination in environmental policy-making, enforcement of regulations and laws, and targeting of communities of color for toxic waste disposal and siting of polluting industries." Reverend Benjamin E. Chavis, Jr., Ex-Chairman of the NAACP

6.3 Some Suggested Activities

- 1) Guest speaker from a local environmental justice organization
- 2) Read “Forward” and “Chapter One” of *Confronting Environmental Racism: Voices from the Grassroots*.
- 3) Students can take photos and create other visual images identifying the sources and impacts of air pollution in their communities.
- 4) Toxic tour of environmental hazards in the community.
- 5) The students will keep an activity log, where they will register events that may affect the results of the study.
- 6) Students can role-play a decision-making process (e.g. a City Council hearing) for reducing or elimination a local stationary or mobile source of pollution in their community. They can incorporate their data presentation into the role-play.
- 7) Students can present their data in a real-world community or government setting, as well as at a school assembly.
- 8) Other related activities – see below.

6.3.1 Brainstorm: "Environment"

Purpose: To encourage students to define and discuss the environment.

1. Briefly introduce the concept of "environment." For example: "Today we are going to be talking about our environment," or point out the list of likes and dislikes the group just generated and say "All of these things in your neighborhood that you talked about liking or not liking, all of those are a part of your environment."
2. Have the group brainstorm definitions and conceptions of the environment. Questions to stimulate discussion include:
 - a. What does the word 'environment' mean?
 - b. What do you think about when you hear this word?
 - c. What are some things in the environment?
 - d. What are some other ways of saying this word?
 - e. What are the words for it in other languages?
 - f. What are some other things that are in your neighborhoods that are a part of the environment?
 - g. What about things not just in the neighborhood, but also in the entire city, the state, the country, and the whole world? What about other places you may have lived?
3. The idea is to have students brainstorm, and think about everything they can that has to do with the environment. Encourage students to call out their ideas. Make sure that they do not put each other down.) If they get stuck, or have difficulty with the word, you can partially describe it, or give an initial working definition. Don't rush to do this unless they are really stuck. If necessary, guide the discussion to include terms relating to the built environment as well as the natural environment.
4. At the end, affirm their responses, and add what it means to you. You may mention, “Where we live, work, play, and go to school, both indoors and out,” and you may include a dictionary definition.

6.3.2 This is what our community looks like. . .

Purpose: To allow students to visually represent their community, and identify positive and negative elements.

1. Break the students up into equal groups of three to five students each, and give each group a poster board and a set of markers. Ask them to draw a picture of their neighborhood or city that shows as many different parts of the environment as possible. They can base their drawing on what we've brainstormed so far, and they should keep the following questions in mind:
 - a. What are the natural elements?
 - b. What kinds of buildings are there?
 - c. What kinds of businesses are there?
 - d. What do the streets look like?
 - e. What does the block that you live on look like? What does the block where you go to school / camp look like?
 - f. Where do you spend time? Where do other young people spend time?
 - g. What is there to do in our community?
 - h. How do people travel? How do people get from one part of the city to another? How do you get to school?
 - i. What are the people like? What do they do? What do they look like?
 - j.
2. Make sure that the groups are thinking about and including elements of their community that they really like, and elements that they wish were different or do not like.
3. When they are finished, have each group share their poster with the rest of the class.
4. Stop here, or continue on to next activity.

6.3.3 Creating Our Ideal Community / Introduction to “Justice”

Purpose: To introduce the concept of “justice” in the context of the natural and built environment.

1. Explain that for the next part of this activity, each group should think about and discuss what their vision of an ideal community is. In other words, if you lived in a “dream” city or community, what would it look like? Participants should keep in mind what they just discussed about positive and negative aspects of the city and of the environment. Encourage them to be creative and fantastic. Each group will then be creating a representation of this ideal community right on the poster board they have, where they have already represented their community. Stress that they are not necessarily replacing (pasting or drawing over) what they have already done; but rather that they are adding things, and in some cases modifying or replacing images they have already created.
2. Tell the larger group that the group that creates the best city will get a prize. They have to work together as a group to make the city, and nobody is allowed to switch groups. Explain that in order to make this a little bit easier you will be giving each group some more materials to use, but each group can only use the materials they are given.

3. Distribute the following materials to each group (the best way to do this is to have the materials in four plastic bags before class). If group numbers or materials differ, make appropriate adaptations. The idea is to provide the groups with different quantity and quality of materials to work with, as a way to introduce the concept of “injustice”.
 - a. Group 1: 2 complete set of markers (thin and thick), box of 64 crayons, glue, tape, 3 scissors, glitter, cotton balls, popsicle sticks, yarn, several different magazines.
 - b. Group 2: 1 complete set of markers, box of 16 crayons, tape, a few magazines, 2 scissors
 - c. Group 3: Half-complete set of markers, box of 8 crayons, one magazine, one pair of scissors, and some pencils.
 - d. Group 4: Opened box of broken crayons, a few markers, and some pencils, and some old newspapers, pair of scissors.
4. If the students notice the inequality of materials and start to complain, tell them you are sorry, but you ran out of enough materials. If they want to take from another group, remind them they have to work only with the materials they were given.
5. After groups have completed their “Ideal City,” have each group present and describe their city. Praise each one, but give the prize to either group 1 or group 2 (the group that began with the most materials).
6. Discussion: Ask the students how they liked this activity. If they say that it was unfair, ask them why they thought that. Lead them into a discussion about "justice." Write the word "justice" on the blackboard, and have students brainstorm their definitions and conceptions of justice. Some questions to guide to discussion:
 - a. Who thought this competition was fair? Why? Who thought it was unfair? Why?
 - b. Ask each group if they were happy with the materials they got and why or why not.
 - c. Did you enjoy doing this activity? Why or why not? What else did you feel as you were doing this?
 - d. Was it easy for you to be able to create the vision of an ideal city you had in your mind? What made it easy or hard?
 - e. What would have been a more just way to conduct this activity?
 - f. Do you think that in real life some communities have an easier time creating and maintaining the things that they really want to have in their community, and changing the things they don't want to have? Why is this so?
7. You may want to use the term “privilege” to segue from this activity to a discussion about environmental justice. In reality, these nice materials represent certain privileges that are preferentially enjoyed by some communities or groups and not others. Often these privileges are taken for granted by those groups that have them, who may not even realize that not all people have them. It is fairly easy for those groups to create the environment and community they want to live in, because they have plenty of tools (the scissors, the tape, the glue) and resources to do so. For the groups that don't have as many tools and resources, it's more difficult to do the same thing, although it's not impossible. You could ask the following questions:
 - a. What do all these nice materials represent, in real life? PRIVILEGE.
 - b. Examples include:
 - i. Money
 - ii. Environmental protection – which makes the laws? Who works for the government? What does the Congress, governor, mayor, city council, look

- like? Do you think that sometimes its natural for them to make laws, or enforce laws, so that those laws benefit the things and the people that are important to them personally, to the communities they come from?
- iii. Resources – do some communities have more information about pollution, it health effects, and how to avoid it? Do you think that makes a difference in the way those communities look?
 - iv. Jobs
 - v. Leisure time
- c. What could we do to make this situation more equitable? (Answers may include: sharing all materials equally, putting the 4 poster boards together and sharing all the materials to make one huge community, group 1 forcibly takes materials from other groups) Discuss all possible solutions.

6.3.4 Environmental Justice Brainstorm

1. Write the term “environmental justice” on the board or on newsprint. Based on the discussion the group just had, and on their initial brainstorm of the term “environment,” brainstorm definitions and visions for this term. If it helps, write “environmental injustice” in smaller letters to the side and brainstorm definitions for that first.
2. Finish the brainstorm by asking the class what a world without environmental injustice would look like. Complete this activity by having participants pool all their resources, and work together on a large mural that represents some of these ideas of environmental justice.

6.3.5 Focusing on our assets and using our power

1. Return to the four groups posters of their “Ideal Cities” and make the following points:
 - a. The community that we live in has many assets / good points / things we are proud of. (emphasize how each these posters all include elements of their communities as they are now).
 - b. However, it also has things that we could do without, things we’d like to change, or things that aren’t here but we wish were here (a classic example is “the beach”).
2. Of all the new elements you wanted to add to your picture of your community or things you wanted to change:
 - a. Which things are impossible to ever really have in real life?
 - b. Which things could feasibly be changed or added in real life?
 - c. What would have to happen to add or change these things?
3. Identify, as a group, one small thing that they can make real.