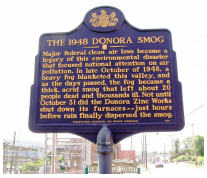
AIR POLLUTION TRAGEDY: A CASE STUDY

Lesson Concepts: Students will build awareness that many disciplines of study and areas of interest can contribute to solving a public problem. Students will build awareness of past air pollution disasters by reviewing historic accounts.

Learning Objective — Students will be able to:

- **Recognize that public awareness and activism can prevent or minimize air pollution tragedies.**

Link to *Air –The Search for One Clean Breath* from Executive Producer Barbara L. Page



In the film, we present the air pollution disasters in Donora, Pennsylvania, and in London, England. In Donora, we visit survivors Bill and Gladys Schempp. Bill was on the fire department during that event and literally crawled door-to-door to deliver oxygen to Donora residents. But there is another historical air pollution event we can learn from: the 1930 tragedy in Belgium's Meuse Valley.

Materials

- Resource sheets

Advanced Preparation

Make copies of Resource 1 information sheets for student groups.

Time and Student Grouping

One or two 50 minute class periods; students will work in six groups to read, summarize and report on evidence to solve a mystery.

Procedure

1. Inform students they will be engaging in a forensic exercise to determine the cause of death of people in an area of Brussels in the 1930s.
2. Group students into six teams: Medical doctors (two groups); Climatologists; Geologists; Chemists; Industrialists.
   Each student group will read and discuss the information sheet provided to them. (See Resource 1 for case studies.)
3. The teacher will lead a class discussion during which time students will report their findings to the class. As information is provided to the class from each group, the teacher or a student chosen by the teacher, will post findings on a chart for all to read.
4. As a group, class will discuss findings and propose solutions to the mystery.

Grade Levels: 9-12

California Science Standards

Grade 9-12 Ecology 6.b. Students know how to analyze changes in the ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.

National Science Standards

Grade 9-12 Science & Technology Content Standard F: Science in Personal and Social Perspective.

Education and the Environment Initiative Educational Principles and Concepts

Principle IV: The exchange of matter between natural systems and human societies affects the long-term functioning of both. As a basis for understanding this principle:

Concept a. Students need to know that the effects of human activities on natural systems are directly related to the quantities of resources consumed and to the quantity and characteristics of the resulting byproducts.

Concept b. Students need to know that the byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect.

Vocabulary

Autopsy: The medical examination of a dead body in order to establish the cause and circumstances of death.

Inversion layer: A layer of the atmosphere in which there is a temperature inversion, with a warmer layer tending to prevent the air below it from rising, thus trapping any pollutants that are present.

Teacher Background

Since the Industrial Revolution, there have been several occurrences of mass illness and death due to air pollution from factories. While none of these tragedies were intentionally perpetrated, factory owners and government officials were reluctant to place blame on the factories due to concerns about production, profit, and liability. In each case, scientific investigation determined causes based on the combination of chemicals released and their affect on human physiology, geographic, and climatic conditions.

Closure: Discuss with the class that a cause of a mystery can always be investigated. Scientific investigation will usually involve many disciplines: medical, chemical, geological, industrial, and political. It is important to carefully consider evidence presented for accuracy and thoroughness.

Assessment: Understanding the Meuse Valley tragedy involves input from a number of disciplines and points of view. To assess student understanding of this situation, have them write a persuasive or expository essay to the prompt: You are the mayor of a town which has just experienced an environmental catastrophe. Detail how you will oversee the investigation and what type of tests you would employ to ensure a quality conclusion.

Extension: Students read *Air Pollution and Historic Tragedies* (Resource 2) and discuss ways in which other tragedies can be prevented.

Homework: Students will read about preventative measures taken to guard against such tragedies. Article entitled *Why Should You Be Concerned About Air Pollution?* (Resource 3).

Resources: *The Journal of Industrial Hygiene and Toxicology*, Year 1937, Volume 19, Pages 126-137.
U.S. EPA: http://www.epa.gov/air/caa/peg/concern.html.

Related Web Sites:
Kyoto Protocol: http://unfccc.int/kyoto_protocol/mechanisms/clean_development_mechanism/items/2718.php.

Teacher Tips

The forensic exercise provided is designed to build students' interest in the nature of a catastrophe through role playing one of the many scenarious which could provide information to help solve the puzzle of the mysterious deaths. Information provided to the students is targeted to lead to a quick resolution of facts without involved research.

As groups present their summaries, the teacher should chart the factors most important in solving the problem. Emission of chemical pollution from the factories, chemical changes occurring when the pollution combines with water, symptoms of respiratory problems in autopsies and medical exams, and the nature of the valley experiencing an inversion layer are the evidence the teacher would want to highlight for the students to conclude that emissions from the factories in combination with geography and weather lead to the deaths. Most of the time damage due to pollution is not obvious but that doesn't mean it isn't there.

Discussion of the benefit of employment at the factories can be weighed against the idea of public health concerns. The medical group is presented with information that lung disease is also caused by smoking cigarettes. If the medical group uses this information to offer a solution, the teacher should point out the suddenness of the medical emergency as it relates to the long time period over which people have smoked.

Have copies of Resource 3, *Why Should You be Concerned About Air Pollution?*, available for groups who finish early to read and review.

Resource 1

Case study Meuse Valley, Belgium

The Meuse Valley in Belgium contains many farms, villages, steel mills, factories, and chemical plants. Its main claim to fame is an 80 year old mystery, still the subject of speculation today.

Early in December of 1930 a thick fog lay over much of the country. Over three days, from December 2 through December 5, many people who lived in the Meuse Valley complained of nausea, difficulty breathing, stinging eyes, and burning throats. By the end of the three days, 60 people had died and thousands more were ill with an unknown "disease." Had they been sprayed with poisonous gas? Were there leaks of gases from the chemical plants? Was it another outbreak of bubonic plague?

You have been named to a commission to determine what caused the deaths and illnesses. You will need to become an expert about certain facts of the case.

Meterologists: As a team, determine if the following conditions could have contributed to the deaths and illnesses.

A. The weather was cold, a little above freezing during the day. At night the temperature reached 10 below.
B. Temperatures had been falling in the days before the deaths, and heavy fog formed as moist air cooled near the ground.
C. There was an unusual weather pattern called a temperature inversion. Warm air usually rises, but in valleys like the Meuse (and Los Angeles) during the winter, once the sun goes down the ground loses heat very quickly which cools the air near the ground. Because air does not conduct heat very well, the air above the surface remains warmer by comparison. Colder air does not rise through warmer air. Therefore, there is little mixing of air.
D. There was no wind those three days in the Meuse Valley.

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Chemists: As a team determine if the following facts could help explain what caused the deaths and illnesses.

A. Homes and factories burned coal in their furnaces.
B. The burning of coal released hydrogen sulfide into the air.
C. Hydrogen sulfide combines with water to produce sulfuric acid.
D. Fluorine is the most reactive element known to science. Fluorine compounds tend to be very toxic, but usually exist only in very small amounts in the environment.
E. Industrial activities in the Meuse Valley released fluorine compounds in the smoke from their chimneys.

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Medical Doctors involved in autopsies: Use the following medical knowledge to determine how the people who died got sick. Does the disease appear to be spread by germs, by massive food poisoning, by something in the air, or by something in the water?

A. The bodies showed little sign of infection. There was little bleeding or open sores.
B. Mucus membranes of the trachea and larger bronchi were red and swollen.
C. Microscopic examination of the mucus membranes of the trachea and bronchi showed tissue damage of the linings and blood vessel enlargement.
D. Lung alveoli contained many particles of soot. Alveoli were swollen, had numerous broken capillaries and damaged linings.
E. Other body organs were normal, as was a thorough chemical analysis of blood.
F. In the United States, smoking is the most common cause of problems such as: cancer, emphysema, shortness of breath, coughing and poor lung function are much more common among smokers than non-smokers.
G. Evidence suggests that respiratory infection, asthma, and conditions listed above are more common in children who live in households where adults smoke, exposing the children to "second-hand smoke."
H. Air pollution can cause problems for persons with lung disease. In poorer countries, indoor air pollution is a major problem due to indoor fires used for cooking.

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Medical Doctors working with ill patients: Use the following medical knowledge to try to determine what was making people suddenly sick. Does the disease appear to be spread by germs, by massive food poisoning, by something in the air, or by something in the water?

A. The cases of illness began on December 3, two days after the mist had settled in. The cases all began about the same time throughout the entire area. After December 5 there were no new cases; by December 6 the fog had disappeared.
B. Those affected tended to be elderly people or people with weakened lungs or hearts.
C. Younger, healthier individuals were also among those who became seriously ill.
D. Some individuals attacked by the disease had not left their homes during the foggy days.
E. The chief symptom was difficulty breathing. Coughing produced a frothy mucus; as the condition worsened the mucus produced was thicker and slimy.
F. In cases where the patient died, the final stages of the disease produced a weak but rapid pulse; a pale, bluish skin color; increasing hoarseness in the voice; nausea, occasional vomiting; and the production of excessive tears in the eyes.
G. Other body organs appeared normal, as was a thorough chemical analysis of blood.
H. Cattle also became ill. Their symptoms included unusual panting, trouble breathing, restlessness, emphysema, and sometimes death. Birds and rats also died in higher than normal numbers.

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Geologists: As a team, you will consider the environment in which the incident took place. Could the shape or location of the valley have contributed to the problems?

A. Locate Belgium on a world map. Describe the basic geography, relationship to the ocean, valleys, mountains, etc. Identify the location of the Meuse Valley.
B. The Meuse Valley runs between a series of steep hills along a river. The valley contained several electrical power plants and heavy industries as well as other pollutant sources.
C. The Meuse River runs southwest to northeast in a valley that is no more than 1 or 2 km wide, but fairly deep (60-80m).

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Industrialists: You are factory owners and can therefore explain how factories can affect communities in which they are located. The following facts relate to factories in the Meuse Valley in the 1930s.

A. A very large percentage of the population worked in the valley industries. For many families, these jobs were their only source of income. Shutting the factories down would destroy the valley economy as well as deprive the country of important products.
B. There were four very large iron works with blast-furnaces and steel works, three large ore refineries, four glass and ceramic factories, three zinc works and one superphosphate factory.
C. At the time industrial fumes were considered stinky, but not dangerous. Taking ore from the earth and removing the metal created smelly fumes, but this was the first time those fumes appeared related to deaths.
D. The factories had been working successfully for years without causing noticeable damage. It appears the heavy fog was somehow involved in the disaster.
E. Today we know more about air pollution than was known in 1930. We know thirty different illness-causing chemicals were released in manufacturing processes used at that time. It is not possible to know for sure at this point which waste gases actually lead to the deaths.
F. The event did not lead to anti-pollution measures, and in September 1972, another industrial accident occurring with fog conditions caused more sickness but no deaths.
G. There are now scrubbers and processes that help reduce pollution waste from factories, but they are very expensive.

Resource 2

Air Pollution and Historic Tragedies

Air is the ocean we breathe. Air supplies us with oxygen, which is essential for our bodies to live. Air is 99.9% nitrogen, oxygen, water vapor, and inert gases. Human activities can release substances into the air, some of which can cause problems for humans, plants, and animals.

There are several main types of pollution and well-known effects of pollution that are commonly discussed. These include smog, acid rain, greenhouse gases, 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.

One type of air pollution is the release of particles into the air from burning fuel for energy. Diesel smoke is a good example of this particulate matter. The particles are very small pieces of matter measuring about 2.5 microns or about .0001 inches. This type of pollution is sometimes referred to as black carbon pollution. The exhaust from burning fuels in automobiles, homes, and industries is a major source of pollution in the air. Some authorities believe that even the burning of wood and charcoal in fireplaces and barbeques can release significant quantities of soot into the air.

Another type of pollution caused by burning fossil fuels is the release of noxious gases, such as sulfur dioxide, carbon monoxide, nitrogen oxides, and chemical vapors. These can take part in further chemical reactions once they are in the atmosphere, forming smog and acid rain.

Pollution also needs to be considered inside our homes, offices, and schools. Some of these pollutants can be created by indoor activities such as smoking and cooking. It is estimated that half a million people die prematurely every year in the United States as a result of smoking cigarettes. In the United States, we spend about 80-90% of our time inside buildings, and so our exposure to harmful indoor pollutants can be serious. It is therefore important to consider both indoor and outdoor air pollution.

Examples of short-term effects include irritation to the eyes, nose, throat, and upper respiratory infections such as bronchitis and pneumonia. Other symptoms can include headaches, nausea, and allergic reactions. Short-term air pollution can aggravate the medical conditions of individuals with asthma and emphysema. In the great "Smog Disaster" in London in 1952, 4,000 people died in a few days due to the high concentrations of pollution.

Long-term health effects can include chronic respiratory disease, lung cancer, heart disease, and even damage to the brain, nerves, liver, or kidneys. Continual exposure to air pollution affects the lungs of growing children and may aggravate or complicate medical conditions in the elderly.

Historic Air Pollution Tragedies

London, England (1873-74, winter)
London is famous for its smoky, dirty skies and "pea-soup" nights wrapped in heavy fog. For many, the fog provides a romantic setting for mystery and intrigue, but even Sherlock Holmes' famous assistant, Dr. Watson, describes the fog as a "greasy, heavy brown swirl… condensing in oily drops upon the window panes." During this winter, the fog lasted from November to February. In the week following the worst of it, deaths rose 75%.

Meuse Valley, Belgium (1930, December 2-5)
An atmospheric event known as a thermal inversion trapped fog over a 15-mile-long stretch of the Meuse Valley that contained many farms, villages, steel mills, and chemical plants. At the end of the first day, many residents complained about nausea, short breath, stinging eyes, and burning throats. In three days, 60 people had died and thousands more were ill with an unknown 'disease'. Some think that the valley had been sprayed with poison gas, fumes had leaked from a chemical plant, or even that bubonic plague had broken out. The sickness was actually caused by pollutants trapped beneath the dense fog clouds. Death rates were subsequently made ten times above normal, especially among the elderly and those with respiratory problems. Thirty different chemicals were identified as causing the illness. The event did not lead to anti-pollution measures, and on September 5-6, 1972, another industrial accident occurred when fog conditions produced large concentrations of toxic sulfur dioxide gas, causing more sickness but no deaths.

London, England (1934, January 21)
This from the Associated Press: "A dreaded black fog settled upon London this afternoon so densely that it penetrated the Great Albert Hall, where Madame Galli-Curci sang to an audience which could only see her thru a fog. The fog was not so bad as the one on New Year's Day but it caused a number of accidents. The fog had lifted in most sections tonight."

Donora, Pennsylvania, USA (1948, October 30-31)
Weather conditions caused toxic gases from industrial and domestic furnaces to float above the coal mining community of Donora. Twenty people died and another 6,000 became sick from the fog and smoke combination.

London, England (1952, December)
Twelve thousand people died from the so-called killer fogs of London, produced by the condensation of water on the daily 2,000 tons of sulfur dioxide and pollutants produced by coal-burning industrial furnaces and home heating systems in the city. The fatal conditions began on Thursday, December 4. A high-pressure system moved over Britain, bringing dry

air, cold temperatures, and light winds. During the night, the winds stopped and the Thames River basin experienced a severe temperature inversion, trapping cold air near the ground beneath a warm humid air layer. Heavy fog then began to form. For the next four days, tons of particulate matter from the furnaces entered this air mass, turning the sky yellow, amber, brown, and finally almost black. The air consequently became a blinding, suffocating cloud of gas that choked breathing passages and stung eyes with enough acidity to cause skin irritation. Cars were stopped in the roads as visibility dropped to a few feet. Air poured through window cracks and under doorways to permeate homes and buildings. Thousands, especially those with respiratory trouble, became seriously ill. The British Committee on Air Pollution reported, "The number of deaths over and above those normally expected in the last three weeks of December indicates some 4,000 people died of the 'smog'. As many as 8,000 others died later as a result of respiratory complications." Since this disaster, stricter restrictions have been placed on coal-burning furnaces. Anti-pollution laws are strongly enforced, and today London's "pea-soupers" have been nearly eliminated.

New York City, New York, USA (1966, November 27)
About 400 people perished because of respiratory failure and heart attacks caused by extreme smog conditions.

Pittsburgh, Pennsylvania, USA (1975, November)
A four day long fog may have caused the deaths of 14 people.

Bhopal, India (1984)
Perhaps the biggest air pollution disaster of all time occurred in Bhopal, India in 1984 when a toxic cloud drifted over the city from the Union Carbide pesticide plant. This gas leak managed to kill 20,000 people and permanently injured a whopping 120,000 people.

Houston, Texas, USA
There have been no large-scale air pollution disasters in Houston, but due to the toxins produced by the vast petrochemical industry, Harris County is the third highest toxic air polluter among all the counties in the United States. Environmental Defense ranks the county among the top 10% of counties in the country for added cancer and non-cancer risk due to toxic air pollution. Earlier cutbacks of the Clean Air Act only added to the intensity of the issue. Carelessly regulated industry can lead to dangerous consequences. It is a form of social injustice that must not be tolerated, for the sake of the health of those who live near and downwind of these industries.

Resource 3
Why Should You Be Concerned About Air Pollution?

- You could go days without food and hours without water, but you would last only a few minutes without air. On average, each of us breathes over 3,000 gallons of air each day. You must have air to live. However, did you know that breathing polluted air can make you sick?

- Air pollution can damage trees, crops, other plants, lakes, and animals. In addition to damaging the natural environment, air pollution also damages buildings, monuments, and statues. It not only reduces how far you can see in national parks and cities, it even interferes with aviation.

- In 1970, Congress created the Environmental Protection Agency (EPA) and passed the Clean Air Act, giving the federal government authority to clean up air pollution in this country. Since then, EPA and states, tribes, local governments, industry, and environmental groups have worked to establish a variety of programs to reduce air pollution levels across America.

Air Pollution and Your Health

- Breathing polluted air can make your eyes and nose burn. It can irritate your throat and make breathing difficult. In fact, pollutants like tiny airborne particles and ground level ozone can trigger respiratory problems, especially for people with asthma. Today, nearly 30 million adults and children in the United States have been diagnosed with asthma. Asthma sufferers can be severely affected by air pollution. Air pollution can also aggravate health problems for the elderly and others with heart or respiratory diseases.

- Some toxic chemicals released in the air are highly toxic and can cause cancer, birth defects, long term injury to the lungs, as well as brain and nerve damage. And in some cases, breathing these chemicals can even cause death.

- Other pollutants make their way up into the upper atmosphere, causing a thinning of the protective ozone layer. This has led to changes in the environment and dramatic increases in skin cancers and cataracts (eye damage).

Air Pollution and the Economy

- The health, environmental, and economic impacts of air pollution are significant. Each day, air pollution causes thousands of illnesses leading to lost days at work and school. Air pollution also reduces agricultural crop and commercial forest yields by billions of dollars each year.

Ways to Reduce Air Pollution

- We make choices everyday that can help reduce air pollution. Below are a few ideas that you can take to help clean our air:
- Conserve energy - turn off appliances and lights when you leave the room.
- Recycle paper, plastic, glass bottles, cardboard, and aluminum cans. (This conserves energy and reduces production emissions.)
- Keep woodstoves and fireplaces well maintained. You should also consider replacing old wood stoves with EPA-certified models. Visit www.epa.gov/woodstoves.
- Plant deciduous trees in locations around your home to provide shade in the summer, but to allow light in the winter.
- Buy green electricity produced by low or even zero-pollution facilities.
- Connect your outdoor lights to a timer or use solar lighting.
- Wash clothes with warm or cold water instead of hot.
- Lower the thermostat on your water heater to 120°F.
- Use low volatile organic compound (VOC) or water-based paints, stains, finishes, and paint strippers.
- Test your home for radon, a dangerous, radioactive gas that is odorless and tasteless. If the test shows elevated levels of radon, the problem can be fixed cost effectively. Visit www.epa.gov/radon.
- Choose not to smoke in your home, especially if there are children. If you or your visitors must smoke, then smoke outside. Visit www.epa.gov/smokefree.

Source: Environmental Protection Agency: www.epa.gov.