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The Cause and Effects of Air Pollution

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PREFACE

In recent years our environment has been dealt with on a very serious level. Today's generation has demanded that something be done to preserve our environment. They are speaking out and asking countless questions. In many ways the environment has been damaged beyond repair. The focus today is on repairing and preserving what remains. The physical aspects of air pollution and its effects on society is the theme of this unit. A teacher would be free to approach the topic from several directions. For example, one could discuss each pollutant individually in terms of sources, methods of emission, how it is affected by chemical reactions in the atmosphere, adverse effects, and ultimate fate, Others may prefer to emphasize the functional approach because in most regions where air pollution is considered a problem, a pollutant coexists with other pollutants and there is a continual evolution of the nature of the atmosphere through chemical reactions.

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I. INTRODUCTION

Children learn in the earliest science experience that problem-solving is an essential part of the learning process. Problems probe one's depth of understanding. Students should be stimulated to delve into areas that are not explicitly covered by this unit. While concentrating on the physical reasoning of air pollution, students should be able to develop skills in reading, language, mathematics, science, and social studies. This unit will be helpful to the self-contained classroom teacher as well as the departmentalized subject teacher. It is geared toward the middle school student from grades five through eight. The time span would vary according to the depth desired by individual teachers. A recommended period of four to eight weeks would allow student from below average range to be successful. Students will be able to: 1. CLASSIFY AIR POLLUTANTS

2. EXPLORE THE ADVERSE EFFECTS OF POLLUTION
3. DETERMINE THE EFFECTS OF SMOKESTACKS
4. DETERMINE THE EFFECTIVENESS OF GOVERNMENT CONTROL ON POLLUTION
5. UNDERSTAND THE MAIN IDEA OF A PARAGRAPH
6. READ FOR HIGH COMPREHENSION AND SUPPORTING IDEAS
7. INTERPRET INFORMATION FROM GRAPHS AND CHARTS
8. USE PICTURES TO SUPPORT MAIN IDEAS OF A SUBJECT

9. USE THE NEWSPAPER TO STUDY POLLUTION PROBLEMS IN THEIR OWN ENVIRONMENT Pollution has become a major problem. It is not a future risk. Pollution is killing and destroying the health of people right now. It is impossible to escape. We have become so accustomed to low levels of exposure that it is hardly noticed.

Eliminating pollution from the environment has not proved as easy as eliminating it from the pages of a book. Industry is now spending several billion dollars a year on pollution control.

The first problem in understanding air pollution is to decide what is and what is not an air pollutant. Many of the things generally considered pollutants are present in the natural air. The amount of a substance locally present in the air is clearly important in defining a pollutant. Also the amount of harm or inconvenience caused by the substance and how long it remains in the atmosphere. These three factors are known as the three T's (tonnage, toxicity, and time in the atmosphere).

A great deal of power is needed to run the factories of modern industrial nations. Automobiles, trains, planes, and buses need power too. Nearly all of this power is produced in the same way—by burning fuels. The burning produces wastes. Some of the wastes get into the air, causing air pollution. The eventual fate of air pollution is to be wasted out of air.

A smokestack with a billowing black plume, for years the proud symbol of America's industrial wealth and technological prowess, has in the last decade acquired another meaning. The puffing smokestack has come to signify the achilles heel, rather than its strength.

II. TYPES OF AIR POLLUTION

Particulates of both natural and human origin also cause pollution. Smoke both natural from fires and human activities cause from industries and other sources are major and cause much damage . The chemicals that are most trouble-some in air pollution are formed in the atmosphere by gases. The pollutant introduced into the atmosphere in the largest quantities by human activity is carbon monoxide. It is the product of incomplete combustion and the largest contribution comes from exhaust. Carbon monoxide is a colorless, odorless, tasteless gas, with the formula CO.

Carbon dioxide (CO_2) is also a product of combustion of fossil fuels. It is a minor constituent of natural air (about 0.03%), but the increased use of fossil fuels may cause an increase in the amount of carbon dioxide in the atmosphere.

The gases given off by engine exhaust are the oxides of nitrogen and the unburned hydrocarbons. The energy that causes these gases to react to form new compounds, comes from the sun. This reaction is called a photochemical reaction. The "air" that is exhausted from diesel engines is also too poor to breathe, although it contains more oxygen per cubic foot, but more particles.

Ozone is a chemically reactive substance (03) that is sometimes used to deodorizing exhausts by oxiding them to less objectionable odorous products before they are released to the atmosphere.

Industrial or gray smog is considered the most serious type of air pollution. Smoke and oxides of that are released by burning coal and oil containing minor amounts of sulfur is the cause.

The oxides of sulfur form sulfuric acid in the atmosphere which is both toxic to life and damaging to many materials. The smoke gives the air a gray color.

Industrial smog has been known to cause air pollution disasters. One of the worst occurred in London in December of 1952. Five days of stagnant air brought about high pressure systems caused between 3,500 and 4,000 deaths. In Donora, Pennsylvania 20 died and 6,000 became ill in 1948 because of a similar instance.

Photochemical smog also know as brown smog is largely caused by exhaust gases. It is common in warm cities in dry areas with lots of sunshine, such as Los Angeles, Denver, and Salt Lake City. This type of smog can obscure vision, cause plant damage, and irritate eyes.

III. EFFECTS OF AIR POLLUTION ON THE LUNGS

One study by Ishikawa et al. provided evidence that air pollution may cause or contribute to emphysema. A comparison was made of autopsy lung material from residents of two cities, Winnipeg Manitoba and St. Louis, Missouri. The Canadian city has a relatively low level of air pollution, whereas the American city characteristicly has high levels of industrial contaminants. Emphysema was found to be seven times more common in St. Louis for ages 20-49 and twice as common for ages over 60. [1] Lets look at a comparison. Smoking was significant but not an isolated factor

(figure available in print form)

A 1960-66 post mortem examination of lungs of 300 residents of St. Louis, Missouri, and an equal number from Winnipeg, Canada. The subjects were matched by sex, occupation, socio-economic status, length of residence, smoking habits, and age at death.

IV. DAMAGES

Throughout the world the damage cause by air pollution is enormous. In money alone it represents a loss of billions of dollars each year. Many flower and vegetable crops suffer ill effects from air pollution caused by exhaust gases. Trees have been killed by pollution. Cattle have been poisoned. Air pollution causes rubber tires on automobiles to crack and become porous. Fine buildings become shabby, their walls blackened with soot as a result of the pollution that has settled on building stones and surfaces for years.

V. COST OF TREATING THE SICK

The high cost of air pollution is strikingly illustrated in its damaging effects on the human body. Besides the unpleasantness of irritated eyes and scratchy throats, it presents a threat to the respiratory tract, contributing to a number of serious diseases. In both the United States and Europe, episodes of high levels of air pollution were implicated in a large number of deaths.

VI. EFFECTS OF AIRPLANES

The jet airplane has revolutionized travel since about 1960. It has brought people and cultures closer together. It has created environmental problems. Harmful chemicals sift down from the smoky trails of low-flying jets. The scream of jet engines is constantly heard by people who live near big-city airports. Jet aircraft, particularly the supersonic transport (SST) could engender stratospheric air pollution with consequent changes in climate. Jet exhaust contains water, CO2 oxides of nitrogen, and particulate matter. It is speculative just how harmful these pollutants can be. For example, it is estimated that a fleet of five hundred SST’s over a period of years could increase the water content of the stratosphere by 50 to 100 percent, which could result in a rise in average. Temperature of the surface of the earth of about 0.2 Celsius degrees and could cause destruction of some of the stratospheric ozone that protects the earth from ultraviolet radiation.

It is a fact that many people prefer air travel rather than ground or water transportation. This has prompted a

critical look at safety and quality control. Contributions to air pollution is a chief concern because of this revolutionary change in public transportation in the United States and around the world. The government must also establish standards for exhaust emissions. Thus manufacturers are forced to develop low-pollutant engines. Contact with government agencies will give a greater insight of this subject. Information on how to contact environmental groups in New England can be found on the reference page of this unit.

(figure available in print form)
This graph shows the dramatic increases in the air traffic since 1950, including passenger miles of U.S. airlines. (Aviation Facts and Figures 1953. Washington, DC: Lincoln Press.)

An airplane needs an energy supply and an engine, for propulsion, that will function whenever they are needed. These internal combustion engines have discharged pollutants into the air. The combustion exhaust must be dealt with. Modification of air/fuel ratios can provide a partial solution. The problem of air pollution from airplanes involve a complex set of interactions among technical, social, and economic factors.

Emission from jet aircraft, particularly on landing and take-offs, are a source of bitter complaints from nearby residents. In a few airports visibility has been dangerously restricted by particulate emissions and photochemical smog. Airlines have a considerable expense in cleaning the obnoxious odors of unburned fuel from aircraft air conditioning systems. Most pilots prefer exhaust plumes, because aircrafts are made more visible.

In a jet engine, air enters through the front and is compressed by rotating vanes as it is forced into combustion chambers arranged around the circumference. Fuel is steadily sprayed into the leading end of each chamber where it ignites in the not compressed air, burns and causes the air to expand. The burning gases push toward the rear, striking turbine blades whose rotation drives the compressor they are connected to. The burning gases are further compressed at the exhaust nozzle to provide a high-velocity exhaust. This provides forward thrust to the aircraft. The diagram below illustrates this operation.

(figures available in print form)
Reliable data on engine exhausts are difficult to obtain because engines operate under many different conditions. Engine design plays an important role in reducing pollution emissions. One engine may emit more than a comparable engine. Older aircraft have experienced a substantial reduction in hydrocarbon, carbon monoxide, and particulate emission because the fuel is more completely burned with the installation of “clean burner cans”. [2]

VII. ALTITUDE

The temperature of the atmosphere is not uniform, but decreases with altitude up to 20 kilometers where it is found to be only 220°K. At altitudes above 20 km, the temperature is observed to increase with altitude as a result of the absorption of solar radiation by ozone in the upper atmosphere. At much higher altitudes the temperature decreases again. Any mountain climber knows there is a decrease of air density with altitude. At the highest permanently inhabited village in the Peruvian Andes, located at an altitude of 5.3 km, the air density is about half of the sea level density. In adapting to these conditions the inhabitants have developed unusually large lung capacities. Because of the exponential decreased of density with altitude, most of the atmospheric mass is beneath an altitude of 33 km, about three times the altitude of Mt. Everest.
(figure available in print form)

VIII. PLUMES OF SMOKESTACKS

A plume from an elevated source such as a tall exhaust stack mixes vertically and horizontally with ambient air as it drifts downwind, Vertical mixing is determined largely by the degree of instability of the lower troposphere. This depends upon the temperature profile. Horizontal mixture can also be influenced indirectly by the elapse rate. For a movement of air in the vertical direction cannot proceed without horizontal movement somewhere.

EXAMPLES

A. LOOPING—large-scale turbulent eddies cause sizable parcels of air, together with portions of the plume, to deviate from a straight downwind direction

(figure available in print form)

B. CONING—the shape of the plume is commonly vertically symmetrical about what is call the plume line.

(figure available in print form)

C. FANNING—suppressed vertical mixing, but not horizonal mixing entirely causes the plume to spread only parallel to the ground and appears to take on the shape of a fan as seen from below.

(figure available in print form)

D. LOFTING—the lapse rate in the upper portion of the plume is unstable and in the lower it is stable. Mixing is vigorous in the upward direction.

(figure available in print form)

E. FUMIGATION—poses a potentially serious air pollution situation. Here the plume is released just under an elevated inversion layer. When the low-level unstable lapse rate reaches the plume, the effluent suddenly mixes downward toward the ground.

(figure available in print form)

In the effluent from a smelter in a valley is trapped in a radiational inversion, diffusing neither upward or downward, but drifting down the valley, the ground level concentration will be highest. The daily uniform warming of the valley floor erodes the inversion from beneath, and when the layer containing pollutants becomes unstable widespread fumigation occurs along a great length of the valley. SEE DIAGRAM BELOW.

(figure available in print form)

PLUME TRAPPED WITHIN AN INVERSION DRIFTS INLAND UNTIL IT EMERGES FROM THE UPWARD-SLOPING BASE OF THE INVERSION. THE VENTING OF AIR UP A MOUNTAIN SLOPE IS KNOWN AS THE CHIMNEY EFFECT.

IX. AIR POLLUTION CONTROL

In an effort to control the concentration of air pollutants at ground level, some companies have built very tall smokestacks—up to a thousand feet high. Tall stacks along with, “intermittent controls”, a term used to describe the practice of cutting back production when weather conditions threaten to raise local pollution levels above ambient air standards. What can be done to avoid air pollution? This question does not have a simple answer. Every industrial process brings its own set of contaminants to the air. Cooking a meal or simply heating your home contributes to this problem. In fact there are very few activities that so not release some type of contaminant into the atmosphere. It is evident that air pollution will never be completely eliminated. So a more realistic question might be: How can air pollution be reduced to a less harmful level?

Legal actions to place control over the emission of air pollutants have been instituted in several ways. One is in the form of a *public nuisance* law. This is when conditions cause discomfort, inconvenience, damage to property, or injury. A court injunction can be placed against the person or corporation responsible. In a case of community smog it would be pretty impossible to identify who is responsible. So the law governing public nuisances is not very effective.

Private litigation may be sought in cases of damages for individuals. The individual must clearly link the damage to the pollutant emitted. Thus the burden of proof is on the complainant. This can be very expensive. Often the court will weigh the costs of improving conditions against the benefits.

The government has also intervened in the protection of the public. As a result of much research; devices for pollution control have been developed, guidelines for air quality were established, tax incentives were introduced, and most importantly, enforcement of ordinances for restricting the emission of contaminants—*prescribed emission standards* .

In 1970, Congress passed the CLEAN AIR ACT, the first comprehensive legislation to reduce air pollution in the United States. This was complemented in 1972 by the similarly aimed WATER POLLUTION CONTROL ACT. Both dealt with industrial sources of pollution.

X. ATMOSPHERIC STRUCTURE

A. TROPOSPHERE—This layer is nearest the surface of the earth and most “weather” occurs here. It extends up about eight miles. In the troposphere the air mixed by vertical circulation. Therefore it is affected by the conditions near the surface. The air in the troposphere becomes warmer or cooler, drier or moister, as surface conditions change from day to day. The temperature falls between 0.65°C per 100 meters (3.5°F per 1000 feet).
B. STRATOSPHERE—This layer extends from the tropopause (the top of the troposphere) to about 50 kilometers (30 miles). Here the air moves up and down very little. It is in layers or strata, so it is said to be stratified. The temperature is constant up to about 20 kilometers (12 miles) and then increases to stratopause.
C. OZONOSPHERE—The ozone layer is a part of the stratosphere and extends from about 10 to 50 kilometers (6 to 30 miles), and the maximum concentration is about 5 parts per million at about 30 kilometers (18 miles). This tiny amount of ozone, which it itself lethal in higher concentrations, shields us from lethal ultraviolet radiation form the sun.
D. MESOSPHERE——Above the stratopause is the mesosphere another zone of falling temperature that extends to about 85 kilometers (50 miles). The temperature at the mesosphere is about -85°C (-120°F).
E. THERMOSPHERE—A zone of increasing temperature that extends several hundred kilometers. Temperatures reach very high, but has little meaning in this zone of very thin atmosphere.

(figure available in print form)

During December, 1952 episode in London the death rate is closely correlated the change in the atmosphere. There was an increase in mortality in all age groups but the highest increase was among the elderly. The main causes were chronic bronchitis, bronchopneumonia, and heart disease. It is quite evident that pollution causes acute respiratory and heart disease.

(figure available in print form)

*** The charts are arranged one above the other so that students from the below average range would be able to make simple comparisons.

XI. GREENHOUSE EFFECT

The short wavelength radiation from the sun can penetrate the atmosphere, but the long wavelength radiation from the earth cannot and so is trapped heating the atmosphere. This is similar to the way the glass in a greenhouse was thought to let the short-wavelength radiation from the interior of the warm greenhouse.

(figure available in print form)

The greenhouse effect keeps the average temperature of the earth's surface about 35°C (63°F) warmer than it would be without it. It is also reason the troposphere is heated from below.

XII.

RESOURCE AGENCIES IN NEW ENGLAND RELATING TO AIR POLLUTION

AIR COMPLIANCE UNIT
DEPARTMENT OF ENVIRONMENTAL PROTECTION
STATE OFFICE BUILDING
HARTFORD, CT 06115
(203) 566-4030
CONNECTICUT AIR CONSERVATION COMMITTEE
45 ASH STREET
EAST HARTFORD, CT 06108
(203) 528-9437
OFFICE OF PUBLIC AFFAIRS
REGION 1
UNITED STATES FEDERAL PROTECTION AGENCY
ROOM 2203, JOHN F. KENNEDY FEDERAL BUILDING
BOSTON, MA 02203
SOUTH CENTRAL BRANCH
AMERICAN LUNG ASSOCIATION OF CONNECTICUT
364 WHITNEY AVENUE

NEW HAVEN, CT 06511
(203) 777-6821

NOTE: Available at the American Lung Association are many brochures, education films (on loan), and Environmental Health catalogs and order forms.

It will be necessary to pursue in more details subjects covered in this unit. The references listed and the bibliography of this unit should be consulted. These references are important because this unit is not intended to cover all aspects of air pollution. Many contaminants will not be discussed in full detail. The basic principles gained from this unit should lead to a good position to consult more inclusive and most recent literature, depending on the time of use. Information constantly change and must be updated.

Understand that the sample lesson plans can be expanded according to the depth in which the individual desires to venture and according to the needs of the students. Many activities can derive from these when it is appropriate. Also the order in which they appear is not necessarily the suggested order they are performed.

XIII. NOTES

1. S. Ishikawa, D.H. Bowden, V. Fisher, and J.P. Wyatt. " 'The Emphysema Profile' in Two Midwestern Cities in North AMerica," Arch. Environmental Health, 18, 660 (1969)
2. Samuel J. Williamson. *Fundamentals of Air Pollution* Addison-Wesley Publishing Co. 321, (1973)

XIV. ACTIVITY I

READING
OBJECTIVE: Students will identify the main idea of a paragraph.

WHAT TO DO: Underline the sentence that states the main idea of each paragraph.

1. The idea that polluted air can be harmful to man dates back to the Middle Ages. Direct evidence of bad effects from polluted air began to accumulate after the first use of coal. This was noticed around the beginning of the fourteenth century. The dark smoke, the unpleasant odors, the blackening of buildings and monuments were clear results.
2. Air pollution has caused widespread damage to trees, fruit, vegetables, and ornamental flowers. The total annual cost of plant damage in the United States has been estimated at close to one billion dollars. The most dramatic instance of such effects were seen in the total destruction of vegetation by sulfur dioxide in the areas surrounding smelters.

ACTIVITY II

READING

SCIENCE

SOCIAL STUDIES

GRADES 5-8

BELOW AVERAGE TO ABOVE AVERAGE LEVELS
OBJECTIVES: Students will identify pollution problems in their immediate environment.

Students will identify the main idea of an article.

WHAT TO DO: Students will use newspapers and magazines to find articles on pollution. Each student must bring in one article per week for four weeks. Have them mount each article on construction paper and write one sentence that give the main idea of the article.

ACTIVITY III

READING

SCIENCE

SOCIAL STUDIES

GRADES 5-8

BELOW AVERAGE TO ABOVE AVERAGE LEVELS

OBJECTIVE: Students will obtain and organize relevant data on a particular subject or theme.

WHAT TO DO:

1. Each student should receive a folder or material to make a folder to keep materials together and organized.
2. Each student will research and write a composition.
    a. FIFTH AND SIXTH graders will use encyclopedias and dictionaries to write a composition entitled “What Is Air Pollution?” (minimum of 1 page)
    b. SEVENTH graders will use encyclopedias, dictionaries, and other reference materials to write an essay called, “The Effects of Air Pollution” (minimum of 3 pages).
    c. EIGHTH graders will write a research paper geared toward the cause and effects of air pollution. Students may choose their own titles. This paper should be four to five pages in length. (Teachers may use this opportunity to introduce footnotes and bibliographies if they have not been taught. Teachers may also wish to monitor students’ note taking skills.)

ACTIVITY IV

READING

SOCIAL STUDIES

GRADES 5-8

BELOW AVERAGE TO ABOVE AVERAGE LEVELS
OBJECTIVE: Students will develop a visual study or outline that will support the main idea of a subject with supportive details.

WHAT TO DO: Have students make a collage using the newspaper, stressing the fact that all sections may be used—cartoons, pictures, ads, printed matter. They will concentrate on the subject of air pollution. Examples may be done by the teacher and shared with students to help them get started.

On completion of the work, each student will present his or her project orally specifying the main idea and showing how each part of the collage supports the main idea. The class will be looking for irrelevant details.

ACTIVITY V

SOCIAL STUDIES

GRADES 7-8

BELOW AVERAGE TO ABOVE AVERAGE LEVELS
OBJECTIVE: Students will be able to develop plans and solutions of social problem solving.

WHAT TO DO: Separate the class into groups of four or five. Give each group the same problem.

PROBLEM: You are a member of a planning commission which has the responsibility for selecting a site which will be zoned for heavy industry.

TASK: List criteria concerning aspects of air pollution which would bear on the matter. Present relevant information.

ACTIVITY VI

READING

GRADES 7-8

BELOW AVERAGE TO ABOVE AVERAGE LEVELS
OBJECTIVE: Students will read for high comprehension and supporting details.

WHAT TO DO: Write the following HINTS TO SUCCESSFUL CRITICAL READING on the board. Go over them with the students and allow them to comment and/or ask questions.

1. READ FOR HIGH COMPREHENSION OF IDEAS AND SUPPORTING DETAILS.
2. RE-READ IF NECESSARY TO INSURE FULL UNDERSTANDING.
3. LOOK FOR AUTHOR'S PURPOSE.
4. NOTE ANY INACCURACIES.
5. DETERMINE IF THE FACTS JUSTIFY THE CONCLUSION.
6. FIND THE BASIC THOUGHTS
7. BE SURE YOU HAVE A CLEAR OVERVIEW.
8. RELATE THE NEW MATERIAL TO WHAT YOU ALREADY KNOW
9. REMEMBER KEY WORDS AS CLUES.

10. DEFINE WORDS THAT ARE NOT FAMILIAR. Now give students selected reading material to read independently. Then ask students to write three important details they remember. Make sure the reading has lots of details and is interesting.

ACTIVITY VII

SOCIAL STUDIES

GRADES 5-8

BELOW AVERAGE TO ABOVE AVERAGE LEVELS
OBJECTIVE: Students will support an idea and use skill of persuasion to substantiate their view.

WHAT TO DO: Divide the class in two teams. One team for and the other against a statement. Each team will develop an argument in favor of their view point. The teams will select 5 students to represent their team. The remaining students will serve as a support group. Rules for alternates can be established by teachers.

PROBLEM: Tall chimneys do not collect or destroy anything, all they do is protect the nearby area at the

expense of more distant places which will eventually get all the pollutants anyway. Are tall smokestacks an asset in control of air pollution?

ACTIVITY VIII

MATH

GRADES 5-8

BELOW AVERAGE TO ABOVE AVERAGE LEVELS
OBJECTIVES: Students will be able to read scales.

Students will be able to obtain information from scales.

Students will be able to compare Celsius and Fahrenheit temperature scales.

WHAT TO DO: Have students study the thermometers and fill in the missing temperatures. Then have them answer the questions.

1. What is the boiling point of water? ___ C, ___ F

2. What is the normal body temperature? ___ C, ___ F
3. What is normal room temperature? ___ C, ___ F
5. What is the difference between the freezing point of water and the boiling point? ___ C, ___ F

(figure available in print form)

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