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# Where, Oh Where is All the Clean Air?

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## Introduction

Air, like water is essential for life. Air pollution, like water pollution is a problem that threatens us all. We are all aware that air and water are the most precious of all our natural resources. We need clean air and accessible water to carry on normal life functions. In past generations, the amounts of fuels burned in home and industry have greatly increased. This increased burning has also increased the amount of impurities discharged into the air. And since a pollutant is an impurity, we cannot have clean air as long as it is being bombarded with impurities.

## History of Air Pollution

Since man discovered how to use fire, he has continuously polluted the atmosphere. The process of combustion or burning provides us with power, but in using this process we pour much waste material into the atmosphere.

a) ancient Romans complained of odor and soot deposits on clothing and crops due to coal burning, wood burning and oil lamp usage.
b) during the middle ages and the colonial period, similar complaints of odors and soot deposits were registered as a result of burning of fuels.
c) the onset of the Industrial Revolution produced an increase in the number of cities, homes and factories causing an increase in the amounts of fuels burned to run the factories and heat the homes.

Only recently, has air pollution been considered a serious threat to our biophysical environment. This threat has two main causes: 1) the rapid growth of our population 2) the expansion of our technological activities.

This same growth has created new waste products harmful to health, detrimental to the growth of living things, negatively aesthetic and expensive in terms of the economy.

## Behavioral Objectives

### Skills and Abilities

1) to become familiar with the history and facts of pollution and pollutants in our atmosphere.
2) to begin to understand the problems of air pollution and how they affect our environment.
3) to understand through inquiries, investigations and activities the effects of air pollution on living things.
4) to develop suggestions for possible methods of addressing the problems arising from air pollution.

### Attitudes and Appreciations

1) to recognize that each person has an affect on the environment.
2) to reach a better understanding of the immediate and long-range dangers of air pollution.
3) to understand that air pollution is a problem that threatens the entire world community.
4) to understand that air is our most important resource and clean air is necessary to maintain a high quality of life.
5) to recognize that modern technology incorporates processes which replace clean, useable air with polluted, potentially harmful air.

## Questions to be answered

Why is clean air important?
How did the air become polluted?

What is air pollution?
How does air pollution affect animal life?
How does air pollution affect human beings?
How are the effects of air pollution on human beings studied? How does air pollution affect land-based organisms and aquatic life? What methods are being used for controlling air pollution?
What are some economic considerations for the control of air pollution?

## Meteorology of Air Pollution (causes and dispersal; effects on living things)

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What is air pollution?

Air pollution is substance in our atmosphere consisting of man-made contaminants that may be harmful to humans, plants, animal life or property. Air pollution consists of *gaseous material* which makes up more than 90% of the total of air pollution. Air pollution consists of *suspended particulates* which make up less than 10% of the total of air pollution.

*Gaseous Material: Sources and Effects*

*Carbon Monoxide* CO—( over 50% of total of U.S. air pollution) colorless, odorless, tasteless.

***Sources:***

1) automobile engines account for 50% of world total (three pounds of CO released for each gallon of gasoline burned)
2) Industry 20%
3) Incomplete fossil fuel combustion

***Effects:***

1) Low concentrations cause drowsiness, dizziness, nausea and contributes to driver fatigue.
2) 10 parts per million—illness reaction time slowed
3) 50 parts per million—eight hour exposure reduces the oxygen carrying capacity of the blood by 15%.
4) 120 parts per million—one hour exposure can affect driver responses noticeably. (rush hour concentrations often exceed 300 parts per million)
5) 1,300 parts per million—fatal in thirty minutes.
6) persons with heart disease, anemia or respiratory disease are most sensitive to the effects of carbon monoxide.
7) contributes to photochemical smog.
*Hydrocarbons* —a class of compounds containing carbon and hydrogen in various combinations. Found mainly in oil, natural gas and coal.

***Sources:***

1) automobiles and other motor driven sources—55% (over 200 different kinds of hydrocarbons are found in auto exhaust)
2) bacterial decomposition*
3) forest fires*
4) combustion processes*

* % variable

***Effects:***

1) many hydrocarbons are cancer producing (carcinogenic).
2) detrimental to balance of the ozone layer in the atmosphere.
3) contributes to photochemical smog.
*Nitrogen Oxides* —reddish brown gas with a characteristic odor.

***Sources:***

1) internal combustion engines—39%
2) residential and commercial burning—47%
3) natural processes—14%

***Effects:***

1) nitrous oxide, like carbon monoxide reduces the oxygen carrying capacity of the blood.
2) nitrogen dioxide can be fatal in high concentrations.
3) increased respiratory infections in children (mainly bronchitis).
4) nitrogen dioxide and water combine to form nitric acid
5) the oxides of nitrogen combine with water on mucous membranes to form mild acid solutions. This leads to irritation of the eyes, nose, bronchial tubes and lungs.

*Sulfur Dioxide*— $SO_2$ a heavy , pungent, colorless gas.

***Sources:***

1) burning of coal and oil as well as other industrial processes.
2) natural decay and volcanic eruptions.
3) smelting and petroleum refining.

***Effects:***

1) pulmonary damage
2) irritation to eyes, nose and throat.
3) kills plant life (damages leaves and stems)
4) can injure the bronchial tubes leading to the lungs and the delicate tissues of the lungs themselves.
5) affects the PH balance of water.

6) forms sulfuric acid with water. This acid attacks metal, concrete, granite and other structural materials.

*Suspended Particulates: Sources and Effects*

*Particulates* —solid or liquid matter, including dust, smoke fumes, fly ash, mists and sprays.

***Sources:***

1) incinerators and fossil fuel burning plants, especially coal burning operations.
2) industrial processes.
3) automobile exhaust.

***Effects:***

1) disturbs the normal cleansing action of the lungs.
2) particles often carry or contain materials that have direct toxic effects on humans (particles often contain bacteria, viruses, sulfuric and nitric acids).
3) particles suspended in the air scatter and absorb sunlight, produce haze, reduce visibility and reduce solar energy reaching earth.

*Photochemical Smog*

***Sources: Photochemical smog is secondary air pollutant produced by the chemical reaction due to the combining of hydrocarbons, carbon monoxide, nitrogen oxides and particulates. The smog making process begins when the sun's ultra-violet rays trigger a photochemical reaction between hydrocarbons and nitrogen oxides, forming a number of secondary pollutants or smog products such as ozone, aldehydes and peroxy-acynitrate (PAN).***

***Effects:***

1) ozone can cause coughing, choking, headaches and severe fatigue.
2) ozone can damage the leaves of plants.
3) PAN causes eye irritation and damages the leaves of plants.
4) aldehydes, with their suffocating, pungent odor, cause severe respiratory irritation.
5) photochemical smog with its brownish haze causes discomfort and decreases visibility.

*Lead Aerosol*

***Sources:  tetra-ethyl lead is the anti-knock compound in leaded gasolines that is responsible for 95% of the lead aerosol in the air.***

***Effects:***

1) exposure to high levels of lead aerosols causes scarring and shrinking of kidney and liver tissue.
2) over-exposure to lead can result in peripheral nerve system damage affecting primarily motor nerves.

## Major Diseases Related To Air Pollution

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*Asthma* —An attack consists of the narrowing of the bronchioles, which is caused by a muscle spasm, an enlargement of the mucous membrane and by abundant mucous secretions. Asthma can be caused by allergins of natural origin such as pollen as well as manmade pollutants.

Bronchitis and *Emphysema* —These two diseases are discussed together because they either occur simultaneously *or* emphysema may be the follow-up to bronchitis. In emphysema, the victim's air sacs or alveoli become enlarged and eventually break down or burst. Both bronchitis and emphysema induce shortness of breath in victims. In advanced cases victims are unable to blow out a lighted match only a few inches away from their mouths.

*Lung Cancer* —Cancer is produced by uncontrolled cell growth. Lung cancer is the abnormal and uncontrolled growth of cells which usually originates in the bronchial mucous membranes. A multitude of carcinogenic substances are known . The best known are the hydrocarbons which are present in the air in cities and

industrial areas.

## Impacts of Air Pollution

In all the major acute air pollution incidences recorded, effects on animals, primarily zoo or domestic animals have been reported. Dogs seem to exhibit the same symptoms of respiratory disease as do humans. The major contaminants such as the oxides and fluorides are known to be highly toxic to animals. Animals appear to be tougher than man When exposed to air borne contaminants, but there is evidence of the deterioration of livestock When exposed to photochemical smog. Studies conducted in large urban zoos demonstrate that wolves and lions developed a susceptibility to lung cancer. Fluorides have been attributed to crippling skeletal defects in cattle. Numerous instances of fluoride poisoning of livestock have been not only reported, but documented.

*Impacts On Aquatic Life*

Water is considered polluted if it is not suitable for its intended utilization such as agricultural and industrial uses, recreation, propagation of fish and wildlife and domestic water supply. The natural purification process utilizes oxygen in the decomposing or breaking down of natural contaminants. Excessive amounts of organic matter will cause a decomposition process which will be absent of oxygen. This anaerobic (absence of oxygen) decomposition produces hydrogen sulfide, an offensive smelling gas.

There are generally *eight categories* of pollutants that can affect the aquatic life of a community. They are heat, sediments, radioactive substances, synthetic organic chemicals, plant nutrients, sewage and disease causing organisms and inorganic substances. *Heat* can reduce the capacity of water to absorb oxygen. Increased water temperature, caused by the introduction of water from a power generating plant or other industries can upset the ecological balance. When heated water is returned to a stream, it can raise the temperature of the cooler water a few degrees. This slight temperature change is enough to be lethal to many forms of aquatic life accustomed to a specific temperature range. Increasing water temperature also makes aquatic plants and animals grow at a faster rate. It also speeds up the use of food, rate of gas exchange and heartbeat in animals. The organisms grow faster, but do not grow as large or live as long as normally in cooler water. Many aquatic animals will not reproduce if the temperature is raised even a few degrees. Studies show that water temperature above 30°C decreases the number of diatoms and increases the number of blue-green algae. Besides the blue-green algae producing an unpleasant odor and unpleasant taste, they seem not to be a good source of food for algae-eating organisms. This type of pollution; dumping hot water into streams, lakes or rivers is called *THERMAL POLLUTION* .

*EXCESSIVE SEDIMENT* will reduce the amount of sunlight penetrating the water and will affect the photosynthesis process of green aquatic plants. These plants are necessary for oxygen production which will maintain a normal balance in the water. Many of these green plants are a necessary food source for the animal life found in the water body.

*RADIOACTIVE SUBSTANCES* can accumulate in living organisms, aquatic life as well as in humans when the exposure is sufficiently severe.

*SYNTHETIC ORGANIC CHEMICALS* include such things as detergents and cleansing agents used in the home,

synthetic organic pesticides and the residue from synthetic chemicals utilized in industrial processes. These chemicals are extremely toxic to fish and other forms of aquatic life as well as causing serious taste and odor problems.

*INORGANIC SUBSTANCES* include a wide variety of acids, metal salts, solld matter and various other chemical compounds. Among these materials are ammonia, arsenic, barium, boron, cadmium, chloride, chromium, copper, fluoride, iron, lead, manganese, nitrates, nitrites, phosphorus, selenium, silver, sulfates and zinc. Pollution by these substances is a result of oil field activities, mining processes, manufacturing processes and agriculture.

*Impacts On Plant Life*

Plants are the means by which the sun's energy can serve all animals, especially man. The plants maintain the oxygen content of the air and provide the basic habitat and food for man and animals. In any ecosystem, the plants, animals and microorganisms exist in a state of interaction and coexistence. This interaction is subject to physical and chemical inputs as well as climate. Plant life is much more sensitive to air pollution than animal life. And many times plants are used to gather new data about air contaminants because of this sensitivity. Among the pollutants that can harm plants are sulfur dioxide, hydrogen fluoride, and ethylene. Some plant damage is caused by the contaminants in photochemical smog as well as by ozone.

Air pollution determines where certain types of vegetable crops can be raised. Every urban area in the United States experiences vegetative damages from air pollution, especially the farming industry in New Jersey, California and parts of Florida. Substances generated by combustion often react with sunlight and moisture to form the oxidant called PAN, which has been identified as the cause of death of plants and trees along California highways. PAN is extremely toxic to many forms of farm produce. Damage to vegetation as a result of air contaminants is so severe that commercial and non-commercial production of crops and forests in many areas has been jeopardized and in some areas discontinued.

## Methods of Controlling Air Pollution vs Economic Considerations

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The principal reason for controlling pollution is to protect human health and the ecological balance of man's life-support systems. Innumerable other benefits can result from clean-up measures, i.e., financial savings, more efficient productivity and aesthetic effect. All arguments against pollution controls are reduced to the money factor. *WE CANNOT AFFORD CLEAN AIR; IT COSTS TOO MUCH* . Electric utility spokespersons maintain that the cost of adequate filtration of smokestacks is too high. They claim the public won't stand for the additional cost of electricity. Yet this same public pays regular increases of its utilities bills, for whatever reasons. The auto makers argue that the car-buying public won't accept the cost of too many emission control devices on new car prices. Yet, the consumer pays time and time again for yearly model changes and frivolous gadgets like hidden headlights, vinyl tops and recessed windshield wipers. We all pay for air pollution. We pay in human life and the destruction of all other life on the earth. Even though we know that air pollution shortens the life span of every living thing that requires air to breathe, these facts seem to have little impact as compared to the money cost factor. For example, life insurance companies have statistics comparing the life expectancies of urban and rural dwellers. The individual who lives and works away from urban centers has a longer life expectancy. One primary reason being the urban dweller s poorer quality of air. The total cost to the nation is billions and billions of dollars.

*Steps Toward Control*

We find many different kinds of processes being studied, experimented with or employed in attempts to clean up air pollution caused by industry, power generating plants, space heating and refuse disposal activities. The four major types of control devices are filter bag systems, cyclone treatment, electrostatic precipitators and scrubber systems. Other processes are being studied and tested for the removal of sulfur oxides from smokestack emissions. Tall smokestacks do not reduce the emission of pollutants, but they *do* reduce the concentration of pollutants at ground level. During the 1960's, the average height of smokestacks for power generating plants was about 240 feet. Today, the average height of these stacks is well over 600 feet with many as high as 1,000 feet or more. Still, this sort of measure, at the most, can only be considered as a sort of interim step or partial solution.

Some cities, like Los Angeles, have banned all backyard incinerators and have laws that require apartment house incinerators to include wet scrubbers on their smokestacks for reduction of particulate emission. Many big cities still dispose of garbage by burning it in huge incinerators. Incinerators can be built that will completely burn the garbage and emit little, if any, contaminants into the air. However, most cities lack such units.

*Considerations*

Many considerations must be investigated and implemented if quality air is to become a reality again. Among these considerations are the following:

1) more research and development should be undertaken for alternative processes that are non-polluting.
2) development of new pollution control equipment and technological information for industrial emissions should be encouraged and supported.
3) low cost pollution control equipment should be developed for small industries.
4) research and development on new methods of removing sulfur oxides from smokestacks should be undertaken and/or increased.
5) continued study of the use of alternative fuels that will reduce emissions should be encouraged, while modifying existing power plants whenever feasible.
6) new effective and more efficient combustion processes with minimal pollutant emissions should be promoted.
7) research and development of energy sources such as hot water, hot air, solar power or steam for space heating needs.

## Summary

All of the major cities of the United States and most of the major cities worldwide have serious air quality problems. The air pollution problem arises from rapidly increasing auto,truck and bus traffic as well as burgeoning industrial development. many valleys, small towns and suburban communities are made vulnerable to such pollution because of natural air inversion. There is abundant evidence that the levels of air pollution in these major cities present serious health problems as evidenced by the increasing rates of emphysema, chronic bronchitis, and respiratory disorders in city dwellers and from experimental data on laboratory animals exposed to ambient air pollution.

## Update

Solar and geothermal energy are being studied and experimented with as non-polluting energy sources for the future because it has become apparent that attaching soot precipitators to industrial chimneys or exhaust converters to gasoline engines is not enough. Researchers must think in terms of new kinds of fuels, new methods of producing energy and possibly a system of rationing the use of energy and natural resources. Industrial giants geared to petroleum production, the manufacture of automobiles and the building of highways offer tremendous resistance to such changes. They persist in wasteful practices.

## Activities For Classroom Discussion

1) *Distribute copies of The Parable of Malengo* . Read the parable aloud with the students having each student, having each student read a paragraph. This activity can serve as an introduction to the subject of air pollution. Introductory activity I.
2) *Introductory Activity II* . Magazine pictures showing temperature inversions, smog, smokestacks belching smoke, cars jamming highways emitting toxic gases, etc., may be posted on a bulletin board or distributed after reading and discussing *The Parable of Malen* go.
3) *Sample Dust Particles and Particulate Matter* . Cover microscope slides with a thin layer of vaseline, which will act as a non-drying adhesive. Place the slides in different locations around the room; near air vents, on the window sills, on the floor, suspended from the ceiling at graduated heights. Make charts as to the areas of greatest concentration of dust and other particular matter. Place sheets of white paper under each slide for better viewing.
4) *Monitor Smokestacks.* Have the students bring in kite from home. Attach to each kite a strip of paper or gauze covered lightly with vaseline. Find a major source of pollution such as a smokestack of an industrial plant, school, apartment or hospital. Instruct the students to fly their kites nearby. Each student should be assigned a specific spot from which to fly his kite. Students should fly their kites at different heights and at different distances from the source of pollution. Amounts of pollution should be determined and compared from spot to spot. This will enable students to learn whether or not weight of particulates has any bearing on distribution.
5) *Monitor Home Furnaces* . Have the students bring in some dirty furnace filters in order to demonstrate the presence of dust and particulates found in the air of the home. Instruct the

students to prepare glass slides covered with vaseline. Shake the filters over the slides. Under the hand lens or microscope, have the students classify particulates according to size, shape and color.

6) *Study Pollution From Coal Combustion* . This activity can be done using a piece of soft coal, a piece of hard coal, or both. Have the students pulverize the coal to facilitate burning. Hold a vaseline coated slide over the burning coal. The coated slide will be able to pick up any particles emitted by the combustion. This is an excellent activity to illustrate the fact that combustion is the basic source of pollution.

7) *Show Damage to Plants* . Certain particulate matter can clog up the openings or *stomata* of leaves of green plants. This clogging will impair or restrain water vapor and other gases from moving in and out of the leaf, particularly carbon dioxide and oxygen. Use vaseline to coat some of the leaves in order to demonstrate the clogging of the leaf pores. Coat both the topside and the underside of the leaf with vaseline. Have the students compare the coated leaves with the uncoated leaves of the same plant over a period of time. A variation of this activity would be to coat all the leaves of a plant and then compare it to a similar plant with uncoated leaves over a period of time.

8) *Study The Effects of Sulfur Dioxide On Plants* . Using one plant per student, have half the group place their plants in plastic bags, one plant per bag. Have the other half of the group place their plants on a shelf or ledge in the room. Measure out 2 grams of sodium sulfite for each plant placed in the plastic bags. Put the sodium sulfite into a small container. Then place the container in the bag with the plant. One container per bag. The sulfur dioxide can now be made by adding some sulfuric acid to the sodium sulfite. *CAUTION* : *THESE TWO CHEMICALS SHOULD BE MIXED ONLY ON A CLOSED CONTAINER. DO NOT BREATHE THE SULFUR DIOXIDE FUMES* .

After the acid is added, *Quickly* seal the bag with tape or a wire tie. Use the non-bagged plants to control the experiment. Observe and record the appearance of each plant for two or three days. Exchange data with students who used the same types of plants. Then Compare data with students who used different types of plants. Compare differences in plants with thick, waxy leaves and those with long, thin leaves. Compare young plants with older plants. Record and discuss differences.

9) *Study The Pollutants We Inhale* . Have students construct a mini-lung model to determine the types and amounts of pollutants inhaled from our immediate surroundings. To construct a minilung model, students will each require the following materials:. one empty half-gallon carton, vaseline, one single edge blade, a medium-sized nail, two plastic soda straws, two small balloons (1-1 1/2 in. diam.), string, plastic wrap, contact cement. To construct the model, open the spout end of the carton wide so as to allow for working inside. Cut a window in one side of the carton (3”x3”). Using the nail, punch two holes side-by-side in the bottom of the carton and push a soda straw through each hole. Working through the window and/or the open end of the carton tie a balloon around the end of each straw. *Be sure to coat the in-* side of each balloon lightly with vaseline. This can be done-by turning the balloon inside out to coat it then reverse it to place it on the end of the straw. Adjust the straws so the balloons appear in the window. Glue plastic wrap over the window and reinforce with masking tape. Glue the spout end closed and reinforce with masking tape also. For additional sealing to insure an airtight unit, put glue around the holes in the carton where the straws protrude. Allow the mini-lung to dry thoroughly. To operate, squeeze the sides in. The balloons deflate with pressure and inflate when released. Have students activate their models in the classroom, in the hallways and in the teacher’s lounge, if there is smoking allowed in the lounge. After activating the model at various sites, have the students remove the

balloons. After removing the balloons, have the students cut them open and examine the inner walls of the balloons with a hand lens or under the microscope to determine the types, size and amounts of particulates that would be inhaled by them during an average school day.

## Air Pollution Pre-Test

WHAT'S YOUR AIR POLLUTION I.Q.?

True False

| | |
|---|---|
| 1. Air pollution is harmful only in cities. | ( ) ( ) |
| 2. Air pollution is worse in big cities than small ones. | ( ) ( ) |
| 3. Nationwide, automobiles are the major source of air pollution. | ( ) ( ) |
| 4. Smog is a problem only in Los Angeles. | ( ) ( ) |
| 5. Inversions—in which air at ground level is trapped by warmer air above—come from air pollution. | ( ) ( ) |
| 6. Chronic respiratory diseases are aggravated by air pollution. | ( ) ( ) |
| 7. Air pollution affects only the respiratory system. | ( ) ( ) |
| 8. Air pollution can kill. | ( ) ( ) |
| 9. When the plume from a smokestack is white, no pollution is coming out. | ( ) ( ) |
| 10. Air pollution is expensive. | ( ) ( ) |

## Answers and Comments To Air Pollution Pre-Test

| | | |
|---|---|---|
| COUNT 10 | YOU'RE WELL INFORMED | 100 |
| FOR EACH CORRECT | GOOD, BUT TRY AGAIN | 80-90 |

ANSWER WHAT YOU DON'T KNOW under MAY HURT YOU 80

| False | True | | |
|---|---|---|---|
| (X) | ( ) | 1. The air carries pollution far beyond the city. So do automobiles and out-of-city factories. | |
| ( ) | (X) | | 2. Although special circumstances cause exceptions, pollution generally increases with population. |
| ( ) | (X) | | 3. Industry, power plants, space heating, and refuse disposal follow far behind, in that order. |
| (X ) | ( ) | 4. Los Angeles-type smog forms in many places— wherever automobile exhaust is acted upon by sunlight. | |
| (X ) | ( ) | 5. Inversions occur naturally. They do keep pollution from being dispersed, however. | |
| ( ) | (X) | | 6. Studies indicate that pollution worsens these diseases and brings more deaths from them. |
| (X ) | ( ) | 7. Among other things, air pollution can aggravate existing heart conditions. | |
| ( ) | (X) | | 8. In a number of famous long-lasting inversions, pollution brought death to many people. |
| (X ) | ( ) | 9. Many polluting gases are colorless and many polluting particles are white. | |
| ( ) | (X) | | 10. The government estimates that air pollution damage to animals, crops, paper, cloth, rubber, leather, and stone costs each man, woman, and child in the U.S. $65 a year. That's a lot to pay for something you don't even want, isn't it? |

## The Air we Breathe: A Parable

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( *Use this parable as an introduction to the subject of air pollution* .)

Once there was a beautiful little country named Malengo. On one side of Malengo, the sea spread out, providing white sandy beaches for children to run on and white-capped blue waves for children to laugh in and a wide expanse of ever-moving blue that quieted restlessness.

On the other side of Malengo, the mountains reached the sky. Their blue sides stood tall, capped by snow hats

so beautiful that women copies them, making white knit hats for the children.

Malengo was a country of farmers, and the farms spread out in the valley and along the foothills, making beautiful checkered patterns of brown and yellow and green. Every farmhouse was surrounded by trees—shade trees and flowering trees and fruit trees of every kind. In between the fields and along the roads, more trees grew.

And the flowers, such beautiful flowers you have never seen. Dainty wild flowers strewed themselves

“But other people do. You could sell them to other countries and get rich.’’

“Get rich? What is rich? Why should we get it’’

The man snorted again. “You are clods,’’ he said. “Dull, backward clods. I’ll not waste any more time in such a backward country.’’ He rode off through the mountains and was never seen again.

But people were no longer happy. “We need factories. We need cities,’’ they said to each other. “We need to get rich, whatever that is.’’ So they sent a delegation through the mountains to their neighboring country to find out about cities and factories and getting rich. The delegation brought back experts, who immediately started bossing.

The experts took the farmers from their fields and se them to work building a city along the beach. House after house was built, then factory after factory. Then the experts made everyone move into the city. The children cried, for there were no trees to climb in the city. The women cried, for there were no flowers in the city. The men even cried, for they could no longer work their own fields and watch their own crops grow.

But the experts reassured them. “You will like the city. You can work in the factories. You can plant new trees and new flowers.’’ And so they did, but there weren’t as many trees and flowers.

The experts divided up the work. Some men still farmed, but now they farmed much more land. At the bidding of the experts, they cut down trees to make bigger fields to grow more crops.

The trees were used in the factories and homes for heat and energy, and black smoke began to fill the sky. The factories started turning out shoes by the thousands, and dumping leftover leather and chemicals into a river that flowed to the sea.

Other factories started making clothes, and the air soon had a perpetually sour smell.

Delegations of salesmen took the shoes and clothes through the mountains and sold them. They brought back automobiles, which were then the newest fad in the neighboring country.

Soon every family had an automobile. And every Sunday, every family got in its automobile and rove, bumper to bumper, up into the mountains over a new road the experts had said they needed, in order to get some fresh air.

Soon the trees were all gone and there was no wood to burn. “We need coal,’’ said the experts, and they began looking for coal. They found it in the foothills. They brought in huge machines that tore up the earth and took out the coal. They took the coal in the city, and as it burned in all the factories and homes, the air got blacker and blacker.

“Let’s start using electricity,’’ said the experts. So a power plant was built and power lines were stretched everywhere in the city. And air got blacker and blacker.

“Let’s build our own automobiles,’’ said the experts. So another factory was built. And the air got blacker and blacker across the shady places, and bold wild flowers captured the sunny meadows. And the people were happy, very happy, in their beautiful little country.

But one day, a stranger came to Malengo. He wore a fancy vest and a high top hat, and he rode a prancing steed.

“What a dull, backward country you have,’’ he mocked. “All you do is farm. Where are your cities and factories? Don’t you make anything?’’

“We make our own clothes and our shoes. We make butter and cheese. We make delectable pies and cakes and soups. We make our own houses.’’

“No, no! That’s not what I mean. Don’t you make buggies to go riding in?’’

“Why should we?’’ We have good strong legs. We can walk.’’

He merely snorted. “In a factory you could make hundreds of shoes in a day, or hundreds of dresses, or 50 buggies.’’

“Why should we? Everyone already has shoes and clothes, and we don’t need buggies.’’

Some days, the wind blew in from the sea, instead of out to the sea. On those days, the black air just hung over the city. People coughed and their eyes watered, but no one paid any attention.

People began coming in from the neighboring country, because Malengo was now such a prosperous country. They brought more automobiles. They built more houses and more factories.

So many people came that all the farmland was bought so people could build houses and factories on it. Now the people of Malengo had to buy all their food from the neighboring country. Food became very expensive. The air got blacker and blacker. But no one paid any attention.

Then, for three weeks straight, the wind blew in from the sea. The black air hung over the city. People wheezed and coughed, and their eyes watered. The black air got thick with grime. Dogs began to die. Old people died , too, and sick people. No one knew why. No one tried to find out why.

Finally, the wind shifted. The black air blew away. Everyone breathed deeply and smiled. A few more old people died, and a few more sick people. But no one paid any attention.

More houses were built, and more factories. The power plant had to expand. Trains were built to cross the mountains, and they made the journey many times a day. Then an airport was built and jets began flying in and out.

Again, the wind blew in from the sea, this time for 48 days. The people coughed and wheezed, and their eyes watered. Dogs died. Old people died, and sick people. Then the children began to die. But no one knew why. The black air hung like a pall, poisoning everything. Trees and flowers died, even weeds, and finally everyone

died, every single person in Malengo.

Then the wind changed, blowing the black death away. But now people were afraid to go to Malengo. No one even went in to bury the dead. And so the country sat there, silent. The factories had stopped. The homes were silent. Nothing moved.

In the silence, the thick, thick silence, thing began to grow—grass and weeds and tree seeds. Once more dainty wild flowers strewed themselves across the shady places and bold wild flowers captured the sunny places. Threes burst up through cracks in the concrete. Vines began growing up walls. Bodies decayed and enriched the earth. Rabbits came, and birds, and many other animals. But still, people were afraid to go to Malengo. They didn't know why the black death had come or when it would come again. To them Malengo was a cursed place, a place of mystery and doom, a monument of death.

* * *

It could happen, you know. Part of it has already happened. Old people and sick people have died. Dogs and cats have died. So have flowers. Someday, all of us could die. The only difference is, we know what causes the black smoke. But, do we care?

## Average air pollution levels

| State | City | Micrograms of particles/cubic metre of air | Micrograms of sulfur dioxide cubic metre of air |
|---|---|---|---|
| Alabama | Montgomery | 61 | 5 |
| Arizona | Phoenix | 135 | 10 |
| California | Los Angeles | 133 | 14 |
| | San Francisco | 52 | 8 |
| Colorado | Denver | 152 | 28 |
| Connecticut | New Haven | 89 | 40 |
| Florida | Miami | 68 | 5 |
| | St. Petersburg | 43 | 16 |
| Georgia | Atlanta | 79 | 22 |
| | Savannah | 65 | 7 |
| Hawaii | Honolulu | 41 | 12 |
| Illinois | Chicago | 144 | 73 |
| Indiana | Evansville | 70 | 19 |
| | Indianapolis | 86 | 11 |
| Iowa | Des Moines | 95 | 7 |
| Kansas | Kansas City | 133 | 8 |
| | Wichita | 76 | 7 |
| Kentucky | Covington | 90 | 19 |
| Louisiana | Baton Rouge | 68 | 10 |

| | | | |
|---|---|---|---|
| Massachusetts | Worcester | 138 | 45 |
| Michigan | Detroit | 121 | 12 |
| Minnesota | Minneapolis | 61 | 23 |
| Missouri | St. Louis | 109 | 28 |
| Nebraska | Omaha | 112 | 13 |
| New Mexico | Albuquerque | 90 | 5 |
| New York | Rochester | 82 | 22 |
| North Carolina | Winston-Salem | 115 | 12 |
| Ohio | Akron | 104 | 31 |
| Oklahoma | Tulsa | 52 | 5 |
| Pennsylvania | Philadelphia | 115 | 54 |
| | Scranton | 211 | 30 |
| | York | 92 | 12 |
| Tennessee | Memphis | 89 | 7 |
| Texas | Forth Worth | 73 | 5 |
| | Pasadena | 83 | 5 |
| Virginia | Norfolk | 75 | 30 |
| Washington | Seattle | 58 | 24 |
| West Virginia | Charlestown | 130 | 7 |
| Wisconsin | Madison | 64 | 12 |

*Microgram is one-millionth of a gram.

## AIR POLLUTION EMERGENCIES

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**What is the New Index?**

It’s a report of the level of certain air pollutants (in winter, average levels of sulfur oxides and particulates; in summer, particulares and peak levels of oxidants) measured during the preceding 24 hours, plus an air pollution “forecast’’ for the following day. The index was developed by the Connecticut Department of Environmental Protection (DEP) in cooperation with the state’s news media and the Christmas Seal/Lung Association to provide a uniform method for reporting air pollution levels.

**How Do Your Read the New Index?**

The index is based on the Federal Health Standards set by the U.S. Environmental Protection Agency. It reports micrograms of pollution per cubic meter of air in four stages:

*(figure available in print form)*

What to do if heavy air pollution is forecast

If there’s danger of an air pollution episode, the following precautions ar recommended:

1. Curtail physical activity, both indoors and outdoors. (The most active you are, the more breaths you take—and the more pollutants you breathe in.)

2. Stay indoors as much as possible and keep windows closed. (Pollution levels are usually lower indoors than out. And buildings themselves act as filters of sorts, blocking or absorbing some pollutants.)
3. Avoid smoke filled rooms. If you are a smoker, stop or cut down smoking.
4. Don't use your fireplace.
5. Don't use your incinerator.
6. Don't drive if possible. If you must travel, use a public transportation. If you must drive, form car pools, avoid busy streets and expressways. If you have a choice, take a bridge instead of a tunnel. If you must use a tunnel, keep car windows and ventilator closed.
7. If you're on the street and a bus or truck emits a cloud of exhaust, hold your breath.
8. Do not wear contact lens.
9. In the winter months, use a humidifier or vaporizer to add moisture to your home. (Moisture helps you breathe easier:)
10. Cut down on water use. (Electricity is needed to pump water and sewage systems, and to run sewage treatment plants.)
11. Cut down on use of electricity. Keep nonessential lights off. Postpone running washing machine, dryer, dishwasher, other non-essential appliances.
12. Lower room temperature in your home if health considerations permit.
13. Postpone indoor cleaning jobs that circulate dust, such as sweeping, vacuuming.
14. Postpone outdoor jobs that raise dust, such as raking leaves, sweeping sidewalks, excavating land, etc.
15. Don't use the phone unless it's essential. (Telephone circuits can be overburdened in emergencies.)

*Special precautions*

(For the elderly, chronically ill, heart and lung patients, bronchitis, asthma, and emphysema sufferers, post-operative patients, and newborn infants)

Stay indoors, keep windows closed, and follow the other appropriate suggestions listed above. In addition:

1. If you have an air filtering system or air conditioner, turn it on.
2. If you're, on medication, take it at the first sign of worsening symptoms and call your physician.

*HOW A NUCLEAR POWER PLANT WORKS*

*(figure available in print form)*

THE CHEAPEST WAY TO GET RID OF WASTE HEAT FROM A POWER PLANT IS TO PUMP LAKE WATER THROUGH

THE COOLING SYSTEM. THIS METHOD IS CALLED THE DIRECT-FLOW METHOD. ALL THE HEATED WATER GOES INTO THE LAKE.. *THIS IS HOW THERMAL POLLUTION IS CAUSED.*

## A thermal pollution index

| Temperature, °C | Water conditions |
|---|---|
| 21 | Normal river temperature. Water is clear. Many kinds of fish, other animals, and plants thrive. |
| 24 | No obvious change in water quality or organisms living in it. |
| 26 | Almost no fish can reproduce. |
| 26.5 | Many desirable kinds of fish, such as trout, have been killed. |
| 29 | No swimming is allowed. |
| 32 | Most kinds of game fish and most animals that live on the river bottom have been killed. |
| 33.5 | Only carp and catfish survive. |
| 35 | Unpleasant odors and tastes produced by increasing numbers of blue-green algae. Water not fit for drinking. |
| 40.5 | Water can no longer be used by industry for cooling, unless it is first cooled. |
| 43 | The river is dead, except for some algae, bacteria and molds. |

## DO SOMETHING ABOUT AIR POLLUTION

**A. You can reduce auto air pollution:**

1. Walk when you can. Use busses and trains. Shop with others. Join a car pool. Ride a bike.
2. Buy gasoline with the least amount of lead and the lowest octane level that your car can take.
3. See that the pollution controls on your car are doing their job. Give your engine regular tune-ups.
4. Switch off the motor when you park, even if it is only for a few minutes.
5. Work with others for a good public transit system so you won’t need your car so much. Work for the development of cars that won’t pollute.

**B. You can reduce power plant pollution:**

1. Turn off the lights, radio, and TV when not using them.
2. Run your dishwasher only when it is full.

3. Use the air conditioner only when someone is home and only when it is very hot.
4. Dry your clothes outside when possible, instead of using the clothes dryer.
5. Work for adequate air pollution control equipment on polluting power plants.

**C. You can reduce air pollution caused by burning:**

1. Don’t burn leaves or trash.
2. Buy unpacked food and liquids in returnable containers whenever possible.
3. If you live in an apartment house with an incinerator, observe regulations for its use and see that it is pollution-controlled.
4. Reuse and recycle whatever you can.
5.Work for the installation of modern municipal incinerators that can produce heat and electricity instead of pollution.
6. Conserve irreplaceable fuel and help clean the air by keeping windows closed when the heat is on. Set the thermostat at 68 or 70 and wear a sweater if you are chilly. Turn down the heat at night or when you are away for more than a few hours.
7. Work for pollution controlled central heating when possible.

## GLOSSARY

*AEROSOL:* a dispersion of solid or liquid particles of microscopic size in gaseous media, such as smoke, fog or mist.
*AIR* : a colorless odorless, tasteless gaseous mixture; mainly nitrogen (78%) and oxygen (21%) with lesser amounts of argon, carbon dioxide, neon, helium and other gases.
*AIR MONITORING* : the sampling for and measuring of pollutants present in the ambient air.
*AIR POLLUTION* : the presence in the outdoor atmosphere of one or more man-made contaminants in quantities characteristics, and of duration such as to be injurious to human, plant

or animal life or to property or which unreasonably interferes with the comfortable enjoyment of life and property.
*AIR QUALITY CRITERIA* : data showing the range of effects that may be associated with exposure to various concentrations of pollutants in the air for various time periods.
*AIR QUALITY STANDARD* : air quality goals established for the purpose of protecting public health and welfare.
*AMBIENT AIR* : the air around you.
*AREA SOURCE* : small diffused individual pollutant sources such as automobiles, homes or commercial heating units, small home incinerators.
*ATMOSPHERE* : the envelope of air surrounding the earth.
*CARBON DIOXIDE* : a colorless, odorless, incombustible gas formed during respiration, combustion and organic decomposition.
*CARBON MONOXIDE* : a colorless, odorless, highly poisonous gas formed by the incomplete combustion of carbon or any carbonaceous material.
*CARCINOGENIC* : cancer producing.
*CHRONIC* : having a long duration or frequent occurrence.
*COH* : abbreviation for coefficient of haze; unit of measurement of soiling index.
*COMBUSTION* : burning; a chemical change accompanied by the production of heat and light; one of the three basic contributing processes of air pollution.
*COMMUNITY AIR* : the air representative of an entire community.
*DUST* : solid particles capable of temporary suspension in the air or other gases; usually derived from larger masses through the application of physical force.
*ECOLOGY* : the science of the relationships between organisms and their environment.
*EFFLUENT* : a discharge or emission of a liquid or gas.
*EMISSION FACTOR* :an average of the rate at which pollutants are emitted from a given source.
*EMISSION INVENTORY* : a compilation of the estimates of emissions from all sources in a community.
*EMISSION STANDARD* : the maximum amount of a pollutant that is permitted to be discharged from a polluting source.
*ENVIRONMENT* : the combination of all the external conditions and influences affecting the life, development, and the survival of an organism.
*EPIDEMIOLOGY* : the study of epidemics and epidemic diseases as they affect populations.
*EVAPORATION* : the physical transformation of a liquid to a gas at any temperature below its boiling point.
*FLY ASH* : finely divided particles of ash entrained in gases arising from the combination of fuel.
*FOG* : condensed water vapor in cloudlike masses close to the ground and limiting visibility.
*FOSSIL FUEL* : coal, oil and natural gas; so-called because they are the remains of ancient plant and animal life
*GAS* : one of the three states of matter, having neither independent shape nor volume and tending to expand indefinitely.
*HYDROCARBONS* : any of numerous organic compounds that contain carbon and hydrogen in various combinations.
*INCINERATION* : burning of waste material.
*INTERNAL COMBUSTION ENGINE* : an engine in which fuel is burned within the engine proper.
*INVERSION* : a state in which the air temperature increases with increasing altitude, holding surface air down along with its' pollutants.

*MICRO* : a prefix meaning one-millionth; abbreviated by the greek letter.
*MICROGRAMS PER CUBIC METER* : unit used to express concentration of many air pollutants; abbreviated µ/m3
*MICRON* : a unit of measurement equal to one-millionth of a meter; symbol µ
*MIST* : a mass of fine droplets of water in the atmosphere.
*MIXING DEPTH* : the depth in which air rises from the earth and mixes with the air above it until it meets air equal or warmer in temperature.
*NITROGEN OXIDES* : gases formed from nitrogen and oxygen when combustion takes place under conditions of high temperature and pressure.
*ORGANIC* : of, pertaining to, or derived from living organisms; in chemistry, a carbon-containing compound.
*OXYGEN* : a colorless, odorless, tasteless gas which makes up 21% of the atmosphere by volume.
*OZONE* : an unstable, poisonous, oxidizing agent with a pungent, irritating odor.
*PARTICULATE* : a particle of solid or liquid matter.
*PARTS PER MILLION* : unit sometimes used to express volumetric concentration of gaseous pollutants; abbreviated ppm.
*PHOTOCHEMICAL* : chemical reaction initiated by sunlight.
*PRIMARY STANDARD* : the levels of air quality necessary, with an adequate margin of safety to protect human health.
*RINGELMANN* : a chart used for measuring the capacity of black smoke.
*SCRUBBER* : a type of control device using a liquid spray to remove solid and gaseous pollutants from an air stream.
*SECONDARY STANDARD* : the levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of pollutants. Public welfare is considered to include among other things vegetation and property.
*SMOG* : irritating haze resulting from the sun’s effect on certain pollutants in the air, notably those from automobile exhaust; also a mixture of smoke and fog.
*STABILITY* : a term used to describe the ability of the air to diffuse pollution vertically; stable air results in little or no vertical diffusion, causing a buildup of pollution; unstable air has much vertical diffusion of pollution and air of neutral stability has “average’’ vertical diffusion.
*STACK* : a smokestack; a vertical pipe or flue designed to exhaust gases and any particulate matter suspended therein.
*STATIONARY SOURCE* : a source of air pollution found in a fixed location such as power plants, factories, municipal incinerators, and refineries.
*SULFUR OXIDES* : compounds formed from sulfur and oxygen primarily by the combustion of fossil fuels.
*THRESHOLD* : the minimum level of a pollutant that causes an effect on human health, vegetation or property.
*TURBULENCE* : air movement and mixing.
*VAPOR* : the gaseous state of any substance which normally exists in a liquid or solid state.
*VAPORIZATION* : the change of a substance from the liquid to the gaseous state; one of the three basic contributing processes of air pollution.
*VOLATILE* : evaporating readily at normal temperatures and pressures.
*WIND* : the natural, horizontal movement of air.

## SELECTED READINGS ON AIR POLLUTION

———. *Automobile Fuels and Air Pollution: Report of the Panel on Automotive Fuels and Air Pollution* . Washington D.C., Dept. of Commerce. 1971.

Bach, Wilfrid. >I>ATMOSPHERIC POLLUTION. New York, McGraw-Hill. 1972.

Battan, L.J. *The Unclean Sky: A Meteorologist Looks at Air Pollution* Garden City, N.Y. Doubleday. 1966.

Brodine, V. Episode 104. *Environment* . 13(1): 2-27 (1971).

Cassell, Eric J. "The Health Effects of Air Pollution and Their Implications for Control.'' *Law and Contemporary Problems* , XXXIII, pp 197-216, (Spring 1968).

Cole. L.C. Playing Russian roulette with biochemical cycles. *In the Environmental Crisis* , Helfrich, H.W. Jr. (ed), New Haven, Yale Press, 1970, pp. 1-14.

Craig, P., and E. Berlin. *The Air of Poverty* , Environment 13 (5); 2-9 (1971).

Esposito, J.C. *Vanishing Air* . (Ralph Nader's Study Report on Air Pollution), Crossman Publishers, 1970.

Goldsmith, J.R. and S.A. Landow. Carbon Monoxide and human health, *Science* , 162: 1352-1369 (1968).

Haagen-Snit, The control of air pollution. *Scientific American* , 1969.

Lansford, H. The supercivilized weather and sky show. *Natural History* , 79(7): 92-113 (1970).

Leinwand, G. *Air and Water Pollution* . New York: Washington Square Press, 1969.

Newell, R.E. The global circulation of atmospheric pollutants. *Scientific American* , 224: 32-42 (1971).

———. *The Economic of Clean Air: Report of the Administrator of the Environmental Protection Agency to Congress* . Washington, D.C., Govt. Printing Office, 1971.

Waggoner, P.E. Plants and polluted air. *Bioscience* , 21: 455-459. (1971).

Young, G., and J.P. Blair, Our ecological crisis: Pollution, threat to man's only home. *National Geographic* , 138: 737-781 (1970).

## BIBLIOGRAPHY

*AIR* , Irving and Ruth Adler, John Day Co. 1962.

*The Only Earth We Have* , L. Pringle, Mac Millan, 1969

*Environmental Pollution* , Laurent Hodges, Holt, Rinehart, Winston

*Vanishing Air, Ralph Nader's Study Group Report on Air Pollution* , John Esposito

*You and The Environment: An Investigative Report* , Gary Day, Houghton Mifflin, 1976.

*Urban Health in America* , Amasa B. Ford, Oxford Press 1976.

*Cost of Air Pollution Damage* , L.B. Barrett & T.F.Waddell, U.S. FPA

*The World's Exhaust* , Vivian Sorvall, Pendulum Press

## TEACHER RESOURCES

*Award Winning Energy Education Activities for Elementary and High School Teachers*

This 38 page booklet contains brief description of prize-winning entries in the National Science Teachers Assoc. *avail* : U.S. Dept. of Energy, Oak Ridge, Tenn.

*Mathematics in Energy* , 1978. 72 pages. This packet is designed to infuse energy into junior and senior high math classes. The unit deals with a wide range of energy math including conversions, statistics, and the manipulation of energy units (BTU, watts, calories, etc). *avail* : U.S. Dept of Energy, Oak Ridge, Tenn.

*An Energy History of the United States* , 1978. 117 pages. Charts the growth of American energy use and traces the history of the major sources of energy in the United States. *avail* : U.S.Dept of Energy, Oak Ridge, Tenn.

## FILMS/FILMSTRIPS

The Roots of Urban Problem

The Air Pollution Menace

Solid Waste A New Pollutant

Air Pollution: What Is It?