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Government leaders, industrialists, and concerned individuals with differing technical and national backgrounds are often called on to formulate policy governing the control of industrial pollutants. This report facilitates that task. It focuses on the growing price of industrial pollution and the way society pays -- either by paying to prevent pollution, or paying its price in contaminated fields and waters, corrosion, and increased human suffering -- and on strategies government and industry can use to control polluting discharges (these strategies are well documented with tables). Also described are the respective cost-benefits of industrial freedom to pollute, and mandatory pollution control. Information sources and a complete glossary are included in the summary.

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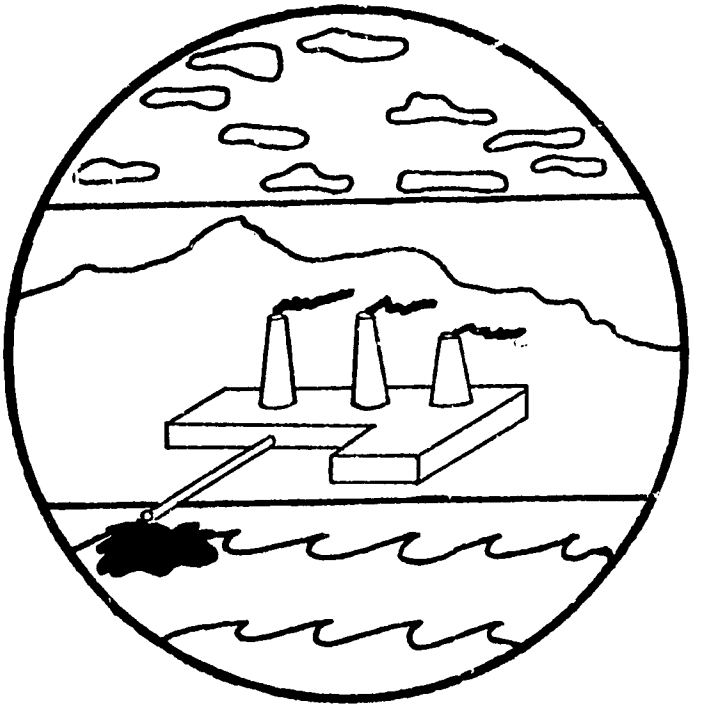
INDUSTRIAL POLLUTION CONTROL

VOLUME 1: EXECUTIVE SUMMARY



RALPH STONE AND COMPANY, INC.

LOS ANGELES, CALIFORNIA, USA

INDUSTRIAL POLLUTION CONTROL

EXECUTIVE SUMMARY

APRIL 1977

BY

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PREFACE

A two-volume study was prepared to provide information relating to the impact and control of environmental pollution from industrial sources. It is intended for the use of government leaders, industrialists, and other concerned individuals who may have widely differing technical and national backgrounds.

Volume I provides background information and reference sources to facilitate general policy decisions relating to the control of industrial pollutants. Volume II is concerned with the technical application and comparative costs of pollution abatement in manufacturing operations.*

Although the purpose of the report is to describe the effects of industrial discharges and their control, it is recognized that other sources of pollution contribute to environmental problems. The problems of pollution abatement however, are similar wherever they originate. The general principles and control methods discussed in the report will therefore usually be applicable to pollutants from both industrial and non-industrial sources.

* See last page for information on ordering Volume II.

ACKNOWLEDGMENTS

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This study was prepared by Ralph Stone and Company, Inc., for the Agency for International Development under AID contract ta-C-1091. Ralph Stone and Company, Inc., is grateful for the assistance extended by AID, Department of State; Department of Commerce; Environmental Protection Agency; and Council on Environmental Quality personnel.

Photograph 1.

Roseate spoonbills in major tourist attraction area take off from clean water where they had been feeding.

CHAPTER 1

THE GROWING PRICE OF INDUSTRIAL POLLUTION

The price of industrial pollution must be paid; there is no way to avoid it. Society has only two options: it can pay to prevent pollution . . . or it can pay pollution's price in contaminated fields and fishing grounds, soiling and corrosion, increased human suffering, disease, and premature death, and all the other ways in which a polluted environment reduces the welfare, or quality of life, of everyone who lives, works, or spends time in it.

The purpose of this report is to describe some of the social and economic costs of industrial pollution, the many ways society pays those costs, the strategies government and industry can use to control polluting discharges, and the respective cost-benefits of industrial freedom to pollute and mandatory pollution control.

Industry is not the sole source of environmental pollution. Natural, commercial, agricultural, domestic, community, and transportation activities can also release harmful substances. In addition, many industrial activities are relatively clean and non-polluting. But industrial sources of pollution are very important for several reasons: 1) they can release large quantities of hazardous substances which limit the environment's ability to sustain healthful human, animal, and plant life; 2) many of the potential impacts are irreversible; 3) the quantities, types, and possible hazards of such pollutants are constantly increasing throughout the world because of continuous industrial expansion and new product development; and 4) they are among the more easily controlled.

Industrial progress, or greater efficiency in the production of wanted goods and services, can greatly increase a country's material welfare. The problem of control is how to minimize polluting discharges without causing undue hardship to the factory or plant being controlled, and without impairing industrial development. But pollution control can also contribute to industrial progress: it uses engineering technology to increase a country's environmental welfare. The industry which produces pollution control equipment and services is similar to the industries which provide heating, lighting, or air conditioning equipment and services. All employ capital and labor, and all try to improve the human environment.

LEARNING FROM PAST EXPERIENCE

It has been said: "Those who don't learn from history are doomed to repeat it." For present purposes, the experience of highly industrialized nations indicates three things: industry's capacity to pollute the environment has been increasing rapidly; industrial growth without effective controls may cause a constant decline in the quality of people's lives; and large supplies of natural resources will eventually be used up.

Advanced industrial technology and the wastes it generates are similar throughout the world. These wastes have been handled in many different ways at different times and places. It is therefore possible to learn about the probable hazards of most pollutants, the best ways to control them, and the relative cost-benefits of freedom to pollute versus environmental protection--before costly decisions are made.

Given the limited supply of all natural resources, conservation is an especially attractive form of pollution control since it can serve two purposes: preserving non-renewable resources for present and future use, and pollution abatement. The wasteful use or production of natural gas or other fuels, for example, increases pollution and uses up valuable resources more quickly than necessary. Better insulation, more efficient fuel consumption processes, and other waste-reducing practices can help to reverse the two-fold problem. In the use of other raw materials, recycling can serve the same purpose.

Concern with environmental pollution caused by human activities is probably as old as the history of mankind. Photograph 2 shows an ancient Iraqi sewer estimated to be over 4,300 years old. Then as today, such efforts to remove wastes from inhabited areas frequently resulted in contamination of the receiving waters. But today the dangerous impacts of polluting the environment are better understood, and the means to reduce those impacts are largely known and available.

A PROBLEM OF ADDITION

The environment is continuous and indivisible. Pollutants from all sources will accumulate, and sometimes interact, in every medium--air, land, or water. In some areas, industrial pollution may be the major offender. Usually, however, pollution from many sources and areas will have a cumulative effect. Municipal effluents and runoff from mining and agriculture, for example, may add to water pollution; motor transport and domestic or commercial heating will contribute to air pollution; and dumping or burning of municipal solid wastes can contaminate air, land, or water. Similarly, the total emissions from several small plants may be quite as harmful as heavier discharges from a single plant.

New findings in the Great Lakes area illustrate the complexity of comulative effects. In spite of a multibillion dollar program to reverse pollution, two problems are likely to remain: the difficulty of removing persistent contaminants, and the large quantities of atmospheric pollutants which rain and snow can wash into the lakes. [1]

First, excessive levels of persistent manmade pesticides and industrial compounds (such as Mirex, DDT, and PCBs) are being found in both fish and aquatic plant life in the lakes. These toxic substances are therefore in the food chain. A little DDT in one's diet may not seem very hazardous, but if DDT and other toxic chemicals persist in many foods, the cumulative effects could be serious. Mirex levels in Lake Ontario have been called "an environmental tragedy," and plans to stock the lake with salmon have been cancelled.

Photograph 2.

One of earliest known examples of a vaulted brick sewer, probably built during the period 2425-2125 B.C.

A more surprising finding, however, was that PCBs were entering the lake from both polluted air and water sources. In two separate studies, containers were placed around Lake Michigan to measure the respective fallouts of phosphorus and PCBs during storms. The fallout of atmospheric phosphorus was estimated as about 18 percent of the lake's total phosphorus content; PCB fallout was estimated at more than 1,400 pounds per year--or almost as much as that flowing into the lake from known surface sources. Since winds can transport dust particles hundreds and sometimes thousands of miles, the origin of the atmospheric pollutants is difficult to pinpoint.

PCBs (polychlorinated biphenyls) are chemical compounds widely used for the past 45 years in the manufacture of paints, printing ink, lubricants, and other products. Like DDT and other chlorine compounds, when discharged to the environment they tend to work their way through the food chain and lodge in animals' fatty tissues. The Great Lakes study, taken with medical research in Japan, the United States, and other countries,[2] indicates at least three possible sources of PCB impact on humans: contaminated air, water, and food. The possibility of a cumulative effect cannot be ruled out.

The following incident indicates that PCBs may have serious health effects. In 1968, some 1,000 men and women ingested PCB in contaminated cooking oil. They have suffered a marked increase in liver cancer and many other problems including numbness of limbs, headache, fever, digestive disorders, and "chloracne" (a persistent skin disease from chlorine compound poisoning). In a recent United States study, PCBs were detected in the milk of 65 out of 67 nursing mothers. The average concentration was about 1.7 parts per million, and the highest about 10.6 ppm. These levels were similar to those found in mother's milk in several other countries. Health authorities, obstetricians, and pediatricians are very concerned about possible damage to nursing infants and are now trying to find ways to minimize the mother's dietary intake of PCBs.[2]

LIMITS TO HUMAN CONTROL

Irreversibility

When scientists speak of "irreversible damage," they mean a major injury to the environment which cannot be contained or reversed. This occurs when the discharge of pollutants sets in motion a chain reaction or series of events whose harmful effects are beyond human control. In sufficient concentration, radioactivity, defoliants, chemicals with mutagenic effects (capable of causing mutations or hereditary changes), heavy metals, and many other hazardous and toxic substances have known and unknown potential for causing irreversible damage.

Air, land, and water are natural resources, and damage to them destroys valuable economic assets. When the damage is irreversible, the loss is permanent. Reducing the value of a country's natural resources will limit its future choices and ability to develop economically. Agricultural, livestock, fishing, and tourist industries will be especially affected. These effects are also part of the growing price of pollution.

A lake in the northeastern part of the United States, for example, was once an attractive tourist and fishing resort. It was also the receiving water for chemical plant wastes which caused large quantities of the lake's sediment to consolidate into rocks. As a result, part of the lake has become a toxic mass that can no longer support marine or plant life. Other formerly beautiful lakes and rivers which provided drinking water, fishing grounds, and tourist income have become trash islands or bags.

Changing Relationships in Nature

Under natural conditions, eutrophication is a very gradual aging process in which a lake changes into a bag or marsh and eventually disappears into a meadow land form over a period of tens of thousands or even millions of years. But if the lake receives industrial or other discharges rich in nutrients (raw materials needed to support organic life--especially nitrogen and phosphorus), the process will be accelerated. Ten thousand years of normal eutrophication may be compressed into ten or twenty years. Thisoccurs when an oversupply of nutrients cauaes algae and other microscopic plant life to become so abundant they "choke" the lake and turn it into a marsh within a relatively short time.

In the Thames and other European rivers, efforts to clean up the formerly polluted waters have been largely successful. Desirable fish species have returned. In many restored areas, however, salmon, sardines, or other highly prized species which once stocked the water have not yet returned. It is possible that the habitats have been changed in such a way that it will be difficult or impossible to completely reverse the effects of former pollution.

THE COST OF POLLUTION--WHO PAYS?

Involuntary Victims

Because the environment is continuous, polluted discharges can travel great distances on currents of wind or water. And because the natural environment is essential to life, the resulting costs are largely involuntary. Those who suffer may have no alternative choice.

Water used to transport industrial wastes from a factory may be dangerous for drinking, irrigating, or fish breeding; air filled with hazardous industrial discharges is not safe to breathe; and many toxic pollutants can leach through the soil to poison groundwater supplies. Everyone, however, must breathe the surrounding air whether it is clean or contaminated. Animal, marine, and plant life also need air and water to survive; they will continue to use the available air and water whatever its quality. Even natural or man-made materials and structures cannot escape soiling if they lie in the path of particulate discharges and most will suffer corrosion from acid discharges. Much of pollution's damage therefore occurs to unwilling victims at a distance from its source.

Shifting the Cost to Others

When industrial pollution is unregulated, factories can dirty the public environment without cost and without legal or economic responsibility for spoiling national resources which do not belong to them. Others who had no part in creating the pollution will pay its costs in many ways. Everyone whose commercial or residential structures are damaged by the smoke or corrosive discharges, every individual who loses work time because of pollution-related illness, and everyone who is affected by the reduced value of the air, land, and water for agricultural, commercial, tourist, or residential use is paying the cost of pollution from industrial sources.

If, for example, a power plant or other industrial firm can freely pollute the air with emissions from its combustion processes, the yield and quality of any nearby crops may be reduced. The polluting firm, however, will pay nothing for misusing the air or damaging the crops. The cost of this pollution has therefore been shifted from its industrial source to the local farmers and growers. Such costs are considered externalities, or outside the conventional market system.

Putting Cost Where It Belongs

When industrial pollution is regulated, the cost of potential pollution is shifted back to the industrial producer, and ultimately the consumer, of the related product. This Internalizes the cost within the responsible system. Since regulation is designed to reduce or eliminate pollution, the major part of industry's related cost will be for pollution abatement. But whether the potential poluter installs air and water waste treatment systems or pays a fine or cleanup costs, a pollution control program helps to return the costs of pollution to their proper place.

AN OUNCE OF PREVENTION

With all human problems, early prevention is usually more effective and less expensive than later correction. This is especially true of industrial pollution. It is usually difficult and costly to retrofit industrial processes for air and water pollution control when no provision has been made for such modification. Under these circumstances, any urgency to meet later pollution control requirements may cause a financial crisis for an otherwise efficient firm. It is therefore usually safer, more beneficial, and less costly to plan for environmental protection as early as possible in any development program before advanced pollution creates overwhelming problems.

COMMON SENSE AND THE NATIONAL INTEREST

Industry contributes greatly to economic development and prosperity. But people living in highly polluted areas become dissatisfied and may press the government for relief. If conditions do not improve, those who are better educated and more affluent will tend to move out of the blighted area. Non-polluting commerce and industry will also be attracted to cleaner areas. Communities will then lose some of their tax bases as depressed areas replace the centers of once prosperous industrial cities.

While the general public and less-polluting business firms generally favor pollution control, firms with highly polluting processes frequently resist such efforts. The control of industrial pollution is therefore a political decision, one that reflects the needs, interests, and political strength of different sectors of the society. In the final analysis, the decision-maker must rely on the best information available--and a large helping of common sense.

FINDING A BETTER WAY

The price of pollution does not have to keep on growing. There are many ways to stop or reduce industrial pollution without halting industrial progress. And better and cheaper ways will surely be found if government, technical, and industrial leaders recognize that a clean environment can contribute greatly to everyone's present and future welfare.

CHAPTER 2

IT COSTS MORE THAN MONEY

The real costs of industrial pollution include all the related effects which reduce total welfare. Some of these costs can be readily expressed in money; others cannot. Costs normally measured in money values are defined as tangible or economic costs; those which are difficult to quantify, as intangible or social costs. In fact, however, social and economic costs are not always easy to separate, and as the following incident illustrates, the so-called "intangible" costs can be far more important than money costs.[3,4,5]

On July 10, 1976, a cloud of deadly dioxin chemical (TCDD) escaped from a factory in a small European town. The cloud soon dispersed into droplets which rained over an area with a total population of 100,000. On July 14, 1976, fourteen children were hospitalized for burns and pains, and adults began to complain of liver and kidney problems. Within a week, thousands of animals were dead or dying, tree leaves began to wither, and doctors were treating hundreds of cases of skin infection and other disorders.

Close to 600 adults and over 1,500 children were evacuated. Others left their homes voluntarily for varying periods. Surviving farm and domestic animals in high-risk areas were systematically slaughtered; all agricultural, industrial, and commercial activities were halted , and six miles of barbed wire were strung around the area of greatest contamination. Where cows were not destroyed, farmers had to dispose of the milk daily in the presence of a veterinarian, and everyone was cautioned not to eat any local produce, farm animals, or wild game.

In a mass check of 10,000 people, several hundred showed a decrease in lymphocytes--or a reduction in the ability of their immune systems to fight disease infections. In addition, possible health injuries could be delayed for many weeks or months. Among the most important of these are damage to kidneys, respiratory tracts, and nervous systems. There are no known antidotes to TCDD and many local people are suffering from unrelenting fear for themselves and their children.

The immediate costs of the pollution are represented by lost earnings, medical treatment, decontamination efforts,policing to prevent looting, and the many other expenses--economic, physical, and psychological--associated with such a frightening and dislocating experience. For some, however, the effects were far more cruel.

Because TCDD is able to cross the placental barrier, it has the capacity to cause serious birth defects in an unborn child. An earlier study on farm animals indicated that TCDD might be thousands of times more dangerous to fetuses than the infamous thalidomide drug which had caused so many infants to be born with tragic malformations and missing limbs.

An estimated 300 to 400 pregnant women had possibly been exposed to dangerous levels of the TCDD. Each had to face the possible termination of her pregnancy. In many cases, religious training, moral judgment, medical judgment, legal restrictions, and

a host of personal factors would make the final decision exceedingly difficult for both prospective parents. Whichever choice was made (some decided to terminate, others did not), doubts would always remain: Was a potentially perfect child denied the right to live? Should the birth of a crippled child have been prevented?

Even if generous payments are made, no amounts of insurance money or civil damages can begin to measure the real costs or compensate for all the harm caused by this particular industrial discharge. Fortunately, dramatic disasters of this type are relatively rare. They indicate, however, that other industrial discharges are probably causing similar or possibly worse problems which escape immediate notice because the cause and effect relationship is less obvious. Perhaps only a few people are affected at a given time, or those affected live in widely scattered areas, or doctors and scientists have not yet established the responsible sources of the related illness or damage. Other effects take many years to become obvious--as in the case of carcinogens (cancer-causing pollutants) in the air, accumulated heavy metals in water, or the gradual concentration of poisons in the food chain.

THE AIR YOU BREATHE

Industrial pollutants in the air can affect the health of all living things and the physical qualities of many inanimate things. For both types of damage, there will be social and economic costs.

Dirty Air and Human Health

Air pollution increases the incidence and severity of respiratory diseases. The impact is greatest on the very young, the very old, the sick, and those subject to bronchitis, asthma, or emphysema. Certain air pollutants also greatly increase the risk of cancer and cardiovascular diseases.

Particulates, or small particles in the air, will cause different health problems depending on their composition. Compounds of lead, fluorine, beryllium, and arsenic are toxic; asbestos and tars (or hydrocarbons) can cause cancer; and very fine particles of any substance can damage normal lungs and cause serious harm to anyone with a respiratory illness.

A recent newspaper headline stated: "Rare cancer turning up among shipyard workers. Researchers say they may be innocent victims of an environment filled with asbestos fibers." [6] The malignancy referred to is mesothelioma ". . .a particularly lethal cancer of the exterior lining of the stomach and lungs." It is associated almost exclusively with inhalation of asbestos fibers.

In 1968 a medical officer at an English dockyard had identified five cases of mesothelioma. The victims were an electrician, a laborer, a carpenter, a shipfitter, and a plumber--none of whom worked with asbestos directly. More recently, environmental scientists have found that families of asbestos workers have a higher than normal risk of developing cancer, probably caused by breathing microscopic fibers brought home in the worker's

clothing. Reports from England, France, and the Netherlands indicate the number of cases of mesothelioma among "bystanders" has been increasing rapidly. Dutch researchers have reportedly ". . . turned up more than 50 cases of the rare malignancy in the small town 'where a shipyard just happens to exist.'"

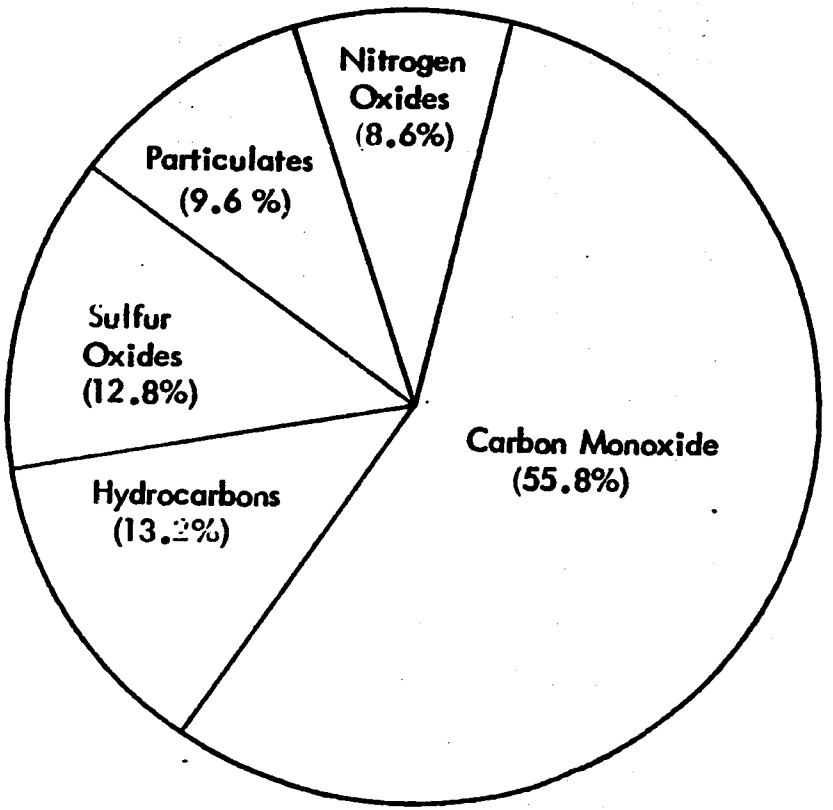
This research illustrates an important consideration in industrial pollution. Workers directly exposed to a hazardous material will suffer the most, but their families and others in the polluted area will also be harmed. By the same token, cleaner industrial production will benefit plant management and workers as much or more than the general public.

Carbon monoxide gas is extremely toxic. At low concentrations, its effects are dizziness, headache, and drowsiness. At higher concentrations it causes unconsciousness and death.

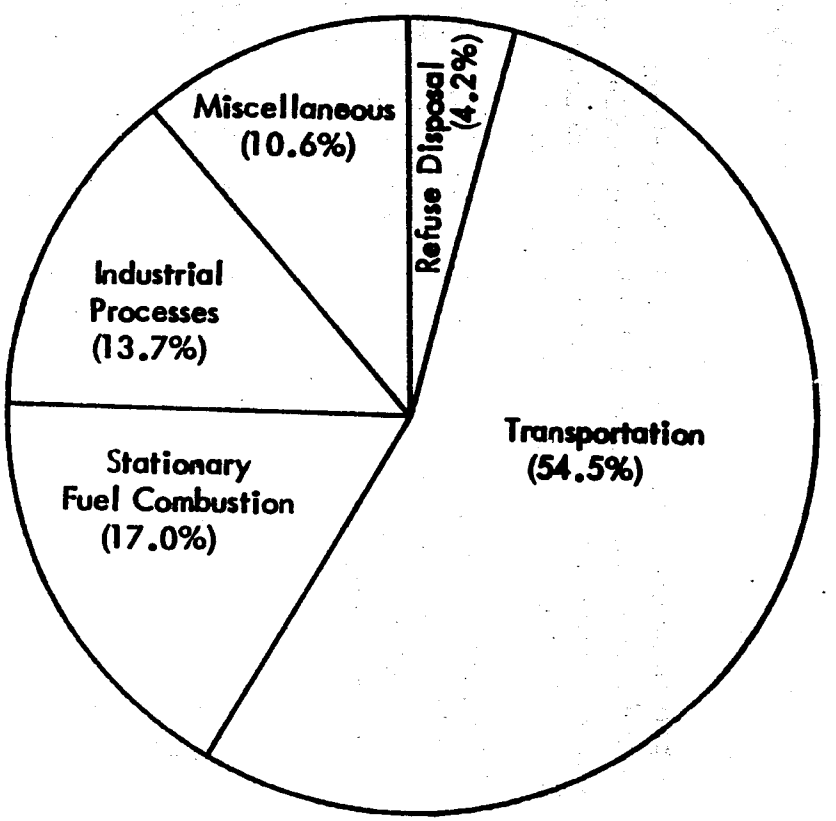
Sulfur oxides, hydrocarbons, and nitrogen oxides react in the atmosphere to produce photochemical smog. All three can cause eye irritation, respiratory problems and lung damage. In addition, high concentrations of sulfur oxides caused many deaths in recent smog disasters in the United States and Great Britain. Hydrocarbons are considered carcinogenic (tending to cause cancer), and even small concentrations of nitrogen oxides have been linked with pulmonary fibrosis disease.

Local and regional air pollution problems will vary depending on the area's industrial development, climate, and other local factors. In the United States, for example, the widespread use of automobiles generates large quantities of carbon monoxide and hydrocarbons. As a result, transportation was responsible for over 50 percent of the quantity by weight of five air pollutants measured in 1970 (Figure 2-1). Table 2-1 shows, however, that stationary fuel (largely used for power generation) and other industrial processes together had produced 96 percent of the sulfur oxides and 78 percent of the particulate emissions. In addition, stationary fuel and industrial process sources accounted for 72 percent of the estimated economic losses from air pollution, compared to only 9 percent for economic losses attributed to transportation sources (Table 2-2).

The greatest economic losses caused by air pollution were due to its harmful health effects. This was true for both total air pollution and air pollution from industrial sources only (Table 2-3). Health related costs include the social costs of physical damage and suffering ranging from death to minor discomfort, and the more direct



a. By Pollutant



b. By Source

FIGURE 2-1
DISTRIBUTION OF AIR POLLUTANT EMISSIONS (UNITED STATES, 1970)

Source: Seneca, J.J., and M.K. Taussig. Environmental Economics. Englewood Cliffs, N.J.: Prentice-Hall, 1974.

TABLE 2-1
MAJOR AIR POLLUTANT EMISSIONS AND SOURCES
(UNITED STATES, 1970)

Source	Pollutant									
	Carbon Monoxide		Sulfur Oxides		Hydro-carbons		Particulates		Nitrogen Oxides	
	(10^9kg)	(%)	(10^9kg)	(%)	(10^9kg)	(%)	(10^9kg)	(%)	(10^9kg)	(%)
Transportation	100.7	75.4	0.9	3.0	17.7	56.2	0.6	2.8	10.6	51.5
Stationary fuel	0.7	0.1	24.0	78.2	0.5	1.7	6.2	26.8	9.1	44.0
Industrial processes	10.3	7.8	5.4	17.7	5.0	15.8	11.9	51.6	0.2	0.9
Refuse disposal	6.5	4.9	0.1	0.3	1.8	5.8	1.3	5.5	0.4	1.8
Miscellaneous	15.2	11.8	0.3	0.8	6.4	20.5	3.1	13.3	0.4	1.8
Total	133.4	100.0	30.7	100.0	31.4	100.0	23.1	100.0	20.7	100.0

Source: Seneca, J.J., and M.K. Taussig. Environmental Economics. Englewood Cliffs, N.J.: Prentice-Hall, 1974.

TABLE 2-2

DISTRIBUTION AND ECONOMIC COST OF AIR POLLUTANTS BY SOURCE (UNITED STATES, 1970)

Source	Distribution by Weight[a]	Economic Loss[b]
	(% of Total)	
Transportation	54	9
Stationary fuel	17	50
Industrial processes	14	22
Refuse disposal	11	2
Miscellaneous	4	17

[a] 1970 estimate.
[b] 1968 estimate; independent of estimated distribution by weight.

Source: Seneca, J.J., and M.K. Taussig. Environmental Economics. Englewood Cliffs, N.J.: Prentice-Hall, 1974.

TABLE 2-3

DISTRIBUTION OF AIR POLLUTION COSTS FOR SELECTED IMPACT CATEGORIES (UNITED STATES, 1968)

Impact Category	Total Ambient Air Pollution	Industrial Air Pollution
	% of Total Estimated Economic Loss	
Human health	37	41
Property values	32	35
Materials	30	23
Vegetation	1	1

Source: Seneca, J.J., and M.K. Taussig. Environmental Economics. Englewood Cliffs, N.J.: Prentice-Hall, 1974.

economic costs of lost work time, lost wages, poor work performance, dislocation of the work staff (replacement of absent workers and training of replacements), and the expenses of health care.

Animal Health

Air pollution also damages the health of livestock and wildlife. The major economic costs for breeders and growers of dairy and meat-producing cattle, poultry, and other livestock are caused by lower milk and egg yields, diseases which require treatment or special care, diseases which make the animal meat unsafe or less desirable for human consumption, and increased mortality or decreased fertility of the animals. Any significant decrease in the quantities of meat, milk, or egg production would also raise consumer prices for those products. In some areas, lower production of animal-product foods and higher prices could mean that some people won't have enough to eat.

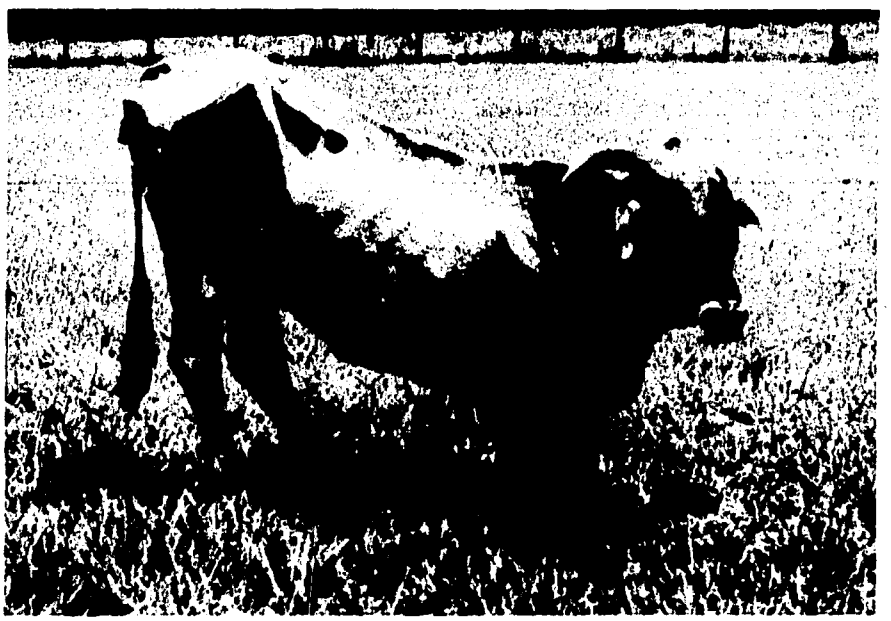
In addition to diseases caused by breathing or direct contact with industrial discharges, animals also suffer from feeding on contaminated pastureland. When sufficient fluorides from nearby industry fall on grazing areas, for example, foraging cattle will develop the crippling bone disease, fluorosis (See Photograph 3.)

Crops and Other Vegetation

Air pollution can reduce or destroy the growth and produce of field, timber, and fruit and nut crops. In the Los Angeles area, for example, high concentrations of photochemical smog have severely reduced the citrus and field crops, and forced many growers to move to alternate locations. Lower yields and quality, the need to relocate farms in cleaner areas, or the substitution of lower profit pollution-resistant crops will cause growers direct economic losses. As with food products of animal origin, the indirect costs can be serious due to a reduction in agricultural products, possible food shortages, and higher consumer prices.

A World Bank study showed that a large copper mining and smelting operation in South America was releasing 60,000 tons of sulfur oxides into the air annually. The resulting pollution " . . . had on occasion reached as far as 60 kilometers upwind from the smelter, with adverse effects on sugar cane and vegetable production."[7]

Another study reported the following damage from air pollutants which can come from industrial sources: alfalfa, grain, potato, apple, and castor bean crop losses due to sulfur dioxide; bean, tomato, and tobacco leaf damage caused by nitrogen dioxide;



Photograph 3.

Typical crippling effects when cattle forage on grass containing high concentrations of industrial fluorides.

pinto bean, tobacco, spinach, and woody plant leaf damage caused by ozone; pinto bean, tomato, lettuce and petunia leaf damage caused by PAN (peroxyacetylnitrate) which is extremely toxic to many plants; and pear, pine, and citrus tree damage due to the presence of fluorides. Rain or snow can wash sulfur oxides and nitrogen oxides from the atmosphere to produce a condition known as "acid rain." Such acid washouts can cause severe damage to crops, trees, and other vegetation.[8]

Structures and Other Objects in Pollution's Path

Industrial air pollutants can dirty, corrode, and cause the decomposition of many materials. These effects will damage the value and usefulness of the related structures and objects, and will increase their cleaning, maintenance,and replacement costs.

Particulates will soil and accumulate on everything: buildings, trucks and cars, roads and bridges, clothing, rugs and drapery, works of art, and every other fixed or movable object upon which they fall. Depending on their composition, particulate may also cause corrosion or other damage.

In large concentrations, sulfur oxides may destroy paint, corrode metals, and cause textiles, paper, and other similar materials to disintegrate. When converted to nitric acid, nitrous oxide discharges become highly corrosive. Ozone is an oxidant harmful to rubber, dyes, and paints; and chlorine and hydrogen chloride fade dyes and cause corrosive damage. The acid rain and PAN (or "smog") discussed above under Crops and Vegetation can also cause the corrosion and disintegration of many materials.

Actual damage to materials in different areas will vary depending on the type, quantity and concentration of pollutants in the air, the nature of the materials they contact, and climatic conditions such as air currents, rainfall, and temperature. As an example, Figure 2-2 shows the distribution of estimated economic costs for air pollution damage to selected materials in the United States. The figure shows that combined air pollutants (from both industrial and background sources) had the greatest economic impact on paint (31 percent of total cost), and zinc (20 percent of total cost). The contributions to economic costs by the related sources of the air pollution were estimated to be: stationary sources, 39 percent; transportation, 23 percent; industrial processes; 17 percent; solid waste, 3 percent; and miscellaneous, 18 percent. Table 2-4 lists, in decreasing order of their economic importance, major air pollutants and the materials they damage.

The study which produced the preceding data measured only the direct costs of physical damage to the affected materials and items. Other types of losses, however, may be more important. Corrosion to a truck body or industrial equipment, for example, may cause lost work or production time. (See Photograph 4). Environmental pollution damage to important works of art, as recently reported in industrialized areas of Spain, Italy,and Greece can cause irreparable harm to national treasures which are part of a country's heritage and also attract tourists. Such damage would include fading and disintegration of paint surfaces, walls, and hangings, and the crumbling, pitting, and soiling of the stone, wood, metal, and other materials in structures and artifacts of artistic, religious, or historic value. The buildings of the Acropolis in Athens,Greece, for example (considered among the most beautiful in the world) have begun to crumble as the result of acid and smog pollution in the city's air. Like many ancient historical monuments, they were made of limestone which tends to disintegrate in the presence of sulfur oxides, nitrogen oxides, and other air pollutants.". . . in the last fifteen or twenty years the sulfur-dioxide emissions from residential

TABLE 2-4

EFFECTS OF SELECTED AIR POLLUTANTS ON MATERIALS

Air Pollutant	Materials Damaged
Sulfur oxides	Metals, cotton, finishes, coatings, building stone, paints, paper
Ozone	Rubber, dyes, paints
Nitrogen oxides	Dyes, paints
Particulates	Stone, clay, glass

Source: Salmon, R. Effects of Air Pollution on Materials. Prepared for National Air Pollution Control Administration. Washington: Government Printing Office, 1970.

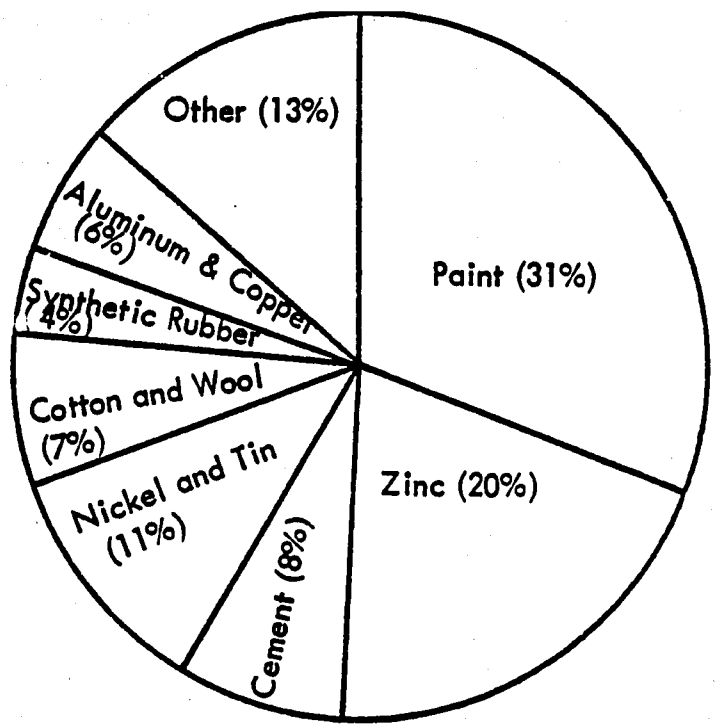


FIGURE 2-2

U.S. DISTRIBUTION OF MATERIALS LOSSES FROM AIR POLLUTION BY TYPE OF MATERIAL

Source: Seneca, J.J., and M. K. Taussig. Environmental Economics. Englewood Cliffs, N.J.: Prentice-Hall, 1974.

Photograph 4.

Corrosion of truck body caused by acid air pollutants.

oil heaters, automobiles, and factory stacks have done dreadful things to the cherished twenty-four-hundred-year-old marble buildings. 'It's the same disastrous effect you get from putting vinegar on chalk.'"[9]

Driving Down Property Values

Industrial air pollution can damage the value and usefulness of public and private lands and facilities, and restrict future development. Tourist and agricultural areas would be especially hard hit, but residential, commercial, and industrial properties in polluted areas would also decline in value compared with similar properties in cleaner areas.

The incident involving the accidental release of TCDD discussed at the beginning of the chapter illustrates a more serious type of possible property damage. Because TCDD is so toxic (a millionth of a gram can kill a rabbit), all soil, materials, and structures which were exposed to it should be destroyed or isolated. This has not been easy to achieve. Homes and trees, for example, were left standing because it was feared their destruction by incineration would cause further dispersion of the dioxin in wind-borne ash.

Suggestions for managing the contaminated area included total burial of everything in the contaminated zones, encasing the entire area in concrete or turning it into a desert, and removing the top layer of soil to a depth of one foot and disposing of it in a safe manner. In an earlier incident involving TCDD in another country, contaminated soil was buried in an abandoned mine shaft.

The basic reclamation plan in effect proposes removing all contaminated vegetation to an incinerator for destruction at 1,000 degrees centigrade, and conducting experiments to identify methods of decontaminating the soil. Whatever is finally done, the land and structures will probably be useless for their original purposes (including farming, industry, artisans' workshops, and housing) for a long period of time. The once valuable property now has a negative value.

Aesthetic Blight

The aesthetic impact of polluted air includes reduced visibility, obscuring of attractive vistas, noxious odors, destruction of historic and artistic materials and sites, and the generally unpleasant experience of being in a polluted environment. Studies indicate that concern with aesthetic damage increases with socioeconomic status, and that frequent high levels of pollution tend to be more noticeably unpleasant than the same total amount of pollution spread more evenly in time.

The major economic costs of aesthetic damage would be its indirect contribution to losses in property values, material values, and tourism.

POLLUTION AND THE MANY USES OF WATER

Wastewater sources are called either point sources (specific, identifiable discharge points) or runoff (the collected wastes and waters from rain, melted snow, and other general sources). Industrial wastewaters and municipal wastewaters (which usually contain domestic and industrial wastes) originate in point sources. After Discharge, however, like most agricultural, municipal, and mine drainage, they may enter natural water bodies directly, or become part of the general land runoff.

Land drainage is a major source of water pollution. In addition to industrial wastes, it may contain important pollutants such as animal and human fecal wastes, residues from air pollution, municipal refuse, pesticides and fertilizers, and acid mine drainage. Runoff is also difficult and costly to control. To reduce water pollution, it is therefore usually necessary to control the pollutants at their point sources, that is, at their industrial or municipal discharge points of origin.

Industrial and municipal point sources are responsible for most of the polluting toxic metal and chemical discharges, and food processing industries contribute large quantities of bacteria, organic, color, and odor contaminants. Table 2-5 lists the major types of industrial water pollutants and their potential adverse effects.

Water is used for many different purposes. Industrial pollutants in water may affect the following: drinking, cooking, and washing (domestic use); crop irrigation and watering of animals (agricultural/farm use); industrial process and cooling water use (industrial use); commercial fishing; and swimming, boating, and sport fishing (recreational and tourist use).

Drinking Water

Industrial pollutants in adequately treated water will usually cause no immediate health hazards to anyone who drinks it, but the cost of achieving a safe drinking water quality would probably be higher, depending on the type and concentration of pollutants present. There are many pollutants, however, which are toxic in small amounts or which accumulate in either the water supply or the human body and can therefore cause serious long-term effects.

There is growing concern, for example, with the possible effects of trace amounts of heavy metals in the drinking supply; once introduced into water, they are difficult to remove. Arsenic in small amounts can accumulate in the body and cause long-term health damage. The additional chlorine needed to purify water of low quality may itself create health problems--especially if it reacts with other substances in the water to form compounds like chloroform, a carcinogen. This problem might occur if consistently large quantities of highly colored food produce or meat processing wastes in the domestic supply increase the need for more intensive chlorination. Conventional water treatment will also be inadequate for removing highly toxic, odorous, or bad-tasting industrial pollutants. Industrial wastes which enter the domestic water supply

TABLE 2-5

TYPES OF INDUSTRIAL WATER POLLUTANTS AND THEIR POTENTIAL EFFECTS

Pollutant	Direct Effects on Water	Indirect Effects
Inorganic salts	Increased water hardness	Dry pipe problems
Acids/alkalies	Change in pH levels	Often toxic to fish, limits recreational water use
Organic compounds	Decreased dissolved oxygen levels	Odor and taste problems often toxic to fish
Suspended solids	Build-up of bottoms and banks	Turbidity and odor problems, diminished recreational values
Floating solids	Oil and grease buildups	Unsightly, obstructed light, taste and odor problems
Heat	Increased temperature	Lowered cooling capacity, stratification, adverse effects on marine life
Color	Altered water color	Turbidity, aesthetic damage, lowered value of water resource
Toxins	Toxicity	Potentially deadly to people, fish and shellfish (and those who eat them), and livestock

Source: Nemerow, N. Theories and Practice of Industrial Waste Treatment. Reading, Me.: Reading, Me.: Addison-Wesley, 1963.

can therefore impair the safety, taste, and odor of drinking water, and increase health problems and medical costs. Photograph 5 shows how pathogenic or other toxic pollutants can endanger a local domestic water resource.

Water for Crops and Animals

Many of the precautions which apply to people would also apply to animals. There is a further problem here, however, because toxic chemicals consumed by farm animals can also affect people who eat the meat or drink the milk of such animals. Since livestock frequently water at open, untreated natural waterways, uncontrolled wastewater discharges from nearby factories could seriously contaminate their water supply. This would affect the health, breeding, and longevity of the animals, the income of the farmer or breeder, and the health of those who consume the related food products.

Some industrial waste discharges, such as cannery wastes, are beneficial for crops or animals; others can be safely disposed to land. Some, however, such as radioactivity, are exceedingly long-lived and hazardous, and should never be allowed to come into contact with food products or the open environment.

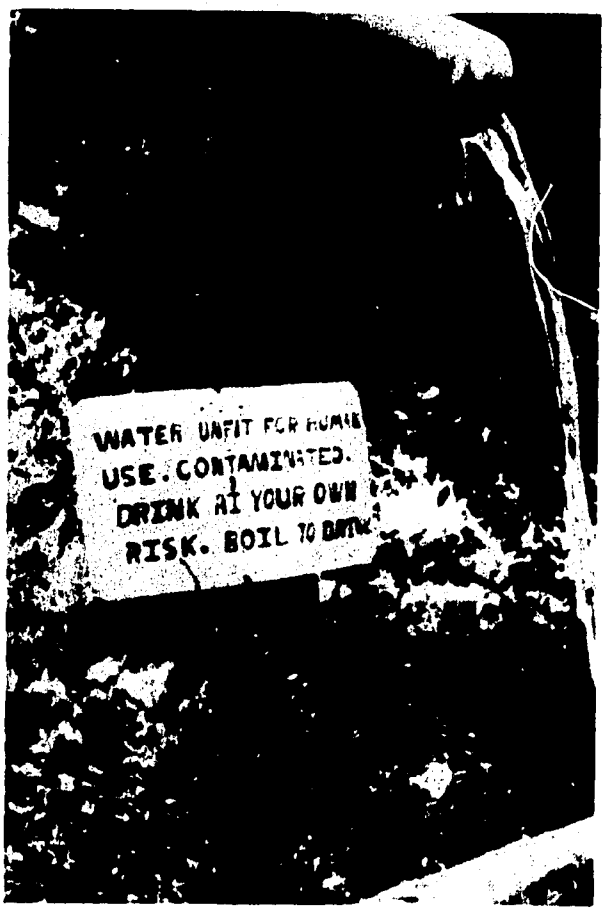
Water for Industry

Some industrial processes require water of exceedingly high quality, Extensive treatment may be necessary to achieve that quality whatever the condition of the raw water used. The additional cost of treating polluted water will depend on the type and quantity of pollutants to be removed, and the intended use of the water. Thermal (or heat) pollution, for example, makes water unsuitable for cooling purposes, and difficult-to-remove toxins would make it unsafe for food processing use. The trace chemical content of industrial non-process or cooling water, however, is relatively less important.

Fishing Grounds

Industrial pollutants which are toxic to marine life can produce three types of damage: they can kill fish or shellfish, cause serious illness or even death in people who eat the poisoned fish, and persist or concentrate in the food chain of fish, birds, mammals, plants, and other living things including humans. Until recently, many people in the Far East suffered severe crippling neurological disorders and premature death caused by eating fish contaminated by mercury wastes. Nearby factories had been discharging these wastes directly into the local fishing waters.

The major economic costs of industrial pollutants in commercial fishing waters would be caused by fish kills, restrictions against fishing in contaminated waters, and government condemnation of fresh and processed fish found to be unsafe. In many areas, local residents who depend on catching fish to feed their families would lose an important protein staple in their diets.



Photograph 5.

Warning sign at a spring which is the main water supply for a small city. This spring has been polluted by wastes.

The South American copper operations referred to above are adjacent to the world's largest anchovy fishing grounds. Here natural conditions favor an abundant supply of phytoplankton on which the anchovy feed; the same fishing grounds also support a large population of guano-producing sea fowl. Without environmental safeguards, copper tailings in offshore waters could therefore disrupt an ecological system which provides large quantities of valuable protein food and fertilizer.[10]

Tourism

Pollution of natural water bodies will discourage visits by tourists and other recreational users. Important water qualities for recreational uses include fishing opportunities; color, odor, and clarity of the water; and safety for swimming and boating. Toxic, odorous, or unsightly pollutants would have the most damaging immediate effects. Phosphates and other nutrients which encourage algal bloom and other undesirable plant growth will progressively alter the ability of the water to support fish life, and will make the estuary, coastal water, lake, or stream unattractive.

Hotels, restaurants, and those who rent or sell equipment or provide pleasure boating, transport, and other related services will suffer reduced incomes if industrial pollution damages the scenic or recreational value of a natural water attraction. These effects will also reduce the value of nearby property, with the greatest loss for shore-front land and structures.

IN SHORT

Industrial discharges which cause environmental pollution will result in economic costs and losses for many individuals, business firms, and institutions which have no connection with the polluting firm. Although some of these economic losses may be substantial, many of the related social costs will be far more serious. These include disease, crippling, premature death, reduced food supply, and irreversible ecological damage. Although health effects will be greatest for those working directly with or near toxic pollutants, such occupational hazard indicates a need to protect others against similar pollutants in the outside environment.

CHAPTER 3

STRATEGIES FOR CONTROL

Effective control of industry's pollutants can only be achieved through the complementary efforts of government and industry. Neither can do it alone. Most companies don't want to damage the environment and many will try to control their harmful discharges voluntarily. But industry's primary function is to provide a product or service and sell it at a profit, and there are few cost-free solutions to environmental pollution. Unless the government requires all similar industrial plants to meet the same requirements, companies with lax pollution controls will have an unfair economic advantage over companies with strict controls.

Government regulation of industrial pollution refers to the legal means which promote abatement activities. It is concerned with the why, how, when, what, and where of pollution control. But it does not physically control pollution through the application of technology. The actual reduction and treatment of industrial discharges is usually done in part by individual plants and factories, and in part by government--as in municipal waste treatment plants which process both domestic and industrial effluent. A comprehensive control program is therefore a complementary undertaking in which regulatory strategies motivate both government and industry to abate pollution resulting from their respective activities.

Photographs 6 and 7 show the striking difference in the air quality of an industrialized city after a government agency imposed strict control regulations on all industrial and other sources of smoke, soot, dust, and odor.

CHOOSING REGULATORY OPTIONS

Regulatory control strategies involve legislation, administration, and enforcement. Government programs usually combine several regulatory options which reinforce each other. The most commonly used are

direct:

- Ambient and discharge standards for air and water
- Specifications of permissible or required operating factors
- Prohibitions and bans

indirect:

- Effluent charges (for air pollutant or wastewater discharges)
- Licenses, permits, and warrants
- Land use planning

supportive:

- Subsidies
- Research, education, and persuasion

Photograph 6.

Before regulatory control of pollution--a sunny day at 1 p.m. in an industrial city.

Photograph 7.

After regulatory control of pollution--a sunny day at the same time and place.

defensive:

- Right to monitor and inspect
- Industrial liability
- Public's right to sue

or punitive:

- Misdemeanor charges
- Criminal charges

Setting Standards

Standards are a direct, flexible, and comprehensive government option for the control of industrial pollutants. They are direct because they identify the pollutants to be controlled, the quantities which may be discharged or the amounts by which present discharges must be reduced, the date by which industry must comply and, usually, the industrial sources which must control the respective pollutants. The option is flexible because standards can be set higher or lower depending on the potential hazard of the pollutant, climatic conditions, economic impacts, changes in knowledge or technology, and many other considerations. And standards are a comprehensive method because they can be applied to any pollutant, and additional standards can be developed when the government wishes to control new or previously unidentified contaminants.

There are two types of regulatory standards for air and water:

Ambient standards set limits for the maximum allowable concentration of specific pollutants in the open air and water. Other government options, however, have to be applied to achieve ambient standards. The most useful for this purpose are discharge standards and land use restrictions.

Discharge standards set limits for the maximum allowable quantity of specific air and water pollutants discharged from known industrial point sources. Waste streams are called emissions (for air) and effluent (for water).

The purpose of discharge standards is to control pollutants at their sources in order to achieve desirable ambient air and water quality. The purpose of ambient standards is to maintain environmental quality at a level which meets social and economic goals based on the defined use of the receiving air and water--such as air which does not impair health, a safe drinking water supply, or protection of food crops.

Standards may be uniform (the same for all areas or for all similar industries) or variable (different for different areas or for similar plants of different sizes and ages).

Variable ambient standards are usually set because environmental needs, resources, and goals are different in different places. Things to consider include: the affected area's present and proposed land and water uses; whether to allow clean or relatively clean environments to become more polluted, and to what extent; whether standards should be

stricter for newly developing areas than for highly industrialized areas; the need to protect valuable natural resources such as prime agricultural land and the water supply; and the need to treat all industry equitably. Variable ambient standards are closely interrelated with urban and industrial development, future land use planning, and discharge standards.

Variable discharge standards may be set to reflect differences in potential impacts. They could, for example, be lower in an isolated area where damage would be minimal, and stricter in a highly industrialized area where it is difficult to maintain ambient standards. They may also reflect differences in climate. Brisk prevailing winds, high moisture content in the atmosphere, and moderate or low temperatures would reduce the hazard of certain pollutants compared with their effects in warm dry areas subject to temperature inversions. A major use of variable discharge standards, however, is to protect smaller, older firms which might have to close if required to meet the same strict standards as large modern plants: One solution is to set very high standards for plants in the planning stage, somewhat lower standards for recently built plants, and minimal standards for older marginal plants. The relaxed standards may have one or more time limits during which the older firm is required to meet specified, higher levels of pollution control.

Specifying How to Control

Specifications define permissible or required types of fuel, other raw material use, production processes, and/or pollution control equipment and methods. Whereas discharge standards define the maximum quantities of pollutants which may be discharged, specifications prescribe the materials, equipment, or methods which must be used to achieve the desired standards.

Outlawing Pollution Hazards

Prohibitions, or bans, are really zero discharge standards. Some discharges, processes, or fuel uses may be prohibited temporarily under special conditions--such as when ambient air quality has reached a hazardous level. Other polluting acts may be prohibited at all times. For example, a law may be passed which prohibits any discharges into a natural body of water, or the manufacture of certain pesticides may be permanently banned because their production generates exceedingly toxic wastes.

Charging for Industrial Effluent

Effluent charges are fees levied on industrial pollution discharges. They are most effective for control when the fees are in proportion to the quantity or concentration of the pollutants to be controlled, and when they are sufficiently high to make pollution control an attractive alternative. Rates for effluent charges can be set higher or lower to reflect differences in the ambient quality of the receiving water, or its ability to assimilate wastes.

It is difficult to establish appropriate fees for control purposes. If effluent discharge rates are set too low, many firms will accept them as normal business expenses rather than try to reduce their polluting discharges. If fees are unrealistically high, however, some firms may become unprofitable and have to close.

To the extent that potential polluters reduce their discharges to avoid the fees, effluent charges "internalize" the cost of pollution; the costs of control are paid by the responsible party, and the costs of pollution to other parties are reduced. To the extent that polluters actually pay the effluent charges, however, the major costs of pollution (environmental damage) may remain, and other firms or individuals will have to pay these involuntary or "external" costs.

Effluent charges also have several advantages. 1) They are relatively simple to adjust if found too high or low to serve the intended purpose. 2) Industry has been known to reduce waste loads rapidly in response to sewer charges. 3) The charges can compensate for pollution control activities which the public sector usually performs more efficiently or safely--such as collective municipal/industrial wastewater treatment or hazardous waste disposal. 4) Effluent charges encourage a least-cost method of pollution control, since self-interest will strongly motivate each firm to invest in the most cost-effective process changes or treatment methods up to the point where further control will cost more than the effluent charges. Firms which can do so most efficiently will therefore tend to make the greatest reductions in their waste loads.

Licenses, Permits, and Warrants

Licenses and permits issued for pollution control purposes grant permission to operate based on probable or proven ability to meet discharge standards. Discharge warrants grant permission to discharge based on payment of fees per unit of discharge.

Licenses and other permits to build or operate an industrial plant can be withheld unless the plant uses approved treatment or process methods and/or discharges wastes which meet regulatory standards. Such permits can be issued for a year or other convenient period with renewal depending on continued compliance with control regulations. Used in this way, licenses and permits reinforce discharge standards by helping to ensure that individual firms meet the standards.

Discharge warrants are a type of permit, but their effects are similar to those of effluent charges. A local or regional government agency can issue warrants whose total represents the maximum total amount of allowable discharge for a given area. The purpose is to limit ambient pollution and encourage control. Discharge warrants are usually sold at auction to the highest bidder. As with effluent charges, all discharges would have to be metered or monitored. A major problem is that larger, more aggressive, and financially stronger firms can use the system to eliminate smaller or weaker firms by buying up all the warrants for the area. This can be avoided in either of two ways: 1) by setting high minimum prices when a plant's warrant purchases exceed a certain proportion of its previous year's purchase, or 2) by limiting the number of warrants which can be issued to a plant based on either its productive capacity or previous discharge quantities.

Using Land Wisely

A factory will usually produce the same waste streams no matter where it is built. The resulting impacts, however, would not be the same in different environments. Land use restrictions are therefore used to reduce environmental impacts related to the geographic location of industrial plants. A regional or comprehensive master plan is usually the basis for most land use restrictions.

A regional land use plan concerned with environmental quality will consider the relationships between possible industrial discharges and various natural, economic, and social factors. Important natural influences on pollution impact include: climate (temperature, wind, humidity, and rainfall patterns), terrain and geology (ground slope and soil permeability), groundwater conditions (underground water supply and uses), characteristics of the receiving waters (water quantities, flow rates, and downstream uses), and present ambient air and water quality. Major economic impacts of pollution include anticipated damage to less polluting industrial, commercial, institutional, tourist, government, and residential properties and activities. Probable health effects will depend on population density, where people live and work, and the types and quantities of pollutants which may be discharged.

Where land and water are in abundant supply and industry is first being developed, it is common to minimize impacts by requiring industry to locate in isolated areas. When population centers and industrial activities expand, however, more specific land use planning becomes appropriate. The most common regulatory options for land use control are zoning restrictions, building codes, easements, and environmental impact studies.

Where and What to Build

Zoning is the backbone of a regional land use plan. Zoning codes divide the map of a region into clearly marked areas or "zones," and state what type of land use is permitted in each. Typical zoning categories are: heavy industry, light industry, commercial, residential, agricultural, extractive (mining and oil), and open space uses.

Undeveloped areas can be zoned for single uses, a combination of two or more uses, or kept as undeveloped open space pending later evaluation. Open space may be privately or government owned, and it may be completely natural or contain man-made features. It includes open recreation areas such as parks, forests, and wildlife sanctuaries; natural or artificial lakes, streams, and ponds; and natural or specially planted greenbelts.

Open space reduces industrial discharge impacts in several ways. It provides a buffer zone boundary between industrial development and other land uses; it helps to disperse pollutants before they reach sensitive areas; and it preserves the aesthetic environment of tourist-attraction, government, cultural, and residential areas. In addition, trees and other plants help to clean the air because their leaves strain many pollutants out of the atmosphere through natural biological action.

Zoning can also help to protect ambient air and water quality by encouraging the development of industrial parks where many firms or plants cooperate in waste treatment or other pollution control plans such as common use of recycled water or heat. The wastes from one industrial plant may be raw materials for another plant. Industrial cooperation to protect the environment can make control both cheaper and more effective. It can also help to preserve limited natural resources by avoiding costly duplication in control efforts, equipment, and raw material use.

Zoning codes are most effective when they are part of a comprehensive master plan which considers the total environment of a region. Establishing zones piecemeal in response to special pressures is usually less satisfactory.

Keeping the Plant Site Open

An easement is a permit to enjoy the noncommercial use of somebody else's property. Easements may give neighboring properties the right to an unobstructed view or the privilege of laying underground sewer and other utility lines along a right of way belonging to others. For pollution control purposes, a regional land use plan might specify that industrial property must include a certain proportion of open space for public access, either as plazas, walkways, or thoroughfares. This type of easement would serve some of the same purposes as open space zoning.

Building for the Environment

Building codes can limit industrial density and polluting discharges. To control the density of industrial development, a building code might restrict one or more of the following: building height or total size, the ratio of building size to lot size, the set-back distance of a building front from the public thoroughfare, the minimum distance between other sides of the building and property lines, the total number of industrial structures permitted in a given area, and minimum vehicular parking requirements. Building codes can also restrict industrial density by requiring sewer or other service hookups in areas where the zoning codes limit the total number of such connections. And they can reduce environmental impacts from industrial sources by requiring installation of plant wastewater pre-treatment systems, smokestacks of minimum height, air emission filters, or other control equipment as suitable for the proposed building use. By restricting the density of industrial development and requiring installation of control equipment and open space at the plant site, building codes can contribute to a cleaner environment.

Estimating Possible Impact

Environmental impact reports or statements may be required for all proposed new plants or plant modifications. The report serves several purposes. It forces the industrial firm to consider all the probable environmental impacts of its proposed building and production activities, and the various alternatives which can minimize potential damage to the environment. It also provides a document which the regulatory agencies, the general public, and the news media can study. If they wish, the interested parties can then express their opinions, hire their own experts, and influence final decisions through public hearings, meetings, or published statements. Based on a thorough airing of possible environmental economic impacts and alternative solutions, the responsible regulatory agency can then make an informed decision to approve the original plans, request certain modifications, or refuse permission to build the proposed plant on the proposed site. Reasons for approval or disapproval would relate to ability of the plant to meet prevailing discharge standards, the probability of increasing ambient pollution beyond allowable limits, and irreparable or inequitable harm to the social and economic interests of others.

Because an environmental impact statement subjects a project to public scrutiny, it strongly motivates the proposing firm to provide effective controls and attractive architecture and landscaping in order to win government and community support. Impact statements or reports are most effective when they are used as a basis for granting licenses or permits to build or operate. They are most urgent where the environmental effects may be far reaching and very hazardous. The whole community, for example, has a direct interest in the possible effects of building a factory which produces very toxic wastes known to cause cancer, birth defects, or other severe health damage. Table 3-1 is a sample outline of subjects which might be included in an environmental impact statement.

Subsidizing Industrial Control

The major purpose of pollution control subsidies is to encourage and enable the purchase and installation of pollution control equipment which meets certain specifications, and to prevent economic hardship--especially to small, older firms. The subsidies are direct or indirect payments to potential polluters who meet certain conditions. Most subsidies are given to cover at least part of the cost of purchasing and installing pollution control equipment. They may also be given for reducing either total discharges or the concentration of pollutants in the waste stream. Although more difficult to monitor and administer, subsidies for reducing pollution instead of for installing treatment equipment have two advantages: they leave the choice of method to the individual firm and encourage consideration of cleaner processes and recovery of resources. In contrast, equipment subsidies tend to specify or favor only end-of-pipe treatment methods.

All industrial subsidies tend to encourage development of the subsidized industry. Any form of pollution control subsidy may therefore lead to an influx of dirty firms in the covered industries. The net effect could be to reduce polluting discharges from individual firms, but to increase total environmental pollution as the result of increased investment in highly polluting industries.

Direct subsidies are monetary payments made directly to the industrial or municipal discharger, usually to compensate for the cost of control equipment which meets certain specifications. Indirect subsidies provide tax or interest advantages, usually for the same purpose. The major types of indirect subsidies are accelerated depreciation, tax credits, and loan guarantees.

Accelerated depreciation gives preferential tax treatment for purchases of pollution control equipment and systems. It is an accounting method which overstates the real capital costs of equipment during a rapid write-off period (perhaps five years or less) and understates them during the remainder of the equipment's useful life. This defers tax liability until after the accelerated write-off period. The tax money temporarily saved is equivalent to an interest-free loan from the government. Because of current inflationary trends, the value of such "loan moneys will usually be greater during the write-off period than when paid back as taxes at a later date.

Tax credits are reductions, exemptions, or defferals of tax liability in return for meeting certain conditions. The corporate tax rate, for example, might be reduced for firms which install waste treatment systems or otherwise reduce polluting discharges. If the control equipment is imported, the purchase could be made exempt from normal import tariffs.

TABLE 3-1
SAMPLE OUTLINE FOR CONTENTS OF AN ENVIRONMENTAL IMPACT STATEMENT

Project description

Present site environment

- Natural resources
- Land use
- Social and cultural factors
- Economic resources
- Pollution problems
- Nearby activities with similar impacts

Probable environmental impacts

- Land
- Water
- Air
- Plant and animal life
- Human health and welfare
- Other social and economic factors
- Solid waste

Unusual environmental impacts

- Accidental
- Catastrophic

Identification and control of potential adverse effects

- Erosion
- Water pollution
- Air pollution
- Traffic
- Plant and animal life
- Vectors
- Emergency or remedial procedures

Unavoidable adverse impacts

- Land
- Air

TABLE 3-1 (Cont.)

- Water
- Plants and animals
- Human health and welfare
- Other social and economic factors

Alternatives to the proposed project and their probable impacts

- Abandoning the project
- Alternative sites
- Alternative procedures

Irreversible resource commitments

- Energy consumption
- Resources needed in construction
- Irreversible damages or alteration of the environment

Duration of environmental impacts and related socioeconomic cost-benefits

- Short-term
- Long-term

Loan guarantees by the government help industry to pay control costs by ensuring loans which banks or other lenders might otherwise be reluctant to make. Government guarantees of loan principal and interest also enable the borrower to get preferred interest rates on conventional loans.

Education and Persuasion

Government and other public interest agencies can provide several types of information and technical support through their own publications, the news media, public meetings and hearings, direct communication with industrial firms and organizations, and pollution-related research and development programs. Technical information might be provided on the harmful effects associated with various pollutants, the industrial processes which generate those pollutants, and the ways in which industry can reduce the harmful discharges or their impacts. Publicizing this type of information can encourage industry to find and use the most cost-effective combination of available manufacturing, recycling, and reclamation processes, raw material use, plant siting, and waste treatment. It could also stimulate interest in related research, and foster public and industrial support for regulatory control programs.

The Right to Know

Government agencies can't properly regulate industrial polluters unless they have some way of determining when individual plants fail to meet government discharge standards. This is no easy matter because there are many ways to avoid detection, such as discharging wastewaters during the night and on holidays. The right to monitor waste streams and inspect plant equipment and operations will help to identify violators. Self-monitoring devices which continuously identify and measure pollutants or waste flows can be required for certain production processes. Industrial compliance usually improves if regulatory agencies periodically exercise their right to independently monitor and inspect.

Monitoring stations can also be set up to measure ambient air and water quality where necessary or appropriate. The information can be used as the basis for: modifying control requirements, warning the public to leave an area or stay indoors during critical conditions, prohibiting burning or other highly polluting activities when ambient levels reach a danger point, or altering proposed land use development plans.

Insuring the Risk

Requiring industry to carry liability insurance against possible damage from its polluting discharges can serve three purposes. Industrial firms will try to use safe, effective control methods in order to lower their insurance costs; in the event of pollution damage, the injured parties can receive compensation for medical care, "pain and suffering," or cleanup costs; and if insurance is required and insurance companies refuse to give coverage to industrial plants with inadequate control programs or bad compliance records, such plants will have to improve controls or close down.

The Right to Sue and Collect

Government regulations or laws can make industry legally liable for its environmental damage, especially when it fails to comply with control requirements, and can grant injured parties the right to sue the responsible firm. These rights and responsibilities will have some of the same effect as requiring liability insurance because industry's

immediate response would be to protect itself by taking out such insurance. Since insurance policies frequently exclude certain types of risk and limit the total amount of coverage, polluting firms would be very vulnerable in the case of disaster-type discharges which may subject them to class action suits, that is, suits by citizen groups with common interests. Allowing such potentially expensive suits would encourage industry to be more cautious with its discharges.

Making It a Crime

Although much environmental damage is caused by accident or ignorance, some is the result of criminal negligence. When violating control laws can lead to serious harmful effects, the violations can be made a criminal rather than a civil offense. If such laws are strictly enforced and management or other responsible parties are subject to criminal indictments and penalties (if found guilty), the incidence of gross negligence should decline.

Other Ways to Pay

Cease and desist orders can either give a time limit within which a plant must eliminate certain violations, or, if the possible harmful effects are very serious, the plant can be required to shut down immediately until it complies with control regulations. Misdemeanor and criminal offenses can both require the payment of heavy fines as a penalty.

Enforcing the Law

Two related problems in regulating industrial pollution are: 1) laws have little effect unless they're strictly enforced, and 2) penalties are meaningless unless they're sufficiently large to make compliance more attractive than paying the penalty. Token fines are a minor nuisance compared with the purchase, installation, and use of an effective pollution control system. Unless regulatory agencies are prepared to enforce control laws vigorously and to impose suitable penalties, industry will have little motivation to comply with control standards.

A recent incident illustrates how two options (large fines and the right of injured parties to sue for damages) can make the discharge of pollutants more expensive than their control.[11,12] In humans, the insecticide Kepone attacks the central nervous system and causes uncontrollable shaking and mental damage. In laboratory animals, it causes cancer. A plant which had manufactured Kepone for sixteen months was closed down in July 1975 because of health risks to its workers. Over thirty employees were eventually hospitalized with Kepone poisoning, and large numbers suffered lesser damages. But the hazard was not confined to the work force.

In violation of government regulations, the plant had been dumping contaminated wastes into a river which empties into Chesapeake Bay. Both bodies of water were important fishing grounds with combined annual sales of about $50 million. Large quantities of fish were condemned, and sales plummeted for any fish thought to come from the Chesapeake Bay area.

All fishing was banned in the river where 100 percent of the fish were contaminated. About one-third of the fish in the southwestern part of the Bay contained hazardous levels of Kepone, and some 300 km to the north, Kepone-contaminated fish believed to have migrated from the Bay were caught in the Atlantic Ocean.

A federal judge imposed a fine of almost $14 million against the responsible chemical company. In addition, fishermen deprived of their livelihoods and disabled plant workers have together filed civil damage suits totalling almost $200 million. Where suitable, making such large penalties and civil damage awards customary can effectively persuade violators to comply with pollution control regulations.

Comparing Alternative Regulation Possibilities

Some of the advantages and disadvantages of two types of regulatory options are summarized in Tables 3-2, and -3.

IDENTIFYING INDUSTRY'S OPTIONS

Government can only plan for industry's control of pollution; industrial firms must carry out the plan. In this, potential polluters may be motivated by more than government regulations. The advantages of a favorable corporate image, a sense of social responsibility, and a wish to be "good neighbors" or have good community relations can also play a part.

Industrial plants can use one or more of the following to reduce polluting discharges or their impacts:

preventive:

- Cleaner fuels and other raw materials.
- Less polluting production equipment and processes.
- Reclamation of wastes.

corrective:

- "End-of-pipe" waste treatment.

general:

- Paying outside collectors to dispose of their hard-to-handle wastes.
- Dispersion of discharges.
- Better plant siting.
- Careful disposal of solid wastes.

Some plants may be unable to achieve required discharge standards within normal profit expectations. Unless there is some reason for the government to relax standards for such firms, they will have to consider three additional options: closing the plant, limiting output to products which do not cause the same difficulties, and transferring the polluting production processes to more efficient plants or firms which specialize in the particular operation.

TABLE 3-2
ADVANTAGES AND DISADVANTAGES OF ALTERNATIVE LEVELS OF CONTROL

Option	Advantages	Disadvantages
Specified standards, voluntary compliance	Simple No red tape or constraints No public effort required Minimum opposition by industry	Almost completely ineffective Politically damaging if public realizes its failure Allows virtually unchecked natural resource exploitation and pollutant discharge
Low standards, mandatory compliance	Achieves some degree of pollution control Least objectionable form to industry of mandatory control	Some costs for implementation and administration Some waste of resources Environmental deterioration only slowed, not checked
High standards, staged mandatory compliance	Environmental deterioration checked or prevented Allows for maximum long-term resource conservation and economic welfare	Industrial opposition Initial capital costs may be large Administrative costs and difficulties due to need for trained technical personnel

TABLE 3-3
ADVANTAGES AND DISADVANTAGES
OF SELECTED REGULATORY STRATEGIES

Option	Advantages	Disadvantages
Ambient standards	Relates directly to environmental quality Allows broad range of alternatives suitable for meeting standards Usually necessary as basis for comprehensive control program Monitoring can provide for emergency measures when toxic levels are dangerous	Requires monitoring of environment and determining plant sources of pollutants May encourage increased pollution in clean areas
Discharge standards (uniform)	Relates directly to environmental quality Simple program Basis for other programs Equitable re. law Sets definite pollution limits but allows industry free choice of abatement methods Most direct and effective guideline for safe discharges	Requires administration and enforcement Possible inability of industries, especially small plants, to meet standards without financial aid Variable standards may be more equitable re. cost of control for plants of differing size, age, and technology Ignores cost-effectiveness Enforcement requires monitoring of individual firms
Prohibitions	Stops further pollution Simple administration, monitoring Usually necessary for highly toxic wastes	May force temporary or permanent industrial closings
Effluent charges	Costs are internalized to polluting firm Decision-making is decentralized Provides a monetary incentive for control A least-cost method of control; relies on a market simulation	Industrial opposition Some delay and inequities inevitable in initial stages Relating charge to amount of pollution is difficult Low effluent charges may become an accepted cost of business and have little impact on abatement

TABLE 3-3 (Cont.)

Option	Advantages	Disadvantages
Licenses	Prevents operation of polluting plants Enforces compliance before pollution occurs Encourages periodic review	Requires monitoring to ensure that compliance continues after licensing
Warrants	Controls ambient quality by limiting number and total quantity of discharges within an area Industry determines economy of control (relates to real market) Simplifies monitoring system	Awards favor financially strong firms Other firms in the area may be forced to close May restrict industrial development rather than encourage better waste management, especially if warrant fees are set too low
Zoning	Forces industry to locate in environmentally suitable areas Protects sensitive areas Allows separation of industrial and municipal waste for more economical and effective treatment and control Simple enforcement	Can supplement but nor replace the need for treatment or other pollution controls Permitted area may be uneconomical for industries Development of zoning plan may be difficult
Subsidies	Cost of cleanup not a burden to any one sector of society Eases control problem for smaller industrial firms Easier to administer than tax incentives and charges	Difficult to determine optimum payment Contrary to the "polluter pays" principle Increased taxes possible Does not encourage cost-efficiency Imposes burden on government budget Provides no incentive to use most cost-effective treatment, equipment, or method Encourages end-of-line treatment rather than process change and recovery methods

Changing the Raw Materials

Alternative raw materials with cleaner properties can frequently be substituted for more polluting materials. Burning coal or fuel oil with lower sulfur content, for example, will reduce sulfur oxide (SO_x) emissions. Using natural gas instead of petroleum fuels will also reduce sulfur oxide.

The use of reclaimed waste materials can sometimes reduce production costs, energy consumption, and environmental pollution. It also helps to conserve s arce natural resources. Reclaimed aluminum from cans, for example, may be substituted for virgin aluminum produced from bauxite. This reduces bauxite consumption and related mining and refining operations. Both mining and refining generate considerable pollution, especially refining which requires large quantities of electric power, a highly polluting source of energy.

Improving the Process

The purpose of developing alternative production equipment and processes is usually to improve manufacturing efficiency rather than to reduce pollution. Sometimes, however, it can do both. In the iron and steel industry, for example, it is more economical to make iron with the direct reduction process than with the older blast furnace method. In addition to being less expensive, direct reduction allows the substitution of natural gas fuel for coke. Using natural gas reduces both sulfur oxide and particulate emissions. Since pollutants are wasted resources, greater efficiency and resource conservation are frequently linked. Where this is true it can provide an attractive cost-free way to clean up industrial discharges.

Process changes which reduce pollution range from simple housekeeping improvements to complex technical changes in equipment and methods. Sweeping up food wastes instead of hosing them down, for example, can reclaim the garbage for animal feed. This reduces contaminated wastewater discharges and also conserves cleanup water. Many other process changes may reduce pollution but increase production costs. Even these process changes, however, frequently provide a cheaper way to meet discharge standards than paying the additional capital and operating costs of end-of-pipe waste treatment.

Making Waste Pay

When wild grasses invade farm crops, they are pulled out as weeds. In a grazing field, however, they would be cultivated as fodder for the animals. Most pollutants are also valuable resources which are wasted because they can't be readily used in their present condition. But those which can be recovered and reclaimed economically can sometimes be reused many times. There are four ways to make waste pay: recycling, recovery, reuse, and by-product reclamation. All four will reduce pollution and conserve resources.

Recycling and reuse are frequently used interchangeably. "Recycling," however, usually implies that the waste product or material has undergone a change. Wastewater from higher uses such as heat exchangers, for example, is frequently recycled as cooling water, and heated water may be recycled to warm shellfish beds. Other industrial effluents may be filtered, purified, or otherwise treated to produce relatively clean water which is suitable for recycling in appropriate in-plant uses. The same treatment may also allow valuable mineral or organic materials to be recovered from the effluent. Depending on their quality, these materials may be reused in the original production process or sold as by-products. The following examples illustrate the successful use of waste reclamation for pollution control.[13]

A paper pulp mill is installing a salt recovery process to separate, recover, and recycle water and chemicals. Because the mill system produces virtually no polluting discharges, it requires only minimum wastewater treatment facilities, and its operating costs are estimated to be lower than those of a conventional pulp mill. Higher productivity and lower chemical, water, and energy requirements are expected to save the company about $4 million per year on an estimated investment of $8 million. (For contrast, Photograph 8 shows typical effluent from paper pulp mills with inadequate wastewater pollution control systems.)

In another paper mill, electrostatic precipitators have been installed as an integral part of both the energy production and air pollution control systems. The precipitators recover valuable fuel by-products which are recycled in plant operations. They have an estimated annual value of about 75 percent of their capital investment cost.

Instead of discharging valuable "waste" materials into sewers, chemical plants are now saving millions of dollars through the use of pollution control/recovery systems. One chemical company anticipates an annual return of 10 percent on its cooling tower investments (because of higher production efficiency and lower water costs), and an annual return of 100 percent on investments in pollution control/recovery systems installed in its latex plants.

Like other process changes which reduce pollution, recovery systems do not always return a profit on investment. But they may still be more attractive and economical for pollution control than comparable waste treatment systems, especially if the recovered materials are in short supply or their costs continue to rise. Unless a plant has been designed for reclamation and recycling processes, however, it will usually be very expensive to retrofit for the purpose. The type of useful material and by-products which may be reclaimed include:

- Water and other solvents for recirculation in plant operations.
- Organically enriched water suitable for agricultural or landscaping application.
- Dilute solutions which may be used to manufacture in-plant products.
- Valuable chemical and mineral discharges which may be collected and processed for re-sale or re-use.
- Currently saleable by-products.
- Useful by-products for which new markets may have to be developed.

Photograph 8.

Wastewater from a paper pulp mill. Similar plants treat their wastes and discharge clean water.

Although the use of waste reclamation is increasing, it is not as widespread as it could be for several reasons. Many recovery systems are new and untried; adequate markets have not been developed for various recovered materials or by-products; and sometimes government price supports or other regulations tend to favor the use of virgin raw materials rather than recycled materials. Government interest in waste reclamation could increase its use for pollution control and resource conservation. Many industrial wastes, however, have little or no reclamation value, and others which do are difficult or costly to recover. To avoid polluting effects, such wastes will require treatment, and/or careful disposal.

End-of-the-Pipe

The preceding methods of control (using cleaner raw materials and processes, and reclaiming waste products) are preventive measures. They either avoid generating pollutants or make use of those which are produced. If preventive methods are not used or don't fully achieve desired discharge quality, end-of-pipe waste treatment methods can be applied. Their purpose is either to catch and hold pollutants for a type of disposal which doesn't harm the air, water, and land environment, or to alter the characteristics of the discharge so as to make it less harmful when released.

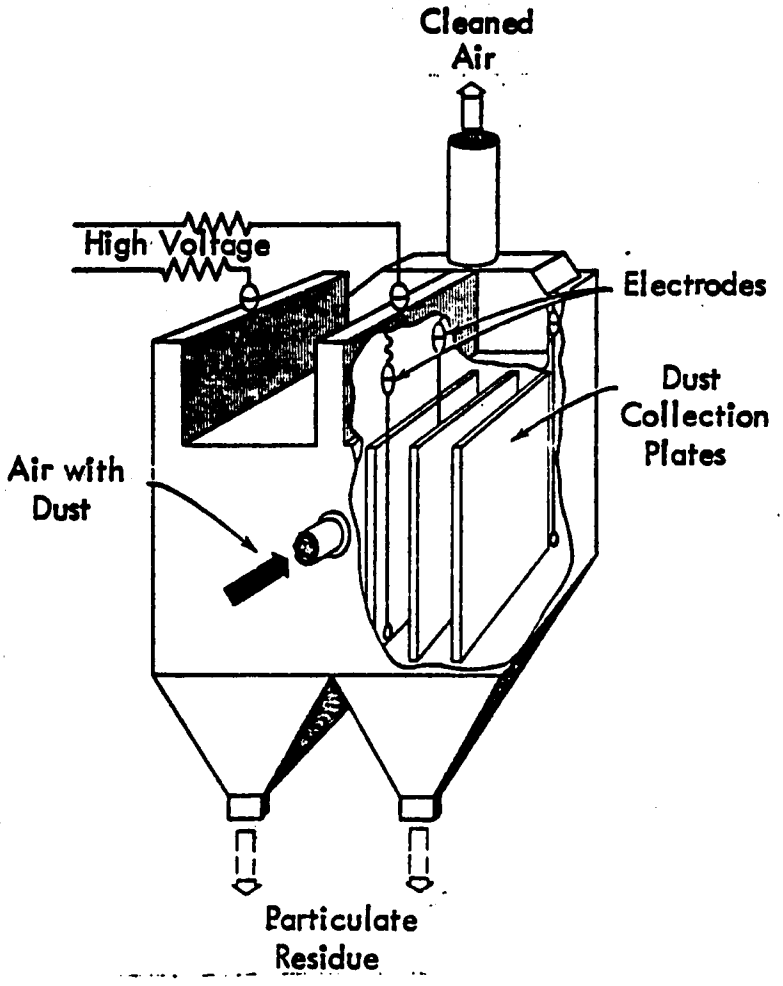
Treatment is the most common means for processing polluted products into a form which is safer and more acceptable for disposal or discharge to the environment. Treatment processes use simple physical separation or more complex physical/mechanical, chemical, or biological systems to alter industrial waste discharges. All produce solid waste residues which require disposal. A few treatment methods for air and water waste streams will be described to illustrate the four types.

Simple physical separation uses dispersion, gravity, screens, baffles, or filters to remove solids from a waste stream.

Dispersion reduces the concentration, but not the total amount, of pollutants in the receiving air or water. The most common type uses tall smokestacks which cause the discharge to mix with cleaner air before returning to ground levels. This reduces the intensity of environmental impact at any one point, but distributes total impact over a wider area or longer time span. Air dispersion is most effective in areas with adequate and consistent winds or air currents and moisture. One rule of thumb is that the smokestacks should be considerably higher than the tallest neighboring structures.

Settling basins and clarifiers are large tanks or ponds in which effluent (wastewater) is allowed to settle for long periods. In time, heavy materials sink to the bottom, clear water is allowed to overflow at the top, and oily wastes which float to the surface can be skimmed off. The remaining sludge is removed periodically.

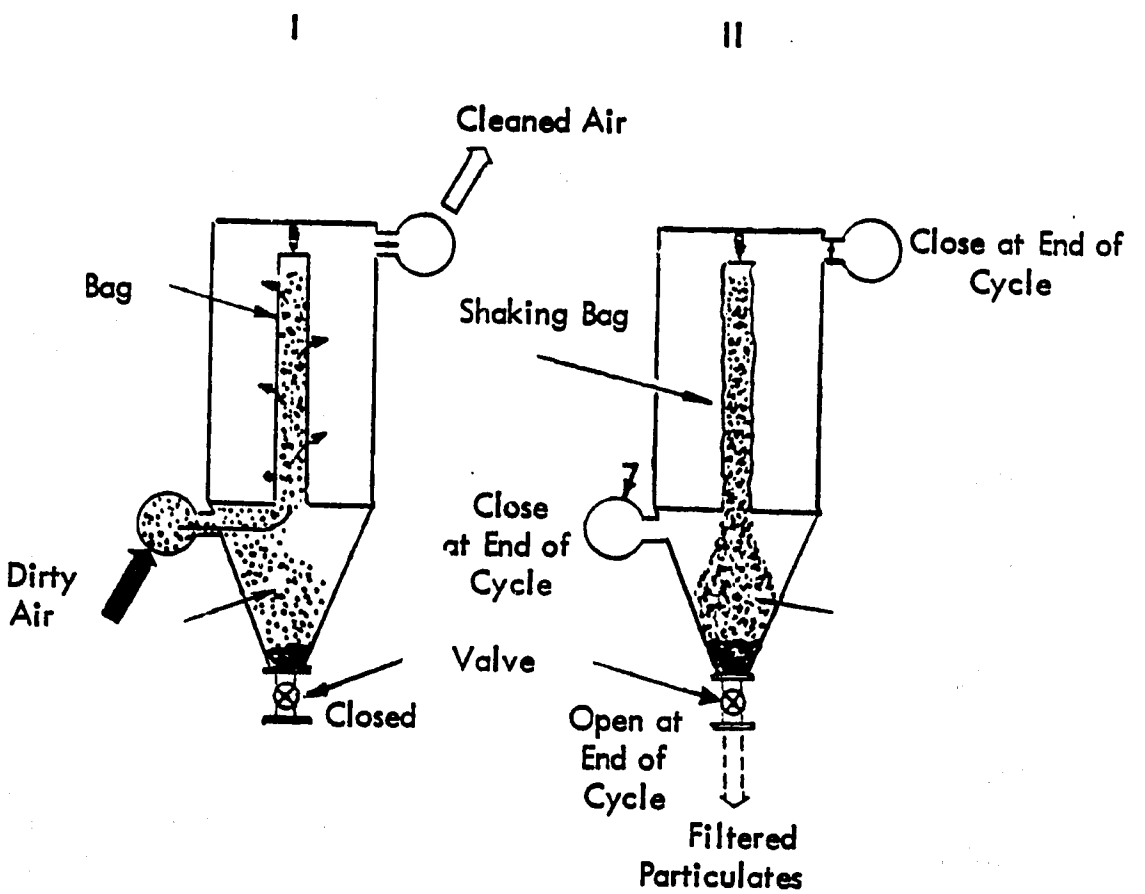
Electrostatic precipitators and baghouse filters are physical separation treatment methods for gases, or air emissions. Both collect particles which must be removed periodically. Electrostatic precipitators (Figure 3-1) attract soot or other particles to electrically charged plates (electrodes) before discharges are allowed to go up the chimney stack. Baghouse filters (Figure 3-2) are like oversized vacuum cleaners. The open-ended bag (usually made of heat-resistant materials) captures particulates in the gas stream as the cleaned gas passes through the holes between the fibers. They are periodically emptied by shaking at the end of the work cycle.



No Scale

Source: Salvato, J. A. Environmental Engineering and Sanitation. 2d ed. New York: Wiley-Interscience, 1972.

FIGURE 3-1
ELECTROSTATIC PRECIPITATOR



No Scale

Source: Ross, R. D. Air Pollution and Industry. New York: Van Nostrand-Reinhold, 1972.

FIGURE 3-2
BAGHOUSE FILTER

Cyclone collectors (Figure 3-3) use centrifugal force (a form of mechanical treatment) to remove large particles from polluted air. In a typical cyclone, flue gas is forced through a funnel-shaped chamber where the centrifugal force of a rapidly whirling gas flow causes larger particles to settle out. Although less expensive than electrostatic precipitators and baghouse filters, cyclones are far less effective in collecting the smallest size particulates which are the most harmful to human health.

Chemical treatment methods can also separate solids or treat pollutants in a waste stream. In flocculation, chemical action causes suspended sewage solids to form clumps or "flocs." In coagulation, chemicals such as alum or lime are used to cause the clumping of impurities in effluents. In chlorination, chlorine is added to disinfect or oxidize undesirable compounds in drinking water, sewage, or industrial wastes.

Biological treatment methods enable bacteria to break down organic wastes. They are commonly used in the secondary or tertiary treatment of wastewater. One example is the trickling filter in which sewage is passed over a bed of rocks or stones which contain fresh air. Activated sludge uses pumped air and micro-organisms to biologically stabilize organic wastewaters. This system provides a favorable environment for bacterial growth and the decomposition of organic wastes.

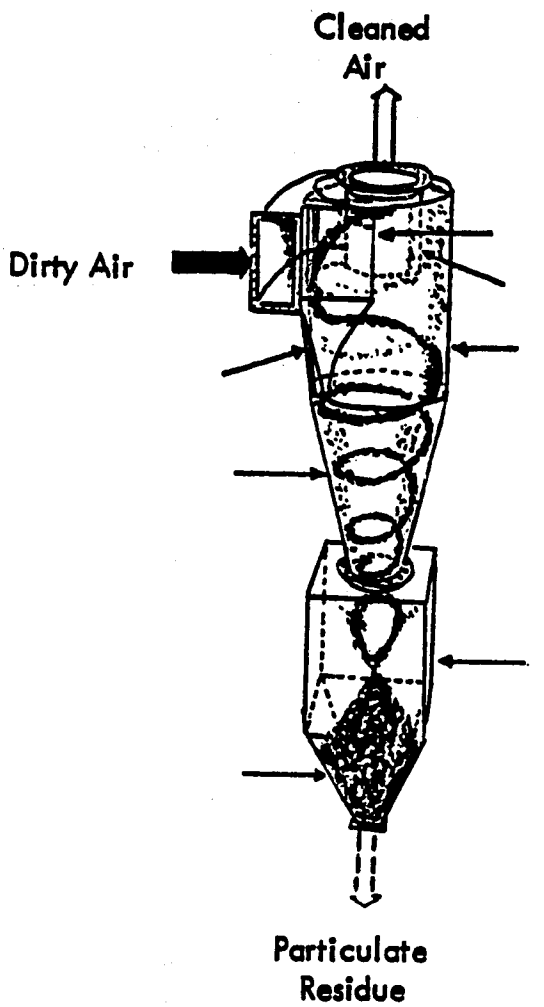
In highly industrialized countries, end-of-pipe waste treatment has been the most commonly used approach to pollution abatement. One reason for the preference is that treatment is frequently the only available method which is economically feasible for existing firms. More and more new plants, however, are considering alternative process and recovery methods to replace or supplement end-of-pipe treatment. Whatever methods are to be used, retrofitting is usually very costly. All new plants or plant modifications should therefore be planned to include at least the fittings for control systems which may be necessary to meet anticipated future discharge standards.

Comparing Industrial Strategies

Table 3-4 summarizes some of the advantages and disadvantages of four major approaches to reducing polluting discharges. In a given plant's control system, the four types of control would usually complement rather than substitute for each other. Recycling water, for example, does not eliminate the need for treating wastewater which has become too contaminated for further economical use in the factory or plant; and using cleaner fuels or reclaiming useful by-products may greatly reduce polluting air emissions, but some treatment will still be necessary to protect the quality of environmental air.

When Wastes Are Too Hard to Handle

Some wastes may be too toxic or difficult to handle for in-plant treatment or control management. Many plants will find it advisable to hire outside services which specialize in the safe collection, transport, and disposal of such problem wastes.



No Scale

Source: Ross, R. D. Air Pollution and Industry. New York: Van Nostrand-Reinhold, 1972.

FIGURE 3-3
MECHANICAL CYCLONE

TABLE 3-4

ADVANTAGES AND DISADVANTAGES OF INDUSTRIAL STRATEGIES TO CONTROL POLLUTION

Option	Advantages	Disadvantages
Cleaner fuels/raw materials	Reduces pollution through prevention	Some substitutes may be in short supply, more costly, and/or less suitable
	Reduces need for waste treatment	
	May be less costly and more effective than treatment methods	
Improved production processes	Conserves limited resources	Alternative processes which reduce pollution may increase costs and reduce efficiency
	Reduces pollution through prevention	
	Reduces need for waste treatment	
	More efficient manufacturing methods can also reduce polluting waste	Additional costs may be higher than those of waste treatment
Waste reclamation (Recovery/recycling/reuse/by-product use)	Conserves limited resources	May be more expensive than waste treatment
	May reduce costs, pay for itself, or return a profit	Not technically or economically feasible for all pollutants
End-of-pipe waste treatment	Conventional treatment methods readily available for most pollutants	Residues remaining after treatment need disposal
	Effluent wastes can be collectively treated in municipal or industrial park waste treatment systems	Pollution usually only reduced, not eliminated
		Can be very expensive when retrofitting is necessary
	Technology is well developed	Wastes resources

Choosing the Best Plant Site

Many site considerations which improve production efficiency will also reduce waste production and pollution impacts. Being close to raw material markets, transportation facilities, and labor sources, for example, will reduce transport needs, fuel consumption and, therefore, air pollution. All of the factors listed in Table 3-1 above relate to the impact of site selection on environmental qualities.

Careful siting which minimizes pollution impacts can serve several purposes. It may be a requirement for a license or permit to build or operate. It may reduce building or operating costs. And it will minimize possible conflicts with neighboring residents, business firms, or agricultural and tourist interests. Photograph 9 shows how poor site management during construction can damage nearby facilities; in this case silting caused municipal sewers and culverts to back up and flood adjacent areas.

MANAGING INDUSTRIAL SOLID WASTE

Industrial solid wastes are generated by production activities and as residues of waste treatment methods. Their disposal may be facilitated by breaking large units of solid waste into smaller pieces, or making the waste more compact. Although recycling is the most desirable way to handle wastes, much solid waste has little or no value, and some is contaminated with toxic materials. Final disposal of solid waste should be where and however it will cause the least environmental damage. Land disposal, dumping into water bodies, and incineration are the most commonly used methods.

Final Disposal

Solid wastes are ultimately disposed to land or water, or reduced through burning. Every method has some potential for environmental damage. Open burning and open land dumps can contaminate both the atmosphere and groundwater. Incineration usually contributes to air pollution. Ocean dumping can harm fish and other aquatic life and spoil tourist attractions. Lake or river dumping causes similar contamination and may also endanger the water supply. Sludge disposal in basins and the use of sanitary landfills can cause surface or groundwater contamination. And every type of disposal may cause odor, noise, and unsightliness and encourage the breeding of disease carriers. Sanitary landfilling and incineration usually cause the least amount of environmental harm.

In sanitary landfilling, solid waste is spread in thin layers which are covered with soil at the end of the working day. Each layer of waste and each layer of soil cover is compacted after it is put in place. If rain or runoff causes more water inflow than the waste deposits can absorb, materials leached from the waste may enter the groundwater or nearby natural bodies of water and cause pollution. Proper site selection and engineering design can minimize possible problems relating to vehicle traffic, leachate and gas production, air pollution, odor, dust, noise, aesthetics, and vectors (insects and other organisms capable of transmitting disease).

Photograph 9.

Silt from new construction fills sewers and culverts in a populated area and causes flooding.

Incineration produces some solid waste residues, but is considered a disposal method because it greatly reduces the total volume of solid waste. For some materials, the reduction will be more than 90 percent. Incinerators are highly polluting to the air unless designed to reduce and control emissions. Scrubbers, for example, use a liquid spray to remove pollutants from the gas stream and also reduce the temperature of emissions. The contaminated scrubbing water then requires treatment or control.

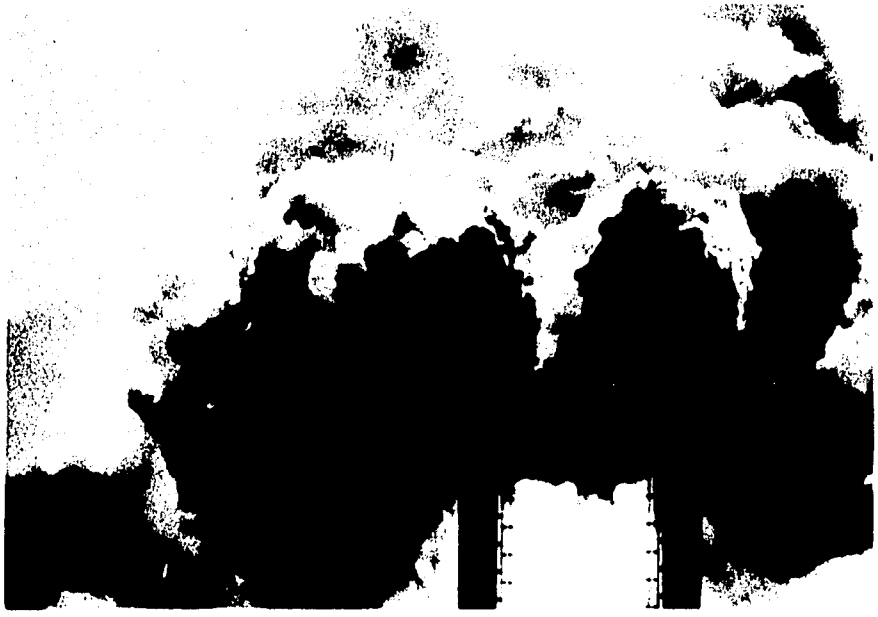
Most incinerators need supplementary fuel in addition to the waste being burned, especially since reclaiming heat from the incineration process usually costs more than using conventional fuel sources. Both the air pollution control devices and heat conservation facilities usually cost more than the furnaces they are designed to modify.

Comparing Solid Waste Disposal Methods

Photographs 10, 11, and 12 contrast possible air pollution from burning in an open dump, incineration of auto batteries, and the clean environment of a carefully engineered sanitary landfill which will be attractively landscaped as a public park for all-year recreational use when the project has been completed.

Table 3-6 summarizes some of the advantages and disadvantages of the most common solid waste disposal methods.

Photograph 10.
Burning solid waste in an open dump sends dangerous ashes and chemicals into the atmosphere.



Photograph 11.
Clouds of polluting smoke from the incineration of automobile batteries.

Photograph 12.

"Mount Trashmore," a sanitary landfill which will be covered with topsoil and planted upon completion. It will provide a rolling, hilly park in an otherwise flat area.

TABLE 3-5

ADVANTAGES AND DISADVANTAGES OF SOLID WASTE DISPOSAL METHODS

Disposal Option	Advantages	Disadvantages
Ocean and lake dumping	Usually cheap and easy	Contaminates fish and aquatic plant life Introduces toxic pollutants in food chain Unsightly and damaging to tourist use Lake dumping may endanger drinking water supply
Open land dumps	Usually cheap and easy	May contaminate air and water Harbors disease-carrying rodents, insects, and micro-organisms Unsightly and odorous
Open burning	Usually cheap and easy	Causes serious air contamination Very odorous and unsightly
Sanitary landfill	Accepts most types of waste Produces little or no air pollution and minor odors Produces less groundwater pollution than open burning and dumping, and doesn't hurt aquatic life Can sometimes be used for land reclamation (see Photograph 12) Minimizes health hazards caused by organic wastes and eliminates nesting places for disease carriers Is fairly economical and easy to operate	Nearby residents may object Requires careful maintenance Completed landfills continue to settle and can produce methane gas and leachates for many years Soil cover material may be difficult or costly to acquire

TABLE 3-5 (Cont.)

Disposal Option	Advantages	Disadvantages
Incineration	Requires little land Process is rapid Doesn't require long hauling	Causes considerable air pollution Unsuitable for many wastes Residues require disposal Pollution control and heat recovery systems are very costly Nearby residents usually object Usually located close to solid waste sources and therefore tend to affect larger populations than other disposal methods

CHAPTER 4

WEIGHING NATIONAL COSTS AND BENEFITS

The benefits of an abatement program are the reverse of the costs of pollution it eliminates. Although the costs of abatement are primarily economic, the resulting benefits are a complex mix of social and economic values. Conventional economic cost-benefit analysis therefore has limited application for environmental decision-making.

The concept of social versus economic values is intended to distinguish qualitative or welfare values from quantitative or monetary values. The distinction, however, is difficult to maintain: social and economic cost-benefits tend to overlap and interact. A resource conservation program, for example, may be promoted to achieve the social goal of protecting the aesthetic quality of local surface waters or preventing the extinction of an endangered species. Either program, however, could have economic impact as well. A water recycling/reclamation program, for example, might protect the appearance of surface waters, reduce manufacturing costs, improve the quality and supply of drinking water, and increase the available water for crop irrigation or other industrial purposes in an crid region. Similarly, protecting game preserves for ethical or aesthetic reasons can also help generate tourist income and an influx of foreign exchange.

There is a further difficulty in weighing control cost-benefits. Because the most important environmental costs of industrial pollution are "externalized" (paid by others in the community rather than the polluting plant), the corresponding benefits from their abatement will also be externalized. Under mandatory control, the producers (and eventually the consumers) of the related product will pay the cost, and the general public will get most of the benefits. Industry may interpret this to mean that control penalizes manufacturers unfairly. Others, however, claim it is unregulated pollution which penalizes innocent parties, and control which shifts the involuntary costs back to their responsible sources. Because the payor and beneficiary of control may have conflicting interests, government decision-makers usually try to weigh the impact of control on the total national interest.

A comparison of two textile factories in a country in Southeast Asia illustrates the above considerations.[14] Because fish is the major protein food in this country's diet, any pollution of its klongs (canals) has serious implications for the well-being of its people. One of the textile factories has a fairly satisfactory wastewater treatment system, and the catch of fish in the nearby klong has changed little since the plant was built.

The second factory provides minimal wastewater treatment. Water downstream from the plant is black and turbid, and all fishing in the klong has been eliminated. Before the factory was built, one hundred families had engaged in fish farming in ponds using klong water. All of the families have apparently given this up. There is great dissatisfaction among the villagers, and complaints about the pollution have appeared in the newspaper.

The first factory pays the costs of control, and the local community and those downstream of the plant enjoy the benefits. The second factory avoids the costs of control, and the local community and those downstream of the plant pay the social and economic costs of the resulting pollution. Although the present report is primarily concerned with environmental pollution from industrialso urces, a third factor is worth considering: where management is indifferent to environmental impacts, both in-plant and community conditions are likely to reflect similar adverse effects.

In the preceding example, the second plant employed 1,601 workers. In a single month, 137 workers (or 8.6 percent of the work force) were clinically treated for respiratory ailments. There were also 61 reported cases of dermatitis, and 24 of auditory problems. It was estimated that in-plant pollution would cause 50 percent of the work force to suffer respiratory damage, and 15 percent to have hearing losses. It was further estimated that these disabilities could be prevented at a cost of about only 20 percent of the corresponding losses in wages and productivity.

It is reasonable to assume two things: extensive air, noise, or other pollution inside a factory will be reflected in similar types of pollution in the outside environment, and better management of potential pollution will simultaneously benefit workers in the plant, people in the affected communities, and those downwind or downstream of contaminated discharges in the receiving air and water.

As previously discussed, some control measures may eventually pay for themselves or even return a profit to the firm because of increased efficiency and reduced waste; others will return a "profit" to the country because they conserve scarce resources for future use or make for a healthier population and more attractive homeland. In general, however, there are no solutions to industrial pollution which are totally cost-free to all interested parties. The decision-maker's problem is therefore to identify and weigh the gains of those who benefit from pollution control against the costs of those who must pay the price of that control.

THE GROWTH OF NATIONAL OUTPUT

Measuring National Production

Gross national product (GNP) measures in money the total quantity or "flow" of goods which a country produces in a given year. It is the sum of all personal consumption expenditures on goods and services, all government expenditures on goods and services, and all investment expenditures (or C + I + G). When it has been adjusted for changes in the price index or current value of money, it is called real GNP. It is called "gross" national product because no allowance is made for investment depreciation. If such depreciation is deducted from gross national product, GNP is re-named NNP, or net national product. Both measures of national production, however, ignore environmental depreciation.

A thousand kilowatts of electricity sold at the same price has the same value in GNP whether it comes from a clean or highly polluting power plant. Money spent on wholesome food, clothing, and housing is treated the same as money spent on candy,

cigarettes, and cosmetics. In this sense, GNP is "value neutral;" it doesn't judge the social values of monetary expenditures. In terms of pollution, however, GNP is not neutral. Since no deduction is made for environmental damage, GNP will overstate national welfare in exact proportion to the social and economic costs of that damage. In this sense, it is biased in favor of pollution.

There is a further fallacy in equating GNP with welfare. Waste inflates cost, price, and GNP. Affluent countries with rich natural resources, for example, have wasted those resources, inflating both pollution and gross national product. Throwing away glass and metal containers, wasting valuable fuel because of poor buildinginsulation, flaring of natural gas, and numerous other wasteful practices will raise GNP. This implies that waste creates value. In fact, it causes pollution, depletes scarce materials, and reduces the quality of life. With these limitations in mind, some of the possible effects of pollution control on GNP will be considered.

Pollution Control as a Growth Industry

The production of pollution control goods (equipment, structures, and materials) contributes to gross national product. Because of this, mandatory control will usually increase gross national product during periods of rapid growth in the control industry. As manufacturers' needs for investment in control equipment diminish, economic growth may be somewhat slowed due to the combined effects of a reduction in control-goods production and higher rates of inflation. Within a few years, however, such differences should stabilize, and the national economy as measured in GNP would show little effects attributable to mandatory pollution control. For the United States, control-related differences in GNP were estimated as reaching a maximum increase of 1.6 percent in 1975, a maximum decline of 2 percent in 1979, and close to zero difference by 1982.[15]

Using Surplus Productive Capacity

The immediate effect of pollution control on GNP will depend on the type and level of control, and the amount of unused productive resources. Possible excess resources include unused industrial capacity suitable for manufacturing control-related equipment and structures, and a surplus of the labor, raw materials, and electric power needed to produce and operate control systems. If these resources are available and adequate, GNP would probably increase or remain constant. Without surplus capacity, the short-term effect of pollution control may be a decline in GNP because clean air and water are not marketed as consumer goods--they are not part of the "national product."

When low domestic demand and high production costs limit exports, there may be considerable surplus capacity. These conditions sometimes occur when government subsidies and import tariffs or other trade restrictions are used to stimulate the development of domestic industries. Factories are sometimes built which can produce more of a given product than domestic demand can absorb, and the price may not be competitive for export--especially if foreign countries impose tariffs of their own. Using these and other types of excess capacity for pollution control purposes may increase both GNP and environmental quality.

Construction, metal, and chemical firms supply most of the industrial inputs to pollution control systems. Excess capacity in such firms can therefore usually be used to produce materials and equipment needed to control industrial discharges. If unemployment is a problem, expanding construction activities for control purposes would be especially attractive since the industry is very labor intensive.

Reducing Damage to Others

When a factory reduces or eliminates its corrosive emissions, the effect is to reduce its own and the neighboring plants' replacement and repair costs due to corrosion. The money saved can be used in more productive investment, thereby increasing the national product. In 1963 before passage of the Clean Air Acts, a United States Senate survey concluded, "Whatever yardsticks are employed, it is clearly evident that the cost of property damages alone from air pollution is great--far greater than the amounts devoted to its abatement by industry and all levels of government.[16] A more recent United States study estimated that for 1977, pollution-caused damage from industry processes would cost $7 billion without controls, and $3.7 billion with controls. Control costs were estimated at $1.2 billion. These estimates indicate that expenditures of $1.2 billion were expected to reduce the cost of industrial pollution damage to health, property, materials, crops, and forests by $3.3 billion. It was therefore anticipated that industrial pollution control would yield a net saving of $2.1 billion.[17]

When the control of industrial discharges eliminates their potential damage to other commercial interests, productive resources are released which may fully or partially compensate for the reduction in GNP caused by pollution control. When all the economic impacts of the costs and benefits of a control program are evaluated, the result will probably indicate a very small decrease in gross national product. This must be weighted against the social and economic benefits which GNP fails to measure.

Health As An Economic Plus

When a factory releases harmful discharges to the environment, the possibility of disease increases for everyone in the affected area. The plant's own operators, however, will have the greatest health risk. Factory workers are as important in the productive process as the machines they operate and tend. And like machines, people work better and more efficiently when they are in good condition. Illness and absence reduce productivity as much as equipment malfunction and downtime. Retraining and replacing personnel is usually costly and wasteful.

Recent studies have been made on the economic value of "human factors" (or human capital). The concept includes education, training, nutrition, and health. The results indicate that these factors have a substantial influence on long-term increases in labor productivity and the growth of national income. To the extent that pollutants diminish the productivity of labor and management, they will also have a depressing effect on GNP.

INVESTING IN CONTROL

When discharge standards are raised, most or all of the affected industrial firms will have to increase their invewtment in control systems. This will affect the allocation of capital in one of two ways. If total production is to remain the same, total capital requirements will have to be increased. If total capital investment remains the same,

some of it will have to be reallocated, or diverted, from customary to environmental productive needs.

Local manufacturing capability, raw materials, land, and labor can usually provide most of the equipment and other resources needed for pollution control purposes. In many instances, simple but properly engineered and operated treatment methods are as satisfactory as more costly capital-intensive pollution control treatment systems.

Capital Distribution

Unless additional capital can be raised, the purchase of pollution control equipment will cause a shift in the distribution of existing capital: total investment in environmental control systems will be matched by total reductions in non-environmental investment. This won't greatly affect the production of consumer goods unless present manufacturing facilities are being used near capacity, and a substantial proportion of the available funds for expansion are diverted to environmental needs.

The most polluting industries will require the largest amounts of capital to control their discharges. Industries which generate large quantities of air pollutants include iron and steel production, power generation, chemical production, and oil refining. Industries generating considerable water pollutants include chemical production, paper and pulp mills, fruit and vegetable canning, and breweries. Under mandatory control and a stationary supply of capital, there will be a shift of investable funds to firms in these or other polluting industries for abatement purposes.

The total impact of re-allocating investment will depend largely on the relation between the total cost of control investments and the value of overall production. Table 4-1 shows this for selected industrialized countries, giving estimates and projections for 1971 to 1980. The total costs of new pollution control investment for four countries during 1971-1980 were estimated to be less than one percent (0.2 to 0.7 percent) of gross national product. Calculated in relation to growth in production during the same period, the total operating and investment costs of pollution control were estimated to range from one percent to 7.6 percent of GNP growth.

HOW CONTROL CAN BENEFIT EARNINGS

Creation of a New Industry

However pollution control is financed, an abatement program means the development of a pollution control industry. Like any other industry, it will generate jobs, cash flow, products, and some wastes of its own which may also have to be controlled. Cleaning up the environment creates three types of directly related employment:

TABLE 4-1

POLLUTION CONTROL INVESTMENT COST
AS PERCENT OF GROSS NATIONAL PRODUCT

Period Country	Cost			
	Investment	Operating	Total	Total
	As Percent of Total GNP			As Percent of Growth in GNP
1971 - 1975				
United States	0.5	0.2	0.8	7.2
Germany	0.6	0.2	0.8	6.1
Sweden[a]	0.4	--	--	4.3
Italy	0.3	0.1	0.4	2.8
Japan[a]	2.6	--	--	9.7
Netherlands	0.4	0.05	0.4	3.8
1976 - 1980				
United States	0.7	0.9	1.7	13.4
Italy	0.6	0.6	1.2	7.4
Netherlands	1.0	0.3	1.3	10.6
1971 - 1980				
United States	0.6	0.7	1.4	6.8
United Kingdom[a,b]	0.2	--	--	1.1
Italy	0.5	0.4	0.9	3.1
Netherlands	0.7	0.2	0.9	7.6

[a] Excluding operating expenses.
[b] Solid waste not included.

Source: Organization for Economic Cooperation and Development. Economic Implication of Pollution Control: A General Assessment. Paris, Feb. 1974, p. 30.

- Constructing pollution abatement systems.
- Manufacturing the equipment and materials used in the systems.
- Operating and maintaining the systems after they are completed and in use.

Some estimates indicate that direct employment represents only one-fourth the total number of jobs resulting from a control program. Structures and services are needed in the manufacture of control equipment, and goods and services must be provided for the direct workers' personal consumption. Transport of people, materials, and equipment, the processing of raw materials, and many other related activities will generate indirect jobs. These effects will be most beneficial when unemployment rates are high. During the recent economic recession in the United States, for example, studies indicate that the unemployment rate was about 0.3 to 0.4 percent lower because of environmental programs.

Using Manual Labor

Where suitable, three approaches to abatement may increase jobs and reduce unemployment: labor-intensive control methods, solid waste recovery methods, and the use of low-polluting, labor-intensive production techniques.

Where alternative control systems are available, some may be more labor-intensive than others. These are simpler, less mechanized systems or parts of systems which are more labor than capital per unit of pollutant removed or treated. After treatment, for example, collected waste residues can be transported by carts instead of automatic conveyor belts and pipelines.

Employment in control operations can also be increased through resource recovery activities. Sorting of recyclable materials in solid waste, for example, can be largely done by hand. Metals, paper, plastics, glass, and other identifiable components are sometimes separated to facilitate both recovery and better processing and disposal of solid waste.

A third way to increase job opportunities through abatement is to substitute low-polluting, labor-intensive production methods for more polluting, capital-intensive technologies. This appears applicable where natural materials can be produced or used instead of synthetics, as in the rubber, leather, and fiber industries. The manufacture of synthetics can generate large quantities of hazardous pollutants and is very capital intensive compared with the production of similar natural products. The usefulness of this approach would depend on the suitability of local conditions for the production and manufacturing use of the natural raw materials, the existence of domestic or foreign markets for their consumption, the possible development of related salable new products, and/or the development of new markets for such raw materials or manufactured products.

HOW CONTROL MAY HURT EARNINGS

A control program may also have negative effects on earnings due to possible plant shutdowns, cutbacks in production, or reduced profits when costs can't be passed along in higher prices.

Shutting Down the Plant

Although strict standards will have greater impact than lower standards, pollution control alone rarely causes a plant to close. Where control contributes to plant closings in industrialized nations, it is frequently found that the plant was older and less efficient than competitive plants, or that it was to be retired or modified in the near future in any event.

In 1974, the United States Department of Commerce surveyed 72 companies which had either closed or planned to close one or more facilities. More than three-fourths of the companies said the following reasons contributed to their decisions: declining consumer demand, plant obsolescence, and higher operating costs.[18] It was also found that about two-thirds of the plants which threaten to shut down for control reasons manage to resolve their compliance problems and remain open, and some plants which actually close later decide to comply with control requirements and reopen.

The net effect on plant owners of control-caused closings will vary greatly depending on the salvage value of the closed plant, the remaining period which the plant could have operated profitably without control requirements, and alternate investment opportunities for capital generated by liquidating the polluting operation.

The net effect on employment of control-related closings will depend largely on local or regional conditions. There may be severe local unemployment, or the workers may be absorbed into other activities including those related to the abatement program. The number of discontinued jobs does not necessarily mean an equal number of workers will become unemployed. Most companies will try to increase or substitute less-polluting products or activities for those which did not meet control standards. Where the closed facility represents only part of an installation or company, workers on the eliminated jobs may simply be shifted to other work within the same firm. In other cases, similar companies which meet discharge standards may be able to employ the laid-off workers--especially if they increase production to meet the unsatisfied demand caused by the shutdowns.

The One-Company Town

Pollutant generation varies greatly among different industries. Industrial diversification will therefore lessen the possibility of severe unemployment. If, however, an area depends heavily on one highly polluting firm, plant cutbacks or closings would have a serious impact on all employment and services in the area.

The Smaller Plant

There are usually economies of scale in the costs of both production and pollution control: the larger the plant, the lower the costs will be per unit of both final product and abatement. Plant size will therefore influence the impact of control on both profits and possible plant closings. If most plants producing a given product are of similar size, similar proportions of the additional costs of control will be passed along in the final price. Where there is great disparity in plant size, the smaller plants will have proportionately larger control costs. This will make it more difficult for them to compete with larger plants, and some may have to close.

HOW DOMESTIC PRICES MAY CHANGE

An abatement program may cause the general price level to rise because:

- Increased costs of production are passed along to the consumer in the form of higher prices.
- Reallocation of investment reduces the supply of consumer goods, resulting in "excess demand."
- The materials and/or skilled manpower needed to produce and maintain the pollution control systems are in short supply.

Higher Production Costs

Most industrial control systems have capital and operating costs which will increase the total cost of production per unit of product. Where competition is keen, the manufacturer may absorb some of these costs. Where product markets are basically noncompetitive because of protective tariffs and subsidies or monopoly conditions, increased production costs will be largely passed forward to the consumer.

Unsatisfied Demand

When control needs cause a transfer of resources from consumer products to the manufacture or importation of pollution control equipment, the available supply of consumer goods will decline. If income and demand at the pre-control price remain the same or increase, there will be excess demand, or more demand than can be satisfied by the reduced supply. This will cause prices to rise unless the government intervenes. Higher income taxes, for example, would reduce the total amount of money available for consumer purchases, thereby reducing consumer demand and pressure on prices.

Shortages of Manpower and Materials

As previously stated, domestic materials and labor can usually supply and service most control system needs. In some situations, however, there may be a shortage of both the necessary skilled labor to install, supervise, operate, and maintain the control system, and of materials used in its operation. If the required manpower and materials must be imported from abroad, their costs will be substantially

higher than if domestic skills and materials can be used. Also, plants may have to shut down temporarily until the necessary workers and raw materials are brought into the country. If the need to import equipment and skills increases production costs, or related shutdowns reduce the supply of goods, prices will tend to rise.

Wage Demands

Unless there are wage and price controls, rises in the cost of living resulting from pollution control may possible lead to demands for higher wages and thus contribute to a wage-price spiral effect. If people associate pollution control with a cleaner environment and better living conditions, demands for higher wages and prices may be somewhat moderated. Government programs of information and persuasion might help to promote this attitude.

Net Effect on Prices

The effect of controls on prices will vary greatly from industry to industry, and country to country. A statistical study was made of probable changes in the United States consumer price index due to Federal clean air and water programs.[19] Annual increases in the index due to pollution control were projected as ranging from 0.09 percent in 1974 to a high of 1.24 percent in 1978, and then declining to 0.22 percent in 1982. In certain industries, however, high control costs might cause a rise of five percent or more in the price of related consumer products; in cleaner industries, controls would have little effect on consumer prices, and for some goods and services, a control program would have no direct effects on prices.

The above study included the effects on the price index of all public and private expenditures for control purposes. This means that increases in the index reflect the annual costs of required municipal sewage treatment systems, automobile exhaust controls, and many other required controls as well as industry's abatement costs. The costs of industrial pollution abatement would therefore be responsible for only a portion of the small estimated increases in the price index attributed to pollution control.

CHANGES IN THE BALANCE OF TRADE

The economic impact of a control program may affect a country's foreign trade and balance of payments. Three control-related factors which may influence foreign trade are: higher domestic prices, the need to import control equipment, and higher efficiency in producing exportable products.

Domestic Price Increases

A rise in domestic prices will usually depress exports and encourage imports, resulting in a less favorable balance of trade. If the price increase is due to an abatement program, however, home products will not be at a disadvantage unless competing products are manufactured in countries where industrial pollution is not controlled. Today, pollution

control programs are being introduced or expanded in practically every country with industrial development. Where they exist, therefore, trade disadvantages due to abatement costs will usually be temporary.

Impacts on the total foreign trade balance will also be small or non-existent if the affected goods are not normally exported, or if they represent only a small share of total exports. Also, if the price increase is only a small fraction of the product's total price, or if the original price was so low that foreign manufacturers can't meet the new price which includes increased control costs, foreign trade effects will be minimal.

A final trade consideration is elasticity of demand, or the degree to which consumer demand changes when prices rise or fall. Demand is called elastic when it falls proportionately more than a corresponding rise in price. It is called inelastic when it falls proportionately less than a rise in price.

When demand is elastic in the buying country (reacts greatly to changes in price), a price rise in the exporting country will cause total export revenues to fall: the rise in price will not compensate for the greater percentage decline in the quantities sold. When demand is inelastic in the buying country (reacts little to changes in price), a price rise in the exporting country will cause total export revenues to rise: the rise in price will more than compensate for the small percentage decline in quantities sold.

Several recent studies indicate that the export demand for manufactured goods is elastic. Price increases in export goods due to control costs will therefore usually reduce export revenues. This impact may be large or small, depending on the degree of increase in export prices, whether or not manufacturers in competing countries are subject to similar discharge standards, and supportive government measures such as export subsidies.

Demand elasticity in the home country will also influence foreign trade. If domestic prices rise and domestic demand is elastic, imports of competing goods will tend to increase unless the government imposes tariff barriers or import quotas. In any event, imports would not have a price advantage unless the basic price difference was greater than the combined costs of shipping and import duties.

Getting Control Equipment and Manpower from Other Countries

Possible imports for control purposes include equipment, materials such as fuel and chemicals, and personnel with special skills. Where any of these factors must be imported, import needs are likely to be large when control standards are high. With more moderate standards, most countries will be able to meet requirements without extensive imports of specialized equipment, materials, and personnel. In countries with an unfavorable trade balance, an increase in control-related imports might make it necessary to curb other imports. The value of a clean environment would then have to be weighed against alternative social or economic goals which also depend on imported equipment and materials. In most cases, however, it is possible to develop alternative satisfactory control methods which rely on domestic production, materials, and manpower.

The Real Price of Foreign Exchange

In countries where the foreign exchange market is strictly managed by the government, the balance of payment accounts frequently understate the real cost of imports to the economy. In these countries, the domestic price structure tends to get out of line with world prices during periods of domestic inflation unless the government devalues its currency. If this is not done, the value of foreign goods will be stated at too low a price compared with the current inflated prices of domestic goods. A simple example will illustrate.

If equipment is imported at a price of $10,000 and inflation doubles the domestic money supply, the equipment will then be worth $20,000 in the importing country's current money. But unless and until the foreign exchange rate is altered by devaluation, the true price or value of the equipment will be understated by half in the balance of payment calculations. Where this problem exists, a "shadow" or true foreign exchange rate may be computed. Based on this rate, more accurate estimates can be made of the impact of control-related imports on the balance of payments.

Reducing Waste to Increase Revenue

Industries which can achieve abatement through more efficient production and waste handling methods may improve their competitive export possibilities. Firms using control methods which reduce the total cost of production will have an advantage over similar foreign firms which do not use such controls. In this instance, pollution control would benefit export trade and the trade balance.

Recovery, recycling, and by-product use have the greatest potential as cost-reducing control methods. In many production processes, costs can be cut greatly by reusing wastewater. This is particularly true in food canning, steel manufacture, and other industries which use large quantities of water, and where different qualities of water are suitable for different processes.

Synthetic Versus Natural Materials

Because of continually rising petroleum costs, the basic cost of producing synthetics is projected to increase relative to the corresponding costs for natural leather, rubber, and fabri materials. Since the manufacture of synthetics generates pollutants, and most industrialized countries are trying to control pollution, abatement programs will further increase the price of synthetic materials. Countries which produce and market competing natural materials with less-polluting potential should therefore find increasing demand for them in foreign countries.

Net Effect of Control on Foreign Trade

Most control efforts will probably raise export product prices slightly. Others will reduce them or have little or no effect. If only one country controlled its industrial discharges, it would be at an economic disadvantage in the world market. This is far from the present situation, however. Countries throughout the world are increasing their present control requirements and planning for stricter future standards. In addition, many loans for developmental purposes require that the operation being financed must meet specified discharge standards. In general, the impact of control programs on the balance of foreign trade will probably be small and will tend to decline as industrial pollution control becomes more universal.

SUMMING UP THE TRADEOFFS OF CONTROL

An effective pollution control program will have a variety of economic costs. Some individuals and firms will be affected more than others. Negative impacts of control may include higher prices, local unemployment, reduced profits for some firms, and temporary or permanent shutdowns of marginal plants. Many of these impacts will be small and, where critical, government policy can minimize them through a more gradual control schedule, supportive loans, lower taxation, or other measures.

There will also be economic gains: the development of a pollution control industry which will generate new business opportunities and jobs; the protection of nearby business and agriculture against damage from polluting discharges; and the encouragement of resource recovery and less wasteful practices. Many gains will be largely social; most will have economic value as well: resource conservation; the protection of health and natural ecological relationships; and making those responsible for creating pollution hazards responsible for their control as well, for in the final analysis, only the polluting source is in a position to control its own discharges.

A recent study by investment analysts summarized: ". . . when all factors are considered, including the impact on health and property, there does seem to be an outright economic advantage to pollution control."[20]

CHAPTER 5

WHERE TO FIND MORE INFORMATION

Possible sources of information on the generation, effects, and control of industrial pollutants include government and institutional agencies throughout the world, an extensive literature published in many countries and languages, and libraries and other repositories of published, microfilmed, computerized, and taped information. This chapter can present only a partial list of the available sources.

GENERAL

Information sources in one's own country or region should usually be consulted first for two reasons: there will be no language barrier, and the information will generally relate to conditions in the home country. National and local institutions which may provide related information services include public libraries, universities, technical schools, public health departments, special government or other public and private agencies concerned with environmental matters, and industrial firms, representatives, and trade associations. Industrial sources can be especially useful for information on production and control equipment, methods, and materials including data on characteristics, costs, and waste discharges.

Embassy representatives can help direct inquiries to appropriate information sources in foreign countries. Initial inquiry should be addressed by mail, phone, or in person to either the foreign Embassy in the requesting party's own country, or to a representative of one's own Embassy in the foreign country where assistance is being sought.

Many information sources represent large complex organizations which provide a variety of services. Many of these services may not be related to the inquiring party's immediate environmental interests. When seeking assistance, it is therefore important to be as specific as possible in describing the problem, the area of interest, and the type of information being sought. This will help the agency or institution to refer the request to the proper office and personnel with the least delay.

Because communication by mail is often slow and time-consuming, personal contact may speed up receipt of materials and advice from any resource being consulted.

PERSPECTIVE

Industry representatives, conservationists, and government agencies frequently have divergent interests or viewpoints. In addition, environmental and industrial conditions vary depending on region, climate, geography, level of industrialization, and other local factors. The technical content and relevance of any information received should therefore be evaluated in the light of its institutional and regional origin. Consulting several sources with different interests and perspectives can help secure representative and balanced information.

Multi-national and National Agencies That Can Help

A three-part list of international, other multilateral, and national public agency information sources follows this chapter. The list gives headquarters addresses and brief descriptions of environmental pollution-related activities for: 1) United Nations Organizations, 2) regional multi-government organizations, and 3) United States Government departments and offices which are primarily or partially concerned with environmental matters. Because there are a great and increasing number of environmental agencies throughout the world, neither the list as a whole or any of its three sections is represented as complete.

For general information about the United Nations, contact the United Nations Information Center, Suite 714, 1028 Connecticut Avenue NW, Washington, D.C. 20036, U.S.A. for more detailed information on services and costs, contact the listed United Nations agencies directly. The regional multi-government organizations are listed as both 1) sources of information and 2) to illustrate multilateral efforts to resolve environmental problems which affect more than one country. Since environmental pollution from one country can impair the air and water quality of neighboring countries, such cooperative efforts may become increasingly important. The United States Government agencies were also selected for two purposes: 1) as sources of information, and 2) to illustrate the types of national organizations and services which may be useful in an individual country's industrial pollution control program. There are, however, many good government sources of information in other countries. Further information on these can be secured through the appropriate Embassy or the International Referral Service of the United Nations Environmental Program (described under United Nations organizations).

The information source list was prepared in August 1976. Government and other public agencies, their structure, functions, and locations, however, are subject to change.

BIBLIOGRAPHIC SOURCES

A bibliography follows the public agency list. It gives two types of bibliographic sources: 1) those which provide direct information on the topic being researched, and 2) indexes, directories, and collections of abstracts which identify the agencies, reports, or books which may provide such information.

Because current literature relating to industrial pollution control is so extensive, the table is only intended to indicate some of the many useful titles available. Further bibliographic information can be secured through reference librarians, card catalogs, and "books-in-print" directories at public, special, and university libraries.

PUBLIC AGENCY ENVIRONMENTAL INFORMATION SOURCES

SELECTED UNITED NATIONS ORGANIZATIONS

Director General
Office of the Secretariat
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO)
Via delle Terme di Caracalla
0100 Rome, Italy

Phone: 5797
Telex: 61181 FOODAGRI
Cable: FOODAGRI ROME

FAO helps promote education, research, training, facilities, and institutions related to food and agriculture--including forestry and fisheries. Its area of concern includes water pollution affecting marine and inland fisheries, use of soil and water resources, and animal production and health.

Director
Office of Executive Directors
INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT (IBRD)
1818 H Street NW
Washington, D.C. 20433, USA

Phone: 202-393-6360
Cable: INTBAFRAD WASHINGTON

NOTE: There are twenty separate Directors representing the Western Hemisphere, South Asia, Western Africa, Eastern Africa, East Asia and Pacific, Europe, Middle East, and North Africa Departments.

IBRD (World Bank) provides loans for productive enterprises and related technical assistance, including information on meeting pollution control requirements for its loans.

An affiliate at the same office, address, and phone number, the INTERNATIONAL DEVELOPMENT ASSOCIATION (IDA) performs the same function under more flexible financial terms.

Secretary-General
Trade and Development Board
UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT (UNCTAD)
Palais des Nations
CH-1211 Geneve, 10 Switzerland

Phone: 34-60-11, 31-02-11
Telex: 22212 or 22349
Cable: UNATIONS, GENEVE

UNCTAD research and assistance relates to agricultural and industrial production and trade, including the transfer of technology and the economic effects of pollution. It is concerned with policies and activities affecting external trade, economic development, and improved technological capacity.

Director General
Office of the Secretariat
UNITED NATIONS DEVELOPMENT PROGRAM (UNDP)
New York, N.Y. 10017
U.S.A.

Phone: 212-754-4790

With over 140 participating governments, UNDP is the world's largest program of technical cooperation. It promotes the sharing of technical knowledge, skills, personnel, and facilities, and provides grants for air and water pollution control and related programs.

Director General
Office of the Secretariat
UNESCO House
UNITED NATIONS EDUCATIONAL SCIENTIFIC, AND CULTURAL ORGANIZATION
7 and 9 Place de Fontenay
75700 Paris, France

Phone: 566-57-57
Cable: UNESCO, PARIS

UNESCO monitors scientific and technical publications throughout the world; provides abstracts and information through World Science Information System (UNISIST); and sponsors fundamental research, education, and training. Its areas of concern include environmental science and natural resources.

Executive Director
Office of the Secretariat
UNITED NATIONS ENVIRONMENT PROGRAM (UNEP)
P.O. Box 30552
Nairobi, Kenya

Phone: 33930
Telex: 22068
Cable: UNITERRA, NAIROBI

The UNEP Secretariat coordinates all environmental programs within the United Nations. It administers the Environmental Fund for research and programs to protect the environment. It recommends programs on air, land, and water pollution, and sponsors the International Referral System described below.

Director
National Environment Secretariat
Office of the President
International Referral System
UNITED NATIONS ENVIRONMENT PROGRAM (UNEP/IRS)
P. O. Box 30552
Nairobi, Kenya

Phone: 33930
Telex: 22068
Cable: UNITERRA, NAIROBI

UNEP/IRS is a referral system for sources of environmental information in participating countries. It provides international cooperation through a worldwide network consisting of National Focal Points, Subfocal points, and sources.

The National Focal Point inventories participating organizations within the given country, prepares a National Directory of Information sources for the IRS International Directory, and provides referral service for domestic and foreign IRS users.

Subfocal points are selected government and non-government agencies which identify and register information sources within their own organizations. A source provides information on a single aspect of the environment; it responds to questions submitted to it through the International Referral System.

Referrals are cost-free; costs of substantive information are the responsibility of the questioner and responding source.

For further information (including a list of National Focal Points), contact UNEP/IRS directly.

Executive Director
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION (UNIDO)
Lerchenfelderstrasse 1
P. O. Box 707
A 1070 Vienna, Austria

Phone: 43500
Telex: 75612
Cable: UNIDO

UNIDO coordinates all United Nations activities in the field of industrial development including industry-related pollution and control. It provides technical and training assistance for research and investigation.

Executive Director
Office of the Executive Director
UNITED NATIONS INSTITUTE FOR TRAINING AND RESEARCH (UNITAR)
801 United Nations Plaza
New York, N. Y. 10017
U.S.A.

The purpose of UNITAR is continuous examination of world problems including long-term trends (e.g., energy, raw materials, environment and technology). It provides training for United Nations diplomats, U. N. agency staffs, and national officials of developing countries. Research areas include the environmental effects of development projects.

Director General
Office of the Secretariat
WORLD HEALTH ORGANIZATION OF THE UNITED NATIONS (WHO)
Avenue Appia
1211 Geneva 27
Switzerland

Phone:	34-60-61
Telex:	27821
Cable:	UNISANTE GENEVE

As the central authority directing international health work, WHO provides administrative, research, technical information and services, and fellowships. Its areas of concern include national environmental health programs, training sanitation personnel, improving water supplies and waste disposal, and the control of air and water pollution. There are separate Regional Directors for Africa, Americas, Eastern Mediterranean, Europe, South-East Asia, and Western Pacific.

SELECTED REGIONAL MULTI-GOVERNMENT ORGANIZATIONS

Director
Environmental and Consumer Protection Service
COMMISSION OF THE EUROPEAN COMMUNITIES (CEC)
Rue de la Loi, 1049 Bruxelles

Phone: 735-0040
Telex: 21877 COMEU B

ECPS (CEC) pollution-related interests include: environmental quality; the prevention of air, waste, and noise pollution; water management; environmental planning and improvement; and international aspects of the Community's environmental quality problems.

Director
INSTITUTO CENTRO-AMERICANO DE INVESTIGACION Y TECHNOLOGIA INDUSTRIAL
Avenida Reforma 4-47, Zona 10
Apdo. postal 1237
Guatemala City, Guatemala

ICAITI (Central American Institute of Research and Industrial Technology) was organized by the five Central American Republics under the aegis of Central American Common Market (CACM), the Organization of Central American States (ODECA). It promotes the sharing of industrial technology and research including that related to pollution problems.

President
INTER-AMERICAN DEVELOPMENT BANK (IADB)
808 - 17th Street NW
Washington, D. C. 20577

Phone: 202-634-8000

The Bank's purpose is to promote the individual and collective economic development of its member countries. It finances industrial and other facilities in Latin America. Like the World Bank, it sets environmental standards as conditions for its loans and can provide information assistance related to meeting those requirements.

Committee on the Challenges of Modern Society
NORTH ATLANTIC TREATY ORGANIZATION (NATO)
NATO Information Service
1110 Brussels

Phone: (02) 241-0040
Telex: 23867 OTAN/NATO

CCMS (NATO) is concerned with international environmental problems. Areas of interest include: air pollution; inland and coastal water pollution; regional environmental planning; advanced wastewater treatment; hazardous waste disposal; and solar, geothermal, and other energy uses. Member countries sponsor research on voluntary basis; study results are available to non-NATO countries.

Secretary General
ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT (OECD)
2 rue André-Pascal
Paris 16, France

Phone: 542-82-00

OECD purposes include contributing to the economic expansion of non-member countries in the process of economic expansion. They conduct seminars and studies on the economics of pollution and environmental problems, and collect information on related activities in member countries.

Secretary General
General Secretariat
ORGANIZATION OF AMERICAN STATES (OAS)
17th Street and Constitution Avenue NW
Washington, D. C. 20006

Phone: 202-393-8450

OAS performs broad regional, technical studies relating to trade, energy, pollution, development, and treaties; and promotes cooperation and the exchange of information among its member countries.

Director
PAN AMERICAN HEALTH ORGANIZATION (PAHO)
Pan American Sanitary Bureau
525 Twenty-third Street NW
Washington, D. C. 20037

Phone: 202-223-4700

PAHO was formed under the aegis of the Organization of American States (OAS), with assistance from the United Nations. It now serves as the Regional Office for the Americas of the World Health Organization. Its purpose is to coordinate health-promoting efforts of countries in the Western Hemisphere.

Note: There are regional organizations associated with the United Nations in Africa, Asia, Europe, and other areas. The above are listed to illustrate some of the types of services available. For information on other regional agencies, contact your own government or the United Nations directly.

SELECTED UNITED STATES GOVERNMENT SOURCES OF INFORMATION

Note: Because Government telephone numbers are subject to change, they have been omitted from the table. Please consult the Washington, D. C. telephone directory or information operator (202-555-1212)

Secretary of Agriculture
Office of the Secretary
UNITED STATES DEPARTMENT OF AGRICULTURE
14th Street and Independence Avenue SW
Washington, D. C. 20250

The Department of Agriculture has many programs of research, education, and public information relating to environmental quality impacts on farm crops and animals.

For general information, contact the Director, Office of Communication, Department of Agriculture, Washington, D. C. 20250.

Administrator
AGRICULTURAL RESEARCH SERVICE
United States Department of Agriculture
14th Street and Independence Avenue SW
Washington, D. C. 20250

ARS performs studies and tests on protecting crops and farm animals against pollution, the use of nonpesticidal methods, and utilizing farm waste products to minimize air, land, and water pollution.

For general information, contact the Information Division, Agricultural Research Services, Department of Agriculture, Washington, D. C. 20250.

Chief
UNITED STATES FOREST SERVICE
Department of Agriculture
Washington, D. C. 20250

The Forest Service manages national forests and grasslands. Its objectives include environmental protection and conservation, and it performs basic research in related areas.

For general information, contact the Information Office, U. S. Forest Service, Department of Agriculture, Washington, D. C. 20250

Chief
Office of Marine Environment and Systems
UNITED STATES COAST GUARD
400 Seventh Street, SW
Washington, D. C. 20590

The Coast Guard enforces environmental laws relating to coastal waters. It has a marine environmental protection program aimed at prevention, detection, and control of pollution on and adjacent to United States navigable waters. It monitors hazardous spills from industrial or other sources.

Secretary of Commerce
Office of the Secretary
UNITED STATES DEPARTMENT OF COMMERCE
14th Street between Constitution and E Street, NW
Washington, D. C. 20230

The Department is a major source of information on available process and pollution control equipment, related materials, basic costs, and shipping details. It does extensive data gathering and analysis in all areas relating to production and trade, including pollution control technology.

Information on Commerce Department publications is available at the Information Center of the National Technical Information Service, Main Commerce Building, Washington, D. C. 20230. For general information, contact the Special Assistant for Public Affairs and Director of Communications, Department of Commerce, Washington, D. C. 20230

Director
NATIONAL TECHNICAL INFORMATION SERVICE
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

NTIS is a clearing house for Department of Commerce publications and for data files and scientific and technical reports of many agencies of other federal departments. Information is available in one or more of the following forms: paper copy, microfiche, magnetic tape, and punched cards.

Major services include: Weekly Government Abstracts, Environmental Pollution and Control (summaries of most unclassified federally funded research as completed and made available to the public); Published Searches (bibliographies on selected subjects developed in anticipation of users' needs--primarily from over 600,000 federally funded citations and the Engineering Index worldwide engineering research data base); On-Line Searches (custom searches to satisfy a very specific information need); Selected Research in Microfiche or SRIM (automatic biweekly service which provides complete government research reports--not abstracts--on users' preselected topics).

All NTIS publications and services must be sold at a price which recovers cost. In some countries, orders can be placed locally through NTIS-trained representatives. Where available, this service reduces mail cost and foreign exchange problems. For further information on all available services, contact NTIS directly.

Chief of Engineers
Office of the Chief of Engineers
UNITED STATES ARMY CORPS OF ENGINEERS
Washington, D. C. 20314

The Corps of Engineers is responsible for structural engineering relating to federal water-waterways, ocean dumping, dredging, draining, and designation of safe disposal sites. Its Civil Works Program involves engineering works such as major dams, levees, harbors, and locks; water supply for industrial and municipal use; generation of hydroelectric power; river regulation for improved water quality; enhancement of fish and wildlife; and protection of ocean and lake shores.

For general information, contact the Public Affairs Office, Office of the Chief of Engineers, Washington, D. C. 20314

Chairman
UNITED STATES COUNCIL ON ENVIRONMENTAL QUALITY
Executive Office of the President
722 Jackson Place, NW
Washington, D. C. 20006

The Council is the national environmental advisor to the President, and assists in preparing the President's annual environmental quality report to the Congress.

For general information, contact the Director, Information Office, Council on Environmental Quality, Washington, D. C. 20006.

Administrator
Office of the Administrator
UNITED STATES ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
20 Massachusetts Avenue NW
Washington, D. C. 20545

ERDA does research and development work relating to energy from fossil, nuclear, geothermal, and other sources. Information on technical reports and other publications is available at the above office.

For environmental information relating to energy operations and development, contact the Division of Biomedical and Environmental Research, ERDA, at the above address. For general information, contact the Director, Office of Public Affairs, Energy Research and Development Administration, Washington, D. C. 20545.

Administrator
Office of the Administrator
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
401 M Street, SW
Washington, D. C. 20460

USEPA is the government's primary regulatory, investigative, and administrative agency in all matters relating to environmental protection. It develops national programs, technical policies, and regulations for air, land, and water pollution control. Its activities include research, monitoring, standards setting, enforcement, environmental impact statement review, training programs, and technical assistance. It publishes extensively on the generation, effects, and control of industrial discharges; and the management of hazardous and toxic wastes including radioactivity, pesticides, and heavy metals.

For general information, contact the Director, Office of Public Affairs, Environmental Protection Agency, Washington, D. C. 20460

Administrator
Office of the Administrator
UNITED STATES FEDERAL ENERGY ADMINISTRATION
12th Street and Pennsylvania Avenue, NW
Washington, D. C. 20461

FEA's primary concern is energy supply and conservation. Its research areas include energy conservation by redesign of industrial processes.

For general information, contact the Director, Office of Communications and Public Affairs, Federal Energy Administration, Washington, D. C. 20461

Secretary of Health, Education, and Welfare
Office of the Secretary
UNITED STATES DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
330 Independence Avenue, SW
Washington, D. C. 20201

HEW has administrative responsibility for all federal health services and activities, including health-related research, training, and investigations.

For general information, contact the Director, Information Center, Department of Health, Education, and Welfare, Washington, D. C. 20201

Director
NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH
United States Department of Health, Education, and Welfare
9000 Rockville Pike
Bethesda, Maryland 20014

The Institute performs research on the biological effects of chemical, physical, and biological substances in the environment.

For information on publications of the National Institutes for Health, contact the Associate Director for Communications, Division of Public Information, Office of Communications, NIH, 9000 Rockville Pike, Bethesda, Maryland 20014.

Assistant Secretary for Health
UNITED STATES PUBLIC HEALTH SERVICE
Office of the Assistant Secretary for Health
Department of Health, Education and Welfare
5600 Fishers Lane
Rockville, Maryland 20852

The United States Public Health Service has overall responsibility for protecting public health against disease from any source and for developing cooperation in health projects with other nations.

For general information, contact the Director, Office of Public Affairs, Public Health Service, 5600 Fisher s Lane, Rockville, Maryland 20852.

Secretary of the Interior
Office of the Secretary
UNITED STATES DEPARTMENT OF THE INTERIOR
C Street between 18th and 19th Streets, NW
Washington, D. C. 20240

Department of the Interior activities include the conservation and development of mineral and water resources; promotion of mine safety; conservation, development, and use of fish and wildlife resources; preservation of scenic and historic areas; reclamation of arid lands; and management of hydroelectric power systems.

For general information, contact the Director, Office of Communications, Department of the Interior, Washington, D. C. 20240

Director
UNITED STATES FISH AND WILDLIFE SERVICE
Department of the Interior
Washington, D. C. 20240

The Service provides leadership in protecting land and water environments (habitats) through scientific research; surveillance of pesticides, heavy metals and thermal pollution; fish, wildlife, and ecological studies; river basin environmental impact statement review; and many education and information services.

For general information, contact the Assistant Director for Public Affairs, U. S. Fish and Wildlife Service, Department of the Interior, Washington, D. C. 20240.

Director
UNITED STATES GEOLOGICAL SURVEY
Department of the Interior
National Center
12201 Sunrise Valley Drive
Reston, Virginia 22092

The Survey supervises industrial operations under geothermal, oil, shale, mining, and gas leases on public domain including the outer Continental Shelf to prevent waste of the mineral resources, limit environmental damage and pollution, and protect public health and safety. It monitors and tests ground and surface water quality.

For general information, contact the Information Officer, U. S. Geological Survey, Department of the Interior, Reston, Virginia 22092.

Director
UNITED STATES BUREAU OF MINES
Department of the Interior
2401 E Street, NW
Washington, D. C. 20241

The Bureau is primarily a research and fact-finding agency. Environmental concerns include solid waste recycling, abatement of pollution and land damage caused by mineral extraction and processing, and mine health and safety.

For general information, contact the Director, Office of Mineral Information, U. S. Bureau of Mines, Washington, D. C. 20241.

Director
UNITED STATES NATIONAL PARK SERVICE
Department of the Interior
Washington, D. C. 20240

The functions of the National Park Service are to protect the natural environment of national park areas, preserve historic properties, and present environmental education programs.

For general information, contact the Assistant to the Director for Public Affairs, National Park Service, Department of the Interior, Washington, D. C. 20240.

Commissioner
UNITED STATES BUREAU OF RECLAMATION
Department of the Interior
Washington, D. C. 20240

To reclaim arid or semi-arid lands, reclamation projects include regulation, conservation, and use of water and related resources; basin-wide water studies; and other multipurpose regional studies. In cooperation with other agencies, the Bureau also gives technical assistance to foreign countries in water resource development and use.

For general information, contact the Director, Office of Public Affairs, Bureau of Reclamation, Department of the Interior, Washington, D. C. 20240.

Director
OFFICE OF WATER RESEARCH AND TECHNOLOGY
Department of the Interior
Washington, D. C. 20240

OWRT conducts research and development activities, training programs for scientists and engineers, and information programs related to water resource problems. Its purpose is to develop new or improved technology and methods for the protection and use of water resources, including the conversion of saline water to water suitable for agricultural, industrial, and municipal use.

Chairman
UNITED STATES NUCLEAR REGULATORY COMMISSION
Washington, D. C. 20555

The Commission's purpose is to ensure that civilian uses of nuclear energy are consistent with public health, safety, and environmental quality.

For a list of Commission reports available from NTIS, United States Department of Commerce, contact the Director, Division of Technical Information, Nuclear Regulatory Commission, Washington, D. C. 20555

Secretary of State
Office of the Secretary
UNITED STATES DEPARTMENT OF STATE
2201 C Street, NW
Washington, D. C. 20520

The Department of State is responsible for the direction and supervision of all foreign and inter-governmental relations.

For general information, contact the Assistant Secretary for Public Affairs, Bureau of Public Affairs, Department of State, Washington, D. C. 20520

Administrator
AGENCY FOR INTERNATIONAL DEVELOPMENT
Department of State
320 - 21st Street NW
Washington, D. C. 20523

AID provides technical and financial assistance to increase economic independence and improve the quality of life in certain less developed countries. Its programs include environmental protection.

For general information, contact the Director, Office of Public Affairs, Agency for International Development, Department of State, Washington, D. C. 20523.

Assistant Secretary for
BUREAU OF OCEANS AND INTERNATIONAL ENVIRONMENTAL
AND SCIENTIFIC AFFAIRS
Department of State
2201 C Street, NW
Washington, D. C. 20520

The Bureau formulates and implements policies for United States participation in international science and technology programs relating to oceans, weather, atmosphere, fisheries, wildlife, conservation, environment, population, food, health, and nuclear energy.

Director
Smithsonian Science Information Exchange, Inc.
SMITHSONIAN INSTITUTION
1730 M Street, NW
Washington, D. C. 20036

The Exchange (SSIE) maintains a central data base of information on research in progress within the past two government fiscal years. It annually collects, indexes, stores, and retrieves information on about 100,000 government, non-government, and foreign research projects in all fields of life and physical sciences (including agriculture, biology, chemistry, earth science, electronics, engineering, materials, mathematics, and medical science).

SSIE can provide a brochure describing the available custom search services and their prices.

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See last page for further information.

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GLOSSARY

abatement: Any reduction in the amount, degree, or intensity of pollution.

absorption: Is the process of dissolving a gas (or a component of a gas mixture) in a liquid to yield a solution.

activated carbon: A highly effective, very porous adsorbent; used to remove organic matter from wastewaters or dirty air, or to reduce odor, color, and toxicity.

activated sludge process: Use of biologically active sewage sludge in secondary waste treatment to speed breakdown of organic matter in raw sewage.

adsorption: The process in which a gas, component of a gas mixture, vapor, or dissolved substance becomes affixed to the surface of a solid material (called a sorbent or adsorbent).

aeration: A process of dissolving atmospheric or pure oxygen in water or wastewater in order to supply sufficient oxygen for biological or chemical treatment processes. Accompanying agitation of liquid speeds biological and chemical action.

aerobic: Referring to life or processes which require free oxygen.

afterburner: A device for additional incineration of unburned or partially burned carbon compounds in emissions before their discharge into ambient air.

air pollution: The presence of contaminants in the air at a level which adversely affects health, safety, comfort, or the full use and enjoyment of property; or act of discharging pollutants into the air.

air quality standards: A defined level of pollutants in outside air which cannot be legally exceeded during a specified time and/or in a specified geographic location.

ambient air: Outside air; any unconfined part of the atmosphere.

anaerobic: Referring to life or processes which exist in the absence of free oxygen.

aquatic plants: Plants which grow in water--either on the surface (floating), under the surface, or from the bottom of the body of water.

assimilation: The ability of receiving air or water to purify itself of pollution.

bacteria: One-celled microorganisms; some cause disease, others are useful in pollution control because of their ability to break down organic matter in air and water.

baffle: A device which deflects (or changes the direction of) flow or velocity as of water, sewage, ash, or particulates.

biodegradable: Refers to the ability of a substance to be consumed in biological processes.

biochemical oxygen demand (BOD): An indirect measure of the amount of organic compounds contained in wastewater; computed from the quantity of oxygen used under standard conditions by aerobic microorganisms in oxidizing the organics in the wastewater in a specified period of time.

capital intensive: Refers to industries or processes in which capital investment requirements are high in comparison with labor requirements, as in highly automated production processes.

carcinogen (carcinogenic): Substance which causes (or is capable of causing) cancer.

centrifugal collector: A mechanical system which uses centrifugal force to remove unwanted substances from a gas stream.

chemical oxygen demand (COD): An indirect measure of the quantity of organic compounds in wastewater; calculated from the amount of a chemical oxidant used in oxidizing those compounds.

chlorination: The application of chlorine to drinking water, sewage, or industrial wastes to disinfect or oxidize undesirable compounds.

clarifier: A settling tank which mechanically removes settleable solids from wastewater.

coagulation: Using chemical agents such as lime, salts of alum, and iron to cause small particles to combine into bigger settleable ones; used for speeding clarification.

combustion: The burning of any substance, and a major contributor to air pollution.

compaction: Reduction of solid waste volume in a landfill through compression by rolling and tamping.

compost: Decomposed, relatively stable, organic material; primarily used as a soil conditioner.

cooling tower: A device for removing excess heat from cooling water used in industrial processes.

cooling water: Water used to reduce the excess heat of materials or equipment in industrial processes.

cover material: Soil used to cover the compacted solid waste in a sanitary landfill.

cyclone collector: Mechanical system which uses centrifugal force to collect particulates in polluted air.

decomposition: Chemical disintegration of organic matter through the actions of aerobic or anaerobic microorganisms.

depreciation: Annual deductions from the investment value of a fixed asset based on its estimated useful life.

digester: Closed tank in a wastewater treatment system which decreases volume of solids and stabilizes (decomposes) raw sludge through anaerobic bacterial action.

discharge standard: See emission (effluent) standard.

dispersant: Chemical agent which breaks up concentrations of organic material; used in oil spills.

dissolved oxygen (DO): Oxygen dissolved in water or sewage. Needed to support aquatic life and prevent offensive odors. Low concentrations often due to inadequate waste treatment (discharge of excessive organic solids with high BOD requirements).

distillation: Separation of impurities in water by evaporation and condensation; vapor is condensed into nearly pure water and impurities remain in residue.

dry limestone process: Method of removing sulfur oxide air pollutants; limestone combines with oxides of sulfur to form manageable residues.

dump: Land site where solid waste is disposed of without taking measures to protect the environment.

ecology: Interrelationships of living things to each other and their respective environments.

ecosystem: Interacting system of any biological community or system and its non-living environment.

effluent: A discharge of wastewaters (treated or in their natural state) into the environment.

electrodialysis: A process using continuous electrical current and semi-permeable membranes to separate soluble inorganic matters from water--especially salt (desalination).

electrostatic precipitator: Air pollution control device which uses electrocharged surface to collect particulates from an emission.

emission: A discharge into the environment of treated or untreated air pollutants.

emission (effluent) standard: Maximum amount of an air (water) pollutant which may be legally discharged from a single source.

enrichment: Addition of nitrogen, phosphorus, carbon compounds, or other nutrients into a body of water, increasing growth potential for algae and other undesirable aquatic plants; enrichment is most frequently due to sewage effluent or agricultural runoff.

environment: All external or surrounding conditions, influences, and forces which affect the life, development, health, and survival of humans and other organisms.

environmental impact statement (or report): A document which reviews the probable environmental effects of a proposed project, legislation, or activity.

environmental medium: Air, land, or water exposed to the natural elements and capable of receiving polluting discharges from industrial, municipal, agricultural, or other sources.

eutrophication: A normally slow aging process of a lake and other bodies of water in which enrichment causes algae and other microscopic plant life to become superabundant, with eventual drying up of the lake; can be greatly accelerated by nutrients discharge (see enrichment).

evaporation pond: A shallow, artificial pond where sewage is pumped for drying.

externalized costs of pollution: All social and economic costs of environmental pollution which are shifted to parties other than the polluting source (outside the market).

fecal coliform bacteria: Organisms common to the intestinal tracts of man and animals; used as an indicator of pollution and bacterial contamination.

filtration: Mechanical process to remove particulate matter in wastewater, usually by passing the effluent through sand, crushed coal, or mixed media.

flocculation: Process of separating suspended solids in wastewater by creating flocs or clumps through chemical action.

flue gas: Mixture of gases emerging from a chimney or smokestack as the result of combustion.

fly ash: All solids carried in a gas stream (ash, cinders, charred paper, soot, and other partially incinerated matter).

fossil fuels: Fuels derived from remains of ancient plant or animal life: coal, oil, and natural gas.

garbage: Food wastes of animal or vegetable origin.

generator: Device which converts mechanical energy into electrical energy.

gross national product (GNP): The monetary value of a country's total quantity or flow of goods and services produced in one year. GNP = C + I + G (consumer expenditures + investment expenditures + government expenditures).

groundwater: Water supply under the earth's surface which forms the natural reservoir for man's use.

hazardous air pollutant: A pollutant which may cause or contribute to mortality or serious illness. Asbestos, beryllium, and mercury are considered hazardous air pollutants.

heavy metals: Metallic elements with high atomic weights; generally toxic to plant and animal life in excessive concentrations. Examples include cadmium, chromium, lead, mercury, etc.

hydrocarbons: Large family of compounds which contain carbon and hydrogen, found especially in fossil fuels. Some are carcinogenic; others contribute to photochemical smog.

incineration: A controlled process for the burning of solid, liquid, or gaseous wastes to produce gases and residues containing little or no combustible material.

inertial separator: Air pollution control device which removes particulate matter from an air or gas stream based on the principle of inertia.

intangible costs: Costs which are difficult to measure in money, such as harmful health or ecological effects caused by environmental pollution.

internalized costs of pollution: Costs of potential or actual environmental pollution which have been shifted back to the polluting source in such forms as pollution control investment, effluent/emission charges, or penalties.

labor intensive: Refers to industries or processes in which labor requirements are high in comparison with capital investment requirements, as in operations which use large inputs of human labor relative to capital investment.

lagoon: A pond (usually man-made) where wastewater is restored to reasonable purity through the interaction of sunlight, bacteria, and oxygen.

leachate: Liquid that percolates through solid waste, soil, or other media from which it has extracted dissolved or suspended materials.

monitoring: determination of the amount of pollutants in the environment.

net national product (NNP): GNP after deductions have been made for capital depreciation.

nutrients: Elements or compounds which are essential for the growth and development of living matter.

organic: Relating to or derived from living organisms; in chemistry, any compound which contains carbon.

organism: Any living human, plant, or animal entity.

outfall: Mouth of sewer, drain, or conduit from which effluent is discharged into receiving waters.

oxidant: Any substance that oxidizes another substance in water or air. Oxidants are primary contributors to photochemical smog.

oxidation pond: Man-made lake or pond where organic wastes are reduced by biological action; process is frequently speeded up by aeration.

ozone: A toxic gas which is a major air pollutant and a component of photochemical smog.

packed tower: An air pollution control device packed with crushed rock or wood chips. Polluted air is forced upward through the packing material, while liquid is sprayed down onto it. Pollutants either dissolve in or react chemically with the liquid.

PAN (peroxyacetyl nitrate): Pollutant caused by reaction between sunlight and hydrocarbons and nitrogen oxides; integral part of photochemical smog.

particulates: Minute, separate solid or liquid particles on the air or in an emission. They include dust, fog, fumes, mist, smoke, and spray.

pathogen: A bacterium, virus, or other microorganism capable of causing disease.

pH (active reaction): Refers to the concentration of hydrogen ions in water solutions. Values of pH equal to 7, more than 7, and less than 7 correspond respectively with neutral, alkaline, and acid reactions. The desirable range for receiving waters is approximately from 6.5 to 8.

photochemical smog: Air pollution involving oxidants rather than particulates, sulfur oxides, etc. Damages plants and irritates human eye and respiratory systems.

point source: An individual source of large discharges to the environment; commonly an industrial source.

pollutant: Any introduced gas, liquid, or solid substance which reduces environmental purity and makes a resource less fit for a specific purpose.

pollution: The presence of matter, heat, or energy which causes undesirable environmental effects.

potable water: Water which is suitable for drinking and cooking from the standpoint of health and aesthetics.

pretreatment: Any process which reduces pollution load in wastewater before it enters a main sewer system or is delivered to a treatment plant for more substantial reduction of the pollution load.

primary treatment: First stage in wastewater treatment in which most floating and settleable solids are removed by screening and sedimentation.

raw sewage: Untreated domestic or commercial wastewater.

real gross national product: GNP which has been adjusted for changes in the price index or current value of money.

receiving waters: Natural bodies of surface waters (rivers, lakes, oceans, etc.) which receive treated or untreated wastewaters.

recycling: Transformation of waste materials into new products for reuse; frequently used interchangeably with reuse.

refuse reclamation: The process of converting solid waste to useful or saleable by-products, as in composting organic wastes to produce a soil conditioner.

runoff: Rainfall, melted snow, or irrigation water which flows over the surface of the ground and is eventually returned to receiving bodies of water. Runoff picks up pollutants from the air and land.

sanitary landfill: A land site where the disposal of solid waste is engineered to protect the environment by alternating and compacting thin layers of solid waste and soil cover.

screening: The process of removing coarse floating and suspended solids by straining wastewater through racks or screens.

scrubber: An air pollution control device which uses a liquid spray to remove pollutants from a gas stream by a process of absorption or chemical reaction.

secondary treatment: Treatment of wastewater beyond the primary state; usually biochemical action in which bacteria consume organic parts of the waste; accomplished through the use of trickling filters or activated sludge. Chlorination is customary final stage of secondary treatment.

sedimentation tanks: Tanks where solids are allowed to settle or float for removal in wastewater treatment.

self-purification: A process in which natural and man-made pollutants in the environment are converted so as to maintain the normal dynamic equilibriums in nature.

settleable solids: Small particles of solid matter which are sufficiently heavy to settle out of wastewater.

settling chamber: An air pollution control device which reduces the velocity of flue gases so that fly ash can settle out.

settling tank: A tank or basin which removes settleable solids from wastewater by gravity.

silt: Fine particles of soil or rock; often suspended in water and eventually deposited as sediment.

sludge: Solids removed from sewage during wastewater treatment. Sludge may be dumped, incinerated, or buried.

smog: Used as an equivalent of either general air pollution or photochemical smog.

social costs: Any costs which reduce welfare. Differences between social and economic costs are not well-defined, and social costs may include both concepts as in unemployment or health costs. See socioeconomic costs.

socioeconomic costs: Relating to or involving a combination of social and economic costs which reduce welfare.

solid waste: Useless, unwanted, or discarded materials with little or no liquid content.

stationary source: A fixed source of pollution as distinguished from moving sources such as automobiles and airplanes.

surface water: Bodies of water on the earth's surface which are exposed to the atmosphere (oceans, rivers, lakes, streams).

suspended solids (SS): Particles of solid pollutants which contribute to water turbidity.

tangible costs: Costs which can be readily measured in money.

temperature inversion: An atmospheric condition in which a layer of cool air is trapped under a layer of warm air which prevents it from rising. Inversions spread polluted air horizontally rather than vertically, thereby interfering with the dispersal of contaminating substances.

tertiary treatment (advanced waste treatment): Treatment of wastewater beyond the secondary stage; includes removal of nutrients and a high percentage of suspended solids, and produces a high quality effluent.

thermal pollution: A condition in which water quality is degraded by the introduction of heated effluent; typically caused by discharge of cooling waters from electric power generation or other industrial processes.

toxic pollutants: Pollutants which can cause disease, death, mutations, deformities, or malfunctions in any organisms (including humans) or their offspring.

trace elements: Metals and non-metals which are significant for the environment, even in minute quantities.

trickling filter: A secondary biological wastewater treatment device using a bed of rocks, stones, or plastic which can support bacterial growth; sewage is trickled over the bed to enable bacteria to break down organic wastes in the presence of counter-flowing air.

turbidity: Haziness in air due to the presence of particulates or other pollutants, or cloudiness in water due to suspended silt or fine particles of organic matter.

vector: A disease carrier capable of transmitting a pathogen from one organism to another. Common vectors include flies, rodents, and vermin.

wastewater: Water which carries wastes from homes, commercial businesses, and industry.

water pollution: Degradation of natural water quality caused by the addition of industrial wastes, sewage, or other harmful material.

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