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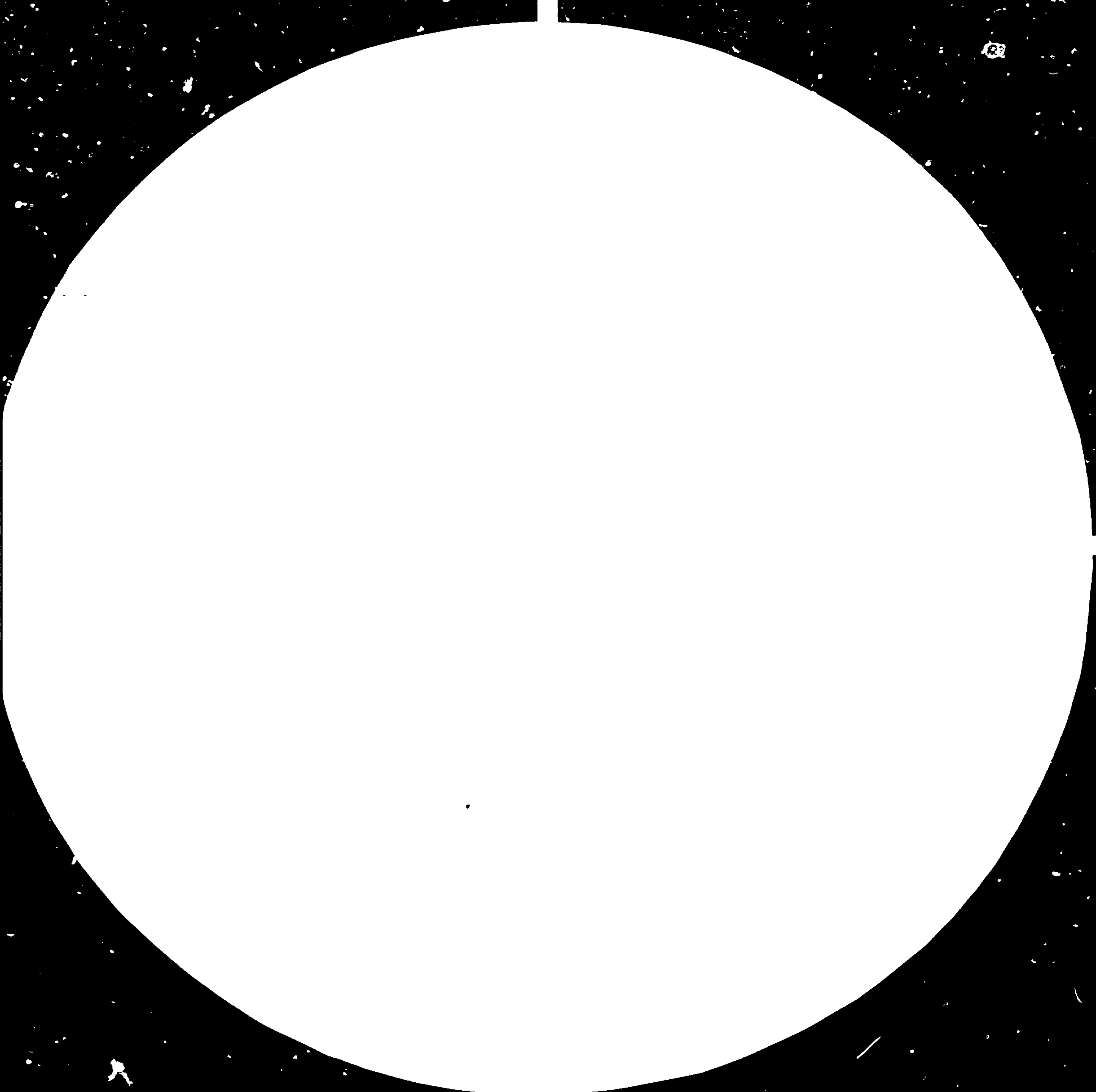

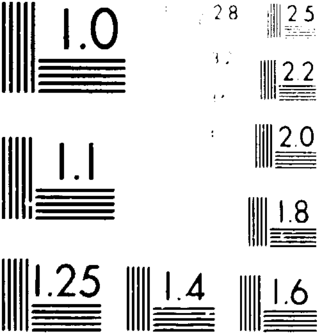
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INDUSTRIALIZATION AND ENVIRONMENTAL QUALITY: A SELECTED BIBLIOGRAPHY[1/]

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1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO.

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FOREWORD

UNIDO has undertaken to develop an active programme in the Environmental Aspects of Industrial Development. To this end, it is providing direct technical assistance to the developing countries in this field as well as conducting studies which are designed to support the technical assistance programmes.

The first study entitled Industrial Development and the Environment was prepared by UNIDO as its basic input into the "UN Conference on the Human Environment" held in Stockholm, Sweden, in June 1972. That study begins with a brief introduction to the main issues involved in the relationship between industrial development and the environment and proceeds to discuss (1) the consequences of industrial processes and/or products upon the environment, (2) the range of available approaches to the management of the environment by industry and (3) recommendations for action in this field which are categorized by major agenda items of the Stockholm Conference. The study also outlines the range of UNIDO's activities in providing technical assistance to the developing countries in this field.

It is common knowledge that without appropriate planning, management and control techniques many industrial processes and products will have a detrimental effect upon the environment. The purpose of the present study was to compile a generalized and selected bibliography of English-language publications on the detrimental environmental effects of industrialization, with particular emphasis being placed upon publications that would be helpful in identifying industries whose operations produce such effects. This bibliography limits itself to publications which discuss only those detrimental environmental effects directly related to the location and operation of the largest polluting industrial sectors. Every attempt was made to select only materials that might be helpful and appropriate to those interested in industrial development. In this context, part II of the study discusses "Environmental Pollution: overview and problems in selected industries" whereas the remainder of the study is devoted to the classification, categorization and listing of specific publications. It is thought that this work will, therefore, provide policy-makers, managers and those interested in the environmental aspects of industrial development with a list of materials that can be helpful to them in formulating and implementing policies and programmes in this field.

Since the present study provides guidance to many printed materials relevant to the identification and generalized aspects of the detrimental environmental effects in selected industrial sectors, UNIDO intends to utilize it as a basis for further work which will concentrate upon specific problems, and methods and technology available for solving these problems, in specific industrial sectors. Any comments on this paper or suggestions regarding additional items for inclusion in subsequent issues would be much appreciated.

Industrial Sectors Development Section
Industrial Technology Division

PART I

INTRODUCTION

Part I of this report discusses the purpose of the project and the general approach and scope of the project. Part II presents first some definitions, concepts, classifications, and relationships that provide a brief introductory overview of environmental pollution and its control, especially of pollution associated with industrialization. Part II also discusses, wherever practicable, the production processes, potential pollutants, and pollution control measures of firms in selected industrial categories. Part III presents a list of selected periodicals and a guide to the bibliography, which is presented in Part IV.

Purpose of the Project

The purpose of the project is to compile a bibliography of English-language publications on the detrimental environmental effects of industrialization, with special attention being paid to identifying materials that would be helpful in identifying industries whose operations produce detrimental effects on the envirorment.

Approach of the Project

The general approach used in this project is (1) to conduct a thorough library search, (2) to survey the economics literature on pollution and relevant related topics, (3) to write to persons and organizations who are interested in environmental quality, (4) to subscribe to the reference service of NTISearch, a service of the National Technical Information Service of the U.S. Department of Commerce, and (5) to carefully select bibliographical references for inclusion.

An exhaustive search was conducted in the general library as well as in the government documents section (a federal depository) of the Northern Illinois University library for materials to be included in the bibliography.

The survey of the literature in economics dealing with pollution and related topics was conducted through the use of the Index of Economic Journals and the Index of Economic Articles (1950 through 1968) and the Journal of Economic Literature (1969 through 1971).

Nearly 200 letters of inquiry, asking about bibliographies and other materials related to the projects, were sent to individuals, selected corporations, private associations, research institutes, federal, state, regional, and selected local or metropolitan agencies, and agencies in six English-speaking foreign countries. There was a 64 per cent response. The mailing list is not reproduced here but details can be furnished on request. Among those who responded, the following parties were especially helpful:

Esso Research and Engineering Company

(The) International Bank for Reconstruction and Development

Mobil Oil Corporation

New England Interstate Water Pollution Control Association

Organization for Economic Cooperation and Development

Resources for the Future (Dr. Allen V. Kneese)

State of California, Air Resources Board

State of New York, Department of Health

Tennessee Valley Authority

U.S. Department of Health, Education, and Welfare, National Air Pollution Control Administration

U.S. Department of the Interior, Bureau of Mines

U.S. Environmental Protection Agency

In order to help assure that the bibliography was compiled from the most comprehensive set of candidate publications, the services of the National Technical Information Service of the U.S. Department of Commerce were purchased. This service, called NTISearch, provided one hundred bibliographical entries of government publications on "what industries emit what gaseous, liquid, solid, or other wastes into the atmosphere, water systems, or onto land and what are the economic and other effects of industrial environmental pollution?" Many of these entries are included in the bibliography (Part IV).

Scope of the Project and Selection Criteria

Because of the potentially broad and pervasive scope of the bibliography, the delineation of selection criteria and the simultaneous definition and interpretation of "detrimental environmental effects of industrialization" required continual evaluation and frequent revision. However, through this process of evaluation and revision, some useful general selection criteria were developed that helped to define and to interprete the purpose of the project and to direct the project tasks. In general, the literature search focused on the direct detrimental environmental effects of industrialization, those that are related quite directly to the location and operation of industrial firms. Publications on the indirect detrimental environmental effects of industrialization, such as those associated with urbanization and consumption, are not emphasized. Consequently, topics such as air pollution from mobile sources, household solid waste management problems, and household incineration are not covered.

Furthermore, the pollution effects of basic agriculture, and extractive industries, such as air pollution from field burning, decaying animals, fecal materials, soil leaching, mine trailings, and environmental effects of timber cutting are not covered, although food-processing and raw material processing industries are included. For the most part, "detrimental environmental effects of industrialization" is interpreted as "detrimental external effects produced by manufacturing firms and industries."

Although many scientific and technical materials from engineering, agriculture, chemistry, biology, and other scientific and technical fields are included, materials on detailed technical topics that probably would be of little or no interest to most industrial developers are generally excluded. Most of the scientific and technical publications deal with various aspects of waste management systems, which are usually designed to act directly upon the polluted environment, rather than to identify and to deal with the sources of pollution. Likewise, most of the detailed legal and public administration literature on pollution and environmental quality management are excluded. Also, most of the currently popular books on environmental pollution that are written to shock or arouse the general public into supporting public policy recommendations by an individual or group are excluded. Every attempt has been made, within the time constraints of the project, to select only those materials that might be helpful and appropriate to those interested in industrial development.

PART II

ENVIRONMENTAL POLLUTION: OVERVIEW AND PROBLEMS IN SELECTED INDUSTRIES

The purposes of this part are (1) to provide an overview of industrialization, pollution, and environmental quality and (2) to discuss, wherever practicable, the production processes, types of potential pollutants, and methods of pollution control in the following selected industrial categories: Chemicals, Electric Power, Iron and Steel, Food and Feed Processing, Nonferrous Metals, Petroleum Refining and Petrochemical Products, and Pulp and Paper. In order to provide a general overview and general discussion of the selected industries, very few statistics are quoted and virtually no references are made to dates or places.

Overview of Industrialization, Pollution, and Environmental Quality

Most of the developing economies of the world today are undergoing a transition from an agrarian economy, with relatively land and labor-intensive production, to an industrial economy, with relative capital-intensive production. In the course of this industrializing process, positive net investment usually takes place at a more rapid rate at some places than at others, and fastest in some urban areas, especially those at transport terminals. Because production involves the use of factors of production other than capital, especially labor, urban areas with the greatest amount of capital, especially recently or newly invested capital, tend to become nodes of population growth, and urbanization begins to occur as the percentage of the total population residing in urban areas begins to increase.

As firms and people agglomerate in space, their production and consumption activities tend to produce external effects, some of which are desirable (external economies and utilities) and some of which are undesirable or detrimental (external diseconomies or disutilities). The desirable external effects tend to promote the further economic and population growth of urban areas. Many undesirable external effects are tolerated totally or partially as part of the cost of economic growth. Undesirable external effects of a given change in many production or consumption activities in a developing economy with a relating dispersed pattern of production and consumption activities may be less than they would be in industrially well-developed high-density urban areas in a developed economy. This difference in external effects may afford a developing economy an advantage in production and trade.

Some undesirable external effects of production and consumption activities are classified as environmental pollution. Environmental pollution can be said to occur when the consumption or production of one person or group of persons adversely affects the utility or productivity of other persons or groups (external effects) through the emission of undesirable matter or energy into the physical or social environment. Such undesirable matter or energy that is emitted into the environment is called a pollutant.

Pollutants are usually identified as either primary or secondary. A primary pollutant is one that is emitted directly into the environment from its source and exists in the environment in its emitted form. A secondary pollutant is one that is formed in the environment. Photochemical smog is an example of a secondary pollutant because it is formed by the solar irradiation of air pollutants that are trapped in an air mass.

Environmental pollutants are usually classified according to the principal part of the physical environment that they pollute -- atmospheric, water, or solid — or other distinguishing characteristics.

The following paragraphs discuss briefly the more common atmospheric, water, and solid industrial pollutants, some of the sources of these pollutants, effects of these pollutants on the environment, and some general control methods.

Atmospheric Pollutants

Types and Sources of Atmospheric Pollutants

Atmospheric pollutants include particulates, hydrocarbons, sulfur oxides, nitrogen oxides, carbon monoxide, and fluorides.

Particulate matter may be solid or liquid, and it includes dusts, fumes, fly ash, aerosols, mists, oil, and smoke. Industrial plants are a major source of particulate matter. Some of the major industrial sources of particulates are food processing and rendering plants, petroleum refineries, foundries, pulp and paper mills, smelting operations, chemicals manufacturing, iron and steel mills, fossil-fuel electric power generating plants, cement and asphalt manufacturing plants, and coking plants.

Hydrocarbons consist of hydrogen and carbon. Hydrocarbon vapors are emitted from coal, natural gas, petroleum, and biological products. Hydrocarbon vapors also join with nitrogen oxides under certain atmospheric conditions to produce photochemical smog, a secondary pollutant.

Gasoline powered engines are one of the primary sources of hydrocarbon emissions. Smaller amounts of hydrocarbons are emitted from industrial sources including the petroleum and petrochemical industry and the fossil-fuel electric power generating industry.

The oxides of sulfur are composed mainly of sulfur dioxide, sulfur trioxide, sulfuric acid, sulfates, and sulfides. Of these the most significant cause of air pollution is sulfur dioxide.

Sulfur dioxide is a colorless and nonflammable gas. It produces an undesirable odor and taste at certain levels.

The primary source of oxides of sulfur in the atmosphere is the burning (combustion) of fossil fuels. Fossil-fuel electric power generating plants, pulp and paper mills, smelting operations, refinery operations, sulfuric acid manufacturing plants and iron and steel plants contribute sulfur oxides to the atmosphere.

Two of the oxides of nitrogen are significant air pollutants. They are nitric oxide and nitrogen dioxide. Nitric oxide has neither color nor odor; nitrogen dioxide has both a rather strong odor and a reddish brown color.

Nitrogen oxides act as air pollutants not only alone but in combination with other contaminants. For example, one combination of nitrogen oxide and hydrocarbons in the atmosphere produces photochemical smog.

The primary man-made source of nitrogen oxide emissions is the combustion of fossil fuels. Fossil-fuel electric generating plants, petroleum refineries, various metals plants and other such industries are contributors of nitrogen oxide pollution.

Carbon monoxide is a tasteless and odorless gas and is a widely distributed and common pollutant. Carbon monoxide results primarily from the incomplete combustion of carbonaceous material (coal, fuel oil, natural gas) used as fuel. A large amount of carbon monoxide is released to the air by gasoline powered vehicles.

Some of the major industrial contributors are steam electric generating plants, kraft pulp mills, steel mills, iron foundries, petroleum refineries, and sintering plants.[1]

There are many other polluting substances found in the atmosphere in smaller quantities. Among the more dangerous of these is lead because of its deleterious effect on human health. The U. S. Department of Health, Education, and Welfare, National Air Pollution Control Administration presently plans to document the effects of these substances and provide air quality criteria within the near future.

Effects of Air Pollutants

There are many and varied effects of atmospheric pollution on man, other animals, and the environment in general. Some of the more obvious and significant are included in the following paragraph.

Particulates, sulfur oxide, sulfur dioxide, nitrogen oxide, hydrocarbons (either separately or in combination as smog), cause decreased visibility, unpleasant odors, eye irritation, damage to respiratory systems, damage to materials of many kinds, and serious damage to vegetation. Carbon monoxide in sufficient quantity affects the nervous system of humans and can cause serious health effects and even death. Fluorides in sufficient quantities are detrimental to animals and vegetation. Fluorides are stored by vegetation and when accumulated in sufficient amounts, they cause adverse effects and possibly death to animals who eat the vegetation. Humans living close to a manufacturing plant that emits fluorides may also suffer adverse general health effects.

Methods of Atmospheric Pollution Control

A large percentage of the industrially caused atmospheric pollutants can be controlled through the proper use of control techniques that are currently available. These include control devices such as afterburners, electrostatic precipitators, fabric filters, cyclones, wet caps, scrubbers, absorbers, adsorbers, baghouses, and recovery furnaces. In addition to the use of these control devices, the use of tall stacks to disperse pollutants over a wide area, the more efficient designing of equipment used in manufacturing processes, the use of good housekeeping practices by industry, and the substitution of low-sulfur fuels for high-sulfur fuels will help to reduce the atmospheric emissions from industrial sources.

Water Pollutants

Types and Sources of Water Pollutants

Water pollutants include settleable and nonsettleable suspended solids, dissolved solids, and a wide variety of organic and inorganic chemical compounds and substances such as oil, pesticides, fertilizers, and phosphates.

An estimated one half or more of the liquid or liquid-borne pollutants that are discharged into waterways come from plants in four industrial categories: pulp and paper, petroleum refining, chemicals, and iron and steel.[2] Other significant contributors include food processing plants, textile manufacturing plants, metals plants, agricultural runoff, mine drainage, and construction projects.

Effects of Water Pollutants

When liquid or liquid-borne pollutants are discharged into a waterway or water body, serious pollution can result unless there is sufficient dilution. If effluents containing organic materials significantly increases the biochemical oxygen demand (B.O.D.) in the waterway, aquatic life can be endangered because of the reduction of dissolved oxygen in the water. Some effluents contain toxic substances that can damage or kill aquatic life. Suspended solids in the effluent of plants can become deposited on the bottom of waterways so thickly that organisms on the bottom cannot continue to thrive, thereby reducing the food supply of fish and other aquatic life. Effluents also often discolor the waterway into which they are discharged and frequently produce undesirable odors and tastes, in addition to presenting an unsightly appearance and rendering the water unusable for other purposes.

Thermal pollution caused by discharging heated waters into waterways can cause some compounds to become more toxic to aquatic life, can alter the reproduction rates of some species of organisms and can reduce the diversity of species, can reduce the dissolved oxygen in the water, and can increase the growth of some plants that produce taste, odor or color problems. Thermal pollution can also reduce the usefulness of the water for further cooling.

Methods of Water Pollution Control

As with other forms of pollution, there are varied types of water pollution control methods and processes. Treatment of industrially polluted waters may be accomplished individually by firms using their own treatment facilities or in the case of some industries through the use of municipal or regional industrial treatment facilities. Types of treatment processes include adsorption, settling and evaporation ponds, filtration, chemical oxidation, incineration (of sludge), coagulation, skimming, reverse osmosis, lagooning, flotation, bacterial decomposition, trickling filters, cooling towers and ponds for discharged heat.

Also as with other forms of pollution, careful operations, substitution of less polluting processes or equipment, and controlling potential pollutants before they are discharged will aid in reducing the pollution of waterways.

Solid Waste

Types and Sources of Solid Waste

There are many kinds of solid wastes that result from industrial processes. A brief listing could include plastics, scrap rubber, dewatered sludge, residuals from various food processing operations, slag from iron and steel manufacturing, catalysts, clay, sediments, glass, wood chips and bark, and many other combustible and non-combustible materials.

Sources of solid waste materials are many and varied but could include wood products manufacturing plants, chemicals manufacturing plants, iron and steel mills, pulp and paper mills, food processing plants, petroleum refining operations, and many others.

Industrial solid wastes as such generally do not have the polluting potential of wastes that pollute the atmosphere and water in that the effects of solid wastes are usually experienced solely or principally by the person, group, or institution that produces the solid waste. Hence, the polluting characteristics of solid wastes are usually experienced most strongly by those who produce the solid wastes and, therefore, are disposed of by their producers through relatively effective solid waste management systems.

Control methods for solid wastes include open dump burning, incineration, sanitary landfill, composting, and deep ocean dumping.

Some waste materials are presently being reclaimed and recycled into comparable or other commercial products. Examples of these are paper, glass, rubber and plastic products that can be relatively easily reclaimed and recycled.

Research

It would appear from this survey that there is some type of research being conducted on virtually every aspect of pollution--types, sources, effects, prevention, and control methods. In addition to efforts within countries, there is participation among countries in an effort to improve environmental quality. Agreements between some countries for the exchange of technical knowledge on pollution control and research are already in existence and others involving additional countries are being negotiated.

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In the following sections, the production processes, types of potential pollutants, and methods of pollution control are discussed for selected industrial categories.

Chemicals[3]

The chemicals category includes firms producing a large number of widely diversified consumer and producer goods. The major product groups constituting the chemicals category are:

Inorganic industrial chemicals
Fertilizers and agricultural chemicals
Organic industrial chemicals
Pharmaceuticals and medical chemicals
Plastics
Soaps, detergents, and cosmetics
Synthetic fibers
Varnishes, paints, lacquers, enamels, etc.
Other groups[4]

Because of the wide variety of products among the firms in this category, it would be impractical to try to describe the processes, potential pollutants, and pollution controls for each product. However, in general, firms in the chemicals category face many of the same air and water pollution and solid waste problems as those faced by most industrial firms and, for the most part, employ many of the same pollution controls.

For example, firms in the chemicals category as a group emit inorganic and organic particulates, sulfur oxides, nitrogen oxides, and other inorganic and organic emissions into the atmosphere, some of which cause odor problems. The concentrations of pollutants in the atmosphere at any given point near a chemical-product plant would be far greater than it is if air pollution control equipment, procedures, and production process changes were not employed. Among the types of air pollution control equipment that might be used are afterburners, adsorbers, electrostatic precipitators, mechanical collectors, cyclones, filters, and scrubbers.

Most chemical-product plants use water from private and public water supplies as process waters and cooling waters. Process waters may contain suspended as well as dissolved inorganic and organic solids. The process waters of firms in the chemicals category constitute a large proportion of the total industrial water effluents in the United States.

Water pollution control measures to remove suspended solids in process waters include evaporation and settling ponds, chemical coagulation, flotation and skimming, filtration, chemical oxidation, incineration, clarification, chlorination, recycling, reduction of the quantity of process water used, process improvements, use of good housekeeping practices, dumping at sea, land irrigation, deep well injection, and reverse osmosis. Although dissolved solids can be removed from process waters, it is expensive to do so. If taste or odor problems prevail, process waters can be passed through granulated or activated charcoal.[5]

Treatment of discharges from chemical-product plants in municipal secondary treatment facilities is a common practice for plants located within municipalities. If such facilities have adequate capacity to treat not only domestic but also industrial process waters and charges or taxes on industrial firms for such treatment are not too large, municipal treatment of industrial process waters can be an efficient alternative.

Cooling waters may pose problems of thermal pollution depending, among other factors, upon the temperatures and and flow rates of the effluent and the receiving body of water.

Solid wastes produced by firms in the chemicals category include combustible and noncombustible process solids and containers. The principal means of processing or disposing of these solid wastes are landfills, contract disposal, incineration, and open dump burning. Often solid wastes are used as a source of energy, along with conventional fuels, to produce the heat needed for various production processes in chemical-product plants.

Electric Power[6]

The electric power category includes all private and public electric power generation, transmission, and distribution agencies. This section deals with the pollution problems associated with the generation of electric power.

There are four types of electric power generation systems: fossil-fuel steam, hydroelectric, nuclear-fueled steam, and geothermal. Currently, the most predominent type of electric generating system is the fossil-fuel system which uses coal, oil, and gas as fuels for producing steam to drive electric turbine-generators.

Electric power plants are one of the leading sources of air pollution, especially of oxides of sulfur, and pose serious problems of thermal pollution of waterways. The major pollution problems of the electric power category are associated with thermal electric power generating systems, namely the fossil-fuel steam and nuclear-fueled steam systems. These pollution problems pertain to combustion by-products, thermal pollution, and radiation emissions.

Depending upon the type of fuel used, a fossil-fuel steam sys em may produce several combustion by-products that pollute the air if they are emitted. The most common of these potential pollutants are oxides of sulfur, oxides of nitrogen, particulates (especially fly ash), carbon monoxide, and unburned hydrocarbons. Sulfur and nitrogen oxides and particulates typically pose the principal air pollution problems caused by electric power generation plants burning coal or oil, and oxides of nitrogen are a major pollutant produced by plants burning gas.

Emissions of oxides of sulfur from fossil-fuel steam plants can be reduced (1) by using natural gas or low-sulfur coal or oil, (2) by reducing the sulfur content of high-sulfur fuels, (3) by removing oxides of sulfur from combustion gases before they are emitted, (4) by increasing combustion efficiency, and (5) by using tall stacks. Efficient and reasonably economical methods that are being developed for removing oxides of sulfur from combustion gases seem to be the most promising methods for controlling oxides of sulfur.[7]

Oxides of nitrogen are formed during high-temperature combustion in fossil-fuel steam plants. The amount of oxides of nitrogen produced can be controlled to some extent by reducing the amount of oxygen, using a two-stage burning process, and by returning combustion gases to the combustion chamber.

Particulates can be very efficiently removed from combustion gases by cyclone filters, fabric filters, electrostatic precipitators, and gas scrubbers.

In both fossil-fuel steam and nuclear-field steam generating systems more energy is dissipated as heat than is converted into electric power. In fossil-fuel steam plants, most of this heat is discharged principally in condenser cooling water. To prevent thermal pollution of waterways by the heated condenser cooling water, plants can use (1) cooling ponds and canals, either with or without spray equipment, for dissipating heat from heated condenser cooling water before the water is discharged back into the waterway, (2) evaporative cooling towers that cool the heated water by spraying the water over baffles to accelerate the evaporation rate, and (3) dry cooling towers through which heated condenser cooling water is piped so that the heat can be transferred to the atmosphere. However, cooling ponds and canals are impractical for use in urban areas because of the large areas of land required, and cooling towers are expensive.[8]

<u>Iron and Steel</u>[9]

The iron and steel category includes firms that produce iron, steel, and gray iron foundry products. This section first discusses the production processes, potential pollutants, and pollution controls in iron and steel production followed by a similar discussion for gray iron foundry products.

The principal production processes in iron and steel production are coking, sintering, blast furnace operations, steel furnace operations, and scarfing.[10] Coking is the production of coke which is used to reduce iron ore. Coke is formed by heating soft coal in slot-type ovens, then exposing the incandescent coke to the air by placing it in quenching cars, then quenching it with water and allowing it to cool.[11]

Coke oven gas includes many compounds, some of which are separated by several methods as by-products of coking. After the by-products are removed, the remaining coke-oven gas is used as a fuel for heating boilers and furnaces.

Sintering consists of aggregating scrap iron, iron oxide fines found in dust collection systems, mill scale, and bits of salvage. This sintering material is placed on pallets and passed through a furnace and thereby formed into large particles or clinkers. These particles are then ready to be used in blast furnaces. During the sintering process air is drawn through the burning mass into a windbox below the pallets and usually out through a stack. This air is cleaned by dust collectors such as cyclones, baghouses, electrostatic precipitators, and venturi scrubbers before being released to the atmosphere.[12]

In blast furnaces, iron oxide ore, limestone, and coke are combined with hot air to produce a molten high carbon alloy of iron called pig iron, slag, and gas. The molten pig iron can be processed to produce steel or can be made into pigs for use in foundry operations. The slag contains basic and acidic oxides and other impurities. Slag is removed from the molten iron and is disposed of as a solid waste or if profitable, is sold for use in manufacturing cement, for filling material, and for other uses. Blast furnace gas is cleaned with cyclones and scrubbers to remove dust, is heated and returned to the blast furnace.

Steel is produced in steel furnaces, of which there are four major types: Bessemer converter, open hearth, basic oxygen, and electric arc. In Bessemer converters, air is forced through the molten iron, and carbon, silicon, manganese, and other impurities are oxidized and removed to form steel as slag. Slags with relatively high phosphorus content can be ground and sold as fertilizer. Smoke and dust pose the most serious air pollution problems in using the Bessemer converter. The Bessemer converter is limited to small lot production and is not used nearly as extensively as it once was.[13]

In the open hearth furnace, pig iron, scrap metal, limestone, and, sometimes, iron oxide ores are placed in a large furnace hearth where the materials are melted and allowed to react, forming refined molten iron and a slag of impurities.[14]

The principal air pollution problem of the open hearth furnace is particulate emission. Baghouses, electrostatic precipitators, and scrubbers are used to try to reduce particulate concentration in open hearth stack gas. Like the Bessemer converter, the open hearth furnace is becoming an increasingly less popular type of furnace.

In basic oxygen furnaces, high-purity oxygen is blown onto or into the furnace to oxidize the impurities in the molten iron to produce steel. The principal air pollution problem is the emission of particulates, and the same basic methods of control are used--electrostatic precipitators, scrubbers, and baghouses. The basic oxygen furnace is becoming increasingly more widely used.

In the electric arc furnaces, scrap is melted by the heat generated by a high amperage arc of current flowing through the slag and air gap between two large carbon electrodes that are injected through the flat-domed roof of the electric arc furnace. The electric arc furnace has several advantages over the other steel furnaces: (1) heating can be easily controlled by controlling the electrical current, (2) high temperatures can be achieved, (3) electricity is relatively cheap to transport, (4) most combustion products are absent, thereby reducing compounds of hydrogen, oxygen, sulfur, and carbons, (5) easily removeable slags, and (6) better control over alloys.[15]

Because the electrodes protrude from the top of the furnace and because the furnace top must be opened to charge the furnace, it is difficult to control gaseous emissions from electric arc furnaces. Furthermore, dust particles from electric arc furnaces not only are difficult to collect but are difficult to process. The effectiveness of dust control equipment, such as scrubbers, filters, and electrostatic precipitators varies.

Scarfing is a technique for removing surface defects from steel.

Although the iron and steel production processes described above produce unwanted particulates, sulfur oxides, carbon monoxide, nitrogen oxides, and fluorides, particulates are the major air pollutants. Gas-cleaning equipment, such as electrostatic precipitators, wet scrubbers, fabric filters, and mechanical collectors are only partially effective in removing particulates.

The gray iron foundry industry produces cast iron products by melting pig iron, scrap, and small amounts of alloys. Production processes in the gray iron foundry industry include sand handling and mixing, shaking, grinding, chipping, cleaning, and welding, all of which produce particulates that are usually controlled by dust-suppressing equipment. The melting operation presents the major pollution problems for the industry. There are three types of furnaces used in the melting process: electric arc, electric induction, and cupolas. The electric arc and electric induction furnaces produce relatively small amounts of pollutants. However, the widely used cupolas produce and emit carbon monoxide and particulates in the form of dust and smoke fumes. Gas-cleaning equipment, including afterburners, can be effectively used to remove most of the carbon monoxide and particulates. The principal pollution control devices are fabric filters, wet scrubbers, multiple cyclones, and wet caps. Nearly half of the gray iron foundries in the United States use wet caps. Although wet caps are relatively inexpensive, they are relatively inefficient and usually do not meet pollution control standards.

Food and Feed Processing[16]

The food and feed processing category includes firms that process food and/or feed but does not include firms engaged in primary agricultural and animal husbandry activities. As a group, firms in this category are one of the major sources of water pollution, and some pose serious air pollution and solid waste problems. This section describes briefly some production processes, potential pollutants, and pollution controls of selected groups within this category.

Production processes vary widely among groups of products. For example, meat processing includes slaughtering, dehiding, cleaning, cleaning, removal of paunch and intestinal manure, meatcutting, storage, smoking, and by-product processing, whereas production processes for grain-based foods might include milling, drying, mixing, and handling, and food canning and freezing involves a different set of processes yet in the preparation of fruits, vegetables, and other foods.

Most food processing operations require a considerable amount of process water, as well as water for cleaning equipment and facilities. Pollution of these waters is the principal pollution problem in the food and feed category as a whole. Potential water pollutants vary with the type of food processing operation. For instance, the principal potential water pollutants from meat processing are organic matter, suspended solids, fats, oils, and grease, nutrients, dissolved inorganic solids, bedding and manure from pens, and cleansing agents. Added potential water pollutants from poultry processing are feathers, litter, and feed in cleaning waters.[17] Process waters used in preparing fruits and vegetables for canning and freezing typically contain suspended solids, have high B.O.D., often contain food pigments that discolor streams, and contain wastes that decompose rapidly. Other examples of water pollutants are whey and other effluents from dairies, brining from pickle plants, evaporation effluents from coffee and tea processes, suspended fats from chocolate plants, and highly putrescible and colored water from seafood processing plants.[18]

Process waters used in food processing plants are, for the most part, biodegradable. This means that waters from food processing plants that are located in or very near a municipal sewage treatment facility can be treated by conventional water treatment processes along with domestic sewage. Seasonal production and wide differences in the concentration of wastes in the effluent of food processing plants can pose serious problems for municipal sewage facilities during peak capacity periods.

Research and development to reduce water pollution in the food processing industries is being directed toward reducing the amount of water needed through recycling and other methods, identifying and treating specific problems in streams, improving equipment and processes to reduce waste, and generally improving techniques and systems for monitoring and controlling effluent.[19]

Solid wastes, most of which are highly decomposable, are a serious problem in many food processing plants. The dehiding and cleaning processes present solid waste disposal problems for meat processing plants, whereas feathers, litter, and other solid wastes present disposal problems in poultry processing plants.[20] The disposal of unusable solids is a problem in canneries and frozen food plants.

Disposal methods for solid waste from food processing include sanitary landfill, production of animal feed, composting, deep ocean dumping, and other methods.

The principal air pollutants from food processing plants include particulates, odors, and smoke. Odors are often emitted from food processing operations, from polluted water, and from solid wastes. Smoke and other particulates from the burning of fuels for cooking foods and from meat and fish smoking operations present serious air pollution. Perhaps the worst source of odors is rendering plants in which animal matter is cooked and used to produce various fats, tallow, bone meal, and additives for animal feed. However, the odors that result from the storage, handling, cooking, and drying of such animal matter are very pungent. These odors are composed principally of ammonia, sulfides, amines, mercaptans, aldehydes, and organic acids. There have been reports of many adverse physiological, psychological, social, and economic effects of a rendering plant on the people in nearby neighborhoods or towns.[21]

Control methods for rendering plants include afterburners, condensers, and wet scrubbers.

<u>Nonferrous Metals</u>[22]

The nonferrous metals category includes firms that concentrate, smelt, and refine aluminum, copper, lead, and zinc. Copper, lead, and zinc are usually produced from sulfide ores, whereas aluminum is produced from bauxite.

Aluminum

Alumi..um is produced principally from bauxite, which is an hydrated ore containing aluminum oxide (alumina), silicon, titanium, and iron. The hydrated bauxite is dried and then mixed with a sodium hydroxide solution to convert the alumina to a sodium aluminate solution, and unwanted insoluble materials are removed by settling and filtering. Small quantities of aluminum hydroxide are added to the sodium aluminate solution to yield aluminum hydroxide, which in turn is converted to aluminum oxide.

Aluminum oxide is dissolved in carbon lined cells. Carbon rods are placed into the molten mixture and high-amperage current is made to flow between the cell walls (cathode) and the carbon rods (anodes), causing oxygen to be deposited on the rods and aluminum on the cell walls. Aluminum setties to the bottom of the cells and is removed and placed into molds where the waste matter is removed and any desired alloys are added.[23]

Emissions from aluminum processing operations include fluorides, various dusts and waste gases. Control methods include electrostatic precipitators, hoods and other enclosures, scrubbers, water spray towers, and tall stacks.

Copper

The basic processes in a copper smelter are roasting, smelting, and oxidation.

Copper ores are crushed, ground wet, thickened, and then mixed with air and frothing agents in flotation cells to produce a foam consisting of copper, water, and other materials. The foamy froth is drawn off, and the separated solids are sent to a smelter for separation of the copper from the iron, sulfur, and gangue.

The roasting process removes excess sulfur from sulfide concentrates. During the smelting process, the concentrate is placed in a reverberatory furnace where it is formed into a copper matte (primarily ferrous sulfide and cuprous sulfide) and a slag which removes part of the iron from the copper. The copper matte then proceeds to a converter for the oxidation process where it is formed into blister copper and where sulfur is released from the copper. The slag still contains copper and is therefore returned to the reverberatory furnace.

All three processes, generate sulfur oxides--copper smelting and refining operations are one of the leading sources of sulfur dioxide pollution. Other emissions are dust and acid mists and varying amounts of other elements. Where possible the sulfur dioxide is diverted to a nearby sulfur dioxide plant, and gas cleaning systems (electrostatic precipitators, scrubbers, and cyclones), and tall stacks are used to reduce omissions.[24] Settling is used to remove solids remaining in the water during the initial separating phase.

Lead

Lead is obtained from galena, a sulfide mineral.

The lead smelting processes include sintering, reducing the sinter to obtain bullion, and refining. The sintering process prepares the lead ore to be placed in a blast furnace along with iron and coke where liquid lead is formed by contact with carbon and carbon monoxide. This lead usually must be further refined. A slag formed by nonreduced elements is then separated, and other trace metals must also be removed during refining.

In lead smelting, the sintering process is the only serious source of sulfur dioxide. Waste gases from the sintering process contain sulfur dioxide, dust, and fumes. Baghouses and electrostatic precipitators are used to collect dust and fumes. A few lead smelters use cleaned gas in the production of sulfuric acid. Waste gases from blast furnaces are usually filtered in baghouses to remove particulates.[25]

Zinc

There are two significant sources of zinc--sulfide ores and zinc oxide recovered from the lead smelting processes.

Zinc concentrates typically contain 60 percent zinc, 30 percent sulfur, and 5 to 10 percent iron. Roasting of the zinc concentrates converts the sulfide concentrate to oxide form thereby releasing most of the sulfur from the concentrate. Some zinc smelters follow the roasting process with sintering.

Zinc is released from zinc oxide by heating the roast concentrate with coke at very high temperatures. The zinc can be further purified by leaching and electrolysis.

Emissions from these processes include some sulfur dioxide, dust and fumes. Sulfur dioxide can be released to the atmosphere, and dust and fumes can be removed by cyclones and/or electrostatic precipitators, and scrubbers.[26]

Secondary Aluminum, Copper, Lead, and Zinc

Secondary metals are those produced from scrap and salvage. The principal scrap sources of copper are electrical wire and cable and automobile radiators. Automobile batteries are an important source of scrap lead. Zinc scrap is reused.[27] Aluminum scrap is obtained from many industrial, commercial, and consumption sources through various waste management processes. These scraps can be cleaned of various contaminants and refined.

Emissions can include particulates, fumes, and oxides of zinc and lead. Gas-cleaning equipment is used.

Brass and Bronze

Brass and bronze are copper alloys containing variable proportions of zinc and tin, respectively. The principal raw material for the production of brass and bronze is copper and copper alloy scrap. Brass and bronze ingots are produced by melting, smelting, refining, and alloying scrap materials. The type of furnaces used depends upon the alloy and the quantity produced. Brass and bronze producers use reverberatory, rotary, or crucible furnaces.

The refining furnace is the principal source of air pollution from brass and bronze production. Fly ash, soot, smoke, zinc oxide, some sulfur oxide, and lead oxide are found in the waste gases of brass and bronze plants. Particulates are also emitted during the preparation of raw materials and while pouring ingots.

The major air pollution control problem in brass and bronze plants is the capture and ducting of dust and fume gases to baghouses, which are the principal means of filtering the waste gases of brass and bronze plants. A few plants use wet scrubbers and electrostatic precipitators. The principal component in the dust collected in baghouses is zinc oxide.

Petroleum Refining and Petrochemical Products[28]

The petroleum refining and petrochemical products category includes firms that produce gasoline, kerosene, jet fuel, gas, oil, fuel oil, coke, asphalt, insecticides, wax, lubricants, and many other products derived from crude petroleum.[29]

Petroleum refining involves four basic processes or stages of processing--separation, conversion, treating, and blending. Separation is the distillation of crude oil into fractions having different boiling temperature ranges such as gas, gasoline, kerosene, naphtha, diesel fuels, fuel oil, and topped crude. Although some of the fractions may be treated and blended to produce a marketable product, many fractions have to be converted to other substances by changing their molecular size or structure by cracking (pyrolysis) and reforming.

There are two types of cracking--thermal and catalytic. Thermal cracking is usually used to crack substances that are heavier than gasoline by heating them at high temperatures and under pressure. Thermal cracking has been made essentially obsolete by catalytic cracking methods that employ catalysts to speed and make more complete the decomposition of the distillate. The two methods of catalytic cracking used today are the fluid-bed and moving-bed methods.[30]

Some of the lighter molecules that result from cracking are recombined or polymerized to form substances with particularly desirable properties. For instance, in the production of gasoline, gaseous olefins are polymerized and then alkylized to form hydrocarbons.

Treating involves the removal of sulfur and sulfur compounds as well as metals and other undesirable substances from the final or intermediate petroleum products. Sulfur compounds are removed in order to improve the quality of the product, to reduce reactions of sulfur compounds with certain catalysts, to reduce odor, and to reduce corrosiveness. Both physical and chemical treating methods have been developed. Hydrogen treating (hydrotreating) is widely used to remove sulfur from refining stocks by converting sulfur compounds into hydrogen sulfide, which can be extracted and converted to sulfur dioxide.

Blending is simply the combining of base and intermediate stocks to produce thousands of petroleum and petrochemical products.

Petroleum refining operations produce gaseous, liquid, and solid wastes that are potential pollutants of the air, water, and land. The major air pollutants from petroleum refining are sulfur compounds, hydrocarbons, particulates, oxides of nitrogen and carbon monoxide.

Sources of waste gases containing sulfur compounds are vacuum exhaust used in distillation, catalytic regenerators used in reforming and in hydrotreating, hydrogen sulfide absorption units, sulfur dioxide removal equipment, and storage tanks. Sulfur compounds can usually be controlled best by scrubbing and/or incineration.

Hydrocarbons are emitted from many potential sources including process, equipment and facilities. The most significant source seems to be storage tanks. Emissions from equipment, sometimes in the form of leaks, can be controlled by various methods including hoods, covers, proper sealing or packing and the like. Waste heat boilers can be a significant method of eliminating hydrocarbons emitted during the cracking process.

Particulates are released from sludge burners, catalyst regenerators, airblown asphalt sills, heaters, emergency flares, and boilers. Control methods include dust collectors, carbon monoxide waste heat boilers, cyclones, electrostatic precipitators, scrubbers, incinerators, and baghouses.[31]

Sources of nitrogen oxide emissions in this industry include fuel combustion in process heaters and boilers, and internal combustion engines. Control methods include air reduction, recycling of flue gases, and the use of two stage combustion.[32]

Carbon monoxide from catalyst regenerators can be eliminated by burning the gases in carbon-monoxide boilers or heaters.

The principal liquid-borne pollutants from petroleum refineries are oil, suspended or dissolved solids, sulfur compounds, alkalies, phenols and creosols, and ammonia. Hydrocarbon contamination of water results from oil leakage and spills, often into cooling water, where emulsions form, from crude-oil desalting and cleaning operations, from oil that was not separated from the water when the water is removed from oil in storage tanks, and from oil that is lost during chemical treating. Sulfur compounds are contained in steam vapor which is condensed and discharged through process sewers and separators to the main sewer system. Alkaline solutions used to purify hydrocarbon streams are usually treated with caustic and washed with water to recover sodium hydroxide. Phenols and creosols, which are produced during cracking, are difficult to remove from process water. Ammonia, which is used to control corrosion and to reduce oxides of nitrogen, is, to a great extent, evaporated in the process sewers.[33]

Most water pollution control systems for petroleum refineries include a collection and sewer system, oil-water separation system, dissolved contaminant treatment system, and secondary treatment systems. Collection facilities and sewer networks are designed so as not to allow process water to contaminate waterways, oil-free waters, or adjoining land.[34]

Oil and water separation processes include (1) the gravity process, which is based on the differences in the specific gravity of oil and water, (2) the flocculation process, which uses coagulants to produce precipitates that are removed by settling, and (3) dissolved air flotation, which uses very small air bubbles to increase the rate of separation and flotation of suspended oil and solids, which are then removed from the surface. The principal problem with the oil-water separation processes is that the removed oil is actually an emulsion of oil and water and solids. Waste waters that contain concentrations of dissolved chemicals that can greatly increase the B.O.D. loading of a waterway, that are toxic to acquatic life, or that produce strong odors must be treated, usually by stripping or by oxidation of the dissolved chemicals.[35]

Some form of secondary treatment is usually required. Secondary treatment involves the bacterial decomposition of wastes. Secondary treatment processes used by petroleum refineries include the activated sludge process, the trickling filter process, oxidation and stabilization ponds, and cooling towers.[36]

Solid wastes from petroleum refineries include catalysts, coke, clay, sediments, sludges including those from secondary treatment facilities, and other solids. Solid wastes are usually disposed of in sanitary landfills. An activated carbon process is being developed as a tertiary treatment process to reduce the B.O.D. in the concentrations of chemical and hydrocarbon pollutants in refinery effluents.[37] Other methods of disposal include deep sea dumping, and doop well disposal.

Pulp and Paper[38]

The pulp and paper category includes firms whose principal products are pulp and paper and paperboard products. Paper products are produced principally from cellulose fibers obtained from wood.

The major processes used by firms in the pulp and paper category are wood preparations, pulping, pulp bleaching, and paper production. Chipped wood from debarked logs, chipped residues, sawdust and the like and recycled paper and paperboard are the principal sources of cellulose fibers. Fibers are separated from the wood by any one of three types of pulping processes--chemical, semichemical, and mechanical. The most widely used processes are the chemical processes, and the draft process is the most successful of the chemical processes because of its suitability for pulping almost all types of wood and the high strength retention of its fibers. During the kraft (sulfate) pulping process, a solution of wood chips, sodium sulfide, and caustic soda is cooked at a high temperature under pressure to produce the pulp or cellulose fibers. After cooking the fibers are separated by washing. The spent chemical solution is a dark liquid called black liquor. In order to recover the cooking chemicals, this black liquor is processed through evaporators to remove moisture and then sent to a recovery furnace to remove the organic substances.[39]

In the sulfite process, a solution of acidic calcium sulfate is used to cook the wood particles. The resultant pulp fibers are white. This should be used only for pulping wood from low-resin softwoods. Sodium-, ammonium-, and magnesium-based liquors are used to facilitate recovery of the cooking chemicals from the black liquor.[40]

The semichemicals (N.S.S.C.) process is similar to the sulfite process except that this process employs some mechanical fiber removal and yields more fibers than the sulfite process. The mechanical groundwood process does not involve chemical pulping. Although water is used in debarking, cleaning and grinding operations, it is easily processed for reuse.[41]

Pulp and paper mills produce many potential gaseous, liquid and liquid-borne solid, and thermal pollutants. Gaseous materials include particulates in the form of fly ash and chemicals and gases, which include odorous hydrogen sulfide and mercaptans that are easily emitted at several points in the kraft process and sulfur oxides from boilers of plants using the sulfite process, and recovery furnaces and kilns used in the kraft process. Liquid and liquid-borne materials include suspended solids, organic materials, dyes and lignin compounds that discolor water, inorganic materials, mercury from a few plants using chlorine and caustic that are produced by a mercury cell process, and microorganisms.

Solid waste materials include sludges from primary and secondary treatment processes and solids. Thermal pollution results when pulp and paper mills discharge heated effluent into streams.[42]

There are several standard as well as specialized air pollution control methods that are available to firms in the pulp and paper category. Electrostatic precipitators and venturi scrubbers can remove virtually all of the particulates produced by pulping mills. Odors from mills using the kraft process can be controlled to a high degree through the use of recovery furnaces, oxidation of the black liquor, certain evaporator systems, scrubbers, and incineration of odorous gases.

Many firms in the pulp and paper category are among the worst sources of industrial liquid and liquid-borne pollutants. Water pollution control methods include the use of magnesium- and ammonium-based bisulfite liquor to reduce the amount of effluent from mills using the sulfite process, recovery of cooking chemicals, removal of fibers and recycling of process water, primary and secondary treatments of process waters, chemical removal of colloidal materials, and the use of lagoons. Primary treatment facilities can reduce from 70 to 90 percent of the suspended solids in pulp mill process waters, and secondary treatment can further reduce the amount of organic materials so as to remove up to 85 percent of the B. O. D. load. Landfill methods are usually used to dispose of sludge from primary and secondary treatment facilities.[43]

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PART III

PERIODICALS AND GUIDE TO THE BIBLIOGRAPHY

Periodicals

Articles of interest to economists and industrial developers that deal with various aspects of industrialization and environmental quality frequently can be found in the following publications:

Environmental Science and Technology
Journal of the Air Pollution Control Association
Journal of Law and Economics
Journal of the Water Pollution Control Federation
Natural Resources Journal
Resources (RfF)
Water Resources Research

Within the last few years, such articles have appeared occasionally in more general economics journals such as:

American Economic Review
Annals of the American Academy of Political and Social Science
Canadian Journal of Economics
Economic Geography
Economic Journal
Economica
Econometrica
Journal of Political Economy
Kyklos
Quarterly Journal of Economics

Review of Economics and Statistics
Scottish Journal of Political Economy
Southern Economic Journal
Swedish Journal of Economics
Western Economic Journal

There is a wide variety of other periodicals, many of which deal with particular aspects of environmental quality. The following list shows only a sampling of such periodicals:

Air Pollution Abstracts
American Industrial Hygiene Association Journal
Analytical Chemistry
Annals of Occupational Hygiene
Archives of Environmental Health
Atmospheric Environment
British Journal of Industrial Medicine
Chemical Engineering
Food Engineering
Industrial Wastes
Industrial Water Engineering
International Journal of Air Pollution
Journal of the American Water Works Association
Journal of Applied Meteorology
Journal of Applied Physiology
Journal of Atmospheric Sciences
Journal of the Institute of Fuel
Journal of Occupational Medicine
Journal of the Royal Meteorological Society
Journal of the Sanitary Engineering Division, American Society of Civil Engineering
Occupational Health Review
Oil and Gas Journal
Public Health Reports

Public Works

Sewage and Industrial Wastes

Sewage Works Journal

Tappi

Wastes Engineering

Water and Sewage Works

Water and Wastes Engineering

Water Resources Abstracts

Water Works and Wastes Engineering

Guide to the Bibliography

Over 760 selected publication entries are compiled in the bibliography (Part IV). These entries include a wide variety of economic, theoretical, empirical, bibliographical, technological, scientific, and public policy and administrative publications on environmental pollution and its control. Many of these publications deal with various aspects of industrial waste management. Although the bibliography is believed to be a good cross-section of the English-language literature that exists within the scope of the project and that generally meets the selection criteria, it is by no means meant to be exhaustive.

For convenience, the bibliographical entries are grouped into six groups; each publication appears only once as a bibliographical entry in one and only one of the following groups:

Bibliographies, Abstracts, Lists of Publications, Research Projects, and Guides to Literature

Books and Reports

Articles

Articles in Collection

Papers and Proceedings

Government Documents (other than those appearing in other groups)

The following subsections of this part of the report constitute a guide to the bibliography; these subsections are headed:

Bibliographies, Abstracts, Lists of Publications, Research Projects, and Guides to Literature

Economic Analysis

Legal and Administrative

Pollution General: Research and Control

Air Pollution: Research and Control

Water Pollution: Research and Control

Solid Wastes: Research and Control

Chemicals

Electric Power

Iron and Steel

Food and Feed Processing

Nonferrous Metals

Petroleum and Petrochemical Products

Pulp and Paper

Other Industries

In each subsection, publications listed in the bibliography that deal with the subject matter for that subsection are referred to by their bibliographical entry numbers.

Within the selection criteria mentioned in Part I, special effort was made to compile materials on the detrimental environmental effects of the operations of firms in the seven industrial categories listed above. In general, relatively little specific, especially quantitative, information of this sort was found for individual firms, industries, or industrial categories. Many publications provide bits of general information on the types of wastes generated by firms in specific industries or industrial categories, but few have any quantitative data, and of those that do have, it is usually fragmentary. Some publications make references to the amount of different types of pollutants in the atmosphere, in water bodies, or on or in the land but do not indicate the sources of these pollutants.

Bibliographies, Abstracts, Lists of Publications, Research Projects, and Guides to Literature

1 through 47, 48, 183, 534, 535, 657.

Economic Analysis

48, 59, 64, 65, 66, 67, 71, 72, 74, 77, 83, 84, 85, 93, 99, 106, 107, 113, 115, 116, 119, 126, 127, 128, 131, 133, 134, 136, 137, 144, 154, 160, 161, 172, 177, 188, 189, 191, 192, 194, 198, 199, 200, 201, 232, 250, 251, 258, 259, 261, 262, 263, 264, 266, 269, 271, 277, 278, 279, 280, 282, 287, 289, 295, 297, 299, 301, 302, 304, 305, 306, 307, 310, 311, 312, 314, 315, 319, 322, 326, 327, 328, 331, 339, 340, 341, 344, 345, 353, 357, 358, 360, 361, 371, 373, 375, 378, 386, 387, 388, 389, 390, 391, 392, 395, 397, 398, 402, 407, 408, 409, 410, 411, 412, 415, 416, 420, 423, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 438, 442, 444, 445, 447, 450, 451, 455, 462, 468, 472, 473, 475, 486, 487, 497, 498, 499, 500, 509, 512, 513, 520, 521, 523, 525, 527, 528, 536, 539, 542, 545, 547, 548, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 567, 572, 574, 575, 578, 580, 582, 584, 587, 588, 594, 612, 620, 719, 720, 750, 761.

Legal and Administrative

56, 139, 163, 176, 190, 230, 252, 265, 276, 282, 287, 288, 299, 300, 308, 316, 348, 368, 393, 399, 454, 515, 519, 541, 543, 643.

Pollution, General: Research and Control

49, 55, 56, 68, 69, 85, 106, 110, 113, 135, 138, 139, 143, 163, 166, 170, 197, 204, 205, 207, 256, 274, 275, 316, 329, 337, 359, 372, 373, 390, 391, 393, 400, 413, 415, 444, 446, 464, 469, 481, 490, 492, 493, 494, 502, 511, 548, 570, 571, 589, 601, 622, 624, 635, 657, 681, 692, 694, 706, 751.

Air Pollution: Research and Control

1, 3, 5, 6, 7, 8, 9, 11, 16, 17, 18, 22, 23, 24, 25, 26, 27, 28, 29, 30, 38, 39, 40, 41, 42, 43, 44, 45, 46, 49, 54, 55, 57, 60, 61, 62, 63, 66, 70, 73, 75, 80, 82, 88, 89, 90, 94, 95, 97, 98, 99, 100, 101, 102, 103, 104, 106, 111, 120, 134, 140, 143, 156, 157, 158, 159, 163, 164, 165, 167, 171, 174, 175, 178, 180, 182, 183, 185, 190, 193, 194, 195, 196, 202, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 220, 223, 224, 225, 226, 227, 228, 229, 231, 232, 233, 234, 236, 238, 241, 244, 248, 249, 250, 253, 254, 257, 259, 265, 291, 292, 302, 303, 304, 309, 318, 319, 320, 321, 322, 330, 336, 338, 343, 344, 346, 348, 349, 350, 354, 356, 362, 364, 365, 368, 374, 377, 383, 399, 401, 404, 405, 406, 414, 417, 421, 435, 439, 440, 441, 449, 451, 453, 458, 460, 463, 466, 467, 470, 480, 482, 483, 484, 488, 489, 495, 496, 513, 515, 516, 517, 518, 529, 532, 540, 541, 543, 544, 549, 550, 559, 560, 562, 564, 565, 573, 575, 578, 580, 581, 582, 585, 586, 587, 588, 591, 592, 594, 595, 597, 598, 599, 603, 604, 606, 607, 613, 615, 617, 618, 619, 620, 626, 634, 636, 638, 639, 640, 641, 642, 643, 645, 653, 654, 657, 658, 659, 667, 673, 675, 676, 679, 680, 682, 683, 684, 685, 687, 690, 691, 696, 701,

(Air Pollution Con't)

703, 705, 713, 714, 715, 716, 717, 718, 721, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 752, 753, 757, 758, 759, 764.

Water Pollution: Research and Control

2, 3, 4, 12, 19, 31, 32, 33, 36, 47, 49, 52, 53, 54, 76, 87, 92, 105, 106, 108, 109, 114, 117, 118, 121, 122, 123, 124, 125, 128, 129, 130, 131, 137, 142, 143, 145, 146, 148, 149, 150, 151, 152, 153, 154, 158, 162, 163, 168, 173, 175, 179, 181, 184, 186, 190, 196, 203, 219, 242, 243, 246, 260, 276, 277, 283, 285, 286, 291, 293, 294, 295, 296, 297, 298, 317, 323, 324, 325, 326, 332, 333, 335, 341, 342, 345, 347, 351, 352, 355, 366, 367, 369, 375, 376, 381, 382, 384, 395, 410, 411, 412, 418, 419, 422, 426, 436, 437, 443, 447, 452, 465, 474, 476, 477, 478, 479, 501, 504, 505, 506, 508, 518, 522, 525, 526, 530, 531, 533, 534, 535, 537, 538, 545, 555, 557, 561, 563, 566, 569, 576, 577, 579, 590, 608, 609, 610, 613, 614, 616, 625, 627, 630, 632, 633, 641, 644, 646, 648, 650, 651, 656, 657, 662, 663, 668, 677, 678, 680, 682, 684, 685, 687, 688, 690, 691, 693, 700, 701, 704, 707, 708, 710, 750, 754, 755, 761.

Solid Wastes: Research and Control

3, 10, 13, 15, 20, 21, 24, 35, 37, 49, 58, 155, 169, 221, 222, 247, 290, 403, 510, 513, 593, 605, 611, 637, 641, 647, 660, 664, 665, 666, 669, 670, 671, 674, 686, 695, 722, 723, 738, 739, 756.

Chemicals

4, 46, 52, 57, 66, 99, 100, 142, 151, 158, 209, 229, 237, 323, 350, 384, 417, 453, 457, 458, 481, 573, 589, 605, 655, 656, 659, 663, 669, 682, 690, 700, 732, 733, 734, 736, 737, 738, 747, 758.

Electric Power

4, 44, 56, 57, 70, 75, 96, 103, 114, 130, 165, 202, 233, 234, 237, 238, 286, 294, 338, 346, 349, 356, 406, 439, 443, 463, 476, 484, 516, 568, 592, 603, 606, 607, 617, 628, 675, 691, 739, 741, 742, 746, 760, 762.

Iron and Steel

50, 51, 57, 66, 72, 99, 120, 158, 226, 227, 229, 237, 268, 272, 275, 362, 363, 364, 370, 448, 459, 460, 518, 586, 600, 602, 626, 638, 642, 643, 652, 671, 737, 738, 740.

Food and Feed Processing

52, 57, 155, 229, 243, 284, 352, 565, 625, 631, 670, 677, 680, 687, 726.

Nonferrous Metals

72, 81, 88, 89, 90, 111, 228, 237, 405, 419, 435, 461, 502, 581, 602, 608, 614, 642, 671, 725, 739, 751, 753.

Petroleum and Petrochemical Products

52, 53, 54, 57, 66, 99, 100, 105, 158, 193, 229, 245, 253, 267, 281, 308, 313, 317, 334, 342, 343, 351, 385, 418, 422, 424, 490, 493, 514, 538, 562, 563, 609, 610, 615, 629, 635, 639, 641, 644, 668, 701, 710, 736, 737, 738, 739, 749.

Pulp and Paper

52, 57, 66, 99, 123, 150, 158, 229, 273, 293, 309, 321, 347, 374, 401, 403, 421, 441, 479, 491, 503, 544, 549, 569, 595, 634, 685, 694, 738, 739, 641.

Other Industries

14, 43, 52, 61, 63, 66, 98, 99, 108, 117, 147, 164, 237, 238, 242, 246, 247, 255, 259, 270, 291, 339, 357, 378, 379, 380, 400, 447, 456, 457, 465, 505, 506, 510, 519, 531, 537, 539, 596, 623, 651, 661, 662, 676, 678, 689, 704, 705, 721.

PART IV

BIBLIOGRAPHIES, ABSTRACTS, LISTS OF PUBLICATIONS, RESEARCH PROJECTS, AND GUIDES TO LITERATURE

1. American Petroleum Institute. Air Pollution--Bibliography (New York, New York, 1960).

2. American Water Resources Association. Water Resources Abstracts (Urbana, Illinois, published monthly).

   Contains abstracts on many aspects of water resources including pollution of waterways.

3. Bennett, G., and J. Hostman. Bibliography of Books on the Environment--Air, Water and Solid Wastes (Toledo, Ohio: University of Toledo, Department of Chemical Engineering, 1969).

4. Christianson, A. G., and B. A. Tichenor. Industrial Waste Guide on Thermal Pollution, for Federal Water Pollution Control Administration (Washington, D. C.: U. S. Government Printing Office, September 1968).

   Presents a guide to sources, effects, and control of thermal pollution and a guide to literature concerned with thermal pollution.

5. Cooper, A. G. Air Pollution Publications, A Selected Bibliography, 1963-1966, for U. S. Public Health Service (Washington, D. C.: U. S. Government Printing Office, 1966).

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7. ________. Carbon Monoxide, A Bibliography with Abstracts for U. S. Public Health Service (Washington, D. C.: U. S. Government Printing Office, 1966).

8. Davenport, S. J., and C. G. Morgis. Air Pollution, A Bibliography (Washington, D. C.: U. S. Government Printing Office, 1954).

9. Gibson, J. R., W. E. Culver, and M. E. Kurz. The Air Pollution Bibliography, Vol. I (Washington, D. C.: U. S. Government Printing Office, 1957).

10. Golueke, C. G., and Staff of the College of Engineering. Solid Waste Management Abstracts and Excerpts from the Literature, Research Grant No. EC-00260 to the University of California, for U. S Department of Health, Education, and Welfare, Bureau of Solid Waste Management (Washington, D. C.: U. S. Government Printing Office, 1970).

Presents a rather comprehensive survey of the literature available in the field of solid waste management.

11. Jacobius, A. J., J. R. Gibson, V. S. Wright, W. D. Culver, and L. Kassianoff. The Air Pollution Bibliography, Vol. II (Washington, D. C.: U. S. Government Printing Office, 1959).

12. Lawson, B. L. Atlas of Industrial Water Use, Publication No. 18 (Ithaca, New York: Cornell University, Water Resources Center, September 1967).

13. Lefke, L. W., A. G. Keene, R. A. Chapman, and H. Johnson. Summaries of Solid Waste Research and Training Grants, 1970, for U. S. Environmental Protection Agency, Solid Waste Management Office (Washington, D. C.: U. S. Government Printing Office, 1971).

Presents a review of completed and active solid waste research projects and training programs supported by the Environmental Protection Agency in the interest of developing economical and efficient solid waste management practices.

14. Livengood, C. D. Textile Wastes--A Bibliography (Raleigh, North Carolina: Water Resources Research Institute, North Carolina State University February 1969).

15. Moore, R. T., J. J. Sabo, and D. M. Vankirk (eds). Grants Activities Supported by the Environmental Control Administration of the Environmental Health Service (Washington, D. C.: U. S. Government Printing Office, 1969).

Describes grants activities funded by the Environmental Control Administration during the fiscal year 1969. The Environmental Control Administration is made up of five bureaus--Community Environmental Management, Occupational Safety and Health, Radiological Health, Solid Waste Management, and Water Hygiene; each bureau has a section in this publication describing its own grants programs.

16. Nuttonson, M. Y. AICE Survey of USSR Air Pollution Literature, Volume IV. Meteorological and Chemical Aspects of Air Pollution, Propagation and Dispersal of Air Pollutants in a Number of Areas in the Soviet Union (Silver Spring, Maryland: American Institute of Crop Ecology, December 1969).

17. ________. AICE Survey of USSR Air Pollution Literature. Volume V. Effects of Meteorological Conditions and Relief on Air Pollution; Air Contaminants, Their Concentration, Transport, and Dispersal (Silver Spring, Maryland: American Institute of Crop Ecology, January 1970).

18. ________. AICE Survey of USSR Air Pollution Literature. Volume VI. Air Pollution in Relation to Certain Atmospheric and Meteorological Conditions and Some of the Methods Employed in the Survey and Analysis of Air Pollutants (Silver Spring, Maryland: American Institute of Crop Ecology, 1971).

19. Ontario Water Resources Commission. Bibliography and Reference Material (Toronto, Ontario, n.d.).

Contains: bibliography and reference material, general reference material, lists of films and filmstrips, publishers, and Provencial Water Pollution Control Agencies.

20. Sponagle, C. E. Solid Wastes Demonstration Grant Abstracts; Grants Awarded January 1 - June 30, 1969, U. S. Department of Health, Education, and Welfare (Washington, D. C.: U. S. Government Printing Office, 1969).

21. Toftner, R. O., D. O. Swavely, W. T. Dehn, and B. L. Sweeney. State Solid Waste Planning Grants, Agencies, and Progress - 1970, Public Health Service Publication No. 2109 (Washington, D. C.: U. S. Government Printing Office).

22. U. S. Department of Health, Education, and Welfare, Air Pollution Control Office. Photochemical Oxidants and Air Pollution: An Annotated Bibliography, APCO Publication No. AP-88 (Washington, D. C.: U. S. Government Printing Office, March 1971).

23. ________, National Air Pollution Control Administration. Air Pollution Translations: A Bibliography with Abstracts--Volume 2, NAPCA Publication No. AP-69 (Washington, D. C.: U. S. Government Printing Office, April 1970).

Presents a bibliography of worldwide technical literature on air pollution, and includes abstracts and indexes. Entries have been translated from 15 foreign languages.

24. ________, National Air Pollution Control Administration. Guide to Research in Air Pollution, Projects Active in Calendar Year 1969, Public Health Service Publication No. 981, 7th ed. (Washington, D. C.: U. S. Government Printing Office, April 1970).

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Descriptions of selected research projects in air pollution supported by the National Air Pollution Control Administration.

26. ________, National Air Pollution Control Administration. Hydrocarbons and Air Pollution: An Annotated Bibliography, NAPCA Publication No. AP-75 (Washington, D. C.: U. S. Government Printing Office, October 1970).

27. ________, National Air Pollution Control Administration. Nitrogen Oxides: An Annotated Bibliography, NAPCA Publication No. AP-72 (Washington, D. C.: U. S. Government Printing Office, August 1970).

28. ________, Office of Air Programs. Hydrochloric Acid and Air Pollution: An Annotated Bibliography, OAP Publication No. AP-100 (Washington, D. C.: U. S. Government Printing Office, July 1971).

29. U. S. Department of the Interior, Bureau of Mines. Air Pollution Publications Selected from Bureau of Mines Publication Series and Journal Articles by Bureau of Mines Authors (Washington, D. C.: U. S. Government Printing Office, January 1, 1970).

30. ________, Federal Water Quality Administration. Projects of the Industrial Pollution Control Branch (Washington, D. C.: U. S. Government Printing Office, January 1970).

Contains summary information sheets of research, development, and demonstration projects administered by the Industrial Pollution Control Branch.

31. ________, Federal Water Quality Administration. Projects of the Industrial Pollution Control Branch (Washington, D. C.: U. S. Government Printing Office, July 1970).

Contains summary information sheets of research, development, and demonstration projects administered by the Industrial Pollution Control Branch; also contains numerous tables on liquid and liquid-borne pollutants by industrial category.

32. ________, Federal Water Quality Administration. Projects of the Industrial Pollution Control Branch (Washington, D. C.: U. S. Government Printing Office, July 1971).

Contains [illegible] of research, development, and demonstration projects administered by the Industrial Pollution Control Branch.

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Contains information sheets on municipal, industrial, agricultural, mining, and other-sources of pollution control technology, water resources planning and resources data.

34. U. S. Environmental Protection Agency. Solid Waste Management: A List of Available Literature (Washington, D. C.: U. S. Government Printing Office, October 1971).

This report presents a list of publications pertaining to solid waste management, research, and demonstration projects collected or published by the U. S. Environmental Protection Agency.

35. ________. Solid Waste Management: A List of Available Literature (Washington, D. C.: U. S. Government Printing Office, 1972).

This report presents a list of publications pertaining to solid waste management, research, and demonstration projects collected or published by the U. S. Environmental Protection Agency.

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37. ________. Solid Waste Management Demonstration Grant Projects - 1971, Solid Waste Management Series Publication No. SW-3d.i (Washington, D. C.: U. S. Government Printing Office, 1971).

38. ________, Air Pollution Control Office. Air Pollution Aspects of Emission Sources: Municipal Incineration--A Bibliography with Abstracts, APCO Publication No. AP-92 (Washington, D. C.: U. S. Government Printing Office, May 1971).

39. ________, Air Pollution Control Office. Air Pollution Aspects of Emission Sources: Nitric Acid Manufacturing--A Bibliography with Abstracts, APCO Publication No. AP-93 (Washington, D. C.: U. S. Government Printing Office, May 1971).

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41. ________, Air Pollution Control Office. Beryllium and Air Pollution: An Annotated Bibliography, APCO Publication No. AP- (Washington, D. C.: U. S. Government Printing Office, February 1971).

42. ________, Office of Air Programs. Air Pollution Abstracts (Washington, D. C.: U. S. Government Printing Office, published monthly).

Presents a monthly survey of technical literature available in the field of air pollution. Subject fields are: emission sources, control methods, measurement methods, air quality measurements, atmospheric interaction, basic science and technology, effects--human health, effects-- plants and livestock, effects--materials, economic aspects, standards and criteria, legal and administrative, social aspects, general and miscellaneous.

43. ________, Office of Air Programs. Air Pollution Aspects of Emission Sources: Cement Manufacturing--A Bibliography with Abstracts, OAP Publication No. AP-94 (Washington, D. C.: U. S. Government Printing Office, May 1971).

44. ________, Office of Air Programs. Air Pollution Aspects of Emission Sources: Electric Power Production--A Bibliography with Abstracts, OAP Publication No. AP-96 (Washington, D. C.: U. S. Government Printing Office, May 1971).

45. ________, Office of Air Programs. Air Pollution Aspects of Emission Sources: Sulfuric Acid Manufacturing--A Bibliography with Abstracts, OAP Publication No. AP-95 (Washington, D. C.: U. S. Government Printing Office, May 1971).

46. ________, Office of Air Programs. Chlorine and Air Pollution: An Annotated Bibliography, OAP Publication No. AP-99 (Washington, D. C.: U. S. Government Printing Office, July 1971).

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Presents a list of projects concerned with research, development, and demonstration activities in the Environmental Protection Agency sponsored water research program.

BOOKS AND REPORTS

48. Adler, J. H. The Underdeveloped Areas: Their Industrialization (New Haven, Conn.: Yale Institute of International Studies, 1949).

49. Aerojet-General Corporation. California Waste Management Study, Report 3056 (Final) (Azusa, California: Aerojet-General Corporation, August 1965).

Discusses types of wastes, their characteristics and effects, reviews methods of processing and disposing of waste, describes the systems concept and its application to waste management in California, discusses the result and purpose of waste management, considers the structure of waste management systems, compares costs of various systems and environmental quality levels, considers the governmental functions and organization required to implement a systems approach to waste management, outlines a plan for future actions to establish a waste management system, and presents a detailed analysis of the Sacramento, California area as a pilot model for the more general systems approach.

50. American Coke and Coal Chemicals Institute. Clean Air and the Foundry Industry (Washington, D. C., n. d.).

51. American Foundrymen's Society. Control of Emissions from Metal Melting Operations (DesPlaines, Illinois, n. d.)

52. American Institute of Chemical Engineers. Industrial Process Design for Water Pollution Control (New York, New York, 1970).

Presents the proceedings of a workshop sponsored by the American Institute of Chemical Engineers Water Committee to study means of diminishing water pollution by industry. Selected industries and pertinent pollution problems are discussed in individual papers.

53. American Petroleum Institute. Manual on Disposal of Refinery Wastes, Volume on Liquid Wastes (New York, New York, 1969).

54. ________. Report on Air and Water Conservation Expenditures of the Petroleum Industry in the United States, 1966-1970 (New York, New York, February 1971).

55. American Society of Mechanical Engineers. Disposal of Industrial Wastes by Combustion: ASME-Industry Survey, Present State of the Art (1971).

56. Anastaplo, G. R., S. Berry, R. H. Coase, H. Demsetz, and M. Friedman. The Legal and Economic Aspects of Pollution (Chicago: Chicago University Center for Policy Study, 1970).

Report of a faculty panel discussion of some basic, philosophical problems affecting current attitudes toward pollution.

57. Anderson, H. S., R. E. Paddock, R. O. Lyon, M. E. Fogel, and E. L. Hill. USSR's Manual of Automated Procedures for Estimating Control Costs and Emission Reductions for Specified Air Pollution Sources, Contract No. PHS-CPA-70-60 (Durham, North Carolina: Research Triangle Institute, December 1970).

Presents a user's manual for using computer programs which were developed to estimate emissions from industrial sources and the costs of control.

58. Anderson, L. E. Comprehensive Studies of Solid Waste Management, A Mathematical Model for the Optimization of a Waste Management System, Rev. by A. K. Nigam, SERL Report No. 68-1 (Berkeley, California: University of California, February 1968).

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Very good selection of readings in welfare economics. Readings are grouped under the following headings: Foundations, Political Aspects of Welfare Economics, Social versus Private Costs and Benefits, Increasing Returns, The Measurement of Welfare, Taxes and Prices, and Investment and Growth.

60. Athanassiadis, Y. C. Air Pollution Aspects of Cadmium and its Compounds (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrence; production and product sources; environmental air concentrations; abatement; economics; and methods of analysis.

61. ________. Air Pollution Aspects of Phosphorus and its Compounds (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrence; production, product, and other sources; environmental air concentrations; abatement; economics; methods of analysis; sampling methods; and quantitative methods.

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(Same outline as for entry 60.)

63. Ayres, R. U., and R. P. McKenna. Alternatives to the Internal Combustion Engine (Baltimore: The Johns Hopkins Press, 1971).

64. Barkley, P. W., and D. W. Seckler. Economic Growth and Environmental Decay: The Solution Becomes the Problem (New York: Harcourt Brace Jovanovich, Inc., 1972).

A very readable introduction to environmental economics. Environmental decay is shown to be a direct result of economic growth which, although necessary up to now, is questioned in light of the environmental problems associated with economic growth.

65. Baumol, W. J. Welfare Economics and the Theory of the State (Cambridge, Massachusetts: Harvard University Press, 1965).

66. Bay Area Air Pollution Control District. Air Pollution and the San Francisco Bay Area, 6th ed. (San Francisco: Bay Area Air Pollution Control District, March 1972).

Nontechnical booklet describing air pollution in the San Francisco Bay Area. Contains a table showing the tons per day of particulates, oxides of sulfur, organic compounds, oxides of nitrogen, and carbon monoxide emitted by each of approximately 100 selected specific industrial sources (by company name) in the area.

67. Bergson, A. Essays in Normative Economics (Cambridge, Massachusetts: The Belknap Press of Harvard University Press, 1966).

68. Besselievre, E. B. Industrial Waste Treatment (New York: McGraw-Hill Book Co., 1952).

69. ________. The Treatment of Industrial Wastes (New York: McGraw-Hill Book Co., 1969).

70. Black, Guy. Energy, Air Quality and the System Approach (Washington, D. C.: George Washington University, Program of Policy Studies in Science and Technology, July 1970).

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71. Bohm, P. External Economies in Production (Stockholm: Almquist & Wiksells, 1964).

72. Borts, G. H. Economic Factors in the Location of Industry (Providence, Rhode Island: Brown University, 1959).

See especially Part II: The Metalworking Industries.

73. Brunelle, M. F., M. J. Leonard, W. G. MacBeth, J. C. Mosher, and T. P. Mullins. An Analysis of Ozone Alerts in Los Angeles County (Los Angeles, Calif.: County of Los Angeles, Air Pollution Control District, September 1, 1968).

74. Bryce, M. D. Policies and Methods for Industrial Development (New York: McGraw-Hill Book Co., Inc., 1965).

75. Bureau of Abatement and Control. Estimates of Air Pollution Concentrations from Four Corners Power Plant, New Mexico (Durham, North Carolina, January 1970).

76. Campbell, T. H., and R. O. Sylvester (eds.). Water Resources Management and Public Policy (Seattle: University of Washington Press, 1968).

Contains fifteen articles by scientists, economists, engineers, lawyers, and industrialists outlining the "relevant technical, scientific, and policy issues that should be considered in the management of water resources."

77. Chapman, R. L. (ed.). Environmental Pollution Instrumentation (Pittsburgh, Penn.: Instrument Society of America, 1969).

78. Chrysler Corporation. Toward A Cleaner Environment, A Report on Chrysler Corporation's Efforts to Combat Pollution (Detroit, Michigan, May 1970).

79. Ciriacy-Wantrup, S. V., and J. J. Parsons (eds.). Natural Resources: Quality and Quantity (Berkeley and Los Angeles: University of California Press, 1967).

80. Colley, D. G., and K. Aziz. Numerical Simulation of Atmospheric Pollution from Industrial Sources, Report No. 1 (Calgary, Alberta: University of Calgary, Department of Chemical Engineering, 1968).

81. Cotterill, C. H. Industrial Plant Location: Its Application to Zinc Smelting (St. Louis, Missouri: American Zinc, Lead and Smelting Co., 1950).

82. Council of Europe, Committee of Experts on Air Pollution. Comparative Study of Certain Provisions in Member States for Controlling Air Pollution, January 1971).

Results of a questionnaire sent to Austria, Belgium, Italy, The Netherlands, Norway, Sweden, Greece, France, Ireland, Germany, Malta, Great Britain, and Turkey for the purpose of surveying legislation on air pollution control.

83. Crocker, T. D., and A. J. Rogers III. Environmental Economics (Hinsdale, Illinois: The Dryden Press, 1971).

84. Culbertson, J. Economic Development: an Ecological Approach (New York: Alfred A. Knopf, 1971).

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87. Davis, R. K. The Range of Choice in Water Management: A Study of Dissolved Oxygen in the Potomac Estuary (Baltimore: The Johns Hopkins Press, 1968).

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Contains a general overview of the cadmium industry, a brief description of industrial processes and a review of the types and extent of cadmium emissions.

89. ________. National Inventory of Sources and Emissions: Cadmium, Nickel, and Asbestos - 1968. Nickel, Section II (Leawood, Kansas, February 1970).

Contains a general overview of the nickel industry, a brief description of industrial processes, and a review of the types and extent of nickel emissions.

90. ________. National Inventory of Sources and Emissions: Cadmium, Nickel, and Asbestos - 1968. Asbestos, Section III (Leawood, Kansas, February 1970).

Contains a general overview of the asbestos industry, a brief description of industrial processes, and a review of the types and extent of asbestos emissions.

91. De Bell, G. The Environmental Handbook (New York, 1970).

92. Di Luzio, F. C., J. W. Heintz, and C. L. Gransee. Engineering Evaluation of Factors Affecting Quality of Water Sources Available for Saline Water Conversion Plants, Contract No. DI-14-01-0001-378 (Baltimore, Maryland: Sheppard T. Powell and Associates, December 1965).

93. Dolan, E. G. TANSTAAFL (There ain't no such thing as a free lunch): The Economic Strategy for Environmental Crisis (New York: Holt, Rinehart and Winston, Inc., 1971).

94. Durocher, N. L. Air Pollution Aspects of Beryllium and its Compounds (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrence; production and product sources; environmental air concentrations; abatement; economics; sampling methods; and quantitative methods.

95. ________. Air Pollution Aspects of Boron and its Compounds (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrences; production and product sources; environmental air concentrations; abatement; and methods of analysis.

96. Erdmann, R. C., S. Hsueth, V. P. Osterli, and R. L. Perrine. Power, Industry, Agriculture and Ecology, Preliminary Report, Project Clean Air (Riverside: University of California, June 30, 1970).

97. Faith, W. L. Air Pollution Control (New York: John Wiley & Sons, 1959).

98. Finkelstein, H. Air Pollution Aspects of Pesticides (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrence; production and product sources; environmental air concentrations; abatement; economics; and methods of analysis.

99. Fogel, M. E., D. R. Johnston, R. L. Collins, D. A. LeSourd, and R. W. Gerstle. Comprehensive Economic Cost Study of Air Pollution Control Costs for Selected Industries and Selected Regions (Durham, North Carolina: Research Triangle Institute, February 1970).

Costs of controlling particulates, sulfur oxides, hydrocarbons, and carbon monoxide in 100 metropolitan areas were estimated. Estimates were made for controlling emissions from the following sources: solid waste disposal, industrial boilers, steam electric generating plants, commercial, industrial and residential heating plants, and 15 industrial catagories.

100. ________, R. E. Folson, E. L. Hill, and F. A. Ayer. Survey Plan for Specified Air Pollution Sources (Durham, North Carolina: Research Triangle Institute, Operations Research and Economics Division, December 1970).

101. Fuller, L. J., R. L. Chass, and R. G. Lunche. Air Pollution Data for Los Angeles County (Los Angeles, Calif.: County of Los Angeles, Air Pollution Control District, January 1968).

102. ________, ________, and ________ . Profile of Air Pollution Control in Los Angeles County (Los Angeles, Calif.: County of Los Angeles, Air Pollution Control District, January 1969).

103. Gartrell, F. E., F. W. Thomas, S. B. Carpenter, F. Pooler, B. Turner, and J. M. Leavitt. Full Scale Dispersion of Stack Gases, A Summary Report (Chattanooga, Tenn.: Tennessee Valley Authority, Division of Health and Safety, August 1964).

104. Germogenova, O. A., J. P. Friend, and A. M. Sacco. Atmospheric Haze: A Review (Cambridge, Massachusetts: Bolt Beranek and Newman, Inc., March 1970).

105. Gloyna, E. F., and D. L. Ford. The Characteristics and Pollutional Problems Associated with Petrochemical Wastes, Summary Report for Federal Water Pollution Control Association (Austin, Texas: Engineering Science, Inc., February 1970).

106. Goldman, M. I. (ed.). Controlling Pollution (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1967).

Contains 17 articles on pollution under the following headings: Introduction; The Nature of the Problem; Economic Analysis; Current Cases; The Soviet Parallel; National Solutions.

107. Graaff, J. de V. Theoretical Welfare Economics (Cambridge: Cambridge University Press, 1957).

108. Gramley, D. I., and M. S. Heath, Jr. A Study of Water Pollution Control in the Textile Industry of North Carolina (Raleigh: North Carolina Water Resources Research Institute, January 1970).

Presents a review of the textile history in North Carolina, production processes, case studies of water utilization in plants, and an economic analysis of waste treatment practices.

109. Grava, Sigurd. Urban Planning Aspects of Water Pollution Control (New York: Columbia University Press, 1969).

110. Gurnham, C. F. Principles of Industrial Waste Treatment (New York: John Wiley & Sons, Inc., 1955).

111. Hardison, L. C., and H. R. Herington. Study of Technical and Cost Information for Gas Cleaning Equipment in the Lime and Secondary Non-Ferrous Metallurgical Industries (Rye, New York: Industrial Gas Cleaning Institute, December 31, 1970).

112. Havemeyer, Loomis, et al. Conservation of Our Natural Resources (New York: The Macmillan Company, 1930).

113. Herfindahl, O. C., and A. V. Kneese. Quality of the Environment: An Economic Approach to Some Problems in Using Land, Water, and Air (Baltimore, Maryland: The Johns Hopkins Press, Inc., 1965).

Discusses the role of economics in analyzing and solving the problems of environmental deterioration.

114. Higgins, J. A Study of Thermal Pollution Abatement Methods (State of New York: Bureau of Air Resource Development, March 1, 1969).

Discusses various methods of cooling water discharged primarily from electric generating plants.

115. Jarrett, H. (ed.). Environmental Quality in a Growing Economy (Baltimore, Maryland: The Johns Hopkins Press, 1971).

Good collection of readings on economic growth and environmental quality. Two readings are included on each of the following six topics, one being written by an expert on that topic and the other by another expert on that topic who is asked "to respond either by critical comment, development of other aspects of the problem, or both": Resources Development and the Environment, Environment and Human Health, Beyond the Market Mechanism, Economic Research in Problems of Environment, Public Attitudes on Environmental Quality, and Needed Improvements in Policies and Institutions.

116. Johnson, W. A., and J. Hardesty (eds.). Economic Growth vs. the Environment (Belmont, California: Wadsworth Publishing Company, Inc., 1971).

117. Jones, L. D., and W. L. Hyden. The State of the Art of Water Use and Waste Disposal in the Textile Industry 1950-1966 (Atlanta, Georgia: Georgia Institute of Technology, Water Resources Center.)

118. Kaiser Industries Corporation, Kaiser Engineers. Final Report to the State of California, San Francisco Bay-Delta Water Quality Control Program (Oakland, California, June 1969).

Studies the effects of wastewater and drainage discharges into the waters of the San Francisco Bay and Delta area, determines the need for and the feasibility of a comprehensive multiple purpose waste collection and disposal system for the area, as well as other measures of maintenance of the quality of the waters, and develops the basic features of a comprehensive plan for the control of water pollution.

119. Kapp, K. W. The Social Costs of Private Enterprise (New York: Schocken Books, 1971).

120. Kearney, A. T., and Company. Systems Analysis of Emissions and Emissions Control in the Iron Foundry Industry. Volume III. Appendix (Chicago, Illinois, February 1971).

121. Klein, L. River Pollution II: Causes and Effects (London: Butterworths, 1962).

122. ________. River Pollution III: Control (London: Butterworths, 1966).

Discusses aspects of river pollution and available methods for pollution control and prevention.

123. Kleppe, P. J., and C. N. Rogers. Survey of Water Utilization and Waste Control Practices in the Southern Pulp and Paper Industry (Raleigh: North Carolina Water Resources Research Institute, June 1970).

A survey of 46 pulp and paper mills was conducted to determine water usage and pollution abatement in the pulp and paper industry. Recommendations for research were made in six areas.

124. Kneese, A. V. Approaches to Regional Water Quality Management (Washington, D. C.: Resources for the Future, Inc., 1967).

125. ________. Water Pollution: Economic Aspects and Research Needs (Baltimore: The Johns Hopkins Press, 1962).

126. ________, R. U. Ayres, and R. C. d'Arge. Economics and the Environment: A Materials Balance Approach (Baltimore, Maryland: The Johns Hopkins Press, 1970).

Uses the materials balance approach to analyze material residuals from major sectors of the economy and presents a mathematical model that unites the materials balance concept with the concept of general equilibrium in exchange.

127. ________, and B. T. Bower (eds.). Environmental Quality Analysis: Research Studies in the Social Sciences (Baltimore, Maryland: The Johns Hopkins Press, forthcoming).

128. ________, and ________. Managing Water Quality: Economics, Technology, Institutions (Baltimore, Maryland: The Johns Hopkins Press, 1968).

An outstanding treatment of the economic, technical, and institutional aspects of water quality management.

129. ________, and S. C. Smith (eds.). Water Research (Baltimore, Maryland: The Johns Hopkins Press, 1966).

Contains a collection of 26 papers reporting primarily on research in the field of water resources.

130. Krenkel, P. A. Notes on Thermal Pollution (Nashville, Tennessee: Vanderbilt University, 1968).

131. Krutilla, J. V., and O. Eckstein. Multiple Purpose River Development: Studies in Applied Economic Analysis (Baltimore, Maryland: The Johns Hopkins Press, 1969).

132. Kryter, K. D. The Effects of Noise on Man (New York: The Academic Press, 1970).

133. Lerner, A. P. The Economics of Control (New York: The Macmillan Co., 1944).

134. LeSourd, D. A., *et al.* Comprehensive Study of Specified Air Pollution Sources to Assess the Economic Effects of Air Quality Standards, vol. I (Research Triangle Park, North Carolina: Research Triangle Institute, December 1970).

Estimates control costs for particulates, sulfur oxides, carbon monoxide, hydrocarbons, fluorides, and lead from stationary sources in 298 metropolitan areas using comparatively stringent control standards.

135. Lipsett, C. H. Industrial Waste and Salvage, Conservation and Utilization (Atlas Publishing Company, 1951, 1963).

136. Little, I. M. D. A Critique of Welfare Economics, 2nd ed. (Oxford, England: Clarendon Press, 1957).

137. Ludwig, H. F., and R. V. Stone, Jr. Present Economic and Technical Status of Water Reclamation from Sewage and Industrial Wastes, Technical Bulletin 4, I. E. R. Ser. 37, Issue 4 (Berkeley: University of California, Sanitary Engineering Research Project, March 1951).

138. Lund, Herbert F. (ed.). Industrial Pollution Control Handbook (New York: McGraw-Hill Book Company, 1971).

139. Macaulay, H. H. Use of Taxes, Subsidies, and Regulations for Pollution Abatement (Clemson, South Carolina: Clemson University, Water Resources Research Institute, June 1970).

Discusses social costs of pollution and possible regulatory methods such as fees or charges imposed upon water polluters.

140. Magill, P. L., F. R. Holden, and C. Ackley. Air Pollution Handbook (New York: McGraw-Hill Book Company, Inc., 1956).

141. Mandelbaum, K. The Industrialization of Backward Areas (Oxford: Basil Blackwell, 1961).

142. Manufacturing Chemists Association. Soluable Organic Chemical Wastes: Control, Treatment, Disposal (Washington, D. C., April 1966).

143. ________. Toward a Clean Environment (Washington, D. C., 1967).

This report presents the results of a survey of the members of the Manufacturing Chemists Association on the control of air and water pollution and solid waste disposal. Data on emissions, effluents, solid waste, expenditures, personnel, fuel consumption, and water usage are tabulated.

144. Marshall, A. Principles of Economics, 8th ed. (London: The Mcmillan Co., 1920).

145. Massachusetts Health Research Institute, Inc. A Study of Small, Complete Mixing, Extended Aeration, Activated Sludge Plants in Massachusetts, for New England Interstate Water Pollution Control Commission (Boston, Massachusetts, June 1970).

Presents the results of a study to evaluate the operational procedures of small activated sludge plants, and to aid in establishing proper operations procedures for both existing and future plants.

146. ________. Operating Manual for Small, Extended Aeration, Activated Sludge Treatment Plants (Boston, Massachusetts: New England Interstate Water Pollution Control Commission, July 1971).

Presents a general guide for operators of activated sludge treatment plants designed for an average daily flow of between 2,000 and 10,000 gallons.

147. Masselli, J. W., Nicholas W. Masselli, and M. G. Burford. A Simplification of Textile Waste Survey and Treatment (Boston, Massachusetts: New England Interstate Water Pollution Control Commission, June 1967).

148. ________, ________, and ________. Controlling the Effects of Industrial Wastes on Sewage Treatment (Boston, Massachusetts: New England Interstate Water Pollution Control Commission, June 1971).

Discusses factors involved in discharging industrial wastes into municipal sewers and methods of controlling potential adverse effects.

149. ________, ________, and ________. The Effect of Industrial Wastes on Sewage Treatment (Boston, Massachusetts: New England Interstate Water Pollution Control Commission, June 1965).

Describes possible effects of industrial wastes on sewage treatment systems and methods of detecting and possibly eliminating the effects.

150. ________, ________, and ________. White Water Wastes from Paper and Paperboard Mills (Boston, Massachusetts: New England Interstate Water Pollution Control Commission, June 1970).

Deals with paper making mills and the sources of pollution and methods of treatment. Includes a brief description of the pulp making industry.

151. McCoy, J. W. Chemical Analysis of Industrial Water (New York: Chemical Publishing Company, 1969).

152. McGauhey, P. H. Studies in Water Reclamation, Technical Bulletin 13, I. E. R. Ser. 37, Issue 13 (Berkeley: University of California, Sanitary Engineering Research Laboratory, July 1955).

153. ________. Water Quality Management (Berkeley: University of California, Sanitary Engineering Research Laboratory, 1966).

154. ________, and H. Erlich. Economic Evaluation of Water. I. A Search for Criteria, Water Resources Contribution No. 13 (Berkeley: University of California, Sanitary Engineering Research Laboratory, December 1957).

155. Mercer, W. A. Composting Fruit and Vegetable Wastes. Part I. Investigation of Composting as a Means for Disposal of Fruit Wastes Solids, Progress Report (Berkeley, Calif.: National Canners Association, Research Foundation, May 1962).

156. Miner, S. Air Pollution Aspects of Ammonia (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrence; production and product sources; environmental air concentrations; abatement; economics; and methods of analysis.

157. ________. Air Pollution Aspects of Barium and its Compounds (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrence; production and product sources; abatement; economics; and methods of analysis.

158. ________. Air Pollution Aspects of Hydrogen Sulfide (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrence; production, product, and other sources; abatement; economics; and methods of analysis.

159. ________. Air Pollution Aspects of Radioactive Substances (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrence; production and product sources; control of radioactive pollution; location of facility site; air cleaning methods; radioactive gases and vapors; economics; sampling methods; quantitative methods; and air quality monitoring.

160. Mishan, E. J. The Costs of Economic Growth (New York: Frederick A. Praeger, Publishers, 1967).

161. _______. Welfare Economics (New York: Random House, 1969).

162. Morse, J. W., and P. H. Flanders. Effects of Industrial Wastes on the Upper Connecticut River (Montpelier, Vermont: Vermont Department of Water Resources, 1969).

First in a series of published water quality surveillance reports.

163. (The) National Petroleum Council. Environmental Conservation, The Oil and Gas Industries, vol. 1 (Washington, D. C., 1971).

An industry report on the effects of the oil and gas industry's operations on the quality of the environment and problems encountered and actions taken to reduce pollution caused by the oil and gas industry. Proposes public policies concerning the oil and gas industry. Chapter headings: The Requirements for Environmental Conservation; Law and Regulatory Policy; The Fundamentals of Industry Operations; Exploration and Production; Refining; Storage, Transportation, and Marketing; Major Oil Spills; The Fundamentals of Product Use; Mobile and Off-Highway Equipment--Emissions and Trends; Stationary Plants--Emissions and Trends.

164. National Research Council. Airborne Asbestos (Washington, D. C., 1971).

165. _______. Abatement of Sulfur Oxide Emissions from Stationary Combustion Sources (Washington, D. C., February 15, 1970).

Reviews the problem of increased sulfur dioxide emissions brought about by increased demand for electric power, and suggests possible means of reducing these emissions.

166. ________, Committee on Pollution. Waste Management and Control, A Report to the Federal Council for Science and Technology, Publication No. 1400 (Washington, D. C.: National Academy of Sciences, 1966).

167. National Tuberculosis and Respiratory Disease Association. Air Pollution Primer (New York, 1969).

A layman's introduction to air pollution problems.

168. New England Interstate Water Pollution Control Commission., Technical Advisory Board. Guides for the Design of Wastewater Treatment Works (Boston, Massachusetts, June 1971).

Discusses current practices and requirements in the design and construction of wastewater treatment works.

169. Nigam, A. K. Comprehensive Studies of Solid Wastes Management - Optimal Strategies in Capacity Expansion. (Berkeley: University of California, Sanitary Engineering Research Laboratory, December 1970).

170. Nuss, G. R., A. J. Darnay, Jr., and G. M. Ford. Environmental Pollution Control--A State-of-the-Art Review, Final Report, MRI Project No. 299-D (Kansas City Missouri: Midwest Research Institute, November 1966).

171. Olsen, D. A., and J. L. Haynes. Air Pollution Aspects of Organic Carcinogens (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrence; production and product sources; environmental air concentrations; abatement; sampling methods; extraction methods; separation; and spectroscopic analysis.

172. Olson, M. The Logic of Collective Action (Cambridge, Massachusetts: Harvard University Press, 1965).

173. Ontario Water Resources Commission and Quebec Water Board. Water Quality and Its Control in the Ottawa River, vol. 1 (Ontario, 1971).

Included in the table of contents are: Basin description and resource use, Water Quality Problems, Water Quality Control, Additional Studies Required, and Summary of Findings from Previous Ottawa River Pollution Surveys.

174. Organization for Economic Co-operation and Development. Developments in Desulphurisation Research on Fuel (Paris, 1971).

Reviews factors influencing research policy on desulphurisation, describes desulphurisation processes, as well as those for removing pyrites from coal, and discusses methods of assessing costs of desulphurisation processes.

175. ________. Environment Policy in the OECD with Special Reference to the Programme on Water and Air (Paris, 1971).

176. ________. Governmental Responsibilities for the Application and Control of Technology in Relation to Man's Environment (Paris, 1971).

177. ________. Manual of Industrial Project Analysis in Developing Countries (Paris, vol. 1, 1968; vol. 2 by I. M. D. Little and J. A. Mirrlees, 1969).

178. ________. Models for Prediction of Air Pollution (Paris, 1971).

Discusses the use of models in various informational applications and the need for improving the capabilities of air pollution models. Describes similarities among several currently used models.

179. ________. Priority Problems in Water Management Research in Southern European Countries (Paris, 1971).

180. ________. Progress Report on the Experiment in Background Measurement (Paris, 1971).

181. ________. Report of Nationally Designated Experts on Eutrophication Control (Paris, 1971).

Provides a general overview of the eutrophication phenomenon and reviews the consequences of eutrophication and methods of control.

182. ________. Report on Current Research Work on Particulate Air Pollution in the Size Range below 10 Microns (Paris, 1971).

183. ________. Report on Present and Future Priorities in Research on Effects of Air Pollution (Paris, 1971).

184. ________. Scientific Fundamentals of the Eutrophication of Lakes and Flowing Waters, with Particular Reference to Nitrogen and Phosphorus as Factors in Eutrophication (Paris, 1971).

185. ________. Technical Problems in Measurement and Monitoring of Air Pollution (Paris, 1971).

Examines the major areas of air pollution abatement, problems of measurement of pollutants, and describes areas of deficiency in technical capability.

186. ________. Water Management Research Group - First Report, 1969 (Paris, 1971).

Describes the membership and purpose of the Water Management Research Group and presents a summary of its progress.

187. Perloff, H. S. (ed.). The Quality of the Urban Environment: Essays on 'New Resources' in an Urban Age (Baltimore, Maryland: The Johns Hopkins Press, Inc., 1969).

Contains nine research papers dealing with various aspects of the environment. Some of the topics included are: pollution, open space, transportation, land values, city location and size.

188. __________, E. S. Dunn, Jr., E. E. Lampard, and R. F. Muth. Regions, Resources, and Economic Growth (Lincoln: University of Nebraska Press, 1960).

A study of regional economic and population development in the United States with chapters grouped into five parts: An Historical Review of Regional Economic Growth; A Framework for Analysis; Regional Economic Development, 1870-1950; The Regional Distribution of Economic Activities in the United States, 1939-1954; and Variations in Levels and Rates of Growth of Per Capita Income.

189. Pigou, A. C. The Economics of Welfare (London: The Macmillan Co., 1946).

190. Pitts, J. N., Jr., and R. L. Metcalf (eds.). Advances in Environmental Sciences, vol. 1 (New York: John Wiley & Sons, Inc., Wiley-Interscience Div., 1969).

Contains nine articles concerned with some of the significant problems caused by man's impact on the environment.

191. Reder, M. Studies in the Theory of Welfare Economics (New York: Columbia University Press, 1947).

192. Resources for the Future, Inc. Annual Report, Year ending September 30, 1970 (Washington, D. C., December 1970).

193. Richtlinien, V. D. I. Restriction of Emission Mineral-Oil Refineries, translated from German (Washington, D. C.: National Science Foundation, May 1967).

Provides an explanation of the causes of emissions of dust and gases by mineral oil refineries.

194. Ridker, R. G. Economic Costs of Air Pollution (New York: Frederick A. Praeger, Publisher, 1967).

195. Robinson, Elmer. Critical Mathematical Evaluation of Air Pollution Concentration Modeling, SRT Project PSC-7985 (South Pasadena, California: Stanford Research Institute, January 1970).

196. Rose, J. Technological Injury (London: Gordon and Breach Science Publishers, 1969).

Contains a collection of papers on air, water, and radioactive pollution.

197. Ross, R. D. Industrial Waste Disposal (New York: Reinhold Book Corp., 1968).

An introductory engineering text on industrial waste disposal with the following chapter titles: The Problem, Waste Gas Treatment, Waste Liquid Treatment, Incineration, Final Disposal, Radioactive Waste Management, and Air and Water Pollution Regulations.

198. Rothenberg, J. F. The Measurement of Social Welfare (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1961).

199. Samuelson, P. A. Foundations of Economic Analysis (New York: Atheneum, 1965).

A classic work in economic analysis. Contains a chapter on welfare economics.

200. Scitovsky, T. Papers on Welfare and Growth (Stanford, Calif.: Stanford University Press, 1964).

201. Scott, Anthony. Natural Resources: The Economics of Conservation (Toronto: University of Toronto Press, 1959).

202. Semrau, Konrad T. Feasibility Study of New Sulfur Oxide Control Processes for Application to Smelters and Power Plants. Part IV: The Wellman-Lord SO_2 Recovery Process for Application to Power Plant Flue Gases (Final Report), SRI Project PMU-7923 (Menlo Park, Calif.: Stanford Research Institute, 1969).

203. Sewell, W. R. D., and B. T. Bower, et al. Forecasting the Demands for Water (Ottawa, Ontario: Canadian Department of Energy, Mines, and Resources, Policy and Planning Branch, 1968).

Eight papers on methods of forecasting the demand for water, including industrial demand.

204. Singer, S. F. (ed.). Symposium on the Global Effects of Environmental Pollution (Springer-Verlag, 1970).

205. Smith, F. The Economic Theory of Industrial Waste Production and Disposal (Unpublished doctor's dissertation, Department of Economics, Northwestern University.)

Applies the concept of materials balance to problems of waste disposal.

206. Sollera, A. A. Ours is the Earth (New York: Holt, Rinehart and Winston, Inc., 1963).

207. Spilhous, A. Waste Management and Control, Publication No. 1400 (Washington, D. C.: National Academy of Sciences, Natural Research Council, 1966).

208. Stahl, Q. R. Air Pollution Aspects of Aldehydes (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrence; production and product sources; environmental air concentrations; abatement; economics; and methods of analysis.

209. ________. Air Pollution Aspects of Chlorine (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

(Same outline as for entry 208).

210. ________. Air Pollution Aspects of Ethylene (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

(Same outline as for entry 208).

211. ________. Air Pollution Aspects of Hydrochloric Acid (Bethesda, Maryland: Litton Systems, Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrence; production, product and other sources; and environmental air concentrations.

212. ________. Air Pollution Aspects of Mercury and its Compounds (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrence; production and product sources; environmental air concentrations; abatement; and methods of analysis.

213. ________. Air Pollution Aspects of Selenium and its Compounds (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

(Same outline as for entry 212).

214. State of California, Air Resources Board. Air Pollution in California, 1971, Annual Report, a report to the State of California (Sacramento, 1972).

215. ________. Air Quality and Emissions, 1963-1970 (Sacramento, November 1972).

216. ________. Emission Inventories (Sacramento, November 1969).

217. ________. Implementation Plan for Achieving Ambient Air Quality Standards for Sulfur Dioxide in the Metropolitan Los Angeles Air Quality Region, a report to the U. S. Department of Health, Education, and Welfare (Sacramento, 1970).

218. ________. The Oxides of Nitrogen in Air Pollution, 2nd printing (Sacramento, November 1969).

Describes the types of nitrogen oxides and reports on the effects caused by nitrogen oxides in air pollution.

219. ________, Department of Water Resources. Water Use in Manufacturing Industries in California (Sacramento, April 1964).

220. Stern, Arthur C. (ed.). Air Pollution, 2nd ed. in three volumes (New York: Academic Press, Inc., 1968).

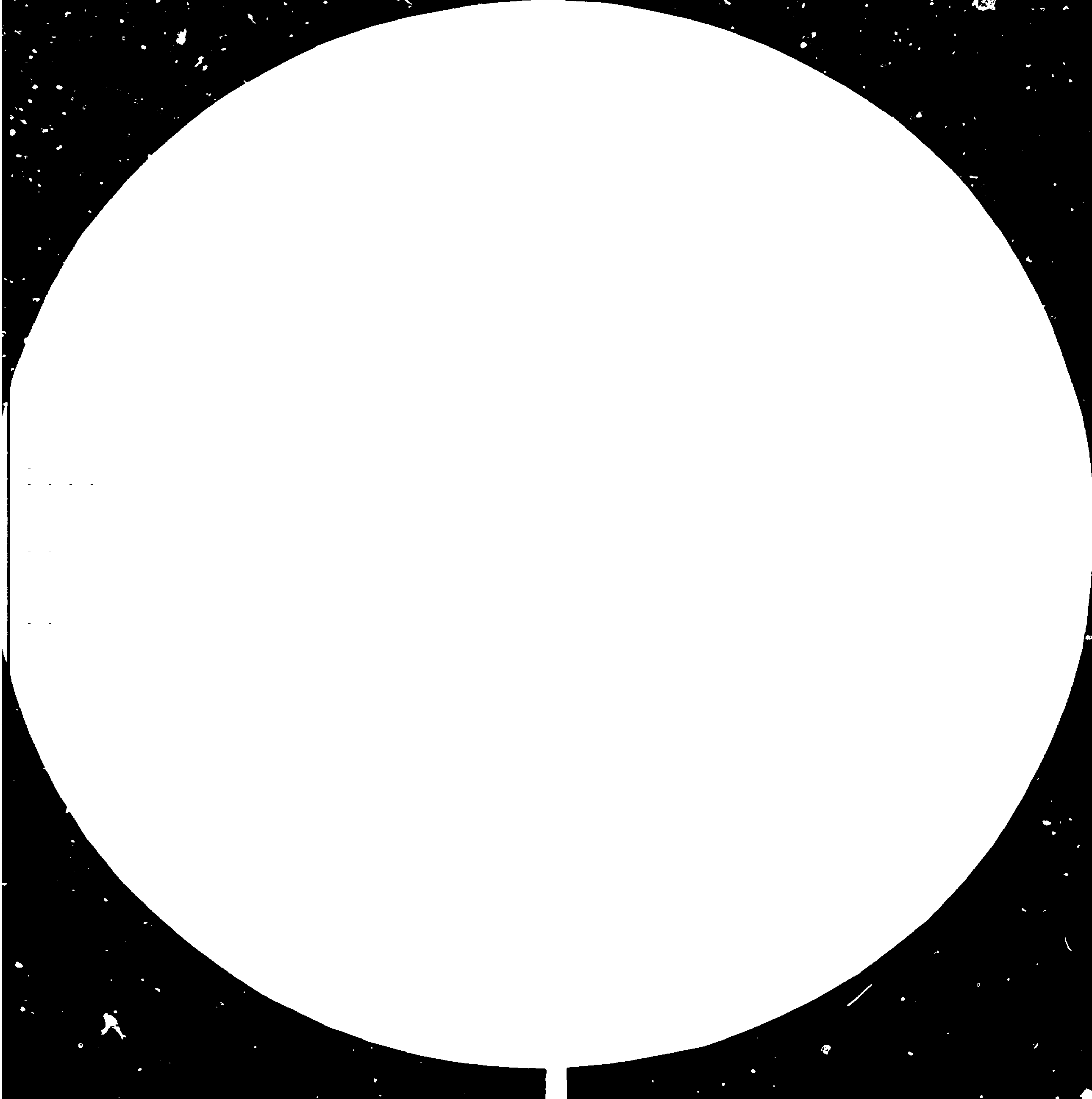
An outstanding collection of papers in the field of air pollution control. "Volume I covers three areas; the nature of air pollution; the mechanism of its dispersal by meteorological factors and from stacks; and its effect upon plants, animals, humans, materials, and visibility. Volume II covers the sampling, analysis, measurement, and monitoring of air pollution, and can be used independently of the other two volumes as a text or reference on the chemical analysis of air pollutants. Volume III covers four major areas: the emissions to the atmosphere from the principal air pollution sources; the control techniques and equipment used to minimize these emissions; the applicable laws, regulations, and standards; and the administrative and organizational procedures used to administer these laws, regulations, and standards. The concluding chapter of Volume III discusses air pollution literature sources and gives guidance in locating information not to be found in these volumes." (Author)

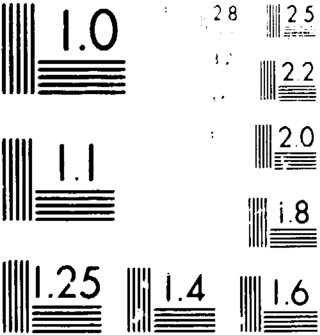
221. Stern, H. I. Comprehensive Studies of Solid Waste Management; Optimal Service Policies for Solid Waste Treatment Facilities, SERL Report No. 69-6 (Berkeley: University of California, May 1969).

222. ________. Comprehensive Studies of Solid Wastes Management: Optimal Service Policy for Solid Wastes Treatment Facility, ORC 69-3 (Berkeley: University of California, Operations Research Center, January 1969).

223. Sullivan, R. J. Air Pollution Aspects of Arsenic and its Compounds (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrence; production and product sources; environmental air concentrations; abatement; economics; and methods of analysis.

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224. ________. Air Pollution Aspects of Asbestos (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

(Same outline as for entry 223).

225. ________. Air Pollution Aspects of Chromium and its Compounds (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

(Same outline as for entry 223).

226. ________. Air Pollution Aspects of Iron and its Compounds (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

(Same outline as for entry 223).

227. ________. Air Pollution Aspects of Manganese and its Compounds (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrences; production and product sources; environmental air concentrations; economics; and methods of analysis.

228. ________. Air Pollution Aspects of Nickel and its Compounds (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

(Same outline as for entry

229. ________. Air Pollution Aspects of Odorous Compounds (Bethesda, Maryland: Litton Systems, Inc., Environmental Systems Division, September 1969).

Covers effects on humans, animals, plants, and materials; environmental air standards; natural occurrence; production and other sources; environmental air concentrations; abatement; economics; and methods of analysis.

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