ENVIRONMENTAL PROTECTION

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FOREWORD

A characteristic which has set people apart from other species has been their ability to control many aspects of their environment. Throughout recorded history man has continually struggled to manage his natural environment in order to improve his health and well-being. The sanitary code of Moses in the Old Testament, which is as sound today as it was when written, gave direction to man's efforts, but it was not until the "sanitary awakening" following the industrial and scientific revolutions that major environmental control progress was made. In recent years environmental sanitation in many parts of the world has led to large reductions or virtual elimination of diseases spread via the environment, such as the insect-, rodent-, water- and food-borne infections. Not long ago these diseases were at the top of the list of causes of death and morbidity.

Continuous environmental vigilance is necessary to keep these weeds in the garden of humanity from increasing to the proportions which still exist among a large part of the earth's population. Man's successes in the control of environmental-borne diseases have not reduced the need for ever-increased efforts of effective management of the total environment. The population explosion, an affluent society with desires for a vast array of products, increased radiations, the automobile, greater energy use, increased food production needs, and other developments have created

strains on parts of the ecological systems. Perhaps never in history has man demonstrated such great concern for his total environment as in now being witnessed in many parts of the earth, particularly in those areas which have benefited most from man's environmental control efforts toward more effective uses of human, material, and natural resources.

This text is appropriately man- and health-oriented in its approach to environmental protection. It recognizes man's place and role in the ecological system and encompasses most aspects of environmental control and protection. Emphasis is placed on the "why" and sufficient treatment of the "what" and "how to" of the following areas: effects on man's health, effects on ecosystems, and effects on comfort, convenience, and esthetics.

The sections of each chapter dealing with Changes and Developments and An Appraisal of management and protection efforts further illustrate man's position in the system and aid the student in the evaluation of progress as well as environmental-control needs.

I used a draft of this book three times for a rather broad one-quarter course on environmental control that met four times per week and was taken by groups of undergraduate students, very heterogeneous as to educational background, including fine arts, education, social science, science, and engineering. I found the text to be very satisfactory for most of the students. Those who had taken college-level biology, chemistry, and physics were able to pursue the text material quite thoroughly. Those whose education in science was very limited, while unable to understand the organic chemistry of pesticides, the detailed biology of certain diseases, or the activated sludge process, did obtain a grasp of the "whys" of environmental control, together with extensive improvement in their overall scientific understanding of concepts that enabled them to analyze more logically environmental information and at least, relate their thinking to scientific principles. On the whole these students of diverse basic educational backgrounds found the text stimulating and interesting. The text material is well organized and cohesive, and the ideas are clearly presented.

This text will be a useful reference for the professional who seeks answers to the "whys" of environmental problems. However, its greatest value should be for the education of the student entering the health, environment, and associated fields, and to those people who, as concerned citizens, wish to acquire a better basic understanding of environmental problems.

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PREFACE

Environmental protection is man-centered. This book states the rationale for the management of our water resources, of our excreta and wastewaters, of our air environment, of our solid wastes, of commensal insects and rodents, of our food, and of exacerbations of physical energy to prevent the impairment of health, to promote our efficiency and comfort, and to safeguard the balances in natural ecosystems. The principles of environmental protection are emphasized. The objectives of design and practice are given without detailing design or practice methods. The consequences of mismanagement of the major environmental components are examined at three levels: effects on health; effects on comfort, convenience, efficiency, and esthetics; and effects on the balances of ecosystems and of renewable resources. The first chapter develops and illustrates these three levels of man's concern for the earth's environmental quality and the interrelations among these. The driving forces of the "P game" are identified. These are the exponential growth of people, production, power, places, and pollutants. The impact of this growth on the water, air, and land cycles of nature are cited.

These three cycles offer one unifying theme for teaching environmental protection. The topical Chapters 3 through 8 are arranged in the order of water, air, and land. The book is fitted to such an approach with the added selective use of the

material on the physical energies in the last three chapters, which cover ionizing radiations, electromagnetic energies, heat, and sound.

Chapter 2 provides an introduction to epidemiology, the study of the environmental and social factors that determine man's health, the fate of biological pathogens in the free environment, and the importance of the mass of the dose in disease processes. Although directed to biological agents in Chapter 2, these matters are equally applicable to chemical and physical agents. These applications are made in the chapters on air, food, vector control, and radiations. Two phenomena that are encountered again and again in environmental protection are examined briefly in Chapter 2. These are the mathematical expression for first-order, or monomolecular, reactions and the electromagnetic energy spectrum. These two common denominators require enough development to impress students of environmental protection with the unity of the processes of nature, which we so readily tend to isolate into specialized studies and exclusive domains.

Chapter 2 provides a base for a second approach to teaching environmental protection. That is the identification and grouping of biological, chemical, and physical agents. The separation of biological and chemical agents in the topics covered in Chapters 3 through 8 would be too disjointing, if followed rigorously. The biological and chemical agents are dealt with jointly under the environmental media of water, wastewater, solid wastes, and food. Except for treating radioactivity in water and food under those subjects, the physical energies stand apart in Chapters 9 to 11.

Each of the nine topical chapters conclude with sections on Changes and Developments and an Appraisal of our management and protection efforts. The views are mine and reflect over 30 years of professional practice in the wide span of environmental protection. There is certain to be disagreement with these views from other professional practitioners. There is the risk that time will speedily make the comments outdated. These have been retained because trial use of draft copies of the text by students at Northwestern University has shown them to stimulate student interest and to provoke lively discussion.

The book is written with the anticipation that its users will have an understanding of chemistry, biology, physics, and mathematics to the extent of basic principles and recallable familiarity with terminology and symbols. New or unusual units are identified and explained. This holds particularly for the treatment of the physical energies. The choice of English and metric units has been a compromise. Design and performance data on water, wastewater, airflow, and solid wastes are in English units. Chemical concentrations and physical energy values are in metric units. Temperatures are given in both the Fahrenheit and Celsius scales. The transition from English to metric units is welcomed with a reluctance to abandon precipitously the familiar design and performance landmarks in English units.

The perplexing issues of chemical toxicants and pollutants in environmental media are met in the context of the media and of their use Therefore, information and comment on low-level concentration of organics in water, of pesticides and weedicides, and of food additives are found in the chapters on water, air, vector control, and food protection. The discussion on rationale of ionizing radiation and limits on exposure and dose contributes to an understanding of the difficulties that are met in decisions on low-level exposures from any environmental contaminants for long time spans. This handling of the issues deprives the reader of a handy compend on the subject. It does provide the information for formulating an understanding and obliges recognition of the use setting in which the choices must be made. A reasoned position on pesticide residues and on food additives requires knowledge of the beneficial uses of these materials.

The book is offered to meet the needs of a one-semester course in environmental protection. It is likely that only a graduate group of students from the several specialties, seeking a broadening of their information on all aspects of the environment, will undertake cover to cover use of the book. For other groups selective use is recommended. Some groups will find that a single reading of the chapters on vector control and food protection suffices without elaboration in classroom work. This may hold for engineering students. Other groups may find the discussion of industrial wastewaters, agricultural wastes, coherent light, and heat can be managed as reading assignments without classroom treatment. This may hold for sanitarians, although that professional group rarely finds itself with an excess of knowledge for the variety of questions addressed to it by the people it serves. The book is fitted to college groups at the undergraduate level who seek an understanding of environmental issues or an introduction to the field with thought of specialization in it by further professional preparation. The first group is usually from very mixed backgrounds ranging from the natural sciences to the fine arts. The task rests with the instructor to delineate the depth and detail of the subject matter which such students are expected to master both from the instructor's material and from any book. For the latter group, a sampling of scientific detail in the form of chemical reactions, organic structural formulas, physics and mathematical equations, and biological classifications and behavior is given to convince such students that environmental protection depends upon the sciences which they have sought to master and that it is a field of applied sciences in which they can test their mettle to solve scientific and social problems.

The book is directed to the question "Why?" rather than to "What?" or "How to?" The data in tables and graphs, in many instances from original sources, are designed to answer "Why?" The answers are not always complete and are sometimes controversial. The text is addressed to the tables and graphs and avoids repetition in words of the data set forth in the tables and graphs. This makes the

projection of the illustrative material from the book during classroom use an effective teaching method. It also provides for assignments requiring analysis of tabular and graphic data as an adjunct to learning by active cerebral engagement with the material in the book. A source of visual aids and a problem manual for teachers are planned.

I would not have had the audacity to undertake writing this book without the strong and active support of my Department Head, Dr. Daniel A. Okun, and my wife, Eliska Lowbeerova Chanlett. The help of those who did technical review of chapters and sections of subject matter for which they are recognized authorities gives me confidence in the scientific accuracy, subject always to more recent findings, and courage to face the discovery of errors which likely persist. Colleagues of my own department who did technical reviews are Morris A. Shiffman on epidemiology and food protection; Charles O'Melia on water resources; Richard Cole on excreta and wastewater; James C. Lamb on industrial, recreational, and agricultural water and wastewater; Arthur C. Stern on the air environment; Newton Underwood on the ionizing and nonionizing radiations; and Robert Harris on heat and sound. Dr. George Kupchik of Hunter College reviewed the chapter on solid wastes. The quality of the chapter on vector control owes much to generous assistance of the scientific staff of the Vector Biology and Control and Malaria Eradication groups of the World Health Organization through interviews, the provision of data, and a painstaking review of the draft text. A particular debt is owed to Roy J. Fritz and N. G. Gratz for reviewing the chapter material on insects, rodents, and control measures; to James Haworth on malaria eradication; and to F. S. Barbosa on schistosomiasis.

My appreciation goes to Miss Gill Ryan of Coventry, England, and Mrs. Pat McCotter of Trenton, North Carolina, for suffering through the task of transcribing the first two-thirds of hand copy to a draft typing. The demanding work of completing the draft and preparing the manuscript was skillfully executed by Mrs. Pat Blunden of Chapel Hill, North Carolina. The many individuals and organizations which have graciously permitted use of previously published material are cited in source references and are here additionally thanked for sharing their work to enrich this book.

EMIL T. CHANLETT

CONTENTS

1

THE QUALITY FACTORS FOR ENVIRONMENTAL PROTECTION

POPULATION TRENDS AND RESOURCE USE

The quality of our environment is determined by the intricate processes of mankind's making a living and enjoying life. In that process water, food, land, and air are used in man's activities. The changes that man produces during this use affect his health, his comfort, his esthetic senses, his efficiency, and his capacity to attain a satisfactory social adjustment. There are individually perceptible benefits or detriments. Additionally his use of the four essentials for life affects the dynamics of all plant and animal life on earth, by altering the ecological balances. Finally, his methods of using land, water, and air particularly as waste disposal sinks have impaired their quality so that these are no longer usable in some instances for his own needs and purposes. The assessment of ecological changes and of the beneficial use of our land, water, and air resources requires collective wisdom. The rapid increase in the world's population and the accelerating rate of use of all natural resources are making the consequences of misuse more drastic, more widespread, and more readily evident to large numbers of people. The response is political action to control gross abuses.

Figure 1-1 graphs the world's population and its rate of growth. Table 1-1

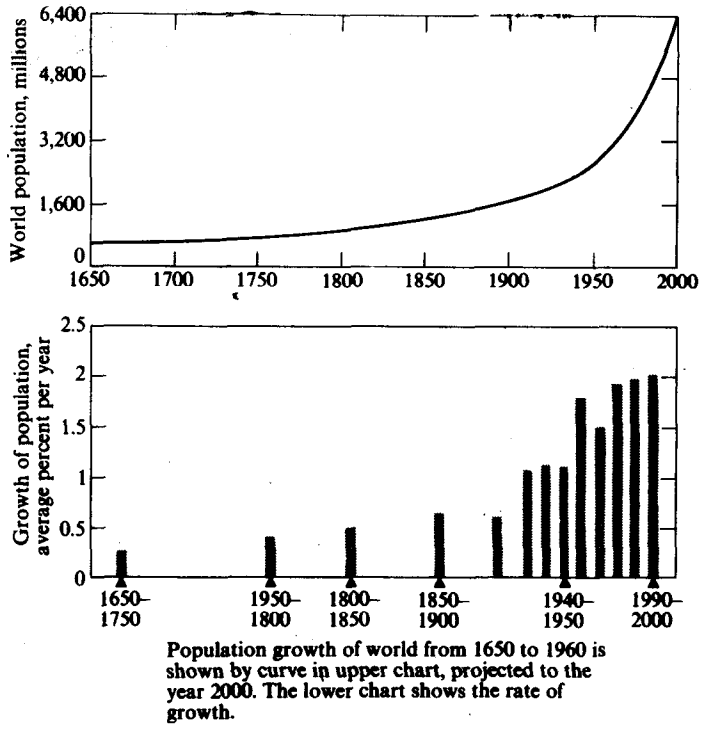

FIGURE 1-1
The world's population. [*Source:* "*Population,*" authors Kingsley and Davis, (Copyright © 1963, *Scientific American, Inc.*) All rights reserved.]

presents the numbers by selected years and by major regions. If resource use remained at a constant per capita rate, a doubling of resultant waste production by the year 2000 would be formidable enough. However, the technological escalation of production makes a rising per capita rate of use the usual pattern. Figure 1-2 states the case for iron ore output for the world, the United States, and other countries. Petroleum use in the world is rising at about 8 percent per year. Table 1-2 projects the natural resource use of 1960 to the requirements of the year 2000. It is the stated goal of governments and of international organizations to achieve a continued increase in the standard of living for all people. Confronting the aspirations of the rest of the world to attain the level of United States consumption throws all the estimates on known reserves into the columns "ridiculous" and "absurd." The Ehrlichs sum it up this way (Ref. 1-1, pp. 61–62): "To raise all of the 3.6 billion people of the world

Table 1-1 ESTIMATED POPULATIONS OF THE WORLD AND ITS MAJOR REGIONS, IN MILLIONS, IN 1900, 1950, 1960, AND 2000, WITH COMPARISONS OF INCREASES FROM 1900 TO 1950 AND FROM 1950 TO 2000 NUMERICALLY AND AS A RATIO

Area	Estimated population, millions			Projected population, millions, year 2000	Increase, millions		Ratio of increase, 1950-2000 to 1900-1950
	1900	1950	1960		1900-1950	1950-2000	
World	1,550	2,518	2,995	6,907	968	4,389	4.6
Africa	120	209	254	663	89	454	5.1
North America	81	168	199	326	87	158	1.7
Latin America	63	163	206	651	100	488	4.9
Asia	857	1,389	1,679	4,250	532	2,861	5.4
Europe, including U.S.S.R.	423	576	641	987	153	411	2.7
Oceania	6	13	17	30	7	17	2.4

Table 1-2 PROJECTIONS FROM 1960 TO 2000 OF NATURAL RESOURCE UTILIZATION BY THE UNITED STATES*

Resource	Unit of measure	1960 use	2000 requirement
Cropland, including pasture	10^6 acres	447	476
Timber	10^9 ft^3	11	47
Freshwater withdrawal	10^9 gpd	84	149
Oil	10^9 barrels	3.2	10.0
Natural gas	10^{12} ft^3	13.3	34.9
Coal	10^6 short tons	436	718
Nuclear power	10^9 kWh	...	2,400
Iron ore	10^6 short tons	131	341
Primary aluminum	10^6 short tons	2.1	13.3
Primary copper	10^6 short tons	1.7	4.5

* These projections are based on a population increase from 180 million in 1960 to 330 million in 2000, and an increase in gross national product value from $503 billion in 1960 to $2,200 billion in the year 2000.

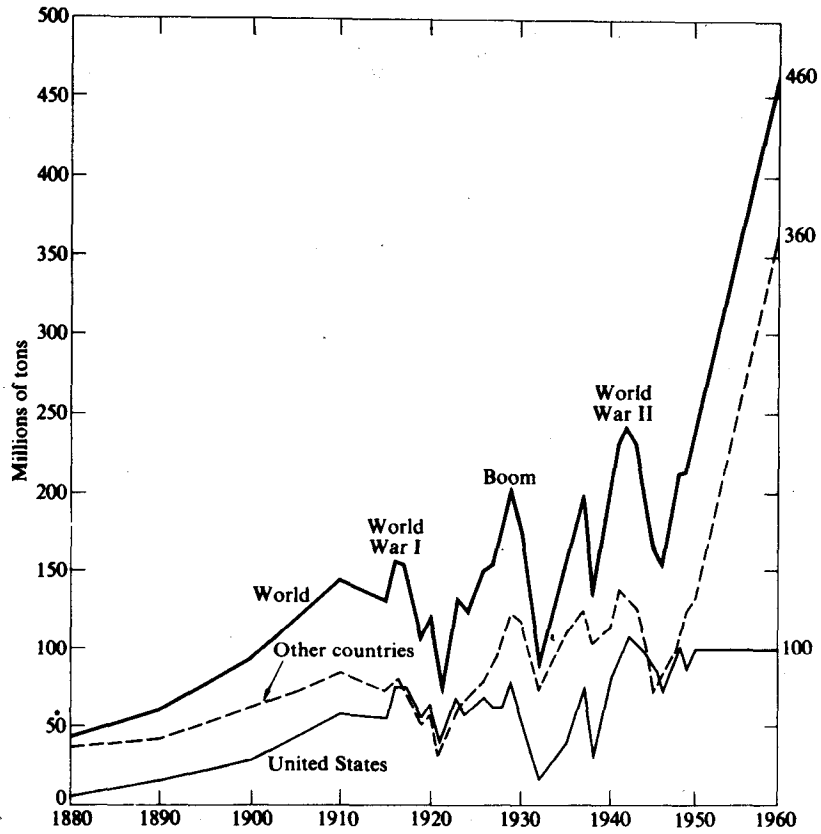

FIGURE 1-2
Iron ore—output of the world and of the United States, 1880 to 1960. (*Source: W. S. Woytinsky and E. S. Woytinsky, "World Population and Production," p. 785, The Twentieth Century Fund, N.Y., 1953, with 1960 data supplemented.*)

to the American standard would require ... the extraction of some 75 times as much iron as is now extracted annually, 100 times as much copper, 200 times as much lead, 75 times as much zinc, and 250 times as much tin."

To meet that long step forward solely from the known reserves, only the iron reserves would meet the need. All others are far exceeded. Note that this extrapolation was solely for the 3.6 billion already on board and that it makes no provision for increased per capita consumption by the present "haves." It only provides for bringing the present "have nots" to the level of the haves. It is conjecture, but it does underscore the finite size of nonrenewable mineral resources, as we now can get at them technologically and economically. These are the constraints which will make recycling a much more attractive engineering feat than it has been.