

Environmental Protection

Second Edition

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ENVIRONMENTAL PROTECTION

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To
ELISKA LOWBEEROVA CHANLETT
and
DANIEL ALEXANDER OKUN

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 people have continually struggled to manage their natural environment in order to improve their 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 people'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. People'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 have people demonstrated such great concern for their total environment as in now being witnessed in many parts of the earth, particularly in those areas which have benefited most from people's environmental control efforts toward more effective uses of human, material, and natural resources.

This text is appropriately human- and health-oriented in its approach to environmental protection. It recognizes people'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 people'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 people'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 TO THE SECOND EDITION

Why a second edition of this book? It is not that there have been sweeping changes in the rationale of managing the open environment to protect people's health or their comfort and convenience or to prevent major ecological imbalances for animal and wildlife. There have been significant advances in the sensitivity of analytical methods moving from detections at the milligram level to microgram, and even nanogram in some instances. There have been developmental advances in the technology of the capture and confinement of contaminants and in their removal from water and air. The application of these advances remains limited in fullscale use. Much of it is in demonstration study units and pilot plant investigations.

What are the issues that have come into sharper focus in the past few years? One is the impact of energy generation and use on environmental quality. The exponential energy use continues throughout the world, moderated slightly by a fourfold increase in the price of crude oil. In nations that have a well defined energy control policy, West Germany, France, and Japan, the goal is to reduce the rate of increase. With employment, trade balances, and economic expansion tied to energy use and availability, the advocates of environmental quality must continue to seek their goals through control of the effluvia of energy use. Society is not yet ready to forego energy use for environmental quality. At best it is willing to consider alternate sources on a market place basis.

Carcinogens are a highly emotional topic. A major source of misunderstanding has been in the use of the word environment. The statements of John Higginson and Richard Doll leading to a very widespread repetition that

from 70 to 90 percent of cancer is environmental in nature, usually ignore the fact that Higginson and Doll consider the molecular phenomena in the cell; the cell in the tissue; the tissue in the organ; and the organ in the body as "environments." Which indeed they are, but not in the usual connotation of the open environment of the water, air, and food we use. In fact Higginson early on used the words "environmental" and "non-genetic" as equivalent. That is whatever is not of "genetic" origin is "non-genetic." Ipso facto environmental in the broadest sense, perhaps every chemical and biological factor outside the cellular DNA structure.

Within the topical coverage of the second edition there are several items examined for the first time or in greater detail. The discovery of trichloromethanes in chlorinated drinking water; the occurrence of *Giardia lamblia* in United States community water supplies; water reuse and water desalination to augment over demands on existing sources; the use of polyelectrolytes to increase water filtration plant capacities; alternates to chlorination; the use of granular activated carbon filtration beds. Our efforts to curb dirty air by motor vehicle emission control and our efforts to anticipate the switch to still more coal and less oil for electricity generation and factory steam are bona fida trench warfare technologically, socially, and politically.

Solid-waste use for heat generation and recovery and for resource reclamation is a very active front of the environmental quality action. The gains, the losses, and the promises are set down. Aircraft noise and airport neighbor disturbance has been notched up to the level of international relations with the British and French insistence on Concorde landings in New York City. The oil pollution of our bays, seas, and oceans is put in perspective. It is easy to rally public concern when an Argo Merchant is foundering off Cape Cod. It is very difficult to gain public attention to a variety of lamentable in-port negligence and high-sea tank washing off the coast of West Africa or East Africa enroute back to the Arabian Gulf for another half million tons of crude.

The use of nuclear fission of uranium 235 is examined in a unified way in the context of our management of ionizing radiation. The dilemmas of high-level waste storage and the potential weapon use of plutonium 239 created in nuclear power plants must be faced. Further delays increase these portentous dangers inherent in controlled nuclear fission. Each and every energy use produces a waste. Nuclear energy is no exception. Its wastes may indeed be more manageable than the carbon dioxide, sulfur oxides, and oxides of nitrogen loads from fossil fuels on the assimilated capacity of our earth's surprisingly thin air envelope.

All these matters and more are incorporated in this second edition. Many tables and figures are updated. New ones have been added. For most of us in the classroom, events prior to high school graduation are not part of our remembered experience of world events. It is history. For a book of this sort, some history is good and necessary. The work of John Snow on cholera, William Budd on typhoid fever, Peter Ludwig Panum on measles, Allen Hazen and Abel Wolman on water, Earle Phelps on stream pollution, Leonard Greenberg and Arthur Stern on air pollution, Robley Evans, Lauriston Taylor, Shields Warren

and Karl Morgan on ionizing radiation, and Leo Beranek on noise are history. It is the history of our building blocks for protecting people's open environment. So there is a touch of history, too. It gives purpose to our own efforts.

Système International d'Unités, the International System of Units, hereafter called S.I., are used throughout this book. In the text, the S.I. is expressed first. The English system unit is in parenthesis. Most tables and figures show both units, although there are instances in which the clutter of two unit systems would make the table or figure useless. Then only S.I. units or English are used. Conversions are rounded in accord with the idea of significant figures. The precise use of a conversion factor creates illusions of accuracy that simply did not exist in the original number. For example the English unit short ton, 2,000 pounds, is not converted at all. The S.I. unit or metric ton, 1,000 kilograms is of course 2,205 pounds. There are very few cases in which environmental data expressed in tons has a precision as good as ± 10 percent. The S.I. use in this book is not pure. The litre is used throughout. It is not an S.I. unit. Pressure is expressed in kilograms of force per square centimeter, kgf/cm². It is not the recommended S.I. unit. Both are metric units, of course, and are considered acceptable company in the S.I. family. We must speed up our use of S.I. units. We can only do so by abandoning the English units. Should there be a third edition of this book, I want to see a total abandonment of English units, without, we trust, alienating its users.

Throughout this book an effort is made to state the case for environmental protection on the basis of the human experience. This requires epidemiology of people's diseases and impairments. What has come over our people? Toxicological studies on selectively sensitive experimental animals is a necessary starting point. It cannot be the final basis for regulatory action which is more easily that of a ban. The loss of benefits and costs of bans or unnecessary controls are too great for unsupported administrative action. The portents of this pattern are casting forward shadows. Their darkening will be to the detriment of sound environmental protection.

Fellow professional practitioners of environmental protection have been generously helpful in sharing their knowledge and resources. Among them are Russel F. Christman, Daniel A. Okun, Frederick M. Junkin, Charles O'Melia, J. Donald Johnson, Morris A. Shiffman, Mark Sobsey, David Fraser, Donald Fox, Donald Lauria, and James Watson. Manuscript preparation was made a tolerable task by the skills of Kathleen Woods and Pat Blunden, who graciously forgot the trauma of the first edition. Julianne V. Brown patiently prodded the work to a completion date. As always the errors few or many are the sole property of the author. Dr. Dade Moeller of Harvard University did a meticulous review of the manuscript. His keen and thoughtful recommendations were very welcome.

EMIL T. CHANLETT

PREFACE TO THE FIRST EDITION

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 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 rational 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 scistosomiasis.

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

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