ENERGY UTILIZATION AND ENVIRONMENTAL HEALTH

METHODS FOR PREDICTION AND EVALUATION OF IMPACT ON HUMAN HEALTH

EDITED BY

RICHARD A. WADDEN

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ENVIRONMENTAL HEALTH SCIENCES
SCHOOL OF PUBLIC HEALTH
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CONTRIBUTORS

Robert J. Allen, Environmental Health Sciences
University of Illinois, School of Public Health

Lyndon R. Babcock, Jr., Environmental Health Sciences
University of Illinois School of Public Health .

Gary R. Brenniman, Environmental Health Sciences
University of Illinois, School of Public Health

Bertram W. Carnow, Occupational and Environmental Medicine
University of Illinois, School of Public Health

Donna O. Farley, Suburban Cook County-Du Page
County Health Systems Agency, Oak Park, Illinois

William H. Hallenbeck, Environmental Health Sciences
University of Illinois, School of Public Health

Richard G. Hankett, Research and Development Division
Chicago Department of Public Works

Janet A. Holden, Environmental Health Sciences
University of Illinois, School of Public Health

Sally J. Jansen, Occupational and Environmental Medicine
University of Illinois, School of Public Health

William H. Kojola, Occupational and Environmental Medicine
University of Illinois, School of Public Health

Edward J. Koval
5018 South Laramie, Chicago, Illinois

Alvin L. Miller, Occupational and Environmental Medicine
University of Illinois, School of Public Health

Niren L. Nagda, Geomet Inc.
Gaithersburg, Maryland

Anneke de Werk Neal, Epidemiology
University of Illinois, School of Public Health

Peter A. Scheff, Environmental Health Sciences
University of Illinois, School of Public Health

Richard A. Wadden, Environmental Health Sciences
University of Illinois, School of Public Health

Arthur H. Wolff, Environmental Health Sciences
University of Illinois, School of Public Health

SERIES PREFACE

Environmental Science and Technology

The Environmental Science and Technology Series of Monographs, Textbooks, and Advances is devoted to the study of the quality of the environment and to the technology of its conservation. Environmental science therefore relates to the chemical, physical, and biological changes in the environment through contamination or modification, to the physical nature and biological behavior of air, water, soil, food, and waste as they are affected by man's agricultural, industrial, and social activities, and to the application of science and technology to the control and improvement of environmental quality.

The deterioration of environmental quality, which began when man first collected into villages and utilized fire, has existed as a serious problem under the ever-increasing impacts of exponentially increasing population and of industrializing society. Environmental contamination of air, water, soil, and food has become a threat to the continued existence of many plant and animal communities of the ecosystem and may ultimately threaten the very survival of the human race.

It seems clear that if we are to preserve for future generations some semblance of the biological order of the world of the past and hope to improve on the deteriorating standards of urban public health, environmental science and technology must quickly come to play a dominant role in designing our social and industrial structure for tomorrow. Scientifically rigorous criteria of environmental quality must be developed. Based in part on these criteria, realistic standards must be established and our technological progress must be tailored to meet them. It is obvious that civilization will continue to require increasing amounts of fuel, trans-

portation, industrial chemicals, fertilizers, pesticides, and countless other products; and that it will continue to produce waste products of all descriptions. What is urgently needed is a total systems approach to modern civilization through which the pooled talents of scientists and engineers, in cooperation with social scientists and the medical profession, can be focused on the development of order and equilibrium in the presently disparate segments of the human environment. Most of the skills and tools that are needed are already in existence. We surely have a right to hope a technology that has created such manifold environmental problems is also capable of solving them. It is our hope that this Series in Environmental Sciences and Technology will not only serve to make this challenge more explicit to the established professionals, but that it also will help to stimulate the student toward the career opportunities in this vital area.

Robert L. Metcalf
James N. Pitts, Jr.
Werner Stumm

PREFACE

The production, distribution, and use of energy is a process basic to an industrial society. A variety of socioeconomic criteria must be considered when choosing how we are to best utilize our energy resources. Of great significance in such considerations is the prediction and evaluation of existing and potential human health effects due to energy sources and usage. Indeed, adverse health impact should exercise veto power over other criteria if construction or operation of energy facilities produces a nonviable environment.

Despite its importance, little attention has been given to health questions in site planning of energy production facilities or pollution control strategies. There have been only limited efforts toward prediction of the environmental health impact of pollutants on populations who may be exposed to such materials. Also of considerable concern is the advent of new processes and technologies for energy production which have their own unique pollution potential.

The purpose of this book is to explain and demonstrate evaluation methods that can be used to incorporate public health considerations into the planning process. The opening chapter (Sources, Receptors, and the Environment) outlines the role of these three major components, and their interrelationship, in the evaluation of environmental impact. Chapters 2 and 3 discuss receptor characterization, particularly emphasizing methods to identify, enumerate, and locate hypersusceptible populations, that is, those individuals who are likely to be first and most affected by pollution exposure. Chapters 4–6 report on several methods for quantitating the biological effects of environmental stress in humans. Characterization of environmental hazards in terms of quantitation and dispersal is covered in Chapters 7–9. The final four chapters show how these basic data and methods can be applied to real problems in environmental planning. The evaluations are carried out in considerable detail in an

attempt to give the reader a practical grasp of how to go about quantitating the potential health ramifications of energy processes.

It is recognized that there are many deficiencies in our understanding of the cause and effect relationship between environmentally discharged pollutants and human health effects. But it is incumbent upon us as planners and scientists to use available information to make the best estimate possible, recognizing that such an estimate must be understood within the limitations of the supporting data, and that continual revision and updating will be a fact of life. We believe that the methods described here will be helpful for all who are concerned with the evaluation of environmental impact. We also hope that publication of these methods will stimulate others to develop even more meaningful measures of human health response to environmental stressors.

The development of this book was supported in part by a grant (G007602055) from the Office of Environmental Education, U.S. Office of Education, U.S. Department of Health, Education, and Welfare whose support is hereby acknowledged. Mr. Alfred Rosenbloom aided greatly with format, and his assistance was much appreciated. Most particularly, great thanks are due to Mrs. Vera Donlan and Ms. Lucille Vaughn for typing of the many drafts before the final manuscript was complete. I also wish to thank all those members of the University of Illinois School of Public Health who contributed in formal and nonformal ways to the final version of the book.

RICHARD A. WADDEN

Chicago, Illinois
May 1978

CONTENTS

1

SOURCES, RECEPTORS, AND THE ENVIRONMENT

Richard A. Wadden

The present American life-style requires use of considerable amounts of air, water, energy, and mineral resources. On a per capita basis Americans use 30 times as much coal, 40 times as much crude steel, 60 times as much refined copper, and 80 times as much primary aluminum as are used in underdeveloped countries (1). How these resources are maintained or destroyed, dissipated or conserved, depleted or restored have significant implications for human health. How our societal needs can be provided for without harming ourselves is a legitimate requirement of the planning process.

Perception of the societal worth of a given project depends on comparison of the project's characteristics with one or more criteria that an individual, or groups of individuals, consider to be important. Projects that require such evaluation include those to do with transportation (shopping centers, highway networks, airports) and with energy production and use (nuclear and fossil fuel power plants, fusion and solar power, coal and oil conversion processes). Criteria that are often considered in the planning process are utility, accessibility, efficiency, and job and profit potential. Criteria that are rarely or cursorily applied include incon-

venience to nonusers, degradation of natural resources to nonvaluable end products (such as the use of natural gas to produce carbon black), pollution potential, and most significantly, risk to human health.

While all the above factors, as well as others appropriate to a specific project, should be taken into account, the impact on human health should have effective veto power over all the rest. Establishment of a nonviable environment is self-defeating for any project. This discussion outlines an organized approach to evaluating the human health implications of projects that have the potential for release of hazardous materials into the environment.

To put in perspective the interaction of hazardous discharges with human health it is helpful to consider the relationships represented in Figures 1.1 and 1.2. Pollutants are discharged from pollutant sources. These discharges are commonly called emissions if they enter the air environment and effluents if entering the water environment. The amounts of emissions and effluents are best described by using a mass/time rate, such as pounds per hour or tons per day. As pollutants are released they are immediately mixed with whatever materials already exist in the air or water (baseline concentrations). In addition, they undergo chemical and physical changes both because of their interaction

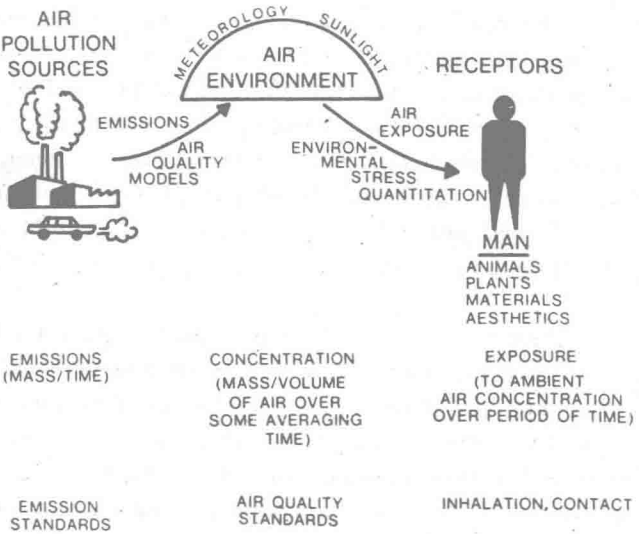

Figure 1.1. Sources, receptors, and the air environment.

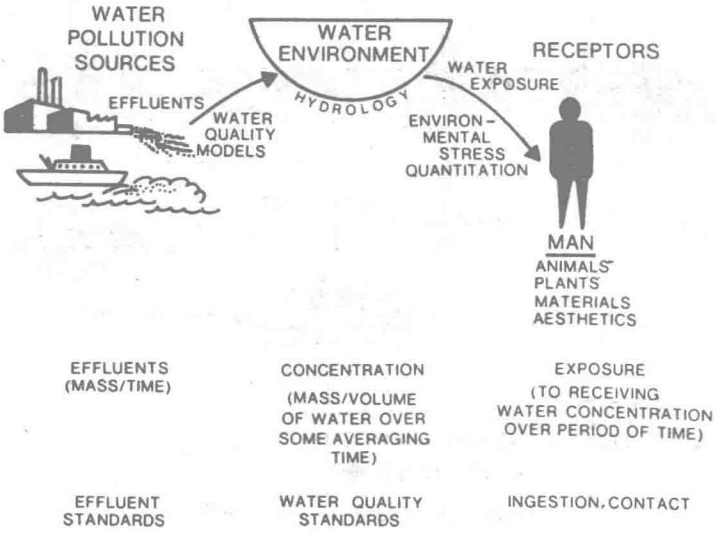

Figure 1.2. Sources, receptors, and the water environment.

with other pollutants, and because of the nature of the receiving air or water. For air, solar radiation and meteorologic effects, such as temperature inversions and windspeed, are important. For water, hydrologic considerations affect the dissipation or concentration of a pollutant.

Pollutants in air (or water) environments are characterized by measuring their mass per unit volume of air (or water), that is, their concentration. This concentration is related to a particular averaging time, which corresponds to the time interval of sample collection, or the time over which a number of samples are combined. The relationship between source emissions or effluents and environmental concentrations can be estimated by using air quality or water quality models.

The most important consideration of air and water pollution is the consequences that their environmental concentrations may have for human receptors. The relevant steps in evaluating such consequences require asking the following questions: What individuals are most at risk to the expected environmental hazards? How many of them are there? Where are they located with respect to the pollution source? How much are they likely to be affected by the additional environmental stress?

The consideration of all the factors noted above should be incorporated into the environmental impact analysis of a new energy source or use.

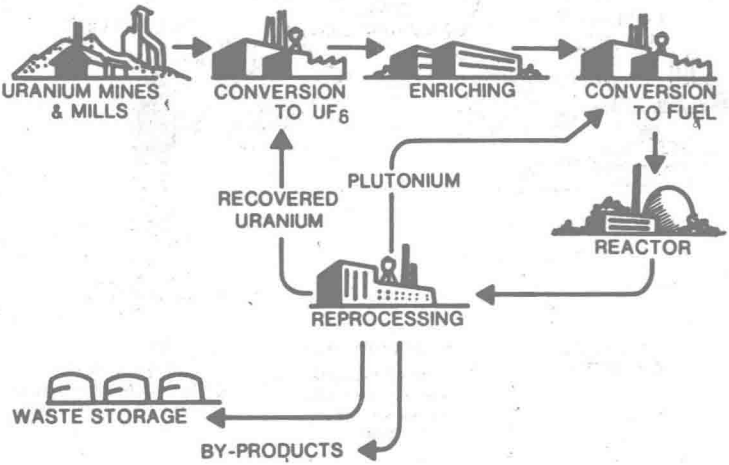

Figure 1.3. The nuclear fuel cycle.

Such an analysis may cover only a specific source and site evaluation with limited geographical considerations, or it may involve an evaluation of a total energy cycle. Figure 1.3 indicates such a cycle for nuclear fuel. The series of steps shown in Figure 1.3 is actually spread out over a large area (nationwide in the United States) and involves many complex processes at each location. At each step there are pollution and health consequences to be considered. Our focus throughout this book is mainly on health implications of specific sources or planning alternatives. However, the same procedures can also be applied to the steps of an energy cycle.

To summarize briefly then, the major steps in the overall review process (2) are:

1. Identification of hazards—raw material, type of process, method of operation.
2. Quantitation of hazardous wastes and byproducts—air, water, and soil.
3. Measurement of "baseline" conditions of the environment—present air, water, and soil quality.
4. Dispersion of hazardous discharges—what and how much goes where.
5. Identification, enumeration, and location of populations at risk.
6. Estimation of exposure levels and related health effects.

Each of these categories is discussed more completely in later chapters. It is important that the items listed above become a regular consideration for

those planning and deciding upon projects with pollution potential. In addition, such considerations should be more specifically incorporated into legislation and regulations involving pollution sources. Finally, public agencies should be encouraged to investigate and follow up the health implications of existing and new projects that discharge environmental hazards. Our concern for material prosperity should not cause us to neglect our responsibilities for human health.

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