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OXFORD
UNIVERSITY PRESS
2001

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Oxford New York

Athens Auckland Bangkok Bogotá Buenos Aires Calcutta
Cape Town Chennai Dar es Salaam Delhi Florence Hong Kong Istanbul
Karachi Kuala Lumpur Madrid Melbourne Mexico City Mumbai
Nairobi Paris São Paulo Shanghai Singapore Taipei Tokyo Toronto Warsaw

and associated companies in
Berlin Ibadan

Published by Oxford University Press, Inc.,
198 Madison Avenue, New York, New York, 10016
http://www.oup-usa.org

Oxford is a registered trademark of Oxford University Press.

Library of Congress Cataloging-in-Publication Data
Basic environmental health / Annalee Yassi . . . [et al.].
p. cm. Includes bibliographical references and index.
ISBN 0-19-513558-X
1. Environmental health.
I. Yassi, Annalee.
RA565.B376 2001 615.9'02—dc21 00-032400

9 8 7 6 5 4 3

Printed in the United States of America
on acid-free paper

PREFACE

This book is intended to be used as a textbook at the university level. It is basic and interdisciplinary in its approach, in recognition of the wide variety of professional groups for whom training in environmental health is desirable. The text is only one component of a "teaching kit" in environmental health; a Teacher's Guide, with a variety of interactive exercises, and a chart book of tables and graphs, ready for transparency projection, supplement the text (available from EHG, WHO, 1211 Geneva, Switzerland, Fax: +41-22-7914123, email:pfistera@who.ch; www.who.int/[search the Environment program]).

The target groups for the book include university students in public health, medicine, nursing, other health professions, engineering, environmental science, management, and others needing a basic introduction to environmental health (including students interested in environmental law, geography, urban planning and social work). The book and the teaching kit can be used in courses to form a component of a traditional program at university level, or in stand-alone courses for in-service training of government agency staff, industry professionals and managers, and interested people in non-governmental organizations or community groups.

The textbook is divided into 12 chapters, each with defined objectives. The first section, Chapters 1–4, introduces the concepts and methods applied in environmental health. Chapter 1 is an overview of the macro-level influences on health, touching on various social science disciplines. Chapter 2 describes the nature of environmental health hazards, introducing toxicology, microbiology, health physics, injury analysis, and psychosocial concepts. Chapter 3 lays out the basic approach to risk assessment and includes a discussion of epidemiological methods. Chapter 4 outlines the principles of risk management. The second section organizes the discussion by route of exposure. Chapter 5 addresses air quality; Chapter 6 water and sanitation; and Chapter 7 food and agricultural issues. The third section is sustainable development: Chapter 8—settlements and urbanisation, Chapter 9–energy, Chapter 10–industry, and Chapter 11–global concerns. Chapter 12 ties the course together focusing on ethical issues and the concrete application of the course material.

Thus the book can form the basis of a full semester course or its equivalent. While it is meant to be a "primer," extensive referencing to other publications should allow as comprehensive a coverage of any topic as the educational setting requires.

The problem solving exercises in the Teacher's Guide can be used to adjust the level of complexity of the course for individual students or the class as a whole. In interdisciplinary classes, for example, the teacher may require more in-depth research from students in the areas of their own disciplines compared to others in different disciplines, who would in turn focus on areas of their own expertise. This permits each student to achieve a maximum learning experience while contributing optimally to the group. It also simulates the real world scenario in which professionals in different disciplines are expected to understand each other, while depending on each other for the more complex details.

The text and teaching kit are part of a sustained effort by WHO, UNEP, UNESCO, and CRE to promote strengthened teaching in environmental health for a wide variety of students at university level.

Winnipeg, Manitoba, Canada A.Y.
Auckland, New Zealand T.K.

ACKNOWLEDGMENTS

This text was developed with the assistance of the United Nations Environment Programme (UNEP), Conference of European University Rectors (CRE), and the United Nations Educational Scientific and Cultural Organisation (UNESCO), and under the overall auspices of the Office of Global and Integrated Environmental Health of the World Health Organisation (WHO). It was tested at workshops in Visby, Sweden; Budapest, Hungary; Cape Town, South Africa; and Amman, Jordan where valuable comments were provided by the participants. Comments received in meetings of reviewers held in Geneva in June 1994 and November 1995, and by many others were also incorporated.

Dr. Theo de Kok (University Maastricht, The Netherlands), the third author of the book, has been developing distance learning materials, in conjunction with this text. Merri Weinger (education specialist, WHO) is the primary author of the Teacher's Guide.

There are many people who have made valuable contributions to this text to date; these and others will hopefully continue to contribute by supplying case studies from which others could learn. Among the many contributors, several stand out for specific mention.

Dr. Jerry Spiegel (formerly of Manitoba Environment, Winnipeg, Canada and now with the Liu Centre for the study of Global Issues at the University of British Columbia, Vancouver, Canada) served as the major editor of the book and contributed substantially to the chapter on risk management. He also wrote a large section of the industry chapter and extensively rewrote other parts of the text.

Dr. Alan Pinter (Johan Béla National Institute of Health [NIH], Budapest, Hungary), and Dr. Evert Nieboer (McMaster University, Hamilton, Canada) both had substantial input to the book, particularly to the toxicology sections, and Dr. Avrum Regenstreif had major input to the chapter on settlements and urban development. The following individuals (listed in alphabetical order) also served as reviewers and contributed valuable comments and materials:

Dr. Pedro Más Bermejo, Director, National Institute of Hygiene Epidemiology and Microbiology, La Habana, Cuba

Dr. Helen Dolk, London School of Hygiene and Tropical Medicine, London, UK

Professor Hunay Evliya, Cukurova University, Turkey

Professor Maria Alvim Ferraz, University of Oporto, Portugal

Professor H.N.B. Gopalan, UNEP, Nairobi, Kenya

Dr. Steve Hrudey, University of Alberta, Canada
Dr. Steven Markowitz, Mount Sinai School of Medicine, New York, USA
Dr. S. Miyagawa, Division of Food and Nutrition, WHO, Geneva
Dr. Monica Nordberg, Karolinska Institute, Stockholm, Sweden
Dr. Peter Orris, Cook County Hospital, Chicago, USA
Dr. Peri Pamir, CRE, Geneva
Dr. David Rapport, University Guelph, Canada
Dr. Yasmin von Schirnding, Environmental Health, Johannesburg, South Africa
Dr. Colin Soskolne, University of Alberta, Canada
Dr. Carl-Einar Stalvant, Stockholm University, Sweden
Ms. Adrienne Taylor, Auckland, New Zealand
Professor Dr. Henk van de Plas, Copernicus Steering Committee, The Netherlands
Dr. Susan van de Vynckt, UNESCO, Paris
and others.

In addition, valuable assistance in assembling the material was provided by Sandrine Chorro (France), and Elissa Neville and Ingra Schellenberg (Canada). The enormous help provided by Simone Beaudet, Lisa Springer, Mavis Puchlik, Dr. Sande Harlos, and Dr. Anthony Morham at the University of Manitoba (Canada) was invaluable; as was the editing assistance provided by Donne Flanigan and Jennifer Dundas. The skillful proofreading and editing conducted by Myrna McGill was especially appreciated.

The support of the Occupational and Environmental Health Unit in the Department of Community Health Sciences at the University of Manitoba, where this book was drafted, rewritten, edited and assembled, deserves special recognition. This project was partially funded through a Programme Development Grant from this University.

The Occupational Health Program of the University of Alberta (Canada) contributed to the production of this work and managed final preparation of the figures. The artwork was drawn, adapted, or enhanced for this book by Ms. Sam Motyka, Health Sciences Media Services, University of Alberta Hospitals, Capital Health Authority, Edmonton, Alberta (Canada). Funding for the preparation of some figures came from the Tripartite Fund for Occupational Health at the University of Alberta.

The final review and editing was coordinated by Dr. Tord Kjellström at the University of Auckland with the assistance of Suzanne Jackson and Adrienne Taylor.

BASIC ENVIRONMENTAL HEALTH

CONTENTS

1

INTRODUCTION

LEARNING OBJECTIVES

After studying this chapter you will be able to do the following:

- explain the basic relationship between environmental factors and health, and how the interrelationship between economic development, the environment, and health can be seen in an ecosystem framework
- interpret environmental health in historical context with respect to changes in technology, economic development, and social organization
- describe the basic requirements for a healthy environment
- discuss the importance of the workplace to environmental health
- explain the basic issues and concerns with respect to methods of measuring environmental quality, exposure, and health effects
- describe the larger socioeconomic issues affecting environmental health

CHAPTER CONTENTS

BIRTH, LIFE, DEATH, AND THE ENVIRONMENT

When human beings first appeared in the world, their maximum life expectancy is believed to have been around 30 or 40 years. Due to the hostile environment in which they lived, they had a short life expectancy compared to that which characterizes most societies today. Still, it was long enough for them to have children and to establish themselves as the species most capable of modifying their environment for better or worse.

To survive, the first humans had to cope with the following:

- the constant search for sufficient food and drinking water while avoiding plants that contained natural toxins (like poisonous toadstools) or rancid infected meat
- infections and parasites that spread from person to person or animal to person, often through food, drinking water, or insect vectors
- injuries from falls, fires, and animal attacks
- cold and hot temperatures, rain, snow, natural disasters, and other adverse conditions.

These health hazards all occurred in the natural environment. In some societies the "traditional hazards" listed above still dominate environmental health concerns. However, as human beings brought these hazards under control in some regions, "modern hazards" caused by technological and industrial development took over as the primary threat to health and well-being.

Over the last few decades, life expectancy has increased significantly in most countries, as examples of survival curves show (Fig. 1.1). Some investigators say that this is largely due to improvements made in the living environment. Others say that improvements in nutrition are an essential reason for longer lives. Still others say that the changes could not have happened without improved medical diagnosis and treatment of illnesses. All of these statements are probably correct. Progress in health has gone hand in hand with improvements in environmental quality, nutrition, and medical care. People who are sick now are more likely to survive because of improved medical care, and the much greater number who are healthy at any given time are likely to stay healthy and fit because of improved nutrition and control of environmental health hazards. Pro-

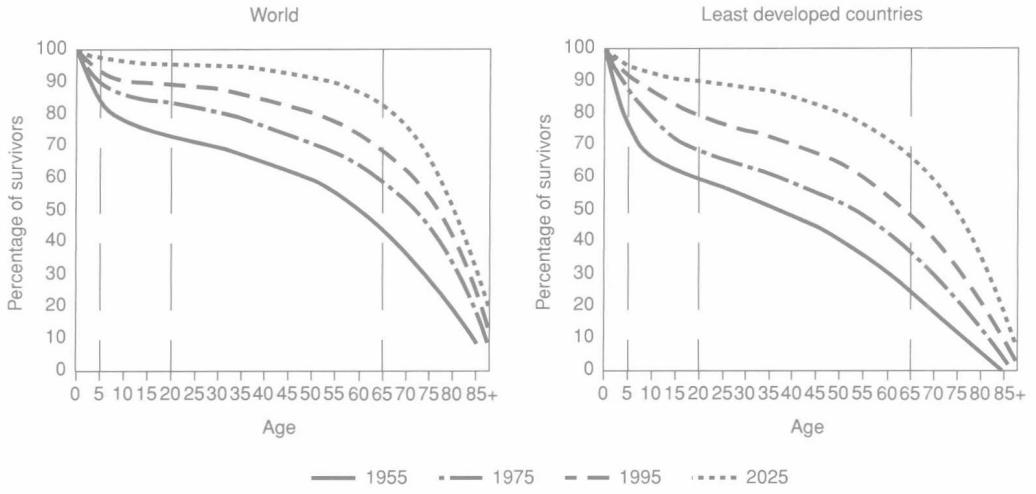

Figure 1.1 Survival curves, 1955–2025. From WHO, 1998a, with permission.

jections of survival and world population through to year 2025 indicate a continual improvement of life expectancy (Fig. 1.1).

Environmental health science is essentially about two things: hazards in the environment, their effects on health, and the variations in sensitivity to exposures within populations; and the development of effective means to protect against hazards in the environment. This book will describe the major environmental hazards that can affect health, show how these hazards can be assessed, and demonstrate how the resulting adverse health effects can be reduced or avoided. The roles of various professionals in protecting health will be explored and the fundamental principles that all environmental health professionals need to understand, regardless of where they work, will be described.

HEALTH AND THE ENVIRONMENT

An Ecosystem Perspective

The term *ecosystem*, coined in the 1930s, can be defined as a system of dynamic interdependent relationships among living organisms and their physical environment. It is a bounded entity that has acquired self-stabilizing mechanisms and an internal balance that has been evolving over the course of centuries. Within a stable ecosystem one species does not eliminate another; otherwise the food supply of the predator species would disappear. Stable and balanced ecosystems will survive longest. An ecosystem cannot sustain massive amounts of materials and energy being consumed by one species without depriving other species and eventually endangering the viability of the entire ecosystem. Similarly, an ecosystem's capacity to absorb wastes and to replenish soil and fresh water is not limitless. At some point an external load can overwhelm the ecosystem's balance, resulting in rapid change or a collapse of the ecosystem. Just as the concept of homeostasis (the body system's capability to function in a coordinated way to ensure the constancy of its internal environment) is now generally understood

BOX 1.1

The Gaia Hypothesis

James Lovelock, a British atmospheric scientist, advanced the hypothesis that the earth and all its components (including the geosphere and the water, gas, nutrients, energy cycles, and all living organisms) constitute a global homeostatic mechanism that ensures constancy of the environment. This hypothesis is known as the *Gaia hypothesis*, as the word *Gaia* comes from the Greek goddess Mother Earth. Lovelock contends that the global biosphere acts in a self-regulating manner, using feedback mechanisms to counter externally imposed disturbances. For example, the heat output of the sun has increased by about 30% since our planet was formed. Yet the earth has maintained a relatively constant temperature. This is believed to be due to the increased solar energy stimulating an increase in photosynthesis, which reduces carbon dioxide levels in the atmosphere. This in turn reduces the "greenhouse" capacity of the atmosphere, causing it to cool and thereby compensate for more heat from the sun. Similarly, the Gaia hypothesis suggests that oxygen has accumulated in the atmosphere to a level that is optimal for biological life on Earth, reflecting the balance of positive and negative feedback from the variety of interdependent living organisms. These changes have taken place very slowly over thousands or millions of years, while the currently debated increase in greenhouse gases has taken place in a few decades.

The controversy surrounding the Gaia hypothesis is due in part to the fact that it cannot be scientifically tested. Additionally, the hypothesis is seen by some investigators to imply that nature acts in a purposeful manner, a concept that does not fit comfortably with the mechanistic view of the world that prevails in contemporary Western civilization. Nonetheless, the Gaia hypothesis has stimulated awareness of the interdependencies within ecosystems and the balance of nature, which, within limits, serve to sustain the planet's life support systems. It has also provided a powerful vision or analogy for treating the Earth with the same respect one would show a mother.

Source: Lovelock, 1988; see also McMichael, 1993.

and accepted, these complex, compensating mechanisms seem to apply to ecosystems as well (see Box 1.1).

Definitions of Health and Environment

In the Constitution of the World Health Organization, *health* is defined as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 1948). This is the most commonly quoted modern definition of health. The concepts of disease, disability, and death tend to be much easier for health professionals to address than this idealistic concept of health. As a result, health sciences have largely been disease sciences since they focus on treating illness or injury rather than enhancing health. In some languages (e.g., Swedish) distinct terms for sick care and health care are in common usage, but unfortunately, this difference is not articulated in the English language.

Similarly inclusive definitions of environment in the context of health have been proposed. Last (1995) defined *environment* as "[All] that which is external to the individual human host. [It] can be divided into physical, biological, social, cultural, any or all of which can influence health status in populations." This definition is based on the notion that a person's health is basically determined by genetics and the environment. From the parents of an individual come genetic factors (genes), consisting of the DNA in each body cell. The genes existed when the embryo was first formed and do not generally change during the course of one's life. If a gene does change (as in the case of a mutation), it may lead to loss of function, cell death, and occasionally to cancer, as a result of very specific mutations. Some studies have suggested that genes provide a built in "clock of self-destruction," as the body can only function properly for a limited time. The limit for most individuals is within the range of 70 to 100 years. An individual's genetic material is one of the major factors that determines how he or she is affected by environmental exposure. While everybody will have problems if subjected to high enough exposures to an environmental hazard, some people are affected at lower exposures because they have preexisting or concomitant risk factors or conditions, and some people are affected at quite low exposures because of an inherited susceptibility (Jedrychowski and Krzyzanowski, 1995).

Poverty, poor living and working conditions, and lack of education have been repeatedly identified as major impediments to health. Over the years it has become clear that substantial improvements in health cannot be achieved without improvements in social and economic conditions. Providing relevant health services in the context of these conditions is addressed in the Health for All policy of the World Health Organization (WHO), established at a conference in Alma Ata in 1978. The final declaration stated that a goal of governments, international organizations, and the world community should be "the attainment by all people of the world by the year 2000 of a level of health that will permit them to lead a socially and economically productive life." It was explicitly noted that this could be attained only through a fuller and better use of the world's resources: "Health is only possible where resources are available to meet human needs and where the living and working environment is protected from life-threatening and health-threatening pollutants, pathogens and physical hazards" (WHO, 1992a).

Environmental pollution and degradation have a huge impact on people's lives. Every year hundreds of millions of people suffer from respiratory and other diseases associated with indoor and outdoor air pollution. Hundreds of millions of people are exposed to unnecessary physical and chemical hazards in the workplace and living environment. Half a million die as a result of road accidents. Four million infants and children die every year from diarrheal diseases, largely as a result of contaminated food or water. Hundreds of millions of people suffer from debilitating intestinal parasites. Two million people die from malaria every year while 267 million are ill with it at any given time. Three million people die each year from tuberculosis and 20 million are actively ill with it. Hundreds of millions suffer from poor nutrition. Almost all of these health problems could be prevented (WHO 1992a).

As noted in the book *Our Planet, Our Health* (WHO, 1992a), the responsibility for protecting and promoting good health extends to all groups in society. No longer is good health the responsibility of only traditional health care professionals, such as doctors, nurses, sanitary engineers, and safety officers, who seek to cure disease, care for the sick, remove pathogens, and reduce injuries. Human well-being is now clearly the responsibility of planners, architects, teachers, employers, industrial managers, and all others who influence the physical or social environment. That is why this book is geared for teaching people in many professions. Naturally, health professionals have a special role in environmental health, but they need to work with all groups in society to promote good health. The ability to work in teams and adopt a transdisciplinary approach is key to being able to solve environmental health problems (Somervile and Rapport, 2000).

Human Interaction with the Environment

Human health ultimately depends on a society's capacity to manage the interaction between human activities and the physical, chemical, and biological environments (Fig. 1.2). It must do this in ways that safeguard and promote human health, while at the same time protecting the integrity of the natural systems on which a healthy environment depends. The physical and biological environments include everything from the immediate home and work environments to regional, national, and global environments. This includes maintaining a stable climate and continued availability of safe environmental resources (soil, fresh water, clean air). It also includes continued functioning of the natural systems that receive the waste produced by human societies without exposing people to pathogens and toxic substances and without compromising the well-being of future generations.

The idea of an inextricable link between human health and the environment has long been recognized. Over 100 years ago, Chief Seattle, an indigenous leader

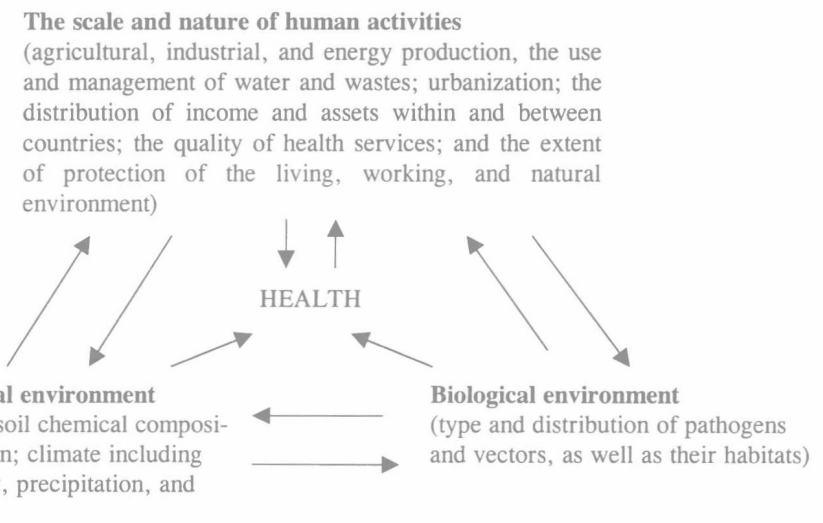

Figure 1.2 Interaction between human activities and the physical, chemical, and biological environments. Adapted from WHO, 1992a, with permission.