Understanding Environmental Pollution

Third Edition

Understanding Environmental Pollution delivers a concise overview of global and individual environmental pollution for undergraduate courses, presenting the tools for students to assess environmental issues. This edition contains more than 30% new material, assessing pollution from an international perspective, including air and water pollution, global warming, energy, solid and hazardous waste, and pollution at home. Both the sources and impacts of pollution are addressed, as well as governmental, corporate, and personal responsibility for pollution. Pollution prevention is emphasized throughout.

- Non-technical language encourages greater understanding of sometimes complex issues.
- "Delving deeper" exercises enable students to apply their learning.
- New chapter on the chemistry basics of pollution.
- Introduces toxicology and risk assessment, assisting students in understanding why chemicals are of concern and how they are regulated.

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This book is dedicated to Dr. Stanley J. Idzerda of Saint Joseph, Minnesota.

Dr. Idzerda, a renowned LaFayette scholar, was the first Director of the Honors College at Michigan State University when as a student I came to know him. I owe him everlasting thanks for his contributions to my life. He was unfailingly helpful, seemed never to notice my faults, and always accentuated my positive attributes.

Contents

Preface

In the early 1990s, I could not find a textbook from which to teach an *Issues in Environmental Pollution* course. So began the writing of class notes, added to by student concerns, misunderstandings, questions, and an ever-increasing volume of information on the issues. The result was the text, *Understanding Environmental Pollution*. It summarizes the basics of many pollution issues, using language understandable to those with a limited science background, while remaining useful to those with more. Four questions are addressed for each pollutant or category of pollutants: what is the pollutant of concern? Why is it of concern? What are its sources? What is being done to reduce, or sometimes eliminate, its emissions into the environment? The impact of pollution on environmental health receives frequent attention with case descriptions posing reflective questions to the reader. Policy issues are often interwoven into the text, as are guidelines on what we, as individuals can do to reduce pollution. This text is not technical, yet provides the basics and, for a number of issues, much detail.

This third edition of *Understanding Environmental Pollution* has been updated and much revised. On the basis of requests, a short chapter on chemistry basics has been added. This edition places greater emphasis on pollutant movement among water, air, soil, and food, and pollutant transformation and degradation. The movement of pollutants across human boundaries is addressed, as are the problems that pollution events can sometimes bring to sites far removed from points of origin. Edition three also places greater emphasis on pollution problems in less-developed nations. China is used to illustrate the major environmental downsides of rapid industrialization occurring with few controls on pollution. The interaction between pollution and poverty is often noted. Most references include Internet addresses, except for those websites not open to the general reader. Many are easily accessed government sites.

A framework: Chapters 1 through 4 provide basic information on pollution and the issues that it poses, and on reducing pollution.

- Chapter 1 addresses the striking ways in which humans are impacting their environment and its ability to provide natural services. It asks us to define pollution for ourselves: high pollutant levels are obviously of concern, but how do we address those that are very small? And, how does an increasing population or large-scale technology impact the environment?
- Chapter 2 introduces *comparative risk assessment* and society's attempts to lower risks including major US laws passed to lower pollution. The chapter moves on to concepts to be used in the rest of the book: the waste management hierarchy with its stress on pollution prevention; and *industrial symbiosis*: treating wastes as resources.

- Chapter 3 introduces toxicity and factors affecting whether a chemical will have adverse effects. It presents the paradoxes with which we must grapple as we think about how or even, in some cases, whether to lower the emissions of a pollutant.
- Chapter 4 examines *chemical risk assessment*. Again, the issue of paradoxes is raised as society systematically, but often inadequately works to understand and describe the risk of particular chemicals and the more difficult problems of the risks associated with mixtures of chemicals.

Basics of pollution issues: Chapters 5 through 12 overview specific pollution issues, especially those starting with emissions into air or water, but in which the pollutants often move on to other environmental media.

- Chapter 5 delves into the principal pollutants in ambient air, the concerns they raise, their sources, and our efforts to reduce emissions. Movements across the globe of massive amounts of pollutants such as dust and smoke are reviewed. So are less prevalent air pollutants.
- Chapters 6, 7, and 8 examine global change issues that originate with air pollutants. In Chapter 6, acid deposition and our success in curbing it is explained, as are some continuing problems, which include increasing levels of acid deposition in Asia. Chapter 7 addresses global climate change, which receives greater emphasis in this edition, although the many relevant issues are difficult to cover in one chapter. The text overviews not just government efforts to lower greenhouse gas emissions, but also those of businesses, cities, and states. Experience gained with the Kyoto Protocol is noted, while simultaneously looking forward to a more robust treaty. In Chapter 8, the Montreal Protocol is lauded for its success in eliminating major pollutants involved in stratospheric ozone depletion; remaining problems are also noted.
- Chapters 9 and 10 examine water pollution and drinking-water pollution, respectively. Chapter 9 emphasizes nonpoint source pollution, and the difficulties in reducing such emissions as compared to point sources. The *nitrogen glut* is examined along with *dead zones*, now a problem of global dimensions. Chapter 10 inspects drinking-water contaminants and drinking-water purification and the conundrums raised by disinfecting water. Problems relating to pathogenic organisms in drinking water are emphasized, especially in less-developed countries. The tragedy of arsenic poisoning in Bangladesh is also examined.
- Chapters 11 and 12 summarize just two of the many wastes that society produces, municipal solid waste and hazardous waste, respectively. Chapter 11 looks at the enormous quantities of solid waste that we produce, and the increasing difficulties that it poses to societies working to deal with it, especially those of less-developed countries. The increasingly prominent role of plastics as a damaging waste is discussed. Chapter 12 summarizes hazardous waste, its sources and treatment, and hazardous waste sites. It shows too how non-hazardous wastes such as discarded computers can, improperly dealt with, become hazardous.

Specific pollutants and pollution issues: Chapters 13 through 17

- Chapter 13 is devoted to the pervasive pollution produced by fossil fuel production and use. It reviews the ways in which many of the issues examined in earlier chapters are energy related. Alternative sources of energy are examined along with the environmental pluses and minuses associated with each.
- Chapters 14 and 15 introduce persistent, bioaccumulative, toxic (PBTs) pollutants. The problems caused by PBTs are out of all proportion to their environmental concentrations. Organic PBTs and metal PBTs are examined in Chapters 14 and 15, respectively.
- Chapter 16 summarizes pesticides and pollution related to the use of pesticides. Alternatives to the use of synthetic pesticides are reviewed, as are the differing approaches and philosophies involved in using pesticides in conventional agriculture as compared to organic and integrated pest management.
- Chapter 17 brings us to home settings, focusing on pollutants within our homes. Many pollutants are often found at higher levels inside our homes than outside. How can we reduce, or even eliminate, many of them? The chapter also discusses the hazardous products that we use.

Hope for meaningful change: Chapter 18

- Chapter 18 addresses the ideal of *zero waste, zero emissions* using two major approaches, dematerialization and detoxification. The tools we use in moving toward these ends are examined. The chapter also introduces some businesses, cities, and even whole countries that are making zero waste, zero emissions their goal.

Chemistry: Chapter 19

- Chapter 19 introduces some basics of chemistry. It was written in response to requests to provide more information on why pollutants act as they do. Several elementary explanations of pollution events using chemistry are provided.

Acknowledgements

I continue to extend warm gratitude to my husband, Professor John C. Hassler, who has faithfully and with much patience over three editions of this text cared for my computer hardware and software. Professor Hassler, a Ph.D. physical chemist, also reviewed the new chapter on chemistry.

Abbreviations and acronyms

(Chemical abbreviations listed separately below)

ADI	Acceptable daily intake
AIDS	Acquired Immune Deficiency Syndrome
ATSDR	Agency for Toxic Substances Disease Registry (a US agency)
BOD	Biochemical oxygen demand
Bt	*Bacillus thuringiensis* (a bacterium)
Btu	British thermal unit (a unit of energy)
CAA	Clean Air Act (a US law)
CDC	Centers for Disease Control and Prevention (a US agency)
CDM	Clean Development Mechanism
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (Superfund) (a US law relating to hazardous waste sites)
CPSD	Consumer Product Safety Division (a US agency)
CRT	Cathode ray tubes
CSO	Combined sewer overflow
CWA	Clean Water Act
DBP	Disinfection by-product
DfE	Design for the environment
DOE	Department of Energy (a US agency)
EMF	Electromagnetic field
EPA	Environmental Protection Agency (a US agency)
EPR	Extended producer responsibility (also called *take-back*)
ETS	Environmental tobacco smoke
EU	European Union
EV	Electric vehicle
FAO	Food and Agriculture Organization (a UN agency)
FDA	Food and Drug Administration
FFDCA	Federal Food Drug and Cosmetics Act (a US law)
FFV	Flexibly fueled vehicle
FIFRA	Federal Insecticide Fungicide and Rodenticide Act (a US law)
GCM	General Circulation Model
GEO	Genetically engineered organism
GHG	Greenhouse gas
GI	Gastrointestinal
HAP	Hazardous air pollutant, also referred to as toxic air pollutant

HEPA	High-efficiency particulate air (filter)
HHW	Household hazardous waste
HW	Hazardous waste
INDOEX	Indian Ocean Experiment
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated pest management
IR	Infrared
KWh	Kilowatt-hour
LCA	Life-cycle assessment
MACT	Maximum available control technology
MCL	Maximum contaminant level
MCLG	Maximum contaminant level goal
MEI	Maximally exposed individual
MIC	Methylisocyanate
µg /dl	Micrograms per deciliter (a concentration)
µg /l	Micrograms per liter (a concentration)
MOPITT	Measurements of Pollution in the Troposphere
MPG	Miles per gallon
MSW	Municipal solid waste
MTD	Maximum tolerated dose
NAPAP	National Acid Precipitation Assessment Program (program evaluating acidic deposition)
NAS	National Academy of Sciences (US body of scientists formed by a Congressional act)
NASA	National Aeronautic and Space Administration (a US agency)
NICAD	Nickel–cadmium batteries
NIMBY	Not in my backyard
NOAA	National Oceanic and Atmospheric Administration (a US agency)
NOAEL	No observed adverse effect level
NPL	National Priority List (a US list of high-priority hazardous waste sites)
NRC	National Research Council (an arm of the US NAS)
NTP	National Toxicology Program (a US program evaluating chemical toxicity)
ODP	Ozone-depletion potential
OECD	Organization for Economic Cooperation and Development (organization of 30 prosperous nations)
P^2	Pollution prevention
PBT	Persistent, bioaccumulative, toxic
pCi/l	Picocuries per liter (a unit of concentration for radioactive substances)
PM	Particulate matter
PM_{10}	Particulate matter that is less than 10 microns in diameter
$PM_{2.5}$	Particulate matter that is less than 2.5 microns in diameter
PNGV	Partnership for a New Generation of Vehicles
POP	Persistent organic pollutant
ppb	Parts per billion (a unit of concentration)

ppm	Parts per million (milligrams per liter, a unit of concentration)
ppt	Parts per trillion (a unit of concentration)
PSC	Polar stratospheric cloud
PV	Photovoltaic
RCRA	Resource Conservation and Recovery Act (a US law)
RDF	Refuse-derived fuel
RfD	Reference dose
SDWA	Safe Drinking Water Act (a US law)
SS	Suspended solids
SUV	Sports utility vehicle
TRI	Toxic Release Inventory (US list of chemicals released into environment)
TSCA	Toxic Substances Control Act (a US law)
TUR	Toxics use reduction
UN	United Nations
UNDP	UN Development Program
UNEP	UN Environmental Program
UNICEF	UN International Children's Emergency Fund
USDA	US Department of Agriculture
USGS	US Geological Survey (a US agency)
UV	Ultraviolet
WHO	World Health Organization (a UN agency)
WMH	Waste management hierarchy
WMO	World Meteorological Organization (a UN agency)
ZEV	Zero-emission vehicle

Chemical abbreviations and formulas

BaP	Benzo[*a*]pyrene (a PAH formed during combustion)
^{14}C	Carbon-14 (a radioactive form of carbon)
CCA	Chromated copper arsenate (used to protect wood against decay)
CCl_2F_2	Freon-12 (the best-known CFC)
CFC	Chlorofluorocarbon (an ozone-depleting chemical)
CFC-12	Freon (the best-known CFC)
CH_4	Methane (a greenhouse gas)
ClO	Chlorine monoxide (in the stratosphere it promotes ozone depletion)
CO	Carbon monoxide (a toxic chemical formed by incomplete combustion)
CO_2	Carbon dioxide (a greenhouse gas)
DDE	Dichlorodiphenyldichloroethene (a DDT degradation product)
DDT	Dichlorodiphenyltrichloroethane (a once common, but now banned, insecticide)
DEHP	Di(2-ethylhexyl) phthalate (used in plastic to make it flexible)
DES	Diethylstilbestrol (a potent synthetic estrogen)
Dioxin	2,3,7,8-TCDD (sometimes refers to the whole dioxin family)
DMSO	Dimethyl sulfoxide (chemical promoting transport of chemicals across skin into body)

DNA	Deoxyribonucleic acid (genetic material)
H^+	Acid hydrogen ion (an ion that makes water acid)
HCFC	Hydrochlorofluorocarbon (a substitute for CFCs)
HCHO	Formaldehyde (a chemical found in many household products, often as a residual)
HCl	Hydrochloric acid (a common acid)
HFC	Hydrofluorocarbon (a substitute for CFCs)
^{40}K	Potassium-40 (a radioactive form of potassium)
MIC	Methylisocyanate (responsible for massive Bhopal explosion)
MTBE	Methyl tertiary butyl ether (a chemical added to gasoline to provide oxygen)
N	Nitrogen
N_2	Nitrogen (diatomic nitrogen, the form found in the atmosphere)
N_2O	Nitrous oxide (a greenhouse gas, also used as anesthetic, known as "laughing gas")
NO_2	Nitrogen dioxide (a common air pollutant, which also leads to acid deposition)
NO_x	Nitrogen oxides (common air pollutants that contain nitrogen)
O	Single oxygen atom
O_2	Oxygen (diatomic oxygen, the form found in the atmosphere)
O_3	Ozone (triatomic oxygen, a common air pollutant)
PAH	Polycyclic aromatic hydrocarbon (common pollutants formed during combustion)
PBDE	Polybrominated diphenyl ether (a fire-retardant chemical which is persistent and bioaccumulative)
PCB	Polychlorinated biphenyl (now banned chemicals once commonly used in electrical equipment to prevent fires)
PERC	Tetrachloroethylene (perchloroethylene, a dry-cleaning solvent)
PET	Polyethylene terephthalate (a common plastic often used to make soft-drink bottles)
PFC	Perfluorocarbon (a greenhouse gas)
PFOS	Perfluorooctane sulfonates (stain repellants and fire-fighting chemicals, environmentally persistent and bioaccumulative)
Po	Polonium (a naturally found radioactive element)
PVC	Polyvinylchloride (a plastic)
Rn	Radon (a naturally found radioactive gas)
SF_6	Sulfur hexafluoride (a potent greenhouse gas)
SO_2	Sulfur dioxide (a common air pollutant, which also leads to acid deposition)
TBT	Tributyltin (biocide used to coat maritime ships to prevent growth of fouling organisms)
TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin (most toxic form of dioxin commonly called "dioxin")
^{238}U	Uranium-238 (a radioactive isotope of uranium)
VOCs	Volatile organic compounds (or volatile organic chemicals)