

Contents

Preface	xiii	3.9 Heavy Pollution's Impact on Disease and Premature Death	60
Acknowledgment	xvi	3.10 Conclusions	61
List of Abbreviations and Acronyms	xvii	Questions	61
<hr/>			
1		4	
Understanding Pollution	1	Chemical Exposures and Risk Assessment	67
1.1 The Anthropocene	2	4.1 Exposure Assessment	68
1.2 Introducing Pollution	2	4.2 A CDC Study on Exposure to Xenobiotic Chemicals	69
1.3 Devastating versus Tiny Levels of Pollution	10	4.3 Epidemiological Studies	70
1.4 Nature's Services	10	4.4 Chemical Risk Assessment	72
1.5 Soil	13	4.5 Risk Management	76
1.6 Root Causes of Environmental Problems	14	4.6 Risks to Children	78
1.7 Personal Actions Have Consequences	16	4.7 Alternative Methods of Chemical Risk Assessment	79
1.8 Living within Our Planet's Boundaries	17	4.8 Conclusions	82
1.9 Burning Fossil Fuels	19	Questions	82
1.10 Conclusions	19		
Questions	20		
<hr/>			
2		5	
Reducing Pollution to Reduce Risk	26	Air Pollution	89
2.1 Chemical Risk Assessment	27	5.1 Introduction to Criteria Air Pollutants	90
2.2 Comparative Risk Assessment	27	5.2 Volatile Organic Compounds	102
2.3 Complex Risk Assessment	29	5.3 Hazardous Air Pollutants	103
2.4 Using Legislation to Reduce Risk	29	5.4 Air Pollution's Major Impact on Global Health	106
2.5 A Right-To-Know Law	31	5.5 Atmospheric Brown Clouds	107
2.6 Using the Waste Hierarchy to Reduce Risk	33	5.6 Sand and Dust Storms	108
2.7 Going Beyond Pollution Prevention	37	5.7 Conclusions	111
2.8 Conclusions	38	Questions	111
Questions	38	Appendix: Particulates and Disease	113
<hr/>			
3		6	
Chemical Toxicity	42	Acid Deposition	119
3.1 Terminology	43	6.1 Background	120
3.2 How Dose Affects Response	44	6.2 Pollutants of Concern	122
3.3 Absorption, Distribution, Biotransformation, and Excretion	46	6.3 Adverse Impacts of Acidic Deposition	123
3.4 Factors Affecting Toxicity	47	6.4 Sources of Acid Deposition	125
3.5 Environmental Hormones (Endocrine Disruptors)	51	6.5 Reducing Emissions of Acid-Precursor Chemicals	125
3.6 Cancer	54	6.6 Recovering from Acidic Deposition	126
3.7 Epigenetics and Disease	57	6.7 Acid Deposition in Asia	127
3.8 How Toxicants Affect Specific Organs	57	6.8 Conclusions	129
		Questions	129

7**Global Warming and Ocean Acidification 133**

7.1	Introduction	134
7.2	Greenhouse Gases	135
7.3	Carbon Dioxide	136
7.4	Methane	139
7.5	Ground-Level Ozone	141
7.6	Nitrous Oxide	142
7.7	Halogen Gases	142
7.8	Water Vapor	142
7.9	Aerosols	142
7.10	Black Carbon (Soot): An Aerosol	144
7.11	Solar Geoengineering Using Aerosols?	145
7.12	Impacts of Global Warming	145
7.13	Ocean Acidification: An Impact Specific to Carbon Dioxide	149
7.14	Adaptation to a Greenhouse World	152
7.15	Reducing GHG Emissions	154
7.16	Solutions to Global Warming	157
7.17	Conclusions	157
	Questions	158

8**Energy and Pollution 166**

8.1	Pollution in Motor Vehicle Use	168
8.2	Is Clean Coal Possible?	169
8.3	Conservation and Efficiency	171
8.4	Increasing Industrial Efficiency in Using Energy	172
8.5	Using Waste Heat to Increase Industrial Efficiency	173
8.6	Renewable Energy: Photovoltaics	174
8.7	Renewable Energy: Wind Power	177
8.8	Renewable Energy and the Electric Grid	178
8.9	Renewable Energy Use Around the World	179
8.10	End-Of-Life Management of Solar Cells, Wind Turbines, and Batteries	180
8.11	Briefs on Other Energies	181
8.12	Conclusions	184
	Questions	186

9**Stratospheric Ozone Depletion 192**

9.1	Background	193
9.2	Pollutants of Concern: CFCs and Halons	194
9.3	Chemical Reactions in the Stratosphere	195
9.4	UV Radiation at Earth's Surface	198
9.5	The Montreal Protocol	200
9.6	Problems, Ongoing Research, and Cheating	201
9.7	Conclusions	203
	Questions	203

10**Water Pollution 206**

10.1	Point and Nonpoint Water Pollution	207
10.2	Pollutants of Concern: Conventional Water Pollutants	208
10.3	Priority Pollutants	211
10.4	Nonconventional Pollutants	212
10.5	Pollution of Groundwater	212
10.6	Pollution in Other Water Bodies	214
10.7	Reducing Point Sources of Pollution	216
10.8	Reducing Nonpoint Sources of Pollution	221
10.9	Confronting Reactive Nitrogen: The Nitrogen Glut	224
10.10	Falling Levels of Oxygen in the Ocean	229
10.11	Phosphorus Pollution	231
10.12	Conclusions	234
	Questions	235

11**Drinking Water Pollution 242**

11.1	Primary Drinking Water Standards	243
11.2	An Ongoing Mass Poisoning: Arsenic	247
11.3	Lead in Drinking Water	249
11.4	Secondary Drinking Water Contaminants	251
11.5	Other Drinking Water Issues	252
11.6	Pathogens and Human Health	254
11.7	Home Water Treatments	257
11.8	Waste and Wastewater as Valuable Resources	258
11.9	Conclusions	259
	Questions	260

12**Solid Waste 265**

12.1	Generating Large Amounts of Waste	266
12.2	Using the Waste Management Hierarchy to Reduce MSW	268
12.3	Recycling	273
12.4	Incineration and Landfilling	279
12.5	When Waste Problems Seem Too Large to Follow the WMH	282
12.6	Plastic Presents Mammoth Problems	283
12.7	Plastics: Improving P ² and Recycling	289
12.8	Conclusions	290
	Questions	291

13**Hazardous Waste 297**

13.1	Introduction to Hazardous Waste	298
13.2	The Waste Management Hierarchy in HW Management	299

13.3	The Coming of Superfund	301	16.10	Reducing Pesticide Risk	365
13.4	Evaluating HW and Superfund Sites	304	16.11	Reducing Risk by Alternative Approaches to Agriculture	366
13.5	Dealing with and Cleaning Up HW Sites	305	16.12	France's Extraordinary Efforts to Reduce Pesticide Use	368
13.6	Reducing the Risk of HW Internationally	308	16.13	Conclusions	369
13.7	The Problem of Electronic Waste: E-Waste	309		Questions	369
13.8	Conclusions	311		Appendix: Biopesticides	371
	Questions	312			

14

Persistent, Bioaccumulative, and Toxic Chemicals	316	
14.1	Why PBTs Are of Concern	317
14.2	The Stockholm Convention: Reducing POPs	319
14.3	Examining One POP Family: The PCBs	321
14.4	A Polybrominated POP Family: PBDEs	322
14.5	A Polyfluorinated Family: PFAS	323
14.6	Conclusions	323
	Questions	324

15

Metals	327	
15.1	Metals: An Introduction	328
15.2	Sources of Metal Pollution	329
15.3	Lead: A PBT Metal	334
15.4	Mercury	337
15.5	Cadmium	343
15.6	Arsenic	344
15.7	Conclusions	345
	Questions	346

16

Pesticides	353	
16.1	Why Use Pesticides and Who Uses Pesticides	354
16.2	Pesticide Categories	355
16.3	An Introduction to Insecticides	356
16.4	The Neonicotinoids	357
16.5	Herbicides Kill Unwanted Plants – Weeds	359
16.6	Pesticide Movement and Contamination of the Environment and Food	361
16.7	Pesticide Resistance	362
16.8	Biodiversity at High Risk, but Causes Go Beyond Pesticides	362
16.9	Pesticide Use in Less-Developed Countries	364

17

Indoor Air Pollution	376	
17.1	Indoor Air Contaminants	377
17.2	Combustion Pollutants	379
17.3	VOCs, Moisture, Biological Pollutants, Dust, and Dirt	380
17.4	Ionizing Radiation: Radon	383
17.5	Indoor Air Pollution in Less-Developed Countries	386
17.6	Household Hazardous Products	387
17.7	Household Hazardous Waste	389
17.8	Conclusions	390
	Questions	391

18

Zero Waste, Zero Emissions	395	
18.1	Sustainable Development	396
18.2	Building a Circular Economy	396
18.3	Industrial Ecology	400
18.4	Closed-Loop Systems	400
18.5	Zero Waste	401
18.6	Lifecycle Assessment	404
18.7	Design for the Environment	406
18.8	Product Stewardship and EPR	407
18.9	Servicizing	408
18.10	Green Chemistry and How It Works	409
18.11	Converting Wastes into Resources	411
18.12	Safely Operating within Earth's Life-Support Boundaries	411
18.13	Conclusions	412
	Questions	412
Appendix: Basic Concepts in Chemistry	418	
A.1	Atoms and the Periodic Table	418
A.2	Organic and Inorganic Chemicals	423
A.3	Free Radicals	424
A.4	Oxidation and Reduction Reactions	424
A.5	Acid Pollution	426
Further Reading	431	
Index	439	