



Essentials of Environmental Health

Second Edition

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Production Credits

Publisher: Michael Brown
Associate Editor: Catie Heverling
Editorial Assistant: Teresa Reilly
Associate Production Editor: Kate Stein
Senior Marketing Manager: Sophie Fleck
Manufacturing and Inventory Control Supervisor: Amy Bacus
Composition: Publishers' Design and Production Services, Inc.
Art: diacriTech
Assistant Photo Researcher: Rebecca Ritter
Cover Design: Scott Moden
Cover, Section Opener, Chapter Opener, and Study Questions Image: © Szabo Photography/Shutterstock, Inc.
Background Images: Petri dish © Olivier Le Queinec/Shutterstock, Inc.; Crowd of people © Veer; Biohazard symbol © Richard C. Bennett/Shutterstock, Inc.; Poison symbol © Yobidaba/Shutterstock, Inc.; Radioactive symbol © WilleeCole/Shutterstock, Inc.
Printing and Binding: Malloy, Inc.
Cover Printing: John Pow Company

Library of Congress Cataloging-in-Publication Data

Friis, Robert H.

Essentials of environmental health / Robert H. Friis. — 2nd ed.
p. ; cm.

Includes bibliographical references and index.

ISBN-13: 978-0-7637-7890-3 (pbk.)

ISBN-10: 0-7637-7890-7 (pbk.)

1. Environmental health. I. Title.

[DNLM: 1. Environmental Health. 2. Environmental Pollution. WA 30.5]

RA565.F75 2012

616.9'8—dc22

2010027788

6048

Printed in the United States of America

14 13 12 11 10 9 8 7 6 5 4 3 2 1



Dedication

To C.A.F.

Contents

Dedication	iii
<i>The Essential Public Health Series</i>	xi
Prologue	xiii
Preface	xv
Acknowledgments	xvii
About the Author	xix
Introduction	xxi
Abbreviations	xxiii
Part I Background of the Field	1
Chapter 1 Introduction: The Environment at Risk	3
Learning Objectives	3
Introduction	3
Significance of the Environment for Human Health	5
Population and the Environment	7
Definitions Used in the Environmental Health Field	14
Historical Background	16
Careers in the Environmental Health Field	21
Conclusion and Overview of the Text	23
Study Questions and Exercises	25
References	26

Chapter 2	Environmental Epidemiology	27
	Learning Objectives	27
	Introduction	27
	Definition of Environmental Epidemiology	28
	Contributions of Epidemiology to Environmental Health	29
	Brief History of Environmental Epidemiology	31
	Strategies of Environmental Epidemiology	33
	Causality in Epidemiologic Studies	40
	Bias in Environmental Epidemiologic Studies	42
	Limitations and Deficiencies of Environmental Epidemiology	43
	Conclusion	44
	Study Questions and Exercises	46
	References	47
 Chapter 3	 Environmental Toxicology	 49
	Learning Objectives	49
	Introduction	49
	Description of Toxicology	50
	Terminology Used in the Field of Toxicology	51
	The Concept of a Dose and Related Terms	52
	Factors That Affect Responses to a Toxic Chemical	55
	Links Between Toxicology and Risk Assessment	58
	Conclusion	63
	Study Questions and Exercises	64
	References	65
 Chapter 4	 Environmental Policy and Regulation	 67
	Learning Objectives	67
	Introduction	67
	Overview of the Environmental Policy Process	68
	Risk Assessment and Policy Development	72
	Case Studies: Environmental Policies to Protect Human Health	75
	Agencies Involved in the Adoption, Implementation, and Enforcement of Environmental Policies	78
	Major US Environmental Health Laws	84
	Conclusion	88
	Study Questions and Exercises	89
	References	90

Part II	Agents of Environmental Disease	93
Chapter 5	Zoonotic and Vector-Borne Diseases	95
	Learning Objectives	95
	Introduction	95
	Terminology Used in the Context of Zoonotic and Vector-Borne Diseases	95
	Examples of Vector-Borne Diseases	96
	Viral Hemorrhagic Fevers (VHFs)	107
	Arthropod-Borne Viral Diseases (Arboviral Diseases)	109
	Emerging Zoonoses	110
	Other Zoonotic Diseases	119
	Control and Prevention of Mosquito-Borne Diseases	125
	Conclusion	126
	Study Questions and Exercises	127
	References	128
Chapter 6	Toxic Metals and Elements	129
	Learning Objectives	129
	Introduction	129
	The CERCLA Priority List of Hazardous Substances	129
	Overview of Sources and Effects of Exposure to Metals	131
	Toxic Heavy Metals	135
	Essential Metals with Potential for Toxicity	145
	Metals for Use in Medical Therapy	147
	Conclusion	147
	Study Questions and Exercises	148
	References	149
Chapter 7	Pesticides and Other Organic Chemicals	151
	Learning Objectives	151
	Introduction	151
	Chemicals Among the Top 20 in the ATSDR List of 275 Hazardous Substances	153
	Pesticides	153
	Dioxins	165
	Polychlorinated Biphenyls (PCBs)	167
	Organic Solvents	168
	Chemicals Used in the Manufacture of Plastics	170
	Cleaning and Household Products	171
	Environmental Estrogens	171
	Conclusion	172
	Study Questions and Exercises	173
	References	174

Chapter 8	Ionizing and Nonionizing Radiation	177
	Learning Objectives	177
	Introduction	177
	Overview of Ionizing Radiation	178
	Types of Ionizing Radiation	178
	Measurement of Ionizing Radiation Dose Units	180
	Health Effects of Exposure to Ionizing Radiation	183
	Sources of Environmental Exposure to Ionizing Radiation	183
	Medical Uses of Ionizing Radiation	191
	Nuclear Waste Disposal	192
	Nonionizing Radiation	192
	Sources of Exposure to Nonionizing Radiation	193
	Conclusion	201
	Study Questions and Exercises	202
	References	203
 Part III	 Applications of Environmental Health	 205
 Chapter 9	 Water Quality	 207
	Learning Objectives	207
	Introduction	207
	The Water Supply	209
	Treatment of Water for Residential Consumption	216
	Drinking Water Contamination	220
	Beach and Coastal Pollution	231
	Conclusion	238
	Study Questions and Exercises	239
	References	240
 Chapter 10	 Air Quality	 243
	Learning Objectives	243
	Introduction	243
	Notorious Air Pollution Episodes in History	246
	Sources and Causes of Air Pollution	247
	Components of Air Pollution	250
	Air Quality Standards	257
	Health Effects of Air Pollution	258
	Indoor Air Quality	264
	Global Climate Change and Global Warming	267
	Controlling Air Pollution and Global Warming	273
	Conclusion	274

Study Questions and Exercises	275
References	276
Chapter 11 Food Safety	279
Learning Objectives	279
Introduction	279
The Global Burden of Foodborne Illness	280
Categories of Food Hazards	282
Common Microbial Agents of Foodborne Illness	282
Bacterial Agents	283
Worms	295
Viral Agents	296
Other Agents	298
Chemically Related Foodborne Hazards	301
Regulation of Food Safety	306
Foodborne Disease Prevention	309
Conclusion	315
Study Questions and Exercises	316
References	317
Chapter 12 Solid and Liquid Wastes	321
Learning Objectives	321
Introduction	321
Historical Background—Solid Waste Disposal	321
Components of the Municipal Solid Waste Stream	324
Solid Waste Management	324
Disposal of Hazardous Materials and Wastes	331
Sewage Processing and Disposal	335
Animal Wastes	340
Conclusion	342
Study Questions and Exercises	343
References	344
Chapter 13 Occupational Health	347
Learning Objectives	347
Introduction	347
Background and History	348
Significance of the Occupational Environment for Health	351
Overview of Agents of Occupational Disease	352
Specific Occupationally Associated Diseases and Conditions	356
Prevention of Occupational Disease	371
Conclusion	374

Study Questions and Exercises	375
References	376
Chapter 14 Injuries with a Focus on Unintentional Injuries and Deaths	379
Learning Objectives	379
Introduction	379
How Injuries are Classified	379
The Significance of Injuries	381
Unintentional Injuries	384
Motor Vehicle Injuries	388
Unintentional Injuries among Children	393
Injuries among the Elderly	397
Schema for Injury Prevention	401
Conclusion	402
Study Questions and Exercises	404
References	405
Glossary	407
Index	419



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Richard K. Riegelman, MD, MPH, PhD, is Professor of Epidemiology-Biostatistics, Medicine, and Health Policy, and Founding Dean of The George Washington University School of Public Health and Health Services in Washington, DC. He has taken a lead role in developing the Educated Citizen and Public Health initiative which has brought together arts and sciences and public health education associations to implement the Institute of Medicine of the National Academies' recommendation that "...all undergraduates should have access to education in public health." Dr. Riegelman also led the development of George Washington's undergraduate major and minor and currently teaches "Public Health 101" and "Epidemiology 101" to undergraduates.



Prologue

Dr. Robert Friis' *Essentials of Environmental Health* was the first book in the *Essential Public Health* Series. In the 4 years since the first edition was published, the importance of environmental health has been brought to the world's attention by crises and challenges ranging from oil spills to climate change, lead in toys, and pandemic influenza.

The second edition of *Essentials of Environmental Health* builds upon the first edition. It keeps up with the changes in environmental health to produce a state-of-the-art introductory text. The second edition provides a wide range of additions and updates including a new chapter on injuries, updates on pandemic flu, and coverage of recent environmental controversies, such as use of bisphenol A in plastics.

Dr. Friis also has produced a comprehensive website to accompany the text. The website provides the most recent information to broaden students' knowledge of environmental health. It also provides faculty with resources to challenge students and deepen their understanding of environmental health.

The *Essential Public Health* Series will soon include over 20 books, readers, and workbooks covering the full range of introductory texts. Dr. Friis has also authored *Epidemiology 101* as part of the series. *Epidemiology 101* is a core undergraduate public health text and a key component of the "101" approach to undergraduate public health education that also includes *Public Health 101* and *Global Health 101*. *Essentials of Environmental Health* has rapidly become a core text as well, key to a comprehensive curriculum in public health.

Dr. Friis brings to all his writing in environmental health and epidemiology a lifetime commitment to teaching, a personal connection to students as they begin their study of public health, and an impressive ability to clearly present complex subjects. I know that you will enjoy and benefit from this book.

Richard Riegelman, MD, MPH, PhD
Series Editor—*Essential Public Health*



Preface

When you follow the media, dramatic pictures and accounts of chemical spills, industrial fires, and other environmental disasters are not unusual. If you read the newspaper, surf the Internet, watch television, or merely observe what is happening around you, you will become aware of the environmental threats that are occurring on a worldwide scale. Within the past decade, public debate about global warming—a controversial topic—has escalated. Some worldwide climate changes such as extreme weather events have been attributed to global warming. The devastation caused by the August 2005 Hurricane Katrina in New Orleans was particularly moving. Other examples of extreme climate variations are increases in desertification in some parts of the world, while at the same time, other areas have experienced periodic massive flooding, such as Pakistan and China during summer 2010. As a consequence of the warming of the Earth's temperature, mountain glaciers, masses of ice in Greenland, and glaciers and sea ice in the Arctic region have been melting. Everyone should be concerned about the potential impact of these dramatic trends and incidents on the global physical environment and the health and survival of the world's population. At the same time, a hopeful attitude is warranted because of the progress that has been made in protecting environmental quality.

I have always been interested in the environment, especially the impact of rapid growth in California, my home state. During my lifetime, I have witnessed the conversion of pastoral northern California farmlands and orchards into densely populated urban zones with consequential environmental degradation. Although destruction of Brazilian rainforests is a focus of environmental advocates, wide swaths of the redwood forests of northern California and the wooded areas of the Pacific Northwest also are impacted by deforestation and are in need of protection.

In addition to urbanization in my home state, rapid growth has also been a global phenomenon. In my travels over the past decades, I have observed this phenomenon in Mexico and some parts of Europe. One example is the transformation of small cities in Baja, California into booming metropolises. Another example is the residential and commercial development that now fills the open, snow-covered fields that I traipsed through as a student in western Germany on the way to language classes. Despite urban growth, German cities have adopted exemplary programs for urban planning and recycling solid wastes. Other northern European countries, such as Sweden, have implemented development policies that preserve open space and encourage citizens to use public transportation. Member states of the European Union have been leaders in the development of wind and solar power, alternative fuels such as biodiesel, and energy-saving technologies.

Increasing population and development pressures affect southern Europe as well. As a result of water overdraft, some European cities along the Mediterranean have had salt water intrude into their public water supplies. When I first traveled to Europe as a student, I was impressed with the fact that people used bottled water instead of tap water, and later I began to understand why—most of the time, the tap water simply was not as palatable as bottled water. Nowadays, however, it is also common for people in the United States to tote around bottles of “prestige water,” perhaps because of their fear of contaminants

and microbes that may be present in the tap water. (In most cases, this fear is unwarranted because the quality of municipal tap water is highly regulated.)

Back in California, we now know that because of the introduction of toxic chemicals and pesticides, sewage contamination, and overfishing, our once abundant fisheries are declining and fishing must be limited. For example, it was once possible to consume fresh abalone, but now this delicious crustacean is almost unavailable from the wild due to excessive human predation. Seafood lovers are advised not to consume certain species of fish, which may be contaminated with mercury and other harmful substances.

During the spring and summer of 2010, a catastrophe at the Deepwater Horizon oil rig off the Louisiana coast caused the largest marine oil spill up to that time—about 5 million barrels. Aside from the immediate impact on wildlife and the fishing and tourism industries, the long-term environmental effects will require years to be ascertained. This catastrophe has called into question the safety of offshore oil drilling operations and focused attention on the adverse environmental consequences of oil extraction in general.

Still another concern is the impact of environmental factors on the safety of the global food supply. During late summer 2010, millions of eggs produced in the midwestern United States and sold widely by supermarket chains were found to be contaminated with *Salmonella* bacteria. Inspection of the poultry farms revealed that chickens were raised in despicable environmental conditions, which could contribute to the proliferation of *Salmonella* contamination. Within the past decade, other foodborne disease outbreaks in the United States have been associated with tomatoes (*Salmonella*) as well as lettuce and ground beef (*E. coli*). Noteworthy is the increasing internationalization of the world's food supply—adulterated and unsafe foodstuffs produced in one country can be shipped globally and threaten all of humanity. An example is the melamine-contaminated baby formula manufactured in China.

The picture is not entirely bleak, however; much progress has been made in informing the public about environmental health hazards and introducing regulations and procedures for the control of these hazards. Notable are the use of unleaded fuels and catalytic converters in automobiles to control air pollution and lead contamination. Not only have important environmental protections such as these been implemented in the United States, they also have been adopted by European countries and elsewhere.

Another example of a successful environmental policy that is now enforced in many parts of the world is the regulation of smoking in alcohol-serving establishments. This policy originated as California's Smokefree Bars Law, which controls occupational exposure to environmental tobacco smoke and also protects bar and restaurant patrons. At national and international levels, regulatory agencies conduct research and develop and enforce laws that control environmental health hazards. Although these efforts hold much promise for maintaining environmental quality, it must be kept in mind that policy and regulation are strongly influenced by the political process. Often economic considerations such as the need to maintain jobs and the prospect of increased taxation must be balanced against environmental protections.

This textbook addresses the major topics and methodological approaches in the environmental health field in order to provide a diversity of learners (from the beginning student to the experienced health professional) with an overview of the field. I believe that knowledge of environmental health issues can lead to an appreciation of humankind's connection with the earth and the precarious balance between human activities and environmental resources.

Robert H. Friis, PhD



Acknowledgments

My colleagues and students were extremely helpful in providing comments and background information necessary to complete this project. For the first edition of the book, I wish to thank the following former students: Ibtisam Khoury, Lillian Camacho, Sheetal Monga, Manohar Sukumar, and Heidi Burkey from California State University, Long Beach; and Nada Hamade from the University of California, Irvine. Students helped with literature searches, reviewed written text materials, and provided feedback. I also acknowledge the contributions of Dr. Robert Phalen and Dr. Yee-lean Lee, University of California, Irvine; Dr. Jan Semenza, European Center for Disease Prevention and Control; Dr. Glenn Paulson, School of Public Health, University of Medicine and Dentistry of New Jersey; and Dr. Michelle Saint-Germain and Dr. Javier Lopez-Zetina, California State University, Long Beach. These professional colleagues carefully reviewed chapters that were relevant to their areas of expertise. For the second edition, I express my gratitude to the following students who helped with literature searches and review of the text: Sarah Long, Paula Griego, Jane Kil, and Dexter Dizon.

Also, I would like to thank anonymous reviewers whose insightful comments greatly enhanced the quality of this text. Mike Brown, publisher for Jones & Bartlett Learning, provided continued encouragement and motivation for completion of the project; Jones & Bartlett Learning staff offered much expertise. Finally, my wife, Carol Friis, was involved extensively with this project—she provided detailed editorial comments, typed final versions of the document, verified the accuracy of the references, and helped with many other aspects of the project. Without her support and assistance, completion of the text would not have been possible.



About the Author

Robert H. Friis, PhD, is a Professor of Health Science and Chair of the Department of Health Science at California State University, Long Beach (CSULB), and Director of the CSULB Veterans Affairs Medical Center, Long Beach, Joint Studies Institute. Previously, he was a faculty member in the Department of Medicine, Department of Neurology, Department of Community and Environmental Medicine, and School of Social Ecology, University of California, Irvine. He is past president and a member of the Governing Council of the Southern California Public Health Association. He serves on the advisory boards of several health-related organizations, including the California Health Interview Survey. He is an epidemiologist by training and profession.

As a health department epidemiologist, Dr. Friis led investigations in environmental health problems such as chemical spills and air pollution. He has taught courses on environmental health at universities in New York City and southern California. He has conducted research and published and presented numerous papers related to tobacco use, mental health, chronic disease, disability, minority health, and psychosocial epidemiology. Dr. Friis has been the principal investigator or a coinvestigator on grants and contracts from the University of California's Tobacco-Related Disease Research Program, the National Institutes of Health, the METRANS program, and other agencies. This funding has supported investigations into topics such as geriatric health, depression in Hispanic populations, and nursing home infections. His interests have led him to conduct research in Mexico City and European countries. He has been a visiting professor at the Center for Nutrition and Toxicology, Karolinska Institute, Stockholm, Sweden; the Max Planck Institute, Munich, Germany; and two times at the Technical University of Dresden, Germany. He reviews articles for scientific journals, including *Public Health*, *Health Education Research*, *International Migration Review*, and *Social Science and Medicine*.

Dr. Friis is a fellow of the Royal Society for Public Health and a member of the Society for Epidemiologic Research and the American Public Health Association. He was awarded a postdoctoral fellowship for study at the Institute for Social Research, University of Michigan, and the Achievement Award for Scholarly and Creative Activity from California State University, Long Beach. His biography is listed in *Who's Who in America*.

He is author of *Epidemiology 101* (Jones & Bartlett Learning), senior author of *Epidemiology for Public Health Practice, Fourth Edition* (Jones & Bartlett Learning), coauthor of *Introductory Biostatistics for the Health Sciences* (Wiley), and editor of the *Praeger Handbook of Environmental Health* (Praeger).



Introduction

The purpose of this text is to inform the reader about the key areas of environmental health and instill awareness about the crucial role of the environment in the health of the planet and all living creatures. The second edition has been updated extensively to reflect the rapidly changing context of the environmental health field. Organized according to three major domains—background, environmental disease agents, and applications—the text begins with background material and “tools of the trade” (environmental epidemiology, environmental toxicology, and environmental policy and regulation). The text then covers specific agents of environmental diseases (e.g., microbial agents, toxic metals, pesticides, and ionizing and nonionizing radiation). Finally, applications and domains of environmental health are addressed (water and air quality, food safety, waste disposal, occupational health, and injuries).

This work is intended for graduate and undergraduate students who take environmental health courses in a variety of settings. Often, these courses are offered by schools of public health and health science departments. The text can also be used in online courses and instruction in intensive courses offered in a nontraditional format. Taking a nontechnical approach, the book should be accessible and interesting to students who have not had a great deal of previous introductory background, especially in the sciences. Nevertheless, the text should appeal to more advanced students as well. In order to generate interest in the subject matter, the author has included many examples and illustrations of environmental health issues. Text boxes provide detailed information on selected topics. Other learning aids are a list of learning objectives at the beginning of each chapter and study questions and exercises at the end.

A summary of the content of each chapter follows. Part I: Background of the Field, includes Chapters 1 through 4. Chapter 1 illustrates the role of environmental health in contemporary society, presents examples from the history of environmental health, and delimits the scope of the environmental health field; in addition, career opportunities are featured. Chapter 2 covers environmental epidemiology, one of the fundamental disciplines used in the study of environmental health. The subject of Chapter 3 is environmental toxicology, which, along with environmental epidemiology, is one of the key disciplines of the environmental health field. Chapter 4 focuses on environmental policy and regulation. Sometimes this content is placed near the end of environmental health textbooks. The author has elected to move it closer to the beginning because an appreciation of policy issues is crucial to the understanding of specific domains of environmental health. In addition, Chapter 4 contains extensive coverage of major environmental regulatory agencies and major U.S. environmental health laws. It is important to cover these topics early in the book because references to agencies and laws are made in the chapters that follow. The reader may want to use this material for reference and consult it later while reading the remaining chapters.

The next group of chapters, Part II: Agents of Environmental Disease, Chapters 5 through 8, covers agents of environmental disease. The respective topics are zoonotic and vector-borne diseases, toxic metals and elements, pesticides and other organic chemicals, and ionizing and nonionizing radiation. Part III: Applications of Environmental Health, Chapters 9 through

14 (Chapter 14 is new to the second edition), deals with applications of environmental health: water quality, air quality, food safety, solid and liquid wastes, occupational health, and injuries.

Other components of the textbook are a glossary of key definitions and a list of abbreviations. For additional information and learning aids that reinforce the didactic content of the textbook, the author recommends that readers access <http://go.jblearning.com/friisEH>. Some instructors enhance the learning experience by conducting field visits to environmentally relevant sites in the community (e.g., the municipal water plant). Other means to support the course are the use of videos and online resources.



Abbreviations

Term	Definition
APHIS	Animal and Plant Health Inspection Service (of USDA)
AQI	air quality index
ATSDR	Agency for Toxic Substances and Disease Registry
BHA	butylated hydroxyl anisole
BHT	butylated hydroxytoluene
BLL	blood lead level
BLS	Bureau of Labor Statistics
BRI	building-related illness
BSE	bovine spongiform encephalopathy
CAA	Clean Air Act
CDC	Centers for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act, 1980
CFR	case fatality rate
CFSAN	Center for Food Safety and Applied Nutrition
CHD	coronary heart disease
Ci	Curie
CNS	central nervous system
CO	carbon monoxide
COHb	carboxyhemoglobin
COPD	chronic obstructive pulmonary disease
Cr(VI)	hexavalent chromium
CTS	carpal tunnel syndrome
CWP	coal workers' pneumoconiosis
dB	decibel

Term	Definition
DBPs	disinfection byproducts (of water)
DDT	dichlorodiphenyltrichloroethane
DES	diethylstilbestrol
DHF/DSS	dengue hemorrhagic fever/dengue shock syndrome
DHHS	Department of Health and Human Services
DNA	deoxyribonucleic acid
EBCLIS	EMF and Breast Cancer on Long Island Study
EDTA	ethylenediaminetetraacetic acid
EEA	European Environment Agency
EIA	environmental impact assessment
ELF	extremely low frequency radiation
EMF	electromagnetic field
EPA	U.S. Environmental Protection Agency
ETS	environmental tobacco smoke
EU	European Union
FAO	Food and Agricultural Organization (of United Nations)
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act, 1996
FoodNet	Foodborne Diseases Active Surveillance Network (of CDC)
FSIS	Food Safety and Inspection Service (of USDA)
FWS	Fish and Wildlife Service
GM	genetically modified
GRAS	generally recognized as safe
HACCP	hazard analysis of critical control points
HAV	hepatitis A virus
HBV	hepatitis B virus
HCV	hepatitis C virus
HIA	health impact assessment
HIV/AIDS	human immunodeficiency virus/acquired immunodeficiency syndrome
HPS	hantavirus pulmonary syndrome
HSEES	Hazardous Substances Emergency Events Surveillance (of ATSDR)
HUS	hemolytic uremic syndrome
IARC	International Agency for Research on Cancer
LD ₅₀	lethal dose 50
MIC	methyl isocyanate
MM	malignant melanoma
MSD	musculoskeletal disorder

Term	Definition
MSG	monosodium glutamate
MSHA	Mine Safety and Health Administration
MSW	municipal solid waste
NAAQS	National Ambient Air Quality Standards
NCHS	National Center for Health Statistics
NEPA	National Environmental Policy Act, 1969
NIEHS	National Institute of Environmental Health Sciences
NIH	National Institutes of Health
NIOSH	National Institute for Occupational Safety and Health
NMSC	non-melanoma skin cancer
NO _x	nitrogen oxides
NORA	National Occupational Research Agenda
NPL	National Priorities List
NRDC	Natural Resources Defense Council
NTOF	National Traumatic Occupational Fatalities Surveillance System
NTP	National Toxicology Program
O ₃	ozone
OAQPS	Office of Air Quality Planning and Standards (of EPA)
OECD	European Organization for Economic Cooperation and Development
OPs	organophosphates
OR	odds ratio
OSCAR	Osteoporosis with Cadmium as a Risk Factor [study]
OSHA	Occupational Safety and Health Administration
PAHs	polycyclic aromatic hydrocarbons
PAYT	pay-as-you-throw
PCBs	polychlorinated biphenyls
PEP	post-exposure prophylaxis
PM	particulate matter
POPs	persistent organic pollutants
ppb	parts per billion
PPCPs	pharmaceutical and personal care products
PPE	personal protective equipment
ppm	parts per million
PSP	paralytic shellfish poison
RCRA	Resource Conservation and Recovery Act, 1976
RDD	radiological dispersal device
RF	radio frequency
RMSF	Rocky Mountain spotted fever

Term	Definition
RR	relative risk
RVF	Rift Valley fever
SARA	Superfund Amendments and Reauthorization Act
SBS	sick building syndrome
SCE	sister chromatid exchange
SDWD	Safe Drinking Water Act
SI	System International
SMR	standardized mortality ratio
SO ₂	sulfur dioxide
SPL	sound pressure level
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCE	trichloroethylene
TFR	total fertility rate
TLV	threshold limit value
TSCA	Toxic Substances Control Act, 1976
UNEP	United Nations Environment Programme
USDA	U.S. Department of Agriculture
USGS	United States Geological Survey
USPHS	U.S. Public Health Service
UVR	ultraviolet radiation
vCJD	Creutzfeldt-Jakob disease, new variant
VHF	viral hemorrhagic fever
VOCs	volatile organic compounds
VSP	Vessel Sanitation Program (operated by CDC)
WHO	World Health Organization
WNV	West Nile virus