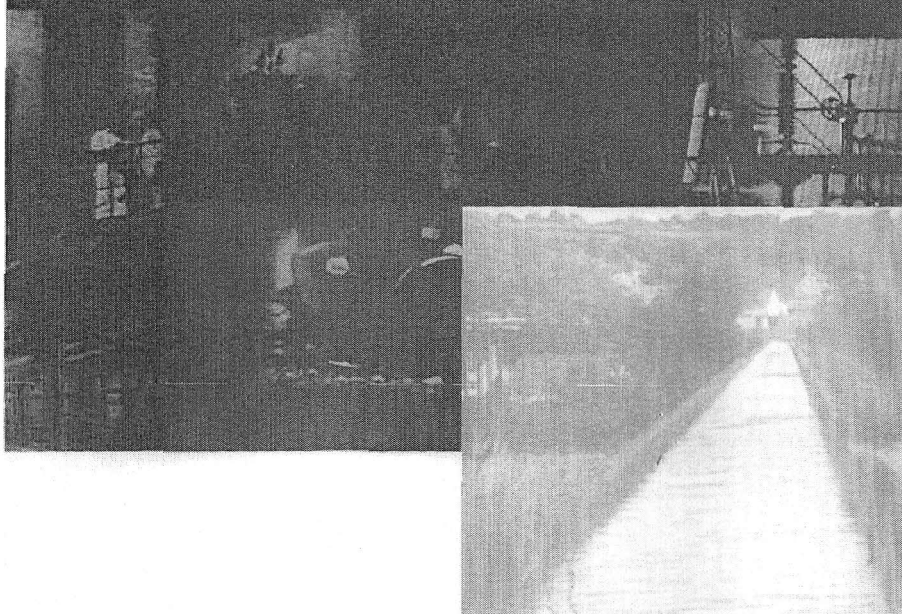


Ruth F. Weiner and Robin Matthews

Updated edition of *Environmental Engineering*, previously co-authored
by J. Jeffrey Peirce and P. Aarne Vesilind.



ENVIRONMENTAL ENGINEERING

Fourth Edition

Environmental Engineering

FOURTH EDITION



ENVIRONMENTAL ENGINEERING

Fourth Edition

Ruth F. Weiner

*Department of Nuclear Engineering and Radiation Sciences
University of Michigan
Ann Arbor, MI*

and

Robin A. Matthews

*Huxley College of Environmental Studies
Western Washington University
Bellingham, WA*

BUTTERWORTH
HEINEMANN

An imprint of Elsevier Science
www.bh.com

Amsterdam Boston London New York Oxford Paris San Diego
San Francisco Singapore Sydney Tokyo

Butterworth-Heinemann is an imprint of Elsevier Science.

Copyright © 2003, Elsevier Science (USA). All rights reserved.

Permissions may be sought directly from Elsevier's Science & Technology Rights Department in Oxford, UK: phone: (+44) 1865 843830, fax: (+44) 1865 853333, e-mail: permissions@elsevier.com.uk. You may also complete your request on-line via the Elsevier Science homepage (<http://elsevier.com>), by selecting "Customer Support" and then "Obtaining Permissions."

∞ Recognizing the importance of preserving what has been written, Elsevier-Science prints its books on acid-free paper whenever possible.

Library of Congress Cataloging-in-Publication Data

A catalogue record for this book is available from the Library of Congress.
International Standard Book Number: 0750672943

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

The publisher offers special discounts on bulk orders of this book.
For information, please contact:

Manager of Special Sales
Elsevier Science
200 Wheeler Road
Burlington, MA 01803
Tel: 781-313-4700
Fax: 781-313-4882

For information on all Butterworth-Heinemann publications available, contact our World Wide Web home page at: <http://www.bh.com>

03 9 8 7 6 5 4 3 2 1

Printed in the United States of America

Contents

<i>Preface</i>	<i>xiii</i>
1 Environmental Engineering	1
Civil Engineering	1
Public Health	4
Ecology	5
Ethics	7
Environmental Engineering as a Profession	10
Organization of This Text	10
2 Assessing Environmental Impact	13
Environmental Impact	13
Use of Risk Analysis in Environmental Assessment	23
Socioeconomic Impact Assessment	24
Conclusion	29
Problems	30
3 Risk Analysis	33
Risk	33
Assessment of Risk	34
Probability	35
Dose-Response Evaluation	38
Population Responses	40
Exposure and Latency	40
Expression of Risk	41
Risk Perception	46
Ecosystem Risk Assessment	47
Conclusion	47
Problems	47
4 Water Pollution	51
Sources of Water Pollution	51
Elements of Aquatic Ecology	54
Biodegradation	57

Aerobic and Anaerobic Decomposition	58
Effect of Pollution on Streams	60
Effect of Pollution on Lakes	70
Effect of Pollution on Groundwater	73
Effect of Pollution on Oceans	75
Heavy Metals and Toxic Substances	76
Conclusion	76
Problems	77
5 Measurement of Water Quality	81
Sampling	81
Dissolved Oxygen	82
Biochemical Oxygen Demand	84
Chemical Oxygen Demand	91
Total Organic Carbon	91
Turbidity	92
Color, Taste, and Odor	92
pH	92
Alkalinity	94
Solids	94
Nitrogen and Phosphorus	97
Pathogens	99
Heavy Metals	102
Other Organic Compounds	103
Conclusion	104
Problems	104
6 Water Supply	107
The Hydrologic Cycle and Water Availability	107
Groundwater Supplies	108
Surface Water Supplies	115
Water Transmission	119
Conclusion	132
Problems	134
7 Water Treatment	135
Coagulation and Flocculation	135
Settling	140
Filtration	141
Disinfection	150
Conclusion	151
Problems	151

8 Collection of Wastewater	153	14 Reuse, Recycling, and Resource Recovery	273
Estimating Wastewater Quantities	153	Recycling	273
System Layout	154	Recovery	274
Sewer Hydraulics	157	Conclusion	292
Conclusion	164	Problems	292
Problems	165		
9 Wastewater Treatment	167	15 Hazardous Waste	295
Wastewater Characteristics	167	Magnitude of the Problem	295
On-site Wastewater Treatment	169	Waste Processing and Handling	298
Central Wastewater Treatment	171	Transportation of Hazardous Wastes	299
Primary Treatment	172	Recovery Alternatives	301
Secondary Treatment	182	Hazardous Waste Management Facilities	303
Tertiary Treatment	195	Conclusion	310
Conclusion	200	Problems	311
Problems	202		
10 Sludge Treatment and Disposal	205	16 Radioactive Waste	313
Sources of Sludge	205	Radiation	313
Characteristics of Sludges	207	Health Effects	321
Sludge Treatment	210	Sources of Radioactive Waste	325
Ultimate Disposal	228	Movement of Radionuclides Through the Environment	333
Conclusion	230	Radioactive Waste Management	334
Problems	231	Transportation of Radioactive Waste	337
		Conclusion	337
		Problems	338
11 Nonpoint Source Water Pollution	233	17 Solid and Hazardous Waste Law	341
Sediment Erosion and the Pollutant Transport Process	235	Nonhazardous Solid Waste	342
Prevention and Mitigation of Nonpoint Source Pollution	241	Hazardous Waste	345
Conclusion	248	Conclusion	350
Problems	248	Problems	350
12 Solid Waste	251	18 Meteorology and Air Pollution	351
Quantities and Characteristics of Municipal Solid Waste	252	Basic Meteorology	351
Collection	254	Horizontal Dispersion of Pollutants	352
Disposal Options	259	Vertical Dispersion of Pollutants	355
Litter	261	Atmospheric Dispersion	361
Conclusion	261	Cleansing the Atmosphere	368
Problems	261	Conclusion	371
		Problems	371
13 Solid Waste Disposal	263	19 Measurement of Air Quality	375
Disposal of Unprocessed Refuse in Sanitary Landfills	263	Measurement of Particulate Matter	375
Volume Reduction Before Disposal	269	Measurement of Gases	377
Conclusion	270	Reference Methods	380
Problems	270		

Grab Samples	381	C Physical Constants	455
Stack Samples	381	D List of Symbols	457
Smoke and Opacity	382	E Bibliography	465
Conclusion	382	<i>Index</i>	471
Problems	382		
20 Air Pollution Control	385		
Source Correction	385		
Collection of Pollutants	385		
Cooling	386		
Treatment	387		
Control of Gaseous Pollutants	399		
Control of Moving Sources	404		
Control of Global Climate Change	407		
Conclusion	407		
Problems	408		
21 Air Pollution Law	411		
Air Quality and Common Law	411		
Statutory Law	413		
Moving Sources	418		
Tropospheric Ozone	419		
Acid Rain	419		
Problems of Implementation	420		
Conclusion	421		
Problems	421		
22 Noise Pollution	423		
The Concept of Sound	423		
Sound Pressure Level, Frequency, and Propagation	426		
Sound Level	430		
Measuring Transient Noise	434		
The Acoustic Environment	436		
Health Effects of Noise	437		
The Dollar Cost of Noise	440		
Noise Control	441		
Conclusion	443		
Problems	444		
Appendices			
A Conversion Factors	447		
B Elements of the Periodic Table	451		