

PHYTOREMEDIATION

Transformation and Control of Contaminants

Edited by

Steven C. McCutcheon

U.S. Environmental Protection Agency
National Exposure Research Laboratory
Athens, Georgia

Jerald L. Schnoor

The University of Iowa
Iowa City, Iowa

 **WILEY-
INTERSCIENCE**

A JOHN WILEY & SONS, INC., PUBLICATION

Contents

Series Preface	xi
Preface	xiii
Contributors	xxi
Editorial Review Board	xxvii
 SECTION I: OVERVIEW OF SCIENCE AND APPLICATIONS	 1
1. Overview of Phytotransformation and Control of Wastes <i>S. C. McCutcheon and J. L. Schnoor</i>	3
2. Uptake and Metabolism of Organic Compounds: Green-Liver Model <i>J. G. Burken</i>	59
3. Making Phytoremediation a Successful Technology <i>N. Marmiroli and S. C. McCutcheon</i>	85
 SECTION II: FUNDAMENTALS OF PHYTOTRANSFORMATION AND CONTROL OF CONTAMINANTS	 121
4. Some Fundamental Advances for Xenobiotic Chemicals <i>J.-P. Schwitzguébel and T. Vanek</i>	123
5. Enzymes Used by Plants and Microorganisms to Detoxify Organic Compounds <i>N. L. Wolfe and C. F. Hoehamer</i>	159
6. Plant Tolerances to Contaminants <i>V. F. Medina, E. Maestri, M. Marmiroli, A. C. Dietz, and S. C. McCutcheon</i>	189
7. Root Development and Rooting at Depths <i>M. C. Negri, E. G. Gatliff, J. J. Quinn, and R. R. Hinchman</i>	233

8. Measuring and Modeling Tree and Stand Level Transpiration <i>J. M. Vose, G. J. Harvey, K. J. Elliott, and B. D. Clinton</i>	263
SECTION III: SCIENCE AND PRACTICE FOR AROMATIC, PHENOLIC, AND HYDROCARBON CONTAMINANTS	283
9. Transformation of Organic Contaminants by Different Plant Systems <i>H. Harms, M. Bokern, M. Kolb, and C. Bock</i>	285
10. Ecology of Rhizosphere Bioremediation <i>P. E. Olson, K. F. Reardon, and E. A. H. Pilon-Smits</i>	317
11. Biodegradation of Petroleum Hydrocarbons in the Rhizosphere <i>S. L. Hutchinson, A. P. Schwab, and M. K. Banks</i>	355
SECTION IV: TRANSFORMATION AND CONTROL OF EXPLOSIVES	387
12. Role of Plants in the Transformation of Explosives <i>M. Subramanian and J. V. Shanks</i>	389
13. Transformation Kinetics of Trinitrotoluene Conversion in Aquatic Plants <i>M. E. Jacobson, S. Y. Chiang, L. Gueriguian, L. R. Westholm, J. Pierson, G. Zhu, and F. M. Saunders</i>	409
14. Proof of Phytoremediation for Explosives in Water and Soil <i>S. C. McCutcheon, V. F. Medina, and S. L. Larson</i>	429
15. Phytorestoration at the Iowa Army Ammunition Plant <i>P. L. Thompson, D. D. Moses, and K. M. Howe</i>	481
SECTION V: FATE AND CONTROL OF CHLORINATED SOLVENTS AND OTHER HALOGENATED COMPOUNDS	497
16. Sequestration and Transformation of Water Soluble Halogenated Organic Compounds Using Aquatic Plants, Algae, and Microbial Mats <i>V. A. Nzengung, W. L. O'Niell, S. C. McCutcheon, and N. L. Wolfe</i>	499

17. Fate of Trichloroethylene in Terrestrial Plants <i>T. Q. Shang, L. A. Newman, and M. P. Gordon</i>	529
18. Uptake, Metabolism, and Phytovolatilization of Trichloroethylene by Indigenous Vegetation: Impact of Precipitation <i>W. J. Doucette, B. G. Bugbee, S. C. Smith, C. J. Pajak, and J. S. Ginn</i>	561
19. Multiple-Process Assessment for a Chlorinated-Solvent Plume <i>S. M. Eberts, G. J. Harvey, S. A. Jones, and S. W. Beckman</i>	589
20. Five-Year Pilot Study: Aberdeen Proving Ground, Maryland <i>S. R. Hirsh, H. R. Compton, D. H. Matey, J. G. Wrobel, and W. H. Schneider</i>	635
 SECTION VI: MODELING, DESIGN, AND FIELD PILOT TESTING	 661
21. Modeling and Design of Phytoremediation <i>L. C. Davis, L. E. Erickson, M. Narayanan, and Q. Zhang</i>	663
22. Hydrologic Feasibility Assessment and Design in Phytoremediation <i>J. W. Weaver, S. C. McCutcheon, and S. L. Hutchinson</i>	695
23. Waste Management Using Trees: Wastewater, Leachate, and Groundwater Irrigation <i>J. L. Jordahl, M. F. Madison, J. K. Smesrud, H. M. Emond, and M. Q. Motte</i>	717
24. Salt Tolerant Plants to Concentrate Saline Waste Streams <i>M. C. Negri, R. R. Hinchman, and T. L. Settle</i>	753
 SECTION VII: LATEST ADVANCES	 763
25. Metabolism and Genetics of Atmospheric Nitrogen Dioxide Control Using Pollutant-Philic Plants <i>H. Morikawa, M. Takahashi, and Y. Kawamura</i>	765
26. Treatment of Atmospheric Halogenated Hydrocarbons by Plants and Fungi <i>P. M. Jeffers and C. D. Liddy</i>	787
27. Phytoremediation of Methyl Tertiary-Butyl Ether <i>S. K. Winnike-McMillan, Q. Zhang, L. C. Davis, L. E. Erickson, and J. L. Schnoor</i>	805
28. Phytoremediation of Cyanide-Polluted Soils <i>S. A. J. Trapp and H. Christiansen</i>	829

29. Phytoremediation of Perchlorate	863
<i>V. A. Nzungung and S. C. McCutcheon</i>	
30. Databases and Protocol for Plant and Microorganism Selection: Hydrocarbons and Metals	887
<i>T. C. McIntyre</i>	
31. Field Evaluations of Phytotechnologies	905
<i>S. A. Rock</i>	
 Index of Names of Plants	 925
Index	939