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PREFACE

Bioremediation: Applied Microbial Solutions for Real-World Environmental Cleanup, as the title implies, describes the environmental applications of microorganisms to remediate contaminated soils and waters. Written for both academics and practitioners, the book provides detailed knowledge of bioremediation research and real-world applicability of that knowledge. The book makes much use of “how to” information, covering how to bioremediate from site assessment to project closure. It provides a truly international perspective, balancing American (United States) and European (largely United Kingdom) coverage and showing the challenges facing bioremediation under differing regulatory frameworks and against differing histories of environmental awareness and public demands for remediation. It provides contemporary examples of the application of bioremediation and establishes the needs for future research and development efforts.

Bioremediation, as defined by the U.S. Office of Management and Budget, involves techniques using biological processes to treat contaminated soil or groundwater. It is a field that combines basic microbiology, advanced biotechnology, and environmental engineering and does so within the context of public demands for clean waters and soils, evolving risk-based regulatory frameworks that govern performance criteria, and public concerns about microorganisms—especially the deliberate release of genetically modified microorganisms into the environment. Thus, bioremediation still is a developing field, one that will be driven by scientific and technological developments, as well as public policy developments.

Although still considered an innovative technique by the U.S. Environmental Protection Agency, bioremediation is increasingly being used to treat contaminated soils and waters. As it is an innovative technology, there is great interest in research and development as well as actual applications. This volume describes both the bioremediation technologies being applied and those being developed. Thus, it is relevant to industrial engineers and managers who must

apply technologies today to remove pollutants from contaminated soils and waters and to academic researchers whose efforts will develop future bioremediation technologies that can be applied for cost-effective cleanup efforts.

Bioremediation begins by defining the role of bioremediation in solving environmental contamination problems—providing an overview of the scientific underpinnings of bioremediation, as well as the practical considerations for applying bioremediation to the real-world problem of environmental contamination. Here, the biodegradative capacities of microorganisms upon which the success of bioremediation rests are highlighted.

The next chapters cover the more practical challenges of bioremediation, from risk-based design criteria, to the legal/regulatory frameworks that are the drivers of environmental remediation, to the engineering approaches for modeling bioremediation projects. The breadth of scientific and engineering principles presented reflects the complexities of applying biotechnological solutions for environmental problems. Risk assessment and risk reduction are critical considerations in establishing the need for remediation and the applicability of bioremediation. Awareness of the interactions between the legal, scientific, and engineering communities is essential for the successful use of bioremediation. We draw attention to the differences in regulatory frameworks between the United States and the United Kingdom since the regulatory requirements serve as drivers for the technological needs of remediation projects.

A knowledge of the basic principles of the legal requirements is essential for understanding how and when bioremediation can be applied for the restoration of contaminated soils and waters. When contaminated sites undergo remediation, there is a clear requirement to protect the environment while ensuring that risks to human health and the environment are minimized. Modeling provides a way of assessing the critical parameters that impact bioremediation and predicting the likelihood of successfully meeting established performance criteria. Effective design of a bioremediation project necessitates the integration of interdisciplinary knowledge developed by microbiologists, geochemists, hydrogeologists, mathematicians, and engineers.

Once the real-world needs and scientific, legal, and engineering challenges for bioremediation have been established, the actual applications of bioremediation are explored. Through extensive use of practical examples where bioremediation has been applied, a balanced international perspective on the applicability of bioremediation is provided. The varied approaches to bioremediation are described: *in situ* or *ex situ* methods and ones which may involve biostimulation, i.e., stimulating microbial activities by optimizing environmental conditions, e.g., by adding nutrients or oxygen to increase the rates of biodegradation; bioaugmentation, i.e., adding microorganisms to increase the diversity of microorganisms capable of biodegrading the contaminants; or natural monitored attenuation, i.e., monitoring the natural biodegradative activities to see that removal of the contaminants occurs at rates needed to meet targets set to reduce risk to human health and the environment. Perspectives for each approach are included, highlighting achievements and discussing limitations that establish the needs for future research and development efforts. The book covers the range of environmental contamination problems for which bioremediation can be and has been applied—from organic contamination of soil and groundwater

with a myriad of compounds ranging from chlorinated solvents to plastics, to marine oil spills, to soils contaminated with metals and radionuclides.

A wide range of examples of successful employment of bioremediation are presented. The importance of monitoring is established, and a number of methods for monitoring the chemical disappearance of contaminants and the activities of microorganisms in bioremediation are described. The monitoring tools needed to manage and to design more effective bioremediation technologies are explained. Finally, the applications of biotechnology for clean environmental products and processes, effectively defining the field of preemptive bioremediation, are depicted. In this context, biotechnology holds great promise for future environmental applications. As highlighted throughout this book, to be successful, bioremediation must be economically and technically competitive with other physical and chemical remediation technologies. Establishing competitive costs for environmental managers, efficacy for regulators, and predictability for engineers will be key in the ability of bioremediation to become more significant in the highly competitive remediation industry. Bioremediation is still very much an evolving technology; there is a need for more research and development to identify and overcome the limitations and a real need to establish a critical dialogue among scientists, engineers, and environmental managers to ensure that discoveries in the laboratory can be successfully applied in the field. As the real-world applications of bioremediation continue to expand, so will the examples of specific successful approaches and the value of our work.

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