Preface to the First Edition
Why Bio?

Bioremediation, or enhanced microbiological treatment, of environments contaminated with a variety of organic and inorganic compounds is one of the most effective innovative technologies to come along in this century. Actually, it is simply a new application of a very old technology once primarily used in wastewater treatment. Today, bioremediation is routinely applied to soils, sludges, groundwater, process water, and surface waters contaminated with such chemicals as crude oil, petroleum hydrocarbons, fuels, industrial solvents, and wood-treating agents.

Authors John Naisbitt and Patricia Aburdene, in their visionary best-seller *MEGATRENDS 2000*, predicted that increased applications in biotechnology would be one of the nation's major new directions during the 1990s, in effect dubbing the decade "The Age of Biology".[1] The Hazardous Materials Control Research Institute (HMCRI), reporting in March 1990 on an assessment of the environmental management market, titled their article "Hazardous Waste Bioremediation Targeted as Fastest Growing Market in Environmental Management".[2] The HMCRI hosts an annual international meeting addressing bioremediation in Washington, D.C. Professor Dave Gibson, speaking at the first annual HMCRI bioremediation conference in 1988, said that it was his opinion that, by the end of the century, the majority of hydrocarbon-contaminated sites would be remediated by employing some form of biological treatment.[3]

Bioremediation has been successfully applied to enhance natural degradation of petroleum hydrocarbon and organic chemicals at sites throughout the world. Gasoline and diesel contamination is especially responsive to this technology, both in soils and groundwater. Even heavy fuels and crude oil have been degraded in a timely fashion through the use of microorganisms.

The bioremediation activities on the oily beaches of Prince William Sound caused by the Exxon Valdez spill in 1989[4] were widely publicized. Similar technology was applied to crude oil spills along the Texas Gulf Coast during 1990.[5,6] In a meeting called by the U.S. Environmental Protection Agency (EPA) (February 22, 1990) to discuss environmental applications of biotechnology, Administrator William Reilly reiterated his support for the development and application of alternative technologies and, specifically, bioremediation. He added that the application of biological treatment might be the breakthrough that is needed to offset the staggering costs of compliance with Superfund.[7]

The Superfund Amendments and Reauthorization Act of 1986 (SARA) emphasizes treatment over containment to remediate Superfund sites. In addition to ensuring protection of human health and environment, two "threshold criteria" for selecting remedies under proposed revisions to the National Contingency Plan are that they provide long-term effectiveness and achieve the greatest reduction in toxicity, mobility, and volume. This amounts to a remedy that provides treatment to the maximum extent practicable.[8] When complete destruction of wastes can be achieved, both of these criteria are met by employment of bioremediation. In addition, the costs of remediation through biological treatment are attractive when compared with other technologies.

In the past, contaminated soils and sludges were either burned, buried, or chemically treated in place. These remedial alternatives are often costly and regulatory compliance is difficult. Incineration is both costly and increasingly harder to implement. Landfill and *in situ* fixation do not destroy waste, and landfilling only changes the place of residence, delaying future liability. Buried liability often does not remain hidden, and solidified waste may simply leach out at a slower rate. Innovative bioremediation technologies may offer complete destruction of contaminants and can often be applied at a lower total cost, at a faster rate, and with no lingering liability.

Biological treatment technologies are finding widespread public support as an "organic" approach to site reclamation. Public hearings concerning proposed use of biotechnology for site remediations have not met with the criticism and outcry that other alternatives have had to face.[7] Bioremediation uses *natural* biological processes to clean up the chemical contamination caused by man's activities. The fact is, whenever organic chemicals and other hydrocarbons are spilled or otherwise introduced into the environment, naturally-occurring microbes immediately begin to acclimate themselves and biodegrade this new food source. The reasoning suggests, "If it happens anyway, why not help it along the best we can?"

The EPA believes so strongly in the future usefulness of bioremediation and other innovative technologies for treating contaminated soils and groundwater that it created a special Technology Innovation Office in August 1990 to encourage and focus on these new technologies.[9]

There has been a long-standing need for a definitive book on bioremediation of contaminated environments. To date (1991), no comprehensive handbook has appeared solely addressing the fundamentals of field application of bioremediation. Contributing to this lack of sufficient texts on this subject may be the highly fragmented nature of the industry, corporate indecision to fully fund and support such a new technology, the hesitation of regulators to issue permits for techniques they don't thoroughly understand, and the natural reluctance of bioremediation contractors to publish data on techniques they believe are proprietary. The reality is that there are no secrets or unique concepts for successful application. There is simply a well-defined set of prerequisites that must be understood, intelligently addressed, and carefully applied to obtain a successfully completed project.

This *PRACTICAL ENVIRONMENTAL BIOREMEDIATION* is written with the benefit of the authors' combined 55 years of environmental management and restoration experience. The authors have worked together for several years actively applying bioremediation technology in the field. Specific and general experience gained from actual field projects where the authors and others have successfully applied this technology are presented in the text.

Dozens of projects have been completed and closures obtained in many geographic settings in the United States, attesting to the expanding role of bioremediation as a viable and cost-effective remedial alternative. It is a fitting tribute indeed to the effectiveness and economics of this blooming technology that research efforts are being funded by industry, government, foundations, and major universities around the world to explore wider applications for bioremediation as a means of environmental restoration.

We believe this book will be of practical value to students, consultants, design engineers, managers, regulators, scientists, and others involved in the environmental sciences and restoration activities. This book focuses on technology that is available today. Incorporated into the text are practical examples familiar to the authors. The concepts presented have been tested and demonstrated successfully in dozens of applications for a variety of clients and have become the basis for seminars, workshops, short courses, and university lectures given by the authors. These concepts and remediation techniques can be immediately and effectively applied if the principles described herein are thoroughly understood and a well organized project plan is constructed, appropriately conducted, and the process is carefully monitored.

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