Journal of Industrial Microbiology & Biotechnology (1997) 18, 73–74

Introduction

Use of microbial processes for remediation of sites contaminated with biodegradable chemicals is central to the field of industrial microbiology. When Editor-in-Chief Joe Cooney approached us about our interest in serving as guest editors for a special issue of the *Journal of Industrial Microbiology & Biotechnology* on bioremediation science and technology, we accepted the challenge because we knew that Society for Industrial Microbiology (SIM) members are doing excellent work in this important area and that the field is seriously underrepresented in SIM ranks. This is somewhat surprising since bioremediation research and process development have a history that can be traced to long-time SIM member Richard L Raymond and his colleagues. These authors developed and successfully commercialized a widely used process for *in situ* bioremediation of gasoline in aquifers through the delivery of nutrients and oxygen [1].

State-of-the-art bioremediation research is truly interdisciplinary and draws on, in addition to microbiology, fields such as geology, hydrogeology, many areas of chemistry and biochemistry, civil and chemical engineering, and to a large extent hydrology and mathematical modeling. Frequently, microbiology and, more specifically, microbial ecology play minor roles in the development and application of bioremediation technologies. For instance, *in situ* bioremediation of petroleum products is a commercial, reasonably low cost, and reliable process that can be designed and implemented by engineers with minimal input from microbiologists. Such technology is often mass transfer-limited, and delivery systems for nutrients and electron acceptors are the focus of process design.

To date, bioremediation research has, as might be expected, addressed the easiest problems first. Investigators are now working on problems that yield to the scientific method slowly and only after a great deal of effort. Bioavailability appears to be more controlled by the physical chemistry of the system. Much of the research on increasing bioavailability of contaminants has focused on effects of surfactants. Hughes and colleagues have addressed this problem using PAH-contaminated sediments. Harmus and Bosma have approached the same general problem using principles of mass transfer and hydrodynamics. Faison and Knapp also approach the problems of bioavailability and accessibility of contaminants through technologies for nutrient delivery and mixing. Also in this series of papers, Venosa *et al* describe the use of hopane as a conservative biomarker for monitoring the bioremediation of oil spills.

Aerobic bioremediation of petroleum hydrocarbons is often oxygen-limited and rates are zero order in most cases, and the challenge has been to design efficient oxygen delivery systems. Fiorenza and Ward describe the adaptation of subsurface microbes to high concentrations of hydrogen peroxide to support aerobic biorestoration and to overcome mass transfer limitations associated with the low solubility of oxygen in water.

Because of the high cost and toxicity of hydrogen peroxide as a source of oxygen, nitrate has been proposed as an alternative electron acceptor to support microbial degradation of gasoline components. Low rates of benzene degradation under denitrifying conditions led Wilson and Bouwer to study biodegradation of aromatic compounds under mixed oxygen-denitrifying conditions. Thomas *et al* report a laboratory-field study to assess the potential for nitrate-enhanced bioremediation of a JP-4 fuel in a contaminated aquifer, and Hutchins used a microcosm study to help design a field demonstration of toluene biodegradation under denitrifying conditions.

Because aerobic biodegradation is better understood than anaerobic processes, the former has been the focus of most bioremediation research and process development. This is changing rapidly as greater attention is given to the need for clean-up of compounds more recalcitrant to biodegradation. Munitions such as 2,4,6-trinitrotoluene (TNT) and related compounds are rapidly biotransformed to the amino forms under both aerobic and anaerobic conditions. However, further biotransformations have been found to occur in pure and mixed anaerobic cultures (Ederer *et al*, Lewis *et al* and Hughes *et al*) and under different electron-accepting conditions (Krumholz *et al*), but complete mineralization of TNT has been difficult to demonstrate. These studies clearly illustrate the importance of anaerobic, sulfate-reducing, and methanogenic conditions on the transport and fate of TNT in environmental media and appear to enhance the potential for development of bioremediation processes for munitions.

The chlorinated solvents such as trichloroethylene (TCE) and related chlorinated alkanes are difficult to biodegrade under aerobic conditions and are widely distributed and persistent in aquifers. Aerobic cometabolism of TCE by methanotrophs has been demonstrated to respond to nutrient amendments (Pfiffner *et al*) and the methanotrophic process is still under active investigation; however, anaerobic reductive dechlorination of solvents promoted through addition of organic substrates is the current focal point of solvent bioremediation research (Lee *et al*).

It is important to recognize that the same physical, chemical, and biological phenomena that control the transport and fate of chemicals in the environment also provide the underpinnings for the development of ‘engineered’ bioremediation technology. Now it appears that bioremediation research has come full circle, and we are returning to transport and fate studies as a front line approach for environmental risk management. A current thrust in bioremediation research is now variously described as natural bioattenuation and intrinsic bioremediation. Until recently these approaches to environmental restoration were considered to be ‘do nothing’ tactics and were generally frowned upon by responsible regulators. However, both the quality and quantity of the database available to support quantitative predictions of the rate and distance that contaminants will move from sources have increased dramatically. Hence, natural bioattenuation is now considered a credible alternative approach for management of risks related to petroleum hydrocarbon releases. The paper by Lovely contributes to the natural attenuation database for aromatic hydrocarbons. The case study reported by Williams *et al* adds to the rapidly growing, but smaller, database on intrinsic bioremediation of chlorinated solvents.

The papers in this Special Issue on Bioremediation all contribute to our knowledge of the principles and practice of bioremediation science and technology, and we trust that readers of this volume will learn from the work presented and will be encouraged to submit the results of their research for consideration for publication in the *Journal of Industrial Microbiology & Biotechnology*.

Special Editors

FK Pfaender
University of North Carolina
Chapel Hill, NC 27599-7410, USA

JM Suflita
The University of Oklahoma
Norman, OK 73019-0245, USA

CH Ward
Rice University
Houston, TX 77005-1892, USA

References

1 Jamison VW, RL Raymond and JO Hudson Jr. 1975. Biodegradation of high-octane gasoline in groundwater. Dev Ind Microbiol 16: 305–311.