Chapter 85
Bioremediation of Oil Contaminated Soil and Water:
In Situ and Ex Situ Strategies for Feasibility Assessment

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ABSTRACT

Pollution from petroleum, plant and animal origin oils, which are released via oil production and shipping operations, refineries, accidental spills, effluents of different industries such as hotels, restaurants, food processing, etc. is ubiquitous in the environment. This necessitates the need for cost effective and efficient remediation technologies. Dealing with the problem chemically and physically is known to generate secondary pollutants and incurs high cost. Expediting natural attenuation via stimulating pollutant degradation activity of residential microbial community and/or introducing competent microflora in to polluted sites has been identified as the most successful and cost effective technology and is termed bioremediation. Phytoremediation, an emerging branch of bioremediation, has also been recognized as a promising treatment technology. Chapter examines the extent of work carried out in in situ and ex situ bioremediation strategies to mitigate oil pollution, the validity of such practices in terms of efficiency of the process and the future research directives.

INTRODUCTION

Generally, microorganisms brake down natural compounds more contentedly in their inhabitant environment and as per nature's rule all natural compounds do decay sooner or later. In such a context bioremediation is the naturally available technique for getting rid of contaminants. When the rate of contamination exceeds the rate of natural degradation, pollution becomes evident making it a requisite

DOI: 10.4018/978-1-5225-8903-7.ch085

to take measures to advance the natural process. This man's intervention over natural decay to increase the rate of microbial degradation is termed bioremediation. It uses microorganisms or plants to completely break down, sequester, reduce toxicity or detoxify substances hazardous to humans and/or the environment (Vidali, 2001). Microbes utilize the target contaminants as a source of energy by taking it through a series of oxidation-reduction reactions in order to make useable energy forms for metabolism. As a result, byproducts of metabolized contaminants are released back into the environment, which are usually in a non-or less toxic form than the original compound. Currently, not only microorganisms but the products of microbial origin such as surfactants and enzymes are also in use, bioremediation should be broadly defined in order to encompass organisms, their products and genes as well.

In the context of bioremediation of oil contaminated environments, new techniques are introduced and existing techniques are improved while providing greater contribution to the pool of knowledge and experiences. Different techniques of bioremediation have been used at a number of sites under diverse environmental conditions, with varying degrees of success. Oil contaminated environments can be treated either at the site of pollution itself (*in situ*) or taking them away from the site (*ex situ*). However, irrespective of the fact that whether the remediation technique is applied *in situ* or *ex situ,* bioremediation approaches for oil contaminated environments fall into three major categories viz. biostimulation, bioaugmentation and introduction of genetically modified microorganisms. Like any other technology, bioremediation also has its limitations; some contaminants may resist microbial degradation completely or degraded either slowly or not at all. Furthermore, being a microbe driven process bioremediation is highly dependent on site environmental conditions which permit efficient microbial growth and activity. Therefore, application of bioremediation often involves the manipulation of environmental parameters in such a way that they allow microbial growth and degradation to proceed at an adequately faster rate.

Therefore, in this chapter it is intended to essentially discuss: (i) Production, usage and pollution caused by petroleum and plant/animal origin oil; (ii) Bioremediation strategies available for petroleum oil contaminated environments; (iii) Factors affecting the bioremediation process; (iv) Limitations/drawbacks of the available technologies; (v) Monitoring of bioremediation applications (vi) Bioremediation of plant/animal oil contaminated environments (vii) Phytoremediation and finally (viii) Recommendations for future research directions and conclusion.

Oils and Fats: Production, Usage and Pollution

In a broad definition, oil refers to any greasy substance that is liquid at room temperature and insoluble in water. Oil can be categorized into two forms based on their origin viz. petroleum origin oil and plant or animal origin fats and oils. Petroleum origin oil generally refers to crude oil formed in deep earth rock strata due to the intense pressure and heat exerted on buried animals and plants over a long time period. Plant oil generally refers to vegetable and/or cooking oil that has been extracted from plants. Animal fats and oils are obtained from rendered tissues of livestock animals. In addition, dairy product industry produces large amounts of fat and oil polluted waters. Fat refers to any substance of plant or animal origin that is non-volatile, insoluble in water and usually solids at room temperatures. Fats and oils differ from each other only from their physical state at room temperature. Chemically, fats and oil are fundamentally the same primarily consisting of triglycerides. Plant origin oils predominantly contain fatty acid esters of the trihydroxy alcohol or glycerol (Kumar et al., 2012).

Despite the source/origin, oils are released into the environment via oil production and shipping operations, from refineries (Vasudevan & Rajaram, 2001), accidental spills (Cipnyte, Grigiškis, & Baškys,