Bioremediation of Petroleum-Contaminated Soils and Wetlands by Indigenous Microorganisms and Bioaugmentation

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ABSTRACT

The bioremediation of oil contaminated soils and wetlands, including fresh and salt-water estuaries by microflora is an expanding field that has increasingly come to the attention of the world via a series of high-profile oil spills: Spills in Alaska, Japan, the Gulf of Yemen and France have brought worldwide attention to how the spills are dealt with from an ecological standpoint. However, bioremediation of contaminated soils and wetlands do not solely come from massive oil spills: contamination from oil refineries, from industry, and simply from passive ships and boats all contribute to oil contamination, and actually make up a larger percentage of polluted ground in the world versus those contaminated by catastrophic spills. As crude oils, diesel fuels, lubricating oils, and manufacturing oil all are added to the landscape, there are increasingly ways to deal with such pollution via microbes and microflora. The microbial world, both through bioaugmentation(introduction of non-native strains) and indigenous microorganisms already present in the polluted landscape, can oxidize, breakdown, and assimilate heavy fractions of oil polluted soils (Shkidchenko and Arinbasarov, 2002). The main oxidative power of the microbes comes from breaking down the hydrocarbon chains present in *n*-alkanes in crude and refined oils (Williams et al., 1998). Other methods, such as anaerobic oxidation and the breakdown of oil-contaminated through respiration of microorganisms with sulfides as their by-products are more efficient and inherently cheaper than mechanical means of cleaning up a polluted landscape. The measurement of bioremediation is the proof behind the theory: Soil lipase activity, measurement by polymerase chain reaction (PCR), and molecular detection via gene-sequencing are all viable ways to prove that the microorganisms are degrading the petroleum products. Respiration rates and microbial growth counts are also indirect ways to measure progress of bioremediation. The role of biosurfactants and bioemulsifiers is also discussed, as their roles are central to microorganisms being able to degrade the petroleum products. Thus, bioremediation is more than simply populating a spill with microorganisms. Stated simply, the optimization of bioremediation involves selecting the most suitable biosurfactant, the best oil degrading microorganisms, the best bioemulsifiers, and the most effective combinations of these to provide the most degradation of oil and its petroleum by-products as possible.

KEYWORDS

Bioremediation, bioaugmentation, hydrocarbons, *n*-alkanes; anaerobic oxidation; biosurfactant; bioemulsifier; crude oil, soil lipase activity, polymerase chain reaction (PCR), diesel fuel

INTRODUCTION

Crude oils and petroleum based products are complex mixtures containing hundreds of individual compounds, the composition of which varies across the board. Among these oils and their refined products, the chemical, physical, and toxicological makeup varies as well. Petroleum bioremediation is carried out by microorganisms capable of utilizing hydrocarbons as a source of energy and carbon (Ron et al., 2002). A great deal of literature has been published on how this type of bioremediation occurs, how it's measured, as well as the time frames of the effectiveness of the microorganisms. Thus, to have an understanding of how bioremediation occurs, how it's measured, and its products, one must first understand the general makeup of petroleum spills, how microbes attach themselves to the petroleum, and finally, what the microbes do and how they degrade and remediate polluted landscapes. In a general sense, the microbes, either indigenous or bioaugmented into the soil or wetland, first recognize the oil and its makeup by biosurfactants and bioemulsifiers, attach themselves, use the hydrocarbons within the petroleum as an energy and carbon source, degrade them, and then move on. Selected aspects of how