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## Comparison of Biological and Thermal Remediation Methods in Decontamination of Oil Polluted Soils

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Petroleum products can be released into the soil environment via spill, leakage, transport, or other incidents which adversely affect agricultural, residential or recreational land use [1]. Since oil pollution is a great environmental threat as it can pollute neighboring soil, surface and ground water, it may damage ecosystems and negatively affect health of plants, animals and human being [2,3]. Therefore, it's a very important issue to control oil pollution in various environments and to remediate oil polluted sites as well.

Soil remediation methods can be divided into three parts; biological, physical and chemical which can be done *ex situ* or *in situ* depending on the type of method. During last decades, biological methods (e.g. bioremediation and phytoremediation) have been noticed in several researches [3,4]. The main reason of using these methods refers to their various advantages. Bioremediation is using microorganism to reduce or break down hazardous organic material to harmless compounds, such as CO<sub>2</sub> and water. Plants and their interactions with microorganisms (e.g. bacteria, fungi etc) can also help degradation or dissipation of organic pollutants in contaminated environments [3]. Usually, the biological methods are environmental friendly and retain the quality of environments (soil or water) during the remediation process. Besides, these methods are cheaper than physical and chemical techniques used for remediation. Despite the interest in bioremediation, uncertainties remain concerning the effectiveness for specific compounds and environment. The toxicity of pollutants for microorganisms and plants used in biological methods can reduce remediation efficiency. Furthermore, microorganisms and plants need a long period of time to degrade organic pollutants in the environment [3,4] Although several approaches (e.g. plant-microorganisms symbiosis, genetically modified microorganisms etc.) have been proposed to enhance the efficiency of the biological methods, however, they may be replaced by other methods which remove or degrade the pollutants very fast in a various range of pollutant concentrations.

There are a lot of studies which report remediation of petroleum polluted soil by the use of thermal decontamination, vapor extraction, surfactants or solvent flushing, chemical oxidation, steam stripping as well as biological treatment [3]. Thermal methods showed great efficiency of 99%, in decontamination of organic polluted soils. Microwave heating technique as a thermal method has advantages of greater time and energy saving, selective and uniform heating compared to conventional thermal methods, which makes it attractive for industrial implementation [5]. This method can also remediate various contaminations of soil, wastewater and sludge [6]. Results have shown that remediation of soil contaminated with petroleum hydrocarbons by the use of microwave method is cost effective and time efficient also the soil can be remediated by microwave without excavation. It is simple and can be easily developed and used in various sites having different types of soils [7]. It should be considered that the thermal treatment methods (e.g. microwave) have some disadvantages. In large scale some disadvantages may be highlighted such as cost and some intermediates which may be produced during the thermal process. This method may also influence soil quality parameters such as microorganisms' activity in soil.

In the practical point of view, the selection of a suitable method for remediation of oil contaminated soils depends on several parameters including, type and concentration of contaminants, which may affect the remediation efficiency, as well as the area of polluted sites, time and cost. Furthermore, the environmental side effects of each method as an important factor should be considered.

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