

Bioremediation of petroleum sludge

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Introduction

Bioremediation, or the use of micro-organisms to decontaminate soil or groundwater, is being increasingly seen as an effective, environment- friendly treatment for oil-contaminated sites. Many reports indicated that, large quantities of organic and inorganic compounds are released into the environments every year as results of human activities causing serious environmental problems. Among those problems are oil contamination of soil and water from industrial sources and other activity, which create a great environmental hazard.¹ Petroleum hydrocarbon continues to be used as principle source of energy and hence a large global environmental pollutant. Petroleum is a complex mixture of non-aqueous and hydrophobic components. Many of these components are toxic, mutagenic and carcinogenic.² Therefore, the release to the environment is strictly controlled and they classified as priority environmental pollutant by US Environmental Protection Agency, due to their adverse impact on human health and environment.³ Various physiochemical treatments techniques have been developed to clean up contaminated soil such as incineration, thermal desorption, chemical oxidation, immobilization and solvent extraction.⁴ In general such treatments are more expensive, energy intensive and not sustainable with respect to their environmental impact which includes damage to the soil structure and toxicity issue associated with chemical additives.⁵ Many of these techniques simply dilute or sequester the contaminants and do not eliminate the problem.⁶ In general such treatments are more expensive, energy intensive and not sustainable with respect to their environmental impact which includes damage to the soil structure and toxicity issue associated with chemical additives.

Traditionally, petroleum hydrocarbon contaminated soils have been dealt with by excavation and disposal to landfill. However, as landfills have become scarcer and more cost prohibitive, this method has become less feasible.⁷ These limitations have been the basis of search for more economical and environmentally sound approaches to remediate contaminated soil. Biological treatment of organic pollutants is a promising field of research, which gives reliable, simple and cheap technologies over chemical and physical process.⁸ Bioremediation has become a major method employed in the restoration of oil polluted environments, and attempts to accelerate the natural hydrocarbon degradation rates by overcoming factors that limit bacterial hydrocarbon degradation activities.^{8,9} Microorganisms, namely heterotrophic bacteria and fungi have evolved a tremendous ability to metabolize simple and complex hydrocarbon contaminants.¹⁰ By harnessing their metabolic ability, it is possible to remediate contaminated environments, a technique referred to as bioremediation.¹¹

During the last 20 years, many bacteria capable of environmentally beneficial degradation properties have been isolated and investigated, but it should be noted that is no single strain of bacteria with the metabolic capacity to degrade all the components found within oil sludge. In nature, biodegradation of crude oil typically involves a succession of species within the consortia of microbes present. Degradation of petroleum involves progressive or sequential

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reactions, in which certain organisms may carry out the initial attack on petroleum constituents. This produce intermediate compounds that are subsequently utilized by a different group of organisms, in the process that results in further degradation.¹² The indigenous populating of microorganism, which are ubiquitous in soil and ground water and self adapted to hard conditions, actually grow by using the carbon from the pollutants as energy source and cells building blocks. This breaks down contaminants into carbon dioxides and water as end products.¹³ Collectively, microorganisms have a great metabolic diversity which allows their ubiquity. Because of their ubiquitous nature, the biotechnological potential of microorganisms is virtually endless with many possible applications. One of these applications is the utilization of enzymes generated by microorganisms in petroleum bioremediation approaches.¹⁴ According to US EPA,¹⁵ bioremediation agents include enzyme additives that are deliberately introduced into an oil discharge and that will significantly increase the rate of biodegradation to mitigate the effects of the discharge. Despite decades of research, successful bio-treatment of petroleum hydrocarbon remains a challenge and several factors must be fulfilled and optimized to determine the outcome of the biodegradation process such as: biomass concentration, population diversity, bacterial growth, metabolic pathways, nature and concentration of pollutants, chemical structure of organic compounds, toxicity of contaminants, and presence of nutrients.¹⁶ Oil sludge generated from the Oil Refinery represent one of the most serious environmental problems in most underdeveloped countries, and efforts needed to develop a strategy to solve such problems. The urgent need for bio-treatment approach has arisen to fully utilize the large number of organisms found in the oil-contaminated sites and to optimize the environmental condition for biodegradation. Many countries faced with significant volume of oil sludge being produced from the Oil Refinery and disposed into ponds causing environmental problems. Although, there is evidence that bioremediation can be used to treat oil sludge effectively, the main limitation is the difficulty in formulation treatment strategies that produce a specified outcome in term of degradation rate while residual contaminate concentration remains. However, performance of hydrocarbon degradation bacterial consortia selectively isolated from naturally occurring microbiota of the oily sludge could be utilized for future oily sludge bioremediation application.¹ It has been reported that successful bioremediation could be estimated by measuring the reduction rate of total organic hydrocarbon (TOC).¹⁷ Future research must focus on the ability of different consortia to degrade hydrocarbon in oily sludge and on efficiency of consortia supplemented with different nutrient is also should be considered.

Discussion

Pioneer study showed the ability of different bacterial consortia isolated from the natural Oil refinery treatment plant to metabolize petroleum oily sludge as a source of energy and carbon aerobically. Isolated organisms from natural habitat have been characterized with standard biochemical identification tests which allow preliminary designation of the isolates as *Bacillus species*.¹ Further identification using 16S rDNA genes, DNA-DNA hybridization could be carried out in the future to fully identify the bacterial strains.¹⁷ The significant of this research is laying the ground for future research to conduct an integrated study including a full analysis using GC-MS technique. Furthermore, this finding could assist decision makers in establishing a baseline or a benchmark for TOC-associated pollution. The biodegradation experiments carried out have assessed the efficiency of consortia based exclusively on the percentage of TOC removal from the oily sludge samples however, other variable should be considered in future study that could affect TOC biodegradation such as pH, or dissolve oxygen.¹⁸ Consortia type and concentration has enhanced TOC degradation rate.¹ Similar observations were reported by other researchers.^{19,20} The significant of consortium concentration on TOC% removal has been also reported.^{1,21,22}

Conclusion

Based on this review, biodegradation could be considered as a key component in the cleanup strategy development in the future for treatment of oil sludge contamination keeping in mind consortia type and concentration. In addition, evaluation of environmental conditions and optimization of biodegradation process on several factors such as biomass type and concentration, temperature, nutrients and pH are areas where further research is necessary. Unlike the conventional treatment technologies, bioremediation technique must be tailored specially to each polluted site. Each waste site has unique characteristics, and thus requires individual attention, so an official criterion for evaluation the success or failure of the particular strategy is needed. In addition, a successful biodegradation program require a multidisciplinary approach, integrating fields such as microbiology, engineering, geology, soil science, and project management.

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None.

Conflicts of interest

The authors declared there is no conflict of interest.

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