Chapter 1

Microbe Associated Phytoremediation Technology for Management of Oil Sludge: Phytoremediation for Oil Sludge Management

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ABSTRACT

Environmental contamination due to petroleum compounds is a serious global issue. Oil/petroleum refineries produce huge amount of oil sludge during drilling, storage, transport, refining which spoil soil and ground water resources. Such activities release different compounds viz. alkane, mono-polyaromatic hydrocarbons (PAH), asphaltene, resins and heavy metals. Due to physico-chemical properties, PAHs are one of most targeted compounds as they are highly persistent, carcinogenic, and have mutagenic effects on ecosystem. Such problems of PAHs drag researcher’s attention to find some reliable and cost effective solution for oil sludge disposal management. Since last few decades, extensive research work has been carried out on various methods for treatment of oil sludge. In recent years, microbial assisted phytoremediation treatment technologies are being studied since these are reliable and cost effective for field applications. Here, we have discussed about combined eco-friendly technology of plant and microbe(s) to treat oil sludge for its better management.

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INTRODUCTION

The demand of oil/petroleum products is increasing day by day due to rapid global industrialization which resulted in pollution load on the environment. These industries release toxic compounds in the form of oil sludge during different upstream and downstream processes viz. drilling, storage, transportation and refining. This oily waste poses a crucial environmental pollutant and creates problem of ground water contamination due to improper disposal/discharge on nearby lands of refineries. The oily sludge is recalcitrant residue which contains hydrocarbons compounds of different classes, viscous liquids, solid particles, heavy metals, asphaltene, resins etc. The total fractions of oily sludge are total petroleum hydrocarbon compounds (TPHs) classified in four main groups including aliphatics, aromatics, nitrogen sulphur oxygen (NSO) containing compounds, and asphaltenes (Hu, Li, & Guangming, 2013). In complex oily sludge, aliphatics and aromatic hydrocarbons usually contribute up to 75% of petroleum hydrocarbons which are comprised of alkanes, cycloalkanes, benzene, toluene, xylenes, naphthalene, phenols, and various polycyclic aromatic hydrocarbons (PAHs) (Ward, Singh, & Hamme, 2003). Among NSO fraction, nitrogen (N) contents are less than 3% whereas sulphur (S) contents can be in the range of 0.3-10% and the oxygen (O) contents are usually less than 4.8% (Kriipsalu, Marques, & Maastik, 2008). However, this group of hydrocarbon compounds is characterized on the basis of physico-chemical properties like water solubility and structural complexity which decides their toxicity on the environment. The lower molecular weight, simple aliphatic compounds are degraded in natural environment by volatization, photooxidation/ natural attenuation etc. However, higher molecular weight aromatic compounds which include PAHs are difficult to degrade due to low aqueous solubility and limited bioavailability. They exert harmful and toxic effect on the environment and have been classified as hazardous chemicals due to carcinogenic and mutagenic nature. Degradation of such compounds is on top priority work and needs most safe and environmental friendly treatment method. During last decade, much research has been carried out on treatment technology for oily sludge management which includes land farming, incineration, solidification/stabilization, solvent extraction, ultrasonic treatment, pyrolysis, photocatalysis, chemical treatment, and biodegradation (Hu et al., 2013; Mater et al., 2006). But no single method is capable for removing / degrading total components of oily sludge.

Bioremediation provides a reasonably viable solution for remediation of sites contaminated with petroleum/oil hydrocarbons (Shukla et al., 2011; Gojgic-Cvijovic et al., 2012; Rahman, Banat, Thahira, Thayumanavan, & Lakshmanaperumalsamy, 2002). Basic microbial metabolism of contaminants involves aerobic reaction(s) that acts on a wider range of hydrocarbon compounds, carry out more difficult degradation reactions and transforms pollutants into more simple molecules than those of plants (Cunningham, Berti, & Hung, 1995; Frick, Farrell, & Germida, 1999). Microorganisms surviving on contaminated sites have the degradation potential as they are flexible in nature and get adapted quickly to contaminants on polluted sites. However, the degradation efficiency is decided by the environment key factors like contaminant concentration, bioavailability, and catabolic strength of micro-flora, nutrients requirement, moisture level and geographical situations. The limitation of low bioavailability of these hydrophobic organic pollutants can be overcome by applying microbial biosurfactant. Microbes produce surfactants or release enzymes in the presence of contaminants which play much important role in pollutants detoxification process (Rahman et al., 2002). Biodegradation pathways of aromatic compounds proceed through certain catabolic enzymes viz. catechol dioxygenase which plays a central role in degradation mechanism. This enzyme attacks on aromatic rings either on meta- or ortho- side. The gene(s) encoding for catechol dioxygenase or other monooxygenases can be used as indicator of PAH/alkane