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BIOREMEDIATION OF OIL SPILLAGE USING MICROORGANISMS

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ABSTRACT

The increasing number of oil spills in the environment nowadays has led to the exploration of operative resolution for the problem. Bioremediation has become the most opted technique for eradicating oil spills and restoring the affected environment. One of the most effective methods in bioremediation is the seeding of new bacteria or relying on the indigenous microbial populations for the biodegradation of oil at the contaminated site. Applications of nutrients such as nitrogen and phosphorus in the form of fertilizers to this ambiguous method have proven to be most effective in quickening the process of biodegradation and safe to the environment. The basics of bioremediation and background information of the technique are presented in this article.

Introduction

Oil spill is a major man-made disaster in the nature. Recently at Chennai due to the collision of two cargo vessels MT Dawn Kanchipuram and MT BW Maple about two nautical miles off Kamarajar Port in Ennore on January 2017, a large quantity of furnace oil has been spilled along the south east coast. The biggest impact of the spill would be on the pelagic fishes which thrive in shallow waters as the spill occurred close to the coast. Subsequently, several mullets and anchovies were found dead due to the ingestion of hydrocarbon as these two species jump out of the water and splash in. Researchers have observed that a large variety, about 76 organisms living in the benthic fauna got affected with oil in their external body parts. The bottom feeding organisms such as crabs and prawns also got affected as the deposits reach the seabed slowly (Tejonmayam, 2017). This petrochemical oils contains paraffins, aromatic and polycyclic hydrocarbons in addition to trace elements such as copper, nickel and vanadium which are toxic to aquatic as well as terrestrial organisms.

The oil film tends to reduce the amount of light penetrating into the waters and it affects the photosynthesis thereby affecting the lives of planktons and micro-organisms. A single oil spill is enough to put all the living organisms in menace. Many such oil spills happen due to accidents are occurring worldwide. The numbers of such incidents are increasing due to the increase of oil transportation on the waters. One cannot stop such accidents happening on the seas but can overcome the bad effects and reduce the damage to the environment created by oil spills using effective methods through bioremediation.

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Bioremediation is the process of degrading the environmental contaminants into less toxic forms with the help of living organisms. Microorganisms have been effectively used in these treatment processes under controlled conditions. Research is been done to prove the effectiveness of bioremediation for oil spills in water bodies. This technique when proved effective on terrestrial and aquatic environments has a vast scope on treating contaminated soils and sediments. Bioremediation involves microorganisms such as bacteria, fungi, etc. as well as plants to detoxify the environmentally hazardous substances. When plants are involved in the process it is called as phytoremediation and similarly when fungi are used it is known as mycoremediation.

In microbial bioremediation the microorganisms breaks down the contaminants and utilize them as food source. The phytoremediation uses plants to bind, extract and clean up pollutants such as pesticides, petroleum hydrocarbons, heavy metals and chlorinated solvents. Mycoremediation utilize the digestive enzyme of fungi to break down the contaminants. All these sources used in bioremediation are promoted by the addition of inorganic nutrients that helps their growth thereby accelerating the biodegradation process.

Oil spills-an overview

Spilling of petroleum products into water bodies is a major concern as petroleum causes both acute and long term problems. The spills can be caused by tankers, refineries, drilling operations, etc. The oil spills accounts for high percentage of complications for the organisms inside the sea (Tanzadeh & Ghasemi, 2016). When an oil spill happens in an ecosystem, it disturbs both the habitat and the organisms. The organisms get affected in growth and reproduction patterns.

Apart from biological impediments, the oil spilled itself is toxic. Petroleum or crude oil is a mixture of many hydrocarbons. It is known to contain aloft of 17,000 organic compounds including both volatile organic compounds and polycyclic aromatic hydrocarbons (Brooijmans *et al.,* 2009). Volatile organic hydrocarbons are carcinogenic and get evaporated into the air very easily which results in the air to be toxic when respired. Polycyclic aromatic hydrocarbons can last much longer in the environment.

Role of microorganisms in bioremediation

Microorganisms such as bacteria and fungi are introduced to the area of the oil spill to clean it up. There they break down the hydrocarbons of the oil into carbon dioxide (CO2). Toxic metals such as mercuric oxide can be converted into nontoxic form of mercury by bacteria. Many species of microorganisms are involved in the process of bioremediation. Some species such as *Alcanivorax borkumensis* produce surfactants to solubilize the oil, whereas other bacteria degrade the oil into carbon dioxide. Some of the families of bacteria and fungi involved in the process of bioremediation are given in table 1. Generally bacteria dominantly degrade hydrocarbons in aquatic systems. They possess diverse metabolic pathways that are not present in fungi. Fungi utilize most recalcitrant hydrocarbons.

Table 1: List of some bacteria and fungi involved in the bioremediation process (Gordon & Ray, 1994)

Bacteria	Fungi
Achromobacter	*Allesheria*
Acinetobacter	*Aspergillus*
Actinomyces	*Aureobasidium*
Aeromonas	*Botrytis*
Alcaligenes	*Candida*
Arthrobacter	*Cephaiosporium*
Bacillus	*Cladosporium*
Beneckea	*Cunninghamella*
Brevebacterium	*Debaromyces*
Coryneforms	*Fusarium*
Erwinia	*Gonytrichum*
Flavobacterium	*Hansenula*
Klebsiella	*Helminthosporium*
Lactobacillus	*Mucor*
Leucothrix	*Oidiodendrum*
Moraxella	*Paecylomyces*
Nocardia	*Phialophora*
Peptococcus	*Penicillium*
Pseudomonas	*Rhodosporidium*
Sarcina	*Rhodotorula*
Spherotilus	*Saccharomyces*
Spirillum	*Saccharomycopisis*
Streptomyces	*Scopulariopsis*
Vibrio	*Sporobolomyces*
Xanthomyces	*Torulopsis*
	Trichoderma
	Trichosporon

The oil metabolizing microorganisms are evolved to use the hydrocarbons and organic compounds as energy. They utilize molecular transfer mechanisms to denature the toxins. The aerobic and anaerobic properties of these microbes consent them to respire and ferment compounds that result in the transformation of toxins into harmless compounds. It has been reported that the percentage of oil-degrading microorganisms in marine ecosystem is less than 1 and when necessary substrates are provided the percentage can be increased drastically (Brooijmans *et al.,* 2009). These microbes with the wide array of enzymes and in presence of nutrients especially nitrogen and phosphorus fertilizers (Atlas, 1991) tend to breakdown the petroleum compounds at an efficient rate (Das *et al.,* 2011). The general mechanisms involved in the bioremediation of toxic compounds such as petroleum oil is shown in figure 1.

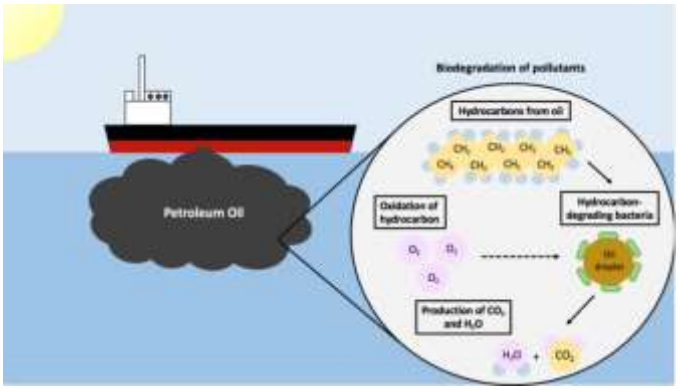

Fig. 1 Mechanisms involved in bioremediation of toxic compounds. Some microorganisms, such as A. borkumensis, are able to use hydrocarbons as their source for carbon in metabolism. They are able to oxidize the environmentally harmful hydrocarbons while producing harmless products, following the general equation C_nH_n + O_2 H_2O + CO_2. In the figure, carbon is represented as yellow circles, oxygen as pink circles, and hydrogen as blue circles. This type of special metabolism allows these microbes to thrive in areas affected by oil spills and is important in the elimination of environmental pollutants (Source: Wikipedia).

Some of the factors which affect the process of bioremediation are pH, redox reaction potential, temperature, moisture, oxygen, nutrient availability, soil composition and solubility of pollutant. The techniques involved in bioremediation are aerobic respiration, inorganic electron donation, fermentation, demobilization and reductive dehalogenation. Bioremediation techniques utilize these above mechanisms to reduce the amount of pollutants (Azubuike *et al.,* 2016). Some of the applications of bioremediation are presented in figure 2.

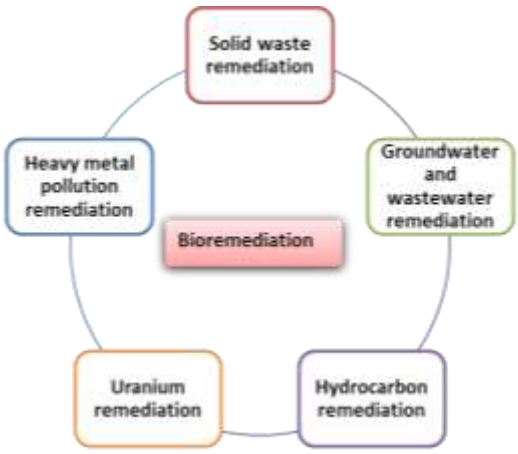

Fig. 2 Applications of Bioremediation

Conclusion

Bioremediation focus on the fast clean-up of oil spills by minimizing the hazardous environmental effects. More research work is on-going to develop the kinetics of degradation. The efficacy and safety of bioremediation must be demonstrated and communicated to the public. Bioremediation is an effective and useful method for the complete destruction of a wide variety of contaminants. It does not create any major disruption in the normal activities of the environment and it has been proved as less expensive technology to clean-up the hazardous waste.

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