



**International Journal of Biology, Pharmacy
and Allied Sciences (IJBPAS)**

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MICROBIAL HYDROCARBON DEGRADATION: MECHANISM AND FACTORS AFFECTING THE PETROLEUM HYDROCARBON OF SOIL

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Received 12th March 2021; Revised 10th April 2021; Accepted 12th May 2021; Available online 1st Jan. 2022

<https://doi.org/10.31032/IJBPAS/2022/11.1.5830>

ABSTRACT

In the entire environment, one in each of the most essential contamination is caused by the organic compound industries, products, effluents that is free from the organic compound industries, road accidents, ship accidents etc. the most environmental pollution of soil and water is as result of organic compound contamination ensuing by the organic compound industries, refineries, human activities etc. elements of organic compound are belong to the family of carcinogens and neurotoxic organic pollutants. Mechanical and chemical ways commonly used to remove hydrocarbons from the contaminated site have limited effectiveness and may be expensive. Bioremediation is that the promising technology for the treatment of these contaminated sites that is cost effective and can cause the entire mineralization of organic contaminants into greenhouse gas, water, inorganic compounds, and cell protein or transformation of complex organic contaminants into alternative simpler organic compounds by biological agents like microorganisms. Many native microorganisms in water and soil are capable of degrading organic compound contaminant.

Keywords: *Bioremediation, Biodegradation, Petroleum hydrocarbons, Emulsification*

INTRODUCTION

Petroleum contamination resulting from leaking above ground and underground storage tanks, spillage throughout transport of oil products, abandoned manufactured gas sites and various industrial processes is dangerous to soil and water ecosystems, and is expensive to change. There is an increased interest in environmental methods within the method of cleaning improvement polluted sites. In compared to physicochemical methods, environmental methods are more cost-effective [18] and do not introduce further chemicals to the environment. Environmental methods like biodegradation are a really possible different for an oil spill response. It is an efficient technology for treatment of oil pollution. The majority of the molecules among the crude oil and pure product are biodegradable. All oil products are derived from crude oil whose major constituents are hydrocarbons. Crude oil consists of mixture of paraffinic, alicyclic and aromatic hydrocarbon and non hydrocarbon compounds [4]. Bioremediation of oil contaminants during the last decade the effectiveness of stress tolerant organic compound degrading microorganisms are less studied. Stress tolerant microbes are great interest for their ability to survive in geographical and climatic conditions [5].

Bioremediation is one of the method used in clean-up of such soil contamination and it is defined because the use of biological processes to degrade, break down, transform, and essentially remove contaminants or impairments of quality from soil and water [1]. Crude oil hydrocarbons also are degraded by microorganisms like microorganism, fungi, yeast and microalgae. Microorganisms are provided with metabolism equipment to use oil product as a source of carbon and energy. Crude oil-derived hydrocarbons constitute the largest group of environmental pollutants worldwide. Their toxicity and action are ultimate need to remove them from marine and soil environments [12]. The biodegradation of hydrocarbons in contaminated sites depends on many factors like molecular composition of the hydrocarbons, the type of microorganism population, and optimal environmental conditions to stimulate the bioavailability of the contaminants to microorganisms [2]. Generally, biodegradation of oil affects physical and chemical properties of the oil, resulting in a decrease of its organic compound content, acidity and viscosity, leading to a negative economic consequence for oil production and refining operations

[16]. One of the most important characteristics of hydrocarbon-degrading microorganism is the ability to emulsify hydrocarbons. Such microorganisms possess the flexibility to provide different types of bio reactive compounds that in addition consists of bio emulsifiers. The use of synthetic emulsifiers is extremely common, but due to their very extremely nature and environmental accumulation, there is extreme need of eco- friendly biological emulsifiers. Bio emulsifiers reduce the surface tension between the oil and water interface. They emulsify oil to sub- droplet level which can be easily used by the microorganisms as a substrate. Such organic compound emulsifying microorganism can be considered as potential organic compound degraders. The isolate that expresses higher oil emulsifying capability can be effectively used for treating oil or organic compound contaminated soils [18]. Bio surfactants are made by many organisms, in order to metabolize water immiscible substrate, allowing its adsorption, emulsification or dispersion [20].

PETROLEUM HYDROCARBON DEGRADING MICROORGANISM

Most petroleum hydrocarbons are detected within the environment are eventually degraded by native microorganism because

of their energy and carbon needs for growth and reproduction, also as the demand to relax physiological stress caused by the presence of petroleum hydrocarbons within the microorganism measurement environment. Microfluidic techniques are beneficial for screening and characteristic functional microorganisms from petroleum hydrocarbon-contaminated environments. several studies have revealed that there is a large range of hydrocarbons degrading microorganism in oil rich environments, like oil spill areas and oil reservoirs, which their riches and amount are closely associated with the types of petroleum hydrocarbons and the surrounding environmental factors.

Petroleum hydrocarbons divided in four classes that are as follows: aliphatic, aromatics, resins and asphaltenes. Various studies have reported that completely different environmental studies have reported that different environmental factors influence the biodegradation of petroleum hydrocarbons. The presence of microorganisms within the environment is one of the most important factors in limiting biodegradability of oil contaminants. Bioremediation of sites contaminated with oil are usually limited because of the poor diversity of local microbes with supplementary substrate properties required for the degradation of

different hydrocarbons presents in oil contaminated sites. Petroleum hydrocarbons with a high molecular weight are probably not degraded at all. Degradation of petroleum hydrocarbons by microorganism is a major and final natural mechanism. Microbes are used to clean up petroleum contaminated environments, which are demonstrated to an appropriate and more alternative compared to the mechanical chemical techniques [13].

Hydrocarbons in the environment are biodegraded essentially by microorganism, fungi, and yeast. Mixed populations with overall inclusive enzymatic capacities are required to degrade complex mixtures of hydrocarbons like petroleum and garage oil in soil. Microorganism are the most active agents in petroleum degradation method, and they effort as primary degraders of spilled oil in environment. Some microorganisms are even known to feed entire hydrocarbons. *Acinetobacter* sp. was found to be capable of utilizing n- alkanes of chain length C₁₀-C₄₀ as a sole supply of carbon. Microorganism genera, namely, *Gordonia*, *Brevibacterium*, *Aeromicrobium*, *Dietzia*, *Burkholderia*, and *mycobacterium* isolated from petroleum contaminated soil that are potential organisms for hydrocarbon degradation [6].

Fungal genera, *Amorphoteca*, *Neosartorya*, *Graphium*, *Talaromyces* and yeast genera,

candida, *yarrowia*, and *pichia* were isolated from the petroleum contaminated soil and these are the potential organisms for petroleum hydrocarbon degradation. Terrestrial fungi, *aspergillus*, *Cephalosporium* and *Penicillium* are found to be conceivable degrader of petroleum hydrocarbons. Algae and protozoa are the microorganism community in both aquatic and terrestrial ecosystems, regarding their involvement in organic compound biodegradation [6].

MICROBIAL APPLICATION IN DEGRADATION OF INDUSTRIAL POLLUTANTS

Petroleum hydrocarbons is presently considered source supply provide of energy and materials for numerous industries and daily activities. Petroleum hydrocarbons are common environmental pollutants worldwide [9]. Petroleum hydrocarbons are unit toxic compounds classified as priority contaminants, and they are one of the major environmental threats caused by production, transportation, coastal oil refining, shipping activities, and leaks or accidental spills. The accidental or intentional release of oil or hydrocarbons into the environment, as well as human activities, is a major source of water and soil pollution [19]. The release of these compounds into the environment in direct or indirect ways have an effect on all

varieties of life. Petroleum hydrocarbons can be classified into four categories: aliphatic, aromatics, resins, and asphaltenes. The aliphatic group is usually degraded by microorganisms, but the large branched aliphatic chains and aromatic hydrocarbons sometimes remain in the environment [3]. Petroleum hydrocarbons consist of 2 or more combine aromatic rings and also include naphthalene, phenanthrene, Fluorine, pyrene and acenaphthene, which are considered model compounds due to their current presence in environments. Petroleum hydrocarbons have a higher remaining because of their low water solubility, which results in their association with particulate and substance material and low bioavailability. Hydrocarbon degrading bacteria are determine from their biodegradation capabilities of aromatic hydrocarbons [10]. In the oil contamination method petroleum hydrocarbons are usually present in a mixture of various aromatic compounds, wherever every of them will influences affecting their bioavailability and increasing the problem for biological degradation. The microbial activity against petroleum hydrocarbons can be affected by factors like temperature, oxygen, pH, nutrient supply, characteristic of soil, saltness (salinity), etc. One of the important factors

that limit biodegradation of oil pollutants within the environment is their limited availability to microorganism. Petroleum hydrocarbons are removed or degraded when they bind. Hydrocarbons are completely different in their susceptibility to microbial attack. Susceptibility of hydrocarbons to microbic degradation are usually ranked: linear> alkanes> branched alkanes> tiny aromatics> cyclic alkanes. The compounds like polycyclic aromatic hydrocarbons are higher molecular weight which cannot be degraded in the least [6]. Petroleum hydrocarbons are mutagenic, cytotoxic, and carcinogenic organic chemicals. That are widely distributed in the environment as a result of the incomplete combination of organic matter, domestic matter, emission sources, automobile exhaust and other factors [14]. Petroleum product contain several hazardous organic chemicals like benzene, toluene, naphthalene, and benzopyrene, some of which are recognized carcinogens [15].

FACTORS AFFECTING BIODEGRADATION OF HYDROCARBONS

Microbes are able to consume oil because they need the genetic directions to supply oil degrading enzymes. Crops will grow faster with the right amount of light, water and fertilizers same like these microbes will degrade oil much more quickly when

environmental conditions are optimal (Figure 1). Some of the important factors are:

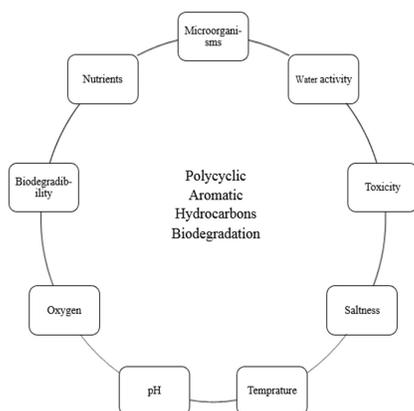


Figure 1: Factors affecting the petroleum hydrocarbon

1) Physical nature of the oil: If the hydrocarbon oil is a single large slick, there is less surface area for the microbes to absorb access of the oil, thus the degradation of oil is slower. If the hydrocarbon oil is significant and viscous, the biodegradable elements initially diffuse through that thick matrix to the oil water interface, there for microbes will examine them. The lighter the hydrocarbon oil, the faster this diffusion occur it makes the biodegradable compounds additional available to the microbes.

2) Chemical nature of the oil:

Biodegradation rates are depending on the particular hydrocarbons that make up the spilled oil. Hydrocarbon Oil consists lots of various compounds belonging to various compound classes, with the main

hydrocarbons and their heteroatom (N, S, and O) containing analogs, known as non-hydrocarbons. Some organic compound may be preferred food sources and be consumed very quickly, others are degraded more slowly. Hydrocarbons in which carbons are organized in an unbranched chain will degrade rapidly, over a period of days or weeks. Hydrocarbons that have a branched structure, in which the carbons are organized in multiple rings, are often far more difficult to biodegrade and thus endure longer time. The most recalcitrant fractions of crude oil including paste and solvents will last for years.

3) Soil characteristics:

Soil characteristics are particularly important for successful hydrocarbon biodegradation, some of the most limiting factors are: soil texture, pH, water holding capability, absorptive, soil temperature, nutrient and oxygen content. Soil texture affect the permeability, water content and bulk density of soil. Soil with low permeability inhibit the transportation and the distribution of oxygen, water, and nutrients. Bioremediation of such soil, it should be mixed with amendments or bulking materials, as the bioremediation method depend on the activity of the microorganism, and microorganisms need oxygen inorganic nutrients, water and

optimum temperature and pH scale to support cell growth and sustain biodegradation [7].

4) Soil temperature:

The solubility of hydrocarbon in oil is also affected by temperature. Hydrocarbon biodegradation will occur in a wide range of temperatures, the rate of biodegradation normally decreases with the decreasing temperature. Highest degradation rates that usually occur within the range of 30- 40 °C in soil environment. The temperature of the environment affected both the properties of spilled oil and the activity of the microorganisms. The colder temperatures also have physical effects on the speed of degradation method. Hydrocarbon oil evaporates additional slowly, therefore there is additional hydrocarbon oil left in the soil or water for the microbes to degrade the oils. The hydrocarbon oil is also additional viscous; therefore, it spreads out and disperses less readily and it provide less surface area for the microbes to access.

5) Availability of nutrients:

All living microorganisms have several nutritional requirements together with nitrogen, phosphate, and different nutrients. This all compounds are gift in environment but may be present in limiting quantities. After an oil spill the food levels are high for

microbes that can only degrade the hydrocarbons as fast because the availability of different nutrients permits. The biodegradation of oil constituents will take place slowly at the time when nitrogen and phosphate levels are very low. Therefore, nutrients were necessary to enhance the biodegradation of oil pollutants. On the other hand, excessive concentrations of nutrients may also inhibit the biodegradation activity.

6) Oxygen:

In the presence of oxygen most of the hydrocarbon oil are breaking down by the enzymatic method. If there is enough concentration of oil and nutrients are present at that time the microorganism populations will grow therefore quickly that they exhaust the oxygen from the nature. Accordingly, oxygen is not demonstrating to be as important a limiting factor as nutrients in oil degradation method. Although the degradation method could be slow if a spill occurred in a location where oxygen levels are low.

7) pH:

Many sites contaminated with hydrocarbon oils are not at the optimal pH scale for bioremediation. For example, retired gasworks sites often contain significant quantities of demolition waste such as brick and concrete. Leaching of this material will

increase the pH scale of the native soil of the site, resulting in less favourable conditions for microorganism metabolism. The oxidization and action of coal produce an acidic environment by the release and oxidation of sulphides. The indigenous microorganisms at the sites will not have the capability to transform hydrocarbon oil under acidic or alkaline conditions [7]. Soil pH scale variations reduce the biodegradation rate by affecting cell membrane Transport the ability of microorganisms to perform their cellular function. Production of some organic acids during the biodegradation method and the alkaline effects of some additional nutrients will alter the soil pH scale and limit further biodegradation. Adding an adequate amount of powdered lime or different conditions will properly change soil pH.

8) Salinity:

The biodegradation rate will drop off if soil salinity increases on the far side an optimum level. There are completely different reasons for high salinity in a soil, for example discharge of salty waste waters or spillage of oils mixed with brine. The addition of large amounts of fertilizers, which is mostly composed of highly soluble nitrates or ammonia salts is the main reason for the increase in soil salinity [8]. Microorganisms

are usually well adapted to deal with the wide range of salinities common to the world's ocean. There is little evidence to suggest they are affected by other than hyper saline environments, such as saltwater from oil wells. If the microbes are to be additional to the environment, it must be known if they are compatible with the saline levels present in the system.

MECHANISMS OF PETROLEUM HYDROCARBON DEGRADATION

The degradation of petroleum hydrocarbons by microorganisms is mainly due to the catalysis of intracellular enzymes. The process involves four main steps: first, petroleum pollutants are emulsified by surfactants secreted by microorganisms; second, the emulsified petroleum hydrocarbon is adsorbed by the surface of the microorganisms; third, the petroleum hydrocarbon adsorbed on the surface of the cell membrane enters the cell membrane through active or passive transport, endocytosis; four, the petroleum hydrocarbon getting into the cell undergoes an enzymatic reaction with the corresponding enzyme to obtain the purpose of degrading the pollutant[11]. The degradation of petroleum hydrocarbons may be mediated by particular enzyme system. Other mechanisms are

attachment of microbial cells to the substrate and production of bio surfactants [6].

CONCLUSION

Petroleum hydrocarbons are one of the most alarming pollutants because of their high toxicity to human and environmental health. In process of biodegradation the petroleum degrading bacteria is widely regarded as an eco-friendly and efficient technology. The oil degrading bacteria showed diverse and varying capacities to degrade the crude oil; with some degrading up to 90% and can be used to clean up sites contaminated with hydrocarbons. The isolation, identification and determination of crude oil degradation efficiency of the bacteria is an important towards the development of bioremediation strategies for cleaning of sites contaminated with oil pollutants and wastes. The degradation activity of the isolates in combination and establish the safety of the isolate and of the by-products of oil metabolism in the environment. There is also to determine the optimum growth requirements of the isolates, test oil biodegradation in the field by the microbes and compare the isolates with well-known characterised organisms.

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