

Research Article

Effective bioremediation technique for recovering contaminated soil with biostimulants

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Abstract

The ecological pollution is considered as a major threat to humans as well as several biological organisms. The release of wide multiplicities of contaminants are pesticides, hydrocarbons, heavy metals, plus various dyes, which are the major contributors in generating toxic products. The upsurge of various industries in manufacture of diverse products for meeting the demands of living beings further initiated the release of residual contaminants into the soils, rivers and lake. Henceforth, bioremediation is regarded as the most effectual technologies for the mitigating of environmental toxicants and helps to restore back to its stable form. The bio-stimulants obtained from animal manure/organic waste enhance in ecological restoration along with degradation of recalcitrant pollutants. Although, it is essential for exploration of cheaper along with eco-friendly selection for augmented degradation of petroleum based hydrocarbon compounds which triggered keen interest among researchers. Thus, the aim of our article is to provide insight about the importance of biostimulants in recovering the soil contaminants.

Key words: Bioremediation, Environmental Pollution, Bio-stimulants, Heavy metals, dyes.

Introduction

The discharge of diverse kinds of toxicants into the environment due to up surging of industrial globalization causes critical threat to all biological organisms [Quintella 2019]. The major Pollutants released involve oil hydrocarbons, heavy metals plus pesticides which cause critical impacts on the health of living beings. The farmers working in agricultural sectors due to seepage of these kinds of contaminants led to enhanced incidence of carcinogenesis along with mutagenesis [Kuppusamy 2020]. Henceforth, the soil pollution is regarded as the chief concern worldwide. However, to restore the normal functioning the removal of contaminants must be followed by using latest bioremediation techniques which helps in preservation of environment along with growth in urban environment. The methods available for soil remediation can be grouped into three categories, namely chemical, physical, and biological methods, the latter being carried out either in the polluted place (*In situ*) or outside it (*Ex situ*). Bioprocesses such as phyto and bioremediation have recently been intensively studied because they are eco-friendly able to quickly remove various contaminants and have a relatively lower cost compared to pre-existing techniques [Scelza 2008; Floch 2011;]. The soil pollution persisted as a serious concern globally. The environmental pollution chiefly involved contamination of the ecosystem. The major contamination involved is soil, water and air.

Nevertheless, in order to preclude the contamination of soil, bioremediation is the apt method. Generally, the pollution of soil can threaten the ecosystem and extinguish the food chain. The remediation method was claimed to be expensive treatments earlier but today with the introduction of biological remediation technique, heavy metals, hydrocarbon contaminants which are made up of complex mixtures of aliphatic and aromatic hydrocarbons plus volatile compounds like gasoline and petrol can be degraded effectively. Hence, the involvement of eco-friendly microorganisms which were found to be cost effective and widely utilized method today [Rimmer 2006; Nie 2009;].

Even though *In-situ* and *Ex-situ* bioremediation is found to be effective in treatment of contaminated soil but most economical method of cleaning up the contaminants of soil is the application of bio-stimulants obtained from animal manures such as pig, poultry, goat etc., which were found to be beneficial in removal of pollutants from environment [Ijah 2003; Okolo, 2005; Yakubu, 2007]. Furthermore, there is very few literature or data on the use of animal manure in the biodegradation of petroleum hydrocarbon in a contaminated environment. Therefore, the purpose of our article is to provide insights on the application of animal manure (poultry manure, pig manure, goat manure) to decontaminate the soil from petroleum hydrocarbon mixtures (kerosene, diesel oil, and gasoline mixtures).

Bioremediation with animal waste

The unconditional obligation for promoting ecological improvement of our society with trivial environmental impact is to exterminate the pollutants present from the environment. The soil polluted with poly-cyclic hydrocarbons effectually lead to destruction of the local ecosystems. The acquisition of these pollutants by the aquatic organisms and tissue of plants can result in mutations of offspring's. However, the release of the toxicants such as petroleum due to industrial globalization turns the cultivable terrain into poor soil attributes. Earlier petroleum lights were in demand as they used to enlighten the rural areas [Varjani, 2017]. Since, the augmenting usage of petroleum and its products caused appalling soil along with groundwater contamination [Lim, 2016]. These petroleum based hydrocarbons are mentioned as the communal primary energy plus fuel resources globally. The distribution of the petroleum based products might have resulted in fortuitous emancipation or seepage [Abbasian, 2015]. The introduction of microorganisms which has the potential to degrade PAH (Polycyclic aromatic hydrocarbons) are bacteria, fungi and microalgae [Andreolli, 2015].

The addition of biocatalyst such as substrates, vitamins, oxygen, nitrogen and phosphorous elements can instigate the growth of microorganisms to biodegrade the environmental pollutants from the soil at a faster rate [Basharudin, 2011; Sutherland, 2000; Liebeg, 1999]. Few literature reports have distinctively signified and emphasized that the application of animal manures such as pig, poultry and goat to soil along with biocatalyst such as vitamins, minerals, trace elements can trigger the bioremediation process rapidly. These animal manures harbour the microorganisms in their gastrointestinal tract such as *Pseudomonas*, *Bacillus*, *Proteus*, *Klebsiella*, *Micrococcus* and *Flavobacterium* etc., which has the potential to degrade the petroleum hydrocarbons [Shabir, 2008] (Figure 1).

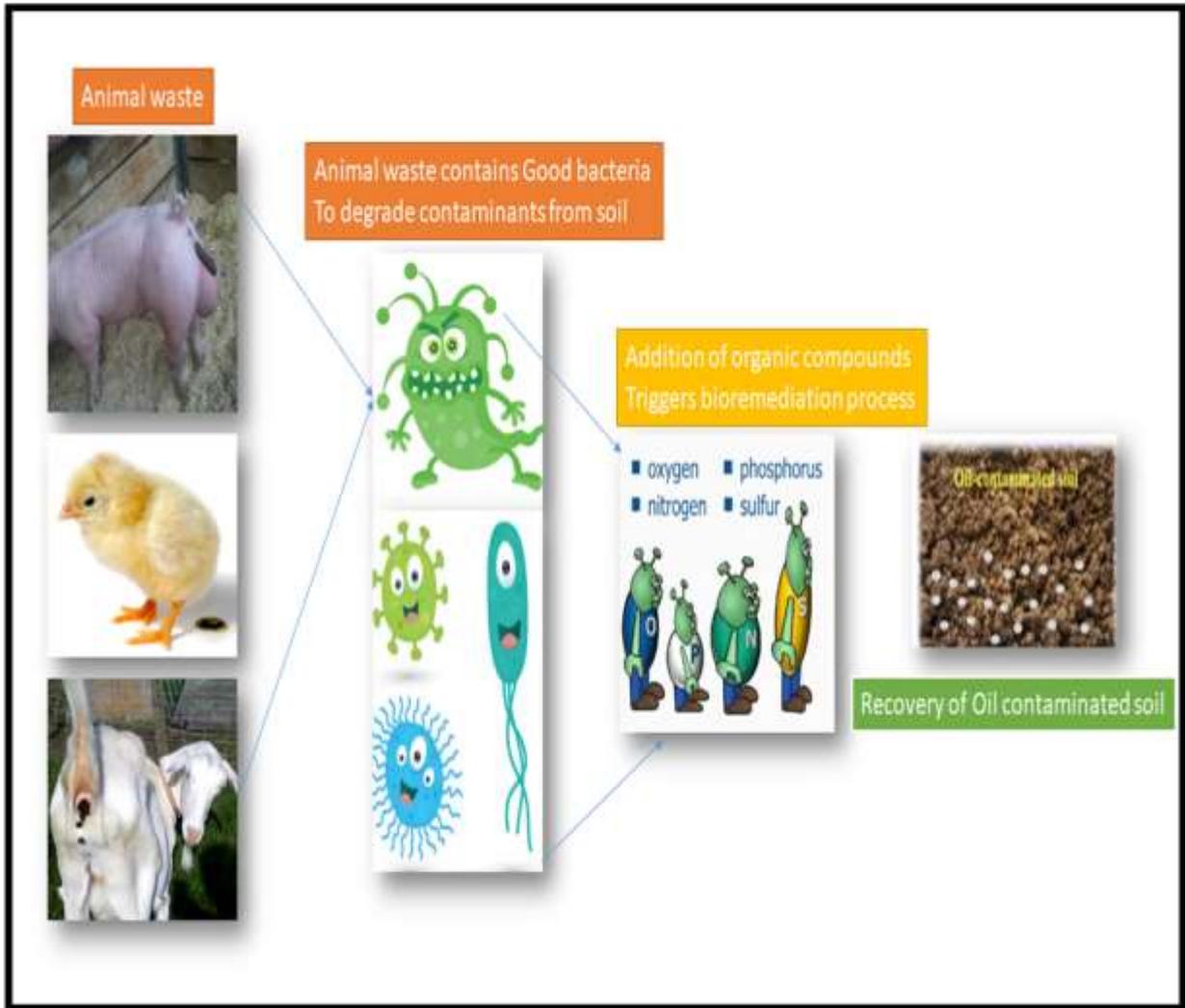


Figure 1: Recovery of soil from contaminants with utilization of animal manure & organic compounds.

Recovery of environmental soil pollution by bioremediation

The major characteristics of bioremediation techniques employed for refinement of different surface layers of soils, freshwater plus marine systems, and groundwater along with the contaminated terrestrial ecosystems. Although, the mainstream of bioremediation methodology are originally encouraged for treatment of petroleum hydrocarbon contamination so that restrain the release of toxic contaminants and transform them to non-hazardous chemical products for human consumption [Baker, 1994]. Several studies reported the removal of different soil pollutants using microorganisms (Table 1).

Table 1: Bioremedial function performed by microorganisms to refine contaminated soil.

S.No	Soil Pollutants	Microorganisms	Functions	References
1	TNT (2,4,6 Trinitrotoluene)	<i>Methanococcus</i> species	Biodegrades the pollutants in soil	Boopathy and Kulpa 2000
2	Atrazine	<i>Pseudomonas</i> species	Biotransformation of polluted soil	Newcombe, 1999

3	Polycyclic aromatic hydrocarbons (PAHs)	<i>Pseudomonas</i> species	Degrades the contaminants existing in soil	Arunkumar Dangi, 2018
4	Polychlorinated Biphenyls (PCBs)	<i>Rhizobium</i> sp. <i>Rhodococcus</i> sp.	Biotransformation of polluted soil	Jitendra Sharma, 2018
5	PAH	Fungi	Helpful in removal of pollutants from the contaminated soil	Sandeep Bisht, 2015

In-situ Bioremediation method

Nevertheless, bioremediation is of two types, *In-situ* and *Ex-situ* based upon the removal of noxious compounds from the environment. In situ techniques involve the treatment of pollutants at their respective place with minimal disturbances. However, this technology is cost effective because it removes toxic contaminants without quarry and also uses less threatening microbes. This is the most reliable method for management of contaminated terrain which are polluted with dyes, hydrocarbons along with heavy metals [Roy, 2015]. At present with advancement of science and technology the engineered in situ bioremediation is utilized for attenuation of contaminated soil with hazardous pollutants. The in situ bioremediation includes bioventing, biosparging as well as bioaugmentation process. Moreover, the Bioventing is the routinely practiced in situ treatment method that entailairing plus sufficient nutrient quantity to augment the growth of the microbial inhabitants for mitigation of volatilization and release of toxicants into soil. Although, this process of bioventing is more effectual in deep soil surface for removal of hydrocarbon toxicants.

The other in situ technique of bioremediation is biosparging where amplification of the amount of the groundwater oxygen by inclusion of pressurized air which subsequently increases the biodegradation rate of the pollutants by native microbes [Lambert, 2009]. This biosparging technique application is especially employed at sites contaminated with petroleum products such as diesel or jet fuel. However, disintegration of viscous compounds such as lubricating oil plus lighter products like gasoline generally requires lengthier time. This method is preferred because it is cheaper process of bioremediation. Bioaugmentation chiefly involves native/exogenous microorganisms which can sustain in extreme conditions and mitigate the pollutants present in the natural environment.

Ex-situ Bioremediation Method

This is the major technique where digging of the contaminated soil to clean up the spilled toxicants. The technique is commonly referred as solid and slurry phase treatment which includes composting, land farming, bio-piles which are effective in treatment of solid wastes either from household or industries [Pandey, 2019]. In the ex situ method the slurry/aqueous bioreactors usage are effective for removal of contaminants through the engineered system. Although, this slurry reactor includes three-phase system (solid, liquid, and gas) in order to enhance biodegradation rate of both soil bound and water sludged toxicants with native microbes. The biodegradation is rapid with employment of bioreactor technique than the *in-situ* method and hence this procedure of disintegration is more predictable and manageable. However, methods of both *in-situ* and *ex-situ* bioremediation have their own benefits (Table 2).

Table 2: Summarizes the Benefits and Limitations of In situ and Ex-situ Bioremediation

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Methodology	Examples	Techniques	Advantages	Disadvantages	Reference
In situ Bioremediation	Biosparging	Injection of air below pressure under the water table to enhance the concentration of oxygen which in turn helps in degradation of contaminants	Natural diminution method which is cost effective	Due to the limitations in treatment time leads to monitoring difficulties	[Sharma 2012]
	Bioventing	This process involves supplements of aeration and nutrients through well	It helps to remove simple hydrocarbon contaminants from deep soil surfaces	The high concentration might lead to negative effect on native microbes	[Atlas 2005]
	Bioaugmentation	The supplementation of genetically engineered microbes for specific pollutants	Naturally weakens the toxicity in soil	The limitation is inconvenience in time of monitoring	[Thapa 2012]
Ex-situ bioremediation	Land farming	In this process excavation of top soil along with addition of nutrients for enhancement of microbial populace to degrade the contaminants	Cheapest method for removal of toxicants	Requires space	[Soccol 2003]
	Composting	Anaerobic method of conversion of solid organic waste into humus	Cost effective method	Requires extended time for treatment	[Nataraj 2007]
	Biopiles	This is a hybrid method of land farming and composting	The favourable environmental conditions is provided for growth of microorganism to degrade	Measures to be taken for abiotic loss	[Wu 2009]

			pollutants		
	Bioreactors	These are like steel vessels in which microbes carry out their biological actions	Most extensively used and preferable technique of bioremediation	Most expensive	[Chikere 2012]

Conclusion

Although, it is obvious that conventional method has been employed for treating the contaminated soil with petroleum hydrocarbons but the major drawback was that it is most expensive methodology which requires very costly equipment's for treatment of contaminated soil. Therefore, with the intense research in science led to introduction of cheapest and safer method of treating contaminated terrain with pollutants. Thus, the employment of biological organisms from animal manures is regarded as the best method for bioremediation. Though, in previous literature reports have emphasized the bioremediation by in situ and ex-situ method.

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