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CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 13, Issue, 12 (A), pp. 2754-2759, December, 2022

ISSN: 0976-3031

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

BIOREMEDIATION OF ORGANIC POLLUTANT CONTAMINATED SOIL FROM ENVIRONMENT

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DOI: http://dx.doi.org/10.24327/ijrsr.2022.1312.0565

ARTICLE INFO

Article History:

Received 11th November, 2022
Received in revised form 25th November, 2022
Accepted 20th December, 2022
Published online 28th December, 2022

Keywords:

Bioremediation, Polycyclic aromatic Hydrocarbon, contaminated soil, pollutants, environmental pollutants, environment contaminates

ABSTRACT

Bioremediation, a branch of environmental biotechnology, uses the ability of microorganisms to degrade, detoxify, and break down hazardous substances to remove the environment contaminates. It transforms or removes organic and inorganic pollutants naturally with the help of microorganisms even if present in low concentration, employs metabolic degradation and can be used in Insitu bioremediation to minimize interruption of cleaning. Waste from agriculture can be treated by Insitu support for pesticide biodegradation and in Ex-situ sawdust, sunflower seeds Husk etc. seems promising material. The technology includes biostimulation and bioaugmentation which reduce the toxic pollutant to obtain useful substances. Contaminates such as polycyclic aromatic hydrocarbons (PAHs), pesticides, etc. Process a huge threat to our environment. All microorganisms are present in contaminated soil, which cannot necessarily do the process. Nutrients and other components are used to break down the contamination by allowing microbes to create enzymes which are readily affected by pH, temperature, and moisture. The Conventional technique used to dig up contaminated soil and remove it to a landfill, contaminated compounds transferred through reaction by the organism taking part in the metabolic pathway. Microorganisms may be indigenous to contaminated areas from which they may be isolated. In the presence of oxygen, aerobic bacteria like *pseudomonas, rhodococcus, mycobacterium* etc. have the ability to degrade pesticides and hydrocarbons. Ligninolytic fungi such as white rot fungus *phanerochaete chrysosporium* have the ability to degrade toxic environmental pollutants. Due to its low cost and generally benign environment impact, it offers unattractive supplements to clean up technology with high acceptance and can be easily carried on site. This article presents a review on approaches to bioremediation there pros, cons and potential areas of application.

INTRODUCTION

Bioremediation, a branch of environmental biotechnology, uses the ability of microorganisms to degrade, detoxify, and break down hazardous substances to remove the environment contaminates. (Zhang *et al*., 2016). Bioremediation means using life to remediate contamination by using nutrients or energy sources. Bioremediation concerns with biological rehabilitation of contaminated sites and clean-up contaminated areas accidentally or incidentally in more recent times, as a result of use of organic and inorganic chemicals. (Zhang *et al*., 2007; Chen *et al*., 2014; Ma *et al*., 2016a). Bioremediation possibly degrades , removes , alters or detoxifies various chemicals from the environment. Microorganisms are widely spread as they have metabolic activity and can easily grow in different environmental conditions. The nutritional versatility of microorganisms that can be exploited for biodegradation of pollutants. Bioremediators are biological agents used such as bacteria, archaea and fungi which have the ability to modify and utilize toxic pollutants to obtain energy and biomass production. Soils are enormous causing serious damage in which bioremediation techniques may enable appropriate treatment of soil and minimize disposal of waste soil providing protection to human health and the environment. (Moscoso *et al*., 2012).

The conventional techniques used for remediations have dig up contaminated soil from the contaminated Area. The methods simply move the contamination and create risks in transport of hazardous materials with difficulty in financial disposal techniques are improving with experience and knowledge as addition of matched microbe strains enhance the resident microbe populations ability to break down contamination. (Dakar, Senegal, (8th ICCA), 30 July-4 August 2001, 1147-1223). As bioremediation is considered innovation technology,

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client and regulatory agencies often scrutinize bioremediation as more costly than conventional technology.

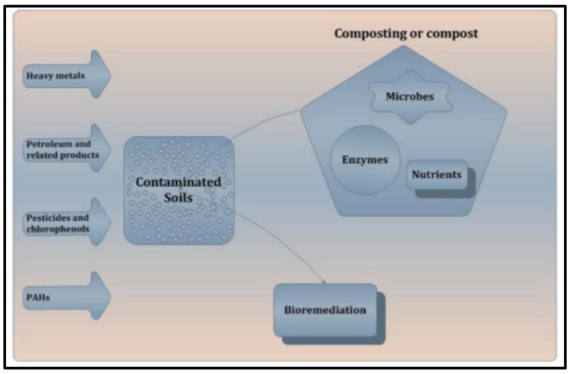

Fig. Bioremediation of soils contaminated with organic pollutants and heavy metals by composting and compost. (M.chen *et al* / Biotechnology Advances 33 (2015), 745-755).

Types of bioremediation

In situ bioremediation

In situ techniques are defined as those that are applied to soil and groundwater at the site with minimal disturbance. In situ processes based on the type and concentration of pollutants, characteristics of the site but are not limited to cost. They will have a solid foundation for research, application, or evaluation of In-situ bioremediation in the future. In situ technology which includes bioventing, biofilters, and bioaugmentation, minimal disruption of site and elimination of handling cost. In situ applications are limited to natives species as the introduction of exotic organisms, restricting possible interesting applications and the treatment is limited by the depth of the soil that can be effective. In situ techniques involve treatment of the contaminated material in place, Transport of materials that can also be constrained by geological, hydrogeological and other environmental factors, resulting in a low efficiency of contaminated removal. Example, - land farming: solid phase treatment system for contaminated soil may be done in In- situ Bioremediation. (R.Boopathy/Bioresource technology 74 (2000) 63-67).

Ex situ bioremediation

Ex situ technologies are those treatments which involve the physical removal of the contaminated material for the treatment process. Ex situ strategies comprises bioaugmentation, biopilling, bioreactors, composting and land farming. Ex situ technologies are advantageous when a safe and effective intervention is required (i.e, in the presence of severe contamination of highly hazardous compounds). Ex situ bioremediation techniques are usually considered based on the cost of treatment, depth of pollution, the development of a rich microbial population and elevated temperature characteristics of composting, the presence of these organic materials support the development of a rich microbial population and elevated temperature characteristics. Example- composting aerobic treatment process in which contaminated material is mixed with a bulking agent can be done using static piles or aerated piles. (R. Boopathy / Bioresource technology 74 (2000) 63-67).

Factors of Bioremediation

The control of the bioremediation process is a complex system of many factors including the existence of a microbial population capable of degrading the pollutant. The availability of contamination to the microbial population has a role in the environment. Types of soil, temperature, pH, the presence of oxygen and nutrients, etc. are the factors involved. The control and optimization of bioremediation processes is a complex system of many factors. (R. Boopathy/Bioresource technology 74 (2000) 63-67).

Table 1 Showing factors of bioremediation

Factors	Condition required	Optimum conditions
Microorganisms	Aerobic or Anaerobic	-
Environmental Factors	Temperature, pH, Oxygen content,	20-30 C, 6.5-8.0 pH, >0.2 mg/L DO,
Soil Moisture	25-28% of water holding capacity	-
Nutrients	Carbon, Nitrogen, Oxygen etc.	C:N:P= 120:10:1 molar ratio

(Asian Journal of Pharmacy and Life Science vol. 2(2), April- June, 2012).

Microorganisms can be isolated from different streams present in almost every different environmental condition. Conditions like extreme temperature, extreme pH, acidic environment etc. The aim requirement is energy and carbon source for the degradation of contaminants. Aerobic Bacteria such as *Pseudomonas, Alcaligenes, Sphingomonas, Rhodococcus*, and *Mycobacterium* have degradative properties to degrade pesticides and Hydrocarbons. (Bacteriol. 2014, 196, 3503-3515). Ligninolytic fungi such as the white rot fungus *Phanerochaete chrysosporium* have the ability to degrade an extremely diverse range of persistent or toxic environmental pollutants. (R. Boopathy/Bioresource technology 74 (2000) 63-67).

Methods applied in Bioremediation

Biostimulation

Biostimulation usually involves the addition of nutrients and oxygen to help indigenous microorganisms.if the soil has too much acid it is possible to rinse the pH by adding lime. These nutrients are the basic building blocks of life that allow microbes to create the necessary enzymes to break down the non-scientific contaminants affecting bioremediation. Several non-scientific factors hinder the development of bioremediation technology. Many industrial chemicals such as pesticide, chlorinated solvents and polynuclear aromatic hydrocarbons are not degraded so readily. (Aniefiok E. Ite, International journal of environmental bioremediation and biodegradation, 2019).

Bioaugmentation

Bioaugmentation is an alternate strategy for the bioremediation of oil contaminated environments, introducing a group of natural microbial strains or a genetically engineered variant to treat contaminated soil. (M. Vidali , (2001), 73, 1163-1172). At sites where soil and groundwater are contaminated with chlorinated ethenes, such as tetrachloroethylene and trichloroethylene, bioaugmentation is used to degrade ethylene and chloride contaminants which are non-toxic. (Iwamoto and Nasu, 92, 2001).

Composting

Composting is a process by which organic wastes are degraded by microorganisms, typically in the range of 55° to 65° C. The degradation of the organic material by microorganisms results from increased temperatures. Composting technique involves combining contaminated soil with non-hazardous organic amendments such as manure or agricultural wastes. The presence of these organic materials supports the development of a rich microbial population and elevated temperature characteristic of composting. (Environ. Ménage *et al.* (2019), 246, 840-848).

Landfarming

Land farming is Solid-phase treatment system for contaminated soils: may be done in situ or ex situ.Landfarming is a simple technique in which contaminated soil is excavated and spread over a prepared bed and periodically tilled until pollutants are degraded, stimulate indigenous biodegradative microorganisms and facilitate their aerobic degradation. In general, the practice is limited to the treatment of superficial 10-35 cm of soil. (M. Vidali, (2001), 73, 1163-1172). Landfarming generally refers to the process whereby hydrocarbon contaminated soils are spread out in a layer about half a meter thick, nutrients are added, and periodically the soils may be mixed. During landfarming, hydrocarbons can be lost through volatilization or bioremediation and thus landfarming refers to the combination of the two processes.Since landfarming has the potential to reduce monitoring and maintenance costs, as well as clean-up liabilities, it has received much attention as a disposal alternative. (Energies 2020, 13, 4664).

Table 2 Methods applied in bioremediation

Technique	Examples	Benefits	Applications
In situ	Bio augmentation	Naturally attenuated process, treat contaminated soil	Biodegradability of pollutants, Chemical solubility, Geological factors, Distribution of pollutants
Ex situ	Land farming	Cost efficient, Simple,	Surface application, aerobic process, application of organic materials to natural soils followed by irrigation and tilling.
	Composting	Inexpensive, self-heating Low cost Rapid reaction rate, Inexpensive, self heating	To make plants alternative to land filling or incineration is practical and convenient.

Contaminants for bioremediation

Polycyclic aromatic hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are widespread environmental pollutants which include benzene rings arranged in linear, angular or cluster ways (Li *et al*., 2014; Chen *et al*., 2015). PAHs have teratogenic, carcinogenic, and mutagenic properties and can pose a huge threat to human health through food-chain bioaccumulation (Moscoso *et al*., 2012).

Bacillus, Escherichia and Mycobacterium are the commonly found bacteria for PAHs and heavy metals bioremediation. They can break down PAHs such as anthracene, naphthalene, phenanthrene, pyrene in the presence of heavy metals. The combined effects of PAHs and heavy metals on bacteria or fungi in environment are much more complex than the separate exposures.Hydrocarbons are hydrophobic compounds with low water solubility, thus microorganisms have developed several mechanisms to increase the bioavailability of these compounds in order to use them as carbon and energy source.

The addition of SS compost into PAH-contaminated soil led to an almost complete decomposition of anthracene and pyrene but a weak removal of benzo[a]pyrene after 15 months (Hamdi *et al*., 2007). As a model substrate of PAHs, phenanthrene is ubiquitously distributed in the environment. Toxic phenanthrene tends to highly bioaccumulate in organisms (Shailaja and Rodrigues, 2003). The interaction between phenanthrene and tricyclazole in medium soil and the mixture of soil and compost was investigated, showing a negative effect on their degradation (Liu *et al*., 2008). °C. High temperature was considered adverse to microbial activity, and volatilization was the leading mechanism of PAH removal (Antizar-Ladislao *et al*., 2008).

Pesticides

Pesticides and chlorophenols entering the soil can bring environmental hazards, and influence soil properties involved in biochemical and microbial aspects. Thus, bioremediation of soils contaminated with pesticides and chlorophenols has drawn considerable research interest (M.Chen *et al*./ biotechnology/Advances 33 (2015) 745-755). Pesticide has also contributed to the extinction of useful organisms present in the soil. In the use of pesticides can result in various health and environmental problem like poisoning of farmers and farm workers, cardiopulmonary, neurological and skin discarder, fetal deformities, miscarriags, lauering the sperm count of applications etc. they are designed to kill or repel pests but may be harmful and fatal to other organisms including humans. pesticide contributes significantly to cancer mortality gilmo Yang *et al*. 2008. Pesticides have also contributed to the extinction of microorganisms useful for recovering soil among pesticides such as DDT chloro organic compounds, and atrazine parathon are of deep concern due to their tendency to accumulate. (Rennels D, Wolfet NL, *et al*. 2000. 34: 1663-1670).

Pesticides play an important role in enhancing yield and providing economical benefit. the use of pesticide not only degrade quality of soil but also infer the fate of pesticide , thus decontamination of pesticide polluted area is very complex effect of contamination may be seen in the loss of biodiversity and soil functioning . (M. Chen *et al*. Biotechnology Advances 33 (2015) 745-755).

Table 3 Some contaminants potentially suitable for bioremediation

Contaminants	Examples	Potential Sources
Polyaromatic hydrocarbons	Naphthalene, Anthracene, Pyrene, Benzo(a)pyrene	Oil production and storage.
Pesticides	Atrazine, 24D Parathon	Agriculture. Pesticides manufacture

Advantages and disadvantages of Bioremediation

Advantages

- Bioremediation have the main advantage that it does not use any toxic chemicals. Typically, it activates the microbial population and utilizes nutrients such as fertilizers. This process is additionally, less labor-intensive and is economical.
- Bioremediation is to convert harmful contaminants into harmless substances.
- It is an eco-friendly and sustainable approach that can destroy a pollutant.

- Bioremediation treatment is done properly, it also makes the soil fertile and it takes very little time (2001).
- Bioremediation is useful for the complete destruction of a wide variety of contaminants. Eliminates the chance of future liability associated with treatment and disposal of contaminated material. Many compounds that are legally considered to be hazardous can be transformed to harm-less products.
- This also eliminates the need to transport quantities of waste off site and the potential threats to human health and the environment that can arise during transportation.
- Bioremediation can often be carried out on site, often without causing a major disruption of normal activities.
- There is no accepted definition of "clean", evaluating performance of bioremediation is difficult, regulatory uncertainty remains regarding acceptable performance criteria for bioremediation and there is no acceptable endpoint for bioremediation treatment. (M. Vidali *et al*. (2001), 73, 1163-1172).

Disadvantages

- Bioremediation have the main disadvantage of technology is that it is restricted to biodegradable compounds. Sometimes the new product developed after biodegradation may be more toxic to the environment than the initial compound. further, researchers have revealed (2001).
- Not all compounds are susceptible to rapid and degradation that way there are some limited compounds of bioremediation that are biodegradable.
- Bioremediation takes longer than other treatment options, such as excavation and removal of soil or incineration. Products of biodegradation may be more persistent or toxic than the parent compound.
- Important site factors required for success include the presence of a metabolically capable microbial population, biological processes are often highly specific. Environmental growth conditions, and appropriate level of nutrients and contaminants.
- Bioremediation products may be more persistent or hazardous than the parent compound. (M. Vidali *et al*. (2001), 73, 1163-1172).

Applications

Bioremediation techniques are used to degrade highly toxic metals, chemicals, effluents and pollutants from the environment. Bioremediation is a process by which biological degradation processes function diverse metabolic capabilities of microbes to detoxify or remove organic contaminants.(Jaspers *et al*., 2002; Scelza *et al*., 2008; Semple *et al*., 2001). Bioremediation in composting manure compost has been successfully applied to the bioremediation soil with PAHs, pesticides, and other pollutants by providing a degrading matrix, available nutrients, and large number of active microorganisms. Composting is a promising technology for soil bioremediation due to its advantages over physical and chemical technologies. (Gonzalez-Lopez, J. (2009). 407(12), 3634-3640). As a remediation option, landfarming is ineffective in treating substances such as metals and complex PAHs, but may be useful for some volatile organic chemicals. on-site treatment of the chemical substances to reduce risk to an acceptable level, off-site treatment of excavated soil to reduce risk to an acceptable level, after which the treated soil is returned to the site, containment of soil on site with a properly designed barrier and disposal of affected soil to an approved landfill. (Azubuike, C. C., World Journal microbiology and biotechnology, 32(11), 1-18).

CONCLUSION

Since in addition to restoring the damaged ecosystem at low cost, it reduces the risk to health and preserves biodiversity, the bioremediation of contaminated soil is considered as an environmentally friendly, versatile and cheap technology. In more aspects the management of contaminated soils promoting the integration of sustainable socioeconomic activities may be created by the well- designed bioremediation project. Ex situ bioremediation techniques are biological processes for decontamination that involve the removal of contaminated material from its original position and its treatment either on-site or at another (e.g. biopiling, bioreactors, composting, and land farming). On the other hand, in situ bioremediation techniques are biological processes for decontamination that are performed with the contaminated material (soil and groundwater) left in its natural original position (e.g. bioaugmentation, bioventing, biosparging, biostimulation). The knowledge of the fate and behaviour of hydrocarbons in an impacted soil can help determine the persistence and degradability of the organic contaminant in the environment and subsequently, the success of any remediation method.

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