Bioremediation of organic xenobiotics (Review)

Mona S. Zaki[1], Nabila El Battrawy[2] , Samy I. Shalaby[3] and Refat A. Youssef [4]

[1]Department of Hydrobiology, National Research centre, Dokki, Giza, Egypt
[2]Department of Microbiology, Reproduction research Institute Egypt
[3]Department of Reproduction, National Research centre, Dokki, Giza, Egypt
[4]Department of Soil and Water Use, National Research centre, Dokki, Giza, Egypt
dr_mona_zaki@yahoo.co.uk

Abstract: Ligninolytic fungi or white rot fungi are found on wood and have lignolytic enzymes capable of oxidizing lignin and other organic material present in wood. Peroxidases and laccases are two types of ligninolytic enzymes secreted extracellularly and oxidise organic matter via a non-specific radical based reaction. Lignin Peroxidase (LP) and manganese peroxidase (MnP) are two types of peroxidase enzyme both of which are capable of oxidising PAHs. Lacassesare basically phenol oxidase enzymes and are also capable of oxidizing PAHs, There is significant interest surrounding the use of ligninolytic fungi to degrade PAHs, owing to their low substrate specificity and hence the capability to degrade even the most recalcitrant of compounds. Also, the enzymes involved are extracellular, and are theoretically able to diffuse into the soil or sediment matrix and potentiallyoxidise PAHs with low bioavailability.
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Factors affecting Bioremediation of organic xenobiotic

(a) Temperature:

Like petroleum bioremediation, organic xenobiotic bioavailability also increases thereby increasing their bioremediation rates. PAH degradation has been reported over a wide range of temperatures from 0°C in seawater to temperature as high as above 75°C in spent-mushroom compost (1-2).

(b) pH

Indigenous bacteria and other microorganisms usually do not act in acidic or alkaline conditions on organic xenobiotics. Phenanthrene degradation in liquid culture with Burkholderiacocovenenas, an organism isolated from a petroleum-contaminated soil was found to be better near neutral pH (3). A similar result was obtained with Sphingomonaspaucimobilis (strain BA 2) for the degradation of the PAHs phenanthrene and anthracene (4). Bioremediation at higher and low pH does occur but the rates are lower than the near neutral atmosphere hence liming so as to normalize pH is suggested.

(c) Oxygen

Though it has been confirmed that PAH degradation may occur even under anaerobic conditions, bioaugmentation of microbial communities by aeration usually has been found to speed up the remediation rates. Under high temperatures oxygen solubility reduces hence artificial aeration of affected sites may be required along with a rise in temperature so as to speed up the bioremediation reactions (5).

(d) Nutrient availability

Nutrient availability for organic xenobiotics is considered to be similar to the requirement for petroleum bioremediation. Carbon being in rich quantities other nutrients like nitrogen and phosphates might be a limiting factor thus fertilization is required(6).

(e) Bioavailability

Bioavailability can he defined as the effect of physicochemical and microbiological factors on the rate and extent of biodegradation and is believed to be one of the most important factors in bioremediation (7). These compounds are hydrophobic and therefore, poor bioavailablity. Moreover, organic xenobiotics can undergo rapid sorption to mineral surfaces (i.e. clays) and organic matter (i.e. humic and fulvic acids) in the soil matrix. Longer the PAH is in contact with soil, the more irreversible the sorption, and the lower is the chemical and biological extractability of the contaminant. This phenomenon is known as 'ageing' of the contaminant. Application of surfactants or use of organic solvents as discussed previously is usually done to increase the bioavailability(8).

Phytoremediation

Plants have long been exposed to different climatic and environmental conditions and therefore have been overcoming various stressors. Plants have evolved various ways to survive by utilizing different

substrates and cleaning up their vicinity so as to perpetuate. Phytoremediation makes use of this characteristic of plants to survive on different substrates. Phytoremediation consists of a set of innovative technologies for environmental cleanup that takes advantage of the unique extractive and metabolic capabilities of plants(9).

Conclusion:

Bioremediation is one such method which is ecofriendly, cost effective and cleans up the contaminants to quite an extent efficiently. But, slaw pace and threat from genetically modified organisms to biodiversity may be deterrents to this technology. Bioremediation by itself may not be a complete solution to the problem of contamination but mixing physical and chemical remediation techniques with bioremediation may be an answer to complete remediation of natural resources.

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