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Review

Contemporary enzyme based technologies for bioremediation: A review

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A B S T R A C T

The persistent disposal of xenobiotic compounds like insecticides, pesticides, fertilizers, plastics and other hydrocarbon containing substances is the major source of environmental pollution which needs to be eliminated. Many contemporary remediation methods such as physical, chemical and biological are currently being used, but they are not sufficient to clean the environment. The enzyme based bioremediation is an easy, quick, eco-friendly and socially acceptable approach used for the bioremediation of these recalcitrant xenobiotic compounds from the natural environment. Several microbial enzymes with bioremediation capability have been isolated and characterized from different natural sources, but less production of such enzymes is a limiting their further exploitation. The genetic engineering approach has the potential to get large amount of recombinant enzymes. Along with this, enzyme immobilization techniques can boost the half-life, stability and activity of enzymes at a significant level. Recently, nanozymes may offer the potential bioremediation ability towards a broad range of pollutants. In the present review, we have described a brief overview of the microbial enzymes, different enzymes techniques (genetic engineering and immobilization of enzymes) and nanozymes involved in bioremediation of toxic, carcinogenic and hazardous environmental pollutants.

Contents

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1. Introduction

A large number of pollutants such as polychlorinated biphenyl compounds (PCBs), hydrocarbons, dyes, pesticides, esters, heavy metals, petroleum products and nitrogen containing chemicals persist in the environment which are released from various industrial and agricultural resources (Dua et al., 2002). These pollutants are highly toxic and carcinogenic in nature and accumulations of these chemicals becomes hazardous to the environment and also flora and fauna living in the environment (Wasilkowski et al., 2012). Recently, removal and degradation of pollutants are major problem for environmental scientists. Initially, wastes released from various industries and agricultural resources were treated by dumping off in a hole, high temperature based incineration and using UV rays. But these methods don't prove very effective due to their less effectiveness, complex nature, high cost and formation of others recalcitrant derivatives (Vidali, 2001). After that, bioremediation provides a way for the degradation of these chemicals (Dzionek et al., 2016).

Generally, bioremediation involves the use of microorganisms and their enzymes for the degradation and transformation of pollutants into another form which is less toxic to the environment. Various species of archaea, bacteria, algae and fungi's demonstrating bioremediation ability have been discovered (Dua et al., 2002). Plants and their associated bacteria also play a significant role in the degradation of compounds present in the soil and air. Use of plants for the purpose of removal of contaminants is known as phytoremediation (Pattanayak and Dhal, 2014). Plants such as *Cyperus brevifolius* and *Helianthus annuus* have the ability to secrete some oxidative enzymes from their roots for the biotransformation of highly toxic recalcitrant chemical compounds into their less toxic derivatives (Adongbede and Majekodunmi, 2016).

Use of microbes and their enzymes for the removal of pollutants is an effective, safe and less expensive method (Karigar and Rao, 2011). Advances in molecular and recombinant DNA technology, genetic machinery of the plants and microorganisms can be changed to enhance the bioremediation (Vallero, 2016; Kumar et al., 2016). There are several types of enzymes such as oxidoreductases, laccases, hydrolases and peroxidases actively involved in bioremediation process (Kadri et al., 2017). Different fields of bioremediation such as microbial, enzymatic including phytoremediation and their strategies are depicted in Fig. 1.

Several environmental parameters such as temperature, moisture content and pH change the microorganism growth. Manipulation and optimization of these parameters can increase the rate of degradation at significant levels (Guarino et al., 2017). There are only a few species of algae (*Monoraphidium braunii*, *Chlamydomonas reinhardtii* etc.), fungi (*Tramates versicolor, Pleurotus eryngii, Phanerochacte chryososporium* etc.) and bacteria (*Pseudomonas aeruginosa, Rhodococcus erythropolis* etc.) have been discovered which have a catabolic pathway for the degradation of pollutants at the sites of pollution. Some species of microorganisms have the ability to degrade contaminants only in laboratory conditions (Joutey et al., 2013).

In this review, our aim is to discuss the bioremediation, its types, major enzymes involved in bioremediation of recalcitrant and harmful chemicals which are toxic to the environment. We have also described the current limitations of enzymes and the

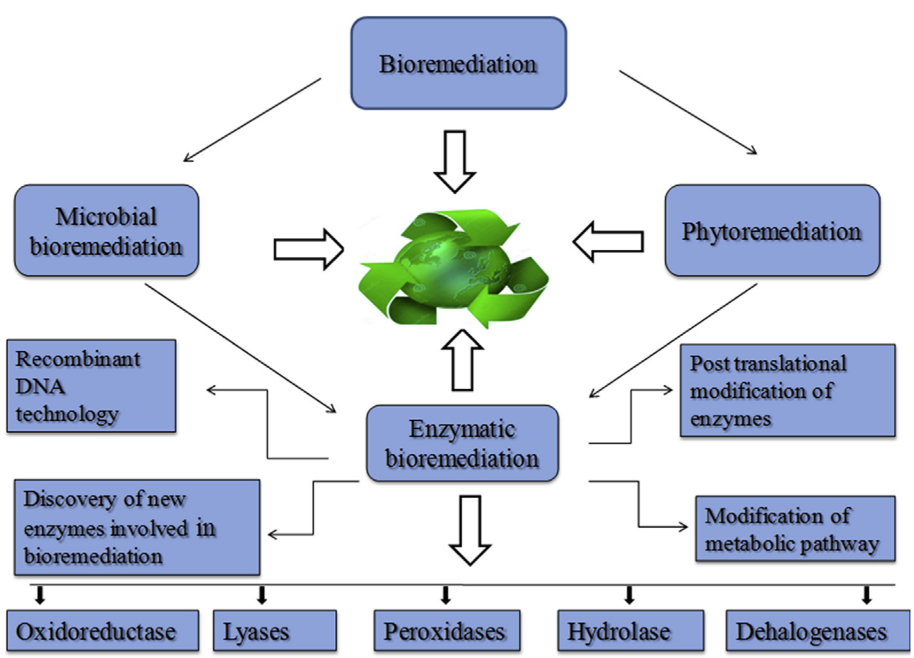

Fig. 1. An overview of combinatory methodologies for bioremediation.