Chapter 4
The Use of Microorganism-Derived Enzymes for Bioremediation of Soil Pollutants

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ABSTRACT

Contamination of soils by xenobiotic compounds is a growing concern for environmentalists amidst the rise of anthropogenic activities that encourage such contamination practices. The use of microbial enzymes is a viable alternative to degrade and mineralize these contaminants, which is a growing research interest owing to its eco-friendly nature. This chapter explores the categories of enzymes used in soil bioremediation such as oxidoreductases and hydrolases, their mechanism of action, and their merits and demerits. Furthermore, molecular biology techniques useful in enhancing the production capacity, stability, activity, and shelf life of bioremediation enzymes is discussed. Ultimately, the need to develop bioremediation enzymes in bulk, using cheap technologies while optimising their activity, stability, and shelf life for effective soil decontamination is emphasized.

INTRODUCTION

Environmental contamination by hazardous compounds that bioaccumulate and resist degradation is one of the world's contemporary ecological problems. Contamination emanates mainly from agricultural, mining and industrial activities. Production of contaminants is promoted by advances in technologies used in the chemical industry leading to ease in production of dyes, solvents, explosives, pesticides, plastics and fuels. Contamination by these chemicals is long-term and has negative effects to human health and the environment due to their high toxicity and persistence (Godheja, Sk, Siddiqui, & Dr, 2016). Additionally, pollution interferes with nutrient cycles and decomposition capacities of soils. A

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case example is the excess use of agrochemicals that is reported to pollute land and water resources that affect humans and other animals once they are incorporated in the food chain.

Cleaning up polluted areas such as soils by removing these pollutants is a growing challenge that requires the use of various technologies so that their levels can be acceptable and cause no harm. Some of the physico-chemical methods used apply biological agents such as microorganisms and plants. Of focus in recent research, is the microbial remediation of xenobiotics, which unlike physicochemical methods, which is cost effective in cleaning polluted soils (Piotrowska-Długosz, 2017). This microbial bioremediation may occur as either bio-augmentation or bio-stimulation. The former is the process of introducing non-native microorganisms such as pollutant- degrading bacteria in contaminated environments to enhance remediation reactions (Sharma, Dangi, & Shukla, 2018). Bio-stimulation on the other hand, entails modifying the environment to enhance the reaction of native bacteria that help in bioremediation processes. These modifications include the addition of electron acceptors and reaction controlling nutrients such as nitrogen, carbon, oxygen and phosphorous (Karigar & Rao, 2011). Specific plant or animal-origin and microbiological enzymes facilitate these microbiological reactions. In particular, cell-free enzymes instead of whole organisms are used in these reactions because they grow independent of nutrients (Rao, Scelza, Scotti, & Gianfreda, 2010). This chapter explores the potential of microbial enzymes in remediating xenobiotics in soils.

THE CONCEPT OF ENZYMOLOGY IN SOIL POLLUTANT BIOREMEDIATION

Enzymes are proteins that speed up biochemical reactions without being changed. To enhance the conversion of reactants to products, enzymes lower activation energy used during the process (Piotrowska-Długosz, 2017). Regions of enzymes involved in catalytic processes are known as active sites whose association with the rest of the protein occur through covalent or non-covalent bonding. An enzyme may have one or more essential catalytic groups or active sites. These are known as apoenzymes if they are made of protein or prosthetic group if they are nonproteins or holoenzyme if it is a combination of the two (Karigar & Rao, 2011). The nomenclature of enzymes is related to their catalytic group, their function and/or the reactions that they catalyse. Identification and classification of enzymes is dependent on their enzyme commission (EC) number, which is defined by the international union of biochemistry and molecular biology[1] (Karigar & Rao, 2011). All enzymes are categorised in six groups: - synthetases also known as ligases, isomerases, lyases, hydrolases, transferases and oxidoreductases.

The use of enzymes in soil decontamination from xenobiotics is advantageous unlike the use of classic microorganisms since the proteins have some unique aspects. Enzyme activity in the soil is associated with different locations and sources. Sources are mainly plant or microbial origin. Their location maybe extracellular or intracellular environments (Piotrowska-Długosz, 2017). In the former, enzymes are in the aqueous phase and occur as temporarily distinct from the substrate or as a complex with organic colloids and clay minerals. In the latter, enzymes occur in non-multiplicative or multiplicative cells and/or cell debris of in dead cells. The locations and sources of these proteins make their associations with soil biological and physicochemical features close. It is because of this relationship that environmental pollution, agricultural practices and human activities influence enzymatic activities in soils (Cele & Maboeta, 2016). Enzymes can therefore be used to optimise short and long-term modifications in soils. According to Piotrowska-Dlugosz (2017), many environmental and human-activity based factors that modify soil quality are attributable to changes in its physicochemical aspects but concurrently, they modify

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