Chapter 8
Biodegradation of Xenobiotic Compounds: An Overview

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ABSTRACT

The continuous accumulation of recalcitrant xenobiotic compounds into the ecosystem released from various sources caused a serious global concern. Xenobiotics compounds are carcinogenic, mutagenic, causing teratogenic effect and persist over a long period of time in the environment. Therefore there is an urgent need for the detoxification of these compounds. Biodegradation is a technique that employs natural biological processes to completely degrade toxic contaminants from the environment. The microorganisms possess a wide range of catabolic biodegradation pathways and, thus, use these toxic xenobiotics as the sole source of carbon and energy. Bacteria and fungi are source of xenobiotic degradation. For the development of successful and improved bioremediation processes, understanding of the biochemical and molecular aspects of xenobiotics biodegradation is required. The chapter aims to provide an overview of xenobiotic compounds, factors affecting biodegradation, the metabolic pathways and genetic adaptation in microorganisms for degradation of recalcitrant xenobiotic compounds.

INTRODUCTION

Environmental pollution caused by the release of a wide range of compounds as a consequence of industrial progress has now assumed serious proportions. It has dramatically changed every aspect of human life and lifestyles (Jain et al., 2005). The industries develop and manufacture diverse group of compounds that improve human's life, but most of them are highly toxic and have adverse effects on biomes. Therefore, the removal of such chemicals from industrial effluents is of great concern (Das & Kumar, 2015). For quite a long time, humans assumed that atmospheric, terrestrial, and aquatic systems were sufficient to

DOI: 10.4018/978-1-5225-2325-3.ch008

absorb and break down wastes from population centres, industry, and farming. In any case, this is not valid. Today there are two major issues: the dumping of vast amounts of wastes that are being continuously produced and evacuation of the harmful toxic compounds that have been accumulating at dump sites in the soil and in water systems over the last few decades. Thus in this way natural conditions have enormous impact on the living beings. Both natural and manmade activities result in accumulation of wide ranges of harmful xenobiotic compounds in the earth, and along these lines cause a worldwide concern. In the past, wastes were disposed by digging hole and filling it with waste material (Versha, Ch, & Chenna, 2011). This mode of waste disposal was difficult to manage owing to lack of new place every time to dump. New advancements for waste disposal that use high-temperature incineration and chemical decomposition (e.g., base-catalyzed dechlorination, UV oxidation) have developed. Although they can be very effective at reducing wide range of contaminants but at the same time have several disadvantages. These strategies are complex, uneconomical, and also generate other toxic byproducts. The associated inadequacies in these techniques have centered efforts towards harnessing advanced bioremediation process as a suitable alternative. Biodegradation is a viable bioremediation technology for organic pollutants by using microorganisms to remove or detoxify toxic or unwanted chemicals in an environment. A goal of bioremediation is to transform organic pollutants into harmless metabolites or mineralize the pollutants into carbon dioxide and water. It has been considered as a cost-effective, safe, and promising method for the removal or detoxification of DDT residues in the environment (Pan et al., 2016). The present chapter emphasizes an outline of the current knowledge in the area of biodegradation of wide range of pollutants with emphasis on the biodegradation processes for better exploitation of microbial abilities in bioremediation challenges.

XENOBIOTIC COMPOUNDS

The word, xenobiotic is a combination of two distinct roots “xeno” and “biotic.” The word xeno is derived from Greek which means strange, unnatural, or different while biotic is a word that implies life. Xenobiotic, therefore, refers to an organic compound that imitates natural biochemicals that are crucial for life, but are strange and unnatural. The xenobiotic compounds are highly thermostable thus persists in the environment. Xenobiotics are often toxic to life. Also, they may not be recognized by biochemical processes in plants and microorganisms and are thus resistant to degradation in the environment. Primarily, xenobiotics are those compounds that are alien to a living individual and have a propensity to accumulate in the environment. Xenobiotics include many compounds that are used in both industrial and agricultural activities. The major xenobiotics include pesticides, fuels, solvents, alkanes, polycyclic hydrocarbons (PAHs), antibiotics, synthetic azo dyes, pollutants (dioxins and polychlorinated biphenyls), polyaromatic, chlorinated and nitro- aromatic compounds. The main issue with xenobiotic compounds is the toxicity threat they pose to public health. It is quite shocking that some xenobiotic compounds (phenols, biphenyl compounds, phthalates, etc.) act as endocrine disruptors (Borgeest, Greenfeld, Tomic, & Flaws, 2002).

There is growing public concern over the wide range of xenobiotic compounds being introduced inadvertently or deliberately into soil. Such contamination can be long term and have a significant impact on both decomposition processes and thus nutrient cycling. For example, the widespread incorporation of herbicides into soil every year constitutes a major concern since they can potentially pose a threat to our health as well as to the quality of soil, surface water, and groundwater resources.