Chapter 78
Bacterial Remediation of Phenolic Compounds

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ABSTRACT

Environmental pollution has been an irrefutable fact of life for many centuries; but it has become a real problem, since the start of the industrial revolution. Discharge of these toxic compounds without treatment results in serious health risks to humans and the marine ecosystem. Several physical, chemical and biological methods have been employed for the remediation of the phenolics. Bioremediation is identified as the most efficient, cost effective and eco-friendly ways for treatment of phenolic compounds. This article is a comprehensive review on the sources of phenolic compounds, their hazards, and their fate once released into the environment; the treatment technologies employed and bioremediation of these compounds using both non-extremophlic and extremophilic organisms. The review, throws light on the enzymes involved in the remediation of phenolic compounds, highlights the importance of extremophilic organisms and biological treatment of phenol containing industrial wastewaters. Such comprehensive information on the research work performed for the remediation of phenolic compounds provide ways to explore the role played by micro organisms in the remediation of phenolic compounds, which could be applied in the remediation of phenol /contaminated sites even under extreme conditions.

INTRODUCTION

Environmental pollution is a by-product of modern industrial society. With the immense growth of industries, a major problem is encountered with regards to the contamination of the environment with hazardous chemicals (Lakshmi & Sridevi, 2009).

The release of man-made (anthropogenic) organic compounds into the environment poses a very serious risk to public health. Phenolics, are one among the major pollutants, are discharged into the wastewater from the various industries such as phenol resin and pharmaceutical, oil refineries, petrochemical plants, ceramic plants, steel plants, herbicide manufacturing, fibre glass manufacturing and petrochemicals (El-

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Ashtoukhy et al., 2013; Veeresh et al., 2004; Jadhav & Vanjara, 2004) and coal conversion processes. Phenol is the basic structural unit in a wide variety of synthetic organic compounds. Due to their toxic nature, these molecules tend to accumulate in water and soil after being discharged without an adequate treatment. Phenol at a concentration as low as 5 mg/L, imparts typical smell upon chlorination. The World Health Organization (WHO) prescribes 1 mg/L as the permissible concentration of phenol in drinking water (Saravanan et al., 2008).

Phenol and its derivatives are some of the major hazardous compounds in industrial wastewater (Watanabe et al., 1996b; Peters et al., 1997). Carbolic acid (hydroxy benzene) and cresols are antiseptic agents used in disinfection, which indicates that they are toxic to microbes. For instance, phenol is released into water from industrial effluent discharges such as petroleum refinery wastewater (Pfeiffer, 1979) and from other industrial discharges (Hawthorne & Sievers, 1984). Phenol has been detected in groundwater due to leaching of phenolic compounds through soil after leakage of phenol (Delfino & Dube, 1976), from landfill sites (Clark & Piskin, 1977), and from hazardous waste sites (Plumb, 1987). Therefore, phenol needs to be disposed-off in a safe and environmentally acceptable way to preserve the environmental quality.

Wastewater generated from various industries like pharmaceutical, textile, tannery which have high pH, salinity, Total dissolved Solids and recalcitrant compound which posses' potential hazards to the environment. Thus the wastewater becomes difficult to treat with conventional microorganisms as high salt and pH content induces cell lysis; hence there is need for microorganisms which can withstand extreme levels of pH, salt content and will degrade the recalcitrant phenolic compounds present in the wastewater and contaminated sites.

A goal of bioremediation is to transform organic pollutants into harmless metabolites or mineralize the pollutants into carbon dioxide and water. A feasible remedial technology requires microorganisms being capable of quick adaptation to and efficiently uses the pollutants of our interest in particular case in reasonable period of time.

This chapter would be a comprehensive review that outlines the sources of phenolic compounds, hazards, their treatment technologies and biological degradation using both non-extremophlic and extremophilic organisms. Therefore the present review focuses on types of pollution caused by the phenolic compounds and the health problems associated with the release of such xenobiotic compounds. The review also focuses on the different ways of remediation of the phenolic compounds and the importance of using extremophiles in the removal of the recalcitrant compounds underlining the importance of extremophilic microorganisms in the treatment of phenol laden- wastewaters and phenolic compounds contaminated sites.

Sources of Phenolic Compounds

The phenol originates in the environment either form natural, man-made and endogenous habitats .Phenol primarily enter the waters from industrial effluent discharges. Phenol is a mono-hydroxy derivative of benzene and the substituent with chloro, nitro, methyl etc that are named as derivatives of phenols or collectively referred to as "Phenolics" in wastewater. The sources of phenol in the environment are shown in Figure 1.