Chapter 3
Insight of Proteomics and Genomics in Environmental Bioremediation

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ABSTRACT

Bioremediation of hazardous substances from environment is a major human and environmental health concern but can be managed by the microorganism due to their variety of properties that can effectively change the complexity. Microorganisms convey endogenous genetic, biochemical and physiological assets that make them superlative proxies for pollutant remediation in habitat. But, the crucial step is to degrade the complex ring structured pollutants. Interestingly, the integration of genomics and proteomics technologies that allow us to use or alter the genes and proteins of interest in a given microorganism towards a cell-free bioremediation approach. Resultantly, efforts have been finished by developing the genetically modified (Gm) microbes for the remediation of ecological contaminants. Gm microorganisms mediated bioremediation can affect the solubility, bioavailability and mobility of complex hazardous.

INTRODUCTION

The habitat is gifted with rich wealth of natural resources such as forests, wildlife, land, soil, air, water, wind, plants and animals. Rivalry, humans started civilization and started to use and overuse, and now the misuse of natural resources like exploitation of natural resources by the use of chemical fertilizers in agriculture, release of industrial waste, anthropogenic activities and burning of fossil fuels etc. Resultantly, a huge waste products generated in the natural niche. In current scenario, these waste products have varieties from raw sewage to nuclear waste. In the past disposal of these wastes intended to digging a hole and dumping then filling all wastage to it. However, these days, it has become insufficient due to heavy amount of wastage. Crucial stage has begun after the presence of toxic wastage among these

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"dig and dump" sites. These toxic materials have begun to leak into water sources and into areas that sustain human life. This problem has led to modern-day bioremediation, always been a serious problem. Bioremediation is classically defined as the transformation or degradation of contaminants into non-hazardous or less hazardous chemicals (Hornung, 1997).

In general, millions of chemicals are commercially omnipresent in our daily activity (According to American database CHEMCATS). The minimization of the impact of potential pollutant is inevitability for environmental protection agencies, researchers, industries, and society as a whole. Deliberate releases of oil can also a major source of extensive contamination. Every year, 1,300,000 tonnes of oil enter the environment, for the utmost part through natural petroleum seeps. Gulf War (1991) was the critical example of oil as hazardous pollutant while it started menacing the desalination plants and coastal ecosystems of the Gulf after releasing of 0.82 megatonnes oil in Kuwait (Pearce, 1993). The facts that beach are not continuously covered with tar balls is due to the activity of microorganisms that can degrade the released petroleum. Unfortunately, some common environmental aromatic pollutants like BTEX (benzene, toluene, ethylbenzene and xylene), derived from petroleum derivatives such as gasoline. But, these hazardous compounds miraculously degraded commonly by the species of the genera *Alcanivorax, Cycloclasticus* and *Thalassolituus*, which can degrade various branched-chain and straight-chain saturated hydrocarbons and even polycyclic aromatic hydrocarbons; in fact, for some species hydrocarbons are the sole carbon source (Head et al., 2006). Although plants are the main producers of aromatic compounds, they lack degradation pathways that could recycle carbon from these substances.

Remarkably, Europe has been reflecting as examples to create the law for any type of uses of chemical, required the Registration, Authorization and restriction of Chemicals (REACH) regulations for biodegradability evaluation of high-production-volume organic chemicals (UE, 2006). Moreover, the abundance of hazardous going at high level risk due to their substance-specific assets, the outcome of each chemical in the environment diverges according to its mode of utilization and way of discharging (Federle & Vink et al., 1997).

Bioremediation of environmental niches such as soil, sediments and water are polluted with petrochemicals, metals or radionuclides can be accomplished through biologically encoded changes in the oxidation state (Wang et al., 2012) has concluded that changes in speciation like detoxification of mercury by methylation [$Hg(CH_3)_2$] can modify the solubility, transport properties and toxicity of radionuclides. The strategies of bioremediation of petrochemicals, metals as well as radionuclides hazardous depend on the active metabolizing capabilities of microorganisms. These pollutants can be solubilized by enzymatic reduction through oxidative reduction, change in pH and Eh (activity of electrons), biodegradation via organic complexes or biosorption by biomass (Law et al., 2010; Hegazy & Emam, 2011). Biotransformation of pollutants through microbial activity can be prominently influenced by electron donors and acceptors, nutrients, and environmental factors. Some possible mechanistic linkages of metalo-remediation via microorganism is represented in the Figure 1.

Therefore, we can say that degradation of aromatic substances is dominated by aerobic and anaerobic bacteria and aerobic fungi (Fuchs et. al., 2011). Regrettably, the aromatic compounds have less reactivity to chemicals and are basically attacked with the help of O_2 by oxygenases (Hayaishi, 2008) and derived the compounds like catechol (1,2-dihydroxybenzene) (in bacteria) or proto- catechuate (3,4-dihydroxybenzoate) (in most fungi and some bacteria) as principal intermediates (Dagley et. al, 1960; 1964; 1971; Ornston &Stanier 1966; Stanier & Ornston, 1973; Harwood& Parales,1996). This peripheral degradation has been performed by ring-cleaving dioxygenases that catalyses the central-ring cleavage (Lipscomb,