Chapter 4
Role of Microbes in Eco-Remediation of Perturbed Aquatic Ecosystem

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ABSTRACT

Anthropogenic and natural hazards put aquatic ecosystem under severe stress due to organic and inorganic pollutants and calls for remediation. Eco-remediation, an ecological blessing for ecosystem stabilization refers to the restoration of the perturbing ecosystem to its original balanced state with a multi-purpose approaches for removing pollutants by vast array of biological components. Aquatic habitats and biodiversity are adversely affected by indiscriminate pollution along with rising levels of carbon dioxide. To overcome the aquatic stress of various pollutants, microorganisms significantly imparting crucial roles in environmentally sustainable bioremediation approaches by adapting themselves in order to survive in perturbed ecosystems resulting in the environmental remediation. This chapter attempts to deal with eco-remediation of ecosystems perturbed by various hazardous pollutants by focusing the degrading and transforming of contaminants into less toxic forms by microbes and carbon sequestration through heterotrophic pathway applying different ex situ or in situ detoxifying mechanisms. Considering the high eco-remedial efficiencies, microbial eco-remediation technologies could be applied as an emerging approach in restoring perturbed aquatic ecosystems in ecological engineering systems.

DOI: 10.4018/978-1-5225-2325-3.ch004

INTRODUCTION

Restoration of the perturbing ecosystem to its original balanced state or resilient state is a multi-purpose approach aimed to improve self-cleaning capacity of elements of ecosystem (Bhakta et al., 2016). Globally referred to as eco-remediation its main environmental benefits include stability of groundwater, enrichment of habitats, increased biotic diversity and, therefore, the growth in biomass and improved (Bardgett & van der Putten, 2014). The desperate need for ecosystem remediation originates as a result of introduction of diverse types of organic and inorganic pollutants both as a result of anthropogenic and natural hazards which put aquatic ecosystem under severe stress (Rombouts, Beaugrand, & Artigas, 2013; Boldt, Martone, & Samhouri, 2014). World aquatic ecosystems are increasingly being perturbed by various types of natural perturbations, including droughts, storms and floods (Hogan, 2010) affecting the organisms as well as the entire biosphere of aquatic ecosystems. A recently focused threat of aquatic ecosystem is nutrient pollution by phosphorus and nitrogen enrichment of aquatic bodies leading to algal bloom and eutrophication (Grizzetti, Bouraoui, & Aloe, 2012). Additionally, the greatest concern of the stress at the microbial level of the freshwater ecosystem where a bulk of biological production and nutrient cycling takes place, is due to the impact of human induced pollution and habitat alteration (Carpenter, Stanley, & Vander-Zanden, 2011; Aracic, Semenec, & Franks, 2014). Due to increasing organic and inorganic pollutants input the natural self-purification capacity of any aquatic environment is highly affected by dwindling decomposing abilities of microorganisms. Inorganic contaminants, in particular heavy metals, are also a prominent environmental concern because they are not biodegradable and can accumulate in living organisms (Bittsanszkya et al., 2005; Fu & Wang, 2011).

The ubiquitous nature of microorganisms and their ability to tolerate the variety of anthropogenic stresses (Crawford & Crawford, 2005) by degrading and transforming environmental contaminants into less toxic forms (Kot & Namiesńik, 2000) as well as carbon sequestration through heterotrophic pathway have made them primary candidate for exploitation in remediation and can be used as signature for eco-remediation. For their survival in heavy metal-polluted habitats, microorganisms have developed and adopted various different detoxifying mechanisms such as biosorption, bioaccumulation, biotransformation and biomineralization, which can be further exploited for bioremediation either *ex situ* or *in situ* (Lin & Lin 2005; Elekwachi, Andresen, & Hodgman, 2014). Pathogenic bacterial contamination of water can be effectively controlled by using bacteriophages (Aracic et al., 2014). It has been reported that microbes can be managed to enhance organic matter sequestration in soils, sediments and aquatic system to remove CO_2 from the atmosphere and reduce greenhouse warming (Lal, 2008; Savage, Afonso, Chen, & Silver, 2010; Gray & Engel, 2013).

Detoxification mechanism of bacterial and micro-algal populations surviving in metal contaminated environments and helping in metal bioremediation and nutrient reclamation from polluted aquatic system have been analysed by molecular tools (Jansson, Björklöf, Elvang, & Jørgensen, 2000; Gambhir, Kapoor, Nirola, Sohi, & Bansal, 2012). An extracellular polymeric substance (EPS) produced by a variety of bacteria has been demonstrated to be a potential bioemulsifier used in the degradation of hydrocarbons as well as biosorbing agents accumulating nutrients and heavy metals (Orsod, Joseph, & Huyop, 2012).

Traditional treatment technologies to produce high quality drinking water have to be modernized by developing materials and methods which are more efficient, cost-effective and environmentally sustainable such as eco-remediation (Schindler, 2012) or reuse of wastewater to restrict the worsening quality of drinking water (Gambhir et al., 2012).