Chapter 3
Microbes and Their Role in Bioremediation of Soil: A Detailed Review

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ABSTRACT

Soil is the Earth's shell and is getting polluted in a number of ways in the present scenario. Human activities are the root cause of different types of soil pollution, which is an alarming issue and has become a major obstacle that needs to be overcome to build a cleaner environment. The area of polluted soil is widening day by day by virtue of a sharp increase in people from all over the world. It has been expected that the global population will continue to increase up to 9 billion by 2050, and such prodigious population may be in need of advanced agricultural and industrial systems, which may inevitably cause soil pollution. Therefore, it is essential to control soil pollution, and fortunately, the solution for this is microbes that are the real creatures of life on Earth. In fact, microorganisms play a unique role in the detoxification of polluted soil environments, and in the last several years, this process has been called bioremediation. Remediation of polluted soils is necessary, and research continues to develop novel, science-based remediation methods.

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INTRODUCTION

Soil on the surface of the earth is a diverse natural entity which is home to a large amount of living elements, including plants, animals and microbes that communicate with each other (Dwivedi, 1997). Soil filters water, decomposes waste, stores heat and exchanges the gases and therefore have great bearing on environmental balance. As the life on earth mainly concentrates on the top of soil, hence, it is extremely important to pay attention on pollutants or hazardous substances affecting predominantly the soil ecosystems. In the past few years an estimated 12.6 million people have lost their lives worldwide from more than 100 diseases resulting from unhealthy environments such as contaminated soils (WHO, 2016). The formation of 1 cm top layer of soil requires 100-400 years (Chandra & Singh, 2009). Soil is the layer of mixture of inorganic and organic material, where inorganic part is composed of fine rock particles produced as a result of weathering and the organic part is produced by decay of plants and animals. Life is believed to emerge from the soil and is an integral part of the environment, ecosystem and also an important natural resource for plant growth, and is a repository for biogeochemical cycle. Soil is highly susceptible to environmental transformations (Yu, 2016) and is often the most important sink for environmental pollution due to its strong binding capacity (Sun et al., 2017). According to Rodriguez et al. (2018), soil pollution is defined as the presence of chemicals or substances in the soil that are inappropriate or at an increased concentration than normal with deleterious effects on any non-target organism. A contaminant is an unwanted substance introduced into the environment. Harmful effects by contaminants lead to pollution, a process by which a resource (natural or man-made) is rendered unsuitable for use. Plants, animals and aquatic life depend on soil for their survival. Plants relay upon soil for anchorage, nutrients, water and even oxygen. The soil influences the distribution of plant species and provides a habitat for a large number of organisms such as both micro and macro organisms. Soils are essential for biodiversity conservation above and below the ground. Huge amount of chemicals employed in day to day lives and excessive amounts of urban, industrial and agricultural wastes, mining etc., have all led to soil contamination across the planet and also leaving it barren and deteriorated.

Industrialization and extensive use of chemical compounds such as petroleum products, hydrocarbons (aliphatic, aromatic, polycyclic aromatic hydrocarbons (PAHs), BTEX (benzene, toluene, ethylbenzene and xylene), chlorinated hydrocarbons such as polychlorinated biphenyls (PCBs), trichloroethylene (TCE) and perchloroethylene, nitroaromatic compounds, organophosphorus compounds) pose an alarming threat to crop production, food safety, and for the health of citizens. Since soil quality is directly linked to food security, human health and sustainable economic and social progress, soil pollution management is important (Esmaeili et al., 2013; Wan et al., 2018). Biological life prevailing in a gram of soil includes tiny microbes such as algae, actinomycetes, bacteria, bacteriophages, protozoa, nematodes and fungi. The role of these organisms is highly complex and form an integral part of cycling the nutrients through the environment and they drive the processes such as decomposition, mineralization, storage and release of nutrients, breakdown of pollutants before they reach groundwater or surface water, carbon cycling, carbon sequestration, and soil organic matter transformations, nitrogen cycling (N fixation, denitrification, nitrification).

The biological transformation by the action of microorganisms led to development of abundant nutrients (Kiflu & Beyene, 2013). Soil microbes are the principal participants of all the soil biochemical processes. These biochemical processes are devices for soil quality stabilization, soil organic matter production, hazardous material decomposition, soil structure formation and physiological cycles. Soil degradation by harmful metals reduces the microbial properties of the soil, such as soil respiration and