Chapter 3
An Overview of the Potential of Bioremediation for Contaminated Soil from Municipal Solid Waste Site

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Abstract The soil contamination due to open disposal of municipal solid waste has become a serious issue particularly in the developing countries. Several studies have revealed variable impacts of pollutant toxicity on the environment and exposed inhabitants. This chapter provides an overview of the application of bioremediation of sites contaminated owing to municipal solid waste. The application of bioremediation technologies and well-organized mechanisms for environmental safety measures of these methods were discussed. Because some pollutants can be seriously affect to the environment, the chapter furthermore suggests strategies for better remediation of site. In addition, more detail studies exploring the linkage between the fates, and environmentally important factors are necessary to better understand the parameters on using bioremediation technologies.

Keywords Municipal solid waste · Soil contamination · Heavy metals · Pollutants · Bioremediation

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1 Introduction

Municipal solid wastes (MSW) mainly include domestic waste generated from community or local municipality. In most of countries, the MSW are produced from mainly three sources: (a) Waste from households and public areas, including waste collected from residential buildings, litter bins, streets, marine areas, and country parks- known as domestic solid waste (b) Waste from shops, restaurants, hotels, offices, and markets in private housing estates known as commercial solid waste, and (c) Waste from industries, excluding hazardous waste- known as industrial solid waste (Chen et al. 2016; Stenuit et al. 2008).

In this context, it has been estimated that approximately 1.3 billion tons of MSW are generated every year worldwide, which is growing quickly as result of rapid growth and development, urbanization, resource consumption, and "Use & Throw" lifestyles become more common. The total volume of MSW production worldwide is estimated to be double in 2025, mainly in developing countries (Hoornweg and Bhada 2012).

Open dumping is a common practice among in several developing countries. In detail, an open dumping is a process where solid wastes are being disposed-off in a way which does not take care the surrounding environment, and is resulting exposed to the human health risk. MSW contain a different type of pollutants such as, heavy metals, and organic pollutants (Gautam et al. 2012). Also, the degradation of the MSW releases gases for example; volatile organic compounds (VOCs) and benzene, toluene, ethyl-benzene, and xylene isomers by oxidation of CO_2, CH_4, and their derivatives. The contaminants turn out in the leachate form and holding a significant level of pollutants is a common incidence in most of the MSW site of developing countries (Gautam et al. 2012; Mani and Kumar 2014).

Therefore, with rapid rising of population and decrease natural resources, it is very important and required to adopt safe disposal methodologies and develop appropriate remediation technologies for soil (Stenuit et al. 2008; Rayu et al. 2012; Bharagava et al. 2017). Soil remediation is the process of returning their functional that existed before to contamination. Different techniques exist for remediation of soil contaminated. This could be through physical, chemical and biological approaches. Beside, several unsuccessful remediation technologies have been reported owing to the use of inappropriate technologies (Zabbey et al. 2017). Therefore, it is important to explore an approach that would be applicable as well as sustainable for the environments.

2 Environmental Pollution and Health Risk from Municipal Solid Waste

Improper management of MSW is one of the sources for environmental pollution in towns, cities and municipalities. Most of the cities do not enforced MSW regulations properly in particularly in developing countries. The improper handling of

Table 3.1 The Public health risk via different environmental media affected due to improper management of municipal solid waste (Lee and Lee 1994; UNEP 2007; Selin 2013)

Routes of exposure	These pollutants can be found in different environmental media such as, air, soil and water, and possibly will find their way to reach human body via, ingestion, inhalation, absorption
Public health effects	Skin problem: – fungal infection, allergic dermatitis, and skin cancer
	Respiratory problem – bacterial upper respiratory tract infections (such as: pharyngitis, laryngitis and rhinitis), chronic bronchitis and asthma
	Intestinal problems – bacterial enteritis, helminthiasis, amoebiasis, liver cancer, kidney and renal failure
	Skeletal muscular systems problem – back pain
	Central nervous system problem – impairment of neurological development, peripheral nerve damage and headaches
	Eye problem – allergic conjunctivitis, bacterial eye infections
	Others problems – septic wounds and congenital abnormalities, cardiovascular diseases and lung cancer etc.

MSW can lead several public health risk (Table 3.1) to nearby residents ‘owing to its appearances as infectious, or toxic nature. Additional environmental impacts are damage of the environmental system by pollution of air, water, and soil. Such improper management of MSW poses a high risk to human health (Cointreau 2006; Lee and Lee 1994).

3 Bioremediation with Historical Insight

Historically, biological methods are being extensively applied across the world. The rapid damage of biologically rich natural ecosystems has accounted to a regular loss of information almost native biodiversity. The traditional societies along by ethno-biologists have ample of information of biodiversity and their usage although the regular socio-economic transformation in their life routine because of rapid globalization, and their immense knowledge should be connected in the developing area of bioremediation. When the whole world is discussion on several areas about the benefits and risks of scientific development in terms of biotechnological advances, at that time the ethno-sciences are debating the option of involving scientific investigation to human priorities (particularly to help traditional societies those are historically excluded), the vital requirements of environmental safety and the more cost effective and environmental friendly application of biological approaches in bioremediation courses (Kavamura and Esposito 2010). The studied suggests that bioremediation has great potential developments in modern era-although these areas are still on the way of constructing a comprehensive theoretical knowledge and integrated methodology. In terms of qualitative perspective, but the development is still required in methodological point of view, quantitative methods and taxonomic accuracy. Also, the bioremediation presently meets to several challenges, and few of them vital matters consist of the founding of well-organized discussions among various areas that edge with biotechnology, and genomics; qualitative advances in research techniques in relative to the findings and the procedures applied; and also the progress of monitoring plans established thorough research interested in the sustainable consumption of natural resources (Chakraborty et al. 2012).

4 Exiting Methods for Soil Remediation

4.1 Physical Remediation Method

The physical method mainly involves soil replacement and thermal treatment, the process is costly, and only appropriate for small polluted sites. This indicates it could be inappropriate for bigger-scale pollution (Dua et al. 2002; Atagana et al. 2003).

4.2 Chemical Remediation Method

Chemical method includes washing of polluted soil by consuming clean water and chemicals that can leach the contaminants from the soil (Fulekar et al. 2012). This method could be attained by chemical leaching, electrokinetic remediation, chemical fixation, vitrify technology, photo-degradation and chemical immobilization among others. The chemical approach is also expensive and has the potential to cause secondary pollution (Iqbal and Ahemad 2015) while the method is comparatively faster to clean-up of chemicals.

4.3 Bioremediation

Bioremediation is an approach that involves biodegradation process of contaminates by using the available nutrients and oxygen essential for microbes. Un-doubtfully, the bioremediation approaches are both resource conservative and economical feasible methods. According to the United States Environmental Protection Agency, the bioremediation is an approach that applies indigenous microorganisms to transform the hazardous substances into lesser toxic substances. The examples for bioremediation technologies are such as: phytoremediation, bioreactor, bioleaching, biostimulation, rhizofiltration, and composting, bioaugmentation (Rayu et al. 2012; Bharagava et al. 2017).

Numerous microbes (fungi, bacteria, algae, yeast, etc.) have ability to remove different heavy metals from soil. The remediation of the contaminants by microbes generally involved via bioaccumulation, biosorption and biodegradation process (Carro et al. 2013; Ghosh and Das 2014). The functional groups are present on the cell wall for example carboxyl, phosphate amine, sulfhydryl and hydroxyl, groups are mainly responsible for binding the contaminants on the microbial cell surface (Ghosh et al. 2015, 2016). For example, fungi have greater ability to resistance to heavy metals and also have higher surface area as well as higher biomass yield then other microbes. These fungi are extremely capable for biodegradation of different dyes owing to the occurrence of several oxido-reductive enzymes such as, peroxidases, lignin peroxidases manganese peroxidases and laccases (Ghosh et al. 2015; Chandra and Chowdhary 2015; Karigar and Rao 2011).

5 Factors Affecting Bioremediation

There are several factors such as, the nutrients supplementation, microbial diversity, pH, and temperature etc., can affect the bioremediation and the bioavailability of contaminates, thus triggering comprehensive changes in the toxic nature of contaminates towards microbes (Chakraborty et al. 2012; Kavamura and Esposito 2010). In this chapter we take up some of the factors briefly discussed as following.

5.1 The Nutrients Supplementation

Supplementation of proper nutrients is one of the important factors for bioremediation, if the nutrients are not enough for proper cellular growth and metabolism of the microbes in the polluted sites. As, in the polluted sites, the organic carbons content is high, and these possibly will be depleted in the course of microbial metabolism (Jing et al. 2017). Various nutrient sources for example potassium, nitrogen, and phosphate to the polluted site can stimulate the microbial growth which increase the bioremediation. Generally, the need of carbon-nitrogen and carbon-phosphorous ratio is 10:1, and 30:1, respectively, for bioremediation (Kensa 2011).

5.2 Temperature

Temperature has a vital role in the bioremediation method of contaminates. The solubility of pollutants such as, PAHs and heavy metals rises with the increase of temperature, which increases the bioavailability of pollutants (Zhang et al. 2006; Liu et al. 2017). Also, the microbial actions rise simultaneously with the rise of temperature in the suitable range, as it can increase the metabolism and the enzymatic activity of microorganisms, which will speed up the bioremediation procedure of contaminates. For instance, the amount of collective O_2 at 43 °C, which is a key for microbial action during the composting, is unusually higher than that at 22–36 °C (Liang et al. 2003). Additionally, temperature can directly affect mechanism of the adsorption and desorption of contaminates on particles or microorganisms. The adsorption ability and strength will rise with the growth of temperature level (Liang et al. 2003). The improved adsorption of contaminates may confine the adsorption of pollutants, as the adsorption area on the microbes is comparatively constant. Remarkably, the co-existing contaminates may help metals adsorption as the contaminants can reallocate among strongly and weakly bound fractions.

5.3 Microbial Diversity

The different species of microbes are being able to affect bioremediation activity. The existence of contaminates such as, heavy metals can also effect microbial diversity. And, the microbial groups are required to adapt the condition to the hazardous environment. The microbial strains isolated and recovered from these polluted sites commonly show great potential against the contamination of heavy metals and PAHs (Paul et al. 2005). The genomic technology advances the approach of remediation potentials of contaminates by microbes (Chen et al. 2009).

The microbial diversity of the MSW site for instance: *Alternaria alternata*, *Acremonium butyri, Aspergillus clavatus, Aspergillus flavus, Aspergillus candidus, Aspergillus luchuensis, Aspergillus fumigatus, Aspergillus nidulans, Aspergillus niger, Aspergillus terreus, Chaetomium* sp., *Chrysosporium* sp., *Cladosporium* sp., *Curvularia lunata, Drechslera* sp., *Fusarium oxysporum, Fusarium roseum, Gliocladium* sp., *Humicola* sp., *Mucor* sp., *Myrothecium* sp., *Paecilomyces* sp., *Penicillium digitatum, Rhizopus* sp., *Sclerotium rolfsii, Trichoderma viride,* etc. have great potential to degradation of MSW (Gautam et al. 2012; Jing et al. 2017; Cui et al. 2017).

5.4 pH

It is usually known that pH is a one of the main factor in bioremediation efficiency of contaminates. Microbes are affected by pH, as the optimum pH for diverse species is changing (Meier et al. 2012). As a result, contaminates such as, heavy metals and PAHs can toughly effect bacteria diversity, their enzyme activity and morphological structure as a result of changing pH, oxygen availability and also other environmental features, in the meantime equally effect the bioremediation of contaminates (Brito et al. 2015; Guo et al. 2010). In addition, pH has influences on the redox potential and solubility of metals. Difference valence states and different forms of metals cause diverse toxic impacts on microbes, which effect heavy metal remediation efficiency at the end. The in situ microbes” are inhibited under alkaline or acidic conditions, and cannot transform heavy metals, on the other hand they are extra tolerance ability to adverse conditions and still have the potential to survive with contaminates (such as, heavy metals) in sub-optimal situations. Thus, amending the pH at contaminated sites could be a best effort (Bamforth and Singleton 2005).

6 Integrating via Microbial Application to Improve Metal Uptake by Plants-Microbes Interaction

Microbes based phytoremediation is a very important bioremediation approach (Becerra-Castro et al. 2011; Yadav et al. 2017). For example, we draw an outline for integrated microbial radiation as shown in (Fig. 3.1) In detail, the bacterial/fungal consortia in the soil to rehabilitate environments polluted with hazardous chemicals, because they cooperatively form the microbial inocula, which have advantageous features, for example heavy metal tolerance ability, solubilization of mineral phosphate, ability of nitrogen fixation, and the ability for bio-mineralization (Iqbal and Ahemad 2015; Passatore et al. 2014). For example, Zimmer et al. (2009) studied the properties of applied ectomycorrhizal bacteria such as, *Micrococcus luteus* and *Sphingomonas* sp. as well as ectomycorrhizal fungi, such as, *Hebeloma crustuliniforme* on the development and metal accumulation of polluted soil. On the other hand, those bacteria, isolated from fungal sporocarps, they ability to improved plant growth because of the mixed inoculation of bacterial and fungal.

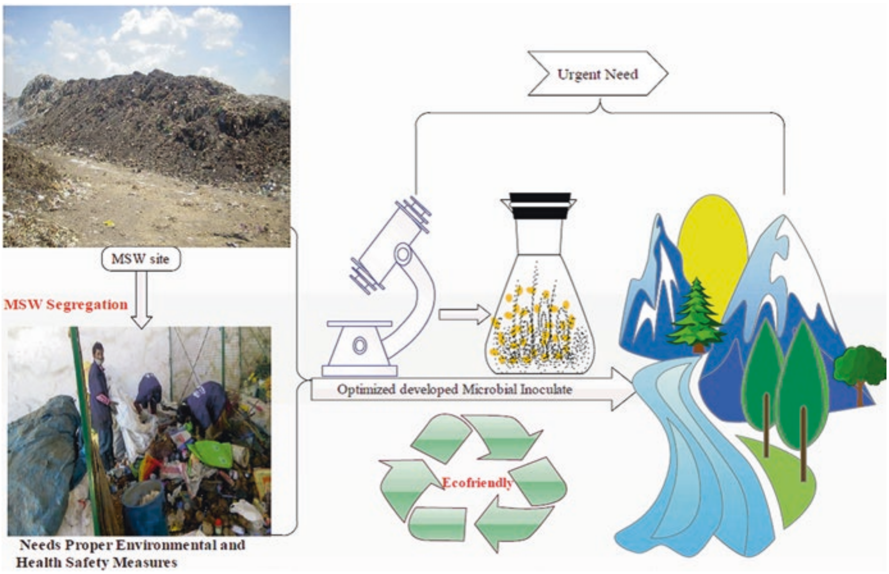

Fig. 3.1 Proposed Systematic brief outline for bioremediation of soil from MSW site

The number of bioremediation studies is subjected to by examination of specific phenomena (Ma et al. 2016). Comparatively some studies report interactions between diverse bioremediation approaches can be integrated in order to make expectations of field level performance. In the context of bioremediation, the process engineering includes the combination of site historic information, geologic description, hydrologic information, chemical as well as microbiological features, both laboratory and field statistics, and potential remedial process in order to estimates and make strategy base conclusions. Execution of integration is very crucial and perhaps the most challenging stage in order to application.

7 Concluding Remarks

There are a number of remediation methods existing, but for the optimal selection, it is very important, earliest, to do an advance examination of the conditions of the contaminated soil and the pollutants. For example, several sites can be contaminated with numerous pollutants, it is important to integrate techniques for remediation systems in order to improve the remedial action. Microbe-assisted integrated remediation can be best option for that specific contaminated site having comparatively low pollution that are adaptable to the option, for instance-biomineralization, phytodegradation, mycoremediation, cyanoremediation, phytostabilization, and hyperaccumulation, for an ecofriendly and sustainable approach. Therefore, there is essential to pursue, integrated advance biotechnological study in field of bioremediation.

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