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Research review paper

Bioremediation of soils contaminated with polycyclic aromatic hydrocarbons, petroleum, pesticides, chlorophenols and heavy metals by composting: Applications, microbes and future research needs

Ming Chen [a,b], Piao Xu [a,b], Guangming Zeng [a,b,*], Chunping Yang [a,b], Danlian Huang [a,b], Jiachao Zhang [c]

[a] College of Environmental Science and Engineering, Hunan University, Changsha 410082, China
[b] Key Laboratory of Environmental Biology and Pollution Control (Hunan University), Ministry of Education, Changsha 410082, China
[c] College of Resources and Environment, Hunan Agricultural University, Changsha 410128, China

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ABSTRACT

Increasing soil pollution problems have caused world-wide concerns. Large numbers of contaminants such as polycyclic aromatic hydrocarbons (PAHs), petroleum and related products, pesticides, chlorophenols and heavy metals enter the soil, posing a huge threat to human health and natural ecosystem. Chemical and physical technologies for soil remediation are either incompetent or too costly. Composting or compost addition can simultaneously increase soil organic matter content and soil fertility besides bioremediation, and thus is believed to be one of the most cost-effective methods for soil remediation. This paper reviews the application of composting/compost for soil bioremediation, and further provides a critical view on the effects of this technology on microbial aspects in contaminated soils. This review also discusses the future research needs for contaminated soils.

Contents

1. Introduction

Soil contamination resulting from industrial and agricultural activities has caused high concerns in recent years (Ha et al., 2014). Various pollutants entering the soil or water pose a huge threat to human health and natural ecosystem (Gong et al., 2009; Hu et al., 2013; Kavamura and Esposito, 2010; Tang et al., 2014; Udeigwe et al., 2011; Xu et al., 2012; G.

* Corresponding author at: College of Environmental Science and Engineering, Hunan University, Changsha 410082, China.
E-mail address: zgming@hnu.edu.cn (G. Zeng).

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Zeng et al., 2013; G.M. Zeng et al., 2013). Main soil pollutants include polycyclic aromatic hydrocarbons (PAHs), petroleum and related products, pesticides, chlorophenols and heavy metals.

Composting, the major process of stabilizing agricultural solid waste and municipal solid waste (MSW) through the degradation of biodegradable components by microbial communities, has been adopted as one of the most cost-effective technologies for soil bioremediation (Alburquerque et al., 2009; Fernandez et al., 2007; Gandolfi et al., 2010; Huang et al., 2008, 2010; Yu et al., 2011; G.M. Zeng et al., 2011). Accordingly, its application for the remediation of contaminated soil is increasing, due to the fact that chemical and physical remediation technologies are either incompetent or too costly. Over the years, large numbers of works have validated its effectiveness for the remediation of soils polluted by a wide range of organic pollutants and heavy metals (de la Fuente et al., 2011; Laine and Jørgensen, 1997; Megharaj et al., 2011; Semple et al., 2001; Tandy et al., 2009). Composting strategies for soil bioremediation are diverse, including direct composting, compost addition, bioaugmentation, incorporation of bulking agent and surfactant application (Fig. 1). Researchers often employed a single or a combination of these strategies to achieve their ends. To reduce costs, organic wastes from industrial and agricultural practices were often selected as the initial composting materials during soil bioremediation. The utilization of these organic wastes for soil remediation is also helpful in decreasing the need for their storage and treatment. Organic matter from composting offers the benefit of improving soil quality and fertility (Pedra et al., 2007). The application of municipal solid waste compost (MSWC) effectively promoted soil organic matter content in Haplic Podzol and Calcic Vertisol (Pedra et al., 2007). The addition of composted sewage sludge (SS) and thermally dried SS to soils induced an increase on the content of available P, total N and total organic C (Fernandez et al., 2009).

Composting is a technology that utilizes microbes to clean up or stabilize the pollutants (Kästner and Mahro, 1996; Lu et al., 2013; G. Zeng et al., 2011; Zhang et al., 2013). A large number of studies showed that many kinds of microbes had strong ability to degrade various organic pollutants and imposed excellent passivation effect on heavy metals (Samanta et al., 2002; Watanabe, 2001; Yu et al., 2011). Bacteria and fungi, the main pollutant-degrading microbes in composts, have been widely considered to be the most crucial factors governing the remediation of contaminated soils. Remediation of contaminated soils by composting or compost addition mainly relies on two mechanisms (Puglisi et al., 2007): (i) adsorption by organic matter and (ii) degradation by microorganisms (Fig. 1). The decomposition of organic pollutants in soil/compost mixture relies mostly on the microbial activity.

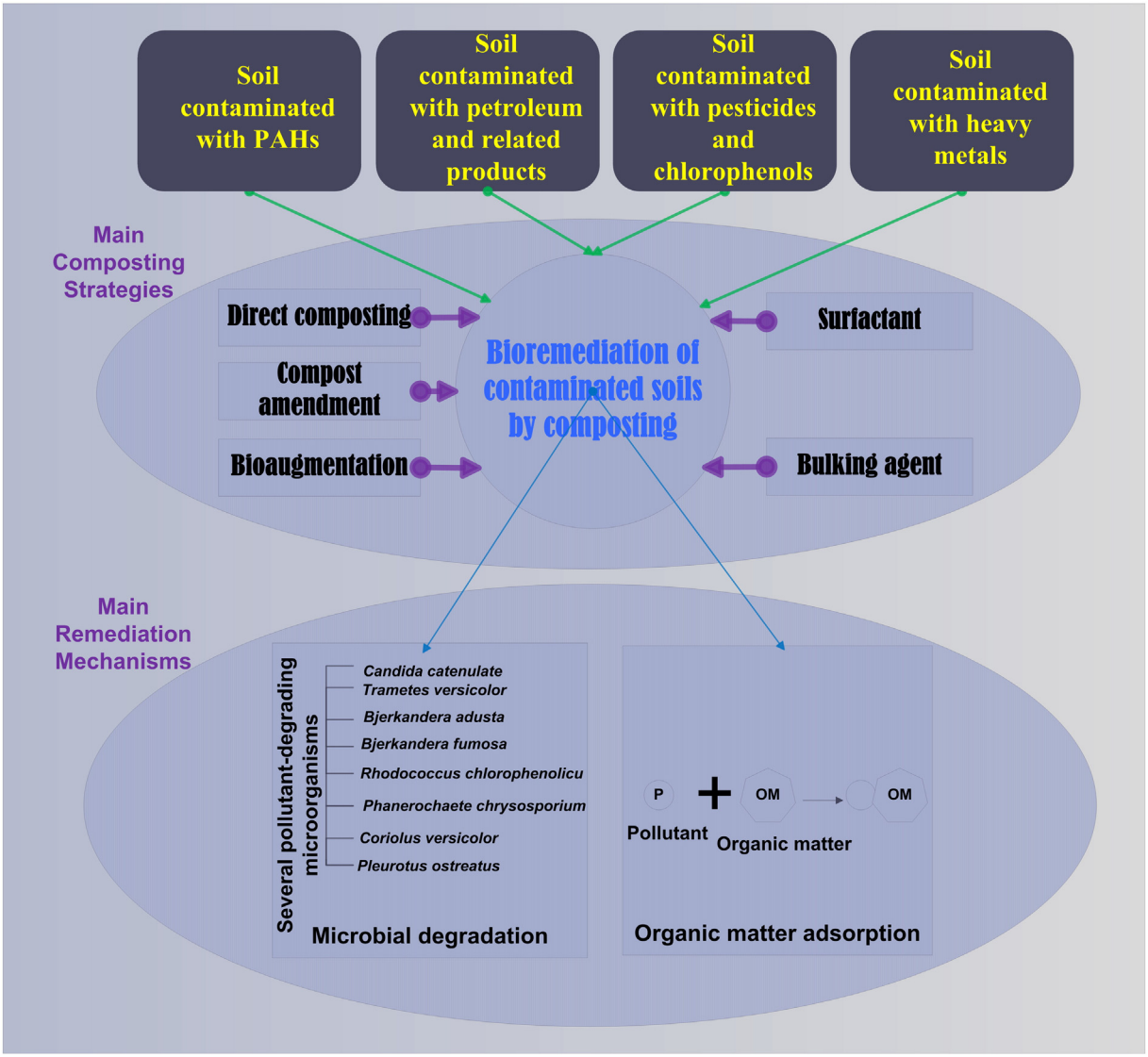

Fig. 1. Main strategies and mechanisms for bioremediation of contaminated soils by composting or compost.

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