Chapter 16
Impacts of Remediation of Halogenated Organic Compounds in Soils and Sediments

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ABSTRACT

Halogenated hydrophobic organic compounds (HOCs) have been used in various industrial applications and are present in many commercial products. Due to their emissions during manufacturing and discharges as wastes, halogenated HOCs such as polychlorinated biphenyls and polybrominated diphenyl ethers are ubiquitously found in the environment and create contaminated sites. To remove the contamination from these sites, various remediation techniques have been useful. The purpose of this chapter is to investigate the impacts of traditional and emerging remediation techniques on ecosystem. One of the traditional remediation techniques is dredging and the mostly studied emerging remediation techniques are bioaugmentation and biostimulation. The efficiency of these techniques is also evaluated regarding reduction in contaminant mass. Overall, this chapter presents the efficiency and possible impacts of dredging, bioaugmentation and biostimulation of soils and sediments, and the implications include the evaluation of most feasible remediation techniques by using life cycle assessment.

INTRODUCTION

Halogenated hydrophobic organic compounds (HOCs) have been produced and used in various industrial applications due to their appealing properties such as chemical and physical stability. They were released into the environment due to their emissions during manufacturing and from products, discharges as wastes and unintentional production. They tend to partition in the organic-rich solid phase, i.e. soils and sediments, and constitute the contaminated sites. After the recognition of the contaminated sites problem, remediation techniques have been deemed as promising solutions. Predominantly used remedia-

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tion techniques are environmental dredging, capping and monitored natural attenuation (Perelo, 2010; Sowers & May, 2013).

Environmental dredging is the mechanical removal of sediments, hence it may create resuspension of sediments and release of contaminants into water, which can affect the ecosystem. Realization of adverse impacts of dredging directed the remediation efforts towards in situ bioremediation, such as bioaugmentation and biostimulation. Both techniques rely on microbial transformation of pollutants in soils and sediments. They are applied to enhance the intrinsic biotransformation of contaminants. Enhancement of biotransformation can be achieved via addition of microorganisms (Payne, Ghosh, May, Marshall, & Sowers, 2019), nutrients (Chen, Zhou, Wang, Zhu, & Tam, 2015), electron donors (Qiu et al., 2012), surfactants (Huang, Chang, & Lee, 2014), and zerovalent iron (Keum & Li, 2005). It is essential to investigate the effects of these amendments in the environment regarding both the efficiency of bioremediation and the impacts on the natural status of soils and sediments. Plausible solutions should be evaluated before application of these techniques in contaminated sites.

The aim of this chapter is to investigate the efficiency and possible impacts of traditional and emerging remediation techniques applied to soils and sediments contaminated with halogenated HOCs. Halogenated HOCs, polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) are selected for this evaluation since they are widely studied in the literature and they have similar molecular structure. The remediation techniques evaluated in this chapter are dredging, biostimulation and bioaugmentation. Previous review studies discussed the advantages and disadvantages of traditional and emerging remediation techniques (e.g. Perelo, 2010). Overall, the dredging has been applied in many sites, and the data collected has been evaluated in terms of effectiveness and impacts (Bridges et al., 2008; National Research Council, 2007). However, since biostimulation and bioaugmentation have not been extensively applied in field, their possible impacts have not been studied in detail. Hence, this chapter, as a new contribution to the literature, compiles the findings of the recent studies on impacts of bioremediation techniques to evaluate them with that of traditional techniques. Furthermore, as the implication of this evaluation, the use of life cycle assessment is discussed regarding the selection of the most efficient remediation technique with the least impact to be implemented in the contaminated site.

BACKGROUND

Hydrophobic organic compounds (HOCs) are released into the environment due to the anthropogenic activities such as emissions during the manufacturing and industrial discharges. They have low water solubility and high octanol-water partitioning coefficient (Kow), which leads to their strong sorption on solid phase. They partition on organic-rich particulate matter, can be transported on suspended particulates and accumulate in soil and sediment particles. When HOCs enter aquatic environment, the ecology of the aquatic environment is affected negatively (Jaffé, 1991). After they reach to bottom sediments, particle-bound HOCs are preserved in sediments and may continue to be accumulated there for decades (Jaffé, 1991), as reflected by core sediment samples (de Souza et al., 2018; Marvin, Waltho, Jia, & Burniston, 2013). Due to the high Kow of HOCs, they are bioaccumulated in the aquatic organisms and hence pose a direct threat to human health. Therefore, the presence of HOCs in the environment has significant impacts on the ecosystem and human health.

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