MASTER'S THESIS

Composting as a bioremediation technology for remediation of PAHs contaminated soil

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Abstract

Bioremediation is recognized as an environmental-friendly and economical method to remediate contaminated soil. As one of the bioremediation technology, composting for hazardous wastes-contaminated soil is still in the stage of infancy. It was therefore the aim of the present study to develop composting as a bioremediation technique to treat PAH contaminated soil.

To select a suitable organic material is the prerequisite for using composting to remediate PAH contaminated soil. Sewage sludge, soybean, and pig manure was separately mixed with sawdust before co-composting with PAHs (phenanthrene, anthracene and pyrene) spiked soil at a ratio 3:1 (w/w dry wt) to obtain a C/N ratio of about 30. Compost samples were collected in duplicate on Day 0, 7, 14, 21, 28, 35 and 49 and analyzed for PAHs. The results of this experiment show that the microorganisms in the pig manure, soybean and sewage sludge played a significant role in the biodegradation of PAHs. Anthracene and phenanthrene of all treatments with organic amendment decreased sharply to about 5 % after 28 days while more than 10% of pyrene were remained in the composting mass. Degradation of pyrene from composting mass was relatively slow as indicating by the kinetic rate constant, which corresponded with its high molecular weight and organic carbon partition coefficient (*Koc*). The degradation rate of PAHs was faster in soil mixed with pig manure and soybean than that with sewage sludge, and pig manure amendment had the highest PAHs removal efficiency. A decrease in total organic matter and C/N ratio in all treatments indicated that degradation process occurred and composting mass reached maturity after 50 days of composting. Cress seed germination test demonstrated that no phytotoxicity was noted after 21 days of composting. The present study demonstrated positively the use of composting as a means to remediate soil contaminated with 3- and 4-ringed PAH compounds within one month, and pig manure was the most effective organic amendment for composting among the three types of waste studied.

After the selection of the best organic amendment for composting, a series of experiments including soil loading rate, PAH concentration and interactions among the three PAH compounds, were performed to optimize the composting process. The effect of pig manure to soil loading rates on the removal of three PAHs (phenanthrene, anthracene and pyrene) was investigated in a bench-scale composting system for 63 days. An increase in pig manure amendment was effective at enhancing the amounts of soluble nutrients in the composting mass as well as organic matter. PAH contaminated soil amended with pig manure could also serve as sources of PAH degraders during composting treatment, but this pattern was restricted only to the early stage of composting process. An increase in pig manure amendment only improved the removal of pyrene, but no obvious effect on phenanthrene and anthracene. Spiked the soil with three PAH compounds i.e., phenanthrene, anthracene and pyrene, each at 100, 200, 400 and 800 mg kg^{-1} (w/w dry weight) did not affect the removal efficiency of phenanthrene, with overall removal efficiency of > 95 %, while the removal percentage of anthracene and pyrene decreased with an increase in their starting concentration. There was a strong negative correlation between percent removal and the starting concentration. The current findings suggest that soil contaminated with these three PAH compounds in the concentration range of 50 mg kg^{-1} to 400 mg kg^{-1} could effectively be reduced to 75 to 95% of the initial

concentrations. The interaction of these three PAHs had a complex effect on biodegradation of these PAHs. The existence of either phenanthrene or anthracene would stimulate the degradation of pyrene. However, the presence of pyrene enhanced the degradation efficiency of phenanthrene but inhibited the degradation of anthracene.

The previous results show that the degradation of these 3 PAHs decreased at high initial PAH concentration. The removal of hydrophobic PAHs is usually severely affected by their low water solubility and high partitioning onto the soil matrix. The results of applying Tween 80 surfactant during composting show that the PAH degradation rate was faster in soil receiving surfactant addition, while addition of surfactant at day 14 had the highest PAHs removal efficiency. The enhanced biodegradation of PAHs was found in all treatment, except for 100 mg kg^{-1}, regardless of the time of addition. The biodegradation of PAHs was decreased at a high application rate of Tween-80 because soil microorganisms are likely using them as a readily available carbon source. This study suggests that composting PAH contaminated soil with the surfactant addition enhanced the degradation of PAHs and carbon balance should be considered by optimizing the concentration of surfactant used.

It can be concluded that composting PAH contaminated soil with pig manure as an organic amendment was an effective and low cost bioremediation technology for PAH contaminated soil. The addition of Tween 80 surfactant during composting process was an appropriate option to improve the biodegradation of PAH compounds in contaminated soils. An amendment rate of 25 % pig manure (dry wt basis) was recommended to be used to co-compost with PAH contaminated soil. Soil containing phenanthrene, anthracene, and pyrene at a concentration of < 400 mg kg^{-1} could be effectively reduced through composting. Moreover, Tween 80 surfactant at a concentration of 20-40 mg kg^{-1} demonstrated the highest efficiency in biodegradation of PAH compounds, and addition of Tween 80 at day 14 was more effective than those add at day 0. The preliminary study showed that this bioremedation technology will provide an economical and environmental-friendly method to treat PAH contaminated soils. However, further research will still be needed to test the feasibility of the technique for PAHs of high ring number and for field collected PAH contaminated soils. In addition, an understanding of the overall mass-balance of carbon during composting will give an evaluation of the fate of PAHs.

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