BIOREMEDIATION OF SOIL HEAVILY CONTAMINATED WITH ORGANOCHLORINE PESTICIDES: DDTs AND HCHs

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Background: Dichlorodiphenyltrichloroethane (DDT) and hexachlorocyclohexane (HCH) are organochlorine pesticides (OCPs), or chlorinated hydrocarbons used extensively from the 1940s till the 1970s in agriculture. Although their production and agricultural use was banned under the Stockholm Convention on Persistent Organic Pollutants (DDT in 2001 and HCH in 2009), their traces can still be found in water and soil. Due to their environmental persistence, toxicity, and pronounced bioaccumulation and biomagnification potential, these OCPs are of great concern. The reported half-lives of DDT in soil range from 4 to 35 years, while those of HCH vary between 2 and 10 years depending on the isomer and soil properties. Even decades ago, remain locations with highest concentrations of these contaminants.
The aim of this study was to evaluate the effectiveness of bioremediation strategies for soil heavily contaminated with organochlorine pesticides (DDT, HCH, and their metabolites).
Materials and methods: A bench scale experiment was carried out, the treatment of contaminated soil included 8 cycles of alternating anaerobic and aerobic conditions. Bioremediation was enhanced through the addition of a locally sourced amendment consisting of 40% iron powder (0.3–0.5 mm), 50% wood shavings, and 10% composted chicken manure.
Results: After eighth consecutive bioremediation cycles, the total concentration of OCPs decreased from initial 600-700 mg/kg dry sol to 90-145 mg/kg, depending on the amount of amendment. The total concentration of DDTs (∑DDTs) in soil, compared to the experimental variant without additives, decreased twofold, while the concentration of DDT declined by 5.5 times. This reduction was attributable both to a decrease in p,p'-DDT and to the near-complete mineralization of o,p'-DDT. The DDD/DDE ratio reached 4.5, indicating that the parent DDT degradation accompanied by the accumulation of metabolites formed under anaerobic conditions.
The application of the amendment also resulted in a 4.6-fold reduction in total HCHs concentrations compared to variant without amendments: γ-HCH isomer decreased by 5.6-fold, while α-HCH declined by 28-fold, accompanied by the formation β-HCH.
The degradation of OCPs was accompanied by a pronounced stimulation of soil microbiota, including both bacteria and microscopic fungi, whose abundance increased tenfold.
Conclusions: The alternating anaerobic–aerobic bioremediation strategy, enhanced with an iron–organic amendment, proved highly effective for the degradation of organochlorine pesticides in contaminated soil. The process favored reductive transformation pathways and stimulated soil microbial activity.

Keywords: organochlorine pesticides, bioremediation, soil microbiota

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