Degradation kinetics of chlorpyrifos and 3,5,6-trichloro-2-pyridinol (TCP) by fungal communities

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Highlights

- Biodegradation of chlorpyrifos (CP) and 3,5,6-trichloro-2-pyridinol (TCP) by five fungal isolates are reported.
- It is found that the Aspergillus sp. is the most efficient isolate.
- Degradation of TCP is higher than that of CP.
- Kinetics of biodegradation of CP and TCP has been investigated and kinetic constants are reported.
- Results of biomass growth experiments are supported by those of kinetic studies.

Abstract

Fungal isolates obtained from soil were used for degrading chlorpyrifos (CP) and TCP. The percentage degradation ranged from 69.4 to 89.8 for CP and 62.2 to 92.6 for TCP after one week. The values of $K_s$ and $V_{max}$ were different for different isolates. The $K_s$ ranged from 66.66 to 169.5 mg/L and $V_{max}$ from 6.56 to 40.4 mg/L/d for CP and from 53.19 to 163.9 mg/L and 3.41 to 40.40 mg/L/d, respectively, for TCP. Fungal community showed high affinity for both CP and TCP. The genetic relatedness of isolate F1 to Aspergillus sp., F2 and F3 to Penicillium sp., F4 to Eurotium sp. and F5 to Emericella sp. were confirmed. The degradation potential was in the order: F1 > F2 = F3 > F4 > F5.

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1. Introduction

Chlorpyrifos [(C₉H₁₁Cl₃NO₃PS) or (O,O-diethyl O-(3,5,6-trichloro-2-pyridyl) phosphorothioate), CP], a member of phosphorothioate class of chlorinated organophosphorous compounds, is a moderately toxic broad-spectrum insecticide. It is widely applied in agriculture, animal houses, and for the control of household pests and subterranean termites. It has low solubility in water (2 mg/L) but strong adsorptive affinity to most organic matter and soil particles (Racke, 1993). The half-life of CP in soil is usually between 10 to 120 days but can range up to one year depending on climate, dose and other environmental conditions (Singh et al., 2006a), thus causing threat to environment and public health (Kulshretha and Kumari, 2011).

Physico-chemical methods used for detoxification of CP and the like are often costly and result in accumulation of recalcitrant residues and transfer of pollutants from one system to the other (Chowdhury et al., 2008). Therefore, biodegradation using native microorganisms is considered to be a safe, cost effective, efficient and eco-friendly method. Biodegradation of CP results in the formation of an antimicrobial compound TCP (Armbust, 2001), classified as mobile, persistent (half-life of 65–360 days), and toxic by USEPA (1997). It is more mobile compared to the parent molecule due to its higher water solubility, thus causing widespread contamination of soil and aquatic environments (Feng et al., 1997). Through chemical and physical interactions with substances, microorganisms have the ability to effect morphological and structural changes as well as complete degradation of the target molecules (Raymond et al., 2001). Therefore, assessment of the potential of microorganisms as bioremediation agents has attracted the attention of several workers (Khan et al., 2011; Maya et al., 2011). Considerable amount of work have been reported on biodegradation of CP and TCP by bacterial strains (Li et al., 2007), Flavobacterium (Mallick et al., 1999), Alkaligenes faecalis DSP3 (Yang et al., 2005) and Sphingomonas sp. (Li et al., 2007) are reported to be CP degraders and Pseudomonas ATCC700113,Ralstonia sp. T6.