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Microbial Degradation of Chlorpyrifos: Challenges, Pathways, and Future Directions in Bioremediation

Among different classes of pesticides, chlorpyrifos (CPF) is an organophosphorus pesticide widely used in agriculture. This pesticide has dramatically degraded the environment due to its overuse and has impacted both terrestrial and aquatic ecosystems. As CPF itself is recalcitrant in the environment, its chlorinated breakdown products are highly persistent and more hazardous to the environment. This requires efficient degradation of CPF and its metabolites, wherein bioremediation seems to be a feasible low-cost option. Though previous research documents microbial strains capable of degrading CPF, this degradative process is complicated since the chlorine atoms are released during the mineralization of the pesticide that inhibits the microbial growth. Therefore, microorganisms capable of simultaneous mineralization of TCP and its metabolites needs to be explored. This review focuses on the metabolic pathways and the challenges faced during the microbial degradation of CPF. It also attempts to give an in-depth overview of the proposed microbial species involved in CPF degradation. Based on the literature survey, this review confirms that bioremediation is a potential intervention for the treatment of wastewater to eliminate pesticide residues. Furthermore, bioremediation can be combined with promising hybrid methods, such as photocatalytic degradation, to be considered as a good option for dealing with recalcitrant pesticide like CPF. A review of this nature calls for continuously furthering investigation on microbial strains and state-of-the-art methodologies for addressing the perennial issue of environmental pesticide contamination.

Keywords: Chlorpyrifos, pesticide, xenobiotics, environmental contamination, bioremediation

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