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9. Role of Microorganism in Bioremediation of Chlorpyrifos Pesticides in Contaminated Soil

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Abstract:

In the modern agriculture technology extensive use of pesticides for increase in crop production but due to its persistence nature in the environment, it is leading various toxic effects in human animals and plants. Chlorpyrifos is commonly used organophosphate pesticide for agriculture. The repeated uses of chlorpyrifos disturb the microbial biodiversity in the soil and associated with potential health risks factors.

Here, we discuss the toxicity level of chlorpyrifos and their association environment pollution and method applicable for degradation of pesticides contamination in the soil.

Microorganism that have excellent capacity to degrade pesticides compound in laboratory condition, generally failed to remediate in the natural condition. To explore the chlorpyrifos degrading bacteria for bioremediation, the present review will significantly increase our knowledge towards degradation of chlorpyrifos and will provide the chlorpyrifos degrading bacteria to remediate chlorpyrifos contaminated site.

Keywords:

Bioremediation, Chlorpyrifos, pesticides.

9.1 Introduction:

In modern agriculture practices, the extensive use of pesticides for pest control is common practice in India. Currently, among the various groups of pesticides that are used to control pests, organophosphorus pesticides form the major and most widely used group that accounts for more than 36% of the total world market.

But due to its accumulation nature into the environment it is associated with various health hazards, hence, its degradation is very important. The organophosphorus pesticides (OP) are all esters of phosphoric acid and due to their high efficiency widely used in agriculture (Fulekar and Geetha, 2008).

The continuous and excessive uses of organophosphorus pesticides have caused serious impact on the soil fertility. Soils contaminated with pesticides have attracted high attention because it impacts human health and environmental pollution (Laxmi *et al.*, 2009). The organophosphate chlorpyrifos has been widely used pesticides in agriculture for the purpose of pest control. However, because of its toxicity and persistence nature in environment, the degradation of chlorpyrifos from contaminated sites of soil and water has become an argent requirement. Hence microbial bioremediation is much promising approach to overcome the pesticide pollution that can surely solve the pesticide contamination of soils.

9.2 Types of Pesticides:

On the basis of chemical composition pesticides are classified into the followings types-

- **Organochlorine**- Organochlorine pesticides are insecticides and due to toxic and persistent nature in the environmental it is not used nowadays. It includes- DDT, HCH, chlordane, and toxaphene.
- **Organophosphorus-** Organophosphates are a diverse group of chemicals and mostly insecticides in nature. They affect the acetylcholine enzyme that regulates a neurotransmitter in nervous system. An example of organophosphates includes- Malathion, parathion, diazinon, fenthion, dichlorvos, chlorpyrifos and ethion.
- **Carbamates-** The carbamate pesticides also affect the nervous system by disrupting an enzyme that regulates the neurotransmitter but the enzyme activities are usually reversible. An example of carbamates includes followings- Thiobencarb, propoxur, molinate, disulfiram, pyridostigmine.
- **Pyrethrin and pyrethroids**- These are a synthetic version of pyrethrin, also called naturally occurring pesticide. They synthesized from chrysanthemums flower. It includes- Allethrin, resmethrin, permethrin, cyfluthrin or esfenvalerate.

9.2.1 Chlorpyrifos Pesticides Structure:

Chlorpyrifos (CPS) [O, O-diethyl O-(3, 5, 6-trichloro-2-pyridyl) phosphorothioate)] is one of the most widely used organophosphate pesticides in agriculture worldwide, but its extensive use has led to the contamination of various soil and water systems.

The half-life of CPS generally ranges between 10 and 120 days in soil but can be up to 1 year depending on abiotic factors such as temperature, moisture, pH, etc. It acts by acetyl cholinesterase inhibition on the nervous system of insects.

There is also a growing concern of widespread contamination of the environment leading to potential risks to non-target organism because of its entry in the food chain and undesirable health issues to humans that include persistent developmental disorders, reproductive defects, endocrine disruptions, nervous system disorders, and immune system abnormalities.

Microbial bioremediation is considered to be one of the most reliable and cost effective approach for the removal of CPS from the environment; however, little is known about the soil bacterial diversity that degrades CPS.

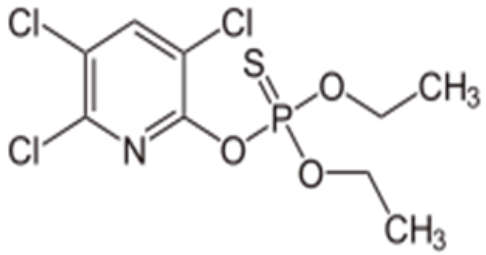

Figure 9.1: Structure of Chlorpyrifos (IUPAC name-*O, O*-Diethyl *O*-(3, 5, 6-trichloropyridin-2yl) phosphorothioate.

9.2.2 Harmful Effect of Chlorpyrifos:

a. In human chlorpyrifos pesticides interfere the action of acetylcholinesterase enzymes there by disturbing the human central nervous system. These neurological effects are associated with elevated risks for children as their brains and nervous systems develop.

b. The immediate effect of low-dose exposure showing symptoms headaches, agitation, inability to concentrate, weakness, tiredness, nausea, diarrhoea and blurred vision and high dose cause the respiratory paralysis and death.
c. Recent studies suggest the adverse effect of chlorpyrifos is also associated with reduced birth size, endocrine disruption, lung and prostate cancer in human.
d. Several studies also shown that reduced birth size, endocrine disruption, lung and prostate cancer
e. The adverse effect of chlorpyrifos exposure in anima, fish, amphibians, birds, reptiles was reported**.**

9.2.3 Persistence of Chlorpyrifos Pesticides in Soil:

Soil productivity is directly or indirectly influence by the pesticides. Pesticides are toxic substances and tend to persist for longer periods in soil due to the chemical residues are rapidly metabolized or diluted in living growing system as compared to soil. Chlorpyrifos half-life in soil is usually between 60 and 120 days.

While persistent pesticides have toxic and harmful effects on soil micro flora and contaminate environment. Chlorpyrifos is less persistence in soil and absorbed by soil particle. The persistency of pesticides in soil is affected by many factors including volatility, chemical structure, solubility in water, method of formulation and application.

9.2.4 Bioremediation:

Bioremediation is a method that uses naturally occurring microorganisms to modify harmful and toxic substances to nontoxic compounds. Also, increased public awareness and concern has prompted the researchers to address ways to detoxify/remove these organic compounds/ pollutants from the natural environment. Remedial strategies require reliable methods to identify and observe contamination, as well as effective procedures to eliminate the pollutant from environment. Traditional physio-chemical remediation strategies such as soil excavation, transport to a reclamation site etc. employed to remediate contaminated sites are inefficient, costly and may also lead to the formation of toxic intermediates and the need for specialized equipment.

Therefore, the bioremediation process has become environment-friendly strategy for removal of pesticides from contaminated site. To date, there are several reports of successful use of bioremediation for the treatment of site is contaminated with different pesticide.

Different techniques were used for bioremediation process it includes-

a. **In situ bioremediation**- In this technique following methods included- Bioventing, biosparging, bio augmentation.
b. **Ex situ bioremediation**- For ex situ bioremediation process land farming, composting, bioreactors were employed.

9.2.5 Microorganism Used for Chlorpyrifos Bioremediation:

Several studies have shown that the microorganism used for degradation of chlorpyrifos. The important role of microorganism in chlorpyrifos degradation pathway is the metabolism and mineralization of 3, 5, 6-trichloro-2-pyrinidinol (TCP) and 3, 5, 6-trichloro-2-methoxypyridine (TMP) metabolites which are toxic intermediates in chlorpyrifos degradation. The previous studies have reported the chlorpyrifos degrading microorganism including *Alcaligenes faecalis* (Yang *et al.,* 2005), *Pseudomonas* sp. (Feng *et al.,* 1997), *Streptomyces sp*. HP-11(Supreeth *et al.,* 2016), Enterobacter Strain B-14 (Singh *et al.,* 2004), *Providencia stuartii (*Rani *et al.,* 2008) Flavobacterium sp. ATCC27551.

Recently, the degradation of chlorpyrifos by fungi in soil has been studied by many researchers including *Trichoderma viride* and *Aspergillus Niger (*Hussain *et al.,* 2007*).* The mixed culture of fungi is also have capacity to degrade chlorpyrifos (Singh *et al*., 2004).

9.3 Conclusion:

Chlorpyrifos organophosphorus pesticides are a highly acutely and chronically toxic to insects, mammals, and other animals. The chlorpyrifos degrading bacteria would be screened for their ability to degrade chlorpyrifos as the sources of carbon and energy.

The characterization of chlorpyrifos degrading bacteria will not only provide strains for degradation of chlorpyrifos pesticides but may also provide some novel species.

Microbial bioremediation is effective and safe technique for chlorpyrifos removal in contaminated soil.

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