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Agricultural Soil Polluted by Pesticide and their Biodecomposition by Soil Bacteria

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Abstract: So far, there have been hardly any studies offering a comprehensive view of biological activity in soil, with little scholarly attention paid to the influence of different pesticides and their metabolites. The impact of the pesticides on soil health is still a current and important problem, which requires constant monitoring. The present review summarizes the recent scientific reports regarding soil enzymes and activities of microorganisms as well as changes occurring in underground biochemistry under the influence of pesticides. It is difficult to interpret enzymatic and microbiological responses after the application of pesticides because of their structural diversity and variety of breakdown pathways. Pesticides applied to soil tend to be a mixture of different active substances. That is why it is difficult to analyze their influence on soil biological activity.

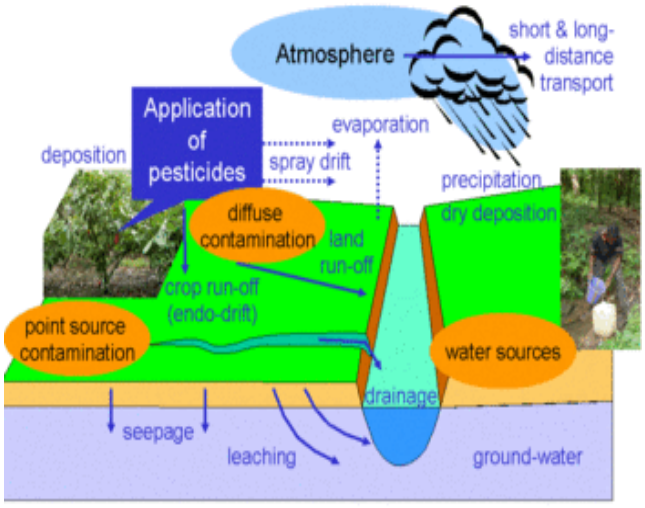
Index Terms – Soil Pollution, Pesticide, Soil Bacteria

I. INTRODUCTION

Soil is the major component of earth's ecosystem which comprises of organic matter, minerals, gases and large numbers of macro and microorganisms. The soil ecosystem is supported by several interactions among its physical, chemical and biological components . Many biological processes take place in soil and determine functions that provide various services within ecosystems: turnover of organic matter, symbiotic and non-symbiotic atmospheric nitrogen fixation, denitrification, aggregation etc.

Soil pollution as part of land degradation is caused by the presence of human-made chemicals or other alteration in the natural soil environment. It is typically caused by industrial activity, agricultural chemicals or improper disposal of waste. The most common chemicals involved are pesticides. A pesticide is a substance used to kill a pest.

(a) Pesticide spraying



(b) pesticide pathway

Fig. 1

ng a substantial environmental health hazard due to uptake and accumulation of these toxic compounds in the food chain and drinking water.

Organophosphate pesticides are a group of highly toxic heterogeneous compounds that share a phosphoric acid derivative chemical structure widely used for plant protection and pest control. These compounds are components of more than 100 types of commercially available pesticides (such as Chlorpyrifos, Parathion, Malathion, Diazinon and Dichlorvos). Most synthetic organophosphate compounds are widely used as insecticides in agriculture. These compounds are powerful inhibitors of

acetylcholinesterase, a vital enzyme involved in neurotransmission, in the form of acetylcholine substitutes and various clinical effects, e.g. neck muscle weakness and diarrhea can occur due to organophosphate poisoning in humans. The toxicity of pesticides from exposure to contaminated food is mostly unknown but there is growing evidence of cancer, neurological damage, endocrine disruption and birth defects consequential from exposure. Due to the magnitude of this problem, which became a big challenge facing the entire world today, several biological techniques involving biodegradation of organic compounds by microorganisms have been developed. The utilizing of microorganisms (fungi or bacteria), either naturally occurring or introduced, to degrade pollutants is called bioremediation . Bioremediation is a rapid, inexpensive, effective and ecologically safe method has been emerged as a cleanup method for the environmental components. The basis for bioremediation is the degrading microorganisms obtain C, N or energy from pesticide molecules and convert organopollutants to carbon dioxide. From an environmental point of view this total conversion is desirable as it represents complete detoxification.

Chlorpyrifos is a toxic organophosphate pesticide. Repeated applications of chlorpyrifos modify the soil microbial community structure and pose potential health risks to the other nontargets. Chlorpyrifos has been reported as the second most commonly detected pesticide in food and water. Extensive use of chlorpyrifos in agriculture and persistence in the environment has raised public concern and demand for safe technologies to overcome the pollution and toxicity problems. Here, we review pollution and toxicity issues associated with chlorpyrifos use and discuss strategies to solve pesticide contamination. Chlorpyrifos, previously shown to be resistant to enhanced degradation, has now been proved to undergo enhanced microbe-mediated decay.

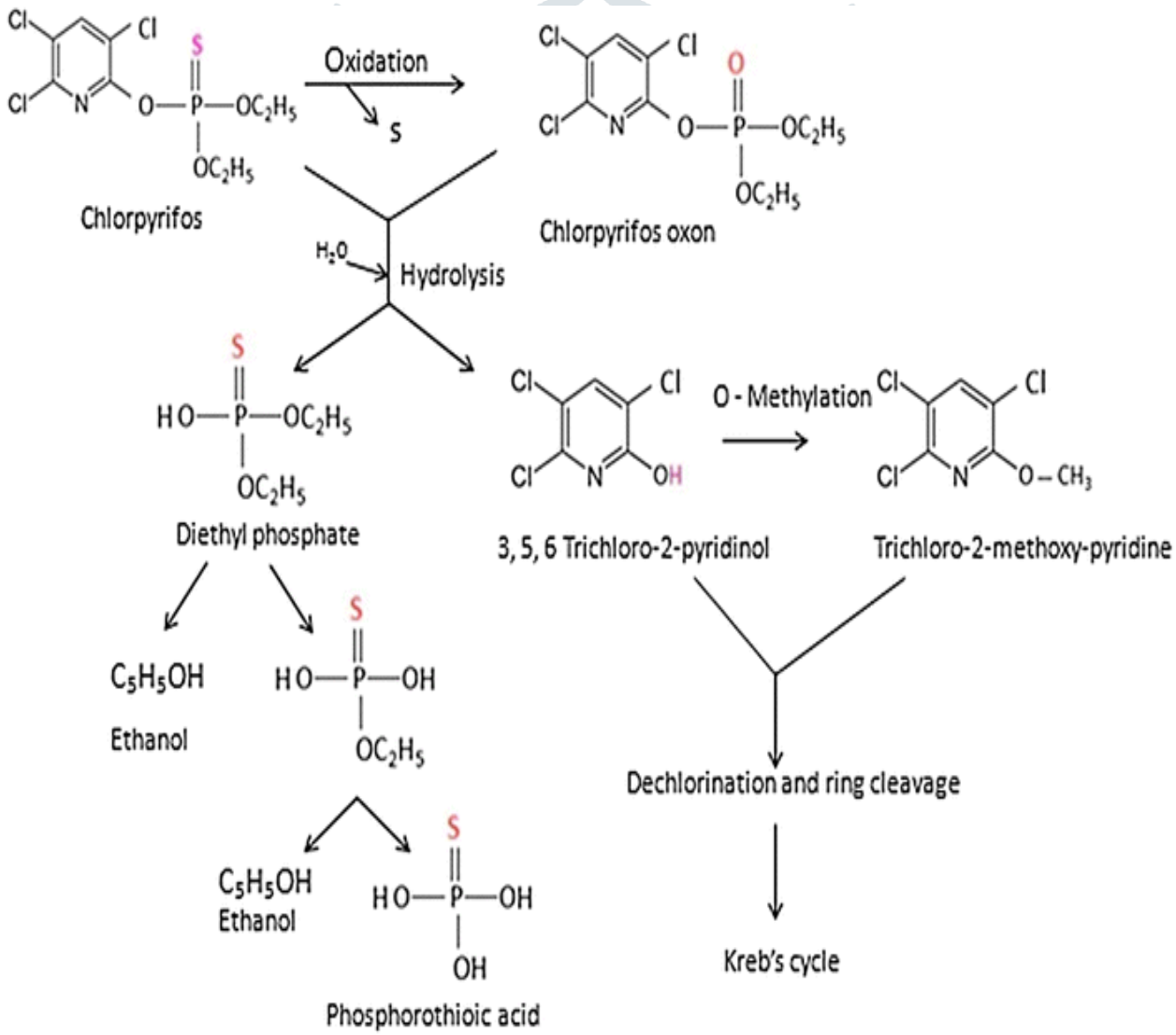


Fig. 2: Biodegradation of Chlorpyriphos

II. CLASSIFICATION O PESTICIDES

The pesticides can be classified by different criteria such as chemical classes, functional groups, mode of action, and toxicity.

2.1 **Classification by Origin**

The pesticides can be classified by their origin, namely chemical pesticides and biopesticides. Chemical pesticides are generally organic compounds that can have natural sources or by chemical synthesis [7]. Biopesticides are natural substances that control pests by nontoxic mechanisms.

2.1.1 Classification by Chemical Composition

With this classification, four main groups can be identified: organochlorines, organophosphates, carbamates, and pyrethrins and pyrethroids (Figure 3 and Table 1). The information on the chemical and physical characteristics of pesticides is very useful in determining the mode of application, precautions that need to be taken during the application, and the application rates [26].

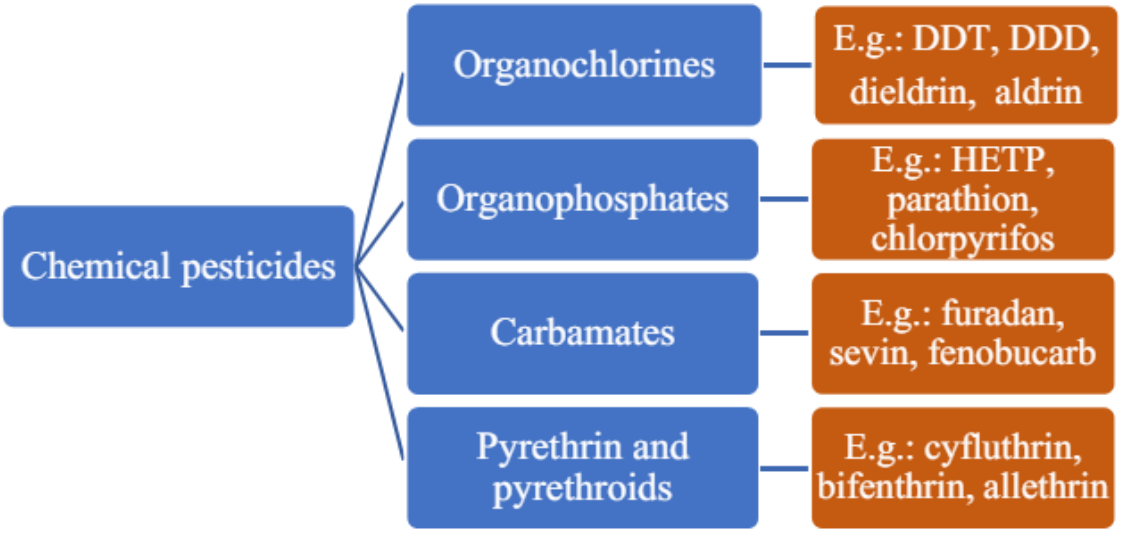
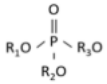
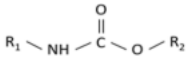
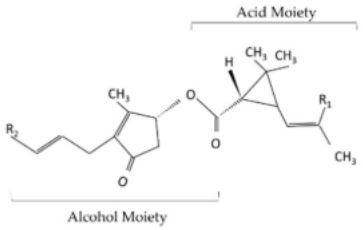


Fig. 3: Classification by Chemical Composition

Table 1: Chemical composition of the pesticides

Group	Chemical Structure
Organochlorines	
Organophasphates	
Carbamates	
Pyrethrins and pyrethroids	

Esters of chrysanthemic acid

	R_1	R_2
Pyrethrin I	CH_3	$CHCH_2$
Cinerin I	CH_3	CH_3
Jasmolin I	CH_3	CH_2CH_3

Esters of pyrethrinc acid

	R_1	R_2
Pyrethrin II	$CH_3OC(O)$	$CHCH_2$
Cinerin II	$CH_3OC(O)$	CH_3
Jasmolin II	$CH_3OC(O)$	CH_2CH_3

Organochlorines: Organochlorine pesticides (OCs) are organic compounds, namely hydrocarbon chains bonded with at least one covalently bonded atom of chlorine (Table 2). These compounds are widely used in agriculture, especially as insecticides to control a broad range of insects. The most common organochlorines are dichlorodiphenyltrichloroethane (DDT), dichlorodiphenyldichloroethane (DDD), dicofol, dieldrin, lindane, aldrin, chlordane, endosulfan, isodrin, isobenzan, toxaphene, and chloropropylate. These compounds are lipophilic and are difficult to decompose, thus tending to bioaccumulate in tissues and remaining in the environment. For their high persistence in the environment, OCs belong to the class of persistent organic pollutants (POPs). They may cause damage to living beings, causing mutagenic effects, histopathological effects, enzyme-inducing and/or enzyme-inhibiting, carcinogenicity, and teratogenicity . For human health, organochlorine exposure may increase the risk of breast cancer.

Organophosphates: Organophosphates (OPs) are synthetic pesticides, which include phosphoric acid esters or thiophosphoric acid esters. The general structure is reported in Table 2. Hexaethyl tetraphosphate (HETP) was the first one synthesized and used as agricultural insecticides. OPs are acutely toxic for insects and other animals, including birds, amphibians, and mammals. The cause of their toxicity is due to inhibition of the acetylcholinesterase (AChE) in the central and peripheral nervous system. The inhibition of this enzyme causes muscarinic and nicotinic effects. Muscarinic symptoms are linked to the assumption system:

- for inhalation, the symptoms may be cough, expectoration of frothy secretions, chest tightness, and wheeze, pulmonary edema;
- for ingestion hypersalivation, nausea, vomiting, abdominal cramps, diarrhea, and tenesmus;

- for eye, miosis, blurred vision, and eye pain. Nicotinic effects are profuse sweating, fasciculation, progressive flaccidity, and weakness of proximal muscle groups, such as the neck flexors, then the extraocular muscles and muscles of respiration.

Carbamates: Carbamates are compounds derived from carbamic acid. Their chemical structure is characterized by an amino group bonded with an ester group. Typically, R1 and R2 are organic radicals or hydrogen. If R2 is hydrogen, it is possible to understand the target considering the functional group R1. It is possible to have:

- insecticides, when R1 is a methyl group;
- herbicides, when R1 is an aromatic group;
- fungicides, when R1 is a benzimidazole moiety.

Carbamates are also biocides for industry and household products for the control of household pests. The common carbamate pesticides are aldicarb, carbofuran, fenoxycarb, carbaryl, ethienocarb, and fenobucarb. As the organophosphates, carbamates are inhibitors of acetylcholinesterase activity, and therefore, their toxicity acts on the neurological system. Exposure to carbamate pesticides increases the risk of non-Hodgkin's lymphoma in humans since they inhibit and induce apoptosis of human natural killer (NK) cells and cytotoxic T lymphocytes that provide defense against tumors.

III. MATERIAL &METHOD

1. Collection of soil samples from crop fields .
2. Experiments have been conducted screening and isolation of bacterial species from soil sample showing resistance towards chlorpyrifos and possible degradation of chlorpyrifos pesticide.
3. Biochemical characterization isolated bacterial species for their partial identification using various biochemical test.
4. The degradation potential performed by inoculating the isolated bacteria in liquid culture medium containing chlorpyrifos and followed by incubation for 48 hrs after incubation the liquid culture medium centrifuge to get the cell free supernatant which was subjected HPLC analysis to detect quantitative reduction in chlorpyrifos on concentration compare to the un-inoculated control.

IV. RESULT

From the above mentioned method chlorpyrifos when mixed in the culture of the bacterial species that showing resistance towards chlorpyrifos were reported to be members of genus pseudomonas on the basis of gram staining and biochemical characteristics and selective media.

v. DISCUSSION

The experiment suggest the possibility of screening the microbial species with the ability not only to survive on the complex toxic chemical like non-biodegradable organophosphate pesticide but also can degrade in to the simple non hazardous compound such an ability of the microbial species could be utilized for the purpose of soil pollution control after extensive investigation and method standardization.

VI. SUMMARY

Due to the fact that in modern agriculture, intensive use of pesticides is a common practice all over the world, soil pollution with pesticides may increase. A significant concentration of active substances of pesticides frequently remains in soil, undergoing biological and physicochemical transformations, influencing microbial growth and enzymatic activity in soils. In the natural environment, microbial degradation of pesticides consists in the distribution of mixtures of many substances, whereas laboratory tests tend to analyze the distribution of a single active substance. Such tests allow for determining the degradation pathways of individual active substances of pesticides. However, there are hardly any studies which discuss the distribution of mixtures of active substances accumulating in soil under the influence of other physical and chemical soil factors. The use of the methods of genetic engineering and various biotechnological techniques makes it possible to analyze how pesticides are biodegraded by microorganisms. New strains generated by genetic engineering have the ability to degrade more efficiently complex mixtures of various compounds, especially environmental pollutants like pesticides.

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