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Review on Effects of Organophosphate Pesticides in Human Health and Way to Mitigates its Harmful Impacts

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ABSTRACT: Due to increasing the human population day by day, for the control of the human population, needs to increase the agricultural productivity, for agricultural production is increasing we use pesticide. Pesticides not only kill the target pest species also affect non-target organisms. Pesticide pollution has become a significant problem all over the world. This is mainly due to the abuse and overuse of pesticides which remain in the soil for several years and leach into water bodies. Pesticides are chemical (synthetic or semi-synthetic) agents that control and destroy pest population. Organophosphate pesticides are major bulk that includes malathion, parathion, diazinon, fenthion, chlordecone, Imidacloprid, dichlorvos, chlorpyrifos, ethion, nerve gases (soman, sarin, tabun, VX), ophthalmic agents (echothiophate, isoflurophate), and antihelmintics (trichlorfon). Herbicides (tribufos or DEF, merphos) are tricresyl phosphate etc. Though various pesticides were banned due to its harmful impacts on human health and environment, but still some has been used in paddy fields, greenhouse culture, horticulture and even hydroponics. They persistent in nature (bio-accumulation and bio-magnification by the food chain, especially through pieces) and cause acute or chronic toxicity. They contain very noxious components that harm our neuronal system by cholinergic effects. Pesticide also has an unfavorable effect on aquatic organisms such as ataxia causing late maturation in fish. Various physical and chemical methods are used for the reduction the toxicity of pesticides, physically and chemically pesticide reduction process is costly and hazardous. One good strategy is applied for the remediation of pesticides is bioremediation, i.e- use of various modified strain of agricultural microbes especially bacteria.

KEYWORDS: Pesticides, Chlorpyrifos, Bio-magnification, Cholinergic effect and Bioremediation.

INTRODUCTION

Organophosphates (OPs) are large group about 40% of total pesticide, (Rao et al., 2005) of chemical that used over past 7 decades in livestock practice, human health and welfare, and defensive agents. These are class of insecticides, several of which are highly toxic as contain cholinesterase inhibitor property thus directly or indirectly deals with CNS, i.e. Neurological disorders, (Gupta, 2001). Besides of this the direct exposure of it causes skin etching, seizure, respiratory disorders and ultimately death of organisms. The route of explosion may be differ in different organism, such as dermal adsorption, inhalation and through diet via food web in ecosystem (Costa, 2018). Thirty-six of OPs are presently registered for use in the United States, and all can potentially cause acute and sub-acute toxicity. Organophosphates are used in agricultural fields, homes, gardens and horticulture, and veterinary practices. Parathion and chlorpyrifos, has no longer registered for any use. All share a common mechanism of cholinesterase inhibition and can cause similar symptoms, although there are some differences within the class. However, that there is a wide range of toxicity in these agents and wide variation in dermal absorption. Organophosphates poison insects and other animals, including birds, amphibians and mammals (via ecological food chain), primarily by phosphorylation of the acetylcholinesterase enzyme (AChE) at nerve end plate. The result is a loss of available AChE so that the effectors organ becomes over- stimulated by the excess acetylcholine (ACh, the impulse-transmitting substance) in the nerve ending. At skeletal muscle junctions, excess ACh

may be excitatory (cause muscle twitching) but may also weaken or paralyze the cell by depolarizing the end plate. Impairment of the diaphragm and thoracic skeletal muscles can cause respiratory paralysis (Routt and Roberts, 1999). In the CNS, high Ach concentrations cause sensory and behavioral disturbances, in coordination, depressed motor function and respiratory depression. Increased pulmonary secretions coupled with respiratory failure are the usual causes of death from organophosphate poisoning. Some of the most commonly reported early symptoms include headache, nausea, dizziness and hyper-secretion, the latter of which is manifested by sweating, salivation, lacrimation and rhinorrhea. Muscle twitching, weakness, tremor, in coordination, vomiting, abdominal cramps and diarrhea all signal worsening of the poisoned state. Organophosphate herbicides interacting with soil biota and altering the biomass of environment (Usman et al., 2017). Some organophosphates, such as diazinon, fenthion and methyl parathion, have significant lipid solubility, allowing fat storage with delayed toxicity due to late release.3,4 Delayed toxicity may also occur atypically with other organophosphates, specifically dichlorofenthion and demton-methy. Many organo-thiophosphates readily undergo conversion from thions (P=S) to oxons (P=O). Conversion occurs in the environment under the influence of oxygen and light and, in the body, chiefly by the action of liver microsomal enzymes. Level of threat are detected in various way: dose determination by LC50 and LD50 of OPs pesticide, various physio-chemical and biological parameter test of target tissue and symptoms (Zhang et al, 2017).Various degradation strategies should be taking now days like abiotic degradation by chemical oxidation, catalytic hydrolysis, adsorbing agents and gamma radiation. Major disadvantages of it are high cost and natural unsustainability. Another most effective and eco-friendly method is bioremediation by microbial strains on which more research and technology involved. In some cases the patient with severe exposure of OPs are treated with atropine like drugs. India is fourth largest producer of pesticide in the world that largely affects on India's GDP and economy. Pesticide Management Bill (PMB, 2020) is an opportunity to clean up India's food and farming system.

RESULT

1.1. The Impacts of Organophosphate Pesticides on Human Health:

Choline Esterase Effects:

The cholinergic i.e. blocked the substrate binding site of Acetyl choline esterase enzyme, effects brought about by repeated administration of less than a single fatal dose are similar in type to the acute single-dose effects (WHO, 1986).

Dermal or Cutaneous Effects:

Shoot particle and pesticide droplets during spray at agricultural field directly expose at dermal contact, cause skin rashes and allergic manifestation.

Immediate or Acute Toxicity:

Acute toxicity is the ability of a substance to cause harmful impacts immediately in a single exposure or dose or any severe poisonous effect resulting from a single short-term exposure to a toxic substance. LD50 (lethal dose 50) is defined as the dose that kills 50% of a test population of the exposed animals (Ghosh and Philip, 2006). In an acute study, neurotoxic signs were seen at 190 mg/kg in rats, and were more prominent in females. Also, in vitro studies have shown butyl cholinesterase to be more sensitive to profenofos inhibition than acetyl cholinesterase (AChE) (McDaniel and Moser, 2004).

Chronic Toxicity

Chronic toxicity is the capacity of a substance to cause long-term or delayed adverse health effects. Several reports proved the chronic toxicity of atrazine on various test organisms. After the sign of respiratory distress and paralysis of the limbs, 40% rats were died at an atrazine oral dose of 20 mg/kg/day for 6 months. Body organs like brain, liver, kidneys, ovaries etc., were affected by organophosphates poisons and made structural and chemical changes, as well as growth retardation. In a study carried out for two years with dogs, results showed that 7.5 mg kg-1 day-1 atrazine dose caused decreasing in food intake and increased heart and liver weights. The NOEL on rat was 70 mg kg-1 whereas in dog it was 15 mg kg-1 of body weight (Sameeh, 2004).

Long term Neuropathic Effects

Delayed neuropathy has occurred occasionally in human being, livestock and experimental animals after intoxication with a variety of OPs esters. However, many OPP that might, theoretically, cause neuropathy, would only do so at a dose far above the lethal dose (WHO, 1986).

Carcinogenic Effects

Many OPs pesticides have not shown carcinogenic potential in animal experiments, but some pesticides do, through induction of tumors in rats and mice. No generalizations can be made due to some compounds exhibit mutagenic activity, whereas other compounds do not (WHO, 1986).

Reproductive Effects

A number of pesticides clearly have the potential to cause reproductive toxicity in animals, and several compounds e.g. (chlordecone) are known to affect human reproduction (Sameeh, 2004). Also OPs included insecticides (malathion, parathion, diazinon, fenthion, dichlorvos, chlorpyrifos, ethion), nerve gases (soman, sarin, tabun, VX), ophthalmic agents (echothiophate, isoflurophate), and antihelmintics (trichlorfon). Herbicides (tribufos [DEF], merphos) are tricresyl phosphate–containing industrial chemicals.

Immunotoxicity

The scientific evidence suggesting that many pesticidesdamage the immune system. Animal studies have found that pesticides alter the immune system's normal structure, disturb immune responses, and reduce animal's resistance to antigens and infectious agents. In case of Malathion which is considered a very low toxic compound (oral LD50= 2100 mg/kg bw), for example, not regulates the immune system, especially affecting non-specific immune mechanisms (Sameeh, 2004).

Cytogenetic Effects

Cytogenetic damage related to pesticides exposure has been reported in various populations. Some investigators have reported significant differences in the percentage of chromosomal aberrations (CAs) in exposed individuals (range, 2.66–10.30%) compared with control (range, 0.53– 5.52%) (Sameeh, 2004).

Teratogenic Effects

Detailed data on the effects of organophosphate occupational exposure on pregnant women and their fetuses are not available, although such information would be valuable. In humans only a few cases of acute organophosphorus insecticide poisoning during pregnancy have been described. A 24-year-old woman in her third month of pregnancy injected herself with Malathion in a suicide attempt. A therapeutic abortion was performed 2 months later. Continuation of the pregnancy was considered to be dangerous, although the condition of the fetus was not described (WHO, 1986).

Effects on the Immune System

The most Organophosphorus pesticides elicit autoimmune reactions and suppress the production of antibodies against various vaccines (**Zackov, 1983**).

1.2. Symptoms of Organophosphate Pesticide Poisoning (Acute to Chronic)

Level of Exposion	Mild Exposion	Moderate Exposion	High Exposion	Very High Exposion
Symptoms	Poor vision	Muscle Tremor	Slow heartbeat	Paralysis
	Nausea/Vomiting	Disorientation and balance	Coma	Fertility Disorder
	Muscle twitching	Diarrhoea	Narrow pupil	Cancer
	Abnormal Salivation	Cough	Excessive saliva, tears, and urination	Pancreatic disorders
	Headache	Sneezing	Neurological impaired	Digestive problems
	Weakness	Severe vomiting	Heart and lung abnormalities	Blood sugar
	Agitation		Difficulty in Breathing	Neurological disorder

Table. Shows level of exposure combine with manifested symptoms. Source: Article, A treatise on Organophosphate Pesticide pollution by Kaushal J. et al., 2020.

4.3 Bioremediation:

Bioremediation reduces pesticide contamination of agricultural soils by biodegradation processes via the metabolic activities of microorganisms. It is an efficient, cost-effective, and environment-friendly treatment. During the bioremediation processes, the microorganisms use the pesticides as co-substrates in their metabolic reactions together with other nutrients, thus eliminating them from the environment. The efficiency of these processes depends on the characteristics of pesticides, such as their distribution, their bioavailability, and their persistence in soil. It is necessary to promote the availability of pesticides to microorganisms: this is negatively affected by the adhesion of pesticides to soil particles and their low water solubility [Ortiz-

Hernández et al, 2014]. In addition, the soil characteristics and the environmental conditions, such as pH, water content, microbial diversity, and temperature, influence the bioremediation efficacy.

Sl. No.	Organophosphate Pesticide	Microbes/ Microbial strain that metabolically degrade
1	Chlorpyriphos	*Bacillus* pumilus strain C2A1, *Pseudomonas. aeruginosa, P. stutzeri, P. putida, Bacillus aryabhatta, Stenotrophomonas* sp., *Leuconostoc mesenteroides, Trichoderma harzianum, Penicillium vermiculatum,* and *Mucor* sp. etc
2	Malathion	*Pseudomonas* sp., *P. stutzeri, Arthrobacter, Stenotrophomonas* sp., *Leuconostoc mesenteroides*
3	Diazinon	*Serratia marcescens* DI101. and *Pseudomonas* sp., *LactoBacillus brevis*, *Mycobacterium* sp., and *Stenotrophomonas* sp.
4	Methyl–parathion	*Pseudomonas* sp., *Xanthomonas* sp., *Pseudomonas* sp., *P. stutzeri, Arthrobacter, Stenotrophomonas* sp., *Leuconostoc mesenteroides*, *Brevis* L., *Plantarum* L., *Sakei.*
5	Fenitrothion	*Burkholderia* sp. strain NF1000, *Arthrobacter aurescenes* TW17, *Corynebacterium* and *Arthrobacter* sp..
6	3-methyl-4- nitrophenol by	*Ralstonia* sp. SJ98

CONCLUSION

Ever bursting human population demands more food, cloth and daily needs thus we must increase our livestock production many more in a poor illegal methods. That leads to the damage of microbial community and natural stability and sustainability, thus human health. Various controlling measurement should take but bioremediation or phytoremediation is most effective one. With modern researches, advance technologies, legislative strategy and human awareness we can protest against it. Controlling human population is one of most effective indirect method. If that is gone continuously the future generation will suffer most hazardously.

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