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A SYSTEMATIC REVIEW ON ORGANOPHOSPHATE PESTICIDES AND THEIR TOXICITY

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Abstract – **Organo phosphorus pesticides are important class of chemical compounds widely employed in agriculture to control pests and increase crop yields. However, their widespread use has created serious concerns about human health and environmental safety due to their intrinsic toxicity. This review carefully explores the elements of Organo phosphorus pesticides, with a focus on their uses in India, methods of action, health consequences and mitigation options. By synthesising existing knowledge and identifying knowledge gaps, it hopes to assist politicians, healthcare professionals and researchers involved in pesticide regulation and public health programmes, ultimately contributing to the promotion of safer and more sustainable agricultural methods.**

Keywords –**Organo phosphorus Pesticides, Acetyl cholinesterase, Oxon, Insecticides.**

I. INTRODUCTION

Pesticides are a group of substances used to eradicate undesirable organisms such as weeds, bacteria, fungi and insects. They are typically known as insecticides, fungicides, bacteria, herbicides or rodenticides. Most pesticides may kill a variety of weeds and pests, while some are specifically designed to eliminate particular pathogens or pests. These compounds are meant to interfere with an organism's physiological functions, which leads to dysfunction and diminished vitality.

The contamination of soil, water and other environmental components by pesticide residues has the potential to be enormous. Pesticide use is increasing as a result of high agricultural production, resulting in increased soil, water and air pollution. Due to pesticide characteristics that involve high lipophilicity, bioaccumulation, prolonged half-lives and long-distance transport ability, the possibility of contamination of the air, water and soil has grown even after many years of application.

It has been recognized that exposure to pesticides is increasingly linked to cancer, immune system suppression and other diseases. Persistent pesticide openness has been connected to an expansion in the rate of malignant growth, ongoing kidney illnesses, sterility in the two genders, endocrine issues and neurological & behavioral issues, especially in youngsters.

II. ORGANOPHOSPHORUS PESTICIDES

Organ phosphorus (OP) compounds are commonly used in agriculture, horticulture, pest control, industrial, vector control, manufacture of plastic, warfare agents and domestic purposes. Among the various pesticides currently in use and accounting for 45% of the global market, Ops are the most widely and extensively used pesticide groups worldwide [1]. The standard structure of OPs compounds is $O=P(OR)_3$. OPs happen in a different run like most other useful bunches. OPs are normally found in bio molecules such as Deoxyribo Nucleic Acid (DNA), Ribo Nucleic Acid (RNA)and Adenosine Tri Phosphate (ATP). They are displayed in chemically synthesised compounds such as pesticides (glyphosate, chlorpyrifos, ethion, malathion, dichlorvos, fenthion, diazinon, malathion), herbicides (tribufos (DEF), merphos), anti-helminthic (trichlorfon) and ophthalmic.

III. USE OF ORGANOPHOSPHATE PESTICIDE IN INDIA

In 1960s, pesticides were introduced in India, which are now widely used and represent a common feature of Indian agricultural production. Due to their easy degradation, OPs have been substituted for chlorine hydrocarbons as a pesticide. Although these xenobiotics degrade under natural conditions, their residues have been detected in soil, sediments and water due to their non-regulated usage practices. OP insecticides dissolve quickly by hydrolysis when exposed to sunlight, airor soil [2]. OPs dissolve quicker than organ chlorines, but have acute toxicity, providing concerns to anyone exposed to high levels. OP pesticides are less persistent in water, soil, food and feed for animals compared to organ chlorine pesticides. However, they are more soluble in water and harmful.

It may be absorbed in several ways, including inhalation, ingestion and cutaneous absorption. In India, commonly used Ops include malathion, methyl parathion, chlorpyrifos, diazinon, dichlorvos, fenitrothion, phorate and monocrotophos.

The Central Insecticides Board and Registration Committee (CIBRC), under the Ministry of Agriculture and Farmer Welfareis in charge of registering pesticides for agricultural pest and weed management.

According to a survey conducted over the vegetable growing districts of Tamil Nadu about insecticide usage patterns, 82.86% of respondents relied on pesticide dealers for advice. The respondents (70.95%) used pesticides exclusively, with the shortest interval between two sprays being 7.57 days in Coimbatore district with 2.82 days of waiting period and the longest interval being 15.65 days in Namakkal district with 6.71 days of waiting.

The highest frequency of pesticide spraying per season per crop was reported in Coimbatore district (7.2 times), while the lowest was in Namakkal (5.38 times). Only 2.38% of respondents were aware of the negative consequences of pesticide residues, and 2.90% used masks when spraying. According to the data, Coimbatore used the most insecticides (19.79%), followed by Dharmapuri (15.63%) and Dindigul (15.53%) [3].

IV.PESTICIDE POISONING

Pesticide poisoning is a serious clinical concern in Warangal area, resulting in thousands of poisonings and hundreds of fatalities annually. Discussions with forensic pathologists in the district indicate that the number of fatalities occurring previous to hospitalisation may be far higher than the number recorded in hospital-based investigation. If the data from Warangal district represents all 23 districts in the state Telangana, India, then mortality from pesticide poisoning may approach 5,000 per year in this state alone [4].

There were many cases showing the administration of pesticides for self-poisoning. The overall mortality rate shown by OP and other pesticides were approximately 22%. Data on time to death following poisoning indicated that half of the deaths occurred in the first six hours of admission, but that many patients died after 24 hours in hospital, notably after OP poisoning.

A case report of OP poisoning in a 24-year-old guy who consumed parathion was administered in the Medical Ward in Tamil Nadu. He was treated with stomach wash, pralidoxime, atropine, ceftriaxone and oxygen support at 2 lit/ml. Continuous cardiac monitoring and mechanical ventilator assistance by nasal prong for 13 days. The cause of death from poisoning is respiratory failure and ventilator-related complications.

Morbidity and death from organophosphate poisoning remain high in rural areas where intensive care services are either unavailable or inadequate. It is a highly poisonous, water-soluble pesticide with strong oral and mild cutaneous absorption. Oral intake is the most prevalent route of exposure in cases of purposeful self-harm. There have been a few recorded cases of intravenous, intramuscular and subcutaneous injections of insecticide linked to local and systemic symptoms [5].

There are studies detecting chlorpyrifosin 100% of about 40 children with more than 6 years of age. The route of entry of these pesticides into children's bodies can be any of these dermal absorption, ingestion or inhalation. Certain exposure related behaviours, such as hand- mouth activity are age dependent. Children less than 6 months have greater exposure through breast milk and inhalation, but when the children begin with crawling, the exposure will be mostly through dermal absorption and ingestion by placing their hands on the dusty surfaces and increasing their hand – mouth behaviour [6].

V. EXPOSURE OF CHILDREN TO OP PESTICIDES AND THEIR POTENTIAL ADVERSE HEALTH EFFECTS

There are studies indicating that developmental chlorpyrifos exposure to low doses, well below those needed to induce systemic toxicity is also linked with neurological alteration in both humans and rodents. These neurobehavioral alterations are also linked with neuro developmental syndromes. Postnatal exposure to low doses of chlorpyrifos induces long-term effects on 5-Choice Serial Reaction Time Task (5C-SRTT) learning and performance, cholinergic and GABAergic systems, and Brain-Derived Neurotrophic Factor (BDNF) expression [7].One potential alternative target for OP that has been identified by several laboratories is adenylyl cyclase and the synthesis of Cyclic Adenosine Monophosphate (cAMP). Studies have demonstrated that chlorpyrifos and other OP inhibit the synthesis of cAMP, but the mechanism is not clearly defined [8].

VI. ACTION MECHANISMS OF ORGANOPHOSPHORUS PESTICIDE

OP pesticides are widely used in agricultural and residential areas. These get rapidly hydrolysed in the air, sunlight and soil and get biodegraded by the microbes, even though a small amount remains in food and drinking water. The oxidised form is a potent neurotoxin called oxons. After entering the body, it gets oxidised to oxons by replacing the P=S bond with a P=O bond. It will inhibit the acetyl cholinesterase by binding to the active site of the enzyme. This action leads to the accumulation of the neurotransmitter and acetylcholine, thereby causes the hyper activation of the postsynaptic cholinergic receptors.

The Paraoxonase 1(PON1) gene has a great role in the hydrolysis of the oxon. This gene codes for the paraoxonase enzymes that hydrolyzeoxon into dialkyl phosphate (DAP) metabolites, diethyl phosphate and dimethyl phosphate. Foetuses and young children who have poorly developed PON1 are more vulnerable to OP pesticides. Some studies also point out that the OP insecticides interfere with the neurotrophic factors and cell signalling involved in normal brain development [9].

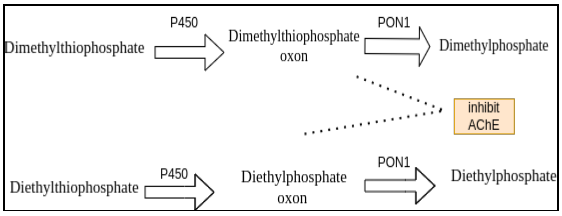

Fig.1. Metabolism of OP Pesticide [10]

VII. EFFECT OF ORGANOPHOSPHORUS PESTICIDE ON LIVING ORGANISM

The study conducted by Abbassy et al.[11] using the insecticides deltamethrin, cypermethrin showed a concentration-dependent increase in total Chromosomal Aberrations (CA) in the pesticide-exposed volunteer groups as compared to the control groups. It was shown that chlopyriphos had the highest genotoxic effect and chlorpyrifosmethyl had the lowest. The overall findings showed that the lymphocyte cells' chromosome abnormalities were elevated in volunteers who had previously been exposed to pesticides.

The typical target for acute OP pesticide toxicity and acetyl cholinesterase in hibition is not the only way that exposure to OP might have long-term negative effects. The OP insecticide chlorpyrifosox on causes a cross-link between aspartate or glutamate (or lysine) in pure proteins, resulting in a loss of water. The study by Schopfer et al.[12] discovered that a common characteristic of OP insecticides and their metabolites is their ability to catalyse protein cross-linking. Because of their quick biodegradability and lack of persistence, OP insecticides are used in agriculture, although their wide range of negative consequences reaches far beyond the pest.

High exposure to OP herbicides increases the incidence of depression, as does a family history of depression, loss and grief, post-traumatic stress disorder and work stress. The use of personal protective equipment lowers the incidence of depression. The risk of anxiety increases with high exposure to OP insecticide, post-traumatic stress, loss and sadness, a family history of depression and work stress [13].

The study by Verma & Rawat (2016) determined how sub-lethal chlorpyrifos affected the freshwater catfish "Heteropneustesfossilis" ovarian protein and carbohydrate levels. Their findings demonstrated that the concentration of ovarian protein and carbohydrates was dramatically ($p<0.05$) reduced by chlorpyrifos. Thus, they noticed that the chlorpyrifos is extremely harmful to aquatic life.

VIII. BIOREMEDIATION

OP insecticides are often used to manage agricultural and household pests. Exposure to OP pesticides cause substantial health risks to humans who consume polluted foods and water. To enhance food safety, OP pesticides' residues must be removed from products. Microbial decontamination is a new biological technique that is regarded as an efficient, safe, environmentally friendly and cost-effective solution for removing harmful substances. Probiotic microbes are said to have the functional ability to break down pesticides [15].

OP pesticides' increase the risk of liver toxicity because they are easily absorbed through the Gastro Intestinal Tract (GIT) and delivered to the liver, the primary site of pesticide metabolism, via the bloodstream [16]. Probiotics have been shown in some studies to reduce the body's toxicity and absorption of pesticides.

IX. CONCLUSION

OP are the most often employed synthetic pesticide families in India. Pesticides are the most common cause of poisoning in humans, accounting for more than 80% of illnesses. Many studies point out that pesticide exposure, which altered cholinesterase serum levels and haematology parameters was determined by pesticide dose, spray frequency, pesticide toxicity and one-day labour duration.

Chronic exposure to organophosphate insecticides can raise the risk of neuropsychiatric disorders like depression and anxiety. Unsafe behaviour by farmers will risk their health, notably in the form of neuropsychiatric illnesses (depression and anxiety).

This review is reflecting on the importance of using personal protection to avoid pesticide absorption in occupational settings. There should be training, advice and guidance about the good and correct the application of pesticides as well as farmer's health checks.

X. REFERENCES

[1]. Mali, H., Shah, C., Raghunandan, B., Prajapati, A. S., Patel, D. H., Trivedi, U. and Subramanian, R.B., (2023),Organophosphate Pesticides - An

Emerging Environmental Contaminant: Pollution, Toxicity, Bioremediation Progress and Remaining Challenges, Journal of Environmental Sciences, Vol.127, (pp.234–250).

[2]. Dhas S, Srivastava M., (2010), An Assessment of Phosphamidon Residue on Mustard Crop in an Agricultural Field in Bikaner, Rajasthan (India), European Journal of Applied Science, Vol.2, (pp.55–57).

[3]. Srinivasnaik, S., Sridharan, S., Bhuvaneswari, K., Nakkeeran, S., Kumar, S. M. and Jalali, S. K., (2022), Identification of Extensive Insecticide Usage Areas through Insecticide Usage Pattern Survey for Exploration of Insecticide Tolerant Strains of Entomophages in Major Vegetable Growing Districts of Tamil Nadu,Environment and Ecology, Vol. 40, (pp. 1481-1488).

[4]. SrinivasRao, C.H., Venkateswarlu, V., Surender, T., Eddleston, M. and Buckley, N. A, (2015), Pesticide Poisoning in South India: Opportunities for Prevention and Improved Medical Management, Tropical Medicine & International Health, Vol. 10, No. 6, (pp. 581-588).

[5]. Santosh, K. S., Prashant, K. D. and Sourabh, K, (2014), A Case Study on Organophosphate Poisoning in Tamil Nadu, Journal of Novel Research in Pharmacy & Technology, Vol. 1, No. 1, (pp.19-21).

[6]. Eskenazi, B., Bradman, A. and Castorina, R., (1999), Exposures of Children to Organophosphate Pesticides and Their Potential Adverse Health Effects, Environmental Health Perspectives, Vol. 107(Supplementary 3), (pp.409–419).

[7]. Pérez-Fernández, C., Morales-Navas, M., Guardia-Escote, L., Colomina, M. T., Giménez, E. and Sánchez-Santed, F.,(2020), Postnatal Exposure to Low Doses of ChlorpyrifosInduces Long-Term Effects on 5C-SRTT Learning and Performance, Cholinergic and GABAergic Systems and BDNF Expression, Experimental Neurology, Vol. 330, (pp.1133-1156).

[8]. Schuh, R. A., Lein, P. J., Beckles, R. A. and Jett, D. A., (2002),Noncholinesterase Mechanisms of Chlorpyrifos Neurotoxicity: Altered Phosphorylation of Ca2+/cAMP Response Element Binding Protein in Cultured Neurons, Toxicology and Applied Pharmacology, Vol. 182, No. 2, (pp. 176–185).

[9]. PubChem. (n.d.).PubChem.PubChem. https://pubchem.ncbi.nlm.nih.gov/

[10]. Miodovnik, Amir and Wolff. M.S., (2011), Prenatal Exposure to Industrial Chemicals and Pesticides and Effects on Neuro Development, Elsevier EBooks, (pp. 648–658).

[11]. Abbassy MA, Belal AH, Seehy MA and Mossa AH, (2005), In vivo Genotoxic Effects of Two Organophosphorus and One Carbamate Insecticides on Male Albino Rats, Journal of Agriculture and Environmental Science, Vol. 4, No. 1, (pp. 57-68).

[12]. Schopfer, L. M., Önder, S. and Lockridge, O., (2022), OrganophosphorusPesticides Promote Protein Cross-Linking, Chemical Research in Toxicology, Vol. 35, No. 9, (pp.1570–1578).

[13]. Fitriyani, A. L., Rahardjo, S. S., and Murti, B., (2020), Effect on Neuropsychiatric Disorders of Organophosphate Pesticides Exposure among Rice Farmers in Sukoharjo, Central Java, International Conference on Public Health, (pp.93).

[14]. Verma, S. and Rawat, A., (2017), Effect of Chlorpyrifos on Protein and Carbohydrate Content of HeteropneustesFossilis, International Journal of Fisheries and Aquatic Studies, Vol. 5, No. 1, (pp. 463-466).

[15]. Sarlak, Z., Khosravi-Darani, K., Rouhi, M., Garavand, F., Mohammadi, R. and Sobhiyeh, M. R., (2021), Bioremediation of OrganophosphorusPesticides in Contaminated Foodstuffs Using Probiotics, Food Control, Vol. 126, 108006.

[16]. Thakur, M., Medintz, I. L. and Walper, S. A., (2019), Enzymatic Bioremediation of Organophosphate Compounds - Progress and Remaining Challenges, Frontiers in Bioengineering and Biotechnology, Vol. 7, No. 289.