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Ecological and Health Impacts of Organophosphorus Pesticides: A Focus on Ethion in Aquatic Ecosystems

Rajoli Vinitha[1], Gijo Ittoop[1*], Ranjith D[2], Theja kannan[1], Rahul Krishnan[1], Safeena MP[1]
[1]Department of Aquatic Animal Health Management, Faculty of Fisheries Science, Kerala University of Fisheries and Ocean Studies, Panangad, Kochi-682 506, Kerala.
[2]Department of Veterinary Pharmacology and Toxicology, College of Veterinary and Animal sciences, Pookode, Wayanad 673576, Kerala.
[*]Corresponding author: gijoittoop@gmail.com
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Abstract

Pesticides play a crucial role in modern agriculture by protecting crops and enhancing yields, yet their indiscriminate use poses significant threats to non-target organisms and ecosystems. In India, annual pesticide consumption ranges from 52,000 to 62,000 tonnes, driven by yield pressures, pest resistance, and limited awareness of sustainable alternatives. Organophosphate pesticides are widely accepted for their rapid biodegradability and reduced environmental persistence. Aquatic ecosystems are particularly vulnerable, as pesticides enter water bodies through runoff, spray drift, and leaching, directly harming fish and invertebrates and disrupting food webs. Human health impacts include cancers, blood disorders, pulmonary dysfunction, and immune deficiencies linked to contaminated water and food sources. Ethion, a thiophosphate-class organophosphorus compound used on crops like tea, cotton, and maize, becomes toxic by converting to ethion monoxon, which inhibits acetylcholinesterase at nerve synapses. This results in uncontrolled nerve stimulation, muscular dysfunction, oxidative stress, and death in susceptible organisms. The toxic effects of Ethion 50EC pesticide on the freshwater fish *Labeo rohita* by measuring changes in aspartate aminotransferase (AAT) and alanine aminotransferase (ALAT) enzyme activities across gill, liver, kidney, brain, and muscle tissues.Which indicate Ethion-induced hepatotoxicity, mitochondrial disruption, and metabolic shifts toward gluconeogenesis for energy production amid oxidative stress, positioning AAT and ALAT as sensitive biomarkers for pesticide pollution in aquatic ecosystems. These findings highlight the urgent need for responsible pesticide management through integrated pest management (IPM), precise dosing, farmer education, and environmental monitoring to protect aquatic biodiversity while ensuring food security.

Introduction:

One of the most rigorous agricultural practices involves using insecticides to manage pests and unwanted plants, thereby boosting food production. While essential for crop protection, their use can have significant repercussions on human health and the environment. Pesticides are chemicals designed to eliminate various pests that threaten crops, livestock, and overall farm productivity (Rani et al., 2010). They also have diverse applications, functioning as plant growth regulators (to either stimulate or inhibit growth), defoliants (causing leaves or foliage to shed), desiccants (artificially speeding up plant tissue drying), and nitrogen stabilizers (preventing nitrification, denitrification, ammonia volatilization, or urease production by affecting soil bacteria) (Sabarwal et al., 2018).

India's total pesticide usage was estimated at about 52,000–62,000 tonnes, with consumption per hectare ranging from 0.28–0.32 kg of active ingredient per hectare of gross cropped area (Reddy et al., 2013; Nayak et al., 2021). Pesticides are often overused to maximize immediate crop yields, combat increasing pest resistance, and manage agricultural risks due to climate change. This practice is driven by a lack of awareness about alternative, sustainable pest management techniques, intense pressure to meet market demands, and often misleading advice from chemical retailers (Xu et al., 2008).

Pesticides are primarily categorized into three groups based on their chemical composition: organochlorines, organophosphates, and carbamates. In India, these groups, along with synthetic pyrethroids, constitute a significant portion of pesticide usage. Some of these chemicals can persist in the environment and accumulate in living organisms, increasing in concentration as they move through the food chain, which raises concerns about their detrimental effects on wildlife and human health. Notable examples include DDT and its related compounds (DDD and DDE), as well as aldrin, dieldrin, PCBs, and HCH. Among pesticides, organophosphorus compounds are extensively used in agriculture as insecticides, herbicides, and pesticides due to their rapid biodegradability, high efficacy in insect control, and lower environmental persistence compared to organochlorine compounds. Organophosphorus pesticides (OPPs) are generally safer and have a milder impact than their organochlorine counterparts (Marsillach et al., 2013; Damalas et al., 2016; Saad et al., 2025).

While pesticides are employed to enhance agricultural productivity, their indiscriminate use leads to environmental pollution. Non-target species suffer due to pesticide transfer in the environment, and some insecticides pose potential risks to human health and the environment. It is estimated that only about 0.1 percent of pesticides reach the intended organisms, with the remainder polluting the environment and causing ecological harm (Gill and Garg, 2014). The adverse effects of applied pesticides on non-target arthropods have been widely documented (Ware, 1980). Soil invertebrates, including nematodes, springtails, mites, micro-arthropods, earthworms, spiders, and insects, are affected. Pesticide application can lead to aquatic environment contamination through spray drift, runoff, and leaching (Van den Brink, 2013; Wijngaarden, Brock, & Van Den Brink, 2005).

Pesticides can directly impact fish, but they also have indirect toxic effects. These include reducing fish food sources such as algae and plankton, altering feeding habits, and degrading the quality of aquatic habitats (Cagauan, 1995; Cochard et al., 2014). The consequences of pesticide pollution extend to human health as well. According to UNEP (1993), pesticides are linked to a range of health issues, including cancer, hematological disorders, pulmonary dysfunction, immune system deficiencies, and congenital deformities. The FAO (1990) also highlights the health impacts of pesticide exposure. Pesticide runoff in water primarily affects human health in two ways. First, consuming shellfish and fish contaminated with pesticides can threaten economies reliant on fish populations in agricultural areas. Second, directly ingesting water contaminated with pesticides poses significant health risks (Hassaan et al., 2020).

Ethion is a widely used organophosphorus insecticide, characterized by a thiophosphate lP=S functional group. Organophosphorus pesticides constitute a significant portion of insecticides globally. Ethion is employed as an insecticide and miticide to combat mites in crops such as tea, cotton, maize, and cucurbits (Cook et al., 1995). The primary mechanism of ethion's toxicity involves its oxidative metabolism to ethion monoxon, which binds to and inhibits acetylcholinesterase at synapses. This inhibition prevents the breakdown of acetylcholine, resulting in continuous nerve stimulation, muscle dysfunction, and eventual death in susceptible organisms. Secondary damage includes oxidative stress and metabolic disruption as neurological pathways are compromised. Studies have reported the toxic effects of Ethion 50EC pesticide on the freshwater fish *Labeo rohita* by measuring changes in aspartate aminotransferase (AAT) and alanine aminotransferase (ALAT) enzyme activities across gill, liver, kidney, brain, and muscle tissues. Healthy fish (6.5-7.5 g) were exposed to sub-lethal (0.12 ppm) and lethal (1.2 ppm) concentrations for 5, 10, and 15 days, revealing significant elevations in both enzymes under sub-lethal stress—peaking in liver for AAT (up to 28.72% increase) and muscle/liver for ALAT (up to 43.50%)—compared to controls, with changes intensifying over time. These rises indicate Ethion-induced hepatotoxicity, mitochondrial disruption, and metabolic shifts toward gluconeogenesis for energy production amid oxidative stress, positioning AAT and ALAT as sensitive biomarkers for pesticide pollution in aquatic ecosystems (Prasanna et al., 2018).

Conclusion

While pesticides aid farmers in safeguarding crops and boosting food production, their misuse poses risks to both the environment and human health. Organophosphate insecticides, such as ethion, effectively combat pests but can also harm non-target organisms, particularly fish and other aquatic life. These chemicals interfere with essential nerve functions, potentially leading to abnormal behavior, stunted growth, or even mortality in aquatic species. The increasing presence of pesticide residues in water bodies underscores the necessity for more judicious and responsible usage. Sustainable farming practices, including integrated pest management (IPM), precise dosage, farmer education, and regular monitoring of environmental contamination, are crucial. Striking a balance between crop protection and environmental safety is vital for preserving ecosystems and ensuring long-term food security.

References:

Cagauan, A. G. (1995). The impact of pesticides on ricefield vertebrates with emphasis on fish. In *Impact of pesticides on farmer health and the rice environment* (pp. 203-248). Dordrecht: Springer Netherlands.

Cook, J. L., Baumann, P., Jackman, J. A., & Stevenson, D. (1995). Pesticide Characteristics that affect water quality. *Farm Chemicals Handbook*, *95*, 429.

Damalas, C. A., & Koutroubas, S. D. (2016). Farmers' exposure to pesticides: toxicity types and ways of prevention. *Toxics*, *4*(1), 1.

Food and Agriculture Organization (FAO). (2023). *Pesticide management and environmental impact assessment guidelines*. FAO Publications.

Gill, H. K., & Garg, H. (2014). Pesticide: environmental impacts and management strategies. *Pesticides-toxic aspects*, *8*(187), 10-5772.

Hassaan, M. A., & El Nemr, A. (2020). Pesticides pollution: Classifications, human health impact, extraction and treatment techniques. *Egyptian journal of aquatic research*, *46*(3), 207-220.

Marsillach, J., Costa, L. G., & Furlong, C. E. (2013). Protein adducts as biomarkers of exposure to organophosphorus compounds. *Toxicology*, *307*, 46-54.

Nayak, P., & Solanki, H. (2021). Pesticides and Indian agriculture—a review. *Int J Res Granthaalayah*, *9*(5), 250-263.

Prasanna, C., Anitha, A., & Rathnamma, V. V. (2018). EFFECT OF ETHION (50% EC) ON ENZYMATIC ACTIVITIES OF AAT AND ALAT IN FRESHWATER FISH LABEO ROHITA (HAMILTON).

Rani, L., Thapa, K., Kanojia, N., Sharma, N., Singh, S., Grewal, A. S., ... & Kaushal, J. (2021). An extensive review on the consequences of chemical pesticides on human health and environment. *Journal of cleaner production*, *283*, 124657.

Reddy, A. A., Reddy, M., & Mathur, V. (2024). Pesticide use, regulation, and policies in Indian agriculture. *Sustainability*, *16*(17), 7839.

Saad, H., Elfeky, S. A., El-Gamel, N. E., & Dena, A. S. A. (2025). Organophosphate pesticides: a review on classification, synthesis, toxicity, remediation and analysis. *RSC advances*, *15*(48), 40802-40822.

Sabarwal, A., Kumar, K., & Singh, R. P. (2018). Hazardous effects of chemical pesticides on human health–Cancer and other associated disorders. *Environmental toxicology and pharmacology*, *63*, 103-114.

UNEP, 1993. The Aral Sea: Diagnostic study for the development of an Action Plan for the conservation of the Aral Sea. Nairobi.

Van den Brink, P. J. (2013). Assessing aquatic population and community-level risks of pesticides. *Environmental Toxicology and Chemistry*, *32*(5), 972-973.

Ware, G. W. (1980). Effects of pesticides on nontarget organisms. *Residue reviews: Residues of pesticides and other contaminants in the total environment*, 173-201.

World Health Organization (WHO). (2023). *Organophosphate pesticides: Environmental health criteria and risk assessment*. WHO Press, Geneva.

Xu, R., Kuang, R., Pay, E., Dou, H., & de Snoo, G. R. (2008). Factors contributing to overuse of pesticides in western China. *Environmental Sciences*, *5*(4), 235–249.