Received: 11 April, 2024 | Revised: 18 April 2024 | Accepted: 30 April 2024

MANUSCRIPT ID: CoAS_V1IS11_07

POPULAR ARTICLE

Chronicle of Aquatic Science

Toxicological Effects of Pesticides in Indian Aquatic Environmental Health

Shailendra Kumar[1] | Lavkush*[2] | Kailas Rathod[3] | Parul[4] | Tamanna Halder[5]

[1]ICAR- Central Inland Fisheries Research Institute, Barrackpore, Kolkata-700120

[2]Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya-224229

[3]College of Fisheries Science, Kamdhenu University, Veraval, Gujarat-362265

[4]Choudhary Charan Singh Haryana Agricultural University, Hisar-125004

[5]Department of Botany, Dhrubachand Halder College, Kolkata-743372

Correspondence

Lavkush, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya-224229

Email: lavkushmaurya0017@gmail.com

Abstract

Pesticides' toxicological effects on aquatic biota, particularly fish, are a major cause for alarm when it comes to the state of India's aquatic ecosystem. Agricultural practices can release pesticides and their residues into aquatic habitats, where they can impact aquatic biota at low concentrations. To name just a few of the many negative impacts that long-term exposure to organic pesticides in waterways can have on fish health, these include death, infertility, weak immune systems, and thinning eggshells. The aquatic environment in India is affected by the toxicological effects, which affect the fish immediately and then ripple through the entire aquatic food chain. Ultimately, this undermines the ecosystem's health and balance. It is critical to employ effective strategies for pesticide management, such as monitoring pesticide levels in aquatic environments, using alternative pest control methods, and ensuring proper application techniques, in order to lessen the detrimental effects that pesticides have on the aquatic habitats in India. As a result, aquatic ecosystems can remain healthy and balanced, aquatic resources can be enjoyed and consumed by humans without risk, and aquatic biota can be protected.

KEYWORDS

Pesticides, pollution, riverine systems, permissible limits

Publisher's Note

The opinions presented in this article are the exclusive views of the authors and do not necessarily reflect the views of their affiliated organizations, the publisher, editors, or reviewers. The publisher does not guarantee or endorse any product evaluated in this article or any claim made by its manufacturer.

Conflict of Interest

The authors assert that the manuscript was developed without any commercial or financial associations that could be interpreted as a potential conflict of interest.

Authors Contribution

All listed authors have contributed significantly, directly, and intellectually to the work and have endorsed it for publication.

INTRODUCTION

Pesticides are substances which are synthetic or natural (pesticides, fungicides, larvicides, rodenticides, bactericides etc.) that are applied to plants to control diseases, sterilize the surface weeds, and pests. Appropriate use of the pesticide destroyed the food born pests and producing the foods around 45% worldwide from the pest outbreaks and as a result variety of pesticide is used for managements of pests. Pesticides are extensively utilized in present-day agriculture to enhance crop quality and quantity at a comparatively lower cost (Abhilash and Singh, 2009). Since from last 50 years, rising population increased and also significantly use of fertilizers and pesticides reduce the insecurity of foods globally (Boliko, 2019). Generally, pesticides are categorized on the nature of chemical composition and presence active compound. There are main four classes of pesticides (chemical and structural): pyrethroids, carbamates, organochlorines, and organophosphates (Buchel, 1983). The oldest class of synthetic and applied pesticides is represented by organochlorine insecticides. The organochlorine insecticides are oldest class of synthetic pesticides are primarily used to control the domestic and agriculture insect with broad-spectrum activity. However, in environment, they exhibit long-term persistence because of low biodegradability. Organochlorines work by upsetting the neurological system, which causes seizures, paralysis, and eventually death in insects. Some typical examples of organochlorines are DDT, aldrin, dieldrin etc. (Garg *et al.,* 2021). Organophosphates were utilized more frequently after the 1990s, when organochlorines were still commonly used. In addition, organophosphates are broad-spectrum pesticides that have nervous poison, gastrointestinal, and contact poison. Parathion, Malathion, diazinon, and glyphosate are a few of the popular organophosphorus pesticides (Karunarathne *et al.,* 2021). Carbamate are insecticides which is derived from the carbamic acid. Carbamtes are affecting their brains and nervous system to kill or destroyed the insects in aquatic or terrestrial ecosystems.

SOURCE OF PESTICIDE POLLUTION

The primary cause of pesticide contamination in water bodies is agricultural operations, particularly the runoff of surface water from farm fields where pesticides are used. This can also happen in residential areas when pesticides are applied to lawns, as well as from the unintentional spread of pesticides during their application, which can result in some of the spray being carried into surrounding bodies of water. Pesticides are intentionally formulated to be poisonous to specific organisms, yet they frequently cause harm to unintended targets, such as fish and birds. Aside from agricultural runoff, aquatic pollution can also stem from industrial facilities lacking adequate runoff control. Depending on the nature of the manufacturing activities conducted at these sites, they may discharge harmful substances into the water (Bashir *et al.,* 2020). Household items, including detergents, cleaners, and paints, can contribute to aquatic pollution. Fuel burning also adds hydrocarbons and metals to the environment, which eventually enter the water through air deposition or runoff. Runoff is the primary cause of nonpoint source pollution, which is a major contributor to marine pollution, accounting for 80% of all pollution in the marine environment. Nonpoint source pollution encompasses numerous minor contributors like septic tanks, vehicles such as cars, trucks, and boats, along with significant sources like farms, ranches, and forested

regions. Each day, countless automobile engines emit small amounts of oil onto roads and parking areas, which can ultimately seep into water bodies. Soil erosion or sedimentation caused by agricultural activities or building sites can result in the contamination of water bodies, leading to detrimental effects on aquatic ecosystems and the habitats of fish and wildlife (Hejna *et al.,* 2022).

PESTICIDE POLLUTION IN AQUATIC ENVIRONMENTS

In India

The application of diverse pesticides resulted in severe pesticide pollution in aquatic habitats in India, affecting numerous river systems and lakes. Pesticides taint the majority of river systems in South Asian nations, including India, according to an analysis of 136 pertinent publications published between 2015 and 2020. The Tapi River and Chilka Lake in India have a significant impact, with contamination levels much higher than those found in other river basins. The two main sources of contamination from pesticides in Indian aquatic environments are chemical runoff from agricultural land and industrial effluent. The predominant pesticide compounds found in South Asian River systems are Hexachloro-Cyclo-Hexanes (HCHs), Dichloro-Diphenyl-Trichloroethane (DDT) endosulfan, heptachlor, and chlorpyrifos (Sarker *et al.,* 2021). These insecticides possess a prolonged lifespan, exhibit high toxicity, and have a sluggish breakdown process, hence posing a substantial risk to aquatic habitats. Pesticide pollution in aquatic ecosystems in India has a significant influence, resulting in mortality, reproductive failure, eggshell thinning, suppression of the immune system, and other health difficulties in fish. Water pollution in India is commonly caused by the presence of pesticides, animal wastes, insecticides, fertilisers, and similar substances in aquatic habitats (Riaz *et al.,* 2021). Numerous methods, including aerosol drift, horizontal spraying, the release of home and industrial sewage, the incorrect dumping of abandoned chemical boxes, and equipment cleaning, allow the hazardous chemical pesticides to enter aquatic environments. In order to tackle the problem of pesticide contamination in Indian aquatic habitats, adequate guidelines and policies must be created and put into place to control the manufacture and sale of dangerous pesticides. It is crucial to minimise potential harm to the atmosphere and the body by decreasing the use of pesticides, obtaining proper approvals from the Environmental Protection Agency (EPA) for disposal methods, and abstaining from placing bottles or chemical trash in communal disposal zones beside roadways, personal trash bags, or public litter bins (Rajmohan *et al.,* 2020).

IMPACT OF PESTICIDES ON AQUATIC ENVIRONMENTS

Generally, single or mixture of pesticides is harmful to the human as well as ecosystem due to its toxicity. There is insufficient information on compound how they will react with aquatic ecosystem. Consequently, the prediction of whether or not a certain combination of substances will result in increased toxicity is sometimes not simple. The water characteristic directly effects the solubility of pesticides have an impact on how much of them bioaccumulate in fish. The solubility of pesticide compounds in water and their bioaccumulation in fish exhibit an inverse relationship. But higher the solubility will decrease the chances of bioaccumulation in the fish. Therefore, one key factor in reducing the dynamics of pesticides in aquatic habitats is their solubility in water. The rate of absorption or elimination of pesticides varies depending on the absorption, metabolic path way of individual and specific of the organism how to react

with this compound. Pesticides that contaminate aquatic environments can lead to the undesirable loss of ecosystems through disease and aquatic animal death. Aquatic microbes, muscles, invertebrates, and vertebrates etc. all suffer from this. These aquatic creatures are found in the food chains of nature. Hence, the dangerous compounds found in pesticides also have an impact on other species that depend on these aquatic organisms for sustenance. Lipophilic in nature, organochlorine pesticides (OCPs) tend to deposit inside the fat storing tissue of body. Due to metabolism, many birds have a half-life of more than a year for pesticides (Jayaraj *et al.,* 2016). By Wiemeyer *et al.* (1988), *Pandion haliaetus*, the osprey, and *Haliaeetus leucocephalus*, the bald eagle, have lower reproductive success rates when exposed to p, p 0-DDE (dichloro-diphenyl dichloroethylene).

PESTICIDE EFFECT ON AQUATIC VERTEBRATES

India has conducted a number of researches to evaluate the effects of widely used pesticides on aquatic animals. Chlorpyrifos is one of the organophosphate insecticides that is frequently used in farming. The pesticides, bifenthrin and chlorpyrifos, genotoxic effects were investigated in an experiment conducted on the Rohu samples. Acetamiprid is a common pesticide used in agriculture in a number of countries. Dimethoate is an organophosphate pesticide with a broad spectrum of use that is used to control a variety of insects and mites. Comparative research on the long-term effects of acetamiprid, dimethoate, and chlorfenapyr on *Cirrhinus mrigala* revealed a considerable alteration in thyroid function in addition to a change in blood profile. Additionally, it was noted that the fish treated with pesticides had higher serum levels of liver biomarker enzymes (Ghayyur *et al.,* 2021). All treated groups showed notable changes in the histology study of their liver and gills. These three pesticides were graded in order of increasing toxicity: chlorfenapyr > acetamiprid > dimethoate. The study's conclusion was that non-target creatures, ecosystems, and human health are seriously threatened by the careless use of such pesticides. Another common organophosphate insecticide used to manage a variety of agricultural pests is malathion. This insecticide is extremely poisonous in addition to being resistant to biodegradation. It could stay in the human body for up to two generations after it enters. At different time intervals, researchers evaluated the impact of a small amount of malathion on *Channa punctatus* fish. The findings indicated that extended exposure periods to malathion led to a gradual decrease in morphometric indices, as well as other biochemical parameters and enzyme levels, especially those associated with antioxidant systems (Bharti and Rasool, 2021) A common 4th-generation halogenated synthetic pyrethroid used in both home and agricultural pest control is cypermethrin (Ore *et al.,* 2023).

CONTROL AND MANAGEMENTS OF PESTICIDE

Chemical control

Over the 50 years, the primary and most efficient method of managing pests has been the "remediation" approach, which uses hazardous chemicals for controlling insects. Environmental disturbances and security measures continue to guarantee and continued calls for substitutes that are adequate in terms of safety, effectiveness, and affordability. The most widely used method of controlling pests is the use of synthetic chemicals, or pesticides. The four main difficulties that come up are toxic residuals from pesticides, resistant pest as intermediate forms, and pest revival. Numerous

environmentally friendly pesticides and environmentally friendly organophosphates must be chosen; synthetic pesticides should only be used as a last resort and only when absolutely necessary (Lewis *et al.,* 1997).

Biological control

Occasionally, the term "biological control" has been interpreted broadly to encompass a wide range of biological organisms and products with a biological basis, such as resistant plant varieties, autocidal methods like sterile insects, and phero-110% (Thiery *et al.,* 2018). Both conventional and new challenges occur in weed and pest control. The main goal of integrated pest management (IPM) is to create systems that employ as many different biological and non-chemical techniques as feasible (Thiery *et al.,* 2018).

Mechanical control

Modern techniques and machinery are employed nowadays, along with other cutting-edge instruments, to manage pests in all agricultural processes. It includes manual hand weeding in addition to farming techniques like slash and burn and tillage. The population of the pest can be decreased by defoliating some standing crops, pruning contaminated fruit sections, and forest tree trimming. Another method for killing the maize borer is to blaze the stubbles and chaff the sorghum/maize portion of the stalks (Sharma *et al.,* 2021).

Sanitary control

Sanitary control of pesticides in aquatic environments entails taking steps to limit or eliminate pesticide runoff into water bodies, employing beneficial insects as pest controllers, meticulously plotting out road and skid trail locations and designs, consistently maintaining buffer strips between logging operations and adjacent water bodies, and finally, establishing control mechanisms and regulatory frameworks for pesticide use. In order to learn about the long-term consequences of pesticide exposure and to find problem regions, it is essential to monitor and evaluate pesticide levels in the water (Pradhan *et al.,* 2022).

Natural control

Some methods of controlling pests solely include enhancing naturally occurring pest management strategies, such as employing beneficial insects. In this case, only insecticides are used realistically, and it is clear that natural predators will aid in pest management (Chandler *et al.,* 2011).

CONCLUSION

Pesticides in the Indian aquatic environment have substantial toxicological effects and pose a serious threat to aquatic ecosystems. Pesticides have been observed to have poisonous effects on economically significant members of aquatic ecosystems at both lethal and sub-lethal concentrations. The impacts encompass fatality, unsuccessful reproduction, reduction in eggshell thickness, inhibition of the immunological system, and various health complications in fish. Pesticide exposure in aquatic species, especially fish, can cause changes in hematological parameters, genotoxicity, and histological abnormalities that impact different organs. As the primary consumers in the aquatic food chain, fish serve as indicators of water quality and contamination by collecting harmful substances in their tissues and

organs. It is essential to monitor the dangerous stress in the aquatic environment, particularly due to the influence of pesticides on fish gills. Fish gills are extensively exposed to water and operate as the major pathway for toxic substances to enter the body. In summary, the harmful impacts of pesticides on the aquatic environment in India emphasize the necessity for strict regulations on pesticide usage, the preservation of aquatic ecosystems, and the protection of the well-being of aquatic animals.

REFERENCE

Abhilash, P.C., & Singh, N. (2009). Pesticide use and application: an Indian scenario. *Journal of hazardous materials,* 165(1-3):1-12.

Bashir, I., Lone, F. A., Bhat, R. A., Mir, S. A., Dar, Z. A., & Dar, S. A. (2020). Concerns and threats of contamination on aquatic ecosystems. *Bioremediation and biotechnology: sustainable approaches to pollution degradation*, 1-26.

Bharti, S., & Rasool, F. (2021). Analysis of the biochemical and histopathological impact of a mild dose of commercial malathion on Channa punctatus (Bloch) fish. *Toxicology Reports*, *8*, 443-455.

Boliko, M.C. (2019). FAO and the situation of food security and nutrition in the world. *Journal of nutritional science and vitaminology*, 65:S4-S8.

Buchel, K.H. (1983). Chemistry of Pesticides, John Wiley & Sons, Inc. New York, USA.

Chandler, D., Bailey, A. S., Tatchell, G. M., Davidson, G., Greaves, J., & Grant, W. P. (2011). The development, regulation and use of biopesticides for integrated pest management. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *366*(1573), 1987-1998.

Garg, P. K., Chishi, N., Kumar, R., Latha, T. K., Rai, S., Banerjee, B. D., & Gupta, S. (2021). Organochlorine pesticide tissue levels in benign and malignant breast disease: a comparative exploratory study. *Journal of Environmental Pathology, Toxicology and Oncology*, 40(1).

Ghayyur, S., Khan, M. F., Tabassum, S., Ahmad, M. S., Sajid, M., Badshah, K., ... & Qamer, S. (2021). A comparative study on the effects of selected pesticides on hemato-biochemistry and tissue histology of freshwater fish Cirrhinus mrigala (Hamilton, 1822). *Saudi Journal of Biological Sciences*, *28*(1), 603-611.

Hejna, M., Kapuścińska, D., & Aksmann, A. (2022). Pharmaceuticals in the aquatic environment: A review on eco-toxicology and the remediation potential of algae. *International Journal of Environmental Research and Public Health*, *19*(13), 7717.

Karunarathne, A., Bhalla, A., Sethi, A., Perera, U., & Eddleston, M. (2021). Importance of pesticides for lethal poisoning in India during 1999 to 2018: a systematic review. *BMC public health*, *21*, 1-13.

Jayaraj, R., Megha, P., & Sreedev, P. (2016). Organochlorine pesticides, their toxic effects on living organisms and their fate in the environment. *Interdisciplinary toxicology*, *9*(3-4), 90-100.

Lewis, W. J., Van Lenteren, J. C., Phatak, S. C., & Tumlinson Iii, J. H. (1997). A total system approach to sustainable pest management. *Proceedings of the National Academy of Sciences*, *94*(23), 12243-12248.

Ore, O. T., Adeola, A. O., Bayode, A. A., Adedipe, D. T., & Nomngongo, P. N. (2023). Organophosphate pesticide residues in environmental and biological matrices: Occurrence, distribution and potential remedial approaches. *Environmental Chemistry and Ecotoxicology*, *5*, 9-23.

Pradhan, S. S., Gowda, G. B., Adak, T., Guru-Pirasanna-Pandi, G., Patil, N. B., Annamalai, M., & Rath, P. C. (2022). Pesticides occurrence in water sources and decontamination techniques. In *Pesticides-Updates on Toxicity, Efficacy and Risk Assessment*. IntechOpen.

Rajmohan, K. S., Chandrasekaran, R., & Varjani, S. (2020). A review on occurrence of pesticides in environment and current technologies for their remediation and management. *Indian journal of microbiology*, *60*(2), 125-138.

Riaz, U., Rafi, F., Naveed, M., Mehdi, S. M., Murtaza, G., Niazi, A. G., & Mehmood, H. (2021). Pesticide Pollution in an Aquatic Environment. In *Freshwater Pollution and Aquatic Ecosystems* (pp. 131-163). Apple Academic Press.

Sarker, S., Akbor, M. A., Nahar, A., Hasan, M., Islam, A. R. M. T., & Siddique, M. A. B. (2021). Level of pesticides contamination in the major river systems: A review on South Asian countries perspective. *Heliyon*, *7*(6).

Sharma, G., Shrestha, S., Kunwar, S., & Tseng, T. M. (2021). Crop diversification for improved weed management: A review. *Agriculture*, *11*(5), 461.

Thiéry, D., Louâpre, P., Muneret, L., Rusch, A., Sentenac, G., Vogelweith, F., ... & Moreau, J. (2018). Biological protection against grape berry moths. A review. *Agronomy for sustainable development*, *38*, 1-18.

Wiemeyer, S.N., Bunck, C.M. & Krynitsky, A.J. (1988). Organochlorine pesticides, polychlorinated biphenyls, and mercury in osprey eggs–1970–79–and their relationships to shell thinning and productivity. *Archives of Environmental Contamination and Toxicology*, *17*, pp.767-787.

How to cite this article: Kumar S, Lavkush, Rathod K, Parul and Halder T. Toxicological Effects of Pesticides in Indian Aquatic Environmental Health. *Chron Aquat Sci.* 2024;1(11):43-49