Effect of Pesticides on Fish: A Review

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DOI: https://doi.org/10.51584/IJRIAS.2026.11110036

Received: 02 November 2026; Accepted: 07 November 2026; Published: 24 November 2026

ABSTRACT

Contaminants or pollutants are entering water bodies due to human activities such as agriculture, industrialization, and domestic activities. Pesticides are often used on crops for crop protection as well as to increase agricultural yields. Contamination by pesticides in aquatic ecosystem is a serious problem, which can lead to decrease in water quality and increase risk to aquatic life. Fish are an integral part of many people's diet. Fish is one of the best organisms to study the impact of pesticide toxicity. This mini-review summarises, the effects of pesticides on fish species regarding their behavior, histopathological alterations, changes in haematological and biochemical parameters. Behavioral changes can affect fish survival, growth, and reproduction. Structural damage to tissues can impair the function of the affected organ. Alteration in haematological and biochemical parameters changes fish physiology.

Keywords: Pesticide, Fish, behaviour, histopathological effects, haematological and biochemical parameters

INTRODUCTION

Fishes are an important part of the aquatic ecosystems. Fish play a vital role in maintaining the balance of aquatic ecosystems and are often used as indicators to assess water quality because they are highly sensitive to environmental changes and pollutants. The use of agrochemicals is essential for pest control and increasing food grain production for the global population. (Khan *et al*., 2013). Freshwater and terrestrial ecosystems are highly polluted by a large number of toxic substances, mainly by the application of pesticides and fertilizers by the agricultural sector (Schwarzenbach, *et al.,* 2006).

World Health Organization (WHO, 2009) classified pesticides according to their toxicity or hazardous effects. In the textbook of Forensic Medicine and Toxicology (Pillay, 2017) pesticides are classified as insecticides, herbicides, fungicides, rodenticides, acaricides, nematicides, molluscicides etc. Control of pests, weeds, rodents result in the high productivity and better quality of crops, which also results in additional economic revenue (Amenyogbe *et al*., 2021). But these agrochemicals often enter water bodies through runoff, leaching, or drainage from nearby fields and affect the non-target aquatic biota, including fish (Omitoyin, 2006). These pesticides have a severe impact directly on the reproduction, fecundity, and survival rate of fishes (Manimekalai *et al*., 2022). Pollutants and toxicants are generally known to produce rapid changes in the blood characteristics as well as organ damage in fishes. Hence, the present review discusses mechanisms of pesticide toxicity to fish as well as the effect of pesticides on fish behaviour, histopathological alterations, changes in haematological and biochemical parameters.

Mechanisms of pesticide toxicity to fish fauna: Pesticides are chemical compounds. On this basis, pesticides are divided into four major groups such as carbamates, organophosphates, organochlorines, and pyrethroids. When fish come into contact with pesticides, these toxic chemicals can accumulate in fish tissues, leading to a range of deleterious effects, such as oxidative stress, immunosuppression, endocrine disruption, and neurotoxicity (Ullah and Zorriehzahra, 2015). Due to effect of pesticides, 'free radicals' are generated within body of fish, leading to oxidative damage, inflammatory responses, and genetic alterations; consequently, the growth and health of the fish are adversely affected (Soliman and Abdelmawgood, 2026). Pesticides promote the production of ROS (reactive oxygen species) and RNS (reactive nitrogen species), which leads to oxidative damage to lipids, proteins, and DNA (Abdollahi, *et al*., 2004).

Effect of pesticides on fish behavior: Pesticides can significantly alter fish behavior, even at sublethal concentrations. The symptoms of glyphosate toxicity observed in the fish *Oreochromis niloticus* juvenile included loss of balance, agitated or erratic swimming, gulping of air bubbles, restlessness, sudden rapid movements, excessive secretion of mucus from the body, and swimming upside down (Ayoola, 2008). The poisoned fish became extremely weak, settled at the bottom, and eventually died. Srivastava and Singh (2013) observed that compounds that inhibit the action of cholinesterase disturbed the normal regular movements of fish. Imbalanced swimming, darting and erratic movements and hypoexcitability can be observed in *L. rohita, C. carpio, O. mossambicus, C. catla* and *C. mrigala* due to the action of sodium cyanide (Ullah *et al*., 2014). Exposure to pesticides generally reduces the expression of conspecific interactions but does not affect the variation in responses among individuals. Courtship behavior is most severely affected, suggesting that pesticide exposure could impair the process by which mating is distributed among individuals in the population (Morrison *et al*., 2025).

Histopathological alterations in fish tissue due to effect of pesticides: Pesticides cause well-documented, organ-specific tissue damage in fish. Gills, livers and kidney are the most-studied target organs because they are directly involved in exposure, detoxification and excretion. Common lesions due to pesticides on gill histopathology include epithelial hypertrophy and hyperplasia, lamellar fusion, epithelial lifting, oedema, blood congestion, aneurysms, and necrosis. Typical changes in liver histopathology include hepatocyte vacuolation, cloudy swelling, pycnotic nuclei, and focal necrosis. Kidney shows tubular narrowing, glomerular atrophy and necrosis due to pesticide toxicity. Ayoola (2008) studied histopathological changes of gills, livers, kidneys due to toxicity of glyphosate herbicide. In the gills, filament cell proliferation, lamellar fusion, lamellar cell hyperplasia, and epithelial lifting were observed. Vacuolation of hepatocytes and necrosis is seen in liver. Kidney lesion consisted of hyaline droplets in the tubular epithelial cells and pyknosis. Borah, *et al*. (2024) observed deleterious effects of herbicide glyphosate on different internal organs of fish *Heteropneustes fossilis.* They found enlargement of hepatocytes with pyknotic nuclei, extensive damage to the chloride cells, hypertrophy and fusion of secondary lamellae of gill, deterioration to the columnar epithelial cells of the intestines due to glyphosate toxicity.

Effects of pesticides on haematological parameters of fish: Blood is the most valuable tool for understanding the toxic effects of pesticide on animal tissues. The haematological profile of fish reflects the pollution status of the aquatic ecosystem. Haematological parameters like RBC, haemoglobin and plasma protein level decreased whereas WBC level increased in a freshwater fish *Cyprinus carpio* after treatment of insecticide chlorpyrifos (Ramesh and Saravanan, 2008). Freshwater fish, *Channa striatus* showed significant reduction in red blood cells count, haemoglobin value, packed cell volume, mean corpuscular haemoglobin, and mean corpuscular volume, but increase in total white blood cells after exposure to methomyl pesticide (Chinnamani *et al.,* 2018). These results indicated that fish were suffering from microcytic hypochromic anaemia (Ghaffar *et al.*, 2015). Siddique, *et al*. (2026) evaluated the toxicity of phenanthrene on juvenile *Oreochromis niloticus*. Their findings indicated phenanthrene as a potent toxicant capable of inducing severe hematological dysfunctions in this fish. They clearly observed a dose-dependent increment of erythrocytic cellular and nuclear abnormalities in the fish, indicating possible cytotoxic and genotoxic effects.

Effects of pesticides on biochemical parameters of fish: Pesticides consistently deplete the three major biochemical energy reserves in fish tissues i.e., protein, lipid, and glycogen. Total protein content typically decreases across liver, muscle, and gill tissues. Fish *Oreochromis mossambicus* shows depletion in protein content after exposure to organophosphate pesticides, synthetic pyrethroids and herbicides (Naqvi, *et al.,* 2017). Ghaffar *et al.* (2018) studied the toxic effects of fipronil on *Cyprinus carpio*. They observed significant increase in biochemical parameters including urea, creatinine, cholesterol, triglyceride and glucose but decrease in albumin content. The biochemical parameters of Nile tilapia exposed to thiamethoxam were studied by Mansour *et al.* (2025). They observed no statistically significant alterations in protein, albumin, globulin, and glucose levels across the tested doses and durations. Conversely, creatinine levels were significantly elevated.

CONCLUSION

Pesticide exposure harms fish at several levels of biological organization. Behavioural, haematological, biochemical and histopathological parameters respond sensitively to pesticide exposure in a dose and time dependent manner. Thus, they serve as reliable biomarkers of aquatic pollution. Even sublethal concentrations impair growth, survival, and reproduction, which threatens fish populations, aquatic food webs, and ultimately human food safety. Therefore, it is recommended to take precautions that pesticides use near water bodies should be regulated and safer alternatives like biopesticides should be promoted.

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