Pesticides Affect Fish: Exploring Physiological, Behavioral and Biochemical Changes

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ABSTRACT

Biologically active compounds used in agriculture that develop near aquatic environments easily spill into rivers or other aquatic system. Pesticides have been found to be highly toxic not only for fish but also to the other organisms which constitute the food chain. Bioaccumulations of these pesticides danger the long-term survival of fishes by disrupting the ecological relationships between organisms and diversity loss. Insecticides, herbicides and fungicides are observed worldwide in aquatic environments and accumulated in aquatic organism. Many insecticides, including organochlorine and organophosphate, have long been banned long ago because of their high persistence and non-target toxicity. Pesticides Effect on hemato-biochemical parameters and histopathology of several important organs of fish.

INTRODUCTION

Pollutants released into the water bodies cause major social and economic losses. Many biologically active substances that apply to humans, animals, and crops are found in aquatic environments. Pesticides are among the most toxic groups of

contaminants introduced into the aquatic environment, due to their high chemical stability and resistance to metabolism, and high lipid solubility. Various aquatic organisms, such as fish, algae, shellfish, and mammals, are physiologically affected by pesticides released from agriculture industry. Along the food chain Pesticides bio accumulated in aquatic environments are transferred to higher predators. Among the aquatic organisms, fish are located at the higher part of the food chain in aquatic environment, so biomagnification of pesticides is commonly observed. Organic pesticides or agrochemicals are synthetic substances that are anthropogenically produced and applied to prevent, or control undesirable species defined as fungal or animal pests. Existence of pesticide residues and their metabolites in various environmental compartments such as water, soil, air and several foods. Several pesticides have been detected in various environmental media and biological tissues, typically at trace concentrations (ng l^{-1} to g l^{-1}). According to WHO Pesticides are divided into four categories based on their level of toxicity: extremely dangerous, highly dangerous, moderately dangerous, and slightly dangerous. Organophosphate, carbamates, organochlorine, nicotinoids and pyrethroids are a few of the different kinds of pesticides. Malathion has low toxicity to mammals and relatively high toxicity to fish. This occurs due to the absence of hydrolytic enzymes in insects and fish. Diazinon is a broad-spectrum insecticide. Within a few weeks of the application, the water may get contaminated with chemical residues from intensive agricultural operations and drift. The use of insecticides slows growth rate and contributes to a variety of metabolic and reproductive disorders. When exposure of insecticide in fish species causes histopathological changes in the gills, liver, hematopoietic tissues like the spleen, kidney, and renal tubules, in endocrine tissues as well as brain, neurological, and behavioural disorders. Pesticide may also result in genetic defects. Some fish species are highly susceptible to environmental water pollution. Pesticide toxicity can lead to harmful effects, including mutagenesis, carcinogenesis, hematological and histopathological complications, as well as endocrinological and reproductive disorders. Pesticides induced toxicity resulted several changes including behavioral changes, histopathological alterations, genotoxic impacts, hematobiochemical and hormonal complexities, nutritional imbalance, as well as caused oxidative stress in different fish species.

Commonly used pesticide

Name of the pesticides

Atrazine (C)

Diazinon

Cypermethrin

Malathion

Endosulfan

Permethrin

Benomyl (C)

Acephate (C)

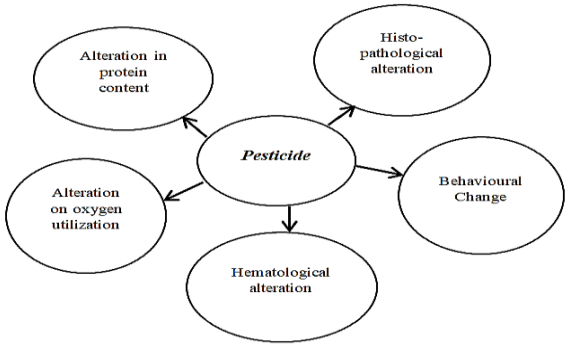
Oxadiazon (C)

Permethrin (C)

Diclofop-Methyl (C)

Effects of Pesticide on Fishes

Acute toxicity caused by the pesticides showed a significant positive correlation between dose and mortality. Increased concentrations of toxic chemicals, present in pesticides in water, resulted in more intake or entry of toxic chemicals in body of the animals.



Behavioural changes

Fish is directly affected by bioaccumulations of different pesticides. Behavioural modification is one of the most sensitive indicators of environmental stress and may affect survival. Pesticides induce different types of toxicity in fish, lead changes in fish behaviour such as rendering fish sluggish and alter their swimming ability making them more susceptible to be preyed, reduce their ability to feed, maintain their position and defend their territories. Behaviour provides a unique perspective linking between physiology and ecology of an organism to its environment (Kumar *et al*., 2020). Behaviour allows an organism to adjust to external and internal stimuli in order to adapt environmental variables. Sub-lethal concentrations of pesticides in aquatic environments cause structural and functional changes in aquatic organisms and this is more common than mortality (Crisp *et al*., 1998).

Alterations in fish behaviour, particularly in non-migratory species, can also provide important indices for ecosystem assessment. Behavioural changes caused by trizole fungicide propiconazole (Gill *et al*., 1991). Aquatic contaminations of pesticides cause acute and chronic poisoning of fish and other organisms. Pesticides damage vital organs and skeletal system and also cause behavioural changes of the exposed fish. Interruption in the schooling behaviour of fish such as dangling, erratic and irregular movements and disturbed swimming have been observed due to inhibition in activity of acetylcholinesterase in *Clarias batrachus* under exposure of propiconazole and mancozeb (Srivastava and Singh, 2013).

Catla catla shows in increased movements of opercula, rapid jerk movement, equilibrium loss, body colour alterations, frequent surfacing and elevated mucus secretion under the effect of methyl parathion (Ilavazhahan *et al*., 2010). Cypermethrin cause darting, erratic and irregular swimming movements, equilibrium loss, hyperexcitability and sinking to bottom in *Labeo rohita* (Ullah *et al*, 2014).

Biochemical and Physiological Changes

Several biochemical and enzymatic changes induced by secondary metabolite of pesticide in in aquatic organisms. Pesticide metabolite react with oxygen present in water that reduced the consumption of oxygen in fish or aquatic organism when expose to the pesticides. Dimethyl parathion pesticide interrupts the oxygen consumption in *Labeo rohita* (Bengeri *et al*., 1984). Dimethoate induces toxic effects and reduces in oxygen consumption in *Oreochromis mossambicus* (Shereena *et al*., 2009) and propiconazole and mancozeb induce toxic effects in *Clarias batrachus* (Srivastava and Singh, 2013).

Glycogen metabolism – Glycogen content fall in the body tissue of fish indicates its rapid utilization of glycogen by the respective tissue because of toxic stress of the pesticide. Depletion of glycogen may be due to direct utilization of the compound for energy generation, a demand caused by pesticide-induced hypoxia. Under hypoxic condition, the fish derives its energy from anaerobic breakdown of glucose which is available to the cells. Concentration of blood glucose level increased caused by stress condition in fish response to acute toxic effects of pesticides. Under stress conditions the secretion of high amount of catecholamine depletes glycogen reserves (Pickering, 1981).

Fish show that epinephrine induction reduces hepatic glycogen by increasing glycogen phosphorylase. Increase concentration of glucose considered as reliable indicator of environmental stress. Das and Mukherjee (2003) reported that the sub-lethal exposure of cypermethrin up to 45 days alter blood glucose level in *Labeo rohita*.

Level of glycogen decreased in the liver of *Heteropneustes fossilis* exposed to endosulfan Rawat *et al*., (2002). Dichlorvos showed significant impact in total protein, tissue glycogen and albumen content in muscles, liver and kidney of *Oreochromis mossambicus* (Lakshmanan *et al*., 2013).

Protein- Decrease in protein level of liver, muscle, intestine, gills and blood of *Channa punctatus* exposed to oleondrin and In *Cyprinus carpio* to endosulfan have been observed (Tiwari and Singh, 2004).Total protein of liver tissue in *Oreochromis niloticus* affected by Thiamethoxan (Bose *et al*., 2011) while propiconazole and mancozeb induced changes in protein content in *Clarias batrachus* (Srivasatav and Singh, 2013).

Enzymes Activity- Several enzymatic pathways changes are also induced by pesticides pollutions in organisms. Torre *et al*., (2002) reported that *Cyprinus carpio* and Cnesterodon decemm-aculatus were highly sensitive to pollutant and showed reduce level of acetylcholinesterase. Brain acetylcholinesterase activity was decreased over a period of 45 days by cypermethrin concentrations and lactate dehydrogenase (LDH) activity in brain and liver was elevated but inhibited in kidney, succinate dehydrogenase (SDH) and ATPase activities were depleted in brain, kidney and liver (Das and Mukherjee, 2003).

Hematological Changes due to pesticide toxicity

Blood is the indicator of pathological changes induced by the pollutants in fishes. Hemato-biochemical parameters have been considered as an essential technique to evaluate the effects of various toxic substances including pesticides in fish. Hematological parameters are important for toxicological research and as indicators of environmental stress and disease in fish. Pesticide pollutions resulted in reduction of RBC (Talas and Gulhan, 2009). Pesticide toxicity cause anaemic and hypoxic condition in fishes. Pesticides toxicity of fish lowers the Hb, erythrocytes count and haemolysis process. Various pesticides including aldrin, dieldrin, DDT, BHC, chlordane, cypermethrin, permethrin, sulfane, endosulfane, endosulfan, delmethrin, diazinon, dimecron, chlordane etc. showed lethal effect on haematology such as changes in WBCs and RBCs, haemoglobin contents and packed cell volume of different fish species such as *Labeo rohita*, *Cyprinus carpio*, *P. ticto*, *Oreochromis mossambicus*, *Channa punctatus* and *Heteropneustes fossilis* (Ullah *et al*, 2014).

Histopathological alterations due to pesticides toxicity

Histopathological examination of key fish tissues is a crucial method for detecting the harmful effects of various toxicants and monitoring aquatic contamination. Alteration in different fish tissues resulted from pesticides oxidative toxicity can provide a basic idea about the severity of the relevant pesticides. Damages of these important organs adversely affect the growth, survival, development, reproductive performances as well as immune system of fish. Exposure of fish to different pesticides will affect the production reactive oxidative stress (ROS) and free radicles which may result in damage. ROS and other free radicals significantly destruct the normal cellular structure of different tissues. Methylation and phosphorylation of cellular proteins by various organic pesticides, particularly organophosphorus compounds, significantly reduce the likelihood of tissue recovery from necrosis.

Possible control measures

Physical methods for pest control

Pesticide use can be reduced by implementing various physical pest control techniques. The

commonly available methods are mass trapping and shooting. Moreover, manual method to eliminate pests can also be used in this aspect.

Several biological methods like introduction of herbivorous fish to control unwanted aquatic weeds, use of biopesticides to control insects. Besides, several fungi can be used as myo-herbicides to manage unwanted species. Utilization of arthropod and pathogenic species as biocontrol methods efficiently to control exotic weeds.

Reducing the pesticide effects on fish by herbal methods

Application of different plants such as *Mentha pulegium*, *Allium sativum*, *Apium graveolens*, *Artemisia absinthium*, *Carum carvi*, *Laurus nobili* and *Ocimum basilicum* can be used for reducing the adverse effects of pesticides on fish. Medicinal plants have antioxidant properties effectively protect fish against the toxic effects of pollutants. Dietray *Moringa oleifera* supplementation positively reduced the toxic effects of sub-lethal fipronil in *O. niloticus*. Besides, dietary *Thymus vulgaris*, *Origanum vulgare* and menthol oil positively ameliorated the thiamethoxam, cypermethrin and chlorpyrifos induced toxicity in *O. niloticus*, *C. gariepenus*, *O. niloticus and C. carpio*, respectively. Moreover, dietary lycopene significantly improved the hemato-biochemical profile of diazinon and endosulfan in toxicated fish. Negative effects of chlorpyrifos can be mitigated in several fish species by numerous natural feed additives such as curcumin, propils, lycopene and *Spirulina platensis (Rohani, 2023)*.

CONCLUSIONS

Pesticides pollution is a serious hazard to the aquatic environment as well as living organisms including fish. Pesticides cause several negative effects on different aspects of fish which result in a massive loss for sustainable aquaculture production. Pesticide toxicity not only undesirably affect the fish but also possess a serious health concern of consumers as pesticide bio-accumulates in fish tissues. Fish act as a major source of pesticides that induce several carcinogenic as well as non-carcinogenic human health problems.

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