



Ecotoxicology of Aquatic System: A Review on Fungicide Induced Toxicity in Fishes

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Abstract

Ecotoxicology is the study of the effects of toxic chemicals on biological organisms, especially at the population, community, ecosystem, and biosphere levels. Pesticides are agrochemicals that are used to control pests, including insects, fungi, molds, mildew, bacteria, nematodes, rodents, unwanted herbs etc. Pesticides after surface runoff enter into aquatic system and impose hazardous condition in the environment. These chemicals have been found to be highly toxic not only to fish but also to the other organisms, which constitute the food chain. The contaminations of the water cause various ill effects on the fish health by altering they physiological status. The fungicides induce toxic effects on biochemical and hematological parameters, genetic material, enzyme profile, protein levels and histological status. In this review we have tried to highlight the ill effects of commonly used fungicides on different fish species by rating the toxicity levels of the toxicants.

Keywords: Fishes; Ecotoxicology; Fungicides; Hematological Effect; Biochemical Effect; Histological Effect; Genotoxic Effect

Introduction

In recent years, the high rate of increase in human population and rapid pace of industrialization have created problem of food grain production. Another major problem is crop damage by various pathogens like insects, weeds, fungus, bacteria, viruses etc. Pesticides are toxic by design-Biocides, designed to kill, repel and reduce pests, unwanted herbs, rodents, fungi or other organisms which impart threat to crop plants. So, they are extensively being used by farmers in modern agriculture practices to increase crop production to sustain the human population. But lack of knowledge and injudicious use of the pesticides leads to lethal effects on organisms. After

surface runoff these toxicants enter aquatic system and impart hazardous effect on non-target organisms specially fishes. These toxic chemicals change the quality of water that affect the fish and other aquatic organisms health [1,2].

Pesticides are ubiquitous in environment and most are synthetic. The mode of exposure to these toxic chemicals in fish and aquatic animals in three primary ways:

- Dermal, direct absorption through the skin by swimming in pesticide-contaminated waters,
- Inhalation, by direct uptake of pesticides through the gills during respiration,

- Orally, by drinking pesticides-contaminated water or feeding on pesticide-contaminated prey.

Among different aquatic organisms, fishes are highly sensitive to the environmental contamination of water. Hence, pollutants such as pesticides may affect significantly certain physiological processes like biochemical and hematological parameters, alteration in genetic and protein level, changes in histology and particularly oxidative stress in fishes. Thus impart serious impairment to health status of fishes. As fish is the mostly consumed aquatic food providing high protein in diet hence it also affects human health. Here, we present a review specially fungicidal effect on fish in aquatic system.

Fungicide Induced Toxicity in Fish

Fungicides are substances used to control fungal organisms causing crop damage and prevent fungal plant diseases. Pesticides usage in agricultural fields to control pests is extremely toxic to non target organisms like fish and affect fish health through impairment of metabolism, sometimes leading to mortality [3]. Pesticides toxicity in

fish has been studied by previous researchers who have shown that at chronic level, it causes diverse effects including oxidative damage, inhibition of ACHE activity, biochemical changes, histopathological changes as well as hematological and developmental changes, mutagenesis and carcinogenicity. Pesticides present in the environment with other similar compounds, may induce lethal or sub lethal effects in fish [4].

A Pesticides capacity to harm fish and aquatic animals is largely a function of its toxicity, exposure time, dose rate, and persistence in the environment. A lethal dose is the amount of pesticide necessary to cause death because not all animals of a species die at the same dose, a standard toxicity dose measurement, called a lethal concentration 50 (LC₅₀), is used. This concentration of pesticide that kills 50% of a test population of fish within a set period of time is usually determined after 24 to 96 hours. Toxicity classification of fungicides based on LC₅₀ values are presented in Table 1. Some common fungicides with their trade names and LC₅₀ in rainbow trout along with their toxicity rating have been precisely presented in Table 2.

Toxicity classification	LC ₅₀ (mg/l*)	Toxicity classification	LC ₅₀ (mg/l*)
Super	<0.01	Slight	11-100
Extreme	0.01-0.10	Minimal or Non toxic 1mg/l = 1part per million (ppm)	>100
High	0.11-1.0		
Moderate	1.1-10		

Table 1: Toxicity classification of different fungicides.

Chemical Name	Trade Name	Toxicity Classification	96 hr LC ₅₀ (mg/l): Rainbow Trout
Benomyl	Benlate	High	0.2
Captan	Agrox, Captan, Captec	Extreme-moderate	0.06
Carboxin	Vitavax	High-moderate	>0.1
Chlorothalonil	Bravo, Daconil, Terlanil	High	0.3
Coppersulfate	Basicop, Bluestone	High-moderate	0.14
Fenarimol	Rubigan	High	0.2
Fosetyl -Al	Aliette	Minimal	428
Iprodione	Rovral	Moderate	4
Mancozeb	Dithane, Fore, Manzate	High-moderate	2 (48 hr)
Maneb	Maneb, Manex	High-moderate	2 (48 hr)
Metalaxyl	Ridomil	Minimal	>100
Propiconazole	Alamo, Orbit, Banner, Tilt	High-moderate	0.9
Thiram	Thiram, Spotrete	High-moderate	0.1
Ziram	Ziram	Moderate	5 (5 hr): Goldfish

Table 2: Common fungicides and their toxicity rating.

Exposure of fish and other aquatic animals to pesticides depends on its biological availability (Bioavailability), bio-concentration, biomagnifications, and persistence in the environment. Bioavailability refers to the amount of

pesticide in the environment available to fish and wildlife [5]. Persistence (long -standing) pesticides breakdown slowly and may be more available to aquatic animals [6]. The information about possible pesticides affect fish and

other aquatic life depend upon different factors like, type of Pesticide product, use rates (frequency), weather conditions, aquatic species involved and number of fish killed upon exposure.

Effect of Fungicides on Fish

Rao and Pillala [7] reported that fish metabolism is directly affected by different pesticides. They induce different types of toxicity in fish such as changes in fish behaviour [8-10], haematological changes [11-13], histopathological disturbances [14-17], biochemical modifications, endocrine system disruption [3,18,19], changes in antioxidant defence system [20-22] and alteration of acetylcholinesterase activity [23-26].

Biochemical Effect

Previous studies have shown devastating effects of pesticides in various biochemical parameters [9]. Studies on *Labeo rohita* by applying organophosphates in sub-lethal concentration led to disturbance in various enzymes such as glutaminases including phosphate activated glutaminase and L-Keto acid activated glutaminase in brain tissue, which were associated with the involvement of these brain regions with metabolism [27].

Hematological Effect

Various researches have suggested lethal effects of pesticides on hematological factors in different fish species. The blood parameters are used to study the extent of stress in fish exposed to different pollutants and toxicants, as heavy metals, pesticides, industrial effluents etc. Toxicology studies show that the impact of different fungicides on the erythropoietic organs like kidney and spleen may result in less erythrocyte number and hemoglobin content which may be regarded as an anemic sign, and even lead to death of fish. Decreased erythrocyte number and haemoglobin concentration in freshwater fish *Channa punctatus* was recorded by Anees [28]. Svoboda, et al. [29] showed decreased lymphocyte and monocyte percentage in *Cyprinus carpio* whereas Banaee, et al. [30] observed significant increase in neutrophil percentage in common carp in during exposure to diazinon.

Histological Effect

The toxicity of commonly used fungicides in different organs in fish include gill, heart, kidney, liver, muscle and spleen. The effect of fungicides in gill was epithelial hyperplasia with lamellar fusion, epithelial hypertrophy,

edema, general necrosis and degeneration of primary and secondary gill lamellae. In Heart remarkable effect upon the cardiac muscle were seen which is associated with the circulatory system of the organism. Toxicity in Liver shows large number of vacuoles, enlargement of nuclei of some cells, nuclear hypertrophy, enlarged sinusoids and atrophic areas as compared to control cells of liver. Nuclear and cytoplasmic degeneration and melanomacrophages were also found. Kidney of fish revealed proximal convoluted tubule and secondary convoluted tubules were degenerated to some extent and cellular contours were not prominent. Devascularisation and innervations of short bundles of muscle, muscular dystrophy, degeneration and disorganization were the characteristics of toxicated fish muscles. The spleen is fibrous capsule with small trabeculae extend into the parenchyma. The parenchyma can be divided into a red and white pulp. Expansion of red pulp and presence of hemosiderin granules in a melanomacrophage center are important histopathological damages observed in spleen of fish exposed to sublethal concentrations of fungicides. Gill histopathological damage was also reported due to exposure of mosquitofish (*G. affinis*) to deltamethrin [31], and maneb and carbaryl application to rainbow trout (*O. mykiss*) [32]. Das and Mukherjee [33] studied the toxic effect of sub-lethal doses of hexachlorocyclohexane (HCH) during 45 days in organs like liver, kidney, gill, skin, muscle, heart and brain of *Labeo rohita*.

Genotoxic Effect

Different studies have been conducted which throws light at genotoxic effect of pesticides on fish. There is rich documented literature witnessing research on molecular level of different fish species showing ill effects of pesticides DNA levels [34-36]. Other researchers, Tripathy, et al. [37] explained that tissue-specific damage in nucleic acid content may be due to differential effects of Fenvalerate or its metabolite(s) on synthesis and/degradation of DNA or RNA in gill and kidney cells of the fish.

Effect on Protein

Choudhury, et al. (2017) [20] reported that due to long term exposure of *Channa punctatus* and *Oreochromis mossambicus* to Hexaconazole 5%SC and Azoxystrobin 23% SC caused over expression of some lower molecular protein as compared to control.

Conclusion

In the light of the above findings we may conclude that judicious use of fungicides should be done by the farmers.

Use of Biopesticides and natural products should be encouraged to reduce the toxic effect of the fungicides. Biocontrol of pests will be a wise selection as compared to synthetic agrochemicals.

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