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# Pesticides and heavy metals toxicity in fishes

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**Abstract**
Aquatic Toxicology is the study of the consequences of environmental pollutants on aquatic organisms, like pesticides especially insecticides, Pesticides are highly toxic not only to fish but also to other organisms, the more acute toxicity are insecticides. Since fishes are important sources of proteins and lipids for humans and stock, that the health of fishes is very important for citizenery. Insecticides are the chemicals accustomed control insects by killing or preventing them from engaging in undesirable behaviors or destructive. Application of insecticides used to control a wide variety of insectivorous and herbaceous pests which might otherwise diminish the number and quality of food productions. The insecticides, are threatening the long-term survival of major ecosystems by disruption of ecological relationships between organisms and loss of biodiversity. The key Chemical groups of insecticides that are usually applied are Organophosphate, Carbamates, Organochlorine, Pyrethroids, and Necotenoides.

**Keywords:** pesticides, insecticides, fish, histopathology

## Introduction
The insecticidal residues which contaminate the water are mainly because of the intensive agriculture combined with surface runoff and surface drainage, usually within some weeks after application. Insecticides cause a decrease rate of growth, reproductive disorders. Also, cause spinal deformities and histopathological changes in gills, liver, hematopoietic tissue like the spleen, head of the kidney and renal tubules, endocrine tissues additionally as brain, neurological, behavioral disorder, and genetic disease are other biological indicators of exposure to insecticides. Fishes are particularly sensitive to the environmental contamination of water. Hence, these pollutants like insecticides may significantly damage certain physiology and biochemical processes that different forms of insecticides can cause serious impairment to the physiological and health status of fishes. This review presents further information concerning the consequences (Acute, subchronic, and chronic) of the various concentrations of pesticides (including insecticides) on various aspects of fish's biology and physiology. Also, depicts the behavior, genetic and immunological system of fish. The knowledge given during this review facilitates the evaluation of potential toxic hazards resulting from exposure to different levels of these compounds. Data can be acquired useful in environmental risk assessment of freshwater organisms and marine. The histopathological changes in fish tissues are used as a biological indicator for pollution with pesticides with special relevancy to insecticides. Finally, Protection of wildlife and water quality is feasible when rationalizing the utilization of pesticides. Also, when Pesticides must choosing judiciously and are utilized in combination with other pest management tools and applied safely, the surface water pollution and contamination of our aquatic life might be avoided (Farid *et al*., 2015) [15]. Experimental studies reveal that insecticides are potent to cause toxic effects, structural alterations in non-target organisms like fishes. Therefore concerted efforts required in reducing the utilization of chemical pesticides. Implementation of natural methods for pest encroachment through organic farming can help in reducing pesticide pollution. Therefore the researches that might provide early warning signals are essential to manage and minimize the hazards caused by them on non-target species (Zeshan and Saltanat, 2020) [35].

Fisheries and aquatic resources (ponds, rivers, streams, the seas, and oceans) are supplying people with long-term benefits. Those benefits may be the direct financial ones that provide employment, profit and economize. For instance, the seafood industry provides hobs for commercial fisheries, wholesalers, and retailers. More indirect, but equally valuable, benefits of fish and aquatic ecosystems include recreational boating, sport fishing, swimming, relaxation, and natural beauty (Wohlriechender, 2008) [33]. There are occupational hazards and safety concerns within the aquaculture industry. Some practices have caused environmental degradation. Public perception of farmed fish is that they're "cleaner" than comparable wild fish.

## Impact of Pollution on health of fish
There is little evidence of pollution affecting the health of fish and shellfish the globe. There's no disrupt that pollution can affect the aquatic organisms under laboratory conditions and will be liable for the decline of populations of such animals in some inland water and a few estuaries, most of the evidence for population causing or increasing diseases in fish in open water is circumstantial. Pollution, especially in inland waters, has for the past 400-500 years are the result of urbanization and industrialization. This has resulted in some major rivers becoming deficient in fish stocks. The

priority that pollution may influence the health status of fish and shellfish stocks has increased over the past 20 years. In general, diseases in fish are much localized, but there's concern amongst scientists that certain cancers, especially liver tumours, occurring in demersal fish inhabiting polluted estuarine and coastal waters, are associated with the discharge of chemicals, e.g., hydrocarbons, pesticides, and heavy metals (Buck, 1993) [10]. However, the link between adverse water quality and fish diseases isn't proven. Many surveys have indicated a greater proportion of diseased fish in polluted compared to non-polluted sites (Austin, 1998) [2], (Shankar et al., 2013) [29].

**Pesticides Toxicity in Fish**

Are substances want to control organisms, including insects, water weeds, and plant diseases? Pesticides usage in agricultural fields to regulate pests is extremely toxic to non-target organisms like fish and affects fish health through impairment of metabolism, sometimes leading to mortality (Shankar et al, 2013) [29]. During those days, the increased human population with the rapid pace of industrialization induced the matter of disposal of wastewaters. The domestic wastes and untreated or partially treated industrial effluents, supplemented with pollutants like heavy metals, pesticides, and plenty of organic compounds, heave greatly contributed to massive fish death of aquatic ecosystems, (Dhasarathan et al., 2000) [12], (Pazhanisamy and Indra, 2007) [28].

**Advantages of Pesticides**

There are many advantages of pesticides like, they'll protect against forest and farm crop losses and may aid in additional efficient food production, they're wont to slow the spread of destructive forest insects like the gypsy moth, they're wont to establish and maintain lawns and recreational areas, they're accustomed help reduce malnutrition and starvation of humans and animals, and are instrumental in controlling many insect-borne human diseases like malaria, encephalitis, and plague. Many authors' considered the pesticides are simple to use, rapid effect, inexpensive, wide spectrum, and long-lasting.

**Disadvantages of Pesticides**

The main disadvantages of pesticides are including their toxicity to some humans, animals, and useful plants, and the persistence (long life) of a number of these chemicals within the environment. And when pesticides enter the aquatic system, became the environmental costs. Unintentional pesticide-related fish kills occur throughout the globe, a number of these kills are large, involving thousands of fishes, similarly as frogs, turtles, mussels, water birds, and other wildlife. Fish and other wildlife species, including rare and enlarged ones just like the peregrine, bald eagle, and osprey, are victims of toxic condition. Pesticide use is one amongst many factors contributing to the decline of fish and other aquatic species. Pesticides are capable of killing salmon and other aquatic life directly and within a brief period. Long-term exposure to certain pesticides can alter swimming ability, which successively can reduce the power to feed, avoid predators, to defined territories, and maintain position in the river system. Many pesticides interrupt schooling behaviour, a critical for avoiding predation, during salmon migration.

**Routes of Pesticides Fish Exposure**

Fish and water animals are exposed to pesticides in three primary means. Dermal, direct absorption through the skin by swimming in pesticide-contaminated waters, Breathing, by direct uptake of pesticides through the gills during respiration, and orally, by drinking pesticides- contaminated water or feeding on pesticide-contaminated prey.

**Integrated Pest Management (IPM)**

IPM may be a system employing a type of methods, including pesticides, to cut back pest populations to acceptable levels. Factors like groundwater contamination, the increasing cost of agricultural chemicals, consumer concerns about pesticide residues on food, and concern for the environment encourage the utilization of IPM. IPM strategies mean the usage of the many of the ways combined to succeed in the required goal of such methods summarized as follows: Cultural control (crop rotation and selected planting dates to avoid pests), Host resistance (using plants and livestock that are immune to pests), Mechanical control (uprooting, weed harvesting, cultivation, and use of insect traps), Biochemical control (Stocking grass carp to go after water weeds), Chemical control with pesticides, and sanitation, (Shankar et al., 2013) [29].

**Effect of the three main kinds of pesticides on fish and Shellfish**

Classifications of Insecticides, the insecticides are classifieds into, Systemic Insecticides are accustomed treat plants and also the insect ingests the insecticide while feeding on the plants. Contact insecticides are working through direct contact with insects (small droplets like aerosols) often improves performance, (Dogan et al., 2011) [13].

**Residual effects of Insecticides**

The application of the pesticides by fish, organ phosphorous insecticides was commonly higher than carbamates insecticides. Diazinon, Fenitrothion, and BPMC caused deformity in fish with abnormality of the backbone, (Kanazawa, 1975) [21].

**Bioaccumulation of insecticides**

After exposure to different concentrations of insecticides in water, the fish absorbs them in its gill, skin, or digestive tract. Because of their lipophilicity, most insecticides easily permeate the biological membranes and it increases the sensitivity of fish to aqueous insecticides. Then, insecticides are rapidly metabolized and extracted and perhaps bio concentrated in various tissues of fish. Bio-accumulation occurs if the insecticides increases, it becomes more harmful to the procurer or animals. The accumulated insecticides can cause death or long-term damage because of the bio-concentration of these compounds in numerous tissues of fish, (Ballesteros et al., 2011) [3].

**Biotransformation of insecticides and the toxic mechanisms**

Enzymes participating inside the biotransformation of insecticides are categorized into phase I clinical test and clinical test enzymes.

**Acute Toxicity of Insecticides**

The acute toxicity of insecticides to fish which mean toxicity rate was determined after 96 hours and this

concentration-dependent, (slightly toxic with 10-100ppm), (Moderately toxic with 1-10ppm), (Highly toxic with 0.1-1ppm), and (Extremely toxic with Less than 0.1 ppm) (Banaee et al., 2011b) [5]. In acute toxicity, sudden, and intense mortality is also observed within the fish population exposed to the insecticides. The foremost apparent symptoms of insecticides in fish are Lethargy, forward extension fins, Pallor or blue part of the body, severe reaction to external stimuli, muscle spasms, sudden fast swimming in circles, disorder and disruption of the nervous function, respiratory dysfunction, and suffocation (Banaee et al., 2011a) [6].

**Sub-Lethal toxicity of insecticides**

Sub-lethal toxicity was planned supported one-tenth or more LC50 doses in moderate periods. In sub-lethal toxicity, the organs or biological systems which can be affected at such exposure can be the respiratory, hepatic, hematopoietic, nervous, cardiovascular, and reproductive, and immune systems. Insecticides cause changes within the blood biochemical parameters and hematological profile of fish, (Kavitha and Rao., 2009) [22]. Insecticides cause a decrease rate of growth, reproductive disorders. Also, cause spinal deformities and histopathological changes (Benli and Ozkul, 2010) [7] in gills, liver, hematopoietic tissue like the spleen, head of the kidney and renal tubules, endocrine tissues also as brain, neurological, behavioral disorder and genetic defects are other biological indicators of exposure to insecticides.

**Effects of Insecticides on different parameters in Fish.**

Alterations in blood biochemical parameters, blood biochemistry test give indicates what happening within the body of fish has exposed to insecticides. When different tissues are injured, the damaged cells release specific enzymes into plasma and we can recognize their abnormality levels within the blood.

Tissue and Organ damage, **i**n histopathology, we will provide information about the health and functionality of organs. Tissue injuries and damages in organs may result in reduced survival, growth, and fitness, low reproductive success, or a rise of susceptibility to pathological changes. The frequency and intensity of tissue lesions depend upon the concentrations of insecticides and also the length of the duration of fish exposure to the toxins. Many insecticides cause-specific or non-specific histopathological damage.

Reproductive Dysfunction, any changes in environmental parameters or physiological conditions of fish can affect its reproductive success. Fish could also be exposed to environmental pollutants, including insecticides, herbicides, heavy metals, and xenobiotics, disorders may occur in their natural reproductive process. Recent researches showed the dysfunction within the reproductive systems of fishes exposed to insecticides. Insecticides effects on the reproductive biology of fishes are numerous and include decreased fecundity, testicular and ovarian histological damage, vitellogenesis process impairment (Haider and Upadhyaya, 1985) [18], and disruption in steroidogenesis process, delay in gonads maturation, alter in reproductive and parental behaviour, impairment in olfactory response and disorder in reproductive migrations, additionally as disruption in coordinating courtship behavior of male and female fish and time of spawning (Jaensson et al., 2007) [19]. Some insecticides are referred to as endocrine-disrupting chemicals which may interfere with the traditional functioning of the endocrinal organisation in fish. Adverse effects of insecticides on the hypothalamus-pituitary gonads axis may also play a major role in causing reproductive failure in fish. Exposure to fish eggs and milt insecticides also reduced the stages of fertilization, hatching rate, and larval survivability. The waste of energy in fish exposed to insecticides residues reduces their reproductive ability (Moore and Waring, 2001) [27].

Development Disorders, the study of developmental disorders caused by insecticides is to stress the links between the concentrations of poisons and dysfunction in normal development from embryonic to puberty periods. Impairment in normal development and growth may reduce the fish's survival chance. Embryos and larvae could also be directly exposed to insecticides, through the yolk or via parental in viviparous fish (Viant et al., 2006) [31].

Neurotoxicity, the synthetic pyrethroids change normal neuronal function by interfering in the function of ion networks in the nerve cell membrane, alterations in the intercellular calcium ion amount, and possibly by blocking GABA receptors. Organochlorine insecticides act primarily by changing the transport of ions across the neuron membranes, thus altering the flexibility of the nerve to stimulate.

Behavioral alterations, fish that were exposed to different kinds of insecticides showed changes in swimming behavior, feeding activates, predation, competition, reproduction, and species-species social interactions like aggression (Cong et al., 2009) [11]. (Banaee et al., 20011a) [6], reported similar behavioral responses in common carp and rainbow trout exposed to sub-lethal levels of Diazinon. Most insecticides influence the behavioral patterns of fish by interfering with nervous systems and sensory receptors (Cong et al., 2009) [11], and this incident may impair the identification of things and also the development of appropriate response by the fish exposed to the insecticide. The effect of certain insecticides on the activity of ACHE may cause decreased mobility of the fish (Bretaud et al., 2000) [9].

Genotoxicity, genotoxic chemicals like insecticides have common chemicals and physical properties that enable them to interact with genetic materials (damage or DNA inactivation), (Gogan et al., 2011) [16]. The mutation which will result from an interaction between a chemical and genetic material may be a heritable change within the cell genotype, and thus the error could also be transferred to the cell or the subsequent generation. Carcinogenic and also the formation of some tumors in several tissues of fish exposed to insecticides may additionally be caused by genotoxic proprieties of these xenobiotics. Chromosomal damage is additionally involved in eggs and larvae of fish exposed to different levels of insecticides. Some insecticides behave as genes leading to unusual concentrations of plasma steroid hormones and reproductive dysfunction or immunosuppression (Jin et al., 2010) [20].

Immuno-suppression, insecticides alter the function of the immune system and leading to immune depression, uncontrolled cell proliferation, and alterations of the host defense mechanisms including immunity and bought immunity against pathogens. The immunity of fish is vital for defense against a range of pathogens. Different insecticides at sublethal levels are recognized as stressors causing immunosuppression in fish (Werimo et al., 2009)

[32]. Exposure to sub-lethal concentrations of insecticides is that probably makes fish vulnerable to infectious diseases because of their immune- depressive effect (Zelikoff et al., 2000) [34].

Effect on the development of fish, biochemically, the ratio of the RNA/DNA can be used as a bio-indicator measure of body growth. Insecticides toxicity indicates the change in supermolecule biosynthesis. Disturbances within the metabolism of macromolecule can result in a decrease in the RNA content. The effect of organophosphate on alkaline phosphatase activity in several tissues of fish may adversely affect macromolecule synthesis. Dichlorvos causes alterations in DNA replication and aberrancy in chromosomes, which causes mutations and cellular hyper-proliferation. Inhibit enzyme activities involved in DNA replication and repair mutations can affect the ultimate product of gene appearance. Cause decreases the amount of RNA in protein synthesis (Banaee, 2013) [4].

Histopathological alteration because of insecticides toxicity: Tissue alterations in fish exposed to different concentrations of insecticides are the functional response of organism which provides information on the character of the toxicant. In histopathology, we will provide information about the health and functionality of organs Tissue injuries and damages in organs may result in reduced survival, growth, and fitness, low reproductive success or increase susceptibility to pathological agents.

Gills, fish gills have many important functions including Gas exchanges, transport mono, and divalent ions, excretion of waste nitrogen and uptake, and excretion of varied xenobiotics (Evans et al., 2005). Histopathology of the gill is that the appropriate bio-indicator for pollution monitoring. One in every of the lesions most often found on the gills of Rainbow trout, Diazinon (0.1 mg/l). Diazinon (0.2 mg/l) causes epithelial hyperplasia of both primary and secondary epithelium RT. Also, noticed Edema, epithelial hyperplasia, mucous cell hyperactivation, and fusion of the secondary lamellae.

Liver, Silver catfish when treated with (2,4-D) herbicides + Diazinon caused cloudy swelling, vacuolar and hydropic degeneration further as necrosis and cytoskeleton disarray, changes in nuclear shape and heterochromatin, intense damages in Diss's space between hepatocytes and sinusoids, enlarged vacuolization of endothelial cells, morphological derangement and necrosis of the diss spaced, (Gunter, 2007) [17].

The kidney, **t**he kidney of bony fish is consists of a diversity of cells, including parenchymal cells, lymphoid and hematopoietic tissues. The functional unit of the kidney is that the nephron. Morphologically, the nephron of fish includes glomerulus, tubules, and collecting duct, (Mata, 2011) [24].

Spleen, the spleen encompasses a fibrous capsule, and tiny trabeculae extend into the parenchyma, which might be divided into a red and white pulp. When the common goby was exposed to RT / 3, 4 dichloramines, the important histopathological changes were hyperactivation of Melano Macrophage Centers (MMC), excessive hemosiderosis and congestion, (Borna et al., 2015).

Intestine, the intestine of RT has a mucosa, submucosa, muscularis, and serous membrane, the mucosal epithelial cells have thin and extended absorptive cells or enterocytes, goblet cells, and lymphocytes. Atrophy, necrosis and exfoliate of mucosal cells, congestion, and hemorrhage, addition of lymphocytes in the lamina propria, also detected in Mosquitoes fish duo to thiodan and deltamethrin (Uner et al, 2006 ) [30].

Gonads, reduced in number and condensation of spermatogenic cells and appearance of an oversized number of intertubular vacuoles, cloudy swelling, spermatocyte necrosis and necrosis of seminiferous tubules are important histopathological alterations observed in tests of fish exposed to Diazinon, (Uner et al., 2006) [30].

Herbicides are the foremost commonly used pesticide. They're widely applied to crops, forest lands, gardens, and lawns. Herbicides often are directly applied to lakes and ponds to regulate nuisance growth of algae (colonial, filamentous, and single cells), submersed water grasses (coattail, milfoil, naiad, pondweed), flowering water plants (water lily, spatterdock, duckweed), and emergent water plants (cattails, rushes, reeds). Regarding the influence of this group of pesticides on fish, fish kills may occur after herbicide application, even when the herbicide used isn't on to fish. Fish die indirectly from suffocation, instead of herbicide poisoning, because masses of rotting water weeds by the herbicide decompose, reducing oxygen levels.

Fungicides, like herbicides, generally aren't as highly toxic to fish and aquatic animals as insecticides. However, some fungicides are banned because of their adverse effects on the environment. Mercurial fungicides accumulated in the environment and concentrated up the organic phenomenon, causing fish kills. Some currently-registered fungicides are extremely toxic to fish. Some fungicides are poisoned to beneficial soil invertebrates. Their use should be avoided or cautiously managed near aquatic systems (Michelle, 2009) [26].

## Conclusion

We can conclude that the long-term exposure of fish to pesticides (including insecticides), means never ending hazard for the population. So, the human population is at high risk of consuming these intoxicated fish. The rationalization usages of pesticides are considered the most vital component in decreasing aquatic environmental pollution with pesticides and various contaminants. Thus impacts the remainder have a minimum of in marine organisms. This diminishes environmental pollutants resulting from these hazards to humans and wildlife. Also, must take the mandatory precautions during the applying of pesticides (using the acceptable machines that reduce environmental pollution) to Protection of wildlife and water quality is feasible when using pesticides. If pesticides are selected wisely, utilized in combination with other pest control measures, and applied safely, the pollution of our surface waters and contamination of aquatic life will be avoided. Approaches using advanced biological techniques will likely revolutionize toxicological applicants that are cheaper and do not require the utilization of animals to detect environmental stressors. Matter of great public health is important to regularly monitor pesticides. Besides for safe use of those pesticides, more experimental work should be performed to see the concentration and time of exposure that do not induce significant sublethal effects on fish. Many pesticides don't seem to be legally registered for application but still are found in several aquatic systems. Vast kind of pesticides introduced within the water systems and there toxicity is primarily identified through single species toxicity testing within laboratory by many researchers.

These forms of tests primarily highlight the requisite of techniques that not only detect the damage caused by pollutant but also detect the biochemical and physiological impairment. Current review shows significant amount of chemical pollutants from industry, urbanization and from agricultural practices are entering aquatic systems posing great threat to fish and other aquatic species. Environmental stressors exert adverse effects at the organism level resulting in the disruptive physiology of organisms together with tissue damage, growth retardation, genotoxicity, reproductive disturbance, tissue bioaccumulation.

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