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Pesticides toxicity in fishes: A review

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Abstract

Pesticides are chemicals used to manage pests which are the source of schistosomiasis, including insects, aquatic weeds, plant diseases, and aquatic snails. Pesticides have been found to be not only extremely harmful to fish, but also to other species that make up the food chain. In general, pesticides are used very widely in agriculture, forestry, public health, and in Practices veterinary. Organophosphate, Carbamate, Organochlorine, Pyrethroids, and Necotenoides are the main chemical classes of insecticides commonly used. The insecticidal residues that contaminate the water, usually within a few weeks after application, are primarily due to intensive farming combined with surface runoff and surface drainage. Insecticides contribute to a decline in growth rate and reproductive disorders. It also induces spinal deformities and histopathological changes in the gills, liver, spleen, head of the kidney and renal tubules, hematopoietic tissue, some biological markers of insecticide exposure are endocrine tissue as well as brain, psychological, behavioural and genetic deficiency disorders. Fish are particularly vulnerable to the pollution of water by the atmosphere.

Keywords: Pesticides, insecticides, fish and contaminants

Introduction

It is understood that pesticides are potentially harmful to the climate, nature, and human beings. Aquatic species are threatened by pesticides as well as other toxins such as herbicides. Pesticides have become an effective instrument of modern agriculture. Pesticides eventually enter the aquatic environment in substantial quantities after application by agricultural run-off from land, polluted groundwater, bottom sediments, urban run-off, municipal water treatment, plant production and formulation, waste and atmospheric fall-out by rain, etc. Pesticides in the aquatic environment pose a significant threat to aquatic species that are not targeted, with fish being the worst among them. Cypermethrin is a synthetic pyrethroid insecticide used to combat many pests, including cotton, fruit and vegetable crop moth pests [1]. It is available in emulsifiable concentrate, and wettable powder formulations [1]. Synthetic pyrethroids have been introduced as substitutes for more harmful pesticides, such as substitutes for more toxic pesticides, such as hydrocarbons, organophosphates and carbamates, for agricultural and domestic use during the past two decades. Several studies have shown that pyrethroids are extremely toxic even at very low concentrations for a variety of non-target species, such as honeybees, freshwater fish and aquatic arthropods [2].

Effect on pesticides on different fish species

For fish and marine invertebrates, cypermethrin is highly toxic. The 90 hour LC_{50} for cypermethrin is 0.82 ppb in the rainbow trout, and 1.78 ppb in the bluegill sunfish. For Daphnia magna, its acute LC_{50}, a small freshwater crustacean, is 0.2 ppb. In a flow through analysis, the bio concentration factor for cypermethrin in rainbow trout was 1200 times [3]. Several authors have researched pesticide toxicity in fish and have shown that it causes a number of effects at chronic stage, including oxidative damage, inhibition of ACHE function, histopathological changes and developmental changes, mutagenesis and carcinogenicity. From 5,000 metric tonnes in 1958 to 102240 metric tonnes in 1998, pesticides were produced in India [4]. As pesticides with other similar organophosphate compounds are present in the environment, they can cause lethal or sub-lethal effects in fish [5]. Prethroids have been reported to be highly toxic in laboratory tests for fish, some beneficial aquatic arthropods (for example, lobster and shrimp). The 48-h LC_{50} of permethrin was 5.4 µg / l for rainbow trout, and 1.8 µg / l for bluegill sunfish and salmon. For bees, it is highly poisonous. If bees are present at the time of treatment or within a day after treatment, severe losses can be expected [6]. Pyrethroids have a high rate of gill absorption due to their lipophilicity, which may in turn be a contributing factor in fish sensitivity to aqueous pyrethroid exposures. In the enzyme system that hydrolyzes pyrethroids, fish tend to be deficient [7].

Singh and Srivastava (1999) [8] exposed freshwater fish *Channa striatus* (Bloch) to permethrin at a dose of 2.0 mg/l (24-h LC_{50}) and found significant reduction in the activity of lactate dehydrogenase and cytochrome oxidase and enhancement in succinate dehydrogenase activity in the tissue. They concluded that the mechanism of action was blocking of aerobic as well as anaerobic metabolism in the exposed fishes. The results of sublethal exposure to an organophosphorus pesticide were observed in catfish liver, *Clarias batrachus*, and hepatocytes showed a reduction in their size and peripheral cytoplasm accumulation when exposed to increased Nuvan concentration (0.16mL). After 20 days of pesticide use, the nuclei of the hepatocytes lost their rounded appearance and the cell boundaries were obliterated in places. Joshi and Kulkarni (2005) [9] studied that toxicity and behavioral changes in a freshwater fish *Garra mullya* (Sykes) exposed to cypermethrin and fenvalerate and found that the LC_{50} values for 24,48, and 72 and 96h were found as 0.179, 0147, 0.116 and 0.787 ppm respectively for cypermethrin, and 0.258, 0.18, 0.177 and 0.147 ppm respectively for fenvalerate. Erratic swimming, difficulty in respiration, jerky body movement, rapid opercular movements prior to death were observed in the fish under toxic stress. Cypermethrin was found to be more toxic than fenvalerate to *Garra mullya*.

Jeva and Vengadesh (2006) [10] researched the toxicological effects of monocrotophos on the tissues of *Cirrhinus mrigala* freshwater fish and found that the sublethal effects of monocrotophos commercial grade organophosphorus on the metabolism of carbohydrates were researched for 24, 120 and 168 hours in selected organs or *Cirrhinus mrigala*. In all the tissues, a large decrease was observed. It has been found that the results and dosage are explicitly proportional. The effect of exposure to sub-lethal concentration of cypermethrin, a synthetic pyrethroid pesticide, on biochemical parameters of muscle, blood and enzyme activities in brain, liver and kidney of the Indian major carp, *Lobeo rohita* was studies. The sub-lethal exposure studies were done for up to 45 days at 1/10 and 1/50 of 96 h LC_{50} of cypermethrin. Acid phosphatase was unchanged while alkaline phosphatase was depleted. Brain acetylcholinesterase activity was decreased ($P<0.05$) over a period of 45 days at both cypermethrin concentrations, Lactate dehydrogenase activity in brain and liver was elevated, but inhibited in kidney, Succinate dehydrogenase and ATPase activities were depleted in brain, kidney and liver. Blood glucose level and total leucocytes were elevated compared with control at either concentrations from day 15 to day 45. Haemoglobin percentage and total erythrocytes decreased in both sublethal concentrations.

Effect of pesticides on fish organs

Ellis (1937) [11] showed that many chemicals induced similar precipitation of mucous which filled the space between gill filaments and gill lamellae ultimately effecting the gaseous exchange leading to stasis of blood and death of the fish. Kumar *et al*. (2001) [12] observed that the effect of an organophosphate insecticide, dimeron. They have worked on haematological parameters of *Heteropneustes fossilis* following exposures to the LC_{50} for 24h and 96h and 1/10 and 1/50 parts of 96h LC_{50} for 90 days. There was a significant decrease in the Hb%, RBC number, HCt% and O2 carrying capacity of blood. But there was significant increase in the MCH and MCV values following both acute and chronic exposures. The results indicate possible induction of anemia in the exposed fish. After the treatment of endosulfan and diazinon pesticides, Gautam and Gautam (2001) [13] made histochemical observations of amino acids in the stomach and intestine of *Channa punctatus*. The observation showed an overall depletion of organ and tryptophan activities, suggesting that these pesticides interfere with cellular proteins. They also found that the effect of two widely used pesticides, endosulfan and diazinon, on two inorganic components, i.e. calcium and gastrointestinal iron, was investigated in the *Channa punctatus* intestinal tract. The calcium content was found to affect the longitudinal and serosal layer in the stomach after treatment with endosulfan and diazinon. An elevation in the presence of calcium ions was noted in the layer of muscularis in the intestine.

Jayarathi and Jebanesan (2001) [14] determined that acetylcholinesterase (AchE) was exposed to a sublethal concentration of 0.014 ppm (1/5th of LC_{50}) of chlorphyrifos for 7 days, 14 days and 21 days in the brain, liver, muscle and kidney tissues of the freshwater fish *Cyprinus carpio* fingerlings. On the 7th day of pesticide therapy and steady recovery thereafter, the highest inhibition of AchE activity in the brain was observed. Kumar (2007) [15] reported that teleost *Channa punctatus* (Bloch) fresh water air breathing was observed in the laboratory after exposure to ammonia sublethal concentration (70 ppm). After 28 days of exposure to exogenous ammonia, Gills displayed marked alterations. Gills showed distinctive lesions such as gill lamella necrosis, epithelial cell hyperplasia, secondary lamella fusion, clubbed tip and vacuolisation. Ram *et al*. (2001) [16] have stated that the effect of chronic exposure to carbofuran (4.5 ppm in static water) for six months on the gonadal histophysiology and hypothalamo neurohypophyseal complex was studied in *Channa punctatus*. Experimental observations revealed significant inhibition of gonadal development with associated degenerative abnormalities as evidenced by ovarian and testicular histology and reduced gonadosomatic index. Degenerative changes in ovary were exhibited by stage I (oogonium) and stage II (immature/non-vitellogenic) oocytes as marked by perinuclear ooplasmic lysis, clumping and dissolution resulting in disintegration of nuclear material altogether attributed to complete degeneration of such oocytes.

In equilibrium conditions, Kanazawa (2006) [17] calculated bioconcentration factors (BCF) for 15 pesticides by freshwater fish (under continuous flow conditions in water containing 5 to 20 µg litres of 1 of each pesticide. A strong association between the fish BCF and the water solubility of the pesticide or its coefficient partition (PC) was found. Moreover, a significant correlation was also found between the BCF by topmouth gudeon and the acute toxicities to carp, rainbow trout and water flea. It would therefore appear that the bioconcentration potential of a pesticide by a fish may be predicted from knowledge of its solubility or PC, and that the acute toxicity of a pesticide to a fish may be predicted from knowledge of the BCF. A fundamental aspect of ecology and ecotoxicology is the fate of environmental toxins, the different isotopes of elements, and inorganic or organic compounds, and bioaccumulation is a phenomenon sometimes discussed in this context. Human activities have significantly altered and introduced several new chemicals to the existing concentrate of several compounds in the environment. An understanding of the processes of bioaccumulation is important for several reasons. (i) Bioaccumulation in organisms may enhance the persistence of industrial chemicals in the ecosystem as a whole, (ii) Stored chemicals are not exposed to direct physical, chemical, or biochemical degradation, (iii) Stored chemicals that have bioaccumulated harmful substances may be endangered by food chain effects.

Behavioural changes on fish by insecticides

Fish exposed to various forms of insecticides have shown improvements in swimming behaviour, feeding activates, predation, competition, reproduction, and social interactions with species such as aggression [18].

Effect on fish gills

The suitable bio-indicator for pollution control is gill histopathology. Diazinon (0.1 mg / l) is one of the lesions most commonly present on Rainbow trout gills. Epithelial hyperplasia of both the primary and secondary epithelium RT is caused by Diazinon (0.2 mg / l). Edema, epithelial hyperplasia, mucous cell hyperactivation and secondary lamella fusion were also noted. Chlorinated hydrocarbons, Aldrin, Dieldrin, BHC and DDT, 0.005, 0.002, 1.00 and 0.002 mg / l for 20-30 days in *Cyprinus carpio* caused gill filament swelling and thickening, secondary lamella epithelial raising from the underlying basement membrane, and lamella fusion, as well as complete epithelial cell necrosis and slough. Lamellar hypertrophy was also caused, and hyperplasia with EGC infiltration [19].

Conclusion

It can be assumed that the long-term exposure of fish to pesticides (including insecticides) is an ongoing danger to the population's health. Thus, by eating these poisonous fishes, the human population is at high risk. The rationalisation of the use of pesticides has been considered a crucial factor in reducing the degradation of the marine ecosystem by pesticides and other pollutants. Thus, at least in marine species, the rest has an impact. The degradation of our surface waters and contamination of marine organisms can be avoided if pesticides are carefully chosen, used in conjunction with other pest control strategies, and implemented safely. It is possible that methods using molecular biology techniques will revolutionise cheaper toxicological applicants and do not involve the use of animals to detect environmental stressors.

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