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TOXICOLOGICAL EVALUATION OF PESTICIDES ON FISH: A REVIEW

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ABSTRACT

The success of green revolution not only backs on the uses of high yielding variety of crops but also on the pest control methods all over the world. A new epoch of pest control begins with the discovery of pesticide like DDT and Lindane in 1940, it takes almost three decades for us to realize the deleterious effect of these compound on flora and fauna on earth, but by that time a flush of new synthetic pesticide comes in use with very few long term studies on their impact of nature. The main problem of use of pesticide is that a very few are there to be specific for a selected pest, and in consequences many other forms of life frequently fall victim of their action. Pesticide use not only affects the biodiversity of fields but severely change the nature of our aquatic life. Fish engage in recreation an imperative job in nutrient cycles because they store a large percentage of ecosystem nutrients in their tissues (Approx. 15-40%) (Kotilla etall 2012), transport nutrients farther than other aquatic animals and excrete nutrients in dissolved forms that are willingly available to chief producers. Although the influence of fish populations on food web structures, nutrient recycling, and productivity is well documented, little is known about the effects on the ecosystem of a reduction in the fish species richness. It is consequently of significant importance to evaluate the possible impacts of ongoing decreases in fish variety.

Aquatic life is very sensitive to a wide variety of pesticide, chemical and toxic conditions may arise, not only from the spillage or deliberate discharge of these chemicals into rivers and lakes, but also from many applications outside agriculture, such as silviculture (the growing and cultivation of trees), horticulture or public health, can also lead to a detrimental influence on fish populations.

The current review will focus on the routes of contamination of pesticides in aquatic systems. Pesticides can create a great economic loss by fish death rate on one hand and on the other hand add them unfit for human and animal consumption. These contaminated fish are very harmful for those who consume these infected fishes.

Keywords: Aquatic ecosystem, Pesticides, Lethal concentration, Immune system etc.,

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INTRODUCTION

Recently, the high rate of increment in human population and quick pace of industrialization have put challenge on disposal of waste waters. Squanders which are present in home, untreated or somewhat treated industrial effluents, enhanced with toxins like toxic heavy metals, pesticides, many organic and inorganic compounds, have enormously added to large fish death of aquatic ecosystems (*Murthy et al., 2013*). Freshwater fish comprise one of the most threatened vertebrate groups with close to one-third of the species in danger of extinction (*Dudgeon et al., 2003*) and several species already extinct (*Baillie et al., 2012*). When these pollutants flow into water bodies *(Seas, river etc.)* in higher concentration than permissible limits then these result in the form of heavy mortalities of all life form residing in those aquatic systems such as fish etc. while in lower concentration these lead to bio accumulation of these pollutants and ultimately go through the food web to human beings (*Ullah et al., 2014*). These toxic chemicals and metals have changed the nature of water that influences the fish and other aquatic animals.

OBJECTIVES OF REVIEW

1. Name the composition of chemical pesticides harmful for aquatic life and its use in India
2. Fish species affected by different group of chemical and pesticides.
3. MRL level for discarding fish suitable for human and animal consumption and present status of aquatic systems in India.
4. Changing living style of aquatic animals, bio chemical, physical and endocrine changes.
5. Life cycle analysis of pesticide residue in different aquatic systems with respect to pollution.

PRODUCTION AND DISTRIBUTION OF PESTICIDES IN INDIA

The production of pesticides in India started in 1952 with the establishment of a plant for the production of Benzene hexachloride, Dichloro diphenyl trichloroethane near Calcutta, and India is now the second largest manufacturer of pesticides in Asia after China and ranks twelve globally (*Bharadwaj et al., 2013*). India is a country which have a large growth in the production of pure grade pesticides, this production has increased from five metric tons in 1958 to 102,240 metric tons in 1998. According Akhtar et al. in 1996–97 the requirement for pesticides in terms of value was estimated to be aroundapprox. Rs. 22 billion (USD 0.5 billion), which is about 2% of the total world market (Akhtar et al., 2009), according to agriculture system in hole world commonly Pesticides are categorized according to their target use to many groups such as Insecticides, Fungicides, Herbicides, Rodenticide, Nematicides, Acaricides, Molluscicides, etc. The herbicides (weed control), insecticides (insect control), and fungicides (Mycotic) three main pesticides groups. Nematicides are those pesticides which are used to control soil, leaf and stem-dwelling nematodes (round worms). An acaricide is a pesticide that control mites and ticks (Louis et al., 2013). All pesticides used must be registered according to Federal insecticide, fungicide, and Rodenticide (FIFRA). The Environmental Protection Agency (EPA) is responsible for the administering this law. The EPA decides whether to register a pesticide after considering many characteristics including, this means the pesticide processing specifications in terms of the method used on the pest, on the vertebrate toxicity and residues in the environment and the method of analysis and other conditions. And are mentioned also in Pesticides and Aquatic animals: A Guide to reducing impacts on aquatic systems (Louis et al., 2013).

Figure 1 is a Pie chart, which has described the use of pesticides in India and other countries of the world. The use of insecticides in India as compared globally is 32 % more, while the use of Herbicides and Fungicides are less comparatively.

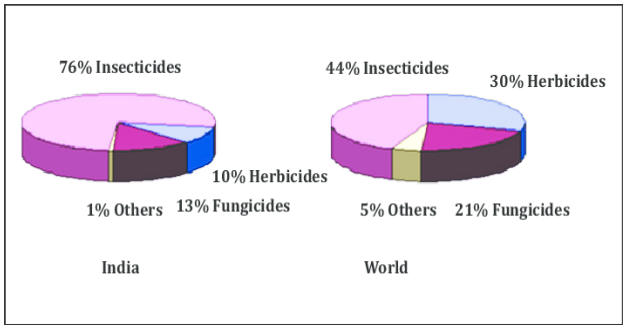


Figure 1: Consumption pattern of pesticides

(Source: Amit et. al. 2010 ResearchGate)

Figure 2. Shows a pie chart covering crop wise facts such as, cotton record for the maximum share of pesticides consumption i.e. around 37% and followed by paddy (20%) only. While the other crops like wheat and different pulses crops consumes of about 4 % of the pesticides, different vegetable crops consume about 9 % and the other plantation crops requires 7 % of the total pesticide used in India

(Ministry of Agriculture, 2009). If we distribute the State wise use of pesticide in India then Andhra is the highest pesticides consuming state (23%) followed by Punjab & Maharashtra as shown in Figure.3.

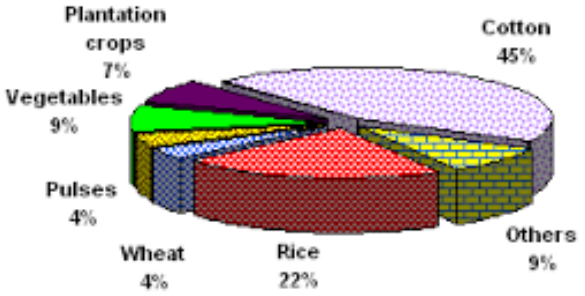


Figure 2: Pesticide consumption of different crops in India
(Source: Vijesh et. al., Integrated Pest Management)

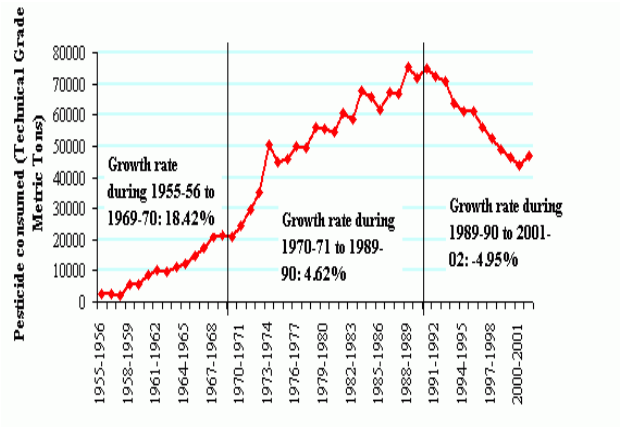


Figure 3: Consumption of Pestisides in India
(Source: Vijesh et. al., integrated pest management)

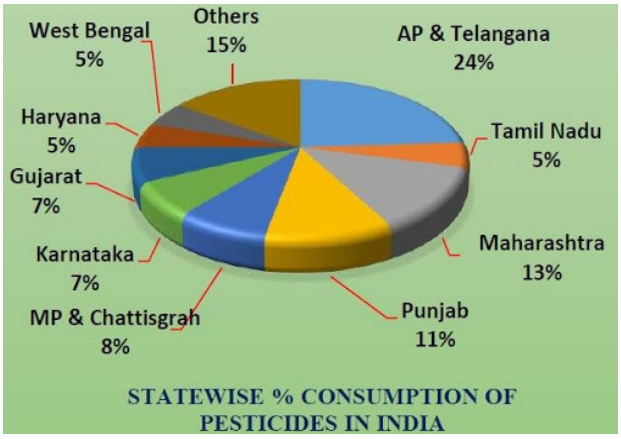


Figure 4: Pie chart showing pesticide consumption by different states of India

(Source: Krishnamurthy Ganeshan Agnews)

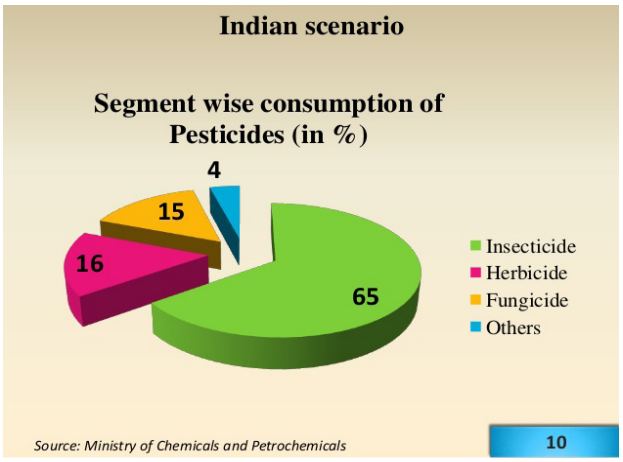


Figure 5: Segment wise consumption of Pesticide (in %) **(Source: Ministry of Chemicals and petrochemicals of India)**

ADVANTAGES AND DISADVANTAGES OF PESTICIDES

Advantages of use of Pesticides

The main advantages are the price of the pesticides' effects – the direct profit expected from their use. Killing caterpillars feeding on the crop brings the primary benefit of higher yields and better quality of vegetables. The three main benefits are ranging from protection of recreational turf to save human and (Pets) animal lives.

Primary Benefits

- Improving productivity
- Protection of crop losses/yield reduction
- Vector disease control
- Quality of food
- Other areas – transport, sport complex, building

Disadvantages of Pesticides

Toxicity in humans, animals, and useful plants, and the persistence (long life) of some of these chemicals in the environment is the main disadvantages of using of pesticides. When pesticides enter aquatic ecosystem, became the environment costs. Unintentional pesticide-related fish kills on a large scale occur across the world some of these involving tones of fishes, frogs, turtles, mussels, water birds, and other wildlife. The main victims of pesticides poisoning are fishes and rare variety of wildlife species. Pesticide use is one of major factors contributing to decline of fish and other aquatic species. Pesticides are very high toxic and capable of killing salmon and other

aquatic life directly and within short to long period. Long-term exposure to certain pesticides can alter swimming ability, which in turn can reduce the ability to feed, to avoid predators, to defined territories, and to maintain position in river system. Many pesticides interrupt schooling behavior (group of fish that stays together for social reasons is said to be shoaling or schooling), a critical for avoiding predation, during salmon migration. Disruption of schooling behavior is thought by some researchers to be a classic method for examining sub lethal common effect of pesticides.Many pesticides have shown many time to cause fish to seek sub optimal water temperatures, thus subjecting them to increased danger of disease attack and predation. Some herbicides have been shown to inhibit normal migration to sea, resulting in severe disruption of the life cycle. These death of animals are the topic of research looking at this effect for common insecticides. Lots of research and studies suggest that certain pesticides can impair salmonid's ability to transition from freshwater to sea water (Farid soliman et. al Asian journal of agg. 2321). So this area have a very much requirement for further research. Adult salmon adjust their migration to avoid polluted areas resulting in delayed spawning . Changes in behavior disrupt the immune system of salmon, cause endocrine disrupting the early stages of development (Farid soliman et. al Asian journal of agg. 2321).

Sometime many pests act as blockers of sex hormones, and causing irregular sexual development, pathological process of males, bad sex ratios and unusual and unsatisfactory mating behavior (Wissem Manif et al. Int, J. 2303) . Many time it convert in hormonal changes, like functions of thyroid and development of bone (J.H. Duncan PMCID: PMC4823381). Beside the hormonal changes you can see many indirect effects of pesticides like interfere fish with their food supply, altering the aquatic behaviour, reduces the growth rate and probability of survival age of the fish. Researchers says that the chronic toxicity are ultimately very dangerous, suddenly cause death or may result in removal of species or individuals over a long period of time, through a host of effects such as produce sterility, interference within an organisms naturally defense mechanisms or you can say destroy the immune system, loss of appetite, blindness or other weakness and reduction in sexuality and in fertility.

Little is known about interactions between nutrition and reproduction in fish and a small number of studies have evaluated the effects of feeds on early and adult reproductive performance.

Table 1: Different nutrients and their effect on habit, reproduction and other genetically changes in fish.

S. No.	Nutrient	Reproduction effect	Changes
1.	Lipids	Low lipid diet reduce reproduction	Source of energy in fish
2.	Proteins	Low protein diet reduce reproduction	Source of energy in fish
3.	Carbohydrates	Don't compromise reproductive performance	Indigestible in fish
4.	Vitamin	Quality of gonads and eggs	Different vitamins useful / harmful for different activity in body
5.	Minerals	Not effect reproduction	Necessary in diet for body action
6.	Probiotics	Larval growth and earlier maturation	Improving digestion and immunity

(Source: Helene Volkoff Jan 2018)

PESTICIDES IN AQUATIC ECOSYSTEMS

The pesticide label must contain the following trade name, active ingredient, direction for use, toxicity rating and EPA registration number. A Pesticides ability to harm fish and aquatic animals is largely outcome of its toxicity, exposure time, dose rate, and persistence in the environment. A lethal dose is the quantity 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 decided after 24 to 96 hours. Toxicity ratingsand ranging from minimal to super and LC50's for normally used herbicides, Insecticides, and fungicides are given in Table (1) (Louis et al., 2013).

Table 2: Hazard Rating of Pesticides

Hazard Rating	Toxicity	Minimal	Slight	Moderate	High	Extreme	Super
	LC50 (mg/l)	>100	10-100	1-10	0.1-1.0	0.01-0.1	> 0.01

Exposures of fish and other aquatic animals to pesticides depend on its biological availability (Bioavailability), bioconcentration, biomagnifications, and presence in the environment. Bioavailability refers to the amount of pesticide in the environment made available for fish and wildlife. (Seyler et al.,1994).

Routes for occurrence of pesticides in Aquatic Ecosystem

Occurrence of pesticides in aquatic ecosystems may be by contrasting ways, but is assessed by identifying three main routes, due to which it leads to water systems (*Sarkar et al., 2014*). These routes are different types of water column, organic substrates such as mosses, algae, leaf litter, vascular hydrophytes and branches, and inorganic substrate including materials from sediments varying in size (*Murthy et al., 2013*). Standing water has higher concentration than lithic biotopes and water column while its quantity is negligible in sediments (*Kingsbury and Kreutzweiser, 1980*). Naturally, pesticide content of interstitial water and sediments is usually much lower than that in the water column; and lithic biotopes are mostly less contaminated than standing waters. For instance, permethrin residues after application to a 640 ha forested block in Ontario attained peak concentrations of 147 µg/l in ponds, but only 2.5 µg/l in streams; while accumulation and persistence of pesticides in bottom sediment was negligible (Murthy et al., 2013).

There are some other causes that subject the fish and aquatic animals to pesticides and after a period lead to toxicity. Through the intake of poisoned animal which have toxicity by any pesticide, we can understand better by this example, if any fish eat poisoned insect or any by-product produces by death of insect due to pesticide confirm that very harmful for fish.

The information about possible pesticides affect fish and other aquatic ecosystems depend upon seven items like, Type of Pesticides product, aquatic species involved, use rates, weather conditions, location, extent of the problem (number of fish killed), and size of pond or lake affected these seven can provide us information about maximum pesticidal effect on fish and aquatic animals..

Table.2 showed the acute toxicity of different types of pesticides depending on fish species and duration of exposure.

Table 2: The Acute Toxicity (LC50) of Some Pesticides against Certain fish species

S.No.	*Name of Pesticide*	*Fish Species*	*Duration of Exposure*	*Reference*
	DDT	Rainbow Trout	96 hrs - 8.7 µg/l	Johnson et al., 1980
	Acephate	Feathed M.	96 hrs >1000 µg/l	Johnson et al., 1980
	Alaclor	Rainbow trout	96 hrs 2.4 µg/l	Johnson et al., 1980
	Malathion	Labeo rohita	96 hrs 15 µg/l	Thenmozhi et al., 2011
	Endosulfan	Channel catfish	96 hrs 1.5 µg/l	Johnson et al., 1980
	Malathion	Heteropneustess fossilis	96 hrs 0.98 ppm	Sanjoy et al., 2012
	Methyl parathion	Catla catla	96 hrs 4.8 ppm	Ilavazhan et al., 2010
	Akton	Channel catfish	96 hrs-400 µg/l	Johnson et al., 1980
	Rogar	Puntius stigma	96 hrs 7.1 &7.8 ppm	Bhandare et al., 2011
	BHC	Carassius auratus	96 hrs 385 µg/l	Johnson et al., 1980
	Carbaryl	Salvelinus namaycush	96 hrs 690 µg/l	Johnson et al., 1980
	Carbofuran	Perca flavescens	96 hrs 147 µg/l	Johnson et al., 1980
	Diazinon	Channa punctatus	96 hrs 3.09 ppm	Rahman et al., 2002

	Diazinon	Anabas testudineus	96 hrs 6.55 ppm	Rahman et al., 2002
	Diazinon	Barbodes gonionotus	96 hrs 2.72 ppm	Rahman et al., 2002
	Elsan	Channa punctatus	48 hrs 0.43 ppm	Rao et al., 1985
	Permethrin	Cyprinus carpio	96 hrs 385 µg/l	Sial et al., 2009
	Biosal	Cyprinus carpio	24 hrs 4.21 mg/l	Sial et al., 2009
	Cypermethrin	Labeo rohita	96 hrs 4.0 µg/l	Marigoudar et al., 2009
	Dimethoate	Heteropneustes fossilis	96 hrs 2.98 mg/l	Pandey et al., 2009
	λ Cyhalothrin	Danio rerio	96 hrs 0.119 µg/l	Ansari et al., 2010
	Cypermethrin	Colisa fasciatus	96 hrs 0.02 mg/l	Singh et al., 2010
	Metasystox	Nemacheilus botia	96 hrs 7.018 ppm	Nikam et al., 2011
	Malathion	Heteropneustes fossilis	96 hrs 0.98 ppm	Deka et al., 2012
	Rogor	Puntius stigma	96 hrs 7.1 ppm	Bhandare et al., 2011

Effects of environmental contaminants on aquatic animals, like effect of pesticides on fish or other aquatic organisms called Aquatic toxicology. A pesticide's capacity to harm fish and aquatic animals is largely a function of its (1) toxicity, (2) exposure time, (3) dose rate, and (4) persistence in the environment (Louis A. Helfrich, VCE Publications / 420 / 420-013).



Figure 6: Representative Images showing the hazardous exposure of pesticides on aquatic life

A dose of pesticide or any poisonous substance use to cause death, called lethal dose. As we know not all animals of any species die at the same dose (some are more tolerant than others), a standard toxicity dose measurement, called a Lethal Concentration 50 (LC50), is used. This is the attentiveness of a pesticide that kills 50% of a test population of animals within a set period of time, usually 24 to 96 hours (Louis A. Helfrich, VCE Publications / 420 / 420-013).

Quantification of Pesticides

The quantification of pesticide residue in water, organic substrates, sediments (and animal tissues as well) is solely chemical. The solid materials or animal/plant tissues are usually homogenized, and 2/ 3 or less are extracted (e.g., using acetone/ hexane), evaporated to a small volume, cleaned and dried, and analyzed by a gas chromatographic and high performance liquid chromatography procedure. For deciding the impacts of pesticides, for example, intense lethal impact of these chemicals aquatic organism biological methods are utilized, in situ bioassays. This test depends on exposing the test animals to the field without disturbing the polluted sediments. After exposure survival percentage is determined. Sometimes when the water column is too deep or too fast, water cages are used for holding the fish in water column (Saha et al., 2014).

Direct and Indirect effects of Pesticides on Fish

Fish and other aquatic animals are directly as well as indirectly affected by various pesticides. Pesticides produce various types of toxicity in fish for example.

Changes in fish behaviour

Behavioural changes are the most tactful indication of potential toxic effects (Ahlawat et al., 2018). Pesticides have shown different types of alterations in behaviour of various fish species such as rendering fish slow moving results in alteration in their swimming ability making them more susceptible to be preyed, reduce their ability to feed, maintain their position and defend their livelihood (Prashanth et al., 2011). Pesticides have also shown interrupting the shoaling and schooling behaviour (Gill and Raine, 2014) of fish due to swimming loosely, erratic and irregular movements and altered swimming ability (Nagaraju et al., 2011). The opercula movement of fishes initially increases and then gradually decreases. Decreased opercula movement probably helps in reducing absorption of pesticide through gills.

Due to effect of pesticides, fish became stressed and

have abnormality in immune system, which make them more allergic and endangered to diseases, secondary infections and pathogens. Flora guard and Neem-On are eco-friendly bio pesticides used against different agricultural pests but they are highly toxic to non-target organisms.

Effects of Methyl parathion resulted to increase the movements of opercula, equilibrium loss, rapid jerk movement, body colour alterations, frequent surfacing, and elevated mucus secretion in fish Catla catla. Fipronil 5% SC for 96hr 0.23mg/l, results in various behavioural changes which, include erratic swimming movements and they appeared to be in distress. Hyper excitation, loss of equilibrium, increased cough rate, flaring of gills, increase in production of mucus from the gills, darting movements and hitting against the walls of test tanks were noticed in Catla Catla (Anita et al., 2018). The effect of certain insecticides on the activity of ACHE may lead to decreased mobility of the fish (Farid et al., 2015). Pesticides Like Cypermethrin and Sodium cyanide also alter the migratory behaviour of migratory fish (Nagaraju et al., 2011), Cypermethrin Caused darting erratic and irregular swimming movements while sodium cyanide cause hypexcitablity and imbalance swimming in Labeo rohita, catla catla, Cyp rinus carpio etc. thus result in disturbing their life cycle such as it can disturb the ability of salmonid fish to transit from fresh water to sea water. However, this phenomenon is seeking further researchers to place particular emphasis on critical period of transition, which occurs in estuaries. Yet studies have shown that adult salmon use to circumvent pollutants and contaminated areas during their migration, altering their migratory pattern, which result in postponement of spawning (Satyavardhan, 2013). Cypermethrin resulted in jumping, increased surface activity, balance loss, increased air gulping, equilibrium loss, abrupt swimming, sluggishness, motionlessness, adopting vertical positions and internal haemorrhage in Tor putitora (Ullah et al., 2014c). Sodium cyanide induced certain behavioural changes such as hypexcitability, darting and erratic movements, and imbalance swimming, in Oreochromis mossambicus, Catla catla, Cirrhinus mrigala, Labeo rohita, and Cyprinus carpio (David et al., 2012).

HISTOPATHOLOGICAL CHANGES

Histopathological changes due to different pesticides have been vastly studied in different fish species. These changes have been noticed in muscles, liver, kidneys, gills, blood vessels, and brain of the fishes. The changes recorded are quite assorted such as partial loss of liver plate radial orientation, cytoplasmic granularity and shrinkage of liver cell mass in liver cells; pycnotic alteration of cell nuclei, atrophy and cytoplasm vocalization in gill lamellae, kidneys and filaments have shown precipitated masses that plugged to the central capillaries and in large blood vessels various changes have also been observed such as alteration in morphology, haematocrit levels and blood cells quantity (Kennedy et. al., 1970).

The Histopathological examination of the liver, gill, and intestinal tissues of the exposed fish indicated that the liver and gills were the organs most affected and indicated that gill was the primary target tissue affected by gammalin 20. Pronounced secretion of mucus layer over the gill lamellae has been observed during gammalin 20 stresses. Secretion of mucus over the gill decreases the diffusion of oxygen, which may ultimately lower the oxygen uptake by the fish. (Lawrence et al., 2010). One of the investigations indicates that the diazinon insecticide is moderately toxic to catfish, Clarias gariepinus, and even low doses of it could modify the biochemical and haematological profile of this fish. Exposure of diazinon to catfish significantly increased the activity of GOT (Glutamic oxaloacetic transaminase) and GPT (Glutamic pyruvic transaminase). Blood sugar level was also increased. Erythrocyte count, Haemoglobin level and haematocrit values were high in the treated fish compared to control specimens (Al-Otaibi et al., 2019). Gill, liver and kidney of Clarias gariepinus were examined histologically after exposure to sub-lethal concentrations of Cypermethrin for 10 days. Cypermethrin produce many Histo pathological changes in the gills of fish like Epithelial hypertrophy, hyperplasia, epithelial lifting, edema, fusion of secondary lamellae, necrosis and desquamation. Hepatic lesions in the liver tissues of fish were characterized by cloudy swelling of hepatocytes, lipoid vacuoles, pycnotic nuclei and focal necrosis. Epithelial hypertrophy, narrowing of the tubular lumen, atrophy of the glomerulus, broader Bowman's capsule, necrosis in the epithelial cells and pycnosis in the hematopoietic tissue were observed in kidney tissues of fish. These lesions grew with increasing concentration (Velmurugan et al., 2009).

HEMATOLOGICAL CHANGES

In response to a stressor such as pesticide exposure, the fish undergo a series of biochemical and physiological changes in an attempt to compensate the challenge

imposed on them and thus cope with the stress. Blood is one of the important path physiological reflectors of the whole body organism. According to Cyprinus Carpio and Puntius tectophases were exposed to sub lethal concentrations of different chlorinated pesticides that is to say aldrin, dieldrin, BHC, DDT, and chlordane. Results showed that Red blood cells counted irrespective of the species and pesticide, the RBC counts uniformly showed decreasing trend with the increase in exposure period, while packed cell volume, PCV(%) showed increasing trend with respect to increase in exposure period in case of aldrin and dieldrin in both the fishes. But DDT, BHC and chlordane showed decreasing trend in PCV (%) values with increasing periods of exposure. The Haemoglobin content reduced from an initial 13 g/100 ml to 8.07 g/100 ml initially and then increase a little as the body start to cope up the changes (Satyanarayan S et al., 2004).

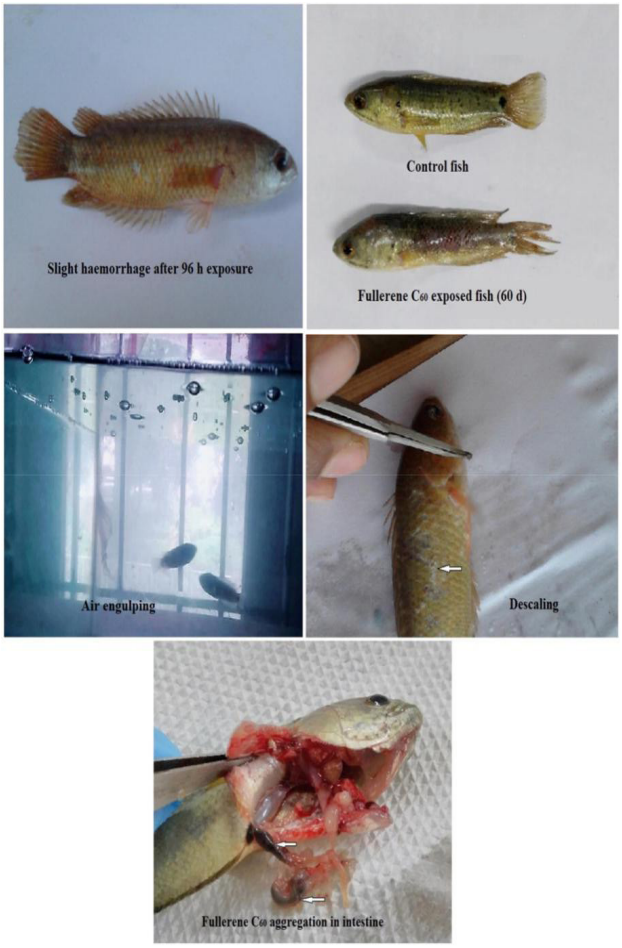


Figure7: "Representative image of: Impact of fullerene C_{60} on behavioral and hematological changes in the freshwater fish, Anabas testudineus

(Source: Bloch et. al. 1792)

ENZYMES ALTERATION AND GENOTOXICITY

Genotoxicity is a property possessed by some substances that makes them harmful to the genetic information contained in organisms. A substance that has the property of genotoxicity is known as genotoxin. Studies says mainly three primary effects of the Genotoxins by which organisms' genetic information can be affected. Genotoxins can be carcinogens or cancer-causing agents, mutagens or mutation-causing agents or teratogens or birth defect-causing agents. Genotoxic chemicals such as insecticides have common physical and chemicals properties that enable them interact with genetic materials (damage or DNA inactivation). Genotoxic effects have emerged as the main biomarkers in assessment of pollution related toxicity (Srivastava et al., 2016). Carcinogenic and the formation of some tumors in various tissues of fish exposed to insecticides may also cause by Genotoxic proprieties of these xenobiotics. Chromosomal damage also seen in eggs and larvae of fish exposed to different levels of insecticides. Some insecticides behave as genes resulting in unusual concentrations of plasma steroid hormones and reproductive dysfunction or immunosuppression (Jin et al., 2010). Interestingly regular exposure was associated with lower frequency of DNA aberrations. Cypermethrin caused changes in nucleic acids (RNA and DNA) in gonadal tissue of Colisa fasciatus (Singh et al., 2010). According to (Devi et al., 2011) Profenofos caused any significant change in tail of all marine fish.

Acetyl cholinesterase (AChE) activity is a biomarker of effect on the nervous system (Minier et al., 2000). AChE (AChE) activity is very much sensitive for carbamate pesticides and organo phosphates in comparison to other types of pesticides and contaminants (Murthy et al., 2013). Various studies has shown that inhibition of this enzyme is associated with the effects and exposure of fish with other contaminants such as crude oil addition to brain homogenate inhibited AchE activity (Rodriguez-Fuentes, 2000). AChE activity in *Labeo rohita* was altered due to effect of Cypermethrin, commonly brain being the most altered followed by muscles, gills and liver tissues. By affecting the AChE activity in fish, the swimming capability and performance of fish is ultimately reduced and disturbed which can attribute to more harmful consequences. Fish exposed to sub-lethal concentration of 60 micro g/L (1/5 of LC 50) were under stress, and reduced their locomotor behavior like distance travelled per unit

time (m/min) and swimming speed (cm/sec) with respect to the length of exposure. The alteration in locomotors activity of fish may be due to an accretion of acetylcholine (ACh), a neurotransmitter at synaptic junctions, due to the inhibition of AChE enzyme activity (40 to 55%) in brain and also bioaccumulation of the toxicant in various parts of fish.

BIOCHEMICAL MODIFICATIONS, ENDOCRINE SYSTEM DISRUPTION

Various studies have shown destructive effects of pesticides in various biochemical activities. These effects in antioxidants systems of fish are often tissue specific such as these effects have been found in brain, gills, muscles, kidneys, lungs and viscera of different fish and have shown varying results in different organs and different fish species such as peroxidase activities was found higher in viscera, gills, brain,, and muscles of tilapia but gills was the organ received highest disturbance in peroxidase (Ahmad et al., 2000). Similarly changes in lipid peroxidase have been observed on account of different pesticides as well as environmental pollutants.

Pesticides have shown disturbance of immune system in fish (Bols et al., 2001; Maskaoui et al., 2005). Studies have revealed serious impact of pesticides on immune system, which results in disease initiation and eventually can lead to death (Dunier and Siwicki, 1993; Halloran et al., 1998). Fish are also vulnerable to endocrine disrupting impacts during early life stages or stages of development (Magare, 1997; Gupta et al., 1997; Kamble et al., 1999). Pesticides also act as sex hormones' blockers, which leads to anomalous and atypical sexual development, irregular sex ratios, males' feminization and disturbed mating behavior. Susceptible fish reproductive behavior depicts its vulnerability by different pollutants such as pesticides (Hoeger et al., 2005). It can also alter other hormonal processes of fish like development of bones and proper thyroid functioning (Murthy et al., 2013). Dimethoate and Lambda-cyhalothrin showed lethal effect on Thyroid hormone of *Labeo rohita* (Dey and Saha, 2014). Several studies have shown that environmental chemicals disturb levels plasma thyroid hormone (Steen land et al., 1997). Disturb plasma thyroid hormone level leads to thyroid malfunction in fishes (Waring et al., 1997).

NUTRIENT PROFILE DISTURBANCE

Reduction in level of protein in experimental fish under pesticides influence indicates hepatic insufficiency and probably malnutrition. The decrease in total protein level and increase in free amino acids level in both tissue and liver suggest the high protein hydrolytic activity due to elevation of protease activity (Muley et al, 2007).Experiments have shown much effect of pesticides in protein contents, in different tissue such as gills, liver, blood, intestine and muscle of various fish species, such as nickel caused decrease in protein level of Heteropneustes fossils (Nanda et al., 2000), nickel chloride caused appreciable decrease in gonads, liver and muscles of Anabus testudineus (Jha and Jha, 1995), phenyl mercuric acetate caused reduction of protein level in muscles and liver of Channa punctatus (Karuppasamy, 2000) while the same species showed low protein level when exposed to oleandrin (Tiwari and Singh, 2004) and arsenic (Hota, 1996). Thiamethoxam affected liver total protein of Oreochromis niloticus (Bose et al, 2011) while propiconazole and Mancozeb induced changes in protein content in Clarias batrachus (Srivastava and Singh, 2013).

Different fish class is susceptible to these pesticides at various concentrations. The changes in different body organs have been observed to be different than each other as well as in response to different pesticides. These effects have been observed in almost all parts of the fish body and systems. On the other hand indirect changes are as follows: Pesticides greatly extinct food organisms' abundance in aquatic bodies and eco system which is important for fish survival (Helfrich, 2009). By this mean it indirectly interrupts the fish food supply and change the habitat of water bodies (Maskaoui et al., 2005). Besides this it can also make the fish more susceptible to predators by decreasing habitat suitability and changing their behavior as well, which is a direct effect as a consequence of indirect effect (Prashanth et al., 2011; Gill and Raine, 2014). Results have shown that the indirect effects are of more concern than the direct ones (Murthy et al., 2013).

CONCLUSION

This article concluded that pesticides can create a great economic and human loss by fish mortalities on one hand and on the other hand rendering them unfit for human utilization. If consumed, these fish can cause health hazard situation for those who utilized these fish. From a health perspective this article depicts that one should take necessary precautionary measure when selecting fish. From a pesticides standpoint

such pesticides should be avoided or should be used to minimum for defending aquatic life. Researchers all across the globe have worked on the toxic effects of pesticides in fish such as behavioral change, Histopathological alterations, haematological and biochemical change, AChE activities inhibition, decrease in protein and lipid contents, change in life cycle, carcinogenesis, mutagenic changes, physiological changes and change in reproductive process. On account of differences in susceptibility of different fish species to various pesticides and other pollutants, fish that are less susceptible and vulnerable to these chemicals and pollutants should be stocked in water bodies. Beside this such species should be stocked that accumulate less quantity of pesticides, heavy metals and other pollutants. Further studies and research regarding new introduced pesticides and other chemicals should be carried out in both natural as well as laboratories. This will be helpful in documenting the toxic effects of these contaminants and on the basis of these experiments, nontoxic or less toxic as well as environmentally friendly chemicals can be employed.

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