DOI: 10.21088/jfct.2454.9363.11125.3

Journal of Forensic Chemistry and Toxicology
Volume 11 Number 1, January-June 2025

Review Article

Toxicological Evaluation of Agrochemicals on Fish: A Review

Susheel Kumar[1], Menka Pathak[2], Akshima Vasishta[3], Jyoti[4], Atul Kumar[5], Sheetal Pal[6], Sourobhi Datta[7]

How to cite this article:

Susheel Kumar, et al. Toxicological Evaluation of Agrochemicals on Fish: A Review. J Forensic Chemistry Toxicol. 2025; 11(1): 20–30.

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%) (Kotillaetall 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

Author's Affiliation:

[1] Department of Chemistry, Monad University, Kasmabad, Pilkhuwa, Hapur, Uttar Pradesh, India.
[2] Indian Pharmacopeia Commission, Ghaziabad, Uttar Pradesh, India.
[3] Institute for Industrial Research and Toxicology, Ghaziabad, Uttar Pradesh, India.
[4] Institute for Industrial Research and Toxicology, Ghaziabad, Uttar Pradesh, India.
[5] Institute for Industrial Research and Toxicology, Ghaziabad, Uttar Pradesh, India.
[6] Department of Chemistry, Monad University, Kasmabad, Pilkhuwa, Hapur, Uttar Pradesh, India.
[7] Department of Chemistry, Monad University, Kasmabad, Pilkhuwa, Hapur, Uttar Pradesh, India.

Corresponding Author:

Susheel Kumar, Department of Chemistry, Monad University, Kasmabad, Pilkhuwa, Hapur, Uttar Pradesh, India.
E-mail: susheelmom@gmail.com

➢ **Received:** 24-03-2025 ➢ **Accepted:** 12-06-2025

Creative commons non-commercial CC BY-NC: This article is distributed under the terms of the creative commons attribution non-commercial 4.0 License (http://www.creativecommons.org/licenses/by-nc/4.0/) which permits non-commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the Red Flower Publication and Open Access pages (https://rfppl.co.in)

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 deathrate 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

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, agrochemicals, many organic and inorganic compounds, have enormously added to large fish death of aquatic ecosystems (*Murthy et al., 2013*). Freshwater plants, eco logical animals like fish comprise one of the most identified vertebrate groups with close to one-third of the species in danger of death and lot of the species already destroyed. When these pollutants agrochemicals 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

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. ₹ 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. 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.

Figure 1 Pie chart, which has described the use of pesticides in India and other countries of the world.

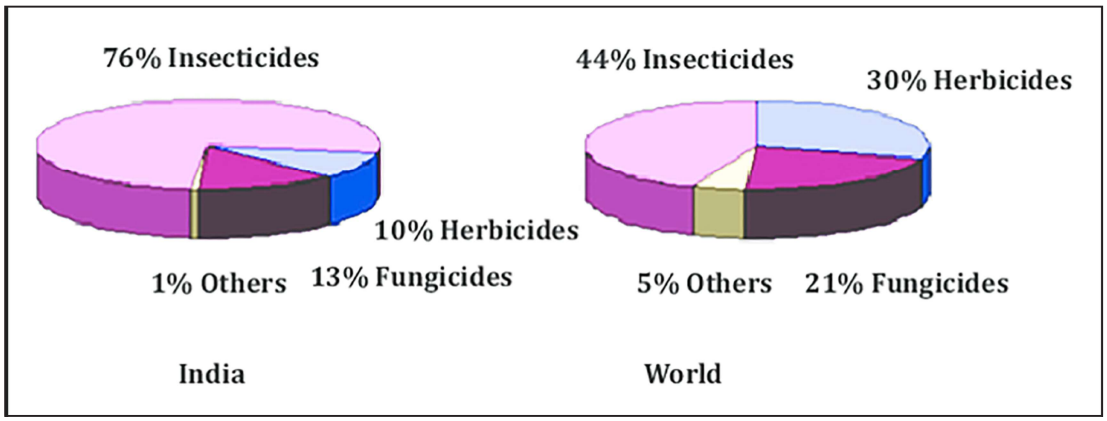

Figure 1: Consumption pattern of pesticides

Figure 2. Pie chart covering crop wise facts followed by as shown in Figure 3.

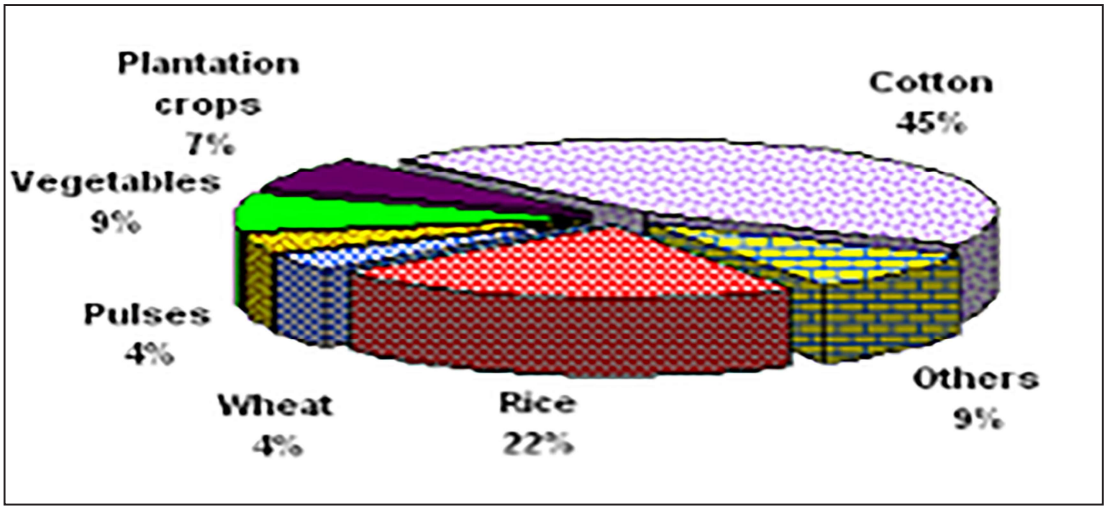

Figure 2: Pesticide consumption of different crops in India

Source: Vijesh *et. al.,* Integrated Pest Management

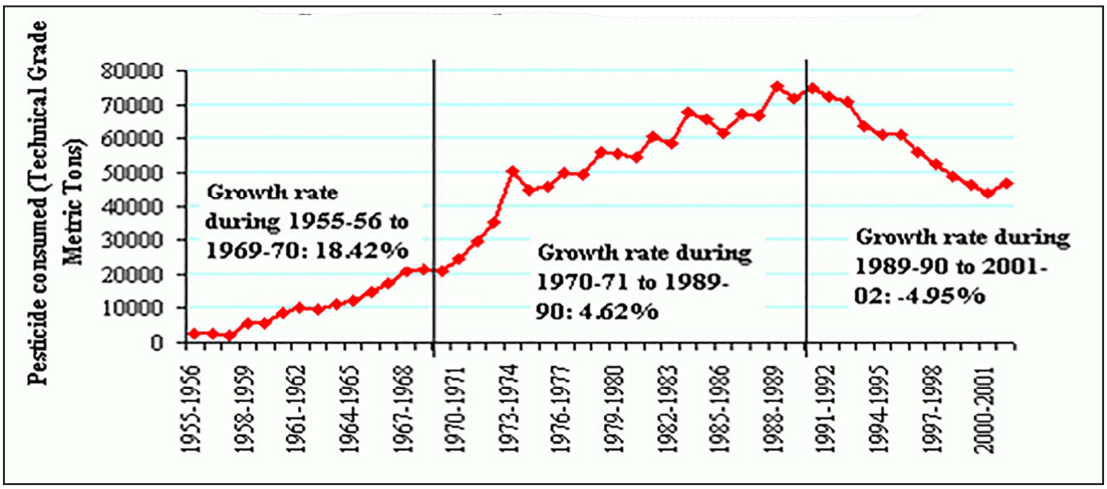

Figure 3: Consumption of Pesticides in India

Source: Vijesh *et. al.,* integrated pest management

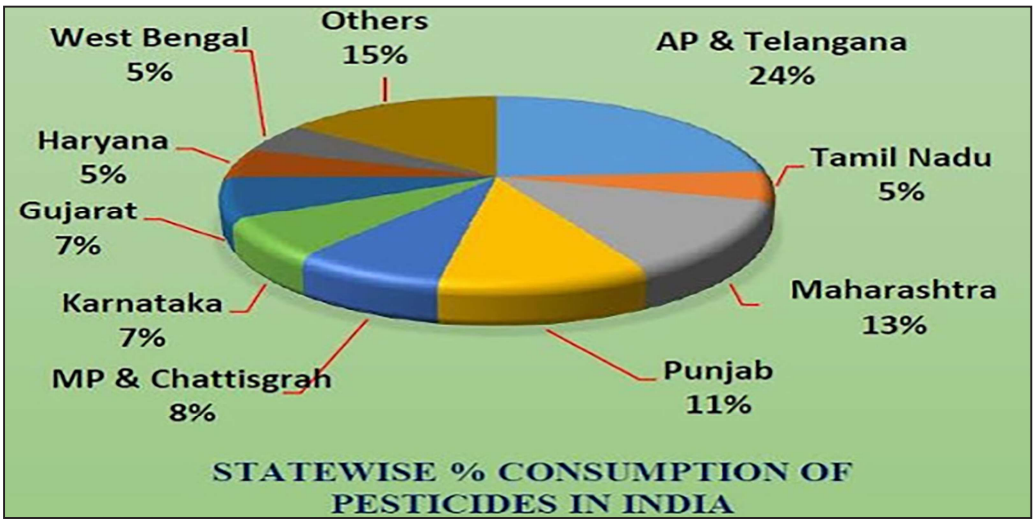

Figure 4: Pie chart showing pesticide consumption by different states of India

Source: Krishnamurthy Ganeshan Agnews

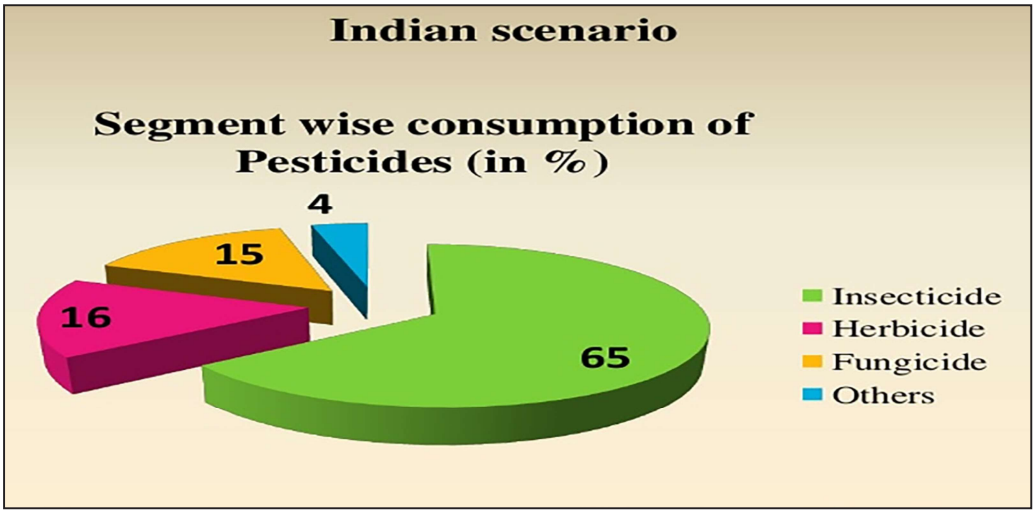

Figure 5: Segment wise consumption of Pesticide (in %)

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. 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 – Building, transport and sports.

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 any agrochemical found in 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. Uses of agrochemicals is very countable factor to death of aquatic bodies. 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 agrochemicals (herbicide) have been shown to inhibit normal migration to sea, resulting in severe disruption of the life cycle. These deaths 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 has a very much requirement for further research.

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). Chronic toxicity isultimately 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 organism 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.

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

Nutrient	Reproduction effect	Changes
Lipids	Low lipid diet reduce reproduction	Source of energy in fish
Proteins	Low protein diet reduce reproduction	Source of energy in fish
Carbohydrates	Don't compromise reproductive performance	Indigestible in fish
Vitamin	Quality of gonads and eggs	Different vitamins useful / harmful for different activity in body
Minerals	Not effect reproduction	Necessary in diet for body action
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 ratings and 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

Interactions of agrochemicals to fish and other aquatic animals depend on its availability, toxicity (LD_{50}), exposure concentration, magnifications, and environmentally presence.

Routes for occurrence of pesticides in Aquatic Ecosystem:

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*). 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 water streams; while accumulation and persistence of agrochemicals 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 affectfish 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 3: The Acute Toxicity (LD_{50}) against Certain fish species

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	Heteropneustessfossilis	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	Percaflavescens	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	Barbodesgonionotus	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	Heteropneustesfossilis	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	Nemacheilusbotia	96 hrs 7.018 ppm	Nikam *et al*., 2011
Malathion	Heteropneustesfossilis	96 hrs 0.98 ppm	Deka *et al*., 2012
Rogor	*Puntius stigma*	96 hrs 7.1 ppm	Bhandare *et al*., 2011

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. Biological methods like, In situ bioassays is use to decide the impact of pesticide on particular aquatic animal or plant.. This test depends on exposing the test animals to the field without disturbing the polluted sediments. After exposure survival percentage is determined by holding the fish in water columns.

Direct and Indirect effects of agrochemicals on Fish

Fish and other aquatic animals are directly as well as indirectly affected by various pesticides. Agrochemicals were always injurious to ecosystems and produce various types of toxicity in aquatic animals like 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 behaviourof 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*). 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-friendlybio 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. Some common disease like loss of equilibrium, increased cough rate, Hyper excitation, flaring of gills, increase in production of mucus from the gills, darting movements and hitting against the walls of test tanks were sign in Catla Catla fish. The effect of certain insecticides on the activity of ACHE may lead to decreased mobility of the fish (Farid *et al.,* 2015). Cypermethrin and Sodium cyanide also alter the migratory behaviour of migratory fish, Cypermethrin Caused darting erratic and irregular swimming movements while sodium cyanide cause hypexcitablity and imbalance swimming in Labeo rohita, catlaCatla, Cyprinuscarpio 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. 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*. Sodium cyanide induced certain behavioural changes such as hypexcitability, darting and erratic movements, and imbalance swimming, in Oreochromis mossambicus, Catla catla, Cirrhinusmrigala, 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).

Gammalin 20 exposure showed the histopathological examination of body organs of fish like (liver, gill, and intestinal tissues) and studies indicated that the gills and liver of aquatic animals primarily targeted parts. Secretion of mucus layer over the gill lamellae has been detected 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, Hemoglobin level and hematocrit values were high in the treated fish compared to control specimens (Al-Otaibi *et al.,* 2019). Cypermethrin sub lethal concentration exposure always effects Gill, liver and kidney of Clarias gariepinus (a fish). 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 lacerations in the liver muscles of fish were identified by cloudy swelling of hepatocytes, lipoid vacuoles, pycnotic nuclei and focal necrosis. Some tissues were observed in kidney tissues of fish as haemopoietic like Atrophy of the glomerulus, broader Bowman's capsule, epithelial hypertrophy, necrosis in the epithelial cells, narrowing of the tubular lumenand pycnosis in the. These wounds grew with increasing concentration of agrochemicals and toxic substance in eco system.

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. Irrespective blood cells count, decreasing of RBCs, (Packed cells count) PCV (%) showed increasing count in the increasing the exposure of the both aldrin and dieldrin in the fishes and in the case of DDT, BHC and chlordane showed decreasing trend in PCV (%) values with increasing time of exposure. It means Hemoglobin content reduced from an initial 13 g/100 ml to 8.07 g/100 ml and then increase a little as the body start to cope up the changes.

Figure 7: Representative image of: Impact of fullerene C60 on behavioral and hematological changes in the freshwater fish, Anabas testudineus ***Source:*** Bloch *et. al.* 1792.

Enzymes Alteration and Genotoxicity:

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. 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). Profenofos can caused any significant change in tail of all marine fish.

Acetyl cholinesterase (AChE) activity is a biomarker of effect on the nervous system. 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 have 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. 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) 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:

Destructive 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 were the organ received highest disturbance in peroxidase. Similarly changes in lipid peroxidase have been observed on account of different pesticides as well as environmental pollutants.

Studies have revealed serious impact of pesticides on immune system, which results in disease initiation and eventually can lead to death. Pesticides also act as sex hormones' blockers, which leads to anomalous and atypical sexual development, irregular sex ratios, males' feminization and disturbed mating behavior and endocrine disrupting impacts during early life stages or stages of development. Dimethoate and Lambda-cyhalothrin showed lethal effect on Thyroid hormone of Labeo rohita. Level of plasma thyroid hormone disturbed by environmental chemical exposure. Disturb plasma thyroid hormone level leads to thyroid malfunction in fishes.

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 *Anabustestudineus* (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: Agrochemicals greatly extinct food organisms' abundance in aquatic bodies and eco system which is important for fish survival (Helfrich, 2009). It means agrochemical indirectly intersects the food supply and change the habitat of water bodies. 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. 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 humanloss 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, hematological 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 kept that accumulate less quantity of agrochemicals, toxic heavy metals and other toxic pollutants. Laboratories should be need to do further studies and research on new introduced agrochemicals. 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.

REFERENCES

1. Ansari B.A., Ahmad M.K. (2010). Toxicity of synthetic pyrethroid Lambda cyhalothrin and neem-based pesticide Neem gold on Zebra fish Danio rerio (Cyprinidae). Glob. J. Environ. Res., 151-154.
2. AV, H. (1973). Effects of pesticides on fish (Environmental Pollution by Pesticides). Environ. Sci. Res., 213-253.
3. Babu Velmurugan, Theresia Mathews & Elif Ipek Cengiz. (2009). Histopathological effects of cypermethrin on gill, liver and kidney of fresh water fish Clarias gariepinus (Burchell, 1822), and recovery after exposure. Environment Technology, 1453-1460.
4. Bhandare R.Y., Pathan T.S., Shinde S.E., More P.R., Sonawane D.L. (2011). Toxicity and behavioural changes in fresh water fish Puntius stigma exposed to pesticide (Rogor). Am-Euras. J. Toxicol. Sci , 149-152.
5. Bols N.C., Brubacher J.L., Ganassin R.C., Lee L.E.J. (2001). Ecotoxicology and innate immunity in fish. Develop. Comp. Immunol, 853-873.
6. C. Minier, F. Levy, D. Rabe, G. Bocquene, D. Godefroy, T. Burgeot and F. Leboulenger. (2000). Flounder health status in the Seine Bay.A multibiomarker study. Marine Environmental Research, 373-377.
7. S.K. Sarkar, B.D. Bhattacharya, A. Bhattacharya, M. Chatterjee. (2008). Occurrence, distribution and possible sources of organochlorine pesticide residues in tropical coastal environment of India: An overview. Environment International, 1062-1071.
8. Sana Ullah, Mohammad Jalil Zorriehzahra. (2014). Ecotoxicology: A Review of Pesticides Induced Toxicity in Fish. Advances in Animal and Veterinary Sciences, 40-57.
9. Impact of Pesticides Application in Agricultural Industry: An Indian Scenario. International Journal of Agriculture and Food Science Technology, pp. 817-822 Impact of Pesticides Application in Agricultural Industry: An Indian Scenario (Tulsi Bhardwaj *et al*). 2 Division of Agricultural Extension, IARI, Pusa, New Delhi.