



EXCESSIVE USE OF PESTICIDES IS A RISK FACTOR TO AQUATIC LIFE FORMS (FISH) AND PUBLIC HEALTH: A REVIEW ON ITS EFFECTS AND CONTROL STRATEGIES

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ABSTRACT

Pesticides are chemical compounds used to kill pests like insects, rodents, fungi, and unwanted plants. They are widely used to control diseases and increase yield in agriculture. However, they are toxic to non-targeted animals, especially fish. Uncontrolled consumption can lead to fish death, and their sub-lethal concentration can affect their organs and functions. Aquatic resources and animals are valuable assets, providing high productivity, protein yield, and essential vitamins and minerals. However, the increasing use of pesticides in agriculture threatens public health and the aquatic ecosystem. Proper care is needed to protect aquatic life forms and human health, and best management practices are adopted to protect water quality.

KEYWORDS: Pesticides, Water, Plants, Biodegradation, Aquatic life.

INTRODUCTION

Pesticide is a chemical substance used to prevent, destroy, repel or minimizing the effect of pests.^[1] Pest can be insects, plant pathogens, weeds, mollusks, birds, mammals, fish, nematodes (roundworms) and microbes. The most common used pesticides include insecticides, herbicides, fungicides and rodenticides, other less well-known pesticides comprise growth regulators, plant defoliants, surface disinfectants and some swimming pool chemicals. Most commonly, pesticides are used in health sector and agricultural crops.^[2] Forests have been utilized for habitation, disturbing environmental balance.^[3] We are also facing the most emerging problem of pollution having diverse variety of pollutants.^[4] These pollutants include domestic wastes, untreated effluents from industries, chemicals like pesticides used in agriculture, organic compounds and heavy metals.^[4,5,6] These pollutants change the water quality which is the habitat of all aquatic organisms^[7] this changed water quality highly affects them and even causes their death in acute concentration.^[8, 9] When these pollutants flow in water bodies at high concentration cause mortalities of all aquatic life including fish and shell fish. While in low concentration leads to their bio accumulation and ultimately effects human being through food web.^[10] This is a serious issue that should be treated and focused properly to ensure the safe fish usage.^[11,12] To determine the effects of pesticides on aquatic organisms different biological methods are used like in situ bioassay.^[13-17] Sometimes water cages are also used to hold fish in water

column when water column is too deep or too fast.^[18-19]

Classification of pesticides

Pesticide includes herbicides, insecticides, fungicides, rodenticides, garden chemicals and household disinfectants used to control or protect pests.^[20] They varies in their physical and chemical nature. So they should classify according to their properties. There are three main modes of their classification.^[21]

Classification on the basis of mode of entry

- I. Classification on the basis of chemical composition of pesticides
- ii. Classification on the basis of their function and the pest, they kill.^[21]

Classification on the basis of mode of entry

The pathways through which pesticides come in contact with their target are called modes of entry. These include the following.

1. Systemic pesticides

Systemic herbicides, such as glyphosate and 2,4-Dichlorophenoxyacetic acid, enter plant tissues and kill specific pests through vascular bundles, affecting leaves, roots, and stems.

2. Non systemic pesticides

Contact pesticides, like paraquat and diquat dibromide, kill target pests through physical contact, entering the body through the epidermis for optimal results.

3. Repellent

Insect repellents, like Benzaldehyde and dimethyl carbate, protect treated areas from pests and interfere with crop locusts, without killing them.

4. Fumigants

Pesticides kill pests through vapors entering their bodies via trachea, killing stored and nursery stock, and treating common soil fumigants like nematocides.

Classification on the basis of chemical composition of pesticides

This method determines the efficiency, physical and chemical properties of pesticides. On the basis of composition they are classified into Organochlorine, Organophosphorus, Carbamates, pyrethrins and pyrethroids.^[22]

1. Organochlorine

Organic compounds with five or more chlorine atoms are used in agriculture and public health as insecticides, causing insect convulsions, paralysis, and death. DDT, endosulfan, lindane, aldrin, and chlordane are banned in tropical countries for malaria control.

2. Organophosphates

Organophosphates are versatile pesticides with a broad spectrum, controlling various pests and causing minimal environmental pollution. Commonly used include diazot, parathion, malathion, and glyphosate.

3. Carbamates

Organophosphates and carbamates are structurally similar but have different origins, affecting nerve signal transfer and pest poisoning.^[21]

4. Synthetic pyrethroids

Organic pesticides, prepared by duplicating natural pyrethrins, are stable and long-lasting, containing pyrethrins 1 and 2, cinerins, and jasmolins. They are toxic to insects, fish, and mammals, with common examples like cyclpermethrin and permethrin.

Classification on the basis of function of pesticides and pest organism they kill

The name of these pesticides is derived by a Latin word Cide means kill or killer, used as suffix after the name of target pest.

Table 1: Types of pesticides.^[23]

Types of pests	Target pests/Function	Examples
Insecticide	It Kills insects and arthropods.	Aldicarb
Fungicide	It is used to control fungi, molds and rusts.	Azoxystorbin
Bactericide	It is used against bacteria.	Copper complexes
Herbicide	It acts against weeds and unwanted Plants.	Atrazine
Pisicide	It is used against fishes.	Rotenone
Lampicide	It acts against the larvae of lampreys, jawless fishes.	Nitro phenol
Virucide	It is used to kill viruses.	Seytovirin
Nematicide	It is used to kill nematodes that are Parasites plants.	Aldicarb
Algaecide	It acts against algae.	Copper sulfate

Some are named on the basis of their functions like growth regulators that increase or decrease the growth of pests; defoliant which causes the plants to drop their leaves; repellents, which repel the pests; attractants, which attract pests usually to a trap.

Occurrence of pesticides in aquatic ecosystem

Pesticides used different ways to enter in water bodies, which is determined by the identification of three main routes.^[24,25] These routes include water column, organic site of attachment like mosses, algae, branches and vascular hydrophytes and inorganic sites of attachments like sedimentary materials.^[26]

Determination of pesticide's contents

In sediments, water, organic substrate and especially in plants or animals tissues pesticides can be determined by using chemicals.^[26] First of all the solid animal or plant tissue s homogenized then they are extracted by acetone, after it evaporation is done into small volumes. At the end cleaning and drying is done and finally sample is analyzed.^[27-31]

Effect of pesticides on Aquatic life (Fishes)

1. Indirect effects of pesticides on fishes

Pesticides are continuously reducing the organisms which are important for the survival of fish^[32] In this way they are effecting the fish indirectly by reducing its food sources.^[33] It also reduces the stability of fish's habitat in this way it increases the chances of predation for fish.^[34]

2. Direct effects of pesticides on fishes

In addition to indirect effect pesticides also affect fish directly.^[35] They cause different types of toxicity in fishes leading to the change in their behavior.^[36-39] They also induce changes in their hematology^[40] Pesticides also disturb the histopathology of fishes.^[41, 39, 20] They are also responsible for biochemical changes and disturb the endocrine system of fish.^[42] They also result in the change of acetyl cholinesterase's activity.^[43-45] Fish species are varying in susceptibility to pesticides, causing changes across various body parts.

Lethal effects of pesticides on Fish

Sub lethal amounts of some pesticides result in abortion of fish. In 1996, in Bear Creek, a branch of Rouge River

high rate of mortality of different fishes was studied including 92,000 steel head, 19 rainbow trout, 114 juveniles of salmon and thousands of non-games fishes due to pesticides.^[46] Small amount of Methyl parathion including 4.8ppm, 8ppm and 10ppm caused 50%, 80% and 100% deaths of *Catla catla*. Dimethotata and Lambda-cyhalothrin are proved to be lethal for *Labeo rohita*.^[19]

Effect of pesticides on Fish's haematology

Pesticides like DDT, Endosulfan, BHC, Aldrin, Chlordane, Karate, Dimelthrin and Sulfan effect the haematology of fish like changes the haemoglobin level, WBCs and RBCs level in different fishes like *Cyprinus carpio*^[48] *Oreochromis mossabicus* due to potassium chlorate and potassium dichromate^[49] and lead^[50] *Channa punctatus*^[51] is effected by endosulfan. The hemopoietic system becomes chronic in *Labeo rohita* due to chlordane many other studies were made to study the effect of pesticides on the haematology fish.^[52]

Effect of pesticides on Fish's behavior

Pesticides impact fish by affecting their ability to swim, reduce feeding, and increase infections and diseases.^[33] Methyl parathion changes body coloration, loss of equilibrium, and increased operculum movement.^[36] They also disrupt fish's migratory behavior, disrupting their life cycle. Sodium cyanide causes imbalanced swimming, arbitrary body movement, and excitability in various fish species, in *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala* and *Cyprinus carpio*.^[20]

Effect of pesticides on biochemical activities of fish

Many studies have done to show the effect of pesticides on the biochemical activities of fish^[3] These changes are tissue specific and have been studied in lungs, gills, kidneys, brain and body viscera and their results differ from organ to organ and specie to specie like peroxidase activity was studied in brain, viscera and muscles of tilapia but gill was the organ in which high level of changes was observed.^[53]

Organophosphates with sub lethal concentration are also responsible for changes in the enzymes such as glutaminase in brain, responsible for the movement of various brain parts in *Labeo rohita*.^[54] Endosulfan subordinated the level of activities of citrate synthase and glucose 6 phosphate dehydrogenase in skeletal muscle, liver and brain of *Clarius batrachus*.^[55] Cypermethrin caused changes in the enzymes including catalase, Glutathion reductase and peroxidase in tissues of brain and muscles of *Tor putitora*.^[3]

Effect of pesticides on protein level of fish

Pesticides have adverse effects on protein level of fishes, like nickel lowers protein level in *Heteropneustes fossilis*^[56] phenyl mercuric acetate reduces protein level in muscles and liver of *Channa punctatus*^[57] Karate decreases protein level in *Cyprinus carpio*^[45] Exposure of Thiamethoxan resulted in significant decrease in the total protein content of liver in *Oreochromis niloticus*^[58] while exposure of thiodonn effected the level of protein content of liver of *Clarias gariepinus*.^[59] While lethal concentration of monocrotrophs resulted in decreased level of carbohydrates, proteins and lipids in *Labeo rohita* There are many pesticides like Dioxin that effect the pathway of genes how they control the synthesis of proteins like vitellogenin which is responsible for egg development.^[60]

Effect of pesticides on immunology and endocrinology of fish:

Pesticides have adverse effect on the immune system of fish, which results in fish diseases and eventually leading to their death Pesticides are also harmful for fish endocrine system. During initial development there are higher chances of damage of fish's endocrine system.pesticides are also act as sex hormone blocker resulting in abnormal sex development, irregular sex ratios and also disturb their mating behaviour^[31] Many environmental chemicals are also harmful for fishes as they disturb the level of thyroid hormone^[45] which leads to the malfunctioning of thyroid in fishes.^[34]

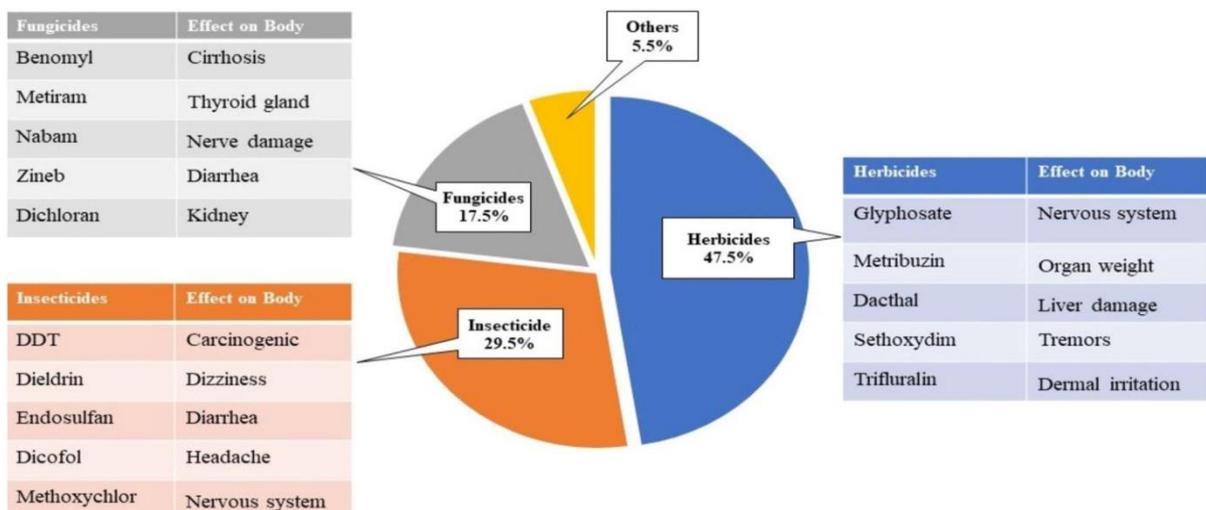


Figure 01: Percentage distribution of pesticides.^[61]

Effect of pesticides on human health

Pesticides are harmful chemicals that can cause acute reactions and chronic diseases like neurotoxicity, cancer, and asthma.^[63] Exposure to pesticides directly or indirectly can lead to toxins being released from the body, affecting the skin, eyes, mouth, and respiratory tract. Long-term consumption of contaminated vegetables and fruits can accumulate toxins, leading to chronic diseases like neurotoxicity, cancer, and asthma.^[64] Organophosphorus, a common pesticide, affects cellular growth and proliferation, and can cause asthma. Additionally, pesticides can reduce fertility and cause genital tract anomalies, affecting endocrine hormones and increasing the risk of coronary artery disease. In some African nations, hunger and undernutrition are serious concerns.^[65]

Role of pesticides in genetic damage

Pesticides interact with DNA, causing conformational changes that can cause gene mutations and lead to adverse health consequences. The long-term effects of chronic exposure to pesticides have become a major concern in recent years.^[66] Pesticide exposure can be direct occupational (farmworkers), direct non-occupational (rural-residents near agriculture fields), or indirect (farmworkers exposed through agriculture products, food chain, and contaminated water). Occupational exposure is the most dangerous, as it are linked to immediate effects like lung disease and airway obstruction.^[67]

Effect of pesticides on asthma

The urban population is chemically intolerant to common chemicals like paints, pesticides, perfumes, and car exhaust, leading to asthmatic and respiratory symptoms. Residential pesticide exposures have increased in the US, with indoor air pollution worsening symptoms. Asthmatic patients experience a decrease in FEV1 and severe bronchial responsiveness, affecting the chest, nose, and eyes.^[68]

Reduce the effect of pesticides

- i. Use of pesticides only on the time of need, excessive use should be avoided.
- ii. Pesticides with less toxicity should use.
- iii. Pesticides should be used in safe and proper way.

Selection of pesticides

- i. Pesticides that are selected should have less acute toxicity.
- ii. Application of pesticides should be restricted in an area with greater water supply.
- iii. Pesticides should be applied when soil conditions are very high.
- iv. Pesticides should have soil absorption, short life time and low water solubility.
- v. Pesticides should have low water runoff.

Best management practices to protect aquatic life

- i. Adopt an Integrated Pest Management (IPM) to use

the least amount and least toxic of pesticides for pest control. Before application of pesticides be sure that it is needed and can be accomplished safely and effectively.

- ii. Determine the chemical control options. Select that option which has least negative effects on water and aquatic organisms including fishes, chemicals (Pesticides) selected for use should be less toxic to fish and other aquatic organisms.
- iii. Read and follow all the directions that are labelled. Use pesticides only as directed, proper care and attention is needed during applying, methods and rates. Control the rate, method timing and types of pesticides being applied. Pesticides label directions are not advice, they are legal requirements.
- iv. Be careful during mixing and loading of pesticides, be sure that the equipment is working and is properly calibrated. Mix and prepare only the amount of pesticide that is required for immediate application.
- v. Apply pesticide at proper time consider the time, weather and life cycle of pest when planning application.
- vi. Store pesticides in a ventilated, well lighted, and secure area from flooding.
- vii. Dispose of empty containers and rinse water properly.
- viii. Keep record of all pesticide use, records will allow low evaluation of pest control efforts and help to plan future treatments.^[62, 64]

CONCLUSION

Pesticide use has increased, causing environmental damage, aquatic life (Fishes) particularly water and soil contamination. Pesticides, their classification based on chemical composition, entry mode, and target pest. These chemicals can negatively impact aquatic organisms, including fish, and can lead to economic loss and health hazards. Toxic pesticides can affect fish's hematology, behavior, protein and lipid levels, biochemical activities, life cycle, enzymatic activities, physiology, and reproduction. To protect water quality and aquatic organisms, it is essential to select less toxic pesticides. Different fish species are susceptible to different amounts of pesticides, and best management practices should be adopted to improve water bodies and protect aquatic life. Proper management strategies are needed to convert these persistent and resistant pesticides into non-toxic compounds. The scientific community is working on eco-friendly management strategies, including bioremediation, which are cost-effective and environmentally benign.

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