Pesticides Toxicity in Fish with Particular Reference to Insecticides

Farid Soliman Sabra[1*] and El-Sayed El-Deeb Mehana[2]

[1]Plant Production and Protection Dept., College of Agriculture and Veterinary Medicine, Qassim University, Qassim, SA (corresponding, Email:sabra1983eg@yahoo.com)

[2]Pathology Dept., Faculty of Veterinary Medicine, Alexandria University, Egypt.

[*]*Corresponding author's email: sabra1983eg [AT] yahoo.com*

ABSTRACT--- ***Aquatic Toxicology is the study of the effects of environmental pollutants on aquatic organisms, such as pesticides especially the insecticides, on the health of fish or other aquatic organisms. Pesticides are substances used to control pests, including insects, aquatic weeds, plant diseases, and Aquatic snails that carry the cause of schistosomiasis. Pesticides have been found to be highly toxic not only to fish but also to the other organisms, which constitute the food chain. Pesticides in general, are used very extensively in agriculture, forestry, public health and in veterinary practices. Pesticides are categorized according to their target use. The three major pesticides are herbicides (weed control), insecticides (insect control), and fungicides (Mycotic control), but the more acute toxicity are insecticides. Since fishes are important sources of proteins and lipids for humans and domestic animals, so health of fishes is very important for human beings. Insecticides are the chemicals used to control insects by killing or preventing them from engaging in unwanted behaviors or destructive. The contamination of surface waters by insecticides is known to have ill effects on the growth, survival and reproduction of aquatic animals. Different concentrations of insecticides are present in many types of waste water and numerous studies have found them to be toxic to aquatic organisms, especially fish species. Application of insecticides used for control a wide variety of insectivorous and herbaceous pests which would otherwise diminish the quantity and quality of food production. Unfortunately, in spite of its advantages, chemistry has great disadvantages as well as insecticides are threatening the long-term survival of major ecosystems by disruption of ecological relationships between organisms and loss of biodiversity. The major Chemical groups of insecticides that are usually applied Organophosphate, Carbamates, Organochlorine, Pyrethroids, and Necotenoides. The insecticidal residues which contaminate the water are mainly due to the intensive agriculture combined with surface runoff and surface drainage, usually within a few weeks after application. Insecticides lead to decrease rate of growth, reproductive disorders. Also, cause spinal deformities and histopathological changes in gills, liver, hematopoietic tissue such as spleen, head of the kidney and renal tubules, endocrine tissues as well as brain, neurological, behavioral disorder and genetic defect are other biological indicators of exposure to insecticides. Fishes are particularly sensitive to the environmental contamination of water. Hence, these pollutants such as insecticides may significantly damage certain physiology and biochemical processes that different kinds of insecticides can cause serious impairment to physiological and health status of fishes. Aquaculture is one of the fastest growing food producing sectors, supplying approximately 40% of the world's fish food. Besides such benefit to the society, the industry does have its problems. Potentially harmful substances are often release into the aquatic environment. When is the launch of large quantities of pollutants there might be an immediate impact as measured by mortality the sudden large-scale aquaculture, for example, fish kills caused by pollution of water ways with agricultural pesticides. Lower levels of discharge may result in accumulation of pollutants in aquatic organisms. The final results, which may occur after a long period has passed pollutants through the environment, and include immune suppression, low metabolism, and damage to the gills and epithelia. This review presents further information concerning effects (Acute, sub chronic and chronic) of the different concentrations of pesticides (including insecticides) on various aspects of fish's biology and physiology. Also, depicts behavior, genetic and immune system of fish. The information given in this review facilitates the evaluation of potential toxic hazard resulting from exposure to different levels of these compounds. Data could be acquired useful in environmental risk assessment of freshwater organisms and marine. The histopathological changes in fish tissues used as a biological indicator for pollution with pesticides with special reference to insecticides. Finally, Protection of wildlife and water quality is possible when rationalize the use of pesticides. Also, when Pesticides must choosing judiciously and are used in combination with other pest management tools, and applied safely, the surface water pollution and contamination of our aquatic life could be avoided.***

Keywords--- Pesticides, Insecticides, fish, Histopathology, Acute exposure, water contaminants

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1. INTRODUCTION

Fisheries and aquatic resources (ponds, rivers, streams, the seas and oceans) are supplying peoples with long term benefits. Those benefits can be the direct financial ones that provide employment, profit, and save money. For example, the sea food industry provides hobs for commercial fisheries, wholesalers and retailers. More indirect, but equally valuable, benefits of fish and aquatic ecosystems include recreational boating, sport fishing, swimming, relaxation, and natural beauty [1]. There are occupational hazards and safety concerns in the aquaculture industry. Some practices have caused environmental degradation. Public perception to farmed fish is that they are "cleaner" than comparable wild fish. However, some farmed fish have much higher body burden of natural and man-made toxic substances, e.g., antibiotics, pesticides, and persistent organic pollutants, than wild fish. These contaminants in fish can pose health concerns to unsuspecting consumers, in particular pregnant or nursing women. The regulations and international oversight for the aquaculture industry are extremely complex, with several agencies regulating aquaculture practices, including site selection, polluted control, water quality, feed supply and food safety, [2]. Some compounds from PCB's which used as insecticides considered estrogenic and anti-estrogenic contaminants in environment causes endocrine disruption and affect fish reproduction. Application of insecticides used for control a wide variety of insectivorous and herbaceous pests which would otherwise diminish the quantity and quality of food production. Sadly, in spite of advantages, the synthesized chemical compounds have significant drawbacks, as well as insecticides threaten the long-term survival of major ecosystems disorder environmental relations between organisms, and the loss of biodiversity. The major Chemical groups of insecticides that are usually applied Organophosphate, Carbamate, Chlorinated Hydrocarbons, Pyrethroids and Nicotinoids. Contamination of water with insecticides is mainly due to intensive agriculture combined with surface runoff and surface drainage, usually within a few weeks after application. Fishes are particularly sensitive to the environmental contamination of water. Hence, pollutants such as insecticides may affect significantly certain physiological and biochemical processes that different kinds of insecticides can cause serious impairment to health status of fishes, [3].

2. IMPACT OF WATER POLLUTION ON HEALTH OF FISH AND SHELLFISH

There is little evidence of pollution affecting the health of fish and shellfish all over the world. There is no disrupt that pollution can affect the aquatic organisms under laboratory conditions and may be responsible for the decline of populations of such animals in some inland water and some estuaries , most of the evidence for population causing or increasing diseases in fish in open water is circumstantial . Water pollution, especially in inland waters, has for the past 400-500 years been the result of urbanization and industrialization. This has resulted in some major rivers becoming devoid of or deficient in fish stocks. The concern that pollution may influence the health status of fish and shellfish stocks has increased over the past 20 years. Initial attention was plaids to epidermal diseases, including fin-rot in demersal fish , and protozoan diseases in mollusces in the heavily polluted areas. In general, diseases in fish and shellfish are very localized, but there is concern amongst scientists that certain cancers, especially liver tumors, occurring in demersal fish inhabiting polluted estuarine and coastal waters, are related to the release of chemicals, e.g., hydrocarbons, pesticides and heavy metals [4]. However, the link between adverse water quality and fish diseases is not proven. Many surveys have indicated a greater proportion of diseased fish in polluted compared to non-polluted sites [5], [6].

2.1. Pesticides Toxicity in Fish

Are substances used to control organisms, including insects, water weeds, and plant diseases .Pesticides usage in agricultural fields to control pests is extremely toxic to non target organisms like fish and affect fish health through impairment of metabolism, sometimes leading to mortality [6]. During those days, increased human population with rapid pace of industrialization induced problem of disposal of waste waters. The domestic wastes and untreated or partially treated industrial effluents, supplemented with pollutants like heavy metals, pesticides and many organic compounds, heave greatly contributed to massive fish death of aquatic ecosystems, [7], [8]. Pesticides toxicity in fish has been studied by several authors who have shown that at chronic level, it causes diverse effects including oxidative damage, inhibition of ACHE activity, histopathological changes as well as developmental changes, mutagenesis and carcinogenicity. Pesticides in India, were developed from 5,000 metric tons in 1958 to 102240 metric tons in 1998. Meanwhile, in 1996-97 the demand for pesticides in terms of value was estimated to be around Rs 22 billion (USD 0.2 billion), which is about 2% of the total world market, [9]. Since pesticides present in the environment with other similar organophosphate compounds, may induce lethal or sub lethal effects in fish, **[10].**

Naturally occurring pesticides have been used for centuries but widespread production and use of modern synthetic pesticides did not begin until the 1940s. Today pesticides are big business .Over billion pounds of pesticides are used in the united states at value of $ b billion per year. Pesticides are categorized according to their target use to many groups such as Insecticides, Fungicides, Herbicides, Rodenticide, Nematicides, Acaricides, Molluscicides, Homicides, Ovicides and so. The three major pesticides are herbicides (weed control), insecticides (insect control), and fungicides (Mycotic control). Nematicides are pesticides used to control soil, leaf and stem-dwelling nematodes (round worms). An acaricide is a pesticide that control mites and ticks, [11].

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 file specifications in terms of the method used on the pest, on the mammalian 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, [11]. The ingredients, manufacturing process, physical and chemical properties, environmental state (mobility, volatility, breakdown rates, accumulation potential in plants and fish). The pesticide label must contains trade name, active ingredient, direction for use, toxicity rating and EPA registration number. A Pesticides capacity to harm fish and aquatic animals is largely a function of its toxicity, exposure time, dose rate, and persistence in the environment. A lethal dose is the amount 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 (LC_{50}) , is used. This concentration of pesticide that kills 50% of a test population of fish within a set period of time is usually determined after 24 to 96 hours. Hazard ratings ranging from minimal to super toxic and LC_{50}'s for commonly used insecticides, herbicides, and fungicides are presented in Table (1).

Table 1: 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**

Exposure of fish and other aquatic animals to pesticides depends on its biological availability (Bioavailability), bio-concentration, biomagnifications, and persistence in the environment. Bioavailability refers to the amount of pesticide in the environment available to fish and wildlife [12]. Some pesticides are rapidly breakdown after application. Some bind tightly to soil particles suspended in the water column or to stream bottoms , thereby reducing their availability .Some are quickly diluted in water or rapidly volatize into the air and are less available to aquatic life. Bio-magnification is the accumulation of pesticides at each successive levels of the food chain. Some pesticides build up in food chain. For example, if a pesticide is present in small amounts in water, it can be absorbed by water plants which are, in turn, eaten by insects and minnows .These also become contaminated. At each step in the food chain in the concentration of pesticide increases .When sport fish such as bass or trout repeatedly consume contaminated animals , they bio-concentrate high levels in their body fat . Fish can pass these poisons on to humans. Persistence of pesticides refers to the length of time a pesticide remains in the environment. This depends on how quickly it breaks down (degrades), which is largely a function of its chemical composition and the environmental conditions .Persistence is usually expressed as "half life" ($T_{1/2}$) of a pesticide. Pesticides can be degraded by sunlight (Photo decomposition) , high air or water temperatures (thermal degradation) , moisture conditions , biological action (Microbial decay) , and soil conditions (PH) .Persistence (long -standing) pesticides breakdown slowly and may be more available to aquatic animals [13] .

2.2. Advantages of Pesticides

There are many advantages of pesticides such as, they can protect against forest and farm crop losses and can aid in more efficient food production, they are used to slow the spread of destructive forest insects like the gyps moth, they are used to establish and maintain lawns and recreational areas, they are used to help reduce malnutrion and starvation of humans and animals, and have been instrumental in controlling many insect-born human diseases such as malaria, encephalitis, and bubonic plague. Many authors' considered the pesticides are simple to apply, rapid effect, inexpensive, wide spectrum, and long-lasting.

2.3. Disadvantages of Pesticides

The main disadvantages of pesticides are including their toxicity to some humans, animals, and useful plants, and the persistence (long life) of some of these chemicals in the environment. And when pesticides enter aquatic system, became the environment costs. Unintentional pesticide-related fish kills occur throughout the world. Some of these kills have been large, involving thousands of fishes, as well as frogs, turtles, mussels, water birds, and other wildlife. Fish and other wildlife species, including rare and enlarged ones like the peregrine falcon, bald eagle, and osprey, have been victims of pesticide poisoning. Pesticide use is one of many factors contributing to decline of fish and other aquatic species. Pesticides are capable of killing salmon and other aquatic life directly and within short period of time. 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 , 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 effects of pesticides the effect is common. Several pesticides have shown to cause fish to seek suboptimal water temperatures, thus subjecting them to increased danger of disease and predation. Some herbicides have been shown to inhibit normal migration to sea, resulting in severe disruption of the life cycle. There is a death of research looking at this effect for common insecticides. Several studies suggest that certain pesticides can impair salmonid' s ability to transition from freshwater to sea water. There is a need for further research in this area. 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. Act as blockers of sex hormones, causing abnormal sexual development, feminization of males, abnormal sex ratios and unusual mating behavior. Interfere with other hormone process, such as thyroid functions and bone development. The Indirect effects of pesticides are interfere fish with their food supply, altering the aquatic habit, reduces the growth and probability of survival of the fish. It is reported that the chronic toxicity may ultimately cause death or may result in elimination of species or individuals over a long period of time , through a host of effects such as induced sterility , interference within an organisms naturally defense mechanisms , loss of appetite , blindness , hyperexitability or other weakness and reduction in fertility, [14], [15], [16], [11], [6].

3. ROUTES OF PESTICIDES FISH EXPOSURE

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

There are some secondary causes that cause the exposure of fish and aquatic animals to pesticides and eventually lead to toxicity. Through the consumption of another animal that has been poisoned by a pesticide first, for example fish feed on insects death poisoned insects may be killed themselves if they eat the insects that contain large amounts of toxic pesticides or byproduct her. The water column, usually first comes in contact with pesticides, and Organic substances (algae, mosses, vascular hydrophytes, leaf litter and branches) may also causes secondary causes, [17], [18], [19].

The exposure of fish and other aquatic life to Pesticides may be a more widespread problem than most people realize. Most pesticide-related fish kills go unreported and, in documented cases, the number of fish killed is often underestimated. Unfavorable conditions in the clarity of the water environment, including water purity and depth, and the small size and camo coloring for many of the fish, and fish, especially youth, and to make accurate counts difficult. Scavenger quickly removes the bodies from the site of murder. Dying and stressed fish may hide in dense cover or leave the area completely. If you have knowledge of sick or dead fish and aquatic life that you suspect may have been poisoned by pesticides, contact with your local game warden or the fish and wildlife service immediately.

The information about possible pesticides affect fish and other aquatic life depend upon seven items like, type of Pesticides product, use rates, weather conditions, aquatic species involved, extent of the problem (number of fish killed), location, and size of pond or lake affected . Table 2 and figure 1 showed the acute toxicity of different types of pesticides depending on fish species and duration of exposure, [6].

Table 2: The Acute Toxicity (LC_{50}) of Some Pesticides against Certain fish species.

Name of Pesticide	Fish Species	Duration of Exposure	References
DDT	Rainbow Trout	96 hrs-8.7 µg/l	[20]
Akton	Channel catfish	96 hrs-400 µg/l	[20]
Acephate	Feathed M.	96hrs>1000 µg/l	[20]
Alaclor	Rainbow trout	96hrs2.4 µg/l	[20]
Endosulfan	Channel catfish	96hrs1.5 µg/l	[20]
Malathion	Labeo rohita	96hrs15 µg/l	[21]
Malathion	Heteropneustess fossilis	96hrs0.98 ppm	[22]
Methyl parathion	Catla catla	96hrs 4.8 ppm	[23]
Rogar	Puntius stigma	96hrs7.1 &7.8 ppm	[24]

Figure 1: The following figures show the exposure of fish to the environmental pollutants in clouding pesticides.

3.1. Integrated Pest Management (IPM):-

IPM is a system using a variety of methods, including pesticides, to reduce pest populations to acceptable levels. Factors such as groundwater contamination, increasing cost agricultural chemicals, consumer concerns about pesticide residues on food, and concern for the environment encourage the use of IPM. IPM strategies means the Use of many of the ways combined together to reach the desired goal of such methods summarized as follows: - Cultural control (crop rotation and selected planting dates to avoid pests), Host resistance (using plants and livestock that are resistant to pests), Mechanical control (uprooting, weed harvesting, cultivation, and use of insect traps), Biochemical control (Stocking grass carp to feed on water weeds), Chemical control with pesticides, and Sanitation, [6].

3.2. Effects of Pesticides

Place the impact of pesticides within the vital systems in the body Exposed object to these pesticides is divided into the following places by the position of impact:-

3.2.1. On Acetycholinestrase (ACHE): ACH*E* activity is more sensitive for organophosphate and carbamate pesticides than other contaminants, but the inhibition of this enzyme have been also used to indicate the exposure and effects of other contaminants in fishes .It has been shown that the addition of crude oil to brain homogenate in a mounts equivalent to sediment concentration inhibit ACHE activity in fish [25]. Both brain ACHE and muscle were inhibited in fish reared in areas heavy polluted with PA, heavy metals and pesticides [26]. Reduction of swimming performance and peroxidative damage in brain and gills occurred in fish exposed to prolonged exposure to organophosphate, [27], [28].

3.2.2. Chromosomal aberrations and Carcinogenic effects, Dichlorvos at concentrations of 0.01 ppm caused chromosomal aberrations in the form of centromeric gaps , chromatid gaps , chromatid breaks , sub-chromatid breaks , attenuation , extrafragements , pycnosis , stubbed arms etc in kidney cells of Channa punstatus fish after exposure periods of 24, 48, 72 and 96 hrs, [29]. Also, toxicity with Diclorvos has been related to alterations in DNA replication, which cause mutations and cellular hyperproliferation as a result of local mutation, [30], {31], [32].

3.2.3 Effect on protein contents, Appreciable decrease in protein level of liver, muscle, intestine, gills and blood of fish (Channa p.) exposed to Oleondrin, Cyprinus carpio fish exposed to Endosulfan, [33], [34].

3.2.4. Effects of pesticides to Salmonid fish, the **l**ong –term exposure to certain pesticides can increase stress in juvenile salmonids and thereby render them more susceptible to predation. Pesticides alter swimming ability, which in turn can reduce the ability to feed, to avoid predators, to defend territories, and to maintain position in the river system, [15], [6].

3.2.5. Effect on Immune System and Endocrine Disruptors, Exposure to low concentrations of pesticides can disrupt the immune system of fish. Pesticides at low concentrations may act as mimics or blockers of sex hormones, causing abnormal sex development, feminization of males, abnormal sex ratios, and unusual mating behavior. Pesticides can indirect affect fish by interfering with food supply or alternating habit, [35].

3.2.6. Toxicity of pesticides to Cyprinid and catfish, Aldrin, dieldriny, DDT, HBC and Chlordan (for 10, 20, 30 days /carp fish) increased hemoglobin content and increased PCV, [36]. Synthetic pyrethroid (LC_{50} for 24, 48, 72 and 96 hrs /carp and cat fish), induced swimming behavior was in crock screw pattern and rotating along horizontal axis and followed by "S" jerks sudden rapid and non-directed sport of forward movement likely to be busted swimming Respiratory disruption. Change in color of the gill lamellae from reddish to light brown. Excessive coagulated mucus on gills also accumulated. Hyperactivity, zigzag movement, loss of buoyancy, elevated cough, loss of schooling behavior, swimming near the upper surface (Gasping). Increased mucous secretion, flaring of the gill arches and covers, head shaking and restlessness before death also, induced, [35]. Malathion, with Ham fish, this pesticide induced reduction in ovarian weight, retardation growth of the pre-vitellogenic oocytes (low doses). In high doses: degeneration of the immature oocytes and rupture of the follicular epithelium and disturbance in the endocrine /hormonal imbalance, [37]. Carbofurane at 0.5, 1and 2mg/l in catfish induced degeneration of the follicular walls, connective tissues and vacuolization in the ooplasm of the stage II and III oocytes, [38]. Malathion (1.2 mg/l –catfish) induced changes in ovigerous lamella, clumping of cytoplasm, Degeneration in the follicular cells, Shrinkage of nuclear materials, increased atretic oocytes, and Ruptured follicular epithelium, [39]. Malathion ,catfish (LC_{50} for 96 hour (0.98 ppm) induced adhesion and cytoplasmic retraction in oocyte, Degeneration and increased in the number of the atretic oocytes, Damage to oocytes, Cytoplasmic retraction and clumping of the oocytes . Partial destruction of the ovigerous lamellae and vitellogenic membrane also were occurred, [22]. Diazinon (Organophosphorous compound) with Bluegill fish induced adhesion of the primary follicles, Cytoplasmic retraction in oocyte II, Cytoplasmic degeneration, increased follicular spaces and vacuolated cytoplasm, Extrusion of karyoplasms and necrosis in the cytoplasm, [39]. Endosulfan, catfish induced decreased the activity of citrate synthesis (CS) and G6-PDH in the brain, liver and skeletal muscles of freshwater cat fish, Impairment of metabolism in fish, which appeared to be due to inhibition of transcription [40]. Methyl parathion (1-10 ppm) with Catla fish increase in opercular movement, loss of equilibrium, irregular swimming activity, rapid jerky movement, frequent surfacing, change in body color, increased mucus secretions and 50% mortality, [23]. Dichlorvos (o.65, 0.90 and 1.17 mg/l) with common carp fish induced decrease in Gonad somatic index (GSI), and ovaries showed histopathological disordered, [41]. Pyrethroid at 0.4 µg/l with carp fish fingerlings induced erratic and darting swimming movements, Excess accumulation of ACH in the cholinergic synapses leading to hyperstimulation, and Respiratory distress, [42].

4. EFFECT OF THE THREE MAIN TYPES OF PESTICIDES ON FISH AND SHELLFISH

4.1. Insecticides, in additional to natural pollutants, varied contaminants exist in surface waters including multiple chemical compounds and different products of industrial and agriculture revolution. The insecticides constitute one group of these pollutants, both synthetic and natural, which contribute to the environmental problems. There are many pathways by which insecticides leave their sites of application and distribute throughout the environment and enter the aquatic ecosystem. The major route of insecticides to water ecosystems in urban areas is through, rainfall, runoff and atmospheric deposition. Another source of water contamination by insecticides is from municipal and industrial discharges. Most insecticides ultimately find their way to rivers, lakes and ponds and have been found to be highly toxic to non-target organisms that inhibit natural environments close to agricultural fields, [43]. DDT, was made by the Swiss scientist Paul Muller and for this discovery, he obtained the Nobel Prize for physiology or Medicine in 1948 [44]. The contamination of surface waters by insecticides is known to have ill effects on the growth, survival and reproduction of aquatic animals. Different concentrations of insecticides are present in many types of waste water and numerous studies have found them to be toxic to aquatic organisms, especially fish species, [45]. Fishes are particularly sensitive to the environmental contamination of water. Hence, pollutants such as insecticides may significantly damage certain physiology and biochemical processes that different kinds of insecticides can cause serious impairment to physiological and health status of fishes, [46].

4.1.1. Classifications of Insecticides, the insecticides are classifieds into, Systemic Insecticides are used to treat plants and the insect ingest the insecticide while feeding on the plants. Contact insecticides, is working through direct contact with insects (small droplets such as aerosols) often improves performance, [47]. Natural insecticides, such as nicotine, pyrethrum, and Neem extracts are made by plants as defenses against insect. Plant –incorporated protectants (PIPs) are insecticidal substances produced by plants after genetic modification. Inorganic insecticides are manufactured with metals and include arsenate, copper compounds and fluorine compounds and sulfur, which are commonly used. Organic insecticides are synthetic chemicals that comprise the largest numbers of pesticides available for use today. According to the mode of action how pesticide kills or inactivates a pest is. The following table 3 contains the common groups of insecticides which classified according to their mode of action, [48]. Also, we can use the LC_{50} value in classification of insecticides based on potential toxicity for fish.

Table 4: Another way of classifying insecticides (fish, birds and mammals)

Insecticide	**Mode of action**
Organochlorne	Act on neurons by causing sodium/potassium imbalance and accumulation of acetylcholine at neuromuscular junction (NMJ) causing rapid twitching of voluntary muscles and eventually paralysis (tremors and convulsion)
Organophosphate	Cause ACHE inhibition and accumulation in NMJ, muscle twitching and paralysis.
Organosulfur	Exhibit ovicidal activity
Carbamates	Cause ACHE inhibition causing CNS effects (rapid twitch of voluntary muscles and eventually paralysis) , highly toxic to fish and other aquatic animals
Formamidines	Inhibit the enzyme monoamino- oxidase that degrades neurotransmitters causing an accumulation of these compounds.
Dinotrophenols	Inhibit oxidative phosphorylation , prevent formation of ATP
Organotins	Inhibit phosphorylation at the site of dinitrophenol uncoupling , preventing the formation of ATP , used against mites , very toxic to fish
Pyrethroids	Open the sodium channels in neuronal membrane , affecting both PNS&CNS , causing hyperexitability , causing tremors , incoordination , paralysis , extremely toxic to fish
Spinosyns	Disrupting binding of ACH in nicotinic ACH receptors at the postsynaptic cell
Nicotinoids	Act on CNS cause irreversible block of the post synaptic nicotinergic receptors , very toxic to fish and birds
Pyrazoles	Inhibit mitochondrial electron transport at the NADH-COQ lead to disrupt of DNA, very toxic to oyster and shrimp.
Pyridazinones	Interrupt mitochondrial electron transport , display toxicity to aquatic arthropods and fish
Quinazolines	Acts on larval stage of most insect by inhibiting the synthesis of chitin in the exoskeleton.
Botanicals:	
Pyrethrum	effect on PNS&CNS
Nicotine	mimics ACH in CNS ganglia causing twitching , convulsion and death
Rotenone	act on respiratory enzyme inhibitor
Limonene	effect on sensory nerves of PNS---slightly toxic to fish
Synergists/Activator	Inhibit Cytochrome P-450 dependant polysubstrate monooxygenases preventing the degradation of the toxicants, toxic to fish.
Antibiotic	Blocking the neurotransmitter GABA at the neuromuscular junction
Fungigants	Act as narcotics
Biorational	Grouped as biochemical (hormones , enzymes , pheromones) , Natural agent, such as growth regulators or Microbial (viruses , bacteria , fungi , protozoa and nematodes)
Benzoylureas	Act as growth regulators by interfering chitin synthesis ,very toxic to fish

The Third way to classify insecticides is according to chemical groups. 1st Organochlorides (Aldrin, Chlordane, Chlordecone, DDT, Dieldrin, Endosulfan, TDE, Mirex, Lindan, Heptachlor, Hexaclorobenzine), [49]. 2nd Organophosphates and Carbamates, it is a synthetic insecticide, act on the insect's nervous system, and interferes with ACHE and other cholinesterases, disrupting nerve impulses, killing or disabling the insect. Organophosphate insecticides such as Sarin, Tabun, Soman and VX (are chemical warfare nerve agent), have an accumulative toxic effect to wildlife. Carbamates have shorter duration, less toxic and similar to the others. Other examples of Organophosphates insecticides are Acephate, Azinphos-methyl, Bensulide, Chlorethoxyfos, chlorpyrifos, Chlorpyriphos-methyl and Diazinon, [50]. Meanwhile, the examples of carbamates insecticides are Aldicarb, Bendiocarb, Carbofuran, Carbaryl, Methomyl, Fenoxycarb, Dioxacarb, and Isoprocarb. 3rd Pyrethroids it is a natural compound pyrethrum, another class of pesticides and characterized as non persistent sodium channel modulators, and are much less acutely toxic than organophosphate and carbamate usually applied against household pests, such as Allethrin, Bifenthrin, Cyhalothrin, Cypermethrin, Cyfluthrin, Deltamethrin, Fenvalerate, Permethrin, phenothrin, Parallethrin, [51], [52], [12]. 4th Neonicotinoids are synthetic analogues of the natural nicotine insecticides and nicotinic acetylcholine receptor agonists applied as sprays, drenches, seed, and soil treatment. And they used as alternative to organophosphate and carbamate. The insect treated with Acetamiprid, Clothianidin, Imidacloprid, Nitenpyram, Nithiazine, Thiacloprid, and Thiamethoxam, [53], exhibited leg tremors, rapid wing motion, stylet withdrawal (aphids), disoriented movement, paralysis and death. 5th Ryanoids is a naturally occurring insecticides extracted from Ryania species (Flacourtiaceae). They black nervous system transmission, bind the calcium ion in both skeleton and cardiac muscles .Only one registered belong to this group called Rynaxpyr, and the generic name is chlorantraniliprole. 6th Biological Insecticides are myrosinase exude substance from plants to prevent insects from eating, this is an enzyme and converts glucosinolates to a variety of compounds that are toxic to herbivorous insects. One product of this enzyme is allylisothiocynate, other biological pesticides products based on entomopathogenic fungi (Beaueria bassiana, Metaarthiziumanisopthiae). Another example nematodes such as Steinernema feltinae and viruses (e.g., cydiapomonella graulovirus), [54]. 7th Bacterial Insecticides is toxin which produced by *Bacillus thuringiensis* are used as larvicide against caterpillars, beetles and mosquitoes through use of genetic engineering. 8th Plant derived Insecticides which used as insecticides are *Anabasine, Annonin, Caffeine, Carapa, Cinamona leaf oil, Tetranortriterpenoid, Thymol, Linalool, Derris, Neem, Polyketide, Pyrethrum and Guassia,* [55], [56]. 9th Others compounds which not belong to the above groups such as Boric acid, Borax, Borate and Diatomaceous earth.

4.1.2. Residual effects of Insecticides:

Freshwater fish, Mostugo was reared in aquarium water tank containing about 1 ppm organochlorine of 3 organophosphorous and three carbamate insecticides for about 30 days .The persistence of these insecticides in water and uptake and excretion of insecticides , Malathion is the most unstable in water , and degrade more that 99% for 7 days . Fenitrothion is moderately stable, and degraded 97% for 29 days. Diazinon is the most stable, degrade more than 95% for 6 days. BPMC is moderately stable, and degrade 80% for 32 days. XMC is the most stable, and degraded 45% for 34 days. The uptake of the pesticides by fish, organ phosphorous insecticides was generally higher than carbamates insecticides. Diazinon, Fenitrothion and BPMC, caused deformity in fish with spinal curvature of the back bone, [57].

[58], stated that the residues of organochlorine insecticides in the muscles and gills, fish collected from polluted water. The published works of monitoring pesticides program indicated the presence of organochlorine insecticides in higher levels in comparison to the permissible limits. Sixty four adult fish (Puntius s (12), Channa (24), Wallago attu (12) and Labeo b. (16) of four different species were collected during November 1986 to September 1987 from Mahla water "India" reservoir. Residues of α,ß,y –HCH , aldrin , P.P-DDT and its metabolites (DDE and DDD) in various tissues (muscles , liver , kidney , brain , alimentary canal and gills). As organochlorine insecticides residues have become an intrinsic part of the biological, geological and chemical cycles of the earth and are measurable in water. The highest detectable levels were detected in brain tissues, [59]. Diazinon use has significantly increased since its introduction more than four decades ago. Thus today we are faced with environmental and health consequences that are largely inseparable from the insecticides benefits. Overall, research shows that the Diazinon is globally wide spread, having distributed to all environmental media .Residential uses, and its ubiquity under many farming practices, contribute to extensive non-point-source pollution. Diazinon exhibit as high acute toxicity to a wide variety of animals, leading to a wide range to sublethal biochemical effects, damage to specific target organs and tissues, cytotoxic and genetic effects, reproductive damage and adverse ecological impact, [60].

Organophosphates and carbamate compounds are among the most widely used pesticides. Contamination of surface water by these compounds is concern because of potential toxicity to aquatic organisms, especially those at lower levels. [61], evaluated the persistence of Diazinon, Chlorpyrifos, Malathion, and Carbaryl in waters from various sites in the Newport Bay SanDiego-California (USA) .The persistence of Diazinon and Clorpyrifos was much higher than that marathon or carbaryl and was further prolonged in sea water. In recent times , the extent of the use of pesticides , and their mode of application including their abuse especially in agriculture have been of much concern to environmental scientists . Alongside their uses are also the residual effect of these pesticides and particularly their replicating effect on human health. The presence of four organochlorine pesticides (dichlorophenyl dichloroethylene (2,4-DDE), 4,4-dichlorodiphenyl dichloroethane (4,4-DDE) , P.P-dichlorodiphenyltrichloroethan (PP-DDT) and Propiconazol and four organophosphorous pesticides (Fenitrothion, Clorpyrifos, dichlorovos and Diazinon) were investigated to detected its concentrations in both water and fish (Lagon sample) reared in Lagoons in Ghana. The percentage of pesticides detected was higher than the permissible limit (2.6 mg/l, 0.4 mg/l, and 1.36 mg/l 0.0155 mg/l and o.0088 mg/kg respectively), [62]. [63], stated that Aldrin appears to be less toxic to gold fish than toxophan (20%), but much more toxic than DDT and BHCC (including the Gama isomer) 0.008 ppm, apparently killed all gold fish.

4.1.3. Bioaccumulation of insecticides

After exposure to different concentrations of insecticides in water, the fish absorbs them in its gill, skin or gastrointestinal tract. Due to their lipophilicity, most insecticides easily permeate the biological membranes and it increases the sensitivity of fish to aqueous insecticides .Then, insecticides are rapidly metabolized and extracted and may be bioconcentrated in various tissues of fish. Bio-accumulation occurs if the insecticides increases, it becomes more harmful to the consumer or animals. The accumulated insecticides can cause death or long-term damage due to bio-concentration of these compounds in different tissues of fish, [64]. In addition, since some fish are lower on the food chain, bioaccumulation of insecticides may increase in tissues of their predators and consumers, such as humans and thus affecting their health and survival. So, the bioaccumulation of these contaminants in fish and the potential biomagnifications in human are perceived as threat [65]. Bioaccumulation rate of insecticides in fish depends on the species, life stages, the amount of fat reservation in different tissues and diet of fish, chemical and physical properties of insecticides and the rate of water pollution [66].

4.1.4. Biotransformation of insecticides and the toxic mechanisms

Enzymes participating in the biotransformation of insecticides are classified into phase I and phase II enzymes. The phase I enzymes , cytochrome P-450 enzymes including CYP 1 A and CYP 3 A are generally involved in the biotransformation of exogenous and endogenous compounds, thereby creating a more polar and water soluble compound. A great diversity of cytochrome p450 enzymes in fish has been recognized, and CYP1A, CYP2B, CYP2E1, CYP2K1 and CYP3A have been recently identified in the liver of some freshwater fish, which play an important role in the detoxification of organophosphate and carbamates insecticides, [67]. The common pathways of biotransformation of different kinds of insecticides include three cytochrome p450 (CYP) and mediated reactions: O-dealkylation, hydroxylation, and epoxidation of insecticides [68]. In phase II reactions , metabolites production in phase I detoxification often conjugate with glutathione , uridyl-diphosphate glucose (UDPG) , uridyl-diphosphate-glucoronic acid (UDPGA), amino acid-derivatives and sulfate derivatives and can readily excreted from the fish body [68]. Final metabolites, also, may be excreted from the body of fish through the skin, gills, genital products, urine as sulphated and glucuronidated metabolites and stool as glutathione conjugated metabolites [68]. Since metabolites produced during detoxification process may be more dangerous that potential compounds, these metabolites can cause serious damage in fish. Furthermore, the production of reactive oxygen species (ROS) during detoxification process can induce oxidative damage and may be a mechanism of toxicity for aquatic organisms living in environments receiving insecticides [69]. ROS can indiscriminately attack and react with susceptible vital macromolecules –lipids, proteins and DNA in living cells, inducing cytotoxicity and can result in serious disturbances in physiological cell processes [47], [70]. Lipid peroxidation, the major contributor to the loss of cell function, DNA damage, enzyme inactivation, and hormone oxidation are bioindicators of oxidative cell damage and examples of toxic mechanisms of insecticide induced ROS being involved in pathological process and the etiology of many fish diseases [47].

4.1.5. Acute Toxicity of Insecticides

The acute toxicity of insecticides to fish which mean toxicity rate was determined after 96 hours and this concentration dependent, (slightly toxic with 10-100ppm), (Moderately toxic with 1-10ppm), (Highly toxic with 0.1-1ppm), and (Extremely toxic with Less than 0.1 ppm) [71]. In acute toxicity, sudden, and intense mortality may be observed in fish population exposed to the insecticides. The most apparent symptoms of insecticides in fish are Lethargy, forward extension fins , Pallor or blue part of body , severe reaction to external stimuli , muscle spasms , sudden fast swimming in circles , neurological disorder and disruption of the nervous function , respiratory dysfunction and suffocation [72]. Acute toxicity test is widely used in order to identify the dose or exposure concentration and the time associated with death 50% of the fish exposed to the insecticides (LC_{50} in parts per million ppm) or milligrams per liter (mg/l). We can use the LC_{50} value in classification of insecticides based on potential toxicity for fish. The relative acute toxicity of insecticides to fish can be categorized as mention by [71] in table 5. Different fish species, even from the same family, show differences in the sensitivity to high concentrations of insecticides in water. Acute toxicity of different insecticides is influenced by the age, sex, genetic properties and body size of fish, water quality and physicochemical parameters, and purity and formulation of insecticides.

4.1.6. Sub-Lethal toxicity of insecticides

Sub-lethal toxicity was planned based on one tenth or more LC_{50} dose in moderate periods. In sub-lethal toxicity, the organs or biological systems which may be affected at such exposure can be respiratory, hepatic, hematopoietic, nervous, cardiovascular, and reproductive and immune system. Insecticides lead to changes in the blood biochemical parameters and hematological profile of fish, [78]. Insecticides lead to decrease rate of growth, reproductive disorders. Also, cause spinal deformities and histopathological changes [79] in gills, liver, hematopoietic tissue such as spleen, head of the kidney and renal tubules, endocrine tissues as well as brain, neurological, behavioral disorder and genetic defect are other biological indicators of exposure to insecticides.

Table 5: Acute toxicity of some Insecticides against certain fish species.

Insecticides	Fish species	96hLC50	References
Azodrin	Rainbow trout(RT),bluegill (BG), Channel catfish ,Feathed minnows (FM)	4.9-50 ppm	[20]
Aldrin	FM ,Chinook Salmon, RT ,blue head ,bluegill	2.5-53 ppm	[20]
Carbaryl	Coho salmon , Chinook salmon , RT ,green sunfish , largemouth bass , yellow perch and black crappie	0.9-39 ppm	[20]
Carbofuran	Walked catfish ,Chubs	0.22-23 ppm	[73], [74]
Chlordane	Coho salmon , cutthroat , RT , FM ,Channel catfish	0.72-11.9 ppm	[20]
Chlorpyrilos	Nile tilapia (NT),Bluegill , FM , RT , Gold fish	0.72-11.9 ppm	[75], [76]
DDT	Coho salmon , cutthroat , RT , FM ,Channel catfish	1.5-21.5ppb	[20]
Diazinon	Guppies ,Channa punctatus	0.9-2.6ppm	[20], [71]
Dieldrin	Coho salmon , Chinook salmon , RT ,green sunfish , largemouth bass , yellow perch and black crappie, Cutthroat	1.2-19ppb	[20]
Diflubenzuron	FM,Brook trout , Yellow perch ,RT and Cutthroat	25-240ppm	[20]
Dinitroceresol	RT and bluegill	66-360ppb	[20]
Dioxanthion	Cutthroat , Largemouth bass	22-110ppb	[20]
Disulfoton	Coho salmon , Chinook salmon , RT ,green sunfish , largemouth bass , yellow perch and black crappie, Cutthroat	60-4700ppb	[20]
Fenthion	Coho salmon , Chinook salmon , RT ,green sunfish , largemouth bass , yellow perch and black crappie, Cutthroat	1.1-3.4ppm	[20]
Trichlofon	Eel ,RT ,Cutthroat , Brown trout , bluegill , Large mouth bass	1.1-3.4ppm	[20], [77]

4.1.7. Chronic Toxicity of Insecticides.

Chronic toxicity tests commonly include the measurement of long-term effects of low concentrations of insecticides on survival, growth, reproduction, nervous system and other biological and physiological aspects of fishes. Type of injury to fish in chronic toxicity is similar to sub-lethal toxicity damage, but the frequency and intensity injury and lesions resulting from chronic toxicity may be more or even less than damage of sub-lethal toxicity, therefore, this experiment is important in insecticides toxicology.

4.1.8. Effects of Insecticides on different parameters in Fish.

4.1.8.1. Alterations in blood biochemical parameters, blood biochemistry test gives indicates what is happening in the body of fish exposed to insecticides .When different tissues are injured, the damaged cells release specific enzymes into plasma and we can recognize their abnormality levels in blood. In some cases due to the severity of the damage to tissues, particularly liver, synthesis of many biochemical parameters may reduce significantly in cells, which can decrease some biochemical factors in the blood of some fishes exposed to insecticides as follows: - Cyprinus carpio exposed to Diazinon [45], Oreochromis niloticus exposed to Carbaryl [80], and Oreochromis niloticus exposed to Bifenthrin [81], [82].

4.1.8.2. Tissue and Organ damage, in histopathology, we can provide information about the health and functionality of organs. Tissue injuries and damages in organs can result in the reduced survival, growth and fitness, the low reproductive success or increase of susceptibility to pathological changes. Frequency and intensity of tissue lesions depend on the concentrations of insecticides and the length of the period of fish exposure to the toxins. Many insecticides cause specific or non-specific histopathological damage [83]. For example, histopathological lesions in the liver of freshwater fish (Cirrhinus mrigala) and Common carp (Cyprinus carpio) [84]. Histopathological changes were also noticed due to, exposure to sublethal concentrations (10-30 days) of dichlorvos and diazinon insecticides treated fish [85].

4.1.8.3. Reproductive Dysfunction, any changes in environmental parameters or physiological conditions of fish can affect its reproductive success. Fish may be exposed to environmental pollutants, including insecticides, herbicides, heavy metals and xenobiotics, disorders may occur in their natural reproductive process. Recent researches showed the dysfunction in the reproductive systems of fishes exposed to insecticides. Insecticides effects on reproductive biology of fishes are numerous, and include decreased fecundity, testicular and ovarian histological damage [45]), vitellogenesis process impairement [86] , and disruption in steroidogenesis process , delay in gonads maturation , alter in reproductive and parental behavior , impairment in olfactory response and disorder in reproductive migrations , as well as disruption in coordinating courtship behavior of male and female fish and time of spawning [87]. Some insecticides are known as endocrine disrupting chemicals which can interfere with the normal functioning of endocrine system in fish. Adverse effects of insecticides on the hypothalamus-pituitary gonads axis can also play a significant role in causing reproductive failure in fish. Exposure of fish eggs and milt insecticides also reduced the levels of fertilization, hatching rate and larval survivability. The waste of energy in fish exposed to insecticides residues reduces their reproductive ability [88].

4.1.8.4. Development Disorders, study of development disorders caused by insecticides is to emphasize the links between the concentrations of toxins and dysfunction in normal development from embryonic to puberty periods. Impairment in the normal development and growth may reduce the fish's survival chance. Embryos and larvae may be directly exposed to insecticides, through the yolk or via parentral in viviparous fish [89]. Spinal deformity, mostly scoliosis, lordosis, and morphological abnormalities were also estmeted. Alterations in the embryo of fish are edema of yolk sac and crooked body of larvae [90]. Teratogenic effects of carbaryl insecticides on the embryo of fish have been proved [91]. Decreased fish growth consists of disorder in feeding behaviors, decrease in feeding rate, dysfunction in metabolism process and waste of energy to overcome the stress caused by insecticides exposure. Disorder in the metabolism of carbohydrates, proteins and lipids were recorded [74].

4.1.8.5. Neurotoxicity, The function of organophosphate and carbamate insecticides is inhibit of ACHE or and butyryl cholinesterase (BACHE) as well as disturbing the metabolism of other neurotransmitters such as γ-aminobutrate (GABA). The synthetic pyrethroids change normal neuronal function by interfering in the function of ion channels in the nerve cell membrane, alterations in the intercellular calcium ion concentrations and possibly by blocking GABA receptors. Organochlorine insecticides act primarily by changing in the transport of ions across the nerve cell membranes, thus altering the ability of nerve to stimulate. Fish exposure to these insecticides is frequently assessed by determining the alterations in ACHE in brain, muscle, plasma and other tissues or probably GABA activity in brain [92]. ACHE is an enzyme responsible for inactivation the neurotransmitter acetylcholine. ACHE inactivation results in the accumulation of neurotransmitter acetylcholine in cholinergic synapses, leading to synaptic blockage and disruption of signal transmission [67]. Inhibition of ACHE induces alterations in the swimming behavior, shaking palsy, spasms and other undesirable effects [93]. Disturbances in ACHE activity can also impair feeding, identified ion and avoidance and escaping from predators, spatial orientation of the species, and reproductive behavior. Thus , ACHE inhibition is considered to be a specific biomarker of exposure to organophosphorous and carbamate insecticides like Diazinon , Clorpyrifos , propoxur , isoprocarb [76], [72] .

4.1.8.6. Behavioral alterations, fish that exposed to different types of insecticides showed changes in swimming behavior, feeding activates, predation, competition, reproduction, and species- species social interactions such as aggression [94]. [72], reported similar behavioral responses in common carp and rainbow trout exposed to sub-lethal levels of Diazinon. Most insecticides influence the behavioral patterns of fish by interfering with nervous systems and sensory receptors [94]. And this incident may impair the identification of situation and development of appropriate response by the fish exposed to insecticide. The effect of certain insecticides on the activity of ACHE may lead to decreased mobility of the fish [95].

4.1.8.7. Genotoxicity, genotoxic chemicals such as insecticides have common chemicals and physical properties that enable them interact with genetic materials (damage or DNA inactivation), [96]. The mutation that may result from an interaction between a chemical and genetic material is a heritable change in the cell genotype, and thus the error may be transferred to the daughter cell or the next generation. Carcinogenic and the formation of some tumors in different tissues of fish exposed to insecticides may also caused by genotoxic proprieties of these xenobiotics. Chromosomal damage also involved 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 immunosuppresion [70].

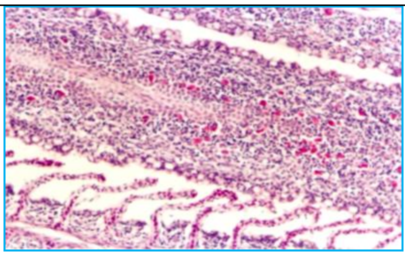
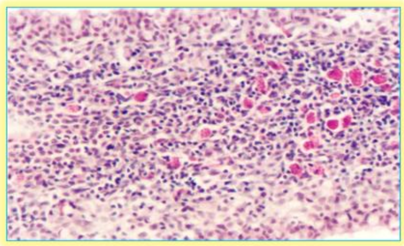
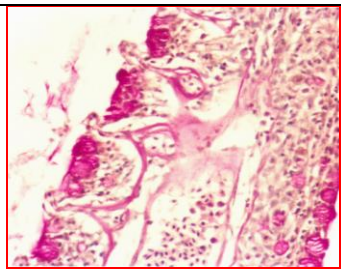
4.1.8.8. Immuno-suppression, insecticides alter the function of the immune system and resulting in immune depression, uncontrolled cell proliferation, and alterations of the host defense mechanisms including innate immunity and acquired immunity against pathogens. The immune system of fish is important for defense against variety of pathogens. Different insecticides at sublethal levels have been recognized as stressors causing immunosuppression in fish [97]. The exposure to sub-lethal concentrations of insecticides is that probably makes fish vulnerable to infectious diseases because of their immune –depressive effect [98].

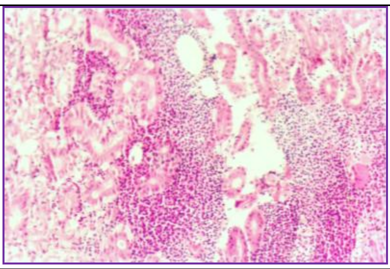
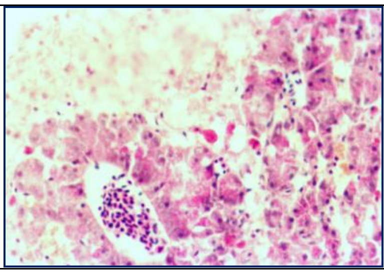
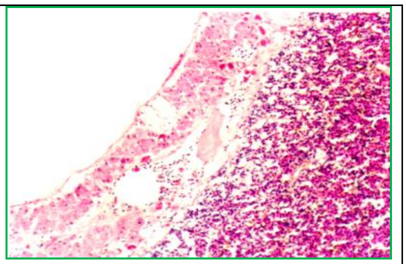
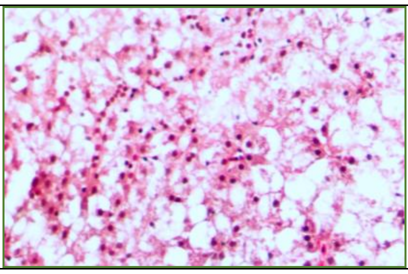
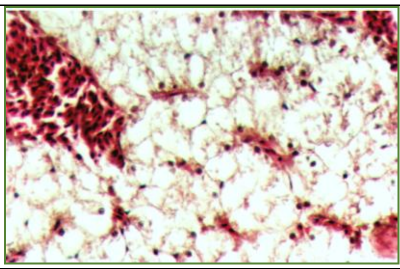
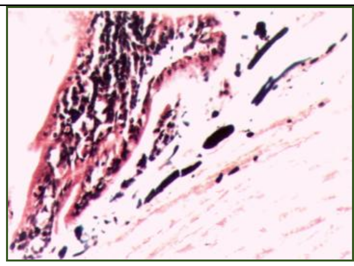
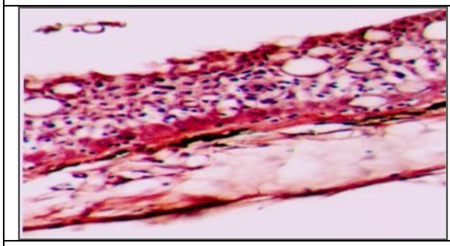
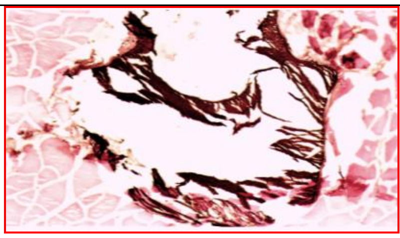
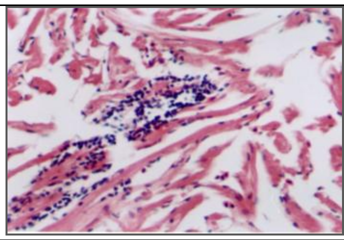
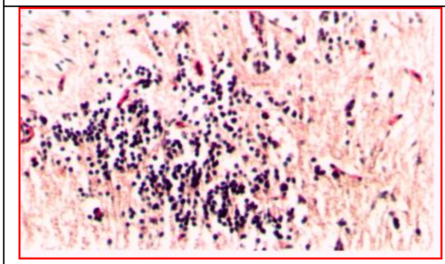
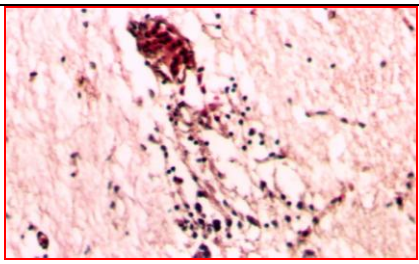
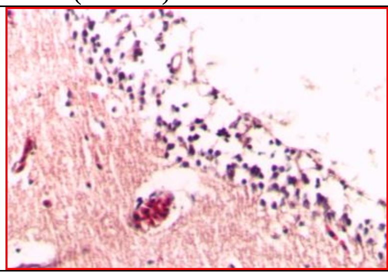
4.1.8.9. Effect on growth of fish, biochemically, the ratio of the RNA/DNA can be used as a bio-indicator measure of body growth. Insecticides toxicity indicates change in nucleic acid biosynthesis. Disturbances in the metabolism of nucleic acid can lead to reduction in the RNA content. The effect of organophosphate on alkaline phosphatase activity in different tissues of fish can also adversely affect nucleic acid synthesis. Dichlorvos causes alterations in DNA replication and chromosomal aberration, which causes mutations and cellular hyper-proliferation. Inhibit enzyme activities involved in DNA replication and repair mutations can affect the final product of gene expression. Cause decreases the level of RNA in protein synthesis [3].

4.1.8.10. Histopathological alteration due to insecticides toxicity, histopathological investigations on different tissues of exposed fish are useful tools for toxicological studies and monitoring water pollution. Tissue alterations in fish exposed to different concentration of insecticides are functional response of organism which provides information on the nature of the toxicant. In histopathology, we can provide information about the health and functionality of organs Tissue injuries and damages in organs can result in reduced survival, growth and fitness, the low reproductive success or increase susceptibility to pathological agents. Reactive oxygen species (ROS) produced during the insecticides detoxification process in liver tissue may react with vital macromolecules such as lipid, protein, protein, carbohydrate and nucleic acid and result in oxidative damage to aquatic organisms [99]. ROS derived damage to natural and structure cellular components are generally considered as serious mechanism involved in the histological disorders [100]. On the other hand, organophosphate insecticides through methylation and phosphorylation of cellular proteins [101] may lead to a reduction in the reconstruction of necrotic tissues. The pathological changes in different tissues such as gills, liver, kidney and spleen of fish treated with different insecticides can disturb homeostasis and lead to physiological disorders in fish. The Histopathological alteration in different organs of Tilapia fish due to insecticides and other contaminants in water were recorded in Figure 2, [102].

4.1.8.10.1. Gills, fish gills have many important functions including: Gas exchanges, transport mono and divalent ions, excretion of waste nitrogen and uptake, and excretion of various xenobiotics [103]. Histopathology of gill is the appropriate bio-indicator to pollution monitoring. One of the lesions most frequent found on the gills of Rainbow trout, Diazinon (0.1 mg/l). Diazinon (0.2 mg/l) causes epithelial hyperplasia of both primary and secondary epithelium RT. Also, noticed Edema, epithelial hyperplasia, mucous cell hyperactivation and fusion of the secondary lamellae. In addition, damage to gill tissue may interfere with gas exchange performance of gill and cause respiratory disorders, ion-regulation and osmoregulation dysfunction and inefficiency of the excretion of waste nitrogen metabolites in exposed fish. Gill histopathology damage was also observed after exposure of mosquito fish to deltamethrin [104], yellow perch and gold fish to oil sands [105]. Yellow perch to naphthenic acid [105], carp to deltamathrin and RT to maneb and carbaryl [106]. DDT,2.0 mg/kg per week for 156 days Congestion , vasculitis and medial necrosis of the blood vessels, mucous coagulated and eosinophilic precipitated in the CVS of the gill filament [107], [108]. 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 swelling and thickening of the gill filament, epithelial liftining of the secondary lamellae from the underlying basement membrane, and fusion of lamellae as well as, complete epithelial cell necrosis and sloughed. Also, caused lamellar hypertrophy, hyperplasia with EGC infiltration.

Figure 2. Histopathological alteration of Tilapia fish organs as affected by insecticides and other contaminants in Water. [102]

		
Gills of Tilapia fish reared in heavy polluted area showing: Lamellar hyperplasia, fusion with extensive eosinophilic granular cells infiltrations .H&E.X.400.	High power of the previous figure showing extensive leukocytic cells infiltration as well as EGC .H&E.X.400.	Gills of Carp fish caught from polluted area showing: Congestion of the CVS, edema, necrosis and hyperactivation of goblet cells .PAS stain, X.400.

		
Kidney of Tilapia niloticus caught from heavy polluted areas showing: Diffuse renal tubular necrosis with diffuse inflammatory cells infiltrations .H&E.X.400.	Liver of tilapia fish collected from a polluted space showing: Diffuse degenerative changes of the hepatocytes, necrosis, congestion (tri) with EGC infiltrations. H&E.X.200	Spleen of tilapia fish reared in polluted areas showing: sub capsular necrosis with EGC infiltrations .H&E.X.200.
		
Liver of carp fish collected from the dirty places showing: Diffuse necrosis and degeneration .H&E.X.400.	Liver of carp fish caught from the polluted areas showing: Diffuse hydropic degeneration and necrosis and congestion .H&E.X.400.	Intestinal villous of the tilapia niloticus collected from the heavily polluted area showing diffuse mycotic colonies infiltration and necrosis .H&E.X.400.
		
Skin of tilapia fish showing : Epidermal hyperplasia and hyperactivation of the goblet cells , dermal melanosis(M) and edema as well as necrosis .H&E.X.400	Dermal calcification and scale sloughing .H&E.X.400.	Heart of tilapia fish in reared polluted areas showing: Diffuse inflammatory cells infiltration in between the myocardial cells (Arrows) .H&E.X.400.
		
Brain of tilapia fish collected from the highly polluted area showing: Diffuse Glial cells infiltrations (Gliosis) .H&E.X.200.	Brain of tilapia fish reared in polluted areas showing: Vasculitis and perivascular edema and lymphocytic cuffing. H&E.X.400.	Brain of tilapia fish Showing: Meningitis (congestion with mononuclear cells infiltrations). H&E.X.200.

4.1.8.10.2. Liver, Silver catfish when treated with (2,4-D)herbicides +Diazinon caused Cloudy swelling, vacuolar and hydropic degeneration as well as necrosis and cytoskeleton disarray, changes in nuclear shape and heterochromatin, intense damages in Diss's space between hepatocytes and sinusoids , increased vacuolization of endothelial cells, morphological derangement and necrosis of the diss spaced, [109], [110], [28]. Carbaryl and Cyfluthrin in /Tilapia nilotica , common carp causing Hypertrophy of the hepatocytes , increase in kuppfer cells and focal necrosis and fatty degeneration, [111], [100], [112].

4.1.8.10.3. Kidney, the kidney of teleost fish is composed of a variety of cell, including parenchymal cells, lymphoid and hematopoietic tissues. The functional unit of the kidney is nephron. Morphologically, the nephron of bony fish includes glomerulous, tubules and collecting duct, [112]. Atlantic salmon /Endosulfan, Diazinon (0.2 mg/l and 0.1 mg/l) record the Degeneration and necrosis of the renal tubular epithelium, necrosis, also showed in the glomerular cells besides, hydropic degeneration of the collecting ducts, hyaline casts inside the tubules and reduced glomerular filtrate also noticed, [114], [36].

4.1.8.10.4. Spleen, the spleen has a fibrous capsule, and small trabeculae extend into the parenchyma, which can be divided into a red and white pulb. When the Common goby exposed to RT / 3, 4 dichloraniline, the important histopathological changes were Hyperactivation of MelanoMacrophage Centers (MMC), excessive hemosiderosis and congestion, [115].

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

4.1.8.10.6. Gonads, decreased in number and condensation of spermatogenic cells and appearance of a large number of intertubular vacuoles, cloudy swelling, spermatocyte necrosis and necrosis of seminepherous tubules are important histopathological alterations observed in tests of fish exposed to Diazinon, [99].

4.2. Herbicides, they are the most commonly used pesticide. They are widely applied to agricultural crops, forest lands, gardens, and lawns. Herbicides often are directly applied to lakes and ponds to control nuisance growth of algae (colonial, filamentous , and single cells) , submersed water grasses (coattail , milfoil , naiad , pondweed), flowering water plants (water lily, spatterdock , duckweed), and emergent water plants (cattails, rushes, reeds). Concerning the effect of this group of pesticides on fish, fish kills may occur after herbicide application, even when the herbicide used is not directly to fish. Fish die indirectly from suffocation, rather than herbicide poisoning, because masses of rotting water weeds by the herbicide decompose, reducing oxygen levels. There are many example discuses the effects, such as, Copper sulfate, Fluridone, Sonar, 2-4-D, Glyphosphate, Rodeo, Diquat, Weedtrine, Endothall, Aquathol, and Hydrothol. Considerations for Application of Herbicides should be considered such as early spring, small weeds, actively growing, less decay, and cool water, [116], [117]. [118] reported that, the fish exposed to sub lethal doses of glyphosate two or more days exhibits moderate liver degeneration and fibrosis. Similarly, despite rebounding of swimming performance, it declines compared to the initial performance and it does not return to normal level after there covery time. Thus, the xenobiotic may have systemic and /or muscular effects resulting in decreased swimming performance. Activity and mRNA expression level of enzymes having rolesin ROS clearance and cellular redox state display significant, although sporadic, changes, perhaps initially as a re sponse to the xenobiotic clearance and then secondarily due to the liver damages.

4.3. Fungicides, fungicides, like herbicides, generally are not as highly toxic to fish and aquatic animals as insecticides. However, some fungicides have been banned due to their adverse effects on the environment. Fungicides containing mercury were discontinued for home and agricultural use in the United States in 1976. Mercurial fungicides accumulated in the environment and concentrated up the food chain, causing fish kills .Some currently –registered fungicides are extremely toxic to fish. Some fungicides are poisoned to beneficial soil invertebrates. Their use should be avoided or carefully managed near aquatic systems [119].

Recently, [120], stated that, through an extensive sampling in the Llobregat River basin, the presence of 50 currently used pesticides belong to the three commonly used insecticides, herbicides, and fungicides in water, sediment, and biota was assessed. Pesticides were detected primarily in water (up to 56% of the analytes), where as their presence in sediments was more intermittent, and in biota was scarce. Those at high concentrations in water were the benzimidazoles (carbendazimin 22% of the samples up to 697 ng L^{-1}), the organophosphorus (malathion in 54% of the samples up to 320 ng L^{-1}), and the ureas (diuron in 54% of the samples up to159 ng L^{-1}). However, this pattern differed in sediments and biota, which were contaminated primarily with organophosphorus (higher Kow) (chlorpyrifos 93% of sediments up to 131 ng g^{-1}). According to the results of this study, pesticide residues in the Llobregat River basin do not seem to represent a high risk to biota, even though some algae and fish can be affected. Nevertheless, the monitoring program can be very useful to control the contamination of the river basin, as the availability of historical data on the basin confirmed background contamination in the last 20 years.

5. CONCLUSION

We can conclude that the long-term exposure of fish to pesticides (including insecticides), means a continuous health hazards for the population. So, human population is at high risk by consuming these toxicated fishes. The rationalization uses of pesticides considered the main factor in reducing aquatic environmental pollution with pesticides and other contaminants. Thus impacts the rest have at least in marine organisms. This reduces an environmental pollutants resulting from these risks to human and wildlife. Also, must take the necessary precautions during the application of pesticides (using the appropriate machines that reduce environmental pollution) to Protection of wildlife and water quality is possible when using pesticides. If pesticides are selected wisely, used in combination with other pest control measure, and applied safely, the pollution of our surface waters and contamination of aquatic life can be avoided .It is likely that approaches using molecular biology techniques will revolutionize toxicological applicants that are cheaper and don't require the use of animals to detect environmental stressors .Matter of great public health significant to regularly monitor the pesticides. Besides foe safe use of this pesticides more experimental work should be performed to determine the concentration and time of exposure that don't induce significant sublethal effects on fish.

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