



Hazardous impacts of chemical Pesticides with special references to edible fishes and their overcoming strategies- A Review

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Abstract

Pesticides are chemicals that are used to control insects by either killing them or preventing them from doing harmful or undesired tasks. The detrimental effects of pesticide pollution on aquatic animal growth, survival, and reproduction are widely acknowledged. Insecticides cause abnormalities in reproduction and a slowdown in growth. Organophosphate, Carbamates, Organochlorine, Pyrethroids, and Nicotinoids are the main chemical classes of insecticides that are typically used. Numerous investigations have demonstrated that different pesticide concentrations present in different types of wastewater pose a risk to aquatic life, especially fish species. Fish are among the aquatic flora and fauna most at danger from pesticide residues that enter the aquatic ecosystem through surface runoff. These leftovers harm the ecological balance and biodiversity of nature by entering non-targeted species through the food chain. Physiological abnormalities, behavioural dysfunctions, histopathological damage, alterations in the haematocrit, and biochemical changes are further biological indicators of pesticide exposure. The primary goal of the study is to decrease the usage of chemical pesticides in agricultural practices as the surface runoff water reaches major water resources, since fish are abundant in proteins and fats, human health depends heavily on them. Even a low dose of Chemical pesticides shows more impact on fishes, which in turn affects human health, hence use of Bio-pesticides paves an alternative way to overcome the ecological challenges.

Keywords: Fish Toxicology, Chemical pesticides, Bio-pesticides, Agro-ecosystem, Bio-remediation, Aquatic-ecosystem.

Introduction

In India, the amount of land used for agriculture has decreased due to rapid industrialization and urbanisation. Farmers use agrochemicals to improve soil health and increase land yield. In order to meet the needs of the expanding population, food production must be increased as a result of population growth. The routine uses of chemical pesticides in the agricultural field to increase the rate of crop production results in the soil pollution which in-turn leads to the aquatic pollution (Shefali *et al.*, 2021). As pesticides are released in the aquatic environment, it leads to imbalance in the aquatic ecosystem. The use of artificial pesticides is facilitated by modern farming techniques which includes Insecticides, herbicide, fungicides etc. (Oerke EC, Dehne HW 2004) (Ralf B *et al.*, 2011). The Aquatic resources and the fisheries such as seas, oceans rivers, pond and stream serves as a very good nutritional supplement for human health benefits (Cornelia Dick-Pfaff 2008). The Majority of Chemical insecticides which are rapidly used in the agricultural practices are organophosphates, Carbamates, pyrethroids, nicotinoids and chlorinated hydrocarbon. The primary cause of water contamination with a high risk of chemical pesticides is intensive agriculture in conjunction with surface runoff and surface drainage, which often occurs after a few weeks of exposure. (M Banaee, 2013). Fish are extremely sensitive to environmental contaminants in water. Unaware customers may have health risks due to these contaminations in the fish, especially women who are pregnant or breastfeeding. (*et al.*, David WC, 2009) (El-Sayed El-Deeb Mehana and Farid Soliman Sabra, 2015). In general In the fields of forestry, agriculture, public health, and veterinary medicine, pesticides are used to control insect pests and prevent plant diseases that are brought on by these pests (Gagnaire *et al.*, 2004; Jain *et al.*, 2005, Mustapha 2008; Neem *et al.*, 2010; Abu- Darwish *et al.*, 2011) (Pallavi Srivastava *et al.*, 2016) Pesticides are Characterized in to various groups Which includes Insecticides, herbicides, rodenticides, nematocides, Molluscicides and fungicide, Which acts as a

Plant growth regulators by controlling the activities of the pests. The most often used pesticides are insecticides, which are used to control insects, fungicides, which are used to control fungus and mycotic infections, and herbicides, which are used to manage weeds. Organo chloride, pyrethroids, triazoles, carbamates, organophosphates, and neonicotinoids make up the majority of chemical pesticides employed (Srivatsava and Singh 2014; Sarba and Mehana 2015). (Pallavi Srivastava *et al.*, 2016). When pesticides are introduced into water bodies at concentrations exceeding allowable limits, it leads to a significant loss of aquatic life while in lower concentration the pollutants gets bio-accumulated and via the food web Pesticides have high harmful effects on fish and other creatures that make up the food chain, according to research on the effects of environmental pollutants on aquatic organisms and how they reach human systems in the subject of aquatic toxicology. Due to bio-accumulation, Disruption of ecological relationship and loss of biodiversity threatens the long-time survival of the fish. (Xie *et al.*, 1996; Morel *et al.*, 1998; Abedi *et al.*, 2013), To ensure safer fish intake, this issue needs to be carefully focused on and treated using alternate, non-toxic sources (Yousaf *et al.*, 2013; Ullah *et al.*, 2014). The primary cause of aquatic life forms' declining survival rates is water pollution, which also contributes to the bio-magnification of non-biodegradable pesticides. Fishes are especially disturbed to any change in the biological or Physico-chemical parameters of water bodies, Hence the Toxic Chemicals released in to the aquatic system will directly target the fishes resulting in the eco-imbalance in the survival rate of the fish species (Caldas *et al.* 1999; Lamai *et al.* 1999; Sayeed *et al.* 2000; Isenring, 2010; Zacharia, 2011).

Effect of Pesticides on Aquatic Ecosystem

To yield more crop Varieties farmers are in need to use highly effective chemical pesticides to protect the crop from various pest infestation and to increase the quality, quantity and productivity of the crops. (Fleeger *et al.*, 2003), (Strak *et al.*,

2004), (USEPA 2004), (Bagchi *et al.*, 2008), (Dias *et al.*, 2020). In spite of all the toxins that run off in to the aquatic ecosystem, Chemical pesticides are a major factor in the direct and indirect hazards that they pose to biological species and humans (Ansara *et al.*, 2012), (Uddin *et al.*, 2013), (Picoet *et al.*, 2020).

Exposure of pesticides in to the Aqua-Ecosystem

There are three major ways by which these harmful chemical pesticides enter in to the biological organism

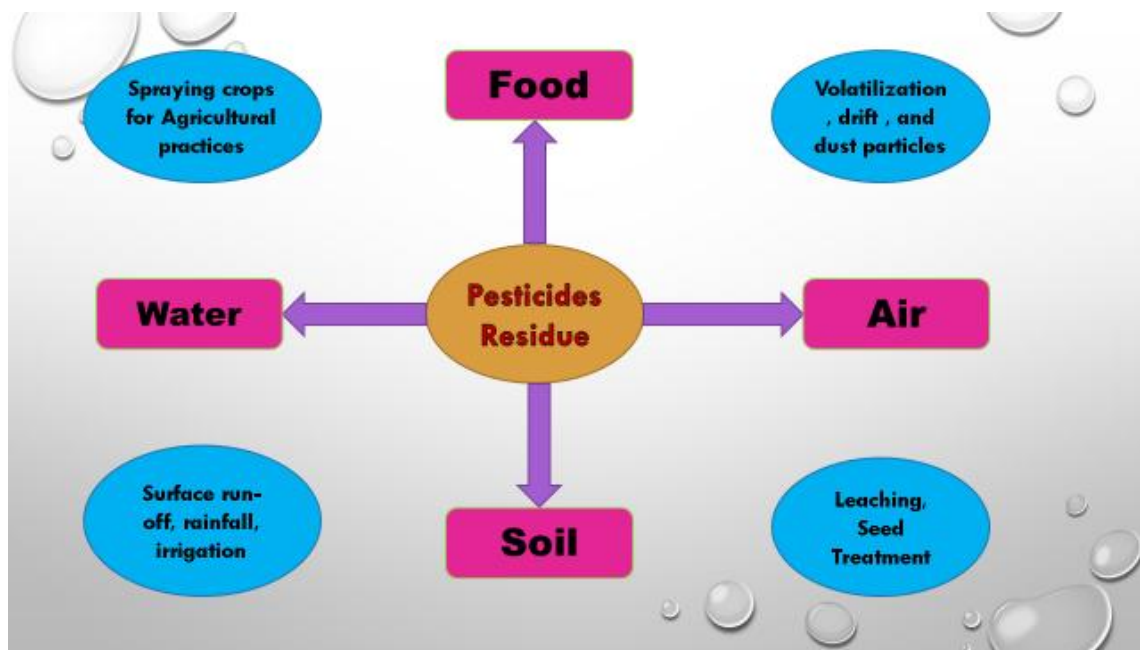
➤ **Through Dermal exposure:** Due to their direct contact with water, aquatic organisms

are susceptible to the damaging effects of pesticides through their skin pores.

➤ **Through inhalation:** As Aquatic organism undergoes the process of respiration through their gills especially fishes, there is a direct inhalation of these chemical pesticides occur rapidly.

➤ **Oral administration:** As Aquatic organism feeds on the insects which has been already treated with the pesticides in the agricultural field, with reference to the food chain, when these chemical pesticides exposed arthropods are eaten by the fishes surviving in the ecosystem, this may cause health issues and even death through the process of Secondary poisoning. (Shefali *et al.*, 2021)

Schematic Diagram for the representation of Residual effect of Chemical pesticides



Pests

Pests is a living organism which may be plant, animal or micro-organisms that shows negative impact on untargeted organisms especially aquatic organism as a primary invasion and human beings

as a secondary invasion. In insects overcome this pest issue in the agro-ecosystem certain chemicals come in to scene which helps to control the pest population by attacking their central nervous system which will not further allow those insects to invade the agro-ecosystem.

Pesticides

Pesticides are defined as any substance or combination of substances meant to prevent, destroy, or control any pests, including disease-carrying insects, unwanted plant or animal species, and anything that could harm or interfere with food production, processing, storage, transportation, or marketing. This definition is provided by the Food and Agricultural Organization. Pesticides may be bio-degradable or persistent. Pesticides have a crucial role in altering the natural fertility in the soil, damaging species and hampering pollinators which has a high cost on Indian agriculture. The pesticide industry has expanded over time, mostly in the name of the so-called Green Revolution, in tandem with chemical fertilisers and high-yield hybrids that are vulnerable to various pesticidal attacks.

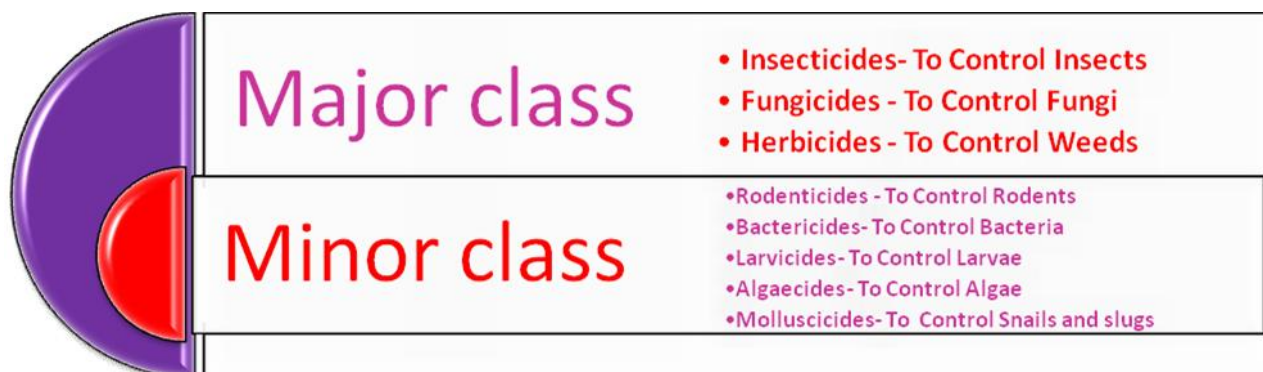
History of Pesticides:

Pest management is one of the important strategies in agriculture. Since the beginning of agriculture, pesticides were used to prevent the crop loss. 4500 years ago, Sumerians employed substances derived from sulfur to manage mites and insects. Pyrethrum, an insecticide derived from dried *Chrysanthemum cinerariaefolium* flowers, was initially employed more than 2,000 years ago. Water from the sea or salt has been used to control weeds. From ancient times, the seeds were covered with different animal, vegetable and mineral products and found to be effective in protecting against various insects.

Olive oil was used as a pesticide and sprayed on grapes and other fruits to control the insect named Wasp (Smith & Secoy, 1975). In China, Mercury was used as a powerful pesticide. Up to the 1940s, most pest control methods relied on organic compounds taken from natural sources or inorganic substances like sulfuric acid and sodium chlorate (Bernardes *et al.*, 2015). During the world war II, the need for the food production was increased which escalates the development of various pesticides. Because of this, the 1940s witnessed a dramatic rise in the use of synthetic pesticides such as 2,4-D, aldrin, dieldrin, endrin, parathion, and Dichloro-Diphenyl-Trichloroethane (DDT). During the 1950s, there was a positive perception of the use of pesticides in agriculture, with little thought given to the potential harm these chemicals could pose to human health and the environment (Unsworth 2010). India began producing pesticides in Calcutta in 1952, and as of right now, it ranks second in Asia and 12th in the world for pesticide manufacturing (Mathur & Tannan, 1995). India's production of technical grade pesticides rose gradually over the years, from 5,000 metric tonnes in 1958 to 102,240 metric tonnes in 1998. According to Aktar *et al.* (2009), the demand for pesticides was projected to reach approximately Rs. 22 billion (USD 0.5 billion) in 1996–1997, or 2% of the global market.

Pesticides – Classification

Based on the mode of action Chemical pesticides can be classified as major and minor classes.



Insecticides

Various insect pests cause damages to the agro-ecosystem by burrowing of leaves, stems, roots and fruits (Prem Rajak *et al.*, 2023) Insecticides are considered to be the group of Chemical agent which encounters the insects which aids in the destruction of crops There are many ways by which they enter the aquatic system from the agricultural system. These pollutants can be harm to the water bodies by disturbing the physiological and biochemical pathways and leads to the serious health issues in fishes. In Agro-ecosystem Insecticides are meant to attack insects which cause crop damage by affecting their nervous system and restrict their further development (Shefali *et al.*, 2021). Some of the pesticides includes. Chloropyrifos, Phosphide, Parathion, malathion, cryolite, and DDT (Dichlorodiphenyltrichloroethane).

Fungicides

Fungicides are Chemical or biological agents helps to prevent and control the growth of fungi on the Agro-Ecosystem and in the presence of air they can easily degradable in the soil. The direct contact of fungi to the plants in the soil media may be parasitic or mutualistic. The plant tissues get destroyed by the harmful toxins produced by the fungi, these Factors are responsible for Spoilage of stored food grains and food materials. Most commonly used fungicides includes Mancozeb, Ethylene-di-bromide, Parathion, Phosphide, mefenoxam, sulfur (Bever *et al.*, 2012) (Prem Rajak *et al.*, 2023)

Herbicides

Herbs are Small unwanted plants which has no economic benefit and it may also be harmful to the neighboring plants which has economic values. Herbicides are substances or certain chemicals designed to Eliminate or to deforest the unwanted plants in an agro-ecosystem, these unwanted plants are said to be weeds. Herbicides can be selective(Specific types of weeds) or non-selective (Wide range of plants). Herbicides will collapse the pathway which is responsible for the

growth and development (Shikimic pathway) and thus inactivation of these enzymes leads the herbs to become yellow and over in a period of time. (Tiwari *et al.*, 2019) (Prem Rajak *et al.*, 2023). Some of the commonly used herbicides are Triazines, Acetanylides, Glyphosate-based chemicals, and Chlorophenoxy substances.

Rodenticides

Rodents are Vertebrate pests that causes direct or indirect damage to growth of crops and stored grains all over the world. (Hoddle, 1999). Rodenticides are Chemical Substances which aids in management of rodent population (Rats and mice). This is applicable in agricultural field,home, and in places where rat population is higher. Rodenticides falls under various categories which includes Anticoagulants, Acute toxicants and non-toxic agents. Precaution should be followed when rodenticides are used to kill the target species, as it may also affect non target-species and also leads in the environment imbalance. Generally used rodenticides are Bromo diolone, Difenacoum and warfarin. (Gabriel *et al.*, 2012).

Algaecides

Algaecides are substances that are used in lakes, ponds, swimming pools, and water treatment plants to inhibit or stop the growth of algae. They function by preventing algae from growing or by killing them. Algaecides are substances that are used in lakes, ponds, swimming pools, and water treatment plants to inhibit or stop the growth of algae. They function by preventing algae from growing or by killing them. Some of the Algaecides are Copper based Algaecides, Quarternary Ammonium Compounds, Peroxygen Compounds and Chelated Copper compounds.

Molluscicides

Molluscs includes snails and slugs more vulnerable In no tillage agricultural system as it feeds on various host plants which includes oats, barley, Syabeab, tobacco (Barua *et al.*, 2021). These pests can feed on by radulal scrapping of

stem, roots, flowers and leaves. Some of the commonly used molluscicides are Metaldehyde, methiocarb, iron phosphate and Ammonium sulfate (Prem rajak *et al.*, 2023).

Bactericides

Agents or chemicals that have the ability to either kill or stop the growth of bacteria are known as bactericides. These can include different compounds, antibiotics, or other substances that are made expressly to target and destroy bacteria in order to help control infections or stop the spread of dangerous bacteria. Bactericides are employed in a variety of contexts, in agriculture, Chemicals that attack the bacteria that cause plant illnesses.

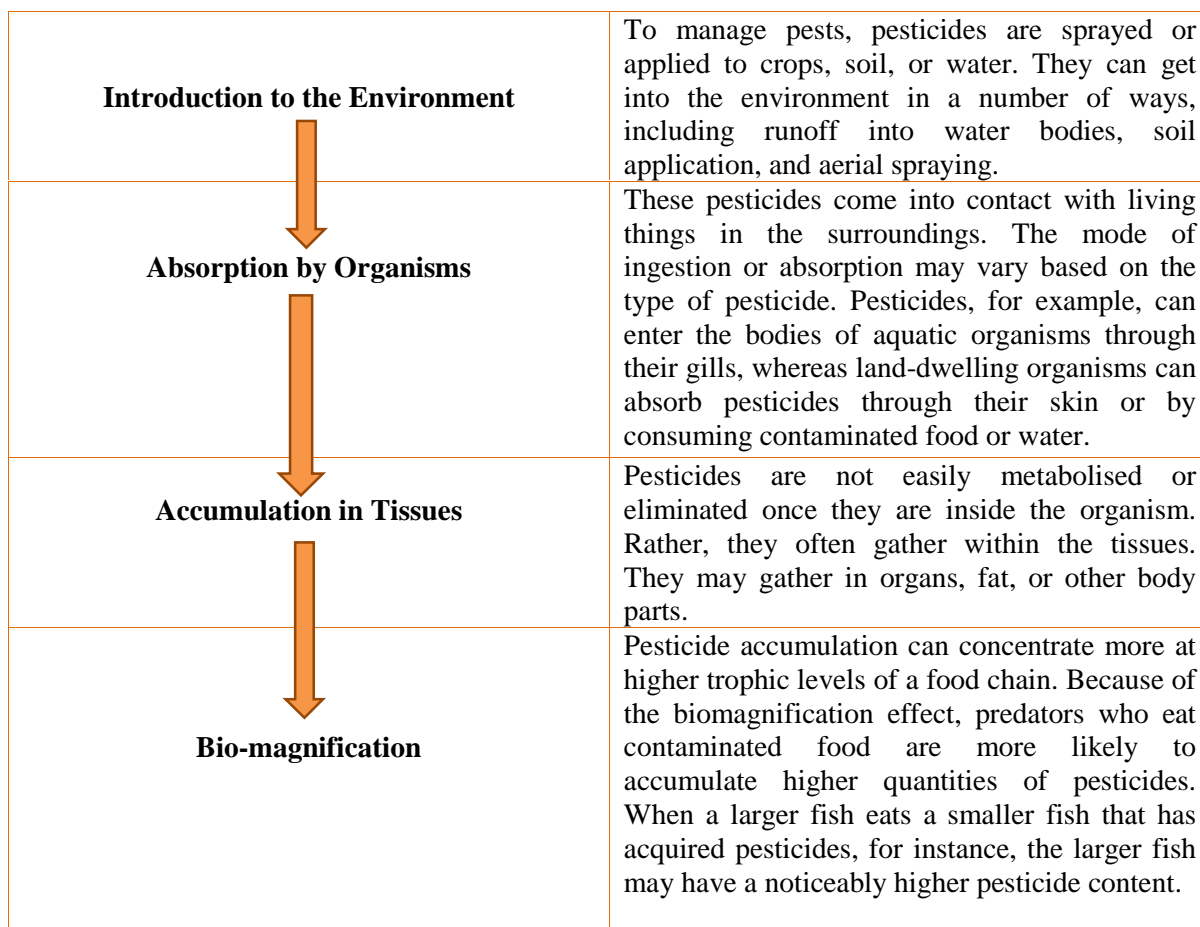
Larvicides

A specialised kind of insecticide called a larvicide is made especially to target and destroy insects in their larval stage, especially mosquitoes. By concentrating on the larvae of mosquitoes in standing water, these chemicals are used to

suppress the number of mosquitoes and stop them from maturing into biting adults. Larvicides are applied to places of stagnant water, such as ponds, puddles, and containers, where mosquitoes lay their eggs. They are available in several forms, such as liquids, pellets, or granules. Programmes to control mosquitoes and prevent the spread of diseases including dengue fever, malaria, and the Zika virus must include the use of larvicides.

Bio-Accumulation of pesticides

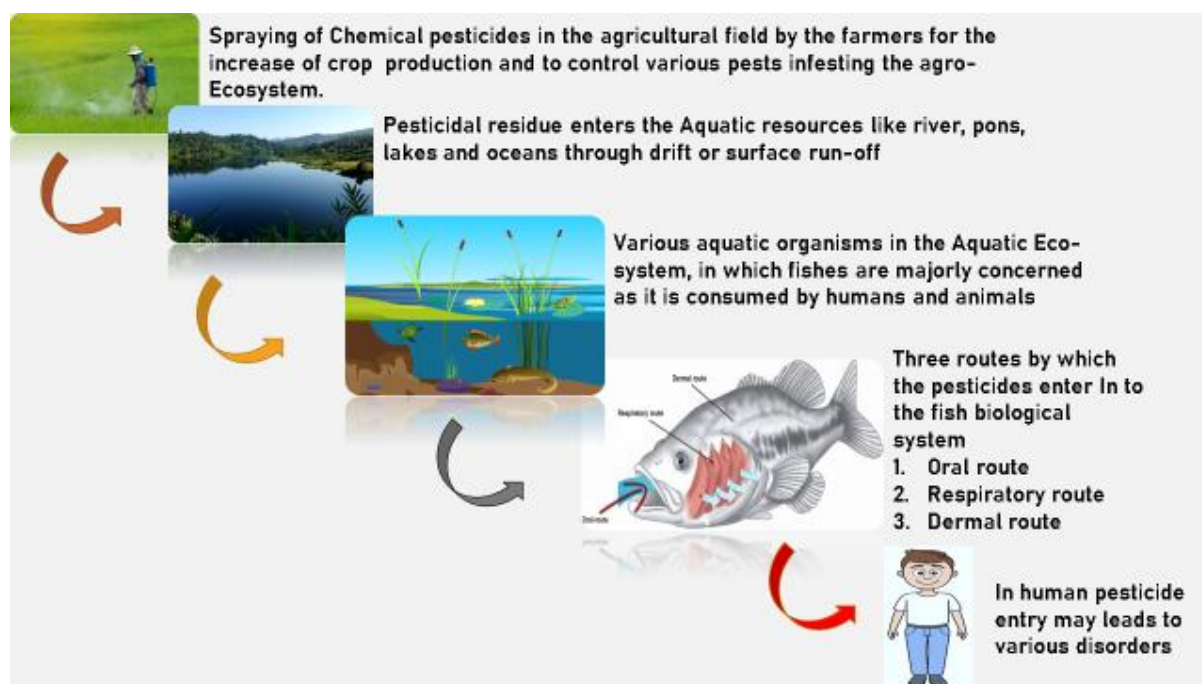
Chemical pesticide bioaccumulation is the term used to describe the process by which some hazardous compounds, such as pesticides, gradually build up in living things. Chemicals known as pesticides are used to eradicate or manage pests, including weeds, fungi, rodents, and insects. These pesticides have the ability to linger and accumulate in the tissues of living things after being released into the environment. The following actions lead to the bioaccumulation process:



Fishes intake the exposed concentration of chemical pesticides in aquatic system through their skin, gills or gastro-intestinal tract. As soon as these pesticides enter the fish biological system they start to undergo metabolism and gets concentrated in various tissues of the fish. (Ballesteros *et al.*, 2011). As fishes are considered to be lipophilic in nature most of the chemical

pesticides may permeable through their membranes. Bio-accumulation takes place when these pesticide concentrated fishes (Primary consumers) are consumed by the secondary consumer (human or higher animals), these pesticides is again bio-transformed to another biological system, hence it is harmful and can cause cellular damage or death.

Schematic Diagram for the representation of bio-accumulation of Chemical pesticides from the Agro-Ecosystem to the Human Biological system



In an effort to reduce the hazards related to bioaccumulation, regulations and best practises for the use of pesticides are being developed, along with less lasting and more targeted pesticide chemicals. For a better understanding and management of these dangers, monitoring and study into the impacts of these chemicals on ecosystems and human health are also essential. The ecosystem and living things are at risk from this process in a number of ways, including:

Ecological Impacts: Pesticides can cause harm to species that are not their intended targets, upsetting ecosystems and causing beneficial organism populations, such as birds, fish, and pollinators, to drop.

Health hazards: When pesticides build up in an organism's tissues, especially in higher-level predators or in species that people eat, there may be health hazards. Extended exposure to these substances may result in a number of health problems.

Bio-degradable or Non-biodegradable nature of pesticides

Pesticides that can be broken down by certain micro-organisms or living organisms in to harmless compounds, these are considered to be bio-degradable pesticides which will not percolate in to the soil rapidly, but in other hand pesticides with take months or years to break down will still persist in the soil biota and will sustain in the soil,

thus enter the aquatic Eco-system through surface run-off of water from the agro-ecosystem to the Aquatic ecosystem.

Chemical pesticides are classified as biodegradable or non-biodegradable according to how easily they disintegrate and degrade in the environment.

❖ **Bio-degradable pesticides:** Certain chemical pesticides have the ability to decompose naturally over time, a process known as biodegradation. Bacteria, fungus, and other microorganisms aid in the breakdown of these chemicals into less toxic and simpler forms. Pesticides that are biodegradable typically decompose more quickly and have a lower potential to have long-term negative effects on the environment. However, depending on the particular chemical compounds involved and the surrounding conditions, the rate of degradation can change.

❖ **Non-Biodegradable Pesticides:** These pesticides persist in the environment for long stretches of time and are difficult for the environment to break down. These pesticides have the ability to linger in water, soil, and even in the tissues of living things, which can contaminate the environment over time. Because of their protracted presence and potential for bioaccumulation, several of these compounds have the ability to accumulate in the food chain and pose a serious hazard to ecosystems and human health.

Factors affecting Bio-degradability

It's crucial to remember that a pesticide's capacity to degrade naturally is dependent on a number of variables, including as its precise chemical makeup, the surrounding environment, and the existence of organisms that can break down the compounds. In order to evaluate their effects on the environment and their biodegradability, many contemporary pesticides go through extensive testing. This process results in the creation and application of chemicals with lower environmental dangers and reduced persistence.

Nonetheless, despite being prohibited in many nations due to their harmful effects, some persistent organic pollutants (POPs), such as several organochlorine insecticides (like DDT), are notorious for their long-term persistence in the environment.

Efforts are underway to transition pest management practises away from conventional chemical pesticides and towards more ecologically friendly and biodegradable alternatives. The creation and marketing of organic or bio-based insecticides, along with integrated pest management techniques that reduce dependency on potentially hazardous chemical remedies, are examples of this.

Direct effect of pesticides

Fish undergoes direct exposure of Different types of pesticides (Rao and Pillala 2001). Different ways of toxicity may occur in fishes which includes changes in the behavior of the fish, histopathological changes, hematological changes, Alteration in the enzymes, Genotoxicity, Bio-chemical changes, Endocrine disruption, Disturbance in the Acetylcholine esterase activity, Changes in the oxygen consumption viz.,(Sana Ullah and Mohammad Jalil Zorriehzahra 2014).

Although pesticides are useful in reducing pest populations and raising agricultural yields, they can also directly affect people, pets, and the environment. Among the immediate consequences are:

1. Human Health Issues: Humans who are exposed to pesticides may experience both short-term and long-term health issues. Skin and eye discomfort, lightheadedness, nausea, and vomiting are examples of acute consequences. Prolonged exposure has been connected to more serious diseases such endocrine disruption, cancer, reproductive disorders, and neurological disorders.

2. Effect on Wildlife: Beneficial insects, fish, and birds are among the non-target creatures that pesticides can destroy. Neonicotinoids, for instance, have been linked to a decrease in bee populations, which has an impact on pollination and the general health of ecosystems.

3. Soil Contamination: Pesticides have the ability to seep into the soil and affect the condition of the soil over time. This may upset the delicate balance of nutrients and microbes needed for plant growth, reducing soil fertility and harming the ecosystem as a whole.

4. Water Pollution: Groundwater, rivers, and lakes in the area may get contaminated by runoff from pesticide-treated agricultural areas. In addition to endangering aquatic life, this pollution may have an impact on human drinking water quality.

5. Pesticide Residue in Food: After crops are harvested, pesticide residues may still be present. Over time, ingestion of these residues by consumers may pose health problems if they become entangled in the food chain due to improper management.

6. Resistance Development: Overuse and continuous application of pesticides can cause pests to become resistant to them, eventually rendering the pesticides less effective. This keeps up a loop of increasing chemical use by necessitating bigger doses or stronger drugs.

Regulatory agencies and agricultural practices are developing and promoting more sustainable and ecologically friendly pest control techniques, like integrated pest management (IPM), which tries to reduce the use of pesticides and use a variety of pest control strategies, in an effort to lessen these direct effects.

Indirect effect of pesticides

In Aquatic Bodies pesticides aids in reducing the food organisms and affects the survival of the fish by disrupting the Aqua ecosystem (Helfrich 2009), Because of this it indirectly interferes the

supply of fish food and there is a drastic change in the Aquatic habitat. (Maskaoui *et al.*, 2005; Chau, 2005).

Chemical pesticide use can affect ecosystems, the environment, and even human health in a number of indirect ways. Among these unintended consequences are:

1. Damage to Non-Target Species: Chemical pesticides are meant to get rid of particular pests, but they can also damage organisms that are not intended targets. They may have an impact on birds, other wildlife, and beneficial insects. For instance, pollination and general biodiversity are greatly impacted by the fall in bee populations brought on by pesticide use.

2. Residue Accumulation: The environment may contain pesticide residues for a long time. They can build up in water, soil, and even the food chain, which can have long-term consequences for ecosystems. Humans and animals may consume these leftovers, raising health risks.

3. Resistance Development: Over time, pests may become resistant to pesticides, necessitating the application of more pesticides or the creation of stronger, possibly more hazardous chemicals.

4. Ecosystem Disruption: By altering predator-prey dynamics and species balance, pesticides can cause havoc in natural ecosystems. The eradication or reduction of a species' number can lead to imbalances and affect the overall functioning of the ecosystem.

5. Water and Soil Contamination: Pesticide-treated agricultural runoff can contaminate water sources, resulting in water pollution. Additionally, these substances have the ability to seep into the soil, altering its quality and possibly endangering creatures that aren't intended targets but rely on the soil for survival.

6. Human Health Concerns: Farmworkers, the communities around them, and consumers may be at risk for health problems due to pesticide exposure. Health problems can vary from acute

poisoning to chronic conditions like cancer, infertility, and neurological damage.

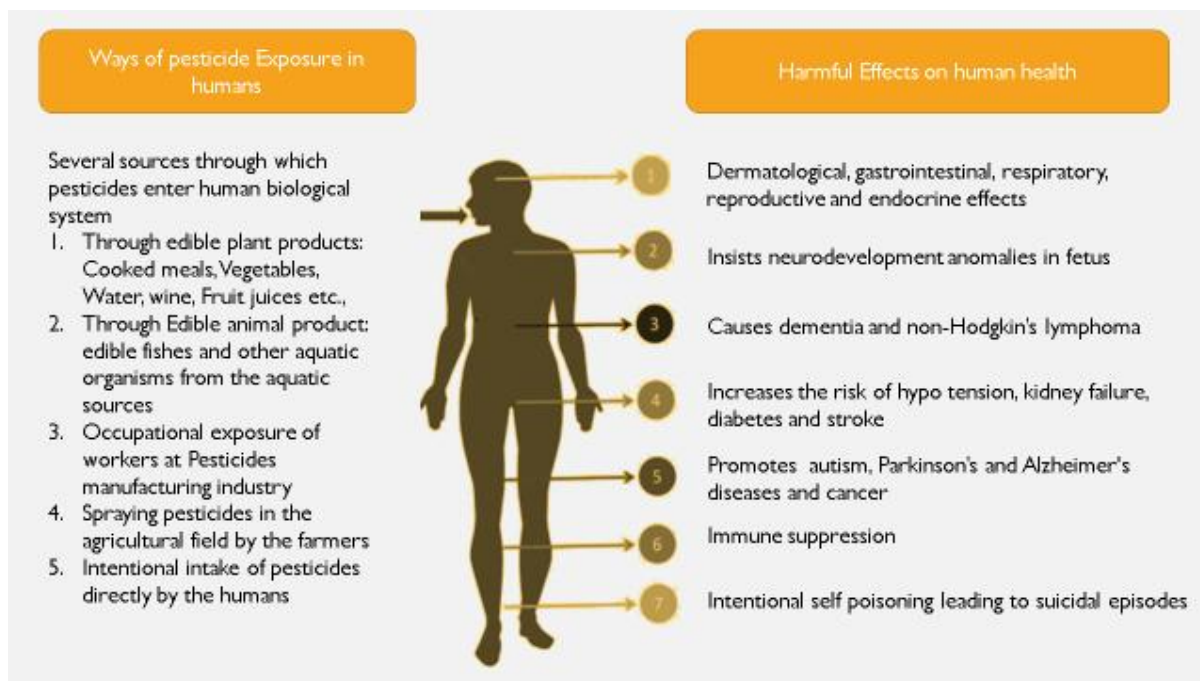
7. Loss of Biodiversity: The use of pesticides carelessly might result in a decrease in biodiversity. This loss upsets the natural balance and might have a domino effect down the food chain on not just the target pests but also other creatures in the ecosystem.

8. Economic Impact: Although excessive use of pesticides can lower soil quality, raise insect resistance, and eventually force farmers to turn to more powerful and costly chemicals, they can initially boost agricultural productivity. Farmers

may experience long-term financial effects from this.

Integrated pest management (IPM) techniques have been pushed in an effort to lessen these collateral consequences. IPM uses a variety of strategies, including crop rotation, biological management, and cautious pesticide application, to effectively manage pests while minimising negative environmental effects. In an effort to lessen the overall impact on ecosystems and human health, research is also being done on the creation and application of less toxic or more targeted pesticides.

Diagrammatic representation of Health hazards of chemical pesticides to humans



Effect of Chemical Pesticides on Human health:

By directly contaminating water supplies or by chain pollution, toxicants like pesticides severely damage the Ganga River's water quality and have a detrimental effect on human health. Direct exposure to these dangerous pollutants occurs when fish and irrigated crops are close to areas with contaminated water. According to Mitra et al. (2012) and Sudhakar (2014), eating

contaminated fish causes bioaccumulation and enlargement at all trophic levels.

Eating polluted fish from Ganga water can occasionally put people's health at risk for non-cancerous diseases. When the reference dose was established, very few agencies calculated the risk of this hazard (USEPA 1992, 2017). A chemical's reference dosage is the one daily intake rate that, when taken over an extended lifespan, does not seem to be harmful (USEPA 1991).

Chemicals known as pesticides are used to kill, repel, or manage pests that can harm crops, spread illness, or cause annoyances. Although they work well to preserve crops, depending on the type and degree of exposure, pesticides can have a variety of negative impacts on human health, some of which may be acute while others may be chronic. The following are a few possible impacts on human health:

1. Acute Poisoning: Immediate poisoning can result from direct, brief exposure to large quantities of pesticides. From mild side effects like headaches, nausea, vomiting, and irritated skin and eyes to more serious ones like breathing difficulties, convulsions, and even death, symptoms can vary widely.

2. Long-term Health Effects: Prolonged, chronic exposure to low pesticide levels has been connected to a number of health problems, such as:

-) Cancer: A number of pesticides are either known to be carcinogenic or may be in the future. Cancer risk may rise with prolonged exposure to certain drugs.
-) Reproductive Problems: Pesticides may have a negative impact on both men's and women's reproductive systems, as well as fertility. Miscarriages, birth abnormalities, and problems with a child's development could result from them.
-) Neurological Effects: In severe circumstances, pesticides can cause neurodegenerative diseases like Parkinson's disease in addition to symptoms including headaches, vertigo, tremors, and other neurological illnesses.
-) Issues with the Respiratory System: Extended exposure to some pesticides can cause asthma attacks and other breathing problems.
-) Endocrine Disruption: Pesticides may cause hormonal imbalances and associated health issues by interfering with the endocrine system.

3. Vulnerable Populations: Those with weakened immune systems, children, pregnant women, and the elderly are especially vulnerable to the health concerns posed by pesticides.

4. Environmental influence: Pesticides can also have a negative influence on the quality of the air, water, and soil. This can have an indirect negative effect on human health by contaminating food and water sources.

To reduce these health hazards, regulatory authorities have set limitations and standards for the use of pesticides in many different nations. The hazards connected with the use of pesticides can be decreased by using, managing, and storing them properly as well as by following safety precautions and instructions. Furthermore, the goal of promoting and implementing integrated pest management (IPM) and organic agricultural techniques is to reduce the use of pesticides and their possible negative effects on the environment and public health.

Advantages of pesticides

1. A rise in agricultural output: Pesticides shield crops against weeds, illnesses, and pests. A more steady and dependable supply of food is ensured by this protection, which raises crop yields and improves produce quality.

2. Pest management: By efficiently managing and controlling pests that can seriously harm crops, pesticides help farmers avoid financial losses and maintain food security.

3. Disease prevention: By halting the transmission of illnesses brought on by pests or insects, pesticides can protect human health as well as agricultural produce from harm. For instance, limiting mosquito populations aids in the prevention of the spread of illnesses like dengue, zika, and malaria.

4. Cost-effectiveness: utilizing pesticides can frequently be less expensive than utilizing other means of pest management. They may be applied more swiftly and easily, and they frequently need less labor.

5. Preservation of stored goods: By keeping pests from invading during storage and lowering post-harvest losses, pesticides help preserve grains and other produce that is stored.

6. Improved public health: By reducing the spread of disease, pesticides are essential to public health. For example, they aid in the management of disease-carrying insects such as mosquitoes, therefore minimizing the spread of infections.

7. Greater food availability: Pesticides help to increase food availability by shielding crops from illnesses and pests, meeting the demands of an expanding world population.

Disadvantages of pesticides

1. Environmental Pollution: The air, soil, and water can all be contaminated by pesticides. Pesticides from crops can enter adjacent water bodies by runoff, contaminating the water. Ecosystems may be disrupted and aquatic life harmed by this contamination.

2. Health Risks: Human health can be jeopardized by pesticides. Extended exposure or inappropriate handling can result in a number of health problems, such as respiratory disorders, skin irritations, and in more extreme situations, neurological disorders or cancer. Those who live close to agricultural areas, farmworkers, and farmers are especially vulnerable.

3. Effect on Non-Target Organisms: Pesticides can damage beneficial insects, birds, and other species because they are not specific to the pests they are meant to eradicate. They may have an

impact on insects that are essential to the health of ecosystems, such as bees, who are pollinators.

4. Resistance Development: Over time, pests may become resistant to insecticides. When a pesticide is used repeatedly, it can produce pest strains that are resistant to the chemical's effects. This creates a vicious loop of increasing chemical usage by necessitating stronger or more frequent treatments.

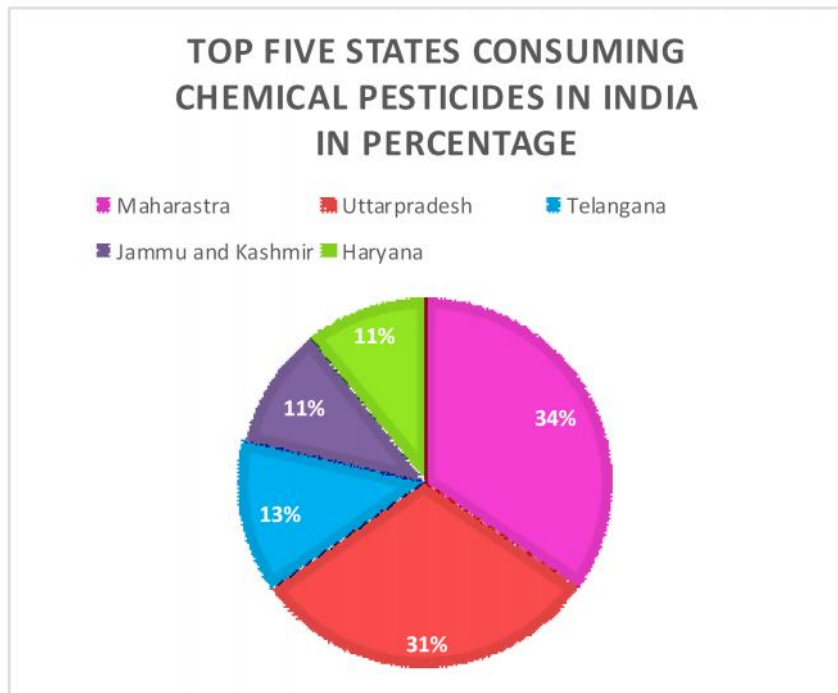
5. Disruption of Ecosystem Balance: By eradicating particular species, pesticides can upset the ecosystems' natural equilibrium and send a ripple effect up the food chain. This disturbance may cause predator-prey relationships to become unbalanced, which would then have an impact on the ecosystem as a whole.

6. Persistence and Accumulation: Certain pesticides can linger in the environment for extended periods of time, causing them to build up in water, soil, and even living things' tissues. The ecosystem and living things may be impacted in the long run by this buildup.

7. Food Contamination: Fruits, vegetables, and other crops may harbor pesticide residue. Pesticide residues on food are subject to restrictions set by regulatory agencies; yet, continuous exposure to or ingestion of these residues, particularly at higher amounts, can be harmful to one's health.

8. Financial Costs: Although treating pests with pesticides can boost crop yields, abuse or misuse can lead to decreasing benefits. Furthermore, farmers may find it difficult to pay for the expenses of pesticides, application tools, and possible environmental or health cleanup.

Pie chart for Top Five States Consuming Chemical pesticides in India and their percentage of usage



Top 5 States Consuming Chemical Pesticides in India in metric tonnes

1. Maharashtra-13,175 metric tonnes
2. Uttar Pradesh- 11,688 metric tonnes
3. Telangana-5090 metric tonnes
4. Jammu&Kashmir-4086 metric tonnes
5. Haryana-4066 metric tonnes

Pesticides Remediation Technology

The goal of pesticide remediation technology is to lessen or eliminate pesticides from the air, water, and soil. Pesticide cleanup uses a variety of techniques and technologies, some of which are as follows:

- 1. Bioremediation:** This technique breaks down or neutralizes pesticides using microorganisms such as bacteria, fungi, or plants. Pesticides can be broken down by microorganisms into less toxic compounds. Additionally, phytoremediation—the use of plants having the capacity to absorb and accumulate pesticides—is employed.
- 2. Chemical Remediation:** This technique uses chemical reactions to degrade pesticides. For example, advanced oxidation processes (AOPs) break down and convert pesticides into less harmful molecules by use of chemical reactions that produce hydroxyl radicals.
- 3. Soil Vapor Extraction (SVE):** Using this technique, volatile pesticides are drawn out of the soil. It functions by creating a vacuum in the soil, which aids in the extraction of volatile substances.
- 4. Soil Washing:** This technique includes washing the contaminated soil with particular

solutions or solvents to extract or dissolve the pesticides in order to remove them from the soil.

- 5. Activated Carbon Filtration:** Because activated carbon filters can absorb and eliminate pesticide residues, they are used to remediate contaminated water.
- 6. Phyto remediation:** Using particular plants to absorb, gather, or break down chemicals in the soil is known as phytoremediation. Certain plants may absorb or degrade these substances, which helps with the cleanup procedure.
- 7. Electrokinetic Soil Processing:** Using an electric field to drive charged soil particles toward an electrode facilitates the removal of pesticides from the soil.
- 8. Nanotechnology:** The use of nanomaterials in pesticide cleanup is being investigated. The effectiveness of pesticide adsorption and breakdown can be improved by nanoparticles.
- 9. Bioaugmentation:** To accelerate the breakdown of pesticides, some microorganisms are introduced into the contaminated environment.

The type of pesticide, its concentration, the surrounding conditions, and the viability of the cleanup project all play a role in the remediation method selection. Effective pesticide cleanup can be accomplished by utilizing a variety of approaches, either separately or in tandem. The choice of effective remediation techniques is also heavily influenced by environmental factors and regulatory requirements.

Bio-pesticides

The pesticides which are the derivatives of natural resources such as bacteria plants and animals which has an ability to play a role of chemical pesticides and protects the Agro-ecosystem without affecting the non-targeted organisms.

Microbial pesticides:

They are a particular class of pesticide originated from microorganisms. Microbial insecticides contain microorganisms as its active ingredient, including bacteria, fungi, and protozoa. These insecticides kill insects by either infecting them or releasing toxins made by microbiological organisms.

Botanical pesticides:

Pesticides that are produced by plants are called as plant-incorporated pesticides. With the help of genetic engineering the pesticides producing genes have been isolated from the plant and inserted into the plant which helps to generate more pesticides.

Biochemical pesticides:

These are organic substances that work as non-toxic pesticides. Examples of biochemical insecticides are insect sex pheromones, which disrupt mating, and a range of aromatic plant extracts. Biochemical insecticides function by drawing insect pests into traps.

Conclusion

Due to rapid increase in the use of Chemical Pesticides in the Agro-ecosystem, which in-turn affects both the vertebrate and invertebrate aquatic organisms, especially fishes. As Edible

fishes are considered to be high in nutrition importantly Omega-3- fatty acid, we as humans mainly depends on them for food consumption. These pesticides infested fishes are highly toxic to humans as they consume for their need. Hence these pesticides Primarily affect the aquatic ecosystem and Secondarily affect the human biological system which even leads to death for both the organisms. Pesticides are mainly designed to kill the pests which infesting the agricultural field, it has been a successful way to encounter the pests which are targeted, but unfortunately it also encounters the non-targeted organisms. As we can conclude that Chemical pesticides can lead to heavy Economic imbalance by destroying the fish biodiversity, and also these affected fish are unfit for human consumption, if accidentally consumed this may create health hazards through food chain to overcome this consequences certain bio-pesticides which are the derivatives of plant and plant products must come in to the agricultural practices to counterpart the use of chemical pesticides.

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