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The Negative Effects of Pesticide Use in Agricultural Production on Aquaculture

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Abstract

Pesticides are used to increase Agricultural food crop productions to fulfill the food requirement of growing population. However these pesticides can cause contamination in aquatic ecosystem through different ways like leaching , runoff and drift spray. These contaminants produce toxicity in aquaculture which becomes threatening to aquatic organisms. For example changing behaviour of fish feeding and movement and even leads to fish mortality. Toxic compounds which were reported includes Atrazine, endosulfan, profenofos, diazinon (organophosphorus) and carbofuran (carbamate). These compounds have severe toxicological effects on fish with different concenterations and even sometime in combination. These toxic compounds also cause eradication of inhabitants in aquatic ecosystem so aquatic organisms also become more vulnerable for predators. Reproductive system of fish also disturbed. For instance, pyrethroid pesticides impact fish reproduction-related systems, The capacity of adult male salmon parr (Salmo salar) to recognize and react to the female priming pheromone prostaglandin F2α (PGF2α) was shown to be decreased when exposed to low amounts of cypermethrin. Most Agricultural pesticides undergo physical, chemical, and biological transformations that gives one or more transformation products. When the concentration is high enough to provide such an impact, aquatic creatures may be exposed to both the original compound toxicity and the transformation products. However these transformed products could be more harmful than the original molecule.

Key Words: *Agricultural Production, Pesticide Use, Aquaculture*

Introduction

Pesticides encouraged food enhancement output in response to the uncontrollably rising population (Rasul & Thapa, 2003). According to Van den Brink (2013), there are several ways in which the use of pesticides can cause pollution of the aquatic environment, including spray drift, runoff, and leaching. Pesticide contamination of water can cause fish mortality or decreased fish productivity in natural waterways, either directly or indirectly. Fish can be directly impacted by pesticides by having their typical activity changed (Satyavardhan, 2013; Ullah et al., 2014; Rani & Kumaraguru, 2014), physiological function as well as modifications to the liver, kidney, gut, and other tissues' histoarchitecture (Saeedi et al., 2012; Salam et al., 2015; Sharmin et al., 2015). By upsetting the aquatic food chain and causing a loss or change in the number of native species, pesticides have an indirect impact on the aquatic ecosystem (Parveen & Faisal, 2002).
Additionally, it may alter the fish's behavior and reduce the appropriateness of their habitat, making them more vulnerable to predators. This is a direct consequence because of an indirect effect (Prashanth et al., 2011; Gill & Raine, 2014). According to the results, these indirect effects can occasionally have a greater impact than the direct ones (Murthy et al., 2013). In addition to creating jobs, lowering poverty, and producing foreign cash, aquaculture is crucial in reducing protein deficiencies. Aquaculture ponds' inherent productivity accounts for most of the fish output. Consequently, the use of pesticides is likely to cause pond ecosystem deterioration, which would lower fish output in aquaculture ponds.
Approximately 60% of the natural food supply for bottom-feeding fish in aquaculture ponds comes from benthic invertebrates, which are an essential part of the aquatic food chain (Ali et al., 1987). Through their burrowing and eating habits, they also contribute significantly to the interactions between sediment and water. They aid in the flow of nutrients, dissolved gases, and other elements between the sediments and the water above them as well as in re-suspending the bottom of the pond. In agriculture, pesticides such as sumithion and O-O dimethyl O-(3-methyl-4-nitrophenyl) are employed to protect crops (Habib et al., 1984). In the paddy fields, it works well to manage a variety of significant insects as well as certain other arthropod pests. It is also employed in fishponds for the development of larvae to manage tiger bugs. Knowing the level of harm that these pesticides give to fish and other aquatic life is crucial since sumithion is frequently used to protect crops and eradicate aquatic insects from aquaponds.

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Effects on water and sediment quality parameters

The characteristics of water quality have a major influence in the toxicity of various pesticides, which in turn has a negative impact on the variety, abundance, and dynamics of aquatic life. Even at low concentrations, fish and aquatic plants find the tastes, smells, and colors of pesticides in water distasteful and repulsive (De, 2003). Furthermore, a number of published studies showed that mass mortalities of grass carp in carp aquaculture ponds were attributed to a multifactorial disease primarily caused by bacterial agents and may be triggered by inappropriate environmental factors, such as low oxygen levels, poor feed bases, poor water quality, and acute or chronic exposure to pesticides dissolved in the water or included in the feed (Anyusheva et al., 2012).

While pH affects the physicochemical characteristics of pesticides such as hydrolysis, volatilization, and ion balancing, it usually has little effect on the toxicity of organophosphate chemicals. The application of sumithion did not alter any of the water quality measures under evaluation, including temperature, dissolved oxygen, pH, alkalinity, and nutrients. A dilution factor with a relatively tiny amount of sumithion relative to a huge volume of water may be the cause of the restricted fluctuation in the water quality variables. Numerous studies in aquaculture ponds have also noted these water quality indicators (Uddin et al., 2012; Rahman et al., 2012; Siddika et al., 2012; Nupur et al., 2013).

Lower levels of bottom resuspensions in ponds treated with sumithion may be connected to lower abundances of benthic invertebrates, which in turn may result in higher transparency and lower concentrations of phosphate and nitrate in comparison to control ponds. These ponds reduced nutrient contents may have led to a decrease in phytoplankton biomass, which is inversely correlated with transparency. In addition to serving as crucial sinks for a variety of pollutants, sediments are crucial in the remobilization of pollutants in aquatic systems when certain circumstances are met. Pesticide residues are incorporated into the aquatic food chain and eventually bioaccumulate into fish tissues through the interaction of water and contaminated sediments (Amaraneni, 2006). Furthermore, Shi et al. (2011) discovered harmful effects on aquatic animals in the water and sediments of Tai Lake in Eastern China due to the detection of trace organic contaminants, including organophosphorus pesticides.

Effects on benthic invertebrates

This research reported three kinds of benthic fauna: Mollusca, Chironomidae, and Oligochaeta. The most prevalent category of benthic fauna among the three groups was Oligochaeta, and during the course of the research, both the high and medium doses of sumithion drastically reduced the number of individual Oligochaeta. Organophosphorus insecticides have been shown to have a negative impact on benthic arthropods (e.g., McCutchan, 1999). Additionally, it has been shown that Oligochaeta colonized more quickly following the administration of herbicide (Kikuchi and Kurihara, 1982). Nonetheless, during the course of the research, the number of Oligochaeta individuals reduced, which may have been brought on by the ongoing impacts of the weekly administration of sumithion.

The second dominating family of benthic invertebrates was found to be less common in ponds containing sumithion. In an experiment to look at how pesticides affect Chironomidae, Marchiori et al. (2012) found that pesticides initially had a detrimental influence on the Chironomidae community. This suggests that the number of benthic invertebrates in aquaculture ponds was significantly decreased by a lower dosage of sumithion. Thus, the usage of pesticides in aquaculture ponds and agricultural areas is concerning for bottom feeder fish's natural food source. Pesticides do, in fact, alter the ecosystem of water bodies and disrupt the fish food supply (Maskaoui et al., 2005; Helfrich, 2009).

Pesticide toxicity to fish

Pesticide toxicity to fish has been investigated in several studies (Hamelink & Spacie, 1977; Kumaraguru & Beamish, 1981; Mulla & Mian, 1981; Barry et al., 1995; Steinberg et al., 1995; Moore & Waring, 1996; Waring & Moore, 1997; Moore et al., 1998; Csillik et al., 2000; Moore & Waring, 2001). Remarkably, not much research has indicated that fish living in natural freshwater habitats might be impacted by accidental pesticide spills (Bálint et al., 1997; Csillik et al., 2000). Many people believe that herbicides are generally safe for fish. There are few direct impacts of herbicides such as atrazine. However, research has shown that atrazine concentrations as low as 5 µg/L have an impact on zebrafish (Steinberg et al., 1995) swimming behavior. For four weeks, the fish was exposed to low doses of atrazine, and during that time, researchers examined whether it preferred bright or dark environments.

Even at the lowest measured dose (5 µg/L), which is about three orders of magnitude lower than acute toxicity data, the zebrafish changed its swimming pattern and showed a preference for darker environments. As a result, changes in schooling and eating habits may occur, potentially making prey more vulnerable to predators.

Reproductive disorders

Fish that are actively reproducing often experience physiological stress, which makes them more vulnerable to natural dangers like illness and predators. Fish that are spawning may also meet a variety of man-made substances, such as insecticides. In comparison to non-spawning fish, this may raise the hazards connected with reproduction and make spawning fish more vulnerable to toxins. For instance, it has been demonstrated that pyrethroid pesticides impact fish reproduction-related systems (Barry et al., 1995; Tanner & Knuth, 1996; Moore & Waring, 2001).

The capacity of adult male salmon parr (Salmo salar) to recognize and react to the female priming pheromone prostaglandin F2α (PGF2α) was shown to be decreased when exposed to low amounts of cypermethrin, according to Moore & Waring (2001). Due to decreased olfactory recognition of the priming pheromone, the pyrethroid decreased the rise in expressive milt and the levels of plasma sex hormones. According to the scientists, the pyrethroid exposure directly affected the sodium channels, which in turn prevented the olfactory system's nerve signals from being sent. According to Moore & Waring (2001), cypermethrin exposure decreased the amount of fertilization in salmon eggs and milt, indicating a further harmful effect of the pesticide on salmon reproduction. Esfenvalerate, another pyrethroid, has also been demonstrated to reduce fry growth, delay spawning, and reduce hatching in bluegills (Lepomis macrochirus; Tanner & Knuth, 1996) as well as to decrease fecundity and egg failure in Australian crimson spotted rainbowfish (Melanotaenia fluviatilis; Barry et al., 1995).

Additionally, additional pesticides that come from a wide range of pesticide groups prevent male salmon from detecting and responding to female priming pheromones, which may have an impact on the effectiveness of salmon reproduction (Moore & Waring, 1996; Waring & Moore, 1997; Moore & Waring, 1998). At doses as low as 1.0 µg/L, the two insecticides—diazinon (organophosphorus) and carbofuran (carbamate)—exhibited comparable effects to cypermethrin (Waring & Moore, 1997). Additionally, the herbicide atrazine affects systems involved in salmon reproduction. It has been determined that atrazine has a 96-hour LC50-value of >18 and 6.3 mg/L for rainbow trout and brook trout, respectively, suggesting that it is a reasonably mild toxicant for fish. At 0.04 µg atrazine/L, the male salmon's reaction to female pheromones was already impacted, leading to a decrease in the priming effect on milt and a reduction in plasma sex steroid levels (Moore & Waring, 1998).

Joint Toxicity of Pesticides

There is less evidence in the literature to suggest that accidental pesticide spills cause ecological disruption in natural aquatic habitats. On the other hand, the lack of knowledge on pesticides can be the biggest threat to aquatic ecosystems. Although we are aware that several pesticide groups have comparable modes of action (Ecobichon, 1991; Belden & Lydy, 2000), nothing is known about their combined toxicity. Since agricultural pesticides are frequently used in combination to protect crops, there is a clear possibility that they will have additive or even synergistic effects.

In Australia, the endosulfan pesticide had detrimental impacts on the macroinvertebrate fauna after cotton field runoff events in the Namoi River watershed (Leonard et al., 1999). In this field investigation, high endosulfan concentrations impacted five out of the six dominating species. While endosulfan has a stronger link with the densities of the examined species, profenofos' presence cannot be completely ruled out. Organophosphorus pesticide profenofos is very hazardous to fish and other macroinvertebrates. It is known that endosulfan and a related organophosphorus pesticide have toxicologically synergistic effects (Arnold et al., 1995).

Moreover, terrible fish fatalities linked to accidental pesticide spills have been documented. Large numbers of eels (Anguilla anguilla) perished in Lake Balaton in Hungary, the biggest freshwater lake in Europe, in 1991 & 1995 (Bálint et al., 1997). Numerous scientific organizations were participating in the effort to identify potential causes of the widespread fish mortality. Among the elements examined were pesticides, bacterial infections, eutrophication, and water temperature. Anguillicola crassus is a parasite. Pyrethriod poisoning appears to be the primary cause of the eel deaths in Lake Balaton, despite the existence of conflicting theories.

In order to repel mosquitoes, the area was treated with both permethrin and deltamethrin. The pesticides were detected in fish tissues, with the gills containing the greatest concentrations. Furthermore, a typical sign of pesticide exposure was a substantial inhibition of AChE in eels and other fish species.

The micro-layer theory, which postulates that pesticides created a very thin layer on the water's surface, provided an explanation for why eels were the primary species impacted. Eels frequently stick their heads above the surface, exposing them to pesticides. Comprehensive 20 study is required to be able to rule out other reasons than pesticides, even when the consequences are evident and catastrophic as in this instance.

There are even more complex situations where the results are difficult to define and quantify. One such pyrethroid, cypermethrin, is primarily used in sheep dips in the United Kingdom to prevent and cure lice, scabs, and ticks on sheep. It is also used to treat infestations of parasitic sea louse (Lepeophtheirus salmonis) in intensive salmonid farming. According to Moore & Waring (2001), sheep are often treated in October, and cypermethrin has been detected in many salmon breeding rivers and tributaries in November and December.

In fish, insects, and mammals, pyrethroids are more poisonous at low temperatures than they are at high ones (Kumaraguru & Beamish, 1981; Song & Narahashi, 1996). Thus, during the cold season—when salmon spawning, for example—there is an increased danger of deleterious effects by pyrethroids on the aquatic ecology. Apart from the potential adverse impacts on salmon reproduction, pyrethroids have the potential to influence olfactory imprinting to the birth river, which might significantly reduce the capacity of adult salmons to return to their home river for spawning (Moore & Waring, 2001). The fact that pyrethroid impacts on salmon spawning regions have not yet been studied may be attributed to their difficulty in quantifying harmful levels in natural water are harder to detect because pyrethroid pesticides can be harmful in extremely low quantities, sometimes even below the detection limit (Hedlund, 2002).
Apart from the parent chemicals, we also need to consider the fact that most pesticides used in agriculture undergo physical, chemical, and biological transformations that result in one or more transformation products. When the concentration is high enough to provide such an impact, aquatic creatures may be exposed to both the parent poisons and the transformation products. Indeed, according to Belden & Lydy (2000), the transformation product can occasionally be more harmful than the original molecule.

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