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DNA Damage in Fish Due to Pesticide Pollution

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Abstract

Toxic contaminants, including pesticides, microplastics, and heavy metals, have a significant impact on aquatic life and other aquatic species. These pollutants come from anthropogenic sources such as crop growing, industrial operations, effluent, residential wastewater, and leaching, as well as environmental events like storms, floods, and seismic processes. Pesticides, particularly pesticides, have been shown to have detrimental effects on aquatic ecology, causing decreased growth, restricted larvae and embryo development, and dysfunction in primary organs like the gill, liver, kidney, and gonad. Genotoxicity from pesticide exposure raises safety concerns, as prolonged exposure can lead to oxidative stress, mutagenicity, and cellular apoptosis. Pesticide exposure can lead to elevated levels, even without measurable concentrations in biological matrices. The toxicity of pesticides directly affects aquatic life, leading to high mortality rates or the complete elimination of species that serve as their food source.To maintain the well-being of aquatic organisms, particularly fish, and protect aquatic ecosystems, it is crucial to investigate safe, acceptable, and efficient alternatives to pesticides. In this study, we focuses on the hematological, biochemical, and histopathological changes induced by pesticide exposure and highlights strategies for mitigating the adverse impacts of pesticides on fish. Further investigation is needed to determine species suitability for toxicity detection, an essential aspect of monitoring aquatic environments for agricultural pesticides.

Keywords:

Pesticide, aquatic organism, genotoxicity

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Introduction

Pesticides are used globally to control and eliminate pests, including germs, fungi, plants, slugs, vermin, rats, and parasites. These products are classified according to the species they are meant to target and are sold in different formats such as fluids, accumulated pellets, substances, polymeric segments, covered pellet tablets, and encapsulating components. However, with the increasing use of pesticides to increase agricultural production, concerns about environmental pollution and dangerous effects on non-target organisms are also increasing (Wang et al., 2021).

Pesticides may be transmitted from the intended medium to other environmental mediums, such as water, the atmosphere, and soil, via numerous mechanisms of transfer, involving a process known as volatilization, and discharge. The effects of pesticide compounds on aquatic ecosystems have been the subject of various studies due to their ability to infiltrate the aquatic environment in various ways. Some pesticides can cause oxidative stress, which is strongly linked to the growth and development of aquatic species. Pesticide exposure may lead to musculoskeletal deformities, spinal curvature, and abnormal growth during the development of fish embryos (Li et al., 2018; Ergenler & Turan, 2022)

Many environmental variables and pesticides, resulting from an imbalance between cellular oxidative and anti-oxidative stress processes, may induce oxidative stress. Antioxidant enzymes and non-enzymatic antioxidants work by absorbing reactive oxygen species (ROS) and safeguarding cells from damage caused by oxidative stress. Oxidative stress amplifies the inflammatory response and impairs cellular responses to infections and toxic substances, which may lead to detrimental aggravation (Jia et al., 2020; Teng et al., 2022)

Fish are immediately exposed to pesticides and mutagens that are discharged into the environment because of agricultural run-off. Fishes demonstrate greater susceptibility to several pollutants and toxins in comparison to invertebrates (Stanley et al., 2016) . Additionally, fish have become valuable biological markers of contamination because they inhabit various trophic stages in aquatic ecosystems and have different degrees of tolerance. The toxicants or pollutants can build up in the bodies of fish via the process of bioaccumulation, which may pose potential dangers to human health. Prior research has shown that exposure to butachlor may cause the development of pericardial edema (PE) and yolk sac edema (YSE) in zebrafish embryos, with the severity of these effects depending on the concentration of butachlor. Zebrafish embryos have been observed to have morphological defects as a result of exposure to chlorpyrifos, pendimethalin, glyphosate, pyriproxyfen, glyphosate, pyraoxystrobin, ziram, and penconazole. Fish biomarkers serve as potential indicators of pollution, facilitating the timely identification of contamination in the aquatic environment (Mazur et al., 2023) Various scientific research on ecological management has focused on using more sensitive tests to identify genotoxicity in diverse samples. Micronucleus assays (MN) and single-cell gel electrophoresis (comet test) are very sensitive, fast, and often used techniques for identifying the mutagenic and clastogenic impacts of xenobiotics in

both prokaryotes and eukaryotes (Turan & Ergenler, 2022a;b; Turan & Ergenler, 2023; Sherif et al., 2023).

Therefore, fish biomarkers may serve as signals of pollution, facilitating the timely identification of pollution in the aquatic environment. Biomarkers are indicators of alterations in biological systems resulting from exposure to harmful substances, offering distinct insights into the well-being of ecosystems and the impact of environmental pollution. Several scientific research on environmental monitoring has focused on the implementation of more sensitive tests to identify genotoxicity in various substances. The micronucleus assays (MN) and single-cell gel electrophoresis, also known as comet assay, are highly sensitive, fast, and often used techniques for identifying the mutagenic and clastogenic impacts of contaminants in both bacterial cells and eukaryotic (Ergenler & Turan, 2022a; Turan & Ergenler, 2023). The objective of this review was to assess the impact of DNA breakage caused by pesticides on aquatic species.

Pesticide-Induced Biochemical Changes/ Oxidative Stress In Fish

The unrestricted use of pesticides in aquatic ecosystems and agriculture presents a substantial danger to human well-being. The presence of insecticides, herbicides, and fungicides in marine and terrestrial environments results in various health problems among numerous animal species. The unforeseen repercussions underscore the need for enhanced oversight and management to mitigate their detrimental impact on the environment and organisms. The use of pesticides in agriculture often results in the dissemination of pollutants into nearby soils, leading to pollution that may infiltrate groundwater and drinking water sources. These compounds pose a significant threat to fish, since they may impede their metabolism and lead to mortality. Ensuring animals get top-notch feed is essential for maximizing their performance and enhancing their general health and well-being. The growing need for animal proteins has resulted in the escalation of livestock farming and the use of commercial feeds. The use of pesticides is considered necessary for achieving high yields of feeds and fodders, however, it might result in detrimental effects on the fish population (Sherif et al., 2023).

Pesticide-Induced Behavioural Changes in Fish

Pesticides have been seen to induce several behavioral changes in different fish species, including reduced activity levels and impaired swimming abilities. These alterations make the fish more vulnerable to predation, hinder their feeding capabilities, and compromise their capacity to retain positions and defend territories (Prashanth et al., 2011). Pesticides have been shown to disrupt the schooling behavior of fish by causing them to exhibit hanging, unpredictable, and irregular movements, as well as disrupted swimming. The disruption of schooling behavior also makes the fish more vulnerable and prone to predation. Due to the presence of pesticides, fish experience stress, and a weakened immune system, making them more prone to illnesses, secondary infections, and pathogens (Nwani et al., 2010; Satyavardhan, 2013). *Catla catla* exposed to methyl parathion caused enhanced opercula movements, sudden jerky movements, loss of balance, changes in body

color, frequent surfacing, and increased mucus production (Ilavazhahan et al., 2010). *Labeo rohita* exposed to cypermethrin caused rapid, unpredictable, and erratic swimming movements, loss of balance, increased sensitivity, and sinking to the bottom of the water (Chanu et al., 2023). Pesticides can alter the migratory behavior of migratory fish, as suggested by Nagaraju et al. (2017). This alteration disrupts their life cycle, specifically affecting the capacity of salmonid fish to transition from freshwater to saltwater. However, this occurrence is prompting further studies to concentrate specific attention on the important time of transition that takes place in estuaries. Research has shown that adult salmon modify their migratory route to avoid pollutants and polluted regions during their migration, leading to a delay in their spawning (Satyavardhan, 2013). Tor putitora exposed to cypermethrin caused many observable effects in jumping, such as increased surface activity and increased air swallowing, loss of balance, sudden swimming movements, weakness, immobility, upright postures, and internal bleeding (Ullah et al., 2015). Moreover, the application of sodium cyanide resulted in specific alterations in behavior, including increased excitability, rapid and unpredictable movements, and impaired swimming abilities in *Oreochromis mossambicus, Catla catla, Cirrhinus mrigala, Labeo rohita,* and *Cyprinus carpio* (David et al., 2019).

Genotoxicity

The majority of pesticides are genotoxic, meaning they can cause DNA damage, increase the occurrence of tumors, and have negative effects on the health and reproduction of aquatic species. These effects may ultimately diminish the productivity of aquaculture. In the study conducted by Bhatnagar et al. (2016) on the emergence of nuclear abnormalities in the blood cells of *C. mrigala*, the micronucleus (MN) test was used and it was observed that micronucleus production was associated with chlorpyrifos exposure. The research revealed the presence of nuclear abnormalities such as cracked eggs and large-sized micronuclei, as well as changes in cell shape. These findings provide strong evidence for the effect of chlorpyrifos on the nucleus. Palanikumar et al. (2014) suggested that micronuclei test findings were a correlation between high doses of chlorpyrifos and the increase in the occurrence of abnormalities in *C. chanos*. In the study by Turan & Ergenler (2022) in which they used the comet test to investigate the genotoxic effects of different doses of abamectin on *C. carpio*, a significant increase in DNA strand breaks, which could cause genetic damage, was observed in *C. carpio* exposed to abamectin. Turan & Ergenler (2022) and Ergenler & Turan (2023) conducted studies showing significant increases in the formation of micronuclei and DNA strand breaks in *C. carpio* after exposure to acetamiprid and thiamethoxamine, and evidence was presented for the genotoxic effects of pesticides on fish.

In conclusion, the use of pesticides for diverse objectives might lead to possible risks to water quality and all aquatic life. The present review research indicates that pesticides affect fish species. Bioaccumulation is a mechanism via which pesticides may accumulate in aquatic organisms, particularly fish species. The proliferation of pesticides resulted in the emergence of

several illnesses in fish species, subsequently leading to a diverse array of health issues. To preserve a healthy ecosystem, it is advisable to minimize the use of pesticides.

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Conflict of Interest

The authors declare that they have no competing interests.

Author Contributions

All authors' contributions are equal for the preparation of research in the manuscript.

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