THE EFFECTS OF PESTICIDE EXPOSURE ON WATER BODIES - A REVIEW

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ABSTRACT

Pesticides and fertilizers are used carelessly in agricultural intensive crop production in order to develop high yield varieties. This protects the crop against pests, which in turn serves to improve the crop’s quality and quantity. Several pathways, including runoff, spray drift, and leaching, allow pesticides to pollute the aquatic environment, endangering both aquatic life and human health. Whether they are invertebrates, fish, or primary producers, this exposure may have an impact on all levels of the biological hierarchy. Pesticides reduce oxygen, particulate organic carbon, and dissolved organic carbon levels in aquatic plants by reducing primary production and increasing respiration rates. Atrazine raises calcium levels in aquatic environments. Reduced precipitation of calcium carbonate (CaCO3) occurs when crystal development is inhibited or the pH decreases. Pesticides including organochlorine and atrazine raise levels of ammonium (NH4+), nitrate (NO3-), and sulphate (SO4). There are numerous techniques to remove pesticides. Aquatic contamination may be biological-bioaugmentation, natural attenuation, and biostimulation, chemical -denitrification, reverse osmosis, electrodialysis, and catalytic denitrification. In order to manage the amount of harmful chemicals in water bodies, it is necessary to include monitoring measures for runoff events in the spraying process. One such approach is the suspended matter sampler, which may be used to measure particle-associated pesticides.

Keywords: Aquatic Environment, Pesticides, Fertilizers, Biostimulation.

I. INTRODUCTION

The natural resources have been greatly affected by the rapid industrialization and urbanisation that has occurred in recent decades, together with the corresponding increase in population. Pollution from harmful compounds, such as pesticides or heavy metals, on a local, national, or international scale is one of many human activities that contribute to climate change. Anthropogenic perturbations have recently been observed to cause widespread mortality of important wildlife species like marine mammals and to increase the risk to human health, including chronic respiratory diseases, cancer, and damage to various major organs such as the kidneys, brain, and lungs [1]. The majority of the pollution in our world’s freshwater supplies comes from human activities, including farming, manufacturing, and household chores. For instance, on a regular basis, the freshwater frameworks get over 300 billion kilograms of mixes used in engineering and agricultural items. A surge of wastewater is produced when 10% of the globally accessible overflow is used; this wastewater then flows into groundwater, rivers, lakes, or the oceans[2].

The current agricultural system is under strain from the world’s increasing population, and increasing food production has become the top priority for most nations in order to keep up with demand.[3]. The use of insecticides in combination with fertilizers has significantly contributed to enhancing food security during the last five decades.[4].

Pesticides are typically classified based on the chemical composition and the qualities of their active components. The classification of pesticides, depending on their chemical makeup, consists of four primary groups: organochlorines, organophosphates, carbamates, and pyrethroids.

Organochlorine pesticides are one of the first category of pesticides that have been created and used. The majority of these insecticides are broad-spectrum, meaning they are effective against a wide range of agricultural and household insects[5]. They exhibit enduring presence in the environment over an extended period of time. Organochlorines exert their mode of action by disrupting the neurological system, resulting in convulsions and paralysis in insects, eventually leading to their death. Organochlorines such as Dichlorodiphenyltrichloroethane (DDT), lindane, endosulfan, aldrin, dieldrin, and chlordane are often seen[6]. Cypermethrin and permethrin are the most commonly used synthetic pyrethroid insecticides. Pesticide
usage has caused pollution and negative impacts on both the environment and human health. Pesticides may enter aquatic environments via several means, including agricultural runoff, spray drift, air fallout, soil erosion, leaching, industrial and home sewage, improper container disposal, equipment washing, and infiltration[7]. Pollution of water bodies harms aquatic species and renders them unsafe for human consumption. Water shortage may result in catastrophic consequences. Pesticides pose a hazard to both terrestrial and aquatic creatures owing to their high toxicity and bioaccumulation potential. Globally, around 3.5 million tonnes of pesticides are used, with insecticides accounting for half. Pesticide contamination affects 64% of global agricultural land, with 31% at high risk. South Africa, China, India. Pesticide contamination causes significant environmental risks, particularly in Asia, Africa, Latin America, the Middle East, and Eastern Europe.[8]. A major issue in rural regions is the careless and potentially harmful application of pesticides, on top of the inherent dangers that these products represent. When applying pesticides in the field, farmers sometimes disregard established safety procedures. This holds true even when considering farmers that have been using pesticides for a long time. Multiple studies have shown that farmers are aware of the need of safety procedures, yet they seldom really implement them while working the fields.[9]. More non-target organisms are exposed to pesticides in the environment as a result of this careless usage. As a result, both the farmer's health and the environment benefit from pesticide usage that is moderate.

However, freshwater and terrestrial ecosystems suffer from significant pollution caused by a multitude of hazardous compounds, particularly due to the widespread use of pesticides and fertilizers in agriculture. This has become a pressing worldwide concern. Pesticides, which are used to eliminate detrimental pests, have become a crucial component of contemporary existence. These substances, such as industrial chemicals, pesticides, heavy metals, and other toxic compounds, have been found to disrupt the normal functioning of many species, including humans and aquatic organisms, despite the intention that they only harm the target organisms. Pesticides that are found in elevated concentrations must be eliminated from drinking water to ensure human safety.[10]. It is necessary to regulate the dumping of industrial and agricultural waste in water bodies and to monitor the presence of trace elements in the water and other consumable items.

**Pesticides:**

Pesticides are a blend of compounds formulated to manage, eliminate, or regulate the growth of undesired organisms known as pests. These pests often introduce plant pathogens, nematodes, bacteria, and insects that compete with human food and are responsible for transferring illnesses and causing crop destruction. Pesticides are often classified as either biological or synthetic. Biological pesticides are obtained from natural sources, such as plant extracts (azadirachtin from neem or pyrethrin from chrysanthemum plants), whereas synthetic pesticides are manufactured using industrial methods. Pesticides can be classified into two categories: broad-spectrum, which are used to control a wide range of species, and narrow-spectrum, which are used to control a small group of species. [11]. Pesticides are also categorized based on the type of pest they target. For example, insecticides are used to control insects, herbicides are used to control weeds, and fungicides are used to control fungi.

**Insecticides**

The majority of insecticides have an impact on the neurological system by targeting various locations. They disrupt the transport mechanism of ions such as sodium, potassium, calcium, or chloride in the cell membranes. This disruption hinders the specific enzymatic activities that are involved in the chemical transmission at nerve terminals.[12].

**Herbicides**

Depending on how they work, herbicides are grouped into several types. Because of this, they are manufactured with the express purpose of eliminating weeds. They are linked to influencing a wide range of processes that take place during protein or lipid synthesis, photosynthesis, respiration, development, cell and nuclear division, and so on [13].

**Fungicides**

A class of insecticides known as fungicides disrupts the energy source of fungus and prevents their spores from germinating. As an example, certain fungicides, such as dithiocarbamates (e.g., maneb and thiram) and R-S-CCl3...
compounds (e.g., captan and dichlofluanid), work by inhibiting enzymes involved in respiratory processes. On the other hand, a class of fungicides called phenylpyrroles (e.g., fenpiclonil and iprodione) prevents spore germination and causes various morphological changes in plant germ tubes, preventing their elongation [14]. Further, fungicides are known to limit the electron transport chain during respiration.

**Pesticides in the Aquatic Ecosystem**

Farmers often employ pesticides to safeguard high-yielding crop varieties from pests and diseases. These crops are particularly vulnerable to such threats, which can result in a significant 40% reduction in crop production. Therefore, the use of pesticides is essential for enhancing both the quality and quantity of the crop by providing protection against pests. Pesticides are a significant worry among the several harmful compounds that enter the aquatic environment. They are recognized to pose considerable dangers to biological creatures, including humans [15]. Toxic compounds infiltrate water sources via several pathways, including spills, industrial effluent, surface runoff, and pesticide-treated soils. Maximum Residual Limits (MRLs) have been announced by the Indian government as part of the Food Safety and Standards (Contaminants, Toxins and Residues) Regulations, 2011. The maximum residue limits (MRLs, CPCB 1986) [16]. Table No.1. For several pesticides are detailed in this database; food producers face severe consequences in the event that these limits are surpassed.

**Table 1:** Permissible limits of major pesticides in drinking water

<table>
<thead>
<tr>
<th>Pesticides</th>
<th>ISI Limit (μg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDT</td>
<td>42</td>
</tr>
<tr>
<td>Aldrin</td>
<td>17</td>
</tr>
<tr>
<td>Organic Phosphate</td>
<td>100</td>
</tr>
<tr>
<td>Carbamate</td>
<td>100</td>
</tr>
<tr>
<td>Heptachlor</td>
<td>100</td>
</tr>
<tr>
<td>Dieldrin</td>
<td>17</td>
</tr>
</tbody>
</table>

**II. IMPACT ON AQUATIC HABITATS**

Pesticides have negative effects on ecosystems when used alone, but their combined toxicity is far worse. We don’t know enough about how these families of herbicides interact with aquatic life. Predicting whether toxicity will be increased or not for a specific mix of substances is sometimes not easy. The degree to which certain pesticides bioaccumulate in fish is affected by their polarity and water solubility. Pesticide bioaccumulation is inversely proportional to the chemical's solubility in water. As the pesticide's solubility in water rises, the degree of bioaccumulation reduces. Thus, water the solubility of pesticides plays a crucial role in reducing their dynamics in aquatic environments. Insecticides attach to invertebrates' receptors, causing irreparable damage that accumulates over time [17]. Neonicotinoids have both deadly and sublethal impacts on many invertebrate populations, as expected. Aquatic arthropods and algae of various classes Chlorophyceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae (Euglenophyceae is the most sensitive class in the among algal members) are the most impacted creatures in the aquatic system, with diverse levels of toxicity. According to Alexander [18], insects are the most sensitive class of arthropods. Reducing the number of algae in any way alters the community structure and causes a decline in the number of gastropods. Because of their habitat in sediments, gastropods are among the most vulnerable species to pesticide exposure [19]. The pesticide-induced mortality of macrophytes has an immediate impact on invertebrates. Herbivorous gastropods use them as a feeding ground, and periphyton thrive on them as a substrate. Pesticides like as atrazine can impair development and metabolic activities. Atrazine has a negative impact on phytoplankton growth. Under lab circumstances, certain species may tolerate pesticides. However, in the natural environment, their abundance reduced due to fewer edible phytoplankton species [20].

**A Biopesticide Technique for Remediating Pesticides in Polluted Ecosystems - removal of Pesticides**

Biopesticides are pesticides derived from natural sources including microorganisms, plants, animals, and minerals. There are three major kinds of biopesticides: i) Plant, ii) microbial, and iii) biochemical insecticides. Plant insecticides are developed from plant genetic material. Bt insecticides insert protein genes into plants,
causing them to create pest-killing compounds. Microbial insecticides include microorganisms such as fungi, algae, bacteria, or protozoa. Bacillus thuringiensis, sometimes known as Bt, is a popular microbial insecticide used on plants such as potatoes and cabbage. Biochemical insecticides use natural substances to manage pests without causing harm. Biochemical insecticides often comprise pheromones and plant growth regulators. Pesticides have many benefits, including being target specific and useful even at low doses. They also dissolve fast, are environmentally benign, less hazardous than traditional pesticides, and leave no trace. The rate of pesticide removal or desorption seems to vary depending on the species.[21].

The concentration of pesticides in a particular species is influenced by the speed at which they are absorbed and eliminated. Significant endeavors have been made to ascertain and record the dispersion of pesticide residues in the aquatic environment. A wide range of harmful consequences linked to organochlorine pesticides and organophosphate metabolites have been identified via an extensive residue analysis Programme. Pesticides entering aquatic environments may lead to the undesirable loss of ecosystems via the disease and death of aquatic creatures. [22]. This leads to a decrease in the population of aquatic microbes and invertebrates such as prawns, frogs, turtles, mussels, as well as vertebrates like fish and water fowl. These marine creatures are key components of ecological food webs. Consequently, other creatures that rely on these aquatic organisms as a food source are also adversely impacted by the toxic compounds included in pesticides. Biological remediation involves using organisms to transform organic pollutants into less toxic products, such as water and CO2. According to Onwosi[23] the primary benefits of this method are its environmental friendliness and cost-efficiency. There are three primary forms of biological remediation include i) bioaugmentation, ii)natural attenuation, and iii)bio stimulation.

A system is bioaugmented when microorganisms that have been genetically modified are introduced to it. Remediation by natural attenuation makes use of the existing microbial community. Nutrient addition is known as bio stimulation [24]. Wastewater is where bioaugmentation works best extermination of pests. Quite a few tactics are laid forth by Herrero [25].

### III. CONCLUSION

The contamination of the aquatic habitat by pesticides, animal waste, insecticides, manures, and other substances is now the most commonly acknowledged water-related problem. Within the amphibian environment, the pesticide has the ability to either adsorb or desorb onto suspended particulates, subsequently settling in the underlying silt. Pesticides attain ecological equilibrium primarily via two mechanisms, namely effluent and filtration. The hydrological cycle is directly linked to these two essential operations. The proliferation of hazardous synthetic chemicals in pesticides has increased due to rapid urbanisation and industrialization. Pesticides have been shown to reduce the levels of oxygen, particulate organic carbon, and degraded organic carbon in amphibian plants, resulting in decreased oxygen production and increased respiration. When atrazine is introduced into a marine environment, it accumulates calcium in the water. This phenomenon may be attributed to the decreased production of calcium carbonate (CaCO3) precipitation due to the inhibition of precious stone formation or the decrease in pH levels. Organisms such as atrazine, and others have the ability to generate ammonium (NH4+), nitrate (NO3-), sulphate (SO4-2), and nitrite inside the amphibian system. Several strategies can be employed to mitigate pesticide contamination in oceanic environments. These strategies include organic methods such as bioaugmentation, characteristic constriction, and bio incitement, as well as synthetic methods like denitrification, switch assimilation, electrolysis, and reactant denitrification. Additionally, physical approaches such as zeolites, activated carbon, soils, and polymer materials can also be applied. Given the propensity of aquatic creatures to collect toxic pesticides throughout the food chain, it is crucial to ensure rigorous enforcement of current rules and the advancement of mitigation techniques in the context of India. The impacts of human population growth on aquatic ecosystems are discussed in this paper. These effects include climate change, nutrient enrichment of aquatic bodies, and pollution from various toxic substances, including pesticides, on a regional and global scale. Developmental defects in invertebrates and larger animals, microorganisms, aquatic algae are caused by these artificial environmental disruptions, which have a negative impact on the regular functioning of all living things. The usage of pesticides has been on the rise in recent years, and this trend is having an impact on non-target creatures across several biological scales.
Compliance with ethical standards:

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**Disclosure of conflict of interest**

The authors declare no conflict of interest.

**IV. REFERENCES**


