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Toxicology Effects Of Pesticides In Aquatic Animals

Dr. Inder Singh Meena

Dept. of Zoology, Govt. College, Tonk, Rajasthan, India

ABSTRACT: Fish can be directly or indirectly impacted by pesticides. Some long-term exposures cause abnormalities or mutations in developing fish larvae, while acute exposure can cause immediate fish die-offs. The liver, kidney, brain and gills of exposed fish are extremely vulnerable to chemical exposure. Linking pesticides to be the cause of harm to fish can be difficult because they are highly mobile animals, and the effects may not show until much later in life.

- A 2015 study showed that when fish larvae are exposed to pesticides through water contamination from runoff, they can develop swimming abnormalities as they grow, making them an easy target for prey and impacting their survival rate.
- In 2012, thousands of fish were found dead in Prince Edward Island, Canada, due to pesticide runoff from nearby agricultural fields after heavy rain. In 2013, dozens more dead fish washed ashore, again after heavy rains and possible pesticide exposure.
- In 2012, the National Marine Fisheries Service (NMFS) drafted a biological opinion to the Environmental Protection Agency (EPA) concluding that three herbicides (oryzalin, pendimethalin, and trifluralin) pose a direct threat to approximately 50% of endangered Pacific salmon and Puget Sound steelhead species, and adversely impact their habitat.
- Fish species are also sensitive to endocrine disruptors. In 2005, researchers in British Columbia, Canada, demonstrated that biological changes induced by sublethal exposure to pesticides include inhibition of important enzymes and growth delay.
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KEYWORDS: fish, toxicology, aquatic, animals, pesticides, chemical, abnormalities, endangered, growth delay

I.INTRODUCTION

Fisheries are valuable resources that are enjoyed by millions of Americans. Fish provide food services for humans and other wildlife. They also provide benefits for citizens through direct financial gain or recreational enjoyment. For example, the seafood industry provides jobs for commercial fishers and retailers, while the other aquatic areas provide the opportunity for recreational activities such as sport fishing. [1,2]

One estimate for the economic cost of the impacts of pesticides on fish uses information provided by EPA's fining of Coors Beer for river pollution ($10 per fish). With this information, it is assumed that the economic value of fish killed by pesticides each year is estimated to be $10-25 million. This is most likely a vast underestimate, as fish kills due to pesticides are hard to trace (see David Pimentel's 2005 study for more information). A separate study has estimated that the entire value of recreational fishing is worth $27.9 billion annually. From this estimate, one can assume that as fish kills due to pesticides increase, there will be less available fish for recreational fishing. As the supply decreases, the cost will increase, leading to increased spending by citizens who partake in this activity.[3,4]

In 2008, more than 13 organizations filed a legal petition demanding that EPA regulate novel nanomaterial pesticides. EPA remained silent, prompting Beyond Pesticides and other organizations to sue the EPA in 2014. Silver nanoparticles are often impregnated into a wide variety of consumer products. These nanoparticles are released when washed, where they exit down the drain and enter into the environment. These products have been found to be toxic and potentially lethal to fish. In early 2015, the EPA finally responded [5,6]and agreed to regulate these novel nanomaterials as pesticides. In 2010, Earthjustice, representing the Pacific Coast Federation of Fishermen's Associations, the Northwest Coalition for Alternatives to Pesticides, and Defenders of Wildlife, filed litigation that called for EPA adoption of reasonable fish protections from insecticides.[7,8] Following the Lawsuit, EPA restored stream buffers to protect salmon from pesticides. The buffers apply to salmon habitat throughout California, Oregon, and Washington to prohibit aerial spraying of broad-spectrum pesticides diazinon, chlorpyrifos, malathion, carbaryl, and methomyl within 300 feet of salmon habitat and prohibit ground-based applications within 60 feet.[9,10]

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In the last few decades, rapid human population growth with its concomitant astronomical increase in urbanisation, industrialisation and technology has had its toll on natural resources of the world. Climate change, acid rain, nutrient enrichment of aquatic environments, pollution by pesticides, metals, and synthesised toxic substances on local, regional and global scales are the result of such anthropogenic disturbances. Recent events, as witnessed the world over such as large scale mortality of wildlife (e.g. sea mammals, birds), increasing menace to human health (e.g. cancerous cells, chronic respiratory disease, damage to organs such as brain, lung, heart, liver, kidneys) and algal bloom in many water bodies are all effects of the anthropogenic perturbations of the biosphere. The biosphere is part of the earth that supports life. It comprises of the lithosphere, hydrosphere and atmosphere. [11,12]The hydrosphere is the total mass of water on planet Earth, which includes oceans, lakes, streams, groundwaters and glaciers. Saline water account for 97.5 % while freshwater accounts for 2.5 %. The bulk of freshwater, 68.7 %, is stored in ice and permanent snow cover, while 29.9 % exists as groundwater. Only 0.26 % is found in lakes, river systems and reservoirs [1]. However, among all the components of hydrosphere, freshwater ecosystems are the most vulnerable to pollution due to anthropogenic stresses [2-3]. Agricultural, industrial and domestic activities are the major sources of this pollution [4]. These activities use more than one-third of the Earth's accessible freshwater resources and have contaminated water with numerous synthetic and geogenic compounds [4]. For instance, about 300 billion kilograms of synthetic compounds used in industrial, consumer and agricultural products find their way into natural freshwater systems every year [5]. Ten percent of the globally accessible runoff is used, generating a stream of wastewater, which flows or seeps into groundwater, rivers, lakes, or the oceans [5].

The use of agrochemicals is necessary to control pests and increase yields in order to produce adequate food for the global population, estimated at 6.8 billion in 2009 [5], and recently reported to have reached 7 billion [6]. Underdeveloped countries, where 1.02 billion people (15 %) are undernourished and 1.3 billion people (19 %) live on an inadequate diet [5], need an adequate food supply. However, the agricultural sector's annual application of over 140 billion kilograms of fertilizers and large amounts of pesticides creates massive sources of diffuse pollution of freshwater systems [4]. The presence of these toxic chemicals in both aquatic and terrestrial ecosystems has become an important issue globally. Growing research-based evidence shows that pesticides, metals and many industrial chemicals interfere with the health and normal functioning of the endocrine systems of a wide range of organisms, including humans [7-9]. It is believed that effects of these chemicals on the normal functioning of the endocrine system are responsible for a number of developmental anomalies in a wide range of species, from invertebrates to higher mammals [10-13].

Before herbicide products are registered for use, the registration authorities require experimental information on their toxicology, biology, chemistry, and biochemical degradation in addition to their effect on air and water quality, soil microorganisms, and wildlife. [13,14]Although commercial herbicide products contain several different ingredients, toxicity tests are usually conducted only on the active ingredient, which is the component of the product believed to actually affect the target organism [20]. The criteria for assessing the possible effects of herbicides on the safety of humans, animals and the environment are the herbicide's toxicity[15,16] (including carcinogenicity, mutagenicity, endocrine disruption, reproduction and developmental abnormalities), biomagnification, and persistence in the environment ([20].

Given the scarcity of water resources in South Africa, aquatic herbicides are of special interest. The potential of an aquatic herbicide to adversely affect aquatic organisms depends on its inherent toxicity to the specific organism and the organism's exposure to the compound in terms of concentration and duration [21]. The inherent toxicity of the pesticide, which is due to its mode of action, is a specific relationship between the organism and the chemical, whereas factors such as application rates and techniques, chemical and physical properties of the pesticide, and environmental conditions at the time of application can make exposures highly variable.[17,18]

Herbicides now lead all other pesticide groups in terms of amount produced, total acreage treated, and total value from sale. Over the past decades, public awareness of the worldwide increase in the use of herbicides and their adverse effects on aquatic ecosystems has been growing [22]. Herbicides may reach water bodies directly by overhead spray of aquatic weeds, or indirectly through processes such as agricultural runoff, spray drift and leaching. Potential problems associated with herbicide-use include injury to non-target vegetation, injury to crops, residue in soil or water, toxicity to non-target organisms, [19,20]and concerns for human health and safety [20]. Herbicides can decrease environmental water quality and ecosystem functioning by reducing species diversity, changing community structure, modifying food chains, altering patterns of energy flow and nutrient recycling, and reducing resilience of ecosystems, among others [22].

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II.DISCUSSION

Glyphosate-based herbicides are used globally to control both aquatic and terrestrial weeds. In recent years, its use has increased tremendously and is likely to impact on non-target organisms in the environment.[21,22] Even though it is generally regarded as having a low potential for contaminating surface waters due to its perceived rapid dissipation and strong adsorption to soils and sediments, it has been detected in surface waters long after being used to kill aquatic weeds [34]. In fact, its mode of action was designed to affect only plants [29], but various studies in recent years have reported adverse impact on non-target animals [23, 33, 35]. These impacts could be lethal or sublethal. Lethal effects are mainly mortality and immobility endpoint measures. However, there are several endpoint measures that can be used to assess sublethal effects. At the 'physical' level, measures of survival, growth, morphological changes, and behavioural changes exposed animals are used as endpoint indicators. Measures of reproductive performance that are often used to assess[23,24] sublethal response include sexual maturity, time to first brood release, time required for egg development, fecundity, gonad histopathology, and alterations in reproductive characteristics. Biochemical measures used as possible endpoints to assess exposed animals include metabolic disruption, steroid metabolism, vitellogenin induction, lipid peroxidation, acetylcholinesterase activity,[25,26] cytochrome P450enzymes and blood glucose levels. The effects of rapid human population growth on aquatic ecosystems have been discussed. These effects are seen in such phenomena as climate change, nutrient enrichment of aquatic environments, and pollution by all types of chemicals including pesticides on local, regional and global scales. These anthropogenic disturbances adversely impact the normal functioning of organisms and are responsible for a number of developmental anomalies in a wide range of species; from invertebrates to higher mammals. It is expected that the use of pesticides, especially herbicides, [27,28]will continue to increase and eventually becoming environmental hazard to non-target organisms at different biological scale levels unless proactive measures are taken. The case study, i.e. lethal and sublethal exposures of C. nilotica to varying environmentally relevant concentrations of Roundup®, showed that C. nilotica can be used as early detection system to assess glyphosate-based herbicides pollution effects on aquatic ecosystems.[29,30]

Pesticides are one of the major pollutants that degrade water quality. Any substance or mixture of substances proposed for avoiding, killing, fighting or weaken any pest or weed is a pesticide. The pest can be unwanted plants, destructive insect, nematods, mammals, birds, fishes, microorganisms. These pests create competition for humans for foodstuff and harm resources, or increase diseases or cause irritation. Insecticides, herbicides, fungicides and rodenticides are generally used as pesticides. The other less well-known pesticides includes growth regulators, plant defoliants, surface disinfectants etc. Mostly, pesticides are used in health management and crop fields. They are helpful in health protection of people as they destroy harmful pests like mosquitoes and also prevent agriculture land from diseases [3].

During last 40-50 years, the application of pesticides has raised rapidly. With increased use, concern about harmful effects on other organisms and humans has also increased [4]. The harmful effects of pesticide are the reason for fish kills, health problems in humans, and reproductive failure in birds. It has been concluded that the amount of pesticide which actually reaches to targeted pest is less than 0.1% and the rest get into the environment gradually and contaminates air, water and soil.[31,32]

At the present time, water pollution by pesticides is a critical issue, especially in range of extensive agriculture where leaching of these harmful chemicals in water systems cause toxic effects on aquatic, animal and human health. [33,34]There is a need of concern for Groundwater and surface water contamination as pesticides can make their approach to drinking water. Currently, various pesticides of different chemical composition are applied to agricultural land in whole world [5]. The toxic substance may runoff into streams, rivers or water bodies and results in water pollution. It is indicated in researches that irrelevant use of fertilizers pollute the water through leaching of nitrate from pesticides and nitrogenous fertilizers. It may also cause death of aquatic animals [6]. Although pesticides are used for beneficiary work, they have some limitations also. According to the Stockholm Convention on persistent Organic Pollutants, 10 of 12 most harmful and persistent organic chemical are pesticides [7].

There is a need for understanding of processes which cause harm to water resources to conserve hygienic quality of water.[35,36] Though, the use of pesticides and fertilizers are in our hand, we can prevent water quality by using them properly. It is necessary to have knowledge about pesticide's nature for an easy understanding of the risks associated with them [8]. The presence of constant toxic chemicals in the environment raised a serious global concern as they have adverse effects on aquatic life, wildlife and human beings. So, we have to state the harmful effects of pesticides [9].

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III.RESULTS

There are more than 500 different types of pesticides that are used in our environment. In the past few years the use of pesticides has increased as they enhanced the quality of food and crops.

Though, because of their high use, the concern about their dangerous effects on non-targetting organisms has also been increasing. Humans, birds and fishes indicated the effect of non-target pesticide poisoning. Some pesticides can persist in environment for long time, for example, organochlorine insecticides are still recorded in surface waters 30 years after their use and had been excluded [15]. They cause adverse effects on health as they collect in the tissues of organisms. Their formation as bioactive molecules to eliminate fungal, vegetal and animal species indicates that they can be harmful. Once these pesticides are applied to the crop fields, they can find different ways to reach aquatic systems depend on their water solubility and polarity. In surface waters, mostly pollutant enters from crop fields by runoff from irrigation or after precipitation [16]. In lakes, pesticide changes clean water into turbid water. As mentioned above, both point and non-point sources of pollution from pesticides are generally anthropogenic. So it is estimated that in surface water the toxic effects of these chemicals are caused due to anthropogenic activities that occur there. The distance between point or diffuse sources and water bodies is also relevant to the concentration of these chemicals in water bodies [17]. Pesticide persistence in the ecosystem is characterized by a number of phenomenons occurring in different environmental chambers, such as plant, surface and groundwater, air and soil [18]. The uncontrolled and improper use of pesticides has become a typical cause of pollution. Though pesticides are directly sprayed to plants and soils, the amount of pesticide reached to target is less than 1%. An unintended delivery of pesticides because of spills, waste dumps, leaking pipes, and groundwater may cause them to live long in the environment. It is necessary to correctly evaluate the condition of contamination in water, soil and air for better management of pesticides [19].

Pesticides and water pollution

Pesticide residue in water is a major concern as they create harmful effects in living organisms. Pesticides can enter into water systems by several pathways like agriculture runoff, spillage, drifts, industrial effluents, washing of spray equipment, aerial sprays and transport from soils treated with pesticide. The most common movement of pesticides from land to water is by runoff or drainage [20]. The high concentration of pollutants could found in river and groundwater than lakes because the detected concentrations of most pesticides follow a seasonal variation, with highest values occurring during the post spring and summer period followed by a decrease during winter [21-25]. Runoff from crop field is the most common way by which pesticides can enter in aquatic systems and pollute them. Pesticides are also applied in forested areas, golf courses, landscape areas and along roadsides [26]. The free and unsystematic use of pesticides has created serious issues for environment as it cause adverse effects in organisms. Some of the environment resist and least biodegradable pesticides are high on use in many countries even they are banned.[37,38]

Pesticides may exert several toxic effects because they are fat soluble and can accumulate even at low concentrations that could be predicted at molecular, behavioral and biochemical levels [27].

Currently in India organochlorine insecticides such as HCH and DDT comprise more than 70% of the pesticides. Reports from Bhopal, Delhi and some other cities and from some rural areas has indicated the availability of high level of pesticides in fresh water systems as well as in bottled drinking water samples.

One of the most shocking effects of pesticides contamination of groundwater was highlighted in 2002 when it was found that bottled water have contained pesticide residues. CSE recognized seventeen brands of bottled water with pesticide contamination which are commonly sold in areas of Delhi. The most common residues which were found in almost all samples are of organochlorine and organophosphates.

ERS conducted a research and calculated the total contribution of runoff in release of sediments and nutrients to streams and lakes. Total ninety nine watersheds were tested and it was found that forty eight had sediments and nutrients in excess levels. This research indicates that the main cause of nitrogen in 9 watersheds, sediments in 34 watersheds and phosphorus in 31 watersheds is agriculture. Another ERS study also investigated that excessive contamination in coastal waters is also by pesticides' runoff from agriculture land. In last few years the pollution level of many rivers were examined and it has been found that there was contamination due to continued runoff from crop lands along with industrial or domestic discharge.

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The key users of pesticides are farmers as they use an enormous quantity of pesticides for protecting their crops or to increase crop yield. Also, a very huge quantity of insecticides is used by wood treatment industry for treating the raw material. Besides, the great usage of pesticides in urban areas majorly in home-gardening for controlling pests is a major source of pesticide pollution in water; insecticides are used very profoundly in urban areas [28].

Sources, entry and fate of pesticides into water

It has been investigated that source of pesticides into water has been depend on the behavior and pesticides' properties and the prevailing climatic conditions. Research has concentrated on understanding and observing the practices which conclude pesticide application to crop land. It is now increasingly accepted that there are also a number of other pathways by which pesticide can enter in water bodies. Usually there are two sources by which pesticides enter into water which are shown in Table 3. Pesticides can enter into water bodies by point and non-point sources.

Point sources: Point source belongs to the fixed sites and also includes chemical runoff during improper handling, storage and discharge. These can be little, simply recognized items or areas where concentration of pesticides is high as containers, spills or tanks. The spills of pesticides or direct movement of pesticides in groundwater is a point source kind of pollution. The use of insecticides in urban areas is typically point source pollution for surface water. These sources can be regarded as point sources as they can be related as a mathematical point to clarify study in mathematical modeling. Pollution point sources are similar to other point sources in chemistry, physics, optics and engineering. It is a single limited source of water, air, noise, light or thermal pollution. A point source has negligible extent which differentiates it from other pollution source configurations.

Diffuse sources: Diffuse sources or non-point sources are the main cause of passage of pesticides in water. It is the movement of pesticides from large regions from the watersheds or from agriculture land to water systems by runoffs, erosion or leaching. It arises from unauthorized sources and diffused land-use activities. Fertilizers, sediments, gross pollutants soil erosion by pathogens, pesticides, salts, toxicants, acid sulfate soils in drained wetlands, etc. are the pollutants of diffused pollution sources.

Spray drift: Spray drift is the most possible route of entry of pesticide into surface water. Sometimes pesticides are applied to such lands which are near to surface water which causes spray drift. The data from a field showed the quantity of substances that creates drift in water. One such report indicated a drift discharge of the normal field extending from 0.3% to 3.5% by use of a pesticide in field.

Surface runoff: Some of the potential pollutants flow across the surface by irrigation, precipitation or some other source and mix up within a water body. Then it starts to percolate into the soil. The soils of elevated slope are more vulnerable to runoff.

Leaching: Leaching is a process in which a soluble chemical or mineral is drain away from a solid (ash, soil etc.) in a liquid. The residues of leaching may transport to underground water directly or it may transfer in a lateral way to surface water. When water Leaching: Leaching is a process in which a soluble chemical or mineral is drain away from a solid (ash, soil etc.) in a liquid. The residues of leaching may transport to underground water directly or it may transfer in a lateral way to surface water. When water

Drainage: Land drainage has an objective as it removes the extra water from surface. Several under drainage systems has been installed for improving the quality of water such as clay pipes, stone drains, horseshoe tiles, and slotted plastic pipes. These drains remove water from permeable soils effectively. When rainfall occurs, artificial drainage is responsible for the movement of considerable amount of dissolved pesticides which may cause loss of about 1%.

Fate of pesticides in water: To know the circulation of pesticides in biosphere, it is important to study the transport and fate of pesticides . After being applying on land, pesticides meet up with a range of fates. The part of pesticides which are not taken up by crops or land would be retain in soil or degrade to some other form. Pesticides which are soluble would be passed away by water molecules particularly during rainfall and percolate downward in the layers of soil and then reach to groundwater or else, the insoluble one will be bound to the particles of soil and get collected in the top most layer of the soil. These accumulated particles have a high tendency to contaminate surface water, streams, lakes and rivers by erosion or runoff [29].

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IV.CONCLUSIONS

Pesticide enters the human body through inhalation, ingestion, or by penetrating into skin. But mostly the people get poisoned by consuming pesticide contaminated water or food. They accumulate in human tissues or storage compartments. Even though the body of human can excrete the toxic chemicals but sometimes it absorbs them in the blood vascular system. When these toxins concentrate in large amount in the body, they show adverse effects. The exposure to pesticides can cause hormonal disturbances, reproductive disorders, immune-suppression, reducing intelligence and also cancer [34,35]. The harmful effect of pesticide on human health can become visible in sometime or few days or they can be long term effects which may appear in months or years. Acute and chronic effects of pesticide exposure on human health are discussed below [36-38].

- Acute effects of pesticides: Instant reaction of pesticides show symptoms like itching, rashes, dizziness, headache, irritation in nose and throat, stinging of the eyes and skin, abdominal pain, diarrhea, vomiting, nausea, blindness, blurred vision and sometimes death. Acute effects of pesticide are not so harsh to look for medical help.

Chronic effects of pesticides: Chronic effects of pesticides may prove fatal and don't become visible for several years. These effects are life long and cause harm to more than one organ. Expose to pesticides for long periods have subsequent effects:

• The vulnerability to pesticides may affect neural health like vision problem, memory loss, loss of coordination, and problem in receiving motor signals.

• The long term contact to pesticide can damage immune system and may be the reason for hyper-sensitivity, allergy and asthma.

• Pesticide is known to cause cancer of testes, ovaries, breast and brain.

• Exposure to pesticides for a longer period alters the female and male reproductive hormones and affects their reproductive ability. As a result it causes birth defects, infertility, impulsive abortion and conceiving problems.

• The presence of pesticides in body for long time can cause blood disease, and may also destroy kidneys, lungs and liver.

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