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A REVIEW ON PESTICIDES POLLUTION IN AQUATIC ECOSYSTEM AND PROBABLE ADVERSE EFFECTS ON FISH

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ABSTRACT

With rapid industrialization and exponential growth in population the contamination of air, water, soil and food by the extensive use of chemicals and other toxic compounds has become a threat to the continued existence of livings. Agricultural run offs badly affect the quality of ground and surface water as they contain pesticides and fertilizer residues. Present review article was undertaken to compile information on pesticide pollution in aquatic ecosystem and probable effects on the fish health. Pesticide pollution is of major concern due to acute toxicity in fishes where sudden and intensified mortality occurs. Mortality data LC50 values of reviewed fishes were based on Finney's Probit analysis statistical method. Sub lethal concentrations of pesticide causes over all changes in the physiology, behavior, histology, hematology, defense mechanism etc. that becomes lethal to the fish. Certain banned pesticides are still being used in agriculture and other house hold practices having their serious impacts on the non target organisms therefore, concerted efforts along with rational use of pesticides and integrated pest management are considered as the main approach to reduce pesticide pollution in aquatic systems. More research should be performed to conclude the lethal and sub-lethal impact of the particular pesticide used on the survival and performance of non target invertebrate and vertebrate animals including fish health.

KEY WORDS : Pesticides, Pollution, Toxicity, Lethal, Sub lethal alterations.

INTRODUCTION

Water quality parameters are prime factors that influence the fish survival, growth, reproduction, physiology and overall behavior (Elchelberger and Liehleuberg, 1971).

Agrochemical pollution to the environment has become one of the major problems in the world (Chandrana *et al.*, 2005). Increased pesticide contamination of aquatic systems gained the attention of researchers all over the world (Dutta and Dalal, 2008) with much increase in the last few decades. Most of the used agrochemicals are not easily degraded but remain in the aquatic environment for considerable period of time, adversely affecting fishes and other aquatic fauna (Ramaswamy *et al.*, 2007).

Studies conducted in the lentic and lotic ecosystems have shown the presence of different pesticides including insecticides such as malathion, endosulfan, diazinon, etc. and herbicides atrazine and glyphosate (Thompson *et al.*, 2004) having a wide range of acute and chronic health effects including cancer, neurological damage, reproductive disorders, immune suppression, birth defects, physiological stresses and are also surmised as endocrine disruptors in aquatic organisms (Kodavanti *et al.*, 2008). Considerable information is available worldwide on the toxic effect of different pesticides on various aquatic organisms (Henderson *et al.*, 1959; Verma *et al.*, 1980; Nebeker *et al*, 1983; Haider and Inbaraj, 1986; Sunderam *et al.*, 1992; Berrill *et al.*, 1998; Wan *et al.*, 2005). Environmental pollution caused by pesticides belonging to class organophosphates, organochlorines, carbamates, pyrethroids and nitrogen containing hetero cyclic compounds in countries like Asia, Africa, America, Middle East and Europe is now serious problem.

About 4.6 million tons of pesticide chemicals sprayed annually, only 0.1% is effective; while the remaining 99.9% has the potential to affect different environment systems such as water, soil and atmosphere and finally absorbed by non target organisms (Zhang *et al*., 2011). Pesticide concentration in the water bodies as reported may reach up to dozens of milligrams per liter. Pesticide pollution level on the earth can be ranked as cropland > field ditch water > run off > pond water > ground water > river water > deep ground water > sea water (Lin *et al.*, 2000). In India Centre for science and Environment (CSE) drew the alarm of exceeding the concentration of organochlorines and organophosphates in almost all brands of bottled water (Narain, 2003). Fish is the most important vertebrate serving as food for humans. They have great economic, nutritional, medicinal, industrial, aesthetic and religious value. Fish provides employment for millions of people across the world. They contribute to food security in many regions of the world, providing a valuable supplement for diversified and nutritious diets. Fish is a rich source of protein, vitamins and polyunsaturated fatty acids which are known to provide protection against cardiovascular diseases. In aquatic ecosystem fish play an important role in nutrient cycles because they store a large proportion of nutrients in their tissues, transport nutrients farther than other aquatic animals and excrete nutrients in dissolved forms that are readily available to primary producers. In tropical aquatic ecosystems, fish population depletion would have serious implications in ecosystem productivity and could, therefore, jeopardize freshwater tropical fisheries.

Incidence of pesticides pollution in aquatic environment

Pesticides pollution can occur when agricultural, industrial, commercial waste discharge enter into the aquatic environment, leaching to the ground water systems or volatilizing to the atmosphere, some of these chemical compounds persist in soil and sediments for decades. Pesticides are typically persistent in the environment and their main sink is rivers through drainage system and surface runoff having affinity for sediments. Kingsburg and Kreuzweiser (1980) reported that standing water bodies has higher pesticide pollution than lithic biotopes and water column, while its concentration is almost negligible in sediments.

Studies conducted to observe adverse effects of pesticide on Fish

Fishes are exposed to chemical contaminants due to direct contact of integuments, through mouth and by respiration through gills. Acute toxicity of chemical contaminants shows potential hazards to the aquatic organisms as reported by John (2007) in *Heteropneustes fossilis* and *Ophiocephalus striatus*, in fresh water fish *Nemacheilus botia* Nikam *et al*. (2011). Toxicity to agrochemicals in fish may be due to differential physiological responses i.e., detoxification, absorption, and excretion capacities (Viran *et al*., 2003). Thompson and Schuster (1968) noted that toxic effects by agrochemicals on behavioral level help ecologists and environmentalists in two ways: (a) agrochemicals that only produce behavioral changes having serious and possibly irreversible deleterious effect on the organism's ability to adapt to stress, can be identified and controlled, (b) behavioral alteration by agrochemicals can be considered as early warning sign before irreversible structural and biochemical damage are caused. Ewing (1999) reported that acute toxicity of pesticides is capable of killing salmonids fishes and other aquatic organisms within short period of time. In 1996 the herbicide acrolein alone killed approximately 92,000 steel-head, 114 juvenile coho salmon, 19 resident rainbow trout, and other thousands of non-game fishes in Rogue river basin of United States.

Pesticide and behavior of fishes

Mortality is not the only end point of lethal effect of chemical toxicants but abnormal behavioral responses are one end point to these chemical toxicants considered recently by ecotoxicologists (Little and Brewer, 2001; Hellou, 2011). Behavior is regarded as the physical illustration of the animal's internal neuronal, endocrine and metabolic processes essential for life (Smith and Weis, 1997; Perez and Wallace, 2004) operating in combination with both central and peripheral nervous systems (Baatrup, 2009; Gravato and Guilhermino, 2009). It allows an organism to adjust both environmental and internal stimuli to challenges life in an altering environment. Behavioral disturbance may be observed in aquatic biota at the concentration of contaminants present in the field. Fishes are ideal sentinels for behavioral assays of chemical toxicants and stressors due to their direct contact with the aquatic environment (Little *et al.*, 1993; Omitoyin, 2007). The behavioral patterns vary widely with different fish species and exposure conditions. Environmental contaminants alter behavioral responses like avoidance, locomotor activity and aggressiveness in fishes to escape or to adjust to the stress conditions (Morgan *et al.*, 1999; Gormley *et al.*, 2003).

In the behavioral study various scientists have studied the in vitro effect of different toxicants on the fishes. Rao *et al*. (2003) reported that *Oreochromis mosambicus* showed abnormal behavior like erratic swimming, loss of equilibrium and abnormalities to the gill lamellae followed by necrosis were evident after exposure to chlorpyrifos. Levin *et al.*, (2003) reported that exposure of zebra fish to chlorpyrifos for 18 weeks of testing caused significant impairment in learning behavior and swimming speed. Chlorpyrifos also caused persistent neurobehavioral impairment in zebra fish with tests conducted on sensomotor response, stress response and learning after embryonic exposure to 100 ng/ml of chlorpyrifos for 5 days as reported by Sledge *et al.* (2011). Halappa and David (2009) reported that chlorpyrifos reduced the ability of *Cyprinus carpio* to adapt to the environment by increasing the time required to learn to escape the external noxious stimuli and also interfered with the previously learned behavior. Chemical toxicants also cause change in operculum beat frequency (OBF) and tail beat frequency (TBF) as reported by Bhavika (2013) in *Oreochromis mossambicus* and *Labeo rohita* on exposure to imidocloprid and curzate. The behavioral response to the agrochemicals with marked decrease in rate of OBF and TBF is due to adjustment as a result of stress (Gibson and Mathis, 2006). Respiration is regulated by internal as well as by external environmental stimuli (Schmidt *et al*, 2005; Patil and David, 2008). Shahi and Singh (2011) reported similar abnormal behavioral changes in *Channa punctata* when exposed to sub-lethal doses of Rutin, teraxerol and apigenin for one week. Susan *et al*. (2010) also reported behavioral changes like swimming on the surface of water, loss of equilibrium, hyper excitation and increase in mucus secretion in Indian major carp *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala* on exposure to fenvalerate pesticide. Alteration in the swimming behavior results in increased expenditure of energy (Venkata Rathnamma *et al.*, 2008) which leads to hyper-excitation. Hyperactivity is primary and principal sign of nervous system failure which alters physiological and biochemical activities in fishes (Matsumura, 1975). Similar results were reported in fishes *Channa striatus* (Yadav *et al.*, 2007) and in *Clarias gariepinus*, *Heterobranchus bidorsalis* (Ekweozor *et al.*, 2001; Bobmanuel *et al.*, 2006) after exposure to chemical toxicants like jumping, increased opercular beat, and tail beat frequency depending on the concentration of chemical toxicant present.

Pesticide and Hematological changes in fishes

Lethal and sub-lethal concentrations of various pesticides induce hematological changes like red blood cell (RBC), white blood cell (WBC) count and histology of blood cells. Adhikari *et al*. (2004) and Saxena and Seth (2002) reported decrease in RBC count on exposure of *Labeo rohita* and *Channa punctatus* respectively to cypermethrin. Gautam and Kumar (2008) reported decrease in total erythrocyte count, haemoglobin concentration (Hb) and packed cell volume (PCV) in *Channa punctata* on exposure to nuvan. Qayoom *et al.*, (2018) reported exposure of dimethoate and chlorpyrifos induced change in hematological parameters *i.e.*, Hb, RBC, mean corpuscular volume (MCV), and mean corpuscular haemoglobin (MCH) and were found to be lower than control whereas WBC count was found to be higher than control, similar results were reported by (Yakeen and Fawole, 2011) in *Clarias gariepinus* on endosulfan exposure. Other workers also reported similar hematological changes in different fishes *Mystus keletius*, *Oreochromis mossambicus* and *Channa punctatus* (James *et al.*, 1993; Sampath *et al.*, 2003; Huda *et al.*, 2016).

Histopathological alteration in fish

Various organs, gills, muscles, brain, liver, kidney, ovary and blood vessels were studied to trace histopathological changes by researchers. Histopathological alterations are used as biomonitoring tool or indicator of health in toxicity studies (Hendricks *et al.*, 1985; Hinton *et al.*, 1992; Teh *et al.*, 1997; Vander Oost *et al.*, 2003). Furthermore, alterations are easier to identify in these organs (Fanta *et al.*, 2003) and are considered as warning signs of damage in these organs (Hinton and Lauren, 1990; Ortiz *et al.*, 2003). Gills are highly vulnerable as they directly come in contact with toxic chemicals present in water. Their greater surface area and absorption facilitates grater toxicant interaction as here detoxification system is not as robust as that of liver (Mallat, 1985; Evans, 1987). Gills are commonly used to assess the impact of different pollutants in marine and freshwater habitats (Haaparanta *et al*., 1997; Craig *et al*., 2007; Fernandes *et al*., 2007). As we are well aware gills not only are important for gaseous exchange but also for osmoregulation and excretion of toxic wastes (Roberts, 2001). Thus any harm to the gills leads not only to impairment in gaseous exchange, but also alterations in excretion and osmoregulation (Dobreva *et al*., 2008; Arnaudova *et al*., 2008). Bhavika (2013) reported imidocloprid and curzate caused necrosis, proliferation and degeneration in gill filaments and in secondary lamellae of *Oreochromis mossambicus* and *Labeo rohita.* Alterations like proliferation of epithelial cells, partial and total fusion of secondary lamellae and lifting of epithelium are considered as defense mechanism as this would result in increased distance between external environment and body fluids (Fernandes *et al*., 2007; Fatma and Mohamed, 2009). Jayachandran and Pugazhandy (2009) reported atrazine exposure to *Labeo rohita* caused histological changes in the gill tissue like epithelial hyperplasia, curling of secondary lamellae and changes in chloride cells besides these changes pyknotic nuclei, vacuolization, degradation of epithelial cells and pillar cells. Butchiram *et al*. (2009) reported that exposure of *Channa punctatus* for 10 days to sub-lethal concentration of herbicide alachlor histological changes like necrosis, vacuolar degeneration, fusion and atrophy of primary and secondary lamellae were recorded, similarly degeneration of cytoplasm of hepatocytes, vacuole formation, and blood vessel rupture like changes were observed in liver. Earlier reports from Sinhaseni and Tesprateep (1987); Alazemi *et al*. (1996) and Erkmen *et al*. (2000) also showed histological changes in the gills of different fish species exposed to pesticides.

The teleostean kidney is among the first organs exposed and damaged by contaminants (Thophon *et al*., 2003). Kidney not only helps in excretion of wastes but also maintains pH, volume of blood and body fluids. Bhavika (2013) reported that on low dose exposure of imidacloprid to *Oreochromis mossambicus* kidney tissues showed complete degeneration of blood vessels in the glomeruli and at high dose there was complete degeneration of tubular epithelial cells and complete disorganization of Bowman's capsule. Low dose of Curzate caused mild necrosis and shrunken glomeruli however at high dose the kidney lost its normal histoarchitecture. Visoottiviseth *et al*. (1999) reported glomerular and tissue lesions in kidney of *Oreochromis niloticus* after triphenyltin hydroxide exposure. Kidney not only is a good indicator of environmental pollution but also acts as primary osmoregulatory organ and also functions in cellular immunity (de Bravo *et al*., 2005). Therefore any histological changes in the kidney induce defense changes harming animal's homeostasis and health (Zapata and Cooper, 1990).

Deka and Mahanta (2012) reported that sub-lethal exposure of malathion decreased ovarian weight, growth of pre-vitellogenic oocytes and also changed histology of liver and kidney of *Heteropneustes fossilis*. Mlambo *et al*. (2009) reported that DDT induced no significant changes in the gonadosomatic index of exposed and non-exposed male and female adults of *Oreochromis mossambicus*, but exposure reduced survival and increased deformities in larvae. Decrease in gonadosomatic index, reduction of follicular diameter and increase in atretic follicles was reported in *Channa orientalis* after sub-lethal exposure of nuvan (0.27 mg) and dimecron (0.55 mg) for a period of 30-40 days (Saksena and Saxena, 1999).

Change in protein content

Protein is an indispensable constituent required in tissue building and is important source of energy during chronic conditions of stress (Remia *et al*., 2008). Bakthavalsalam (1980) and Ramani (2001), reported decline in protein content of different fish organs exposed to pesticides. Physiological status of organisms is usually indicated by metabolic status of proteins (Nelson *et al*., 2005; Magar and Shaikh, 2012). Dalela *et al*, (1981) reported decrease in protein content in *Mystus vittatus* on pesticide exposure and reported that decrease might be due to kidney failure or impairment in protein synthesis as a result of liver disorder. Dubhat and Bapat (1984) and Parmar and Patel (1993) reported maximum decrease in protein content in liver of *Channa orientalis* and *Baleopthalmus dussumieri*. Arunachalam *et al*. (1990) reported that decrease in level of protein, carbohydrate, lipid content of muscle, liver, intestine and gill of *Mystus vittatus* on exposure to malathion, thiodon and carbaryl. Similar observations were made by Sheela and Muniandy (1992) in *Channa striatus* after exposure to sub-lethal concentration of phosphamidon. Jaroli and Sharma (2005) reported alteration in protein content in *Channa punctatus* when exposed to chlorpyrifos and reported reduction may be due to stress conditions.

Venkataraman *et al.*, (2006) reported decline in protein content in *Glossogobius giuris* while studying metabolic dysfunctioning on exposure to malathion. Lakshmanan and Rajendran (2013) reported that on exposure to dichlorvos *Oreochromis mossambicus* showed significant decrease in the protein content of liver, kidney and muscle, and suggested that decrease in protein content might be due to the proteolysis thereby contributing free amino acids to meet the stress conditions. Decrease in protein content also suggests impairment of protein synthesis or increase in degradation of protein to free amino acids, which can result in the production of free amino acids for tricarboxylic acid cycle for energy production (Naveed *et al.*, 2010; Ganeshwade, 2011). Works from Aniladevi (2008); Varadarajan (2010); Al-Kahtani (2011) on *Oreochromis mossambicus* and Sivaperumal (2008); Indirabai *et al.*, (2010); Rajput *et al.* (2012) on *Labeo rohita* showed depletion in protein content. Decrease in protein content was found to be maximum in liver followed by muscle, kidney, gills respectively, the decrease in protein content of both fishes suggested metabolic calibers of individuals tissues (Satyanarayana, 2005; Venkataramana *et al.*, 2006). Tripathi *et al.*, (2003) reported exposure of *Channa punctatus* to dimethoate caused depletion in protein level similar observation were reported by Singh *et al*. (1996) in fresh water cat fish *Heteropneustes fossilis* after sub-lethal exposure to aldrin. The depletion of cellular protein content might be due to one or more of the following factors: Inhibition of free amino acids incorporation for protein synthesis during translation, breakdown of complex proteins into free amino acids and diffusion of free amino acids out of the cell. The decline in protein content is due to repair mechanism and detoxification mechanism during stress conditions.

Increase in blood glucose level

On sub-lethal and acute exposure of pollutants blood glucose level increase is the quick response (Luskova *et al*., 2002; Sepici-Dincel *et al*., 2009). As stated by Wedemeyer and Mcleay (1981) increase in blood glucose level is a response of carbohydrate metabolism disturbance due to physio-chemical stress. Pesticide contaminants are well known to stimulate adrenal gland resulting in increased level of gluco-corticoids (Hontela *et al*., 1996) and catecholamines. Both hormones are well known for hyperglycemia. Dose dependent increase in blood glucose level in *Oreochromis mossambicus* and *Labeo rohita* on exposure to imidacloprid and curzate (Bhavika, 2013), well supported by findings of Omoregic *et al*. (1990); Haggag, (2004), Sweilum, (2006), Venkataramana *et al*. (2006). Increase or decrease in blood glucose level indicates environmental conditions in which fish is present (Abdel-Baky, 2001). Hyperglycemic condition induced by pesticide might be due to inhibition of cholinesterase (De Aguiar *et al*., 2004) in the adrenal gland leading to hypersecretion of cortisol which stimulates conversion of glycogen to glucose by glycogenolysis (Witold *et al*., 2007; Logaswamy and Remia, 2009) or the increase may be due to enhancement of the breakdown of liver glycogen as supported by Bakhshwan *et al*. (2009). Hyperglycemic condition arises as physiological response to meet energy crises under stress.

Alter Enzyme activity of fishes

Change in the activity of enzymes is often related with changes in many other metabolic functions and thus represent over all physiological alterations in the organisms. Change in activity of Aspartate aminotransferase (AST) and Alanine transaminase (ALT) in fishes are frequently used as an indicator of toxicant and contaminants present in the aquatic systems (Kim *et al*., 2008; Hedayati *et al*., 2010). Both AST and ALT are liver specific aminotransferases and are indicators hepato-toxicity (Balint *et al*., 1997). Pesticide exposure caused change in AST and ALT activity as reported by Begum (2005) and Gabriel *et al*. (2012). Acute toxicity due to deltamethrine has been reported to increase AST and ALT in *Oreochromis niloticus* (Velisck *et al*., 2006; Velisck *et al*., 2007). Sivaperumal and Sankar (2013) reported that acute exposure of *Labeo rohita* to methylparathion caused increase in liver ALT and AST activity. Imidacloprid and curzate caused change in ALT activity in *Oreochromis niloticus* and *Labeo rohita*, with significant elevation in liver and kidney as reported by Bhavika (2013). Increased activity of ALT clearly indicates that the attempt to overcome pesticide toxicity with increased operation of transamination or increased synthesis of amino-acids, indicating that stress brings metabolic reorientation in the tissue by increasing energy resources by transamination. Studies by Rao (2006); Arshad *et al*. (2007); Velmurugan *et al*. (2008) and Gabriel *et al*. (2012) reported that increased transaminase activity was due to increased utilization of amino acids for energy synthesis. Ram and Singh (1988) reported increase in alkaline phosphate and acid phosphate activity of liver in *Channa punctatus* on exposure to carbofuran, similar observations were reported by Jyothi and Narayan (2000) in tissue and serum of *Clarias batrachus*. Significant increase in alkaline phosphatase activities were reported in liver, kidney, gills, muscle of *Oreochromis mossambicus* and *Labeo rohita* on exposure to imidacloprid and curzate (Bhavika, 2013). Elevation in the alkaline phosphatase may indicate renal and liver damage (Gill *et al*., 1990; Bhattacharya *et al*., 2005; Vardharajan 2010; Stalin and Das, 2012). Shakoori *et al*. (1994) reported that increase in enzyme activity of liver leads to damage of cells and finally to necrosis. Villatte *et al*. (1998) reported that enzyme acetylcholinesterase is more susceptible to a broad range of organophosphates and carbamates than other enzymes. Crude oil also inhibits acetylcholinesterase activity in brain homogenate extract of *Oreochromis niloticus* (Rodriguez-Fuentes and Gold-Bouchot, 2000). Rudragouda *et al*. (2009) reported that cypermethrin at different concentrations and exposure periods showed inhibitory effect on acetylcholinesterase activity and maximum inhibition was observed in brain followed by muscle, gill and liver. Following single and multiple in vitro exposure of chlorpyrifos and carbosulfan significant decrease in cholinesterase activities in brain and liver tissues of *Oreochromis niloticus* was observed (Chandrasekara and Pathiratna, 2007). Preshant (2008) reported that cypermethrin caused disruption in enzyme activities of aspartate aminotransferase, glutamate dehydrogenase in gills, liver and muscles of *Cirrhinus mrigala*. Goel *et al*. (2005) reported that chlorpyrifos toxicity caused significant reduction in glutathione catalase and glutathione-S-transferase activity.

Induces chromosomal aberration and carcinogenic effect

Exposure to different chemicals leads to chromosomal aberration. Rishi and Grewal (1995) observed chromatid gaps, sub-chromatid gaps, centromeric gaps, precocious separation and polyploidy etc. in kidney cells of *Channa punctata* on exposure to dichlorvos. Saxena and Chaudhari (2010) reported similar chromosomal abnormalities in the kidney cells of same model organism on exposure to synthetic pyrethroid fenvalerate. Dichlorvos toxicity has been related to alteration in DNA replication which causes mutation and cellular hyperproliferation as a result of local mutation (Gilot *et al*., 1983), all these factors are responsible for hepatocarcenogenecity (Mirsalis *et al*., 1989). DNA damage repair took place slowly in fish compared to mammals as reported in cancer resistant fish *Fundulus heteroclitus* when assayed for its ability to genomic damage repair by alkylating agent (Espina and Weis, 1995). Ultra-structural biomarkers study of gills, liver and kidney of brown trout, stone loach can be correlated with the pollution status of the fish environment based on cellular damage study in fish, and they are regarded as sentinel organism (Gernhofer *et al*., 2001). Mutagenic pollution investigation was performed using piscine micronucleus tests in two fresh water fish species, *Astyanax bimaculatus* and *Hoplias malabaricus* (Pantaleao *et al*., 2006). Similarly different tests were conducted like sister chromatid exchange test (Sahoo *et al*., 1998), DNA repair synthesis (Grummt, 2000). Environmental pollutants may act as main cause of carcinogenesis which reduces growth and finally decreases rate of survival due to abnormal development, body deformation etc (Ericson and Larsson, 2000; Akpoilih, 2012).

Changes in immune system and endocrine system

Pesticides show serious ill impacts on the immune system leading to the diseases initiation and finally to death of the organism (Halloran *et al*., 1998) and also cause disruption in endocrine system making developmental consequences in the early or later stages of growth (Kamble *et al*., 1999). Steenland *et al*. (1997) reported that environmental chemicals like ethylene thiourea are known to cause decrease in thyroxine and increase in thyroid stimulating hormone. Waring and Brown (1997) reported increased plasma T3 and T4 leads to dysfunctioning of the thyroxine target organ in female *Salmo trutta*. Pesticides also block sex hormones causing irregular or abnormal sexual development and also disrupt mating behavior (Baatrup and Junge, 2001; Hoeger *et al*., 2005). Pesticides can also disrupt other hormone related processes in the body like development of the bones and functioning of thyroid gland (Murthy *et al*., 2013). When fish are exposed to stressors the level of thyroid hormones has been demonstrated to decrease (Deane *et al*., 2001). Exposure of *Labeo rohita* to dimethoate and lambda cyhalothrin causes decrease in the level of triiodothyronine and thyroxine but increase in thyroid stimulating hormone level (Dey and Saha, 2014).

CONCLUSION

Many pesticides are not legally registered for application but still are found in different aquatic systems. Vast variety of pesticides introduced in the aquatic systems and there toxicity is primarily identified through single species toxicity testing in the laboratory by many researchers. These kinds of tests primarily highlight the need of techniques that not only detect the damage caused by pollutant but also detect the biochemical and physiological impairment. Present review shows considerable amount of chemical pollutants from industry, urbanization and from agricultural practices are entering aquatic systems posing great threat to fish and other aquatic species. Environmental stressors exert adverse effects at the organism's level leading to the disruptive physiology of organisms along with tissue damage, growth retardation, genotoxicity, reproductive disturbance, tissue bioaccumulation.

Experimental studies reveal that pesticides are potent to cause toxic effects, structural alterations in non target organisms like fishes. Therefore concerted efforts required in reducing the use of chemical pesticides. Implementation of natural methods for pest encroachment through organic farming can help in reducing pesticide pollution. Besides, regular biomonitoring to know the hazards caused by them, there is need of research that would give early warning signals of the pollution of particular pesticides in the aquatic systems. Therefore the researches that could provide early warning signals are essential to control and minimize the hazards caused by them on non target species.

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