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A REVIEW ON ADVERSE EFFECTS OF ORGANOCHLORINE PESTICIDE AND OTHER RELATED CHEMICALS ON VERTEBRATE BIODIVERSITY

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ABSTRACT

Globally organochlorine (OC) pesticides are synthetic pesticides and widely used for controlling of pest in agriculture field and assumed to be having adverse effects on vertebrate biodiversity. Pesticides experience leads to effects on non-target living organisms, and fish being one of the most important examples among these. Acute absorption of chlorinated pesticides leads to increased death ratio, while secondary toxic concentration caused different lethal changes. These changes may be in behaviour of the exposed fish in aquatic bodies such as change in feeding, reproduction, and some histological changes in liver, kidney, gill, muscle and intestine. The lipophilic nature of fish muscle tissues in aquatic ecosystem, higher level of OCs measured in fish muscle tissue through gas chromatography and other advanced chromatographic techniques with the help of detectors. Organochlorine pesticides and their related chemicals are accumulated in animal's bodies through food chain and food web. Some organochlorine pesticides reduced the cholinesterase activity of amphibians and reptiles. Several studies were reported that number of non-target species can be affected when pesticides are used because of their inhibition of cholinesterase activity. Small levels of organochlorine were also observed in the tissues and blood samples of birds species. In this review we summarizes the some adverse effects of the use of organochlorine pesticides and related chemicals in the selected vertebrate biodiversity.

Keywords: Organochlorine, pesticides, amphibian, fish, reptile, bird.

INTRODUCTION

The presence of chemicals in the environment has become a global issue (Khan and Law, 2005). In the modern age, the human population is being growing swiftly. Due to increasing of human population forest areas are destructed used for the construction, affecting ecological stability (Ullah, 2014). Some pesticides and related chemicals are found in the terrestrial and aquatic ecosystems and have the potential to adverse affect on the natural communities with (Ali *et al*., 2011). We are facing emerging and increasing problems of pollution (Klumpp *et al*., 2002). These pollutants are household, industrial and agricultural wastes such as chemicals used in agricultural field (Naeem *et al*., 2010; Abu-Darwish *et al*., 2011). Those pollutants are supplemented with unusual pesticides, carbon containing compounds and heavy metals such as Mg, K, Zn etc (Jabeen *et al*., 2011). The changed aquatic quality due to pollutants can adversely affects to fish, amphibian and other organisms (Sabae *et al*., 2014; Abedi *et al*., 2013).

In the agriculture use of pesticides have increased adverse effects on biodiversity (Garces *et al*., 2020). Studies shows some pesticides can have effects on aquatic ecosystem and directly or indirectly on the normal life cycles of animals (Ali *et al*., 2011). In the aquatic environment pesticides are caused physiological changes in the organisms (Khan and Law, 2005; Ali *et al*., 2011).

In the agriculture field the use of pesticides for high agricultural production has led to increased environmental pollution and adverse effect to biodiversity (Jayaraj *et al*., 2016). Classification of pesticides is mainly based on nature of chemical, application requirement and target organism. Classification of chemical nature based pesticides is given in Table 1 (Jayaraj *et al*., 2016).

Organochlorine are one of the important classes of chlorinated hydrocarbon, it is widely used since the 1940s -1960s in the agricultural field. The monitoring of OCPs in the ecosystem is of great value because of their perseverance, bioaccumulation and effects on both mankind and wildlife species (Vos *et al*., 2000). Organochlorine chemicals have been implicated in reproductive harm and changed immune functions (Köhler and Triebskorn, 2013). Conversely, ecological concentrations are still high and can cause a probable health risk (Van den Steen *et al*., 2009). Khan and Law

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(2005) conducted a research study and reported that development of mammals, amphibians, fish and birds may have been impacted by chemicals that interact with the endocrine system.

Table 1. Chemical Nature based Classification of Pesticides.

S. No.	Group	Chemical names
1	Organochlorines	DDT, DDD, Dicofol, Eldrin, Dieldrin, Chlorobenziate, Lindane, BHC, Methoxychloro Aldrin, Chlordane, Heptaclor, Endosufan, Isodrin, Isobenzan, Toxaphene, Chloro propylate
2	Organophosphates	Dimefox, Mipafox, Methyl Parathion, Ronnel, enitrothion, Bidrin, Phorate, Fenthion, caumphos, Abate, Dichlorovas, Diptrex, Phosphomidon, Demetox, Oxydemeton-methyl, Malathion, Dimethoate, Trichlorofan
3	Carbamates	**Methyl** Carbaryl, Carbanolate, Prupoxur, Dimethan, Dimetilan, Isolan, Carbofuran, Pyrolan, Aminocarb, Aldicarb **Thio** Vernolate, Pebulate, Diallate, Monilate, Butylate, Cycloate, Trillate, Thiourea **Dithio** Methan, Thiram, Ferban, Amoban, Naban, Zineb, Maneb, Ziram Polyran, Dithane M-45
4	Pyrethroids	Allethrin, Bonthrin, Dimethrin, Tetramethrin, Ptrethrin, Cyclethrin Furethrin, Fenevelerate, Alphamethrin, Decamethrin, Cypermethrin
5	Phenyl amides	**Carbanilates** Barban, Carbetamide, Chlororprofan, Prophan, Phenyl Urea, Fenuron, Monuron, Diuron,Flumeturon, Chloroxuron, Neburon, Bromuron **Acylanalide** Propanil, Solan, Dicryl, Karsil, Propachlor, Alachlor, Butachlor **Toluidines** Trifluralin, Dipropanil, Benefin, Oryzalin, Isopropanil, Nitralin **Acetamide** Diphenamid
6	Phenoxyalkonates	2,4-D(2,4 Dichloro phenoxy acetic acid) 2,4 5 T(2,4 5 Trichloro Phenoxy acetic acid) Dichloroprop, Mecoprop, Erbin, Sesone
7	Trazines	Atrazine, Simazine, Ametryn, Atratone, Chlorazine, Cynazine, Cyprazine, Metribuzin, Propazine, Turbutryn, Simetryn
8	Benzoic acid	Dicamba, Dichlorobenil, Chloroambin, Tricamba, Neptalan, Bromoxynil
9	Phtalimides	Captan, Diflotan, Folpet
10	Dipyrids	Paraquat, Diaquat
11	Others	Pentachlorophenol, Floroacetate, Phenyl mercuric acetate, Ethyl mercuric Phosphate, Methyl mercuric chloride, Sodium arsenate, Calcium arsenate, Lead arsenate, Cacodylic acid, Aluminium phosphide, Zinc phosphide

Effects on Fish

Several studies shows pesticides were directly affected to fish behavior, physiology and reproduction (Kegley *et al*., 1999). Occurrence of pesticides in water bodies is assessed by identifying three main routes. Three routes are water column, organic substrates such as mosses, algae and leaf litter etc and third route is inorganic substrate including sediments material of different size (Murthy *et al*., 2013; Kosygin *et al*., 2007; Sarkar *et al*., 2008). Some studies have shown that fish sampled collected from the USA agricultural areas contained detectable levels of agricultural chemicals. In particular, high levels were detected in fish samples collected from the Los Angeles and San Diego harbours and the Sacramento and San Joaquin Rivers (US EPA, 1992). Another study Singh *et al*. (2005) detected the haphazard and careless use of OCs have led to the pollution of water (rivers and estuarine) bodies resulting in high of OCPs concentration levels in aquatic animals such as prawns, otters, cat fish and shrimps etc.

In an earlier study Jana and and Byopadhyaya (1987) observed that liver, kidneys, brain and gills of a fish are the most susceptible organs exposed to the medium contain any type of toxic chemical. So for this reason, this result was compared with Haider and Inbaraj (1986)

stated that fish show restiveness, swift body movement, convulsions, respiration problem, more mucous secretion, change in coloration, and changes in behavior are also observed. Another study Saqqib *et al*. (2005) reported that the residues of dieldrin, DDE and aldrin in fish tissues of fresh water. Jabber *et al*. (2001) also reported about presences of DDT, aldrin, dieldrin, lindane, heptachlor and DDT in the fish organs.

For determining the effects of pesticides and related chemicals on aquatic organism, biological method is used, *in situ* bioassays (Akcha *et al*., 2003; Pandey *et al*., 2011; Kushwaha *et al*., 2012). This analysis is on the basis of exposing the trial animals to the field without disturbing the contaminated sediment. After exposing, survival proportion of test animal is determined. Occasionally, when the water line is too deep, dampen cages are used for griping the fish in water column (Dey and Saha, 2014). For the determination of pesticide contents, the solid tissue of animals were used. Solid materials are firstly homogenized and then extraction phase is done by acetone/ hexane, then evaporated into a small volume by the help of cleaning and drying process, and finally analyzed by different chromatographic techniques (Hong *et al*., 2003; Hong *et al*., 2006; Hong *et al*., 2008).

Pesticides significantly decrease large quantity of food in aquatic bodies and environment which is essential for fish survival (Helfrich, 2009). By this means pesticides indirectly entered in the fish food chain and change the territory of aquatic bodies (Maskaoui *et al*., 2005; Chau, 2005). Another research study Rao and Pillala (2001) reported that some pesticides are directly affected to fish body. In addition, it can also make the fish vulnerable to predators in water bodies by declining environmental suitability and altering their behavior as well, which is a direct effect as a result of indirect effect (Prashanth *et al*., 2011; Gill and Raine, 2014). Outcome, have shown that indirect effect can be more crucial than the direct effect (Murthy *et al*., 2013). Pesticides stimulate different types of toxic actions in water bodies of fish such as changes in fish behavior, swift movement, excess mucous secretion etc (Satyavardhan, 2013).

Effects on Amphibians

In the aquatic ecosystem amphibians are important components. Global decline of amphibian populations is associated with climate change and anthropogenic activities including using of pesticides (Fagotti *et al*., 2005). The health of amphibians can effected from exposure of pesticides (Harfenist *et al*., 1989; Khan, 2004).

Amphibians are exposed to pesticides indirectly as non-target species and inhibited cholinesterase activity in Frog *Rana tigrina* (Khan, 2004; Khan *et al*., 2002a,b and 2003a) and *Rana cyanophlyctis* (Khan *et al*., 2003b,c,d; Khan and Yasmeen, 2005; Khan *et al*., 2006; Khan *et al*., 2007).

Several studies reported that sub lethal effects of some pesticides are shows as delayed metamorphosis, reproductive problems, reduced size, deformities and depressed immune systems (Mann *et al*., 2009; Wagner *et al*., 2013; Christin *et al*., 2013; Hayes *et al*., 2010). Studies shows metabolism of DDT cause decrease in CYP26 gene and protein expression and decrease growth rate in amphibians (Relyea, 2005). Another study Fagotti *et al*. (2005) have been detected the level of organochlorine pesticides in the tissues of frog Species *Pelopylax esculentus* and *Pelopylax lessonae*.

Effects on Reptiles

As Crocodiles are top predators, can bioaccumulate high concentration of organochlorine pesticides in their fat due to their habitat in food chains (Campbell, 2003) that may have toxic acute effects on their physiological systems. Recently due to illegal uses of OCs in Mexico City could affect the American crocodile (*Crocodylus acutus*), which are already exposed by other factors. Researchers analyzed about 16 OCs compounds by using gas chromatography and electron capture detectors in seven infertile eggs and nine in the nests substratum of American crocodiles in Banco Chinchorro. Ecosystems get polluted by industries, agriculture and household pollutants are the major threats to reptilian protection (Gibbons *et al*., 2000). Some biochemicals, such as organochlorine pesticides can caused problems in the normal functioning of the reptilian endocrine system which may lead to reproductive, immunological, behavioral, and developmental disorders (Keller *et al*., 2005; Burger, 2005; Willingham, 2005). Organochlorine pesticides have been prohibited in most industrial countries after decades, mainly DDT (1,1,1- trichloro-2,2-bis(4-chlorophenyl) ethane is still stocked and certified for use in most progressive tropical countries for control on vector borne disorders (van den Berg, 2008). Organochlorine pesticides remains have been found cosmopolitan in air, residue, snowfall, earth, water, and flora and fauna (at high altitudes and latitudes) around the globe (Grimalt *et al*., 2001; Zitko, 2003). Pesticides have been analyzed in reptilian blood plasma, eggs, muscle tissues, internal organs, their fat and scutes in different Species (Campbell, 2003) (Table 2). In addition, OCs can alter the standard sex ratio of growing Crocodile species (Milnes *et al*., 2005).

The largest aquatic Snapping turtle (*Chelydra serpentina*) occurring in Canada. Snapping turtle eggs contain high concentrations of fat-soluble contaminants from Great Lakes. These include OCPs, PCBs, dioxins, and furans. Abnormal growth, such as unhatched eggs or distorted fauna is increasing in the contaminated region (Shirose *et al*., 1995). Due to rapid failing status of aquatic reptiles

(turtles and tortoises) in Southeast Asia has resulted in an increasing quantity of reptilian species being threatened listed as in the IUCN Red List (IUCN, 2020). Pesticides are also reduced protein contents and cholinesterase in Agama lizard *Calotes versicolor* (Khan, 2002a,b).

Table 2. Crocodilian Species in which Organochlorine residues have been detected.

Species	Location	Tissues analyzed
Crocodylus niloticus (Nile crocodile)	Zimbabwe, Africa Zimbabwe, Africa Kenya, Africa	Egg Egg, Embryo, abdominal fat Body fat
Crocodylus acutus (American crocodile)	Florida, USA	Eggs
Crocodylus porosus (Saltwater crocodile)	Belize, Central America Costa Rica, Central America	Egg contents Scutes
Crocodylus moreletii (Morelet's crocodile)	Belize, Central America Campeche, Me´xico	Egg contents Eggs
Crocodylus johnstoni (Freshwater crocodile	Northern Territory, Australia	Intraperitoneal fat
Caiman crocodilus (Spectacled caiman)	Surinam, South America	Brain, Liver
Alligator mississippiensis (American alligator)	Florida, USA	Eggs

Effects on Birds

Due to adverse effects of some organochlorine pesticides birds are decline (Cox, 1991). Through sprayed of pesticide, birds can be directly exposed or can be exposed by consuming food with the pesticide on it. Some time birds can be indirectly impacted if their prey-base is adversely affected. Several earlier studies indicated that a decline in invertebrates can lead to a decrease in the food that is available for birds and could have negative impacts for health and nesting success (Mineau, 2005).

Flickinger *et al*. (1991) conducted a research study on the poisoning of Canada Geese in Texas by pesticide parathion sprayed for control of Russian wheat aphid and reported that brain cholinesterase activity was reduced by 62 and 77% below normal in two Geese collected at the mortality area compared to that in control. Pesticides that inhibit the neurotransmitter hydrolysing enzyme acetylcholinesterase in birds species, and affecting to physiological functions and behavioural changes (Burn, 2000).

Post exposure of some pesticides reduced cholinesterase level on birds (Mineau, 1993). Organochlorine pesticides also have been found in the tissues and blood samples of vulture species from different regions in South Africa. Canadian researchers identified that some pesticides as the best predictor of grassland-bird declines in the USA, followed by loss of cropped pasture (Mineau and Whiteside, 2013).

CONCLUSION

Based on reported studies use and misuse of organochlorine pesticides were affect on vertebrate biodiversity directly or indirectly through accumulating in the food chain and ecosystem. Toxicity of organochlorine pesticides is influenced by species, sex, age, and stress of diverse kinds, and many additional factors. Most OCPs, mainly DDT, aldrin, dieldrin, and heptachlor etc. are more poisonous for use in the surroundings, particularly for the most sensitive species of ecosystem. The most chemicals could be a major threat to many species of fish, amphibians, reptiles and birds, also aquatic system by diminishing production and fecundity. We concluded that adverse effects can cause major population decline of fish, amphibians, reptiles and birds.

REFERENCES

Ali, S., Shieh, BHH., Alehaideb, Z., Khan, MZ., Alvin Louie., Noor Fageh. and Law, F. 2011. A Review on the Effects of Some Selected Pyrethroids and Related Agrochemicals on Aquatic Biodiversity. Canadian Journal of Pure and Applied Sciences. 5(2):1455-1464.

Abu-Darwish, MS., Al-Fraihat, AH., Al-Dalain, SYA., Afifi, FU. and Al-Tabbal, JA. 2011. Determination of essential oils and heavy metals accumulation in Salvia officinalis cultivated in three intra-raw spacing in ash-shoubak. Jordan. Int. J. Agric. Biol. 13(6):981-985.

Abedi, Z., Hasantabar, F., Khalesi, MK. and Babaei, S. 2013. Enzymatic Activities in Common Carp (*Cyprinus carpio*) Influenced by Sublethal Concentrations of Cadmium, Lead, Chromium. World J. Fish Marine Sci. 5(2):144-151.

Akcha, F., Vincent-Hubert, F. and Pfhol-Leszkowicz, A. 2003. Potential value of the comet assay and DNA adduct measurement in dab (*Limanda limanda*) for assessment of in situ exposure to genotoxic compounds. Mutat. Res. 534(1-2):21-32.

Burn, AJ. 2000. Pesticides and their effects on lowland farmland birds. In Ecology and conservation of Lowland Farmland Birds. Eds. Aebischer, HJ., Evans, AD., Grice, PV. and Vickery, JA. Tring. British Ornithologist's Union. 89-105.

Burger, J. 2005. Neuro toxicology and behavioral effects in reptiles. In: Toxicology of Reptiles. Eds. Gardner, SC. and Oberdörster, E. Boca Raton, Florida. CRC Press. Taylor and Francis Group. 173-198.

Cox, C. 1991. Pesticides and birds: from DDT to today's poisons. 11(4):2-6.

Chau, KW. 2005. Characterization of trans boundary POP contamination in aquatic ecosystems of Pearl River delta. Mar. Poll. Bull. 51(8-12):960-965.

Campbell, KR. 2003. Ecotoxicology of Crocodilians. Applied Herpetology. 1:45-163.

Christin, MS., Menard, L., Giroux, I., *et al*. 2013. Effects of agricultural pesticides on the health of *Rana pipiens* frogs sampled from the field. Environ. Sci. Pollut. Res. 20:601- 611.

Dey, C. and Saha, SK. 2014. A Comparative Study on The Acute Toxicity Bioassay of Dimethoate and Lambda-cyhalothrin and Effects on Thyroid Hormones of Freshwater Teleost Fish *Labeo rohita* (Hamilton). Int. J. Environ. Res. 8(4):1085-1092.

Flickinger, EL., Juenger, G., Roffe, TJ., Smith, MR. and Irwin, RJ. 1991. Poisoning of Canada Geese in Texas by parathion sprayed for control of Russian wheat aphid. Journal of Wildlife Diseases. 27(2):265-268

Fagotti, A., Morosi, L., Rosa, LD., Clarioni, R., Simoncelli, F., Pascolini, R., Pellegrino, R., Gaston-Denis Guex. and Hotz, H. 2005. Bioaccumulation of organochlorine pesticides in frogs of the *Rana esculenta* complex in central Italy. Amphibia-Reptilia. 26(2005): 93-110.

Gibbons, WJ., Scott, DE., Ryan, TJ., Buhlmann, KA., Tuberville, TD., Metts, BS., Greene, JL., Mills, T., Leiden, Y., Poppy, S. and Winne, CT. 2000. The Global Decline of Reptiles, De´ja` Vu Amphibians. BioScience. 50(8):653-666.

Grimalt, JO., Fernandez, P., Berdie, L., Villanova, LR., Catalan, J., Psenner, R., Hofer, R., Appleby, PG., Rosseland, BO., Lien, L., Massabuau, JC. and Battarbee, RW. 2001. Selective trapping of organochlorine compounds in mountain lakes of temperate areas. Environmental Science and Technology. 35:2690-2697.

Gill, RJ. and Raine, NE. 2014. Chronic impairment of bumble bee natural foraging behaviour induced by sublethal pesticide exposure. Function. Ecol. 28(6):1459-1471.

Garces, A., Pries, I. and Rodrigues. 2020. Teratological effects of pesticides in vertebrates: a review. Journal of Environment Science and Health, Part B. 55(1):75-79.

Harfenist, A., Power, T., Clark, KL. and Peakall, DB. 1989. A review and evaluation of the amphibian toxicological literature. The. Rep. Ser. No. 61. Canadian Wildlife Service, Ottawa, Canada.

Haider, S. and Inbaraj, M. 1986. Relative toxicity of technical material and commercial formulation of malathion and endosulfan to a freshwater fish, *Channa punctatus* (Bloch). Ecotoxicol. Environ. Saf. 11:347-351.

Hong, SH., Yim, UH., Shim, WJ., Oh, JR. and Lee, IS. 2003. Horizontal and vertical distribution of PCBs and chlorinated pesticides from Masan Bay, Korea. Mar. Pollut. Bull. 46(2):244-253.

Hong, SH., Yim, UH., Shim, WJ., Li, DH. and Oh, JR. 2006. Nationwide monitoring of polychlorinated biphenyls and organochlorine pesticides in sediments from coastal environment of Korea. Chemosphere. 64(9): 1479-1488.

Hong, SH., Yim, UH., Shim, WJ., Oh, JR., Viet, PH. and Park, PS. 2008. Persistent organochlorine residues in estuarine and marine sediments from Ha Long Bay, Hai Phong Bay and Ba Lat Estuary, Vietnam. Chemosphere. 72(80):1193-1202.

Helfrich, LA. 2009. Pesticides and Aquatic Animals: A Guide to Reducing Impacts on Aquatic Systems. Communications and Marketing, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University, USA.

Hayes, TB., Falso, P., S. Gallipeau., *et al*. 2010. The cause of global amphibian declines: a developmental endocrinologist's perspective. J. Exp. Biol. 213:921-933

IUCN. 2020. IUCN Red List of Threatened Species. Version 2020-2. https://www.iucnredlist.org/

Jana, S. and Bandyopadhyaya, S. 1987. Effect of heavy metals on some biochemical parameters in the freshwater fish *Channa punctatus*. Environ. Ecol. 5:488-493.

Jabber, SA., Khan, YS. and Rahman, MS. 2001. Levels of organochlorine pesticide residues in some organs of the Ganges perch, *Lates calcarifer*, from the Ganges–

Brahmaputra–Meghna estuary, Bangladesh. Mar Pollut Bull 42(12):1291-1296.

Jabeen, G., Javed, M. and Azmat, H. 2011. Assessment of heavy metals in the fish collected from thr River Ravi, Pakistan. Pak. Vet. J. 32(1):107-111.

Jayaraj, R., Megha, P. and Puthur, P. 2016. Organochlorine pesticides, their toxic effects on living organisms and their fate in the environment. Interdiscip. Toxicol. 9(3-4):90-100.

Kegley, S., Neumeister, L. and Martin, T. 1999. Ecological Impacts of Pesticides in California. Pesticide Action Network, California, USA. pp 99.

Kosygin, L., Dhamendra, H. and Gyaneshwari, R. 2007. Pollution status and conservation strategies of Moirang River, Manipur with a note on its aquatic bio-resources. J. Environ. Biol. 28(3):669-673.

Khan, MZ., Fatima, F. and Ahmad, I. 2002[a]. Effect of Cypermethrin on Protein Contents in Lizard *Calotes versicolor* in comparison to that in Frog *Rana tigrina.* Online Journal of Biological Sciences. 2(12):780-781.

Khan, MZ., Shah, EZ., Ahmed, I. and Fatima, F. 2002[b]. Effects of agricultural pesticides permethrin (pyrethroid) on protein contents in kidney and liver of lizard species *Calotes versicolor* in comparison to that in frog *Rana tigrina*. Bull. of Pure & App. Sc. 21A (2):93-97.

Klumpp, DW., Huasheng, H., Humphrey, C., Xinhong, W. and Codi, S. 2002. Toxic contaminants and their biological effects in coastal waters of Xiamen, China. I. Organic pollutants in mussel and fish tissues. Mar. Poll. Bull. 44(8):752-760.

Khan, MZ., Tabassum, R., Naqvi, SNH., Shah, EZ., Tabassum, F., Ahmad, I., Fatima, F. and Khan, MF. 2003[a]. Effect of Cypermethrin and Permethrin on Cholinesterase Activity and Protein Contents in *Rana tigrina* (Amphibia).Turk. J. Zool. 27: 243-246.

Khan, MZ., Nazia, M., Fatima, F., Rahila, T. and Gabol, K. 2003[b]. Comparison of the effect of Lamda cyhalothrin with permethrin on cholinesterase activity in *Rana cyanophlyctis* and *Rana tigrina (*Ranidae: amphibian). Bull. of Pure & App. Sc. 22A (1):43-49.

Khan, MZ., Maria, Z. and Fatima, F. 2003[c]. Effect of Lamda Cyhalothrin (Pyrethroid) and Monocrotophos (Organophosphate) on Cholinesterase activity in liver, kidney and brain of *Rana cyanophlyctis.* Korean J. Biol. Sciences. 7(2):165-168.

Khan, MZ., Fatima, F., Mahmood, N. and Yasmeen, G. 2003[d]. Comparison of Cholinesterase activity in the brain tissue of lizard *Calotes versicolor* with that of frog *Rana cyanophlyctis* under the effect of Cypermethrin, Lamda Cyhalothrin, Malathion and Monocrotophos. Bulletin of Pure and Applied Sciences. 22 A (2):105-112.

Khan, MZ. 2004. Effect of Pesticides on Amphibians and Reptiles. Exper. J. Zool. India 7(1):39-47.

Khan, MZ. and Law, FCP. 2005. Adverse Effects of Pesticides and related Chemicals on Enzyme and Hormone Systems of Fish, Amphibians and Reptiles. Proc. Pakistan Acad. Sci. 42(4):315-323.

Khan, MZ. and Yasmeen, G. 2005. Pesticide dependent cholinesterase activity in brain of *Rana cyanophlyctis* (amphibian). J Exp. Zool. India. 8 (1):135-140.

Keller, JM., Peden-Adams, MM. and Aguirre, AA. 2005. Immuno toxicology and implications for reptilian health. In Toxicology of Reptiles. Eds. Gardner, SC. and Oberdorster, E. Boca Raton, Florida: CRC Press, Taylor and Francis Group. 199-240.

Khan, MZ., Yasmeen, G. and Hamid, S. 2006. Effect of Sundaphos (Organophasphate) and beta-cypermethrin (Synthetic Pyrethroid) on Cholinesterase Activity in Liver and Kidney of *Euphlyctis cyanophlyctis*. Hamadryad. 30(1&2):176-180.

Khan, MZ., Rais, M. and Yasmeen, G. 2007. Inhibitory effects on cholinesterase activity produced by the two different pesticides on brain, liver and kidney of *Euphlyctis cyanophlyctis.* J. Exp. Zool. India.10(1):89-93.

Kushwaha, B., Pandey, S., Sharma, S., Srivastava, R., Kumar, R., Nagpure, NS., Daba,s A. and Srivastava, SK. 2012. *In situ* assessment of genotoxic and mutagenic potential of polluted river water in *Channa punctatus* and *Mystus vittatus*. Int. Aquat. Res. 4: 16-26.

Köhler, HR. and Triebskorn, R. 2013. Wildlife ecotoxicology of pesticides: can we track effects to the population level and beyond. Science. 341:759-765.

Mineau, P. 1993. The hazard of carbofuran to birds and other vertebrate wildlife. Technical Report Series No. 177. Canadian Wildlife Service.

Mineau, P. 2005. Direct losses of birds to pesticides-beginnings of a quantification. USDA Forest Service Gen. Tech. Report PSW GTR-191.

Maskaoui, K., Zhou, JL., Zhen, TL., Hong, H. and Yu, Z. 2005. Organochlorine micropollutants in the Jiulong River Estuary and Western Xiamen Sea, China. Mar. Pollu. Bull. 51(8-12): 950-959.

Milnes, MR., Bryan, TA., Medina, JG., Gunderson, MP. and Guillette, LJ. Jr. 2005. Developmental alterations as a result of in ovo exposure to the pesticide metabolite p,p0 - DDE in Alligator Mississippiensis. General and Comparative Endocrinology. 144:257-263.

Mann, RM., Hyne, RV., Choung, CB., *et al*. 2009. Amphibians and agricultural chemicals: review of the risks in a complex environment. Environ. Pollution. 157:2903-2927.

Mineau, P. and Whiteside, M. 2013. Pesticide acute toxicity is a better correlate of US grassland bird declines than agricultural intensification. PLOS One. DOI:10.31371/journak.pone.0057457.

Murthy, KS., Kiran, BR. and Venkateshwarlu, M. 2013. A review on toxicity of pesticides in Fish. Int. J. Open Sci. Res. 1(1):15-36.

Naeem, M., Salam, A., Tahir, SS. and Rauf, N. 2010. Assessment of the essential element and toxic heavy metals in hatchery reared *Oncorhynchus mykiss*. Int. J. Agric. Biol. 12(6):935-938.

Pandey, AK., Nagpure, NS., Trivedi, SP., Kumar, R. and Kushwaha, B. 2011. Profenofos induced DNA damage in freshwater fish, *Channa punctatus* (Bloch) using alkaline single cell gel electrophoresis. Mutation Res. 726(2):206-214.

Prashanth, MS., Sayeswara, HA. and Goudar, MA. 2011. Free cyanide induced physiological changes in the Freshwater fish, *Poecilia reticulate*. J. Exp. Sci. 2(2):27-31.

Rao, AS. and Pillala, RR. 2001. The concentration of pesticides in sediments from Kolleru lake in India. Pest Manag. Sci. 57:620-624

Relyea, RA. 2005. The lethal impact of Roundup on aquatic and terrestrial amphibians. Ecological Applications 15:1118-1124.

Shirose, L., Bishop, C. and Gendron, A. 1995. Amphibians and reptiles in Great Lakes Wetlands: Threats and Conservation. Environment Canada. Catalogue No. En 40-222/4-1996E 46.

Saqqib, TA., Naqvi, SNH., Sidiqui, PA. and Azmi, MA. 2005. Detection of pesticide residues in muscles, liver and fat of 3 Species of *Lobeo* found in Kalri and Haliji Lakes. J. Environ. Biol. 26(2):433-438.

Singh, KP., Malik, A., Mohan, D., Sinha., S. and Singh, VK. 2005. Chemometric data anaysis of pollutants in wastewater: A case study. Anal. Chim. Acta. 532:15-25.

Sarkar, SK., Bhattacharya, BD., Bhattacharya, A., Chatterjee, M., Alam, A., Satpathy, KK. and Jonathan, MP. 2008. Occurrence, distribution and possible sources of organochlorine pesticide residues in tropical coastal environment of India: An overview. Env. Int. 34(7):1062-1071.

Satyavardhan, K. 2013. A Comparative Toxicity Evaluation and behavioral observations of fresh water fishes to Fenvalerate. Middle-East J. Sci. Res. 13(2):133-136.

Sabae, SZ., El-Sheekh, MM., Khalil, MA., Elshouny, WAE. and Badr, HM. 2014. Seasonal and Regional Variation of Physicochemical and Bacteriological Parameters of Surface Water in El-Bahr ElPherony, Menoufia, Egypt. World J. Fish Marine Sci. 6(4):328-335.

US Environmental Protection Agency. 1992. Pesticide Fact Sheet Number 199: Cypermethrin. US EPA, Office of Pesticide Programs. Washington, DC, USA.

Ullah, S. 2014. GIS Integrated Approach for Assessing Drinking Water Quality. VDM Publishing Heinrich-Böcking-Str. 6-8 D - 66121, Saarbrücken, Germany.

Vos, JG., Dybing, E., Greim, HA., Ladefoged, O., Lambré, C., Tarazona, JV., Brandt, I. and Vethaak, AD. 2000. Health effects of endocrine-disrupting chemicals on wildlife, with special reference to the European situation. Crit Rev Toxicol. 30:71-133.

Van den Berg, H. 2008. Global status of DDT and its alternatives for use in vector control to prevent disease. Stakeholders' Meeting to review the interim report for the establishment of a global partnership to develop alternatives to DDT, Geneva, 3-5 November 2008. Stockholm Convention on Persistent Organic Pollutants, United Nations Environment Program.

Van den Steen, E., Pinxten, R., Jaspers, VL., Covaci, A., Barba, E., Carere, C., Cichoń, M., Dubiec, A., Eeva, T., Heeb, P., *et al.* 2009. Brominated flame retardants and organochlorine in the European environment using great tit eggs as a bio-monitoring tool. Environ Int. 35:310-317.

Willingham, E. 2005. Developmental and reproductive effects. In: Toxicology of Reptiles. Eds. Gardner, SC. and Oberdörster, E. 149-172. Boca Raton, Florida: CRC Press, Taylor and Francis Group.

Wagner, N., Reichenbecher, W., Teichmann, H., *et al*. 2013. Questions concerning the potential impact of glyphosate based herbicides on amphibians. Environ. Toxicol. Chem. 32(8):1688-1700.

Zitko, V. 2003. Chlorinated pesticides: Aldrin, DDT, Endrin, Dieldrin, Mirex. In: The Handbook of Environmental Chemistry (vol. 3, Part O). Persistent Organic Pollutants. Ed. Fiedler, H. Springer-Verlag Berlin Heidelberg. 47-90.

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