Review Article

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Journal of Toxicological Analysis

2018
Vol.1 No.2:3

Impact of Pesticides on Amphibians: A Review

Atika Islam* and Muhammad Faheem Malik

Department of Zoology, University of Gujrat, Punjab, Pakistan

***Corresponding author**: Atika Islam, M. Phil, Department of Zoology, University of Gujrat, Gujrat City, Punjab, Pakistan, Tel: +923338233149; E-mail: atikaislam018@gmail.com

Received date: November 22, 2018; **Accepted date:** November 22, 2018; **Published date:** November 26, 2018

Citation: Islam A, Malik MF (2018) Impact of Pesticides on Amphibians: A Review. J Toxicol Anal Vol.1 No.2:3.

Abstract

Amphibians (cold-blooded vertebrates) show more effect to pesticides than any other vertebrate group from terrestrial as well as aquatic environment. Risk for pesticide exposure increases due to permeable skin for water and ions. Contamination may cause alteration in their behavior. The goal of this review is to assess the risk of pesticides exposure to the juveniles and adult frog. The main emphasis is on dermal exposure of pesticides by directly spray over them or by indirectly spray in aquatic and terrestrial habitat. The reason for the sensitivity to climatic change is that they spend most of their life in aquatic environment and spend minimum life in terrestrial environment. Almost 600-amphibian population is reported in Western Europe and 53% of them is declined in the beginning of 1950s. Chronic effect of low dose on particular pesticides may lethal as compared to the acute exposure. Chemicals which are used to make pesticides are very dangerous for growth and reproduction and cause mutation in developing tadpole. Oral exposure of DDT and Malathion may lead to the immunosuppressive effect. Several pesticides show influence on meta morphological stages and prevent larval development, which reduces the rate of growth in amphibian and decline their population. Further studies require to examine high and low level of pesticide. Further investigation is needed to reduce the population decline of amphibian globally.

Keywords: Pesticide; Amphibian; Susceptibility; Exposure; Immunosuppressive effect; Metamorphosis; Decline; Physiology; Behavioral changes; Carbaryl; Contamination; Malathion

Introduction

Amphibians are more susceptible to pesticides than mammals and birds. Pesticides are the group of chemicals that cause harmful effect on animal and also influence on morphology and physiology of animals. Amphibians are very sensitives to environmental changes and contamination because they spend most of their life span in aquatic environment [1]. The total number of endangered species of amphibian include 32.5% and 12% birds and 23% of mammals [2]. Contamination cause alteration in their behavior. Skin of amphibian is highly penetrative to gas, water, and ion transport with the environment [3]. Globally, Amphibian's population seem to be declined and have threat of habitat loss. Especially, they are vulnerable to contaminants such as DDT and chlorpyrifos [4]. Assessment of extortion indicates the ecological characters such as life history, feeding biology, toxicological vulnerability and behavioral characteristic [5]. The proximity of pesticides with amphibians are mostly perceived in agricultural landscape. A correlation between pesticide effect and amphibian population deterioration was discovered in southern mountain yellow-legged frog, which exist in the United States [6]. The goal of this review is to assess the risk of pesticide exposure to the juveniles and adult frog. The main concern of this review is to find out how much effect a particular pesticide cause on life stages of frog. The main emphasis of study is to indicate the direct dermal exposure of pesticides or indirect exposure in aquatic and terrestrial habitat [7].

Experiments have proved the accumulation of two pesticide chemical such as Mannitol and antipyrine in skin of frog. In mammal's pig show more effect to pesticide exposure as compared to others [8]. Deterioration of amphibian population is recorded since 1980s. The main reason of extinction of biodiversity is overexploitation, loss of natural habitat and environmental stress directly or indirectly by human beings [9]. Specifically, amphibians are at great risk by all such type of activities in small geographic area and is highly affected by climatic stress especially high temperature. The reason for the sensitivity to climatic change is that they spend most of their life in aquatic environment and spend minimum life in terrestrial environment [10]. It is studied that amphibians got adverse effect due to field application of pesticide exposure, which is highly used all around the world. Mortality rate of amphibians are very high and risk for their reduction is exist from past few years in those countries where there is excessive use of pesticides [4].

Estimation of declined population

Globally, it is mentioned that population of amphibians are declining day by day due to excessive use of pesticides which contaminate the natural environment and influence on climatic condition of amphibians. Data is recorded for reporting the mortality rate of amphibians [6]. Almost 600-amphibian population is reported in Western Europe and 53% of decline begin in 1950s. In North and South America, there is 54% and 60% respectively substantial decrease in population. In Australia and New Zealand, approximately 70% of the amphibian populations is declined [7]. According to the 2004 IUCN Red List, approximately 20 countries have threatened species and their number increases due to fast anthropogenic activities. Environmental pollution including pesticides play vital role in decline of amphibian population [5]. Throughout years of 2000 to 2004, the number of extinctions in fishes, amphibian, and other aquatic animals are increased. Pesticides exposure increase their mortality rate. Available data is considered to study the lethal and toxic effect of pesticide exposure on amphibians [11]. Eco toxicological research tells us about the physiological and behavioral changes on life stages such as egg, embryo, tadpole and adult amphibian especially frog [8]. While studying the effect of pesticides on the body of amphibian, literature is reviewed about the toxicity of pesticides that is how lethal or toxic a particular pesticide is [6].

Pesticides classification that effects on amphibians

Following are the classification of pesticides:

Organophosphates: Organophosphorus (Ops) compound formed for the first time in 1940s. The chemical arrangement of OPs consists of phosphorus (P) atom bound with a double bond to an oxygen (O) or sulfur (S) and with three more single bonds to two alkoxy groups (OCH_3 or OC_2H_5) and with a leaving group. Generally, OP insecticides have a sulfur bound to the phosphorus [12]. Organophosphorus acts on the acetylcholinesterase that is act on the enzymes of amphibians. It can hydrolyze acetylcholinesterase AChE. As acetylcholine is the major neurotransmitter so, it may cause destructive effects on central and peripheral nervous system [13].

Carbamates: Carbamate insecticides originate from carbamic acid and have different degrees of acute oral toxicity that is ranging from moderate to low toxicity (carbaryl) to particularly high toxicity. The mechanism of toxicity of carbamates is related to that of OPs, as they also inhibit AChE. Moreover, the symptoms include urination, diarrhea, salivation, muscle fasciculation and CNS effects [14].

Pyrethroids: Pyrethrin are natural insecticides originated from yellow Chrysanthemum cinerariifolium and Tanacetum cinerariifolium. It was used in 1800s for the first time. From pyrethin, many drugs are derived to control the pest population. These synthetic drugs known as pyrethroids. Pyrethroids are chemically stable as compared to pyrethin [14]. Pyrethrin and pyrethroid aerosols are often used as automated insect sprays in public areas. Pyrethroid pesticides show high toxicity to various kind of insects and low toxicity to amphibians. Pyrethroid is easily degradable that is why have wide range of usage, but it has drastic effects on CNS [15].

Organochlorine compounds: The organochlorine comprises of carbon, chlorine and hydrogen. They are also denoted as chlorinated hydrocarbons, chlorinated insecticides and chlorinated synthetics. Organochlorine further divided into four major groups such as DDT (dichlorodiphenyltrichloroethane) second is cyclodienes further include (aldrin, endrin, heptachlor, dieldrin, chlordane, endosulfan and chlordecone. the third group is hexachlorocyclohexane (lindane) and the forth one is related compounds of hexachlorocyclohexane. Their acute toxicity is temperate but chronic exposure may be related with damaging health effects particularly in the liver and the reproductive system of organism [16].

Toxicity with respect to exposure

Acute toxicity: Acute toxicity is short term toxicity. It is caused by only single exposure of pesticide. Major harmful effects only by single exposure are dermal (skin), inhalation (lungs), oral (mouth), and the eyes [17]. It is inspected by dermal toxicity, inhalation toxicity, and oral toxicity of test animal. Eye and skin irritation is also inspected. It is measured LD50 (lethal dose 50) which is the amount or concentration of toxicant that can kill 50 percent animal in a test population [18].

Chronic toxicity: Chronic toxicity is the long-term exposure of toxic material. Harmful effect is caused by small repeated dose over many times [19]. Long-term exposure cause birth defects, toxicity to a fetus, formation of benign or malignant tumors, genetic changes, blood syndromes, nerve infections, endocrine disorder, and effects of reproduction. The chronic toxicity of a pesticide is more dangerous as compared to acute toxicity determine by lab experiment [20].

According to these two types of toxicity, chronic toxicity is very lethal for aquatic life because they remain in aquatic medium and absorb pesticide repeatedly by mouth and skin which is lethal for their survival [21]. Pesticide is very dangerous for growth and reproduction and cause mutation in developing tadpole. Study is taken for investigating physiological or behavioral changes and investigate the influence of chemicals on pesticide [22].

Toxic effect on physiology of amphibian

Dermal exposure: Amphibians are exposed to chemicals when moving in agricultural field to seek food and shelter in terrestrial environment [23]. Skin of amphibian is highly penetrative and function as respiration and water uptake. Toad uptake water from pelvic area of skin. Pesticides absorb from the skin along with water molecules [21]. These pesticides may move to venous circulation through lymph channels. Thus, pesticide chemicals move through the skin of frog and cause serious consequences that may leads to several diseases some time tumors or brain diseases [24]. Vertebrates

other than amphibians have protective barrier for skin penetration. Pesticides inhibit the production of cholinesterase that means accumulation of acetylcholine in postsynaptic membrane thus cause Parkinson's disease, which may lead to death of amphibians [25]. Tiger salamanders when exposed to Malathion, it causes change in physiology of liver, bones and muscle. It may also cause inhibition of cholinesterase that leads to several diseases [26].

Oral or subcutaneous exposure: Sometimes amphibian inject pesticides orally by any kind of food piece. It may also lethal for the development of amphibians. DDT and Malathion when orally exposed may leads to the immunosuppressive effect [18]. Metabolism of DDT cause decrease in CYP26 gene and protein expression. It can affect the reproductive abilities and decrease growth [27].

Excessive of pentachlorophenol results in deduction of food uptake. Direct exposure is risky other than indirect exposure [28]. Distribution of parathion, permethrin and dieldrin in the liver and blood is 6-10% and 2-4% respectively. Excretion of pesticides checked by lab report is very low. They may penetrate in internal organs. Site of action of pesticides is metabolism, storage in addition, excretion excluding skin penetration [29].

Effect on Life Stages

It is suggested that amphibians have ability to taste water with its skin and can check appropriateness of water before oviposition in the water so it may avoid the contamination of pesticides [30]. Juveniles of western toad prevent urea socked paper towel but it cannot avoid urea in soil thus infected by chemicals. Juvenile of American toad may also not avoid the contamination thus their mortality rate is high because of terrestrial contamination of chemicals with atrazine [31]. Malathion exposure to skin cause inhibition of cholinesterase both in adult and juveniles. Metamorphological changes occur in northern cricket frog due to exposure of pesticide DDT [17]. Terrestrial exposure to carbaryl for 24 h have no impact on food seeking behavior and growth on American toad but have serious impact on larval stages [20]. Chronic exposure of carbaryl have dangerous effect on eggs and tadpole larvae of frog [32]. High dose of pesticides cause increase in mortality rate approximate 50% mortality in juvenile toads are reported. Glyphosate exposure have significant mortality rate that is 68–86% in gray tree frog and wood frog [27]. Several pesticides delayed the metamorphological stages and delay in larval development, which then reduce the rate of growth in amphibian, thus decline their population [32].

Local effect on ecology

Study on mortality rate of amphibians due to pesticides provide us data of threatened species of amphibians. As the use of pesticides increases day by day so there must increase the risk of decline in species of amphibians. Amphibians are the important component of ecosystem as they clean fresh water and eat insects. Larvae of amphibians are filter feeder, so they clean fresh water. Adult feed on insects, so a lot of disease causing insects can be controlled by amphibians. If their number reduce in an ecosystem it may leads to serious consequences.

Conclusion

The brief summary of effect on life stages of amphibians by pesticides show the decline in population of amphibian. Studies revealed that acute exposure is somehow manageable as compare to chronic exposure. Chronic exposure to low doses of particular pesticides may responsible to the etiology of some neurodegenerative diseases (most remarkably Parkinson's disease). Developmental exposure of pesticides during metamorphosis of amphibian results in growth reduction and low reproductive activity. Juveniles are more sensitive than adult and may die from chronic exposure of pesticides. Skin is the main cause of pesticide exposure. Pesticides exposure more likely possible in amphibian as compared to other vertebrates. Mortality rate is very high from past few years due to excessive use of pesticides in terrestrial agricultural environment. Study is needed for checking sensitivity level for particular species of amphibians and their side reaction such as pathogen or parasitic transfer during pesticides exposure. Further studies require for examination of high and low level of single pesticide and its effect on particular species of amphibian. After these researches, enough data will have collected for protection of amphibian's form pesticides and reduce their mortality rate. Precautionary measure is required to control the mortality rate of amphibians. Suggestions are given for avoiding the use of pesticides where there will be possibility of habitat of amphibian. This hypothetical probability needs to be investigated in experimental animal models.

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