Impact of pesticides on human and environment: A Review

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Abstract: Pesticides the agrochemicals are used not only in agricultural fields, but also for public health protection. The pesticides have negative impact on environment, human health, wildlife, and ecosystem. About 1000 different organic and inorganic compounds are used as pesticides. Several pesticides are not only toxic but persist in the environment for decades and are bio accumulated. Because of persistence the pesticide residues or related daughter products enter the soil, surface water, groundwater, and air and crop yields. Humans are exposed to pesticides by inhalation (breathing); oral (getting in mouth or digestive tract) and dermal (Contact with skin and/or eyes). Some short-term effects of pesticides to human is headaches, nausea, asthma, sore throat, eye irritation, skin irritation, diarrhoea, pharyngitis, nasal irritation, sinusitis, contact dermatitis, inflammation, endocrine disruption. Long-term exposure of pesticides to human may cause birth defects, infertility, endocrine disruption, depression, diabetes, neurological deficits besides cancer. As the pesticides in soil affect the soil microbe' population and soil enzymatic activities, the soil fertility and nutritional quality of soils are also influenced.

Keywords: Pesticides, Human, Environment, Aquatic organisms, Soil microbes, Soil enzymes

1.Introduction

Pesticides which are used, in agriculture, to protect plants from pests, plant regulators, desiccant, in public health protection to protect humans from vector–borne diseases like malaria, dengue fever, since last 150 years are the integral part of our modern life. Globally annual consumption of pesticides is about 3.5 million tonnes (**Steingrimsdottir *et al*., 2018**). The ever growing human population which is expected to be 9.7 billion by 2050 (**U.N., 2015**) will require more agricultural production, especially in tropical regions. Increasing agricultural production in these regions relies on the use of agrochemicals, as shown by the growth of agrochemical market by approximately 4.5 % annually. There are approximately 1000 chemicals inorganic or organic are used as pesticides. The applied pesticides not only affect the targeted pests, but also other organisms, about 95% of the applied pesticides reaches other organisms via water bodies, air, etc. An application of pesticides improves the crop quality and soil health by controlling pests and plant diseases, controls pests like termites, cockroach harmful to human activities and structure. Globally about 35% of all the potential food crops are destroyed by the pests before harvest (**Ghorab and Khalil**, **2015**). Despite these advantages the pesticides are toxic to humans and have negative impact on the environment and ecosystem. Several pesticides are stable, toxic and are bio accumulated. Majority of pesticides viz, DDT, HCH persist in the environment for decades, resulting the pesticide residues or related daughter products found in the soil, surface water, groundwater, air, and crop yields (**Pan *et al*., 2019; Bai *et al*., 2018; Wang *et al*., 2012**). Several researchers (**Blaznik *et al*., 2016; Del Prado-Lu 2015; Witczak and Abdel-Gawad, 2014; Chourasiya *et al*., 2014**) have also reported residues of pesticides in wine, fruit juices, cooked meals, animal feeds and human breast milk samples. The pesticides not only destruct biodiversity also destruct non- target species. The pesticides can enter the atmosphere because of (i) volatilization from the soil; plant leaves (ii) evaporation from surface water (iii) drifting and losses during application (iv) wind erosion. Therefore, it becomes imperative to identify and quantify the chemical and biological processes that controlling the behavior of organic chemicals in the environment, to improve pesticidal management for minimize contamination of our natural resources, and remediating contaminated environments.

The aim of this review is to discuss the effect of the common class of pesticides (organochlorine, organophosphorous, carbamate and pyrethroids) on the environment and human.

2.Types of Pesticides

2.1.Organochlorine pesticides: Organochlorine pesticides which are first synthetic pesticide group is the organic compounds having cyclodiene ring and five or more chlorine atoms. These are widely used in agricultural field and domestic purposes to control vector-borne diseases. Few common organochlorine pesticides are DDT, HCH, aldrin, dieldrin and chlordane.

2.2.Organophosphorus pesticides: Organophosphorus pesticides which were first synthesized in 1937 from phosphoric acid are the broad spectrum pesticides. These pesticides are biodegradable and inhibit the activity of acetylcholinesterase in both vertebrates, and invertebrates. Most of the organophosphorous pesticides because of their polar nature are water-soluble. Some commonly used organophosphorous pesticides are Parathion, Malathion, Diazinon and Glyphosphate.

2.3.Carbamate and Dithiocarbamate pesticides: Carbamate pesticides which have the chemical structure R-O-CO-N-CH (sub)-3) R' (where R is an alcohol, oxime or phenol and R' is ether, H or alkyl group) are the broad spectrum biodegradable pesticides and can be used against those pests which have gained immunity against organochlorine and organophosphorus pesticides. These pesticides are used as stomach, contact poison and fumigant. Commonly used carbamate pesticides are carbaryl, oxamyl, carbofuran, aminocarb, propoxur.

Dithiocarbamate pesticides which have the chemical structure (R, R') N- (C=S)-SX, where R, R' can be an alkyl, alkylene, aryl, or similar other group, and X a metal ion. Based on the metal cation present the dithiocarbamate pesticides are classified into two groups (i) dimethyl dithiocarbamate and (ii) ethylene-bisdithiocarbamate. These pesticides show oral and dermal toxicity. Ethylene thiourea which induces thyroid

cancer is the metabolite of the dithiocarbamates. These pesticides were introduced after World War II. Commonly used dithiocarbamate pesticides are Thiram, disulfiram, ziram, and ferbam.

2.4.Pyrethrins and pyrethroids pesticides:

Pyrethrins are the natural compounds, having active pesticidal agents' pyrethrins I-VI, got from the plant *Chrysanthemum cinerariaefolium* while pyrethroids are synthetic pesticides. Both the pyrethrins, and pyrethroids pesticides exist in cis and trans forms and carries a central ester bond. These pesticides affect the muscular system of pest and affect the sodium channel in the target.

3.Routes of pesticide exposure to Human

Pesticides enter the body of mammals and other animals via dermal exposure (contact with eye or skin), inhalation exposure (breathing), by drinking water and oral exposure (via mouth or digestive tract). Plants absorb through roots. The human beings inhale pesticides mainly by breathing air containing pesticides as a vapour or as an aerosol or as small particles, oral exposure occurs when we take pesticides containing food or water, dermal exposure occurs when our skin came in contact of the pesticides. Several studies have shown that worldwide over 50% of samples of groundwater have more than one pesticide beyond their permissible limits. Commonly found pesticides besides DDT and DDE are 2, 4-D, acetachlor, diazinon, dicamba, HCH, MPCA, bromoxynil, imazethapyr and imazaquin etc.

Pesticides are used not, only in the agriculture sector but also used for pest control in homes, restaurants, hospitals, etc. To prevent food damage by the pests' worldwide over 1000 pesticides, having different properties, toxicological effects are used. Excessive use of the pesticides, the water solubility of pesticides, improper irrigation and rainfall are the main reasons for the leaching of pesticides in the groundwater (**Rai and Pandey**, **2017**). Several studies **(Agarwal *et al*., 2010; Zhao and Pei, 2012)** have shown Pesticides in groundwater. **Ghose *et al* (2009)** found organochlorine pesticides Lindane, DDT in the groundwater samples of greater Kolkata. The groundwater of Gurgaon and Ambala is contaminated with the isomers of HCH, endosulfan and metabolites of DDT were the findings of **Kaushik *et al.*** (**2012**). Delhi's groundwater also contains atrazine; simazine was the report of **Aslam *et al.*** **(2013**). In Chennai, 20% of samples contain aldrin beyond the permissible limit (the maximum concentration was 13. 33ug/L; the WHO permissible limit is 0.03 ug/L). The concentration of pesticides aldrin, β-BHC exceeds beyond permissible limit in 4% groundwater samples of Madurai city and Vijayawada city while α-BHC, γ-BHC and δ-BHC in 8% groundwater samples of both the cities were beyond permissible limit. Long- term studies (11 years) made by **Bansal** (**2008**) revealed that pesticides 2, 4-D, HCH, DDT, parathion are present in the groundwater of Aligarh city. The concentration of pesticides DDT and BHC were more in domestic well water than in irrigating well water while the concentration of 2,4- D in the irrigated well water was 2-3 times than domestic well water. The concentration of these pesticides became beyond permissible limit after the year 2002. **Munawar and Hameed** (**2013**) reported that 65-70% Pumpkin, okra, eggplant; cucumber spinach and cabbage vegetables collected from Lahore city market were contaminated with the pesticides Cypermethrin, Chlorpyrifos, and imidacloprid. **Szpyrka *et al*., (2015**) during their studies found that in Poland 38% fruit samples and 16% samples of vegetables contain pesticides. The samples of gooseberry and apple are most affected. **Mutengwe *et al*.,** (**2016**) reported that in Africa that 91% of fruit and vegetables sample contains pesticides residues beyond maximum permissible limit. **Park** (**2018**) found that pesticides and their degraded products are present in the 70% of conventionally grown fruits and vegetables. They also found that few samples of strawberries were contaminated with 20 different pesticides; at least one pesticide was present in more than 98% of studied samples of peaches, cherries, and apples. In The USA the Environmental Working Group led by **Meyer** (**2019)** found that two or more pesticides are present in more than 90% of samples of strawberries, apples, cherries, spinach, nectarines, and kale, while 50% samples tested positive for residues of two or more pesticides, while multiple samples of kale indicated the presence of 18 pesticides.

4.Impacts of pesticides on Human

As per data of **World Health Organization (2019**) since 1990 the most adverse effect of pesticides in the Asian and Latin America countries is the use of pesticides for suicides. Some short-term effects of pesticides are headaches, nausea, asthma, sore throat, eye irritation, skin irritation, diarrhoea, pharyngitis, nasal irritation, sinusitis, contact dermatitis, inflammation, endocrine disruption causing an exacerbation of asthma. Long-term exposure to pesticides causes birth defects, infertility, endocrine disruption, depression, diabetes, neurological deficits besides cancer (**Bourguet and Guillemaud, 2016; Amr *et al*., 2015; Mostafalou and Abdollahi, 2013**). Exposure to DDT may cause neurological and immunodeficiency disorder, brain, pancreatic, breast, prostate cancer (**Khanna and Gupta, 2018; Shrivastava *et al*., 2015**). Acetyl cholinesterase enzyme activity is also inhibited by DDT (**Koutros *et al*., 2015)**. Organophosphorus pesticides also have carcinogenic, mutagenic, and tetragenic effects and their exposure to human cause Leukaemia, Lymphoma, and Parkinson's diseases. Groundwater contaminations by the pesticides pose significant risks to insects, plants, fish, and birds besides the human. The risk of human health hazards by the pesticides depends on the active ingredient and exposure level. Pesticides are related to various diseases such as cancer, asthma, leukaemia, nausea, damage to the nervous system, birth defects, etc. Organophosphorus and carbamate pesticides affect the nervous system (**Khanna and Gupta, 2018; Shrivastava *et al*., 2015**). The hormonal/ endocrine system of the body is also affected by some pesticides. Muscle paralysis, pneumonia, fetal malnutrition, and respiration failure is caused by pesticide Chlorpyrifos. **Jaacks and Staimez** (**2015**) during their research studies found a positive correlation between diabetes and serum concentration of organochlorine pesticides (DDT, DDE, HCH, etc), dibenzofurans, PCBs. **Moisen *et al*.,** (**2015**) during their studies on vineyards found that Parkinson's dis-

ease is associated with the pesticide exposure. During the studies in the Netherlands did by **James and Hall** (**2015**); **Brouwer *et al*.**, (**2015**) it was observed that chronic exposure to metals and pesticides enhances the development of Parkinson's disease at a younger age. Similar inferences were also reported by other workers (**Mark *et al*., 2012; Pezzoli and Cereda, 2013**). Risk of developing acute leukaemia was more in occupational farmers than in other jobs in Iran were the findings of **Maryam *et al*., (2015).** Exposure of pregnant women to residual pesticides enhances childhood leukemia (**Turner *et al*., 2011**). **Lee *et al*.**, (**2016**) during their studies in Sweden found that individuals with high levels of organochliorine, organophosphorus pesticides exposure has three times more risks of cognitive impairment than those who are exposed with low levels. Prolonged exposure to organophosphates affects the male reproductive system by reduction of sperm activities, by damaging sperm DNA (**Mehrpour *et al*., 2014**). Hypospadias is also induced by exposure to organophosphates and organochlorine (**Lal, 2018; Michalakis *et al*., 2014**).

5.Impact of Pesticides on aquatic organisms

As aquatic organisms cannot escape from the aqueous medium their existence is always under threat by the chemicals present in the medium. The aquatic ecosystems and the organisms are affected by the exposure of synthetic pesticides in water. Pesticide atrazine decreases the gill function, and migratory activity in the Pacific salmon (**Moore *et al*., 2008**). **Macneale *et al*.**, **(2014**) reported that the feeding behaviour, and the decrease in the population with the exposure of Pacific salmon to pesticides chlorpyrifos and carbaryl. Pesticides in the aquatic system not only reduces biodiversity, aquatic species, but also affects the ecosystem functioning. **Chagnon *et al*.**, (**2015**); **Gilbert** (**2016**) have reported that pesticides even at a very low concentration is bioaccumulated and acts on sensitive species or larval stages of biota affecting the healthy functioning of the ecosystem. The pesticides affect the entire ecosystem by the reduction in the number of pollinating insects and dying of the Great Barrier Coral Reef **(Nøstbakken *et al*., 2015; Park *et al*., 2015). Hanifuddin *et al*., (2016**) studied the effects of organophosphorous pesticide Sumithion on seven genera of benthic invertebrates belonging to Chironomidae, Oligochaeta and Mollusca. They reported that in the presence of pesticide Sumithion the number of benthic invertebrates per m^2 significantly decreased. **Hanifuddin *et al.,* (2016**) also reported that pesticide Sumithion has the adverse impact on culture animals in aquaculture ponds. **Maurya and Malik (2016**) during their studies reported that the swimming behaviour of the zebra fish is changed by the exposure to a very low concentration of pesticide atrazine. Pesticides cause several biochemical changes in the fish viz, inhibition of enzymatic activities, retardation of the growth, metabolic disturbances. On exposure with the pesticides liver, kidney, brain, and gills are the organs of a fish which are most affected (**Malik and Maurya**, **2015**) which causes restlessness, rapid body movement, convulsions, difficulty in respiration, change in colour in the fish. Organophosphorous pesticides cause reproductive disorders in the fishes and decrease the plasma levels of testosterone and 17B-estradiol. **Sánchez-Bayo *et al*.**, (**2016**) studied the implication of neonicotinoids on the aquatic ecosystem and reported that the pesticide neonicotinoids affects the structure, and function of aquatic ecosystems by decreasing the aquatic invertebrate population which affects the vertebrates whose food resource is the only aquatic invertebrates. **Munze *et al*.**, (**2017)** studied the effect of pesticides from the wastewater treatment plant effluent on the aquatic macro-invertebrates and reported that over 52% of taxa are adversely affected. **Affum *et al*.**, **(2018**) studied the toxicity of pesticides on non-targeted aquatic organisms and reported that toxicity of pesticide mixtures was in the order of fish > Daphnia magna >algae. Indiscriminate use of pesticides are not only affecting our environment, but also influencing the ecosystem by affecting the aquatic food web needed to bird, fish, insects, and small aquatic organisms' survival. Pesticides are showing devastating effect in the animal kingdom and plants by destroying habitats, reducing food supplies, impairing reproduction reducing species diversity which causes population decline of animals and plants **(Nabi *et al*., 2019). Miles *et al*., (2017)** found that clothianidin, Water bugs, Belostoma flumineum showed behavioural changes and growth in presence of pesticide neonicotinoid in the aqueous medium. During last 20 years several researchers (**Widenfalk *et al*. 2008; Ma *et al*., 2010; Staley *et al*., 2015**) have reported that in the aquatic medium most of the pesticides inhibit the growth of cyanobacteria Pseudoanabaena, *Anabaena inaequalis*, green algae *Scenedesmus acutus, Scenedesmus subspicatusin*. The heterotrophic ciliates and flagellates of diatom genera were also reduced. The pesticides in water cause fish mortality. In Europe and West Bengal several species of freshwater fishes are affected by the pesticides (**Ibrahim *et al*., 2013**). **Egea-Serrano *et al*.**, (**2012)** have reported that development and growth of amphibians is also affected by the pesticides. The pesticides in the water retard, the growth of several types of algal community (**Pestas and Vagi**, **2017**), dissolved oxygen level in the water (**Kaoga *et al*., 2013**).

6.Impact of Pesticides on the Soil Environment

Pesticides adversely affect the soil microbes and soil enzymatic activities which causes the alteration in the biological balances of the soil affecting nutritional quality of soils. Pesticides in soil retards the fungal species in the soil viz, the growth of symbiotic mycorrhizal fungi is retarded by pesticides oryzalin and trifluralin, triclopyr. Pesticides in soil also check the growth of bacteria especially of those who converts ammonia into **nitrate and/or nitrite (Udochukwu *et al*., 2018). In the soil the population** of earthworms have also been influenced by carbamate and and organophosphorous pesticides. Effects of pesticides on soil enzymatic activities depend on nature of the pesticide, pesticide persistence, concentration and bioavailability of pesticides. **Bansal** (**2015)** reported that the higher doses of carbamate pesticides have adverse effects both on microbial biomass and microbial population. All the enzymatic activity significantly decreased up to 2-3 weeks of incubation (14 d for DHA, acid phosphatase and urease, 21 d for alkaline phosphatase and catalase) and thereafter activity decreased till

the end of the experiment got weaker. The activities of all the studied enzymes decreased with the increase in the dose of pesticides. **Tomkiel *et al*., (2014)** reported that the carfentrazone-ethyl in soil retards the enzymatic activities of dehydrogenases, catalase, urease, alkaline phosphatase, acid phosphatase and β-glucosidase, while the activity of the aryl sulfatase remains unchanged. **Wyszkowska *et al*., (2016)** during their studies on the effect of pethoxamid and terbuthylazine herbicides on soil ecosystem found that a shift in the organotrophic bacteria from the r-strategy to the K-strategy occurs due to these herbicides. It was also reported that these herbicides significantly reduces the enzymatic activities of dehydrogenases, catalases, ureases, acid phosphatase, alkaline phosphatase, arylsulphatase and β-glucosidase in the soil.

Saramanda and Kaparapu (**2017**) studied the effect of nine pesticides and two biocides on fungal isolates from agricultural soil samples during their studies they found that the studied pesticides shows the short term inhibitory effect on the total fungal population. DDT showed a 20% decline in the crop yield. Few pesticides interfere with the chemical signing of legume- rhizobium causing reduction in nitrogen fixation, and crop yield. **Arora *et al*., (2019)** during their field studies on the effect of pesticides on the soil microbial population, soil microbial biomass carbon and dehydrogenase activity found that the soil microbial population, soil microbial biomass carbon and dehydrogenase activity decreases in the presence of pesticides which affect soil fertility. **Walia *et al*., (2018**) studied the effects of Malathion and chlorpyrifos on soil microflora and enzymatic activities in the soil of Jalandhar, and reported that the bacterial population and actinomycetes population decreases. The fungal population decreases drastically with the treatment of malathion while chlorpyrifos has no significant impact on fungal population. They also reported that the enzymatic activities of the enzymes' amylase, cellulose, and phosphatase in presence of pesticides Malathion and chlorpyrifos decreases significantly, while has very little impact at the lower concentration. **Ataikiru *et al*.**, **(2019)** found that the soil microbial population and soil enzymatic activity which is the indicator of soil fertility is temporally affected by pesticides.

Conclusion

Indiscriminate use of pesticides in the last 20 years to increase the crop production and limit the loss because of pests, and crop disease to feed the increasing population has caused the increment of pesticides in water (surface and ground), air, soil, and crops, vegetables, and fruits. Almost 65-70% of the marketed vegetables and fruits in the developing and developed countries contain one or more than pesticide beyond its permissible limit. Adverse effects of pesticides in the environment are the increases in resistant pest population, the decline in the beneficial organisms, changes in the soil environment and contamination of the aquatic system. Pesticides in soil affect microbial population, microbial activities and enzymatic activities in the soil which reduces soil biomass, carbon and nitrogen mineralization (soil fertility), and crop produce. Exposure to persistent pesticides for a longer period may cause neurological and immunodeficiency disorder, brain, pancreatic, breast, prostate cancer, inhibition of acetyl cholinesterase enzyme activity.

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