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Toxic Effects of Pesticides on Humans, Plants, Animals, Pollinators and Beneficial Organisms

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Authors' contributions

This work was carried out in collaboration among all authors. Author MHH wrote the first draft of the manuscript. Author RH edited and revised the manuscript according to the journal style and author QR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Pesticides are a hidden threat to humans, animals, insects, as well as to all ecosystems. They control pests and play an important role in crop productivity and prevent vector borne-diseases in humans, but they also extremely pollute our surroundings. These toxic substances are found in soil, water, air, plants, food and feed. Their residues enter plants and animal products and accumulate in humans and animals by the food chain. They endanger our lives and put down our health, as well as demolish beneficial organisms in the environment. This paper expresses a piece of information that has been obtained from reviewing academic papers, books and other sources. People take these toxic chemicals from water, air, and agricultural products, as well as their surroundings. They are stored in humans and animals' tissues or excreted by different routes, but their adverse effects have no end. Brain, kidneys, skin, gastrointestinal, liver, lungs, spleen and every organ of humans are suppressed by them. They cause various diseases, cancers, mutations, as well as lead to death. These chemicals destroy honeybees' colonies and decrease pollinator's populations. Additionally, birds, wildlife and soil organisms are extremely suppressed by the heavy application of pesticides. They damage human beings, animals, pollinators, honeybees, and soil microorganisms. Increasing the application of pesticides decreases the population of pollinators, honeybees, and other beneficial organisms, as well as impacts human health. If these living organisms are diminished, our lives are threatened by food shortage, a collapsed economy, and increased food and feed demand,

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therefore new crises including famine and diseases put down our prosperity. All pesticides should be used cautiously and need to develop a new type of pesticides that do not harm seriously our environment.

Keywords: Pesticides; insecticides; herbicides; environment; neurotoxicity mutagenicity; beneficial microorganisms.

1. INTRODUCTION

Pesticides have been developed to protect our lives from mice, mosquitoes, flies, insects, and pests. They are used in schools, homes, offices, parks, public lands, agriculture, wood lots, and so on [1,2]. They are widely used for (1) agricultural, (2) municipal, (3) home, (4), and medical purposes in the world [3]. They can be found in our soil, water, air, food, and even in breast milk [1,2]. Currently, modern agriculture should deal with some important global issues, such as population growth, food security, agrochemicals risks, pesticide resistance, natural environment degradation, and climate change [4]. These chemicals protect crops and crop commodities from pests including weeds, insects and diseases. They increase the effectiveness of agricultural production, and so they are called plant protection products. Pesticides are an essential compartment of agricultural management; they take an important part in increasing the yield and quality of crops [5]. These chemicals control pests, diseases, and weeds more easily, cheaply, and effectively; therefore, they are used extensively in the world. However, the usage of pesticides has increased crop productions, but the extensive, unselective, excessive, and wrong use of these chemicals caused heavy damage to the ecosystem, extending toxicity and pollution in the environment [6].

Soil, water, plants, and crops are the major components of the agro-ecosystem. These components make the ecosystem active and sustainable through dynamic interaction among them [6]. The parts of the ecosystem are contaminated by toxicants. Furthermore, anthropogenic activities intensively threaten ecosystem health, global food security, and safety [5]. The global concerns and worries are raised due to soil biodiversity declination and food safety, as these are contaminated by pesticide usage [7]. All pesticides are active substances and bear risks and hazards; therefore, they should be passed and approved by the authority department. The wind and water transport contaminated soil and impair ecosystems functions and additional exposure routes can impact humans and other non-target organism health [7]. These chemicals can contaminate soil, water, air, and plants. If they kill pests, they also can be toxic to non-target organisms such as birds, fish, beneficial insects, non-target plants, as well as humans and animals. The United States Geological Survey (USGS) reported that more than 90% of water and fish samples from the United States (US) streams contained one or more pesticides [8].

On one side, pesticides control vector-borne diseases of plants and play an important role in crop production, on the other side, they threaten the health of a large human population. These chemicals are not always selective, but they impact adversely on non-target organisms. Generally, people are exposed to these toxic chemicals in the working environment and food chain, the affected people reveal acute and chronic toxicity symptoms throughout the time [9]. In the world, there are 1500 types of pesticides used, they have special structure and nature, and they can cause serious environmental and health problems. The pesticides used are approximately 2 million tons in agriculture production per year, 69% of them are used in Europe and the US alone [10]. The residues of pesticides are accumulated in plants and their products, causing environmental pollution [6]. Developmental exposure to various types of environmental chemicals and pesticides has the potential to induce adverse neurological effects in humans or animals [11]. These toxicants cause some health problems, such as central nervous system diseases, endocrine (hormones) system disorders, birth defects, and cancer [12]. It was realized that the enormous usage of pesticides has ecotoxicological effects in birds as well as carcinogenic effects in humans [13].

2. PESTICIDES AND THEIR EFFECTS

The pesticide is a substance or a mixture of substances that are used to control agricultural pests (insects, weeds, etc.) which are harmful to humans, animals, plants, and other organisms and affect the environment and society's health [14]. Pesticides are not only beneficial but they also endanger humans and animals' health due to their toxicity characteristics. They are harmful to all organisms and pollute our surroundings. Broad-spectrum pesticides control a wide range of pest organisms [15], they can be immediately toxic for both target and non-target species [16]. Narrow spectrum pesticides control a particular of pest organisms [17]. It is the best way to use narrow-spectrum pesticides to control specific pests and minimize the impacts of natural enemies [18]. They can target only desired pests; however great numbers of pesticides are broad spectrum in the world that not only kill target organisms but also put down non-target organisms in the surrounding environment of the target pest [19].

The great variety of pesticide residues can be found in daily foods and beverages, including cooked meals, water, fruits, juices, refreshments and animals' feeds, and so on. Additionally, it is mentioned that washing and peeling cannot remove completely the residues of chemicals [4]. The occupational exposure of pesticides often happens in agricultural workers, pesticide industry workers, and home pest exterminators [3]. Children, pregnant women, a sick or aging population may be more sensitive to the pesticide's effects than others [2]. The pesticide residues have been diagnosed in human breast milk; therefore, its adverse effects in children are a concerning issue [4].

Pesticides are classified according to their (1) chemical structure, (2) working principles, (3) target molecules, and (4) possible health effects. Without the above factors' pesticides can be broadly classified as (1) organochlorine pesticides, (2) organophosphorus pesticides, (3) carbamates pesticides, (4) pyrethroids pesticides, (5) biorational pesticides, (6) microbial pesticides, (7) growth regulators and (8) Neonicotinoids. These chemicals are often persistent in the environment, their residues are found in food, plant, soil, and waterways [12,20]. World Health Organization (WHO) classified pesticide toxicity as shown in Table 1.

Pesticides suppress the target and non-target organisms both but their effects will be more serious for target organisms than other non-target organisms. The risk assessment of pesticides for beneficial organisms is evaluated by the International Organization for Biological and Integrated Control (IOBC) through the mortality rate. It said that specific chemicals kill less than 25% beneficial species, it is harmless but when it kills more than 75% beneficial species, it is called harmful chemicals. Therefore, IOBC categorized chemicals into 4 ranges through the effects on beneficial species as shown in Table 2 (23).

The WHO categorized a globally harmonizes system for chemical classification. The substances are classified into 5 classes. Their intensity, signal words, hazard symbols, and color are shown for people's awareness. This information is presented in Table 3.

Pesticides are classified by their relevant effects, all pesticides cannot demolish all organisms, therefore every pesticide has its characteristics and effects on a living organism. Herbicides kill plants and weeds, insecticides kill insects, while bactericides destroy bacteria [26]. The pesticides are classified as target pest organisms as shown in Table 4.

The pesticides are further classified by formulation status such as dry, liquid, and other forms. The pesticides are classified as a mode of action that repels insects such as (1) Desiccant,

Table 1. Pesticides toxicities categories according to the world health organization

WHO class		LD_{50}* for the rat (mg/kg body weight)		Example in terms of active ingredients
		Oral	**Dermal**	
Ia	Extremely hazardous	< 5	< 50	Aldicarb, Parathion, Mercuric Chloride
Ib	Highly hazardous	5–50	50–200	Acrolein, Cadusafos, Ca-arsenate
II	Moderately hazardous	50–2000	200–2000	Alachlor, Bentazone, Copper f sulfate
III	Slightly hazardous	Over 2000	Over 2000	Hexaconazole, Atrazine, Butachlor
U	Unlikely to present acute hazard	5000 or higher		Mancozeb, Captan, Bifenox

LD_{50}: the lethal dose is that to kill half of a test population of animals. Modified from [21,22]

(2) Disinfectant, (3) attractant, (4) Chemosterilant, (5) Growth Regulator, (6) Hormone, (7) Pheromone/Kairomone, and (8) Repellant [26]. These chemicals are categorized site of action such as (1) acetylcholinesterase inhibitors, (2), Nervous System Stimulants, (3) Cytotoxins, and (4) Allergins [26].

Table 2. The toxicity rate between pesticides and beneficial organisms is shown according to the IOBC), the toxicity rate represents the reduction in the ability of beneficial species tested to provide pest control and range from 1 to 4

No.	Categories of Chemicals	Kill beneficial species of insects (%)
1	Harmless	<25%
2	Slightly harmful	25-50%
3	Moderately harmful	50-75%
4	Harmful	>75%

Modified from [23]

2.1 Pesticide Effects on Humans

Humans take pesticides from food, air, water, soil, flora, and fauna. When absorbed in the human body, they are distributed by the bloodstream in the whole body. They can be excreted through the gastrointestinal tract (GIT), urinary tract, skin, and respiratory tract. The dermal, oral, eyes and respiratory are the common pathways to pesticide entry into the human body [4]. The WHO estimated that more than 4 million people are poisoned by pesticides each year in the world, of these, at least a million people are hospitalized [29]. It is estimated that about 350,000 people are killed by unintentionally poisoning of pesticides every year in the world. Many incidents happen in developing countries because they use commonly banned dangerous pesticides, which have been greatly restricted by developed countries [20]. United Nations Environment Programme (UNEP) estimated that pesticides intoxicate at least 3 million agriculture workers in less-developed countries and at the minimum 300,000 workers in the United States each year. The Academy of Sciences mentioned that pesticide residues in food cause approximately 4,000-20,000 cancer cases annually in the United States [30].

Nowadays, synthetic pesticide use has increased more than 50-fold, and also their toxicity enhanced by 10-100 folds for pest than those used in the 1950s. Some synthetic pesticides that are toxic for beneficial species including organochlorine (e.g. Dichlorodiphenyltrichlo-roethane or DDT), organo-phosphates (e.g. malathion and parathion), carbamate, pyrethroids, and neonicotinoids [30]. At the same time, two or more chemical substances work together and may have synergetic effects, and their effectiveness is increased [3]. Pesticides have two types of ingredients; one is active and the other is inert. Active items kill the pest, while inert ingredients assist with the active part to work better and effectively [2]. Pesticides are toxic at particular doses for all living organisms. When they enter into the human body, they inhibit enzymatic function and interrupt the normal reactions in the body which are required for metabolism [31]. The numerous negative health effects have been diagnosed that have a link with pesticides. The common pesticide effects are revealed in the skin, gastrointestinal tract, central nervous system, respiratory system, reproductive systems, renal system, and so on. Their adverse effects are carcinogenicity, teratogenicity, mutagenicity,

Table 3. The WHO classified a globally harmonized system and labeling of chemicals

Class	Intensity	Signal words	Hazard symbols	Color
Ia	Extremely hazardous	Very toxic		PMS[1] Red 199 C[2]
Ib	Highly hazardous	Toxic		PMS Red 199 C
II	Moderately hazardous	Harmful		PMS Yellow C
III	Slightly hazardous	Caution	No symbol	PMS Blue 293 C
U	Unlikely to present acute hazard in normal use	No signal word	No symbol	PMS Green 347 C

[1]: PMS= Pantone Matching System. It is a system that is used for color accuracy and consistency.
[2]: C= Coated. (C, U, and M indicate the type of color in Pantone Matching System). Modified from [24,25]

endocrine-related disorders, and some others. Moreover, high exposures to pesticides in occupational, accidental, or intentional can severe intoxicate, leading someone to hospitalization and death [4].

Table 4. Pesticides and their effects on relevant microorganisms [27,28,26]

No	Target organism	Pesticide category
1	Bacteria	Bactericide
2	Fungi (yeast, molds)	Fungicide
3	Algae	Algicide
4	Repels pests such as mosquitoes	Repellants
5	Insects	Insecticide
6	Termites and ants	Termiticide
7	Nematodes	Nematicide
8	Acarids (mites, ticks)	Acaricide
9	Rodents	Rodenticide
10	Larvae such as mosquitoes	Larvicides
11	Eggs of pests (e.g., fleas)	Ovicides
12	Gastropods (slugs, snails)	Molluscicides
13	Weeds	Herbicide
14	Trees, shrubs, or forests	Silvicide
15	Birds	Avicides
16	Slime	Slimicides
17	Fish	Piscicide
18	Pests in buildings or soil	Fumigants
19	Vertebrate predators	Predacide
20	Insects	Pheromone/ Kairomone
21	Organisms that attach to underwater surfaces	Antifouling agents

The exposure to pesticides has been linked to different pathological disorders, including metabolic diseases, neurotoxicity, immune toxicity, endocrine disruption and reproductive disturbances, and cancers. The human intestines have about 100 trillion microbes and there are equal numbers of microbial and human cells. The gut microbiota assimilates nutrients, digest fiber, absorption of fatty acids, calcium, and magnesium. The microbes are essential for the development and maturation of the gastrointestinal tract [32]. The first physical and biological barrier against chemicals in the GI tract, as a result, it is their first target. These chemicals depress microbiota and create dysbiosis conditions in the gut, as well as the impact on metabolites, demolish intestinal mucosa, and gut cells. They cause some non-communicable diseases, including irritable bowel syndrome, inflammatory bowel disease, food allergies, nonalcoholic fatty liver disease, and autoimmune diseases [32,33,34].

The pesticide rendered mild poisoning symptoms are anorexia, dizziness, sweating, nervousness, irritation of the skin, nose, throat, and eyes, dizziness, diarrhea, fatigue, restlessness, and insomnia. Besides, some other symptoms are revealed during moderate poisoning status including nausea, vomiting, headache, lacrimation, excessive salivation, respiratory depression, seizures, loss of consciousness, reduced visual ability, allergy, abdominal cramps, and rapid pulse. In severe poisoning exhibit inability to breathe, extra phlegm or mucous in the air routes, burn of the skin, increase the rate of breathing, pulmonary fibrosis, myocarditis and necrosis, pancytopenia, and adrenal hemorrhage, loss of reflexes, extreme weakness, and even death [35,2,10,36,37].

Organochlorine pesticides have a connection with endocrine disorders, carcinogenicity, adverse effect on embryonic development, lipid metabolism, hematological and hepatic alteration [4]. Someone exposed to these chemicals exhibits acute clinical symptoms; these are paresthesia (tongue, lips, and face), apprehendsion, tremors, tonic colonic convulsions, and hyperthermia [38]. It is reported that pyrethroid damages deoxyribonucleic acid (DNA) in human sperm, and reveals possible negative effects on the human reproductive system and central nervous system and endocrine system [4] and may cause cancer. Additionally, it can cause hyper-excitation, aggressiveness, incoordination, whole-body tremors, and seizures [2]. Organophosphate pesticides are responsible for various health effects and diseases, such as stroke, diabetes, hypertension, autism, kidney failure, Parkinson's disease, Alzheimer's disease, and cancer. Furthermore, some organophosphate pesticides have strongly teratogenic and mutagenic effects. Carbamate pesticides cause neurobehavioral disorders, increased risk for dementia, and non-Hodgkin's lymphoma [3]. Neonicotinoid pesticides play a role in some central nervous system disorders, including Parkinson's disease, schizophrenia, Alzheimer's disease. and depression. In a mammal, these chemicals reduce sperm production and function, reduce pregnancy rate, increase the rate of embryo death, happen stillbirth and premature birth, and reduce the weight of offspring [39].

2.2 Pesticide Toxicity to Plants

The herbicides are not only exposed to target plants, but they also contact non-target plant species. The non-target plant species are affected by these chemicals, when they are sprayed and sublethal doses reached plants by droplet drift, vapor movement, runoff, leaching, erosion, and unsuitable disposal [40,41]. These toxicants demolish plant biodiversity [42]. The sensitive plants are affected in the four stages of the growth by herbicides. (1) seedling stage, the vegetative growth of a new plant is damaged by pesticides, (2) the same plants may show negative effective during the later stages in seed production, (3) the spray may express bad effects on reproductive organs of plants during the seed formation, and (4) often the vegetative parts of the plant have been affected in F1 generation [41]. The half of plants, one-third of insects and four-fifth of bird species' population has been declined by heavy pesticide usage, in the farmland habitats. Nowadays, non-crops plants (weeds) are threatened to extinction in the United Kingdom [42].

Various herbicides represent different site actions and functions in plants. Some common herbicides mechanisms of actions are (1) Inhibitors of photosynthesis, (2) Inhibitors of pigment production, (3) Cell membrane disruptors and inhibitors, (4) Fatty acid biosynthesis inhibitors, (5) Cell growth inhibition, (6) Auxin-like action-growth regulators, (7) Amino acid biosynthesis inhibitors, (8) Inhibitors of respiration, and (9) Unknown mechanism of action [43]. The study reported that 104 different species of plant were exposed to herbicides application in their experimental plots, of these, 35 species (34%) were impacted by pesticides application and shown marks, such as epinasty, leaf mottling, withering, yellowing, leaf and stem twisting, necrosis and bud malformation [41].

2.3 Pesticide Toxicity to Animals

The scattering of pesticide residues in our environment, kill greatly nonhuman biota, such as bees, birds, amphibians, fish, and small mammals [20]. The pesticides further decline the population of animals, such as marine mammals, alligators, fish, fish-eating birds. It is considered that thousands of Arctic seal's deaths had a connection with the accumulation of persistent chlorinated hydrocarbons, such as DDT, Polychlorinated biphenyls (PCBs), and dioxins, in the food chain. These chemicals are accumulated in fat and they weaken immune systems of animals. Similarly, it is thought that the mortality of striped dolphins in the Mediterranean, Beluga whales in Saint Lawrence estuary, and sea lions in the Pacific Ocean are caused by the accumulation of toxic pollutants [44].

Atrazine exposure to animals has contributed to reproductive toxicity and delays in sexual maturation [4]. PCBs are extremely toxic organic compounds that were widely used in industry and agriculture in the 20th century. In 2001, it was banned in the world. This toxic substance has been detected in birds, fish, and animals of migratory species. This contaminant can minimize the population of these organisms [45]. Although the intentional poisoning of domestic and wild animals is a crime in European Union countries, it is still currently used for harmful animals in many countries. Furthermore, humans and domestic animals are repeatedly intoxicated by pesticides. It is reported that nearly 52.5% of birds are poisoned by pesticides as well as the major cause of wild mammal death. Many people use poisoned baits in illegally, massively, and non-selectively methods, thus large numbers species are affected. In Spain, poisoned baits were used to kill wild animals that were harmful to different activities including agriculture, apiculture, pigeon breeding, and so on. Now their population has been drastically eliminated [46].

2.4 Pesticide Toxicity to Pollinators

Pollinators perform a good job in the ecosystem. Cross pollinated and self-incompatible plants need pollination to sustain and conserve biodiversity through seed production [6]. Bees not only collect nectars, but they also take part in pollination. The pollen grains are attached to the specialized hair on the body of the bee, thus, when bees move from flower to flower accidentally pollinate flowers [47]. All over the world, approximately 300 commercial crops are grown, of them about 84% are insect-pollinated, which expresses the importance and value of pollinating insects [6]. Globally, honeybees are important for agroecosystems, they take part more than $200 billion in pollination services and 2/3 crops and most wild flowering plants are pollinated by bees and other beneficial insects [48]. Honey contributes greatly to the food market and a good source of income, globally. Food Agriculture Organization (FAO) reported that 1.6 million tons of honey and 65,000 tons of bee wax were produced in 2013 [49].

Plant biodiversity enhances bees and other pollinator insects' populations [50], but herbicides decrease the plant communities, as well as their adverse effects, are also represented in birds, mammals, fish, insects, amphibians, reptiles, and humans. These toxicants demolish the plant biodiversity kingdom [42]. The United States Fish and Wildlife Services (USFWS) estimated that one-fifth honeybee colonies are killed by pesticides in Europe. Moreover, 67 million birds and 6-14 million fish are killed by agrochemicals each year in the world [30]. Dose and time of exposure contribute to toxicity. These two factors are very important for bee intoxication. In the United States, out of 6 million, 3 million bees' colonies have been decreased due to agrochemical usage during 63 years (1947-2010) [51].

These important and valuable insects are at a risk, due to various chemical usages in plants. They feed on plant flowers and collects nectar to produce honey, but they are severely impacted by chemical toxicity when they are in duty to bring food for honey making. Neonicotinoids are toxic to bees and cause colony collapse disorder. The laboratory results have shown that pesticides could weaken the insect's immune system [47]. It is shown that cypermethrin impact on the nervous system and is toxic to bee, other beneficial insects, earthworms, fish, and shrimps [52]. The severe damage and the great mass of death are occurred in bee colonies, causing a pollination crisis. Generally, many of these types of crises have happened due to neonicotinoid pesticide usage, the most widely used chemical class of insecticides [48]. In 2013, the dinotefuran insecticide was used on tilia flowering trees in Oregon state, it was estimated that 50 thousand bumblebees were killed in this incident. The most common insecticides are used, they are neurotoxic, such as organophosphates, carbamate, pyrethroids, phenylpyrazoles, and neonicotinoids. These toxicants stimulate the nervous system leading to loss of coordination, paralysis, and eventually death. The fungicide of captan can induce larval mortality and developmental malformation in honeybees. The herbicides potentially interfere with metabolic and reproductive processes in pollinators. For example, paraquat is extremely toxic to honeybees when applied externally [53]. Moreover, pesticides and viruses have synergetic relations with each other; therefore, they increase the mortality rate of bees [54]. The 8 impact drivers that influence the pollinator population. They are (1) urbanization of agriculture land, (2) pesticides usage, (3) invasive alien plants, (4) local and global climate change, (5) contest with invasive alien pollinator species, (6) dispersion of pests and pathogens, (7) extension of electromagnetic pollution, and (8) genetically modified crops [55].

The pesticide droplets and dust can fall directly on the bees or the wind could carry the particles of pesticides hundreds of meters away from the fields or the bees can fly across the treated fields. In all these cases, insecticides may be sufficient to kill a bee, because the concentration of these chemicals may be enough for their mortality. Insecticides are the most toxicants to bee, while herbicides are largely harmless. Herbicides disturb the surroundings in which bees and other pollinators live. The bees are at risk when (1) they are surrounded in the spray drifts (2) agrochemicals residues are found in pollen, honey, water, hive, larvae and feed, and (3) the combs treated with acaricide products and bees are exposed with them [51].

2.5 Pesticide Toxicity to Beneficial Microorganisms

Pesticides are sprayed on plants and soil to control pests; therefore, they are mixed with soil and residue of plants that are added to the soil. The pesticides are transformed by physical, chemical, and biological processes in soil. Some chemicals products are highly toxic to soil living organisms [6]. Various reports stated that insecticides exert adverse effects on the microbiological properties of soil. They alter the enzymatic activities of organisms. For instance, buprofezin is caused adverse effects to invertase in soil. The enzyme activity is stimulated after a single addition, but there is a progressive decline after three repeated applications [56]. The contaminants have adverse effects on microorganism's growth. They interfere in the microbial metabolic functions. One report indicates that compost having Pentachlorophenol (PCP) chemical inhibited microbial abundance in soil [57]. Separate and combined pesticide usage in low concentration reduces and alters the community of microbial diversity [58].

However, microorganisms degrade all types of pesticides including insecticides, herbicides, fungicides in soil, and water, they play important role in degradation of pesticides, but they are also adversely affected by their toxicity [59,60]. Many pesticides have long half-lives and their presence in the ecosystem can be extremely harmful [61]. The contamination of soil is caused by the increasing usage of toxic pesticides. These chemicals are used to destroy selective pests, but they also suppress unselective beneficial organisms that are extremely important for soil and plant health [62,63]. When agrochemicals kill beneficial non-target microorganisms of soil, they impact negatively on nutrient cycling and retention, impoverish nutrients pool of soil, and eventually decrease soil fertility. These chemicals persist in soil and remain for a long time; therefore, the impact negatively on soil microbial flora constantly. The fate of pesticides in soil depends upon (1) characteristics of chemicals, (2) properties of soil, (3) method of application, and (4) site conditions [64].

Macro and microorganisms perform vital functions and services of the ecosystem. Soil organisms play an important part in the formation of soil including earthworms. They are the most important macro-organisms of soil that is called soil ecosystem engineers. They contribute to making nutrients available to plants [6]. They play important roles in soil functions; they take part in the breakdown of organic matter, increase soil fertility, as well as contribute to soil formation. They are very sensitive to soil chemicals [65]. These chemicals increase the potential risk of toxicity for earthworms and soil-dwelling microorganisms [6]. These chemicals are accumulated in food; thus, microorganisms are affected by them when they are absorbed or ingested at high levels [65]. Legumes crop fix 100-200 kgN/hectare/year, but the rate of nitrogen fixation is decreased due to chemical usage especially pesticides. Organochlorine pesticides and pollutants prevent symbiotic signaling between alfalfa and *Rhizobium meliloti*. Finally, symbiotic nitrogen fixation is delayed and the crop yield is also declined; therefore, pesticides reduce the efficiency of symbiotic nitrogen fixation [66].

3. CONCLUSION

Pesticides are used in agriculture to protect plants from pests; therefore, agricultural products have been increased via the usage of these chemicals. Although their application plays an important role in crop productivity, their excessive usage also pollutes our surroundings. Our soil, water, air, food, feed, and other sources have been polluted by the heavy application of pesticides. They are widely applied in agriculture, home, medical purpose, and municipality; therefore, many people are exposed to them in working place, as well as their residues transfer from one organism to another through the food web. Some chemicals destroy specific organisms but many other's effects are broad and demolish a great number of organisms; therefore, they draw calamity for nature, by diminishing beneficial insects, microorganisms, animals, fish, and so on. They kill organisms, prevent their growth, and cause various diseases and birth defects. These toxicants enter into the human body through oral, dermal, lungs, and eyes as chemical substances and affect a living organism. These chemicals influence kidneys, lungs, skin, liver, spleen, gastrointestinal tract, cardiovascular system, and nervous system. Cancer, mutation, and some other common diseases have been linked with pesticides. Acute and chronic exposures with pesticides express various toxicity symptoms. Different types of diseases endanger our health. The agrochemical use should be done carefully and the guidances should be employed during application time, it reduces the noxious effects of pesticides in the surroundings. Moreover, for a healthy environment, it is necessary to follow all recommendations and suggestions about pesticides that prescribed by authority agencies. Scientists consider producing effective pesticides for target organisms and their side effects will be less for humans, animals, pollinators, and beneficial organisms. It can help with the sustainability of non-target organisms.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by the personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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