The Harmful Effects of Pesticides on the Environment and Human Health: A Review

Israa Mahmood Ali

[1]Rusafa Second Directorate of Education, Iraqi Ministry of Education, Baghdad, Iraq.

Corresponding author: is87raa@yahoo.com

Article history:

Received: 17 March 2023
Accepted: 1 June 2023
Published: 30 June 2023

Keywords: *adverse effects of pesticides, human health, pesticides, pesticide risks, environment.*

Abstract

The population inflation that countries are witnessing during this century, makes it imperative to provide sufficient quantities of agricultural products to meet their urgent needs. Therefore, it became very necessary to use pesticides to improve agricultural crop productivity and reduce losses resulting from agricultural pests. The indiscriminate use of pesticides causes severe risks not only on agricultural fields, but also workers in their manufacturing processes and individual use in homes and institutions. The main adverse effects of utilizing pesticides on human health, soil, microorganisms of soil, surface water and groundwater have been covered in this review. This investigation is aiming to elevate environmental awareness, highlight the serious harms of pesticides and provide guidance for implementing a serious solution from the people and authorities. In addition, the most important strategies to reduce the pesticides risks have been summarized.

https://dx.doi.org/10.52951/dasj.23150112

Introduction

Pesticides are chemical preparations intended to kill fungal or animal pests. It can also be defined specifically as any substance or mixture of substances used for preventing, destroying, repelling, or mitigating any pest. They can also serve as plant regulators, desiccants, or defoliants. A pesticide is a poisonous chemical compound or combination of biological agents or a substance that is deliberately introduced into the environment to prevent, dissuade, control, kill, and/or eliminate populations of weeds, insects, fungi, rodents, or other undesirable pests. Pesticides function by luring in, enticing, and then killing or controlling pests. The term "pests" can widely refer to “the animals or plants that endanger our food, health and / or comfort” (Mahmood *et al.*, 2016).

On the other hand, the majority of pesticides target not only the undesirable pest; rather, they also affect non-target animals and plants during their application. Pesticides are lost in significant amounts during application to weeds and pest, less than 1% of the total amount of pesticides can reach the target. The lost amounts may have negative consequences on specific communities, species, or ecosystems, as well as on human health, through processes including spray drift, off-target deposition, run-off, and photodegradation, for example (Hernández *et al.*, 2013).

Pesticides, despite their benefits, can be toxic compounds that are ecologically stable, bioaccumulative, and environmentally stable (Fenik *et al.*, 2011). Pesticides can persist in the environment for years because many of them are persistent and difficult to degrade. They persist in soil, permeate groundwater and surface water, and pollute the environment on a large scale. Depending on their chemical properties, they can enter organism cells, bioaccumulate in food chains, and thus impact human health. Humans can also be exposed to harmful pesticide residues through occupational use (Mostafalou and Abdollahi, 2013). The cycle of pesticides in

the environment is depicted in Fig. 1 (Rajmohan *et al.*, 2020).

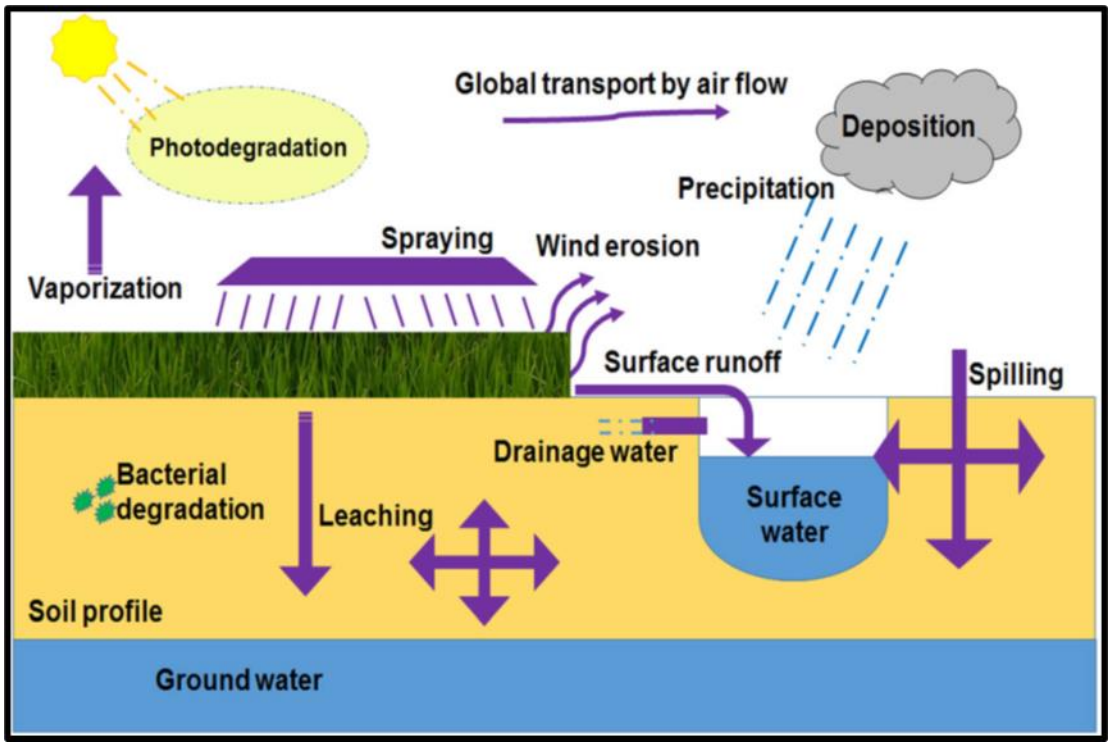

Figure 1. Pesticide cycle in the environment

The maximum development in pesticides occurred during and after the World War-II period, when there was a pressing need to increase food production in response to the situation at hand. Various powerful and reasonably priced pesticides were synthesized and produced during this time period, including DDT, dieldrin, aldrin, 2,4-D, endrin, and parathion. Acute poisoning events in the late 19th century led to a public concern for ecotoxicology ,where the potential drawbacks of the indiscriminate use of pesticides were discussed in " Silent Spring" book by Rachel Carson (Bernardes *et al.*, 2015). The use of DDT was banned internationally wide (Levengood and Beasley, 2007). Despite the stringent prohibition, DDT is still consumed unlawfully in many places, particularly in developing countries. The dangers of DDT on human health were recognized and widely disseminated in order to warn people and prevent unforeseen events. DDT still has negative health impacts on people even though it is no longer used because of its long-lasting effectiveness and accumulations in the food chain. Insecticides are thought to be the most harmful type of pesticide, followed by fungicides and herbicides, which are ranked second and third in terms of toxicity. In the recent past, around 2 million tons of pesticides were used worldwide, with 47.5% of those being herbicides, 29.5% being insecticides, 17.5% being fungicides, and 5.5% being other pesticides (Sharma *et al.*, 2019).

Classification of pesticides

Pesticides can be categorized in a variety of ways, including by the target they control (EPA - Environmental Protection Agency, 2004):

- Herbicides work on grasses, plants and weeds, in another meaning they are used as plant growth regulators.
- Insecticides fight insect growth or survival.
- Rodenticides fight against rodents and rats.

- Avicides act against undesirable bird populations.
- Fungicides work by inhibiting or killing fungi and fungal spores.
- Nematicides which combat nematodes.

The division of pesticides can also depend on their chemical structure as shown below (EPA - Environmental Protection Agency, 2004):

- Organophosphorus (like diazinon and chlorpyrifos).
- Organochlorine (aldrin and DDT).
- Carbamates (like aldicarb and carbaryl).
- Benzoic acids (dicamba).
- Pyrethrins and pyrethroids (cypermethrin and cyfluthrin).
- Triazines (simazine and atrazine).
- Derivates of phenoxyacetic (2,4-D).
- Derivatives of dipyridyl (like paraquat and diquat).
- Derivatives of glycine (glyphosate).
- Dithiocarbamates (ziram and maneb).

Adverse effects of pesticides on human health

According to the World Health Organization, developing nations record 220000 fatalities and approximately 3000000 cases of pesticide poisoning each year (Lah, 2011). Approximately 2.2 million people, primarily in developing nations, are at an increased danger from pesticide exposure (Hicks, 2013).

Pesticides enter the human body through inhalation, ingestion or penetration via skin, however, most people get affected through the intake of contaminated food. Vegetables and fruit have a higher rate of fatal contamination since they receive the greatest pesticide application rates (Van der Werf, 1996). Pesticide toxicity is not limited to people working in agriculture; workers in industrial fields face increased risk as a result of handling a variety of toxic compounds, such as inert carriers, pesticides, toxic solvents, and raw materials. In the agriculture field, some observe that farmers do not follow the safety instructions, such as wearing safety masks, gloves or other protective gear during the spraying of pesticides (Bhandari, 2014).

Acute Effects

Immediate effects of pesticide exposure could be through oral, respiratory or skin exposure. They could appear in many days and are sudden in symptoms like stinging of the eyes and skin, headache, irritation of the throat and nose, itching of the skin, appearance of rash and blisters on the skin, dizziness, abdominal pain, diarrhea, nausea and vomiting, blurred vision, blindness and scarcely the death. organophosphate pesticides are related with acute human health problems.

Chronic Effects

Pesticides' chronic side effects can be fatal and take years to manifest. Various body organs deteriorate as a result of these long-term impacts. Consequences of persistent pesticide exposure include the ones listed below.

- Pesticide exposure can cause a variety of neurological system defects, including loss of memory and coordination, decreased motor signaling, and impaired vision (Lah, 2011). Many studies have found a link between pesticides and the diseases Parkinson's and Alzheimer's.
- There are many types of cancer associated with pesticides (especially

DDT), like brain cancer, leukaemia, lymphoma, breast cancer, ovarian cancer, prostate cancer, and testicular cancer anywhere that cancer patients' blood has included pesticide traces. Organophosphate pesticides used in vegetables gradually accumulate in the human body and have been associated with a link with cancer (Miah *et al.*, 2014). Hodgkin lymphoma (NHL) is a group of blood cancers that includes all types of lymphomas except Hodgkin lymphomas. NHL is caused by pesticide ingestion, mainly phenoxy acid herbicides, NHL risk has been found to be six times higher in Sweden in people who use phenoxy acid herbicides (Singh *et al.*, 2018). The incidence of cancer depends on the intensity and exposure duration of pesticides. Chlorpyrifos (CPF) is a chemical compound that has been demonstrated to cause a redox imbalance in human cells when coupled with pesticides. These substances alter the antioxidant defense mechanisms in cells, which leads to breast cancer tumors (Rivero *et al.*, 2015). Heterocyclic aromatic amines cause a number of cases of colon or bladder cancer like Imazethapyr which increases the danger of colon and bladder cancer by 78% and 137% respectively (Asghar, 2016).

- Long-term exposure to pesticides alters the amounts of female and male reproductive hormones, which have an impact on an individual's ability to reproduce. As a result, it causes birth malformations, stillbirths, abortions, and infertility. It was found that testicular dysfunction was caused by pesticides widely used in plant pathogen control Dibromochloropropane (DBCP) which in turn caused human infertility *(Rajmohan et al.*, 2020).

- Exposure to pesticides can cause hypersensitivity, asthma and allergies. Also, it may aggravate asthma through irritability, inflammation, immunosuppression, and hormonal imbalances (Amaral, 2014). Pyrethroid insecticides are regarded as being hazardous to the respiratory system through inhalation. The bronchial mucosa is mostly damaged by the chemical compounds generated by pesticides, which makes the airways very susceptible to allergens. Many pesticides have been considered as one of the most important links between asthma, household or environmental pollutants like carbamate, organophosphate, organochlorine, paraquat or pyrethroid insecticides (Singh *et al.*, 2018).

Effects of pesticides on the soil

Pesticides can enter the soil via wash-off from treated foliage spray, drift during foliage treatment, or release from treated seeds or granulates in the soil. Some pesticides like nematocides and direct application of soil fumigants dominate plant diseases and pests presented in the soil. The pesticides transportation, degradation or persistence in the soil rely on their chemical characteristics (like molecular structure, solubility and the volatility) in addition to the soil's chemistry, physics, and biology. Soil properties, soil pH, and soil organic matter all these factors affect sorption/ desorption, degradation, volatilization, run-off, uptake by plants, and leaching of pesticides. The most significant interaction between soil and pesticides is sorption, which determine both pesticides decomposition and movement through soil. Rapid sorption frequently happens shortly after a pesticide application; as time passes, the sorption mechanism becomes slower.

However, it has been detected that sorption of many pesticides proportional to increasing time, and frequent application, that could increase the formation of bound non-extractable residues. Soil pH is one of important factors that affect the adsorption which increase for ionizable pesticides with a declining soil pH (e.g. picloram,2,4-D,2,4,5-T, and atrazine) (Andreu and Picó, 2004). Although adsorbed residues are thought to have a low effect because they are inert and non-available, it has been discovered that they can release over time. These residues may be released using because of a pH change or the addition of nitrate fertilizers to the soil, there is evidence that certain organisms, such as plants and earthworms, can absorb and remobilize old, tightly bound residues (Gevao *et al.,* 2001).

The amount of organic matter in the soil is the most important feature. The adsorption of pesticides increases when the organic matter content is large. The absorbing ability of the soils to pesticides depends on their large content of organic matter and keeps water with dissolved compounds. Additionally, there are higher microorganisms in these soils that can breakdown the pesticides (Farenhorst, 2006). Pesticides bound to soil organic matter or clay particles are immobile and bioavailable, but they are also less microbially degradable and thus more persistent. The soil's capacity to attract positively charged ions in an exchangeable form is also essential with paraquat and other pesticides that carry a positive charge. These chemicals are stable and required a strong mineral acid for their extracting (Andreu and Picó, 2004).

Pesticide travel can also be influenced by soil properties. One of these properties is the soil structure, sands and gravel with a coarse texture have higher infiltration rates, and therefore, the water seeps over the soil to the groundwater. While clays and other fine-grained soils typically have modest seepage capacity, therefore water tends to flow out of these soils into lakes and streams, soil with more clay in its texture has a larger surface area available for adsorbing pesticides. In terms of permeability, soils with high permeability allow water containing dissolved pesticides to leach through them more easily, allowing the pesticides to reach the groundwater. Texture influences soil permeability (Lourencetti *et al.,* 2008).

Pesticides' behavior influences their final fate in the soil; they can be classified as (a) hydrophobic, nondegradable, and bioaccumulable pesticides that are strongly linked to soil particles, such as the organochlorine DDT, endrin, endosulfan, heptachlor, and lindane. Most of these pesticides are presently prohibited in agriculture but their residues are still present. (b) Polar pesticides are represented generally by herbicides but they also include fungicides, carbamates and some organophosphorus insecticides (Aktar *et al.,* 2009).

Pesticides' effects on soil microorganisms

Microorganisms include bacteria, algae, actinomycetes, protozoa and micro fauna they are also called microbial biomass. Another definition of microbial biomass is the part of organic matter in soil that contains living microorganisms smaller than 5–10 cubic micrometers and it is a fraction of soil organic matter that is affected by control practices and pollution (Sai *et al.,* 2019).

Pesticides applied to soil are transformed into one or more transformation products through biological and nonbiological actions. The microorganisms considered to play an essential role in these transformations through mechanisms include oxidation, hydrolysis, reduction, conjugation etc, catalyzed by many types of enzymes resulting in less bioactive compounds (Beigel *et al.,* 1999). Therefore, microorganisms are among the most significant biological factors that remove

and degrade waste materials and chemical products into less complicated compounds reducing their risks in the soil. In addition, soil microflora, mainly fungi, algae, bacteria and protozoa play a major role in making the soil fertile through their primary catabolic role in the degradation of animal and plant residues in the cycling of the organic, inorganic nutrients content of soil. Overuse of chemical pesticides requires adverse effects on the soil organisms, because it can decrease of beneficial soil microorganisms. Indiscriminate use of chemicals will be beneficial for a few years, but after a while, there are not enough beneficial soil organisms to hold on the nutrients (Savonen, 1997).

As a result, pesticides that slow down the soil microorganism's effectiveness could have an adverse impact on the soil's nutrient quality and, consequently, cause significant ecological issues. Therefore, an ideal pesticide should be toxic only to the target organism, biodegradable and undesirable residues should not affect nontarget organisms *(*Chowdhury *et al.,* 2008).

Effects of pesticides on surface and groundwater

Contamination of water by pesticides is widespread. Pesticides can reach surface water through runoff from treated soil and plants or by being applied immediately to the water's surface e.g., for elimination of mosquitoes. The pesticides can damage aquatic vegetation, lower dissolved oxygen content of the water causing harmful algal blooms and could influence behavioral and physiological alterations in fish populations. A drop in the numbers of various types of fish is noticed, that associated with the excessive use of pesticides (Scholz *et al.,* 2012). Aquatic plants contribute about 80% of the dissolved oxygen in surface water, which is essential for the survival of aquatic life. Destroying these plants with herbicides causes a sharp drop in oxygen content, which eventually kills fish and lowers their production (Helfrich *et al.,* 2009).

The U.S Geological Survey (USGS) has conducted a set of comprehensive studies on the main river basins that have shown that more than 90% of water and fish samples collected from all streams contained one, or more pesticides (Kole *et al.,* 2001).

In general, surface water pesticide contamination is substantially higher than that in groundwater, mainly as a result of ground runoff from agricultural land and pollution from spray drift. Pesticides can infiltrate into the ground through polluted surface water, incorrect disposal, and unintentional leaks and spills (Mahmood *et al.,* 2016).

The factors that affect pesticide migration in the environment are site depth down to the groundwater, topography, geological characteristics, and climate. When the groundwater is shallow, a smaller quantity of contaminants can be adsorbed and degraded by the soil so pollution is a significant worry. Topographically, flat terrain, regions with closed drainage systems where water flows into a basin's center, and mostly sinkhole sites, are vulnerable to groundwater pollution. In terms of geological conditions, highly permeable soils with gravel in their texture increase groundwater contamination, as does the presence of wells. On the other hand, the surface water could be contaminated by the rainfall or irrigation that collected in streams, ponds and lakes if they exist. In terms of climatic conditions, heavy irrigation or rainfall could cause large amounts of water seeping through the soil and reaching groundwater. Furthermore, rain can transport pesticides to far-off locations and introduce them to surface waters, contaminating rivers, lakes, and seas (Bernardes *et al.,* 2015). The nature of pesticides (hydrophobicity, water solubility) also plays a significant role in water contamination. The higher solubility of pesticides increases the possibility of contamination.

Effect of pesticide in aquatic environments

Water bodies are most at risk from pesticide exposure. They can have an impact on aquatic life at different trophic levels, ranging from algae to fish. Through the food chain, the pesticides that have accumulated in the water become stronger and enter fish that are dangerous to consume (Karr, 2000). There are three typical ways that fish and aquatic life can expose to various type of pesticides: orally (by drinking contaminated water), dermally (direct absorption via the skin), and breathing (gill uptake through breath).

The use of herbicides near weedy fish nurseries, aquatic species' capacity to reproduce was impacted (Helfrich *et al.,* 2009). The water contaminated by Atrazine showed markedly reduced peripheral leukocyte counts, indicating an effect on the immunological system of fish and amphibians (Forson and Storfer, 2006; Rohr *et al.,* 2008). With reports of fish poisoning from pesticides like endosulfan, Winam Gulf is the most polluted area of Kenya's Victoria Lake. As a result, the European Union banned the import of fish from the lake (Abong'o *et al.,* 2014). Endosulfan, chlordanes, and hexachlorocyclohexane isomers were detected in fish tissues and dietary components of Cynoscion guatucupa, demonstrating high bioaccumulation and biomagnification of these chemicals at various trophic levels. Nineteen pesticide standards were employed to detect the pesticides (Lanfranchi *et al.,* 2006).

The Great Barrier Reef in Australia's keystone marine creatures, which include seagrass, corals, and algae, have highlighted the potential catastrophic effects of pesticide runoff (Cantin *et al.,* 2007).

Many amphibian families were negatively impacted by carbaryl (1-naphthyl methylcarbamate), and the herbicide glyphosate increased the mortality rate of tadpoles and young frogs (Relyea, 2005). Tadpoles adversely affected by malathion's alteration of periphyton and plankton abundance and composition (Relyea and Hoverman, 2008). Endosulfan and chlorpyrifos both caused substantial harm to amphibians (Sparling and Fellers, 2009). The bioaccumulation of DDT was evaluated, in Müller's clawed frog Xenopus muelleri that captured from South Africa's lower Phongolo River floodplain, it was revealed that its concentration had significantly increased during the study period (Wolmarans *et al.,* 2018).

A study conducted in Brazil over a period from 1994 to 2004 discovered residues of DDT, chlordane, and hexachlorobenzene in the blubber of franciscana dolphins. (Leonel *et al.,* 2010).

Generally, the polarity and water solubility of the pesticides affect the amount of bioaccumulation of certain pesticides in fish. The bioaccumulation of a pesticide chemical in fish is inversely correlated with its water solubility. Water solubility is a crucial factor in reducing pesticide dynamics in aquatic habitats (Haque *et al.,* 1977).

Impact of pesticides on birds and honey bees

Birds are extremely vulnerable to toxic pesticides, which can kill them instantly or cause physical deformities, lower mating success, and a reduced ability to travel and evade predators (Aktar *et al.,* 2009).

DDT is sprayed in malaria-prone areas annually following the rainy season, according to information gathered from the ministry of health. The regional office of agriculture's information verified that DDT is sprayed close to water bodies where mosquito flies are thought to be nesting (Yadav, 2010). Birds are most exposed to DDT through the food chain when they prey on fish, earthworms, and other aquatic and/or terrestrial animals that have high DDT body loads.

According to studies, the contamination of bird populations with chlorinated insecticides is a factor in the decline of bird populations (Mineau and Whiteside, 2013). It has been reported in India that aldrin and organophosphate insecticide monocrotophos-related pesticide toxicity has caused bird deaths (Muralidharan, 1993; Pain *et al.*, 2004).

The variety of pollutants also negatively impacts adult water birds' ability to reproduce and results in developmental flaws in embryos. Through hormonal mimicry of estrogens, the consequences on embryos include mortality, decreased hatchability, failure of chicks to flourish, and other teratological effects such skeletal deformities, defective differentiation of the reproductive system and brain system. Acute death, sublethal stress, decreased fertility, eggshell thinning, suppression of egg production, altered incubation and chick-rearing behaviors are just a few of the effects that chemicals can have on adult birds (Fry, 1995).

According to a study, common bird species experienced an average loss of 10% between 1980 and 2006, however in the United Kingdom, common agricultural bird species experienced a reduction of up to 50% in 2006, leaving no chance for recovery and pointing to the environment-harming effects of pesticides (Gibbs *et al.*, 2009). In the United States, it is estimated that pesticide applications kill 72 million birds annually (Fimrite, 2011). 1211 species of birds were threatened as a whole, and 86% of those are endangered because of habitat loss and construction projects that use pesticides and other synthetic substances selectively (Mitra *et al.*, 2011).

Pesticides have extremely detrimental impacts on honey bees. Apiculturists and ecologists have been alarmed by the decline of bee species and collapse of honeybee colonies during the past several years as a result of widespread pesticide use on agricultural crops. The excessive use of pesticides in American and European countries is to blame for a 25–30% drop in the honey bee population. In North American regions, more than half of native bee species are threatened with extinction (Sanchez-Bayo and Goka, 2014). The effects of imidacloprid, diafenthiuron, and ethofenprox were seen in response to metabolic alterations in wild honey bee larvae and adults. According to the researches, honey bees' immune systems were largely destroyed by pesticides exposure. Bees' haemocytes were severely damaged, which led to a lack of immunity to illnesses as well as other abnormalities such agglutination, denucleation, and cell shape distortion (Perveen and Ahmad, 2017). The quantity of haemocytes, the encapsulation reaction, and the antibacterial activity were all decreased by thiacloprid and imidacloprid. These anomalies were brought about by clothianidin at apparently high amounts (Brandt *et al.*, 2016). Pesticide residues have also been discovered in honey and bee-wax samples worldwide, Besides bee damages, which is dangerous for the final consumers (Al-Waili *et al.*, 2012).

The potential strategies for minimizing pesticide effects

Many environmental disasters that were recorded over the past decades, it has become necessary to develop global strategies for dealing and applying pesticides in the correct manner to protect humans and the environment from their risks. Legislations were put in place to prevent the use of some pesticides that were classified as highly toxic like DDT. There are Many international agreements that states accept obligations to incorporate into their national policies. One of the most relevant international policies and tools for reducing risks associated with the use of pesticides is:

- The Rotterdam Convention aims to protect the environment and human health by regulating global trade in

dangerous chemicals (the majority of which are pesticides).

- The Stockholm Convention is an international environmental treaty, signed in 2001 and effective from May 2004 that aims to restrict or eliminate the production and use of persistent organic pollutants (POPs), some of them are pesticides.

- The FAO Members have endorsed the International Code of Conduct for Pesticide Management, which is supported by key pesticide industry associations and civil society organizations (FAO and WHO, 2014).

- The Strategic Approach for International Chemical Management (SAICM) is a voluntary policy framework and approach that UNEP has helped to implement in order to improve chemical safety globally its objective by 2020 "that chemicals are used and produced in ways that minimize adverse effects on human health and the environment".

- The Joint Meeting of Pesticide Residues (JMPR) is a specialized entity that is jointly run by FAO and WHO which recommends the maximum levels of pesticide residuals in food and feed products and offers recommendations on the quality standards for pesticide products (Eyhorn *et al.*, 2015).

In contrast, the efforts directed towered changing the agronomic practices. Some of these steps that recommended to be following are:

- Increasing the organic farming application which is environmentally friendly and sustainable that leads to increasing the earth fertility, and consequently protect human health (Dubey, 2013).

- Managing the irrigation in appropriate manner to avoids water stress (wasting or reducing water) that reduces proliferation of weeds, and makes crops vulnerable to diseases and pests.

- Rotating crops stopes the spread of pathogens, pests, and weeds into the following season.

Using gene technology to create resistant crop types, this can be achieved using conventional breeding techniques such as selection and crossing through genetic engineering. In both situations, an identified resistance is combined into a plant with high yield potential and other desired agronomic traits. Conventional breeding considered a main role to improvement the crop, but their disadvantage requires a long time in the growing and testing of large samples of crops over multiple generations. Genetic engineering and marker assisted breeding can make this process faster (Jiang, 2013). Genetic engineering, which refers to the direct modification of an organism's genetic material using biotechnology. Gene editing is based on the CRISPR (clustered regularly interspaced short palindromic repeats) mechanism, which enables highly precise introduction of particular genes into types (Christou, 2013).

Conclusion

While the society couldn't live without using pesticides to enhance agricultural crop production, even though their disadvantages to humankind and the environment. DDT is a major contributor to many cancers in humans, lung damage, reproductive organ damage, acute and chronic nervous system injury, endocrine and immune system dysfunction, and birth defects. The negative environmental effects of pesticides have been recognized for decades and are still being recognized today. To overcome these

risks, it is necessary to emphasize compliance with international legislation, and orientation towards the manufacture of organic pesticides, raising farmers' awareness mainly to regulate pesticide usage and follow the safety precautions, this also includes the workers in the manufacturing field. Suitable agronomic practices are essential in order to obtain healthy crops and prevent the build-up of weed, pest, and disease pressure. It is necessary to generalize the dangers of pesticides to human health and the environment in order to raise awareness among individuals worldwide and reflect well on societies.

Conflict of Interest

Regarding the publication of this manuscript, the authors declare that there are no conflicts of interest**.**

Acknowledgements

Great acknowledges to editor in chief of the Diyala Agricultural Sciences Journal.

References

Aktar, W., Sengupta, D., and Chowdhury, A. (2009). Impact of pesticides use in agriculture: their benefits and hazards. *Interdisciplinary toxicology*, *2*(1), 1-12. https://doi.org/10.2478%2Fv10102-009-0001-7

Abong'o, D., Wandiga, S., Jumba, I., Madadi, V., and Kylin, H. (2014). Impacts of pesticides on human health and environment in the River Nyando catchment, Kenya. *International Journal of Humanities, Arts, Medicine and Sciences*, *2*(3), 1-14.

Al-Waili, N., Salom, K., Al-Ghamdi, A., and Ansari, M. J. (2012). Antibiotic, pesticide, and microbial contaminants of honey: human health hazards. *The scientific world Journal*, *2012*, Article ID 930849. https://doi.org/10.1100/2012/930849

Amaral, A. F. (2014). Pesticides and asthma: challenges for epidemiology. *Frontiers in public health*, *2*, 2014. https://doi.org/10.3389/fpubh.2014.00006

Andreu, V., and Picó, Y. (2004). Determination of pesticides and their degradation products in soil: critical review and comparison of methods. *TrAC Trends in Analytical Chemistry*, *23*(10-11), 772-789. https://doi.org/10.1016/j.trac.2004.07.008

Asghar, U., Malik, M. F., and Javed, A. (2016). Pesticide exposure and human health: a review. *J Ecosys Ecograph S*, *5*, 2. https://doi.org/10.4172/2157-7625.S5-005

Beigel, C., Charnay, M. P., and Barriuso, E. (1999). Degradation of formulated and unformulated triticonazole fungicide in soil: effect of application rate. *Soil Biology and Biochemistry*, *31*(4), 525-534.

Bernardes, M. F. F., Pazin, M., Pereira, L. C., and Dorta, D. J. (2015). Impact of pesticides on environmental and human health. *Toxicology studies-cells, drugs and environment*, 195-233. https://doi.org/10.5772/59710

Bhandari, G. (2014). An overview of agrochemicals and their effects on environment in Nepal. *Applied Ecology and Environmental Sciences*, *2*(2), 66-73.

Brandt, A., Gorenflo, A., Siede, R., Meixner, M., and Büchler, R. (2016). The neonicotinoids thiacloprid, imidacloprid, and clothianidin affect the immunocompetence of honey bees (Apis mellifera L.). *Journal of insect physiology*, *86*, 40-47. https://doi.org/10.1016/j.jinsphys.2016.01.001

Cantin, N. E., Negri, A. P., and Willis, B. L. (2007). Photoinhibition from chronic herbicide exposure reduces reproductive output of reef-building corals. *Marine Ecology Progress Series*, *344*, 81-93. http://dx.doi.org/10.3354/meps07059

Chowdhury, A., Pradhan, S., Saha, M., and Sanyal, N. (2008). Impact of pesticides on soil microbiological parameters and possible bioremediation strategies. *Indian*

Journal of microbiology, *48*(1), 114-127. https://doi.org/10.1007%2Fs12088-008-0011-8

Christou, P. (2013). Plant genetic engineering and agricultural biotechnology 1983–2013. *Trends in biotechnology*, *31*(3), 125-127. https://doi.org/10.1016/j.tibtech.2013.01.006

Dubey, R. K. (2013). Organic farming beneficial to biodiversity conservation, rural livelihood and nutritional security. *Indian Journal of Applied Research*, *3*, 18-21.

Eyhorn, F., Roner, T., and Specking, H. (2015). Reducing pesticide use and risks-What action is needed. *Briefing paper: Helvetas, Swiss Intercooperation*. http://dx.doi.org/10.13140/RG.2.2.17146.80324

FAO, WHO (2014) International code of conduct on pesticide management, Rome. World Health Organization.

Farenhorst, A. (2006). Importance of soil organic matter fractions in soil- landscape and regional assessments of pesticide sorption and leaching in soil. *Soil Science Society of America Journal*, *70*(3), 1005-1012. https://doi.org/10.2136/sssaj2005.0158

Fenik, J., Tankiewicz, M., and Biziuk, M. (2011). Properties and determination of pesticides in fruits and vegetables. *TrAC Trends in Analytical Chemistry*, *30*(6), 814-826. https://doi.org/10.1016/j.trac.2011.02.008

Fimrite, P. (2011). Suit says EPA fails to shield species from poisons. *The San Francisco Chronicle*.

Forson, D. D., and Storfer, A. (2006). Atrazine increases ranavirus susceptibility in the tiger salamander, Ambystoma tigrinum. *Ecological Applications*, *16*(6), 2325-2332. https://doi.org/10.1890/1051-0761(2006)016[2325:airsit]2.0.co;2

Fry, D. M. (1995). Reproductive effects in birds exposed to pesticides and industrial chemicals. *Environmental health perspectives*, *103*(suppl 7), 165-171.

Gevao, B., Mordaunt, C., Semple, K. T., Piearce, T. G., and Jones, K. C. (2001). Bioavailability of nonextractable (bound) pesticide residues to earthworms. *Environmental science and technology*, *35*(3), 501-507.

Gibbs, K. E., Mackey, R. L., and Currie, D. J. (2009). Human land use, agriculture, pesticides and losses of imperiled species. *Diversity and Distributions*, *15*(2), 242-253. http://dx.doi.org/10.1111/j.1472-4642.2008.00543.x

Haque, R., Kearney, P. C., and Freed, V. H. (1977). Dynamics of pesticides in aquatic environments. *Pesticides in Aquatic Environments*, 39-52.

Helfrich, L. A., Weigmann, D. L., Hipkins, P. A., and Stinson, E. R. (2009). Pesticides and aquatic animals: a guide to reducing impacts on aquatic systems.

Hernández, A. F., Parrón, T., Tsatsakis, A. M., Requena, M., Alarcón, R., and López-Guarnido, O. (2013). Toxic effects of pesticide mixtures at a molecular level: their relevance to human health. *Toxicology*, *307*, 136-145. http://dx.doi.org/10.1016/j.tox.2012.06.009

Hicks, B. (2013). Agricultural pesticides and human health. National Association of Geoscience Teachers.

Jiang, G. L. (2013). Plant marker-assisted breeding and conventional breeding: challenges and perspectives. *Adv. Crop Sci. Technol*, *1*, e106. http://dx.doi.org/10.4172/2329-8863

Karr, J. R. (2000). River conservation in the United States and Canada. *Global perspectives on river conservation: science, policy, and practice*.

Kole, R. K., Banerjee, H., and Bhattacharyya, A. (2001). Monitoring of market fish samples for Endosulfan and Hexachlorocyclohexane residues in and

around Calcutta. *Bulletin of environmental contamination and toxicology*, *67*(4), 554. https://doi.org/10.1007/s001280159

Lah, K. (2011). Effects of pesticides on human health. *Toxipedia*, *16*, 2014.

Lanfranchi, A. L., Menone, M. L., Miglioranza, K. S. B., Janiot, L. J., Aizpun, J. E., and Moreno, V. J. (2006). Striped weakfish (Cynoscion guatucupa): a biomonitor of organochlorine pesticides in estuarine and near-coastal zones. *Marine Pollution Bulletin*, *52*(1), 74-80. https://doi.org/10.1016/j.marpolbul.2005.08.008

Leonel, J., Sericano, J. L., Fillmann, G., Secchi, E., and Montone, R. C. (2010). Long-term trends of polychlorinated biphenyls and chlorinated pesticides in franciscana dolphin (Pontoporia blainvillei) from Southern Brazil. *Marine pollution bulletin*, *60*(3), 412-418. https://doi.org/10.1016/j.marpolbul.2009.10.011

Levengood, J. M., and Beasley, V. R. (2007). Principles of ecotoxicology. In *Veterinary toxicology* (pp. 689-708). Elsevier Ltd.

Lourencetti, C., de Marchi, M. R. R., and Ribeiro, M. L. (2008). Determination of sugar cane herbicides in soil and soil treated with sugar cane vinasse by solid-phase extraction and HPLC-UV. *Talanta*, *77*(2), 701-709. https://doi.org/10.1016/j.talanta.2008.07.013

Mahmood, I., Imadi, S. R., Shazadi, K., Gul, A., and Hakeem, K. R. (2016). Effects of pesticides on environment. *Plant, soil and microbes: volume 1: implications in crop science*, 253-269.

Miah, S. J., Hoque, A., Paul, A., and Rahman, A. (2014). Unsafe use of pesticide and its impact on health of farmers: a case study in Burichong Upazila, Bangladesh. *cancer*, *21*(3), 22-30. http://dx.doi.org/10.9790/2402-08155767

Mineau, P., and Whiteside, M. (2013). Pesticide acute toxicity is a better correlate of US grassland bird declines than agricultural intensification. *PloS one*, *8*(2), e57457. https://doi.org/10.1371/journal.pone.0057457

Mitra, A., Chatterjee, C., and Mandal, F. B. (2011). Synthetic chemical pesticides and their effects on birds. *Res J Environ Toxicol*, *5*(2), 81-96. http://dx.doi.org/10.3923/rjet.2011.81.96

Mostafalou, S., and Abdollahi, M. (2013). Pesticides and human chronic diseases: evidences, mechanisms, and perspectives. *Toxicology and applied pharmacology*, *268*(2), 157-177. https://doi.org/10.1016/j.taap.2013.01.025

Muralidharan, S. (1993). Aldrin poisoning of Sarus cranes (Grus antigone) and a few granivorous birds in Keoladeo National Park, Bharatpur, India. *Ecotoxicology*, *2*, 196-202.

Pain, D. J., Gargi, R., Cunningham, A. A., Jones, A., and Prakash, V. (2004). Mortality of globally threatened Sarus Cranes Grus antigon from monocrotophos poisoning in India. *Science of the Total Environment*, *326*(1-3), 55-61. https://doi.org/10.1016/j.scitotenv.2003.12.004

Perveen, N., and Ahmad, M. (2017). Toxicity of some insecticides to the haemocytes of giant honeybee, Apis dorsata F. under laboratory conditions. *Saudi journal of biological sciences*, *24*(5), 1016-1022. https://doi.org/10.1016%2Fj.sjbs.2016.12.011

Rajmohan, K. S., Chandrasekaran, R., and Varjani, S. (2020). A review on occurrence of pesticides in environment and current technologies for their remediation and management. *Indian journal of microbiology*, *60*, 125-138. https://doi.org/10.1007/s12088-019-00841-x

Relyea, R. A. (2005). The lethal impact of Roundup on aquatic and terrestrial

amphibians. *Ecological applications*, *15*(4), 1118-1124. https://doi.org/10.1890/04-1291

Relyea, R. A., and Hoverman, J. T. (2008). Interactive effects of predators and a pesticide on aquatic communities. *Oikos*, *117*(11), 1647-1658. https://doi.org/10.1111/j.1600-0706.2008.16933.x

Rivero, J., Luzardo, O. P., Henríquez-Hernández, L. A., Machín, R. P., Pestano, J., Zumbado, M., ... and Valerón, P. F. (2015). In vitro evaluation of oestrogenic/androgenic activity of the serum organochlorine pesticide mixtures previously described in a breast cancer case–control study. *Science of the total environment*, *537*, 197-202. https://doi.org/10.1016/j.scitotenv.2015.08.016

Rohr, J. R., Raffel, T. R., Sessions, S. K., and Hudson, P. J. (2008). Understanding the net effects of pesticides on amphibian trematode infections. *Ecological Applications*, *18*(7), 1743-1753. https://doi.org/10.1890/07-1429.1

Sai, M. V. S., Revati, G. D., Ramya, R., Swaroop, A. M., Maheswari, E., and Kumar, M. M. (2019). Knowledge and perception of farmers regarding pesticide usage in a rural farming village, Southern India. *Indian Journal of Occupational and Environmental Medicine*, *23*(1), 32-36. https://doi.org/10.4103%2Fijoem.IJOEM_121_18

Sanchez-Bayo, F., and Goka, K. (2014). Pesticide residues and bees–a risk assessment. *PloS one*, *9*(4), e94482. https://doi.org/10.1371/journal.pone.0094482

Savonen, C. (1997). Soil microorganisms object of new OSU service. *Good Fruit Grower*.

Scholz, N. L., Fleishman, E., Brown, L., Werner, I., Johnson, M. L., Brooks, M. L., and Schlenk, D. (2012). A perspective on modern pesticides, pelagic fish declines, and unknown ecological resilience in highly managed ecosystems. *Bioscience*, *62*(4), 428-434. https://doi.org/10.1525/bio.2012.62.4.13

Sharma, A., Kumar, V., Shahzad, B., Tanveer, M., Sidhu, G. P. S., Handa, N., and Thukral, A. K. (2019). Worldwide pesticide usage and its impacts on ecosystem. *SN Applied Sciences*, *1*, 1-16. https://doi.org/10.1007/s42452-019-1485-1

Singh, N. S., Sharma, R., Parween, T., and Patanjali, P. K. (2018). Pesticide contamination and human health risk factor. *Modern age environmental problems and their remediation*, 49-68.

Sparling, D. W., and Fellers, G. M. (2009). Toxicity of two insecticides to California, USA, anurans and its relevance to declining amphibian populations. *Environmental Toxicology and Chemistry: An International Journal*, *28*(8), 1696-1703.

United States. Environmental Protection Agency. Office of Pesticide Programs. (2004). *Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs, US Environmental Protection Agency: Endangered and Threatened Species Effects Determinations*. DIANE Publishing.

van der Werf, H. M. (1996). Assessing the impact of pesticides on the environment. *Agriculture, Ecosystems and Environment*, *60*(2-3), 81-96.

Wolmarans, N. J., Du Preez, L. H., Yohannes, Y. B., Ikenaka, Y., Ishizuka, M., Smit, N. J., and Wepener, V. (2018). Linking organochlorine exposure to biomarker response patterns in Anurans: a case study of Müller's clawed frog (Xenopus muelleri) from a tropical malaria vector control region. *Ecotoxicology*, *27*, 1203-1216. https://doi.org/10.1007/s10646-018-1972-y

Yadav, S. K. (2010). Pesticide applications-threat to ecosystems. *Journal of Human Ecology*, *32*(1), 37-45. https://doi.org/10.1080/09709274.2010.11906319