P-ISSN: 2305-6622; E-ISSN: 2306-3599
International Journal of Agriculture and Biosciences
www.ijagbio.com; editor@ijagbio.com
Review Article https://doi.org/10.47278/journal.ijab/2022.017

A Review: Pesticide Application in Agriculture and its Environmental Consequences

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Article History: 22-277 Received: 16-Jul-22 Revised: 02-Aug-22 Accepted: 09-Sep-22

ABSTRACT

Pesticides are required to generate agricultural products. Farmers have to manage insects, weeds and there is proof that agricultural productivity has greatly increased. Without a rise in food supply, population expansion was impractical in the 20th century. Pesticides are necessary for about one third of agricultural crops. Fruit, vegetable, and cereal production would decrease by seventy-eight, fifty-four and thirty-two percent respectively, without pesticides. Pesticides are crucial for disease prevention and elevating crop productivity on a global scale. Therefore, it is crucial to talk about the development of agriculture, the historical context, the uses and formulations of pesticides, as well as pesticide behavior, contamination, and detrimental effects on the environment. Three main eras can be identified in the history of pesticide use. Pesticides are categorized using a variety of factors, such as chemical classes, functional groups, modes of action, and toxicity. Pesticides use chemicals that may be harmful to other living things to control weeds and eradicate pests. Beneficial insects, non-target plants, fish, birds along with air, water, soil, and crops, are a few examples. Pesticide contamination damages the ecology and extends past the plants it was designed for. The contamination of food and the chemical residues make them detrimental to human health. Climate change-related factors also have an impact on how pesticides are applied, increasing pesticide use and contamination. Therefore, this study will offer the essential scientific information for managing and using pesticides in the future.

Key words: Review pesticide, Environment, Agriculture

INTRODUCTION

The general consensus is that pesticides are essential to agricultural productivity because they can lower losses in agricultural product output while raising affordable production and food quality (Gill and Garg, 2014; Hillocks, 2012). Due to the requirement to decrease insect-borne diseases and improve the food supply during WWII, pesticide development took place (1939-1945). Additionally, a greater boost in food production was made possible by the advent of synthetic crop protection agents in the 1940s (Mahmood *et al.*, 2016). Additionally, from 2 lac tonnes in the 1950s to nearly 50 lac tonnes in 2000, pesticides worldwide climbed by 11% annually. Only 1% of all pesticides are utilized effectively to control insect pests on target plants, despite the three billion kg of pesticides used annually worldwide (Özkara *et al.*, 2016; Sharma *et al*., 2019). Pesticides that are still present in large amounts seep into or reach environmental media and non-target plants. Both the ecosystem and human health are negatively impacted by pesticide contamination (Hillocks, 2012). Agricultural development, historical pesticide use, current pesticide classifications, and pesticide function in agriculture are all covered in the first section of this literature review. The specific impacts of pesticide use on the ecosystem are then examined, together with pesticide environmental behaviour and climate change factors. This study presents a brand-new method for administering and applying pesticides.

Advantages of Using Pesticides

The main advantages are the pesticides' effects or the anticipated immediate benefits of their use. Eliminating crop-feeding caterpillars, for example, enhances productivity and improves cabbage quality (Isman *et al*., 2011). The three main advantages range from the protection

Cite This Article as: Safdar U, Ahmed W, Ahmed M, Hussain S, Fatima M, Tahir N, 2022. A review: pesticide application in agriculture and its environmental consequences. Int J Agri Biosci, 11(2): 125-130. https://doi.org/10.47278/journal.ijab/2022.017

of recreational areas to the saving of lives. Secondary advantages arise from core benefits but are less visible or apparent. They could be more quiet, less evident immediately away, or last longer. Because of this, it may be more challenging to establish a causal link between secondary benefits and pesticide usage, even though these benefits may still be strong justifications (Hassaan and El Nemr, 2020). For instance, increased cabbage production could generate extra funds for healthcare or education expenses for kids, leading to a population that is healthier and more intellectual. Additional advantages include bettering human health and preserving biodiversity (Gill and Garg, 2014).

Improving Productivity

Pesticide use has had a positive impact on family life, public health, forestry, and agriculture, an important component of the world economy. From an estimated 1690 lac hectares of permanently cultivated land, food grain output increased by almost four times, from 50o lac tonnes in last decades. To achieve this achievement, modern irrigation techniques, agricultural chemicals, and high-yielding seed varieties were utilized (Hillocks, 2012; Isman *et al*., 2011).

Protection of Crop Losses/yield Reduction

Rice crop in medium land requires an efficient and cheap weed management strategy to prevent a 28 to 48% drop in rice output owing to weeds throughout the critical period, even under puddle circumstances. Weeds diminish dry land crop productivity by 37-79%. Heavy weed infestation is finally connected to a 40% loss in overall yield (Damalas and Eleftherohorinos, 2011).

Quality of Food

The benefits of a diet rich in fresh vegetables and pesticides have been demonstrated to far exceed the risks of ingesting foods with very little pesticide residue. Emerging data suggests that eating fruits and vegetables on a regular basis reduces the risk of numerous malignancies, high blood pressure, heart disease, diabetes, and other chronic disease (Rohila *et al.,* 2017). According to researched the nutritional benefits of guava and citrus in the American diet, their high levels of antioxidants provide protection against cardiovascular disease and cancer. But this linked the increase in wild citrus consumption and production to greater herbicide use for weed control (Clay, 2013).

Hazards of Pesticides

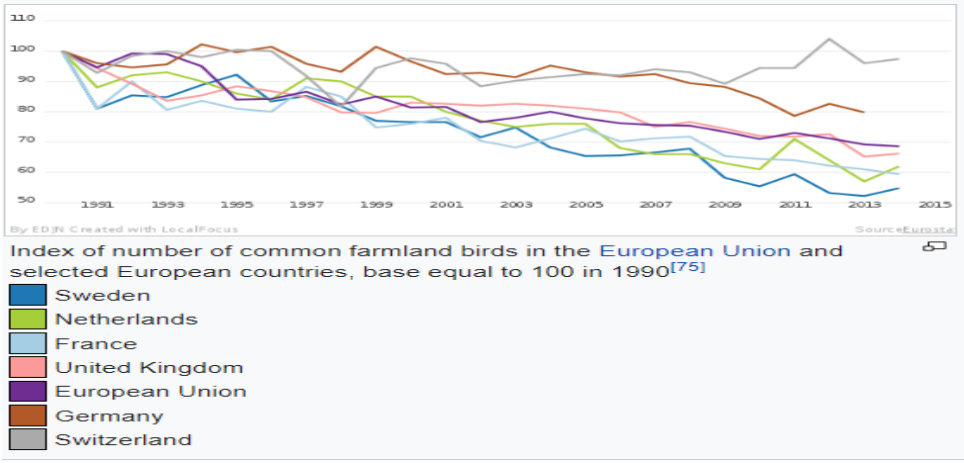
Effects on Animals

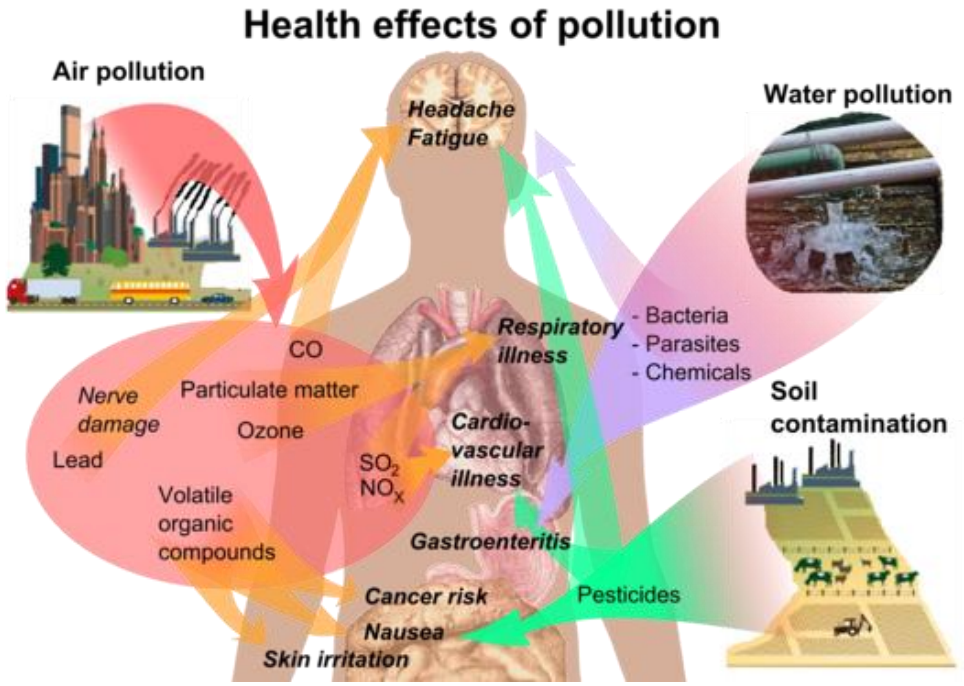
Annually, 720 lac animals are killed by pesticides in the United States. Eagles are among the non-target organisms affected by pesticide use. Rachel Carson was the first to discuss the dangers of DDT bioaccumulation. Farmland birds are declining faster than birds from any other biome in North America, and this reduction is correlated with growing pesticide use (Mahmood *et al*., 2016). Due to a decline in plant and invertebrate species, the nesting population of ten distinct bird species on British farms declined by 1 crore. In Europe, 116 bird species were threatened with extinction in 1999. The spraying of pesticides at specific times and locations has been shown to be connected with a drop in bird populations. Egg shell thinning caused by DDE is particularly hazardous. The EU, France, Belgium, and Sweden experienced a decline in the number of common farmland birds between 1990 and 2014; Germany, which relies more on organic farming and fewer pesticides, experienced a slower decline; and Switzerland, which does not rely on intensive agriculture, experienced a decline in the early 2000s before returning to 1990 levels. Despite the fact that several fungicides used in peanut production are only moderately toxic to animals and birds, they may kill earthworms, hence limiting the quantity of mammals and birds that consume earthworms. Rarely are granular pesticides available (Garcês *et al*., 2020). The granules may be consumed by animals that mistake them for food and ingest them. A few pesticide granules may be sufficient to kill a small bird. Herbicides may threaten bird populations by damaging their habitats. In addition, both the loss of natural habitat and the conversion of natural habitat to other land uses (such as agriculture and residential development) contribute to the decline of these birds (Clay, 2013; Damalas and Eleftherohorinos, 2011; Garcês *et al*., 2020; Gill and Garg, 2014).

Direct Impact on Humans

If the economic benefits of pesticides include increased food and fibre production as well as a reduction in vector-borne diseases, then the negative consequences on human health and the environment must be significant. There is currently a large body of information indicating that many of these substances are hazardous to humans and other creatures, as well as to the environment. In every country, the poor and those most likely to be exposed to pesticides bear a disproportionate share of the possible health dangers. No population is fully safe from pesticide exposure (Hashimi *et al.,* 2020). Pesticide poisoning kills and injures around a million people worldwide each year. Pesticide exposure poses a significant risk to agricultural employees, including formulators, sprayers, mixers, and loaders. The risk associated with the required procedures is not zero, raising the possibility of hazard during production and formulation. Because of their exposure to dangerous chemicals such as pesticides, raw materials, poisonous solvents, and inert carriers, industrial workers are more vulnerable to poisoning. OC compounds can damage almost every living thing on Earth (Zacharia, 2011).

Aerosols, dust, and vapour inhalation, as well as intake of tainted food and drink, are all ways that pesticides can enter the body. Spraying pesticides has the potential to contaminate drinkable water, harm the environment, and spread. Pesticide toxicity, exposure length, and exposure intensity all have an impact on how pesticides affect human health. Agricultural chemicals are more likely to come into touch with farm workers and their families. Pesticides are present in the adipose tissue of every person (Yazicioglu *et al.,* 2013). Children are more vulnerable to more sensitive to pesticides than adults since their immune systems are still forming and are less developed than those of adults. Due to their close touch with the ground and propensity to put foreign objects in their mouths, children may be particularly vulnerable. Hand-to-mouth contact varies with a child's age, much like lead exposure does. Breast milk and inhalation of small particles are the two most common ways that young infants under six months old are exposed.





The risk of pesticide exposure rises when family members bring pesticides inside the house on their shoes. A baby's exposure to poisons may rise as a result of food residues (Hassaan and El Nemr, 2020). Epidemiological studies have shown that several pesticides, at current exposure levels, adversely affect children's cognitive development. Over time, the substances may bioaccumulate in the body. Minor skin rashes can progress into cancer, genetic abnormalities, blood and nerve illnesses, endocrine system disruption, unconsciousness, and death after exposure (Gill and Garg, 2014; Hashimi *et al.*, 2020). Pesticides have been associated with detrimental impacts on growth. Somatic cell mutations may be the cause of the recent rise in teen cancers like leukaemia in North America. The nervous systems of mammals may be adversely affected by insecticides used to remove insects. Exposures have been connected to both acute and long-term changes. DDT and the byproduct of its breakdown, DDE, may promote the growth of breast cancer by obstructing the action of oestrogen. Pregnancy-related DDT exposure shrinks male genitalia and may cause undescended testicles. Early developmental stages, in utero development, and even conception can be harmed by a parent's exposure to pesticides. Structure modifications and chemical reactivity may have an impact on reproduction (Kalyabina *et al.*, 2021).

Impact Through Food Commodities

Per pesticide or pesticide class, an average of 9,800 samples are examined. Each pesticide or pesticide group had residues in 6.2% of the samples, with 0.51% of these samples above the MRL for the corresponding pesticide. The best results were found in lettuce, where residue levels routinely exceeded MRLs compared to residue levels in other crops (Craddock *et al.*, 2019; González-Rodríguez *et al.*, 2011). The greatest level of mancozeb residue was found in lettuce and cabbage. where a maneb group chemical with a measurement of 221 mg/kg was found. Acephate, chlopyriphos, carbendazine, DDT, endosulfan, methamidophos, diazinon, iprodione, methidathion, thiabendazole and metalaxyl were among the thirteen pesticides and four products that were studied in 2010 (mandarins, pears, bananas, beans, and potatoes). A total of 7,000 samples were examined. Chlorpyriphos residues exceeded MRLs the most frequently (0.31%), followed by methamidophos residues (0.22%), and iprodione residues (0.21%). Despite food contamination, the bulk of hospital mortality from pesticide use is caused by self-poisoning. These contaminants Another study found that Indians ingested more HCH and DDT than those in the majority of developed countries, at 225 and 51 mg per person, respectively (Craddock *et al*., 2019).

Outcomes for the Environment

Pesticides have the potential to destroy vegetation, water, and lawns. Pesticides can be harmful to non-target plants, birds, fish, beneficial insects, and weeds in addition to insects and weeds. Although insecticides are often the deadliest pesticides, herbicides can also be harmful to species that are not their intended targets (Gill and Garg, 2014; González-Rodríguez *et al*., 2011; Hashimi *et al*., 2020).

Surface Water Contamination

Pesticides can infiltrate surface water through soil runoff and treated plants. Water is regularly contaminated by pesticides. In the early to mid-2000, the United States Geological Survey (USGS) conducted extensive research on the major river basins around the nation. The findings were stunning. More than 89% of stream water and fish tests revealed the presence of one or more pesticides. Pesticides were present in 98 percent of urban stream samples and 99 percent of big river samples with agricultural or urban land use impacts (de Souza *et al*., 2020).

Ground Water Contamination

The pollution of groundwater with pesticides is a global issue. The USGS reports that groundwater contains at least 145 different pesticides and 22 transformation products, including pesticides from every major chemical family. Over the past two decades, more than 44 states have discovered ground water. 61% of drinking water samples taken from multiple hand pumps and wells in and around Bhopal were contaminated with organo chloride pesticides that exceeded EPA standards, according to an Indian survey. Once something has been contaminated with a dangerous poison, it may take a long time for the contamination to disperse. Cleanup may be extremely expensive, complicated, or even impossible (Srivastav, 2020).

Soil Contamination

Numerous transformation products (TPs) produced from different pesticides have been identified. Due to the fact that few pesticide TPs have been studied in soil, there is an urgent need for additional research on this topic (Meftaul *et al.*, 2020). The following are examples of pesticide and TP categories: (A) insecticides that are soil-bound, hydrophobic, persistent, and bioaccumulative. These pesticides consist of lindane, endosulfan, endrin, and heptachlor, as well as its associated TPs and DDT. In spite of the fact that the bulk of them are no longer authorised, remnants of them can still be found in agriculture. b) Although carbamates, fungicides, and several organophosphorus insecticide TPs are present, herbicides constitute the majority of polar pesticides. Because they can be transmitted from the soil by runoff and leaching, they may threaten the population's access to safe drinking

water (Morillo and Villaverde, 2017). Probably the majority of soil-based investigations have focused on pesticide TPs. Hydrolysis, methylation, and ring cleavage are among the hypothesised metabolic processes that generate dangerous phenolic chemicals. Pesticides and their TPs are retained to variable degrees in soils, depending on how the soil and pesticide interact, with the amount of organic matter in the soil being the most important factor. The absorption of insecticides and TP increases as the concentration of organic matter rises. When employing positively charged herbicides such as paraquat and other herbicides, the soil's capacity to maintain exchangeable positively charged ions is crucial. Although there have been no notable advancements in analysis or study, a strong mineral acid is required to extract these chemicals. The soil's pH is also essential. As soil pH decreases, additional ionizable pesticides (Morillo and Villaverde, 2017; Sharma *et al*., 2019).

Influence on the Fertility of the Soil

The population of helpful soil microorganisms may decline as a result of pesticide use on soil. Dr. Elaine Ingham, a soil scientist, asserts that the soil will degrade if both bacteria and fungi are lost. Chemical pesticides and fertilisers used improperly have similar effects to humans who take too many antibiotics. If chemicals are applied carelessly, they might work for a while, but eventually there won't be enough beneficial soil organisms to keep soil nutrients stable (Prashar and Shah, 2016). For instance, plants rely on a variety of soil bacteria to transform atmospheric nitrogen into useable nitrates. Glyphosate impacts the quantity and activity of nitrogen-fixing bacteria in soil, whereas triclopyr prevents soil bacteria from converting ammonia to nitrite 2,4-D prevents soil bacteria from converting ammonia into nitrates, nitrogen fixation by bacteria on bean plant roots, and the growth and activity of nitrogen-fixing blue-green algae. The roots of many plants can better absorb nutrients with the help of mycorrhizal fungus (Tripathi *et al.*, 2020). These fungi are susceptible to soil herbicides as well. Numerous mycorrhizal fungi were found to be suppressed in one study by oryzalin and trifluralin. Roundup was found to be hazardous to mycorrhizal fungi in lab studies at concentrations lower than those seen in soil following typical applications. Triclopyr poisoned some mycorrhizal fungus species, whereas oxyadiazon reduced the number of mycorrhizal spore (Kaur *et al*., 2017).

Conclusions and New Directions

In many parts of the world, agricultural development has a lengthy history. There are three main pesticide application windows during agricultural development. Numerous terms, including as chemical classes, functional groups, modes of action, and toxicity, are used to categorise pesticides. Pesticides have been extremely beneficial to numerous industries, including agriculture and public health. Insects, ticks, rodents, and mice are killed every day with pesticides in homes, offices, retail malls, and streets. As a result, the enormous disease burden that these vectors were responsible for has been significantly decreased or eliminated. Pesticides have been used by farmers to manage weeds and insects in agricultural operations, and their use has significantly improved agricultural pesticides. The environmental surroundings of pesticides, such as transfer and degradation, must be taken into account when applying pesticides to target plants. Pesticide behaviour in the environment, which includes soil pollution, water pollution, air pollution, and food contamination, adds to environmental pollution in addition to pesticide usage and management. Climate change alters the environmental conditions under which pesticides are used as well as socioeconomic and environmental factors such soil quality, crop growth, and the prevalence of insect pests, weeds, and diseases. (1) Changes in pesticide use are caused by how climate change affects soil properties such as soil organic matter, soil's capacity to store and cycle carbon and the size and frequency of cracks in soils. Climate change, which includes an increase in temperature, precipitation, and CO_2, has an impact on crop distribution and agricultural productivity. The quantity and diversity of pesticides may rise as a result of climate change. (3) The impacts of climate change on agricultural growth, environmental conditions, insect pest migration and distribution, insect pest abundance, insect pest outbreak frequency and vector transmission, weed evolution, and disease stimulation. A larger range of pesticides are now being used as a result. (4) Pesticide degradation, including photolysis as well as chemical and microbiological breakdown, is also encouraged by climate change, as are pesticide volatilization, runoff, leaching, and degradation. The increased use of insecticides and pesticides as a result of climate change exposes more people to pesticide contamination and raises concerns for human health. Therefore, pesticide contamination and the effects it has on the environment, non-target creatures, and the environment as a whole, need to be regulated. To better understand pesticide use and management, future research should concentrate on occupational and environmental exposures as well as the health risks associated with pesticides. A national implementation plan (NIP), integrated pest management (IPM), regulations banning the use of high-risk pesticides, and new scientific methods and technology should all be put into practise to lessen the negative impacts of pesticides on the environment and non-target creatures. In order to provide scientific training for pesticide application, prevent negative health effects from pesticide use, and promote applicator and community safety, it is crucial to communicate the scientific findings of exposure and occupational and environmental health risk assessments. This will support sustainable development. To lessen pesticide pollution, bio pesticides should be developed in addition to chemical pesticides.

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