

# A Review of the Impact of Pesticides Pollution on Environment Including Effects, Benefits and Control

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## ABSTRACT

Pesticides are substances that are used for controlling, repelling, mitigating or killing pests that are harmful to man. Some of the pesticides that have been used include but not limited to herbicides, insecticides, fungicides and rodenticides. Most of these pesticides can be grouped in three groups of pesticides namely, organo-chloride, organo-phosphates and carbamates. Some of the characteristics of these pesticides include toxicity, persistence and bioaccumulation. The application of pesticides affects both the targeted as well as the non-targeted species including man. The parent pesticides, their degradation products together with metabolites can be harmful to the environment, ecosystem and to the human health. Due to this the aim of this study was to look into the articles studied on the impact of pesticide pollution on the environment, ecosystem as well as on human health. This was done by assessing both the benefits, effects and risks associated with the continuous use of pesticides as well as ways to mitigate the pesticides pollution problems. The methodology used in the study to look for the review articles was through the internet by going through websites which include Google, Google Scholar and PUBMED. About 70 studies were retrieved which included articles and abstracts. Books from the library with relevant information about the study were also included. The reviewed studies have revealed that there are benefits and risks as well as effects of pesticides pollution on environment. The studies have also revealed that in order to control pesticide pollution, the use of other methods of controlling pests such as integrated pest management (IPM) strategies such as biological as well as cultural could be used to control pests instead of chemical pesticides.

**Keywords:** Chemical Pesticides, Pesticides Persistence, Integrated Pest Management

## INTRODUCTION

A pesticide is defined as any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest (insect, termites, nematodes, weeds, rats etc.) including insecticide, herbicides, fungicides and various other substances to control pests [1]. They are used to recoup agricultural crop yields that would otherwise have been lost through the ravages of diseases and insect pests [2]. Instead of solving the pest problem, the pesticides are compounding the problem by killing natural predators, posing serious threat to human health and degrading the environment that feeds this and future generations [3].

Pesticides are found as common contaminants in soil, air, and water and non-targeted organisms in our urban landscape which can harm plants, animals, beneficial micro-organisms and insects, non-targeted plants, fish, birds and the wildlife [4]. Pesticide promises effective mitigation of harmful pests but they have risks associated with them such as non-selective pesticides kill non-targeted plants and animals along with the targeted ones [5]. Multiple pesticide

residues are found in food, drinking water, surface water, breast milk and urine [6]. Pesticides are used to control pests but remain a big source of air, water and soil pollution which negatively affect human health and living organisms in the environment [7]. Once pesticides are introduced into ecosystem, the pollution is hard to remove because the pesticide is placed on to the cultivated land and the chemical characteristics of the pesticide compounds often make decomposition slow or impossible [8]. The pesticides cause an array of harm such as from runoff of treated crops frequently pollute the surrounding ecosystem and beyond with unpredicted consequences [9].

While pesticide use is generally undertaken to target specific specie, their application always cause harm to non-targeted species and due to differences in chemical composition, mode of action and application techniques, the substitution of one pesticide for another may result in different effects on non-targeted population [10]. Improper use of pesticides can cause negative effects of non-targeted organisms such as bees, fish, birds, beneficial organisms

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such as earthworms, plants and human beings [11]. Pesticides are supposed to be lethal to the targeted species but not to the non-targeted species including man. The ranges of compounds covered under the term pesticide include insecticides, fungicides, herbicides, rodenticides, molluscicides, nematocides and plant growth regulators [4]. This review summarizes the impact of pesticides on environment including effects benefits and control. The risks associated with the pesticide pollution on environment are also summarized.

## METHODOLOGY

### Search Criteria

To carry out this study required review of documents and literature materials available from online publications that were obtained from the internet through Google, Google Scholar, PubMed and ACS publications. The following criteria were used to search for the studies that were used in this paper. Studies that were selected were those that have addressed pesticides use to targeted organisms, pesticide use and their effects on non-targeted organisms, toxicity of pesticides, persistence and bio-accumulation of pesticides, health effects of pesticides and environmental as well as economic effects of pesticides. Also chosen were studies that have addressed integrated pest management as a method of reducing pesticides usage, major classes of pesticides including organochlorides, organophosphorus and carbamates, types of pollution caused by pesticides such as soil water and air pollution and use of pesticides for agricultural production and sustainability.

### Terms used in the search

The terms used in the search were: 'Pesticides', 'targeted organisms', 'non-targeted organisms', 'pesticide toxicity', 'bioaccumulation of pesticides', 'persistence of pesticides', 'health effects of pesticides', 'environmental effects of pesticides', 'integrated pest management', 'water pollution by pesticides', 'soil pollution by pesticides', 'air pollution by pesticides', 'organochloride pesticides', 'organophosphorus pesticides', 'carbamate pesticides', 'bio-magnification of pesticides', 'agricultural production and sustainability', 'economic effects of pesticides', 'active ingredients in pesticides'.

### Screened publications

The total number of publications screened was seventy two. Among the studies identified thirty two publication reported on the effect of pesticides on the environment. Five publications reported on water pollution effect of pesticides. Eighteen publications reported on pesticides effects on human health. Three publications reported

on responsible management of pesticides. Thirteen publications reported on pesticides use in agriculture. One publication reported of persistent organic pollutants.

## RESULTS AND DISCUSSION

### Pesticides effects on environment

Pesticides can have potentially harmful environmental impacts particularly when a pesticide move from intended application site [12]. Figure 1 shows the processes that are involved in moving pesticides from their application site. These processes involve volatilization, microbial breakdown, leaching, adsorption, absorption, chemical breakdown, spray drift, photo-degradation breakdown and runoff of pesticides from land into water bodies. Three main types of pesticides pollution are water pollution, soil pollution and air pollution.

The best pesticides policies need to reconcile environmental concerns with economic realities and pest management is mandatory and farmers should survive economically [13]. Humans are exposed to pesticides via food chain throughout the world. Some recent research suggest that the presence of pesticides can be detected not only in the environment but also in human milk, tissue and blood and this is the impact on environment and human health [14]. Intensive monoculture needs pesticides as a standard control for pests that diminish the quality and quantity of food produced [15]. Also agricultural use of pesticides has a major impact on environment especially on water quality, wildlife sensitive ecosystems and loss of habitat biodiversity. Ecolabelling system is used to influence consumers' opinion on purchase. Ecolabels or green labels bring environmental impact assessment to the market place by encouraging the production and purchase of goods that meet a set of environmentally sensitive criteria [16]. Criteria underlying ecolabels on agricultural products may include organic or integrated pest management (IPM) standards that exclude or limit the use pesticides of hazardous or which shift acceptable pest control towards preventive practices, soil management to reduce erosion, runoff and leaching of agrochemicals, local origin farm produce either as a measure of support of local rural communities and open space and or indicator of less fossil fuels use in transport, guarantee of safe pesticide disposal and methods of farm worker safety standards [16].

A research done by Semalulu et al. [17] concerning the agricultural chemicals and metal contaminants in the Ugandan catchment of Lake Victoria revealed that a number of banned organo chlorinated pesticides (e.g. endosulfan, DDT, dieldrin and lindane) in the air showing that they may still be in use in the lake Victoria basin.

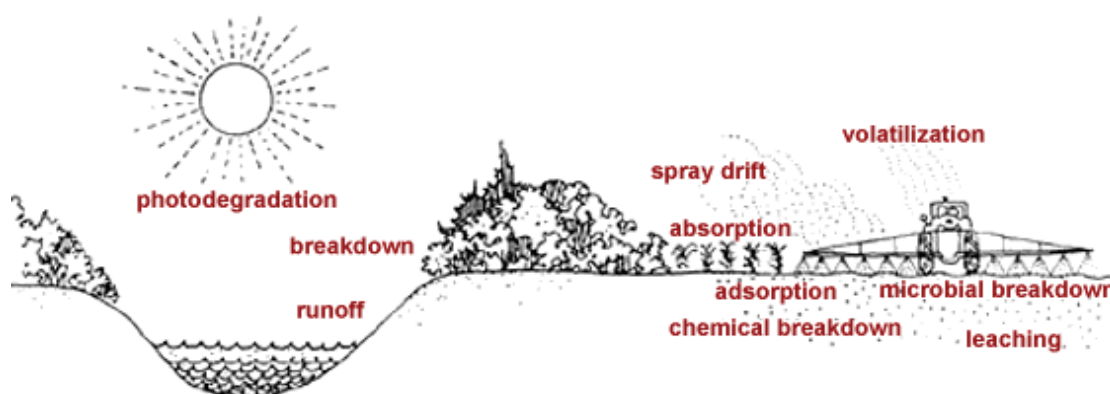


Figure 1: Transfer processes of pesticides from the site of application [12].

The UK's plan for sustainable use of pesticide is to ensure that pesticides are used sustainably by reducing the risks and impact of use on human health and the environment and encouraging the development and introduction of pest management alternative approaches and techniques [18].

### **Pesticides Use and Human Health**

Pesticides exposure have been linked with adverse health effects such as dizziness, muscular pain, sneezing, itching, skin burns, blisters, difficulty breathing nausea and sore eyes [19]. Chronic exposure to pesticides is linked to non-communicable diseases such as diabetes, hypertension and cancer. Pesticides have significant chronic human health effects including cancer, neurological effects, diabetes, respiratory diseases, fetal disease and genetic disorder [20]. Most common pesticide exposures are through inhalation, dermal and oral routes but also pesticide residue exposure in the general population [21]. The use of pesticides have not only influenced level of agricultural production and their sustainability but have also affected health of users (mainly farmers) those living near the farm and consumer of food products [22]. Pesticides are chemicals used to prevent pests from damaging crop grain and seed with the following inherent toxicity to farm workers: Neurological effects such as weaknesses of arms, legs, hands, memory loss and loss of concentration, reproductive health effects such as alteration in sexual behaviour, fertility, pregnancy and organic disorder which include disruption in the body of kidney, liver, blood or digestive tract [23].

Acute effects which are exposure of high dose of a toxic chemical like pesticides on one occasion can lead to lack of coordination and paralysis. Very high dose may lead to unconsciousness, convulsion and death, while chronic effects of long term exposure include impaired memory and concentration, disorientation, severe depression irritability, confusion, headache and speech difficulty [24]. For development of modern and environmentally friendly agricultural management a new quantified approach is needed to evaluate the overall impact of pesticides on the health of human and ecosystem [25]. Pesticides are designed to kill pests but some pesticides can cause negative effects in people and damage ecosystem while residues absorbed by inhalation, ingestion and dermal contact can lead to chronic toxicity [26].

When fertilizers and pesticides are used in farmlands, they are transmitted directly or indirectly into the corns and vegetables that affect the human health [27]. Different pesticides have been implicated in chronic neurotoxicity, endocrine disruption, immune impacts, genotoxicity, mutagenicity and carcinogenesis [28]. Health effects of pesticide exposure include asthma, diabetes, Parkinson's diseases leukaemia and cancer [29]. Kumari and Sharma [30] did a research on farmers' perception on environmental effects of pesticides use and strategies used in mountains of Western Himalaya. They concluded that all farmers who didn't have awareness on the impacts of pesticides use were underestimating the use of pesticides which make an increase in agricultural production and productivity and have adverse effects on human health and ecosystem.

### **Advantages of using pesticides in agriculture**

Pesticides have proven to be indispensable tools in combating damage from pests and ensuring sustainable food production with improved yield and greater availability of food all year [31]. When properly used pesticides can be effective in managing harmful insects, fungi, and weeds and help farmers to increase productivity

and income [32]. The most common easiest benefit of pesticides is economic benefits calculated for farmers that are obtained from the protection of common commodity yield and reduction of other costly inputs such as labour and fuel. For example, insects cause destruction of 15% of crop diseases and pathogens and weed 13% each and the postharvest pest infestation another 10% [33]. The increasing world population has exerted a tremendous pressure on existing agricultural system so that same food can be obtained from the same resources like land, water and in the process of increasing crop production the use of herbicides, insecticides, fungicides, nematocides, fertilizers and soil amendments are used in higher quantities than in the past [34].

Pesticides have proven to be indispensable tools in both in both pre-harvest and post-harvest losses by combating damage from pests and ensuring sustainable food production with improved yield and greater availability of food throughout the year [35]. In Tanzania, insecticides, herbicides and fungicides, account for over 90% of all pesticides used in the country mainly on cotton, coffee, maize and paddy [36]. Philbert et al. [37], conducted research on pesticide usage practices in malaria endemic in the region of North Western Tanzania and the implication to control of malaria vectors and found that among the pesticides used in the control of crops and livestock pests were: Pyrethroids (50%) followed by organophosphates (15%), carbamates (11%), organochlorides (9%) and 15% were of other chemical groups. They also found that based on the type of pest they control, insecticides were the most used group (57%) followed by fungicides (15%), acaricides (9%) and herbicides (6%).

### **Effects of pesticides to non-targeted**

A review of ecological impact of cotton pesticides in Australia rivers in 1996, found that the pesticide endosulfan was observed in rivers at very high concentration well above guidelines for safety of aquatic life but there was little evidence of biological impact [38]. Different pesticides have affected the non-targeted organisms such as plants, earthworms, termites, ant colonies, snakes, birds, toads, lizards and other amphibians negatively [28]. Soils with organophosphate pesticide residues not only affect the non-targeted organisms but also lead to disequilibrium in the ecology of pesticide degrading microorganisms [39]. Many pesticides are toxic to beneficial insects, birds, mammals, amphibians or fish and poisoning depends on pesticides toxicity and other properties (e.g. water soluble pesticides may pollute surface water). The quantity applied, frequency, timing and method of spraying, weather, and vegetation structure and soil type are also other factors [40]. Pesticides use reduces population of insects, spiders and birds that naturally control pests [6].

### **Pesticide persistence and resistance**

The persistence of pesticide in food, soil, water and air of the human environment is affected by factors such as solubility, volatility, surface adsorption, systemic action, hydrolysis, oxidation, ultraviolet irradiation and chemical rearrangement of the pesticides [41]. Chlorinated pesticides such as BHC, DDT, endosulfan, heptachlor, Aldrin etc. have been used extensively for protection of crops and prevention of vectors borne diseases. These chlorinated pesticides persist in the environment for very long periods, undergo bioaccumulation and bio-magnification and therefore impart toxicity to non-targeted organisms including human beings [42]. Development of resistance by pests to organochloride pesticides coupled with their environmental persistence which

make them to remain in soils, sediments and accumulating in non-human organisms for long time urged to replace them by new less persistent chemicals such as organophosphates (OP), carbamates and pyrethroids compounds which are supposedly more specific in the fight to pests [43]. Some pesticides such as Aldrin, chlordane, DDT, dieldrin, heptachlor and hexa-chlorobenzene contain persistent organic pollutants (POPs) [29]. One of the main strategies currently employed to deal with resistance is to deal with a wider range of active ingredients to avoid pests and diseases developing resistance [44].

### Integrated pest management for control of pests without use of pesticides

Integrated pest management (IPM) are methods used to control pests without use of pesticides. Several events stimulated the necessity for developing IPM programs in entomology (e.g. cultural biology and physical control [45]). Another way of controlling pests without use of pesticides is the cultural control which is a deliberate alteration of the production system by targeting the pest itself through agronomical practices to avoid or reduce pest injuries to crops [46]. IPM is defined as a pest management strategy that uses a combination of methods (sampling, forecasts, thresholds, biological and cultural etc.) solely relying on the chemical pesticides to produce a safe economic crop [47]. IPM refer to practices that modify the agricultural environment in ways that favour crop protection by trap cropping aimed at attracting pests away from the main crop in one of these cultural practices [48]. A research was conducted by Russel et al. [49] on environmental effects of mosquito insecticides on salt marsh invertebrate fauna. They used *Bacillus thuringiensis*, var. *israelensis de Barjac* (Bti) and *methoprene*. They came out with a conclusion that both these products appear safer than organophosphate alternatives that are toxic to a range of arthropods including insects and crustaceans [46].

### CONCLUSION

The reviewed studies revealed that the application of the pesticides to kill pests have both advantages as well as disadvantages. The advantages of pesticides application arises from the economic advantage that comes from obtaining good production yield from the agricultural crops due to application of pesticides to kill pests. The disadvantage of the application of pesticides comes from the effect of pesticides to non-targeted organisms and to human health. Some pesticides especially the organochloride are persistent to the environments that make them not to degrade. This make them to have long term environmental effects that are harmful to both non-targeted organisms as well as to human beings. The pesticides are used to kill pests that harm crops during pre-harvest season and post-harvest period for agricultural products preservation. Also the reviewed studies revealed that the use of integrated pest management could be used to control pests without using chemicals. Using the combination of methods such as sampling, forecasting, thresholds, biological and cultural control can manage pests and produce safe economical crop.

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