



**PESTICIDE RESIDUES IN CROPS: SOURCES, MEASUREMENTS AND REMEDIES
(REVIEW)**

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ABSTRACT

Pesticide residues persist in the environment, contaminate food, and contribute to the development of pest resistance. This review examines the detrimental effects of pesticide residues in agricultural produce and explores potential solutions. While pesticides are crucial for controlling insect infestations and minimizing crop losses, their overuse and misuse has severe consequences. There are various methods for measuring pesticide residues in crops, and these include gas chromatography, liquid chromatography, and mass spectrometry. Pesticide residues present on air, water, soil, animals, and the environment, have adverse effect on human health such as cancer, neurological disorders, and reproductive issues. Therefore, there is need for alternative pest control methods that minimize environmental and health risks. These include biological control, integrated pest management, and the use of biopesticides. Proper pesticide labeling, rational use and effective post-marketing surveillance are very important to ensure pesticide safety. The need for sterner regulations and enforcement to minimize pesticide residues in agricultural produce and protect human health and the environment are crucial. This will aid in promoting sustainable agricultural practices that prioritize ecological balance and minimize reliance on synthetic pesticides.

Keywords: Ecosystem, Environment, Food, Man and Pesticide.

INTRODUCTION

Postharvest losses could be attributed to external factors such as mechanical injury (bruising, cutting, breaking, impact wounding) pest infestations, Parasitic Diseases (fungi, bacteria, other organisms) and internal factors such as physiological deterioration, mineral deficiency, low or high temperature injury, or undesirable environmental conditions. Insect infestation on harvested crops have caused so much harm as insects competes with food produced for man, thereby resulting to food losses between 24 and 40% in developing countries, and between 2 and 20% in developed countries (Oparaeke and Bunmi, 2006).

In an attempt to tackle one of the major challenges faced with post harvested crops, farmers have resulted to the use of pesticides. These pesticides are used in agriculture to protect crops from the disastrous effects of pests both on field and during storage but they also cause some hazardous effects, such as their persistence in the environment, the toxic residues they leave in food, and development of resistance by insect pests; therefore, more reduced-risk alternatives are sought (Ileke and Oni, 2011). Control measures with little or no negative impacts on the environment and human health are logical alternatives to eradicate these insect pests (Ileke, 2008).

Natural compounds derived from plant sources and some environmentally benign substances like diatomaceous earth are good potential alternatives. Furthermore, *Piper guineense* Schumacher, *syzygium aromaticum*, *Monodora myristica* and *Dennettia tripetala* (Baker f.) are spice plants that have been used to control stored-product insects (Okonkwo and Ewete, 2000; Abdullahi and Muhammad, 2004; Nwaubani *et al.*, 2014; Adegbola *et al.*, 2023).

MATERIALS AND METHODS



Pesticide and Pesticide Residue

Pesticides are compounds or mixture of compounds that are used to eradicate insect pests that affect agricultural produce and this occur during practices such as planting, harvesting and post-harvest storage of crops. They include compounds such as insecticides, herbicides, nematicides, fungicides, molluscicides, rodenticides and plant growth regulators (Bhatt *et al.*, 2021). World health organization (WHO) opined that pesticide residue are any specified substances in or on food, agricultural commodities or animal feed resulting from the overuse and misuse of a pesticide.

Measurements of Pesticide Residue in Crops

Measurements of the quantity of pesticide residue in a particular crop can be determined using various scientific methods, so as to identify the safety of the consumption of such food crops. The various methods are discussed as follows:

Gas chromatography

It is a type of chromatography that is commonly used for the separation and analysis of mixture of compounds that can evaporate without been denatured. It is also used in testing the purity of specific compounds. It is used to analyze all pesticide mixture, whether they are volatile or semi-volatile. It has multiple detectors; choice will depend on the characteristics of the target analytes and it also offers higher resolution and lower detection limits (Skoog and Leary, 1992).

Liquid Chromatography (LC)

LC has emerged as a great separation tool. It allows for effective separation of non-volatile and thermally unstable pesticides that are incompatible with Gas Chromatography. It allows extracts to pass through multiple adsorbent columns that can differentiate between the components of the matrix and target analyte. The degree of selectivity will vary according to the adsorbent present in the column (alumina, silica gel, or Florisil), mesh size, and activity levels. Columns can be reused separately or in combination (Andreu and Pico 2012).

Capillary Electrophoresis (CE)

CE is a powerful tool to separate and identify a wide range of molecules. It provides high resolution, and large separation efficiency. It requires small sample size and low solvent consumption, analyzes is faster and operational cost are low (Assuncao *et al.*, 2008). An ideal detector should ensure adequate sensitivity, good stability and reproducibility, and linear response to various concentrations of the analytes. It should also operate in a wide range of temperature, have reduced response time (independent of the flow), and be easy to handle.

Cells, Drugs and Environment Detector

The detector response should be equivalent for all the analytes or selective to certain classes of compounds. Ultimately, the detector should not destroy the sample. Several types of detectors are commercially available which can be coupled to other separation devices. These detectors use photometric or fluorimetric methods, thermal conductivity, diode array detection, electrons capture, atomic absorption, or pesticides mass/charge evaluation.

Electron capture Detector (ECD)

The electron capture detector (ECD) is usually employed to search for organic pesticides, because it is highly sensitive and selective toward molecules containing electronegative functional groups. It also detects masses in the order of pictograms and can analyze traces of pesticides. However, ED cannot detect compounds with low electron affinity. Its excellent properties are useful for analysis of pesticides in both the environmental area and hospitals. A detector called



μ ECD is also available in the market. It is advantageous over ECD with respect to the sensitivity, stability, and robustness (Poole, 2013).

Mass spectrometry (MS)

It is based on the ionization, acceleration, and separation of the generated molecules and ions according to their mass/charge (m/z) ratio. This provides a typical spectrum that gives the relative mass abundance of the different ionic species as a function of m/z , which permits unambiguous identification of molecules. Mass spectrometry is a confirmation technique that is less subject to misunderstanding. Nevertheless, it has a drawback – it destroys the analyte (Di Stefano, 2012). As mentioned previously, the choice of method will depend on the case.

LC-MS and GC-MS

They are the methods that generally separate and detect pesticides most suitably. These methods play a very important role in the analysis of pesticides and related compounds and are applicable in several areas like environmental analysis, food safety, and occupational toxicology, among others. These methods also help to detect compounds in different samples, such as water, soil, sediment, sludge, vegetables and fruits; animals; human tissues and fluids (Niessen, 2012). Obviously, the method to use will be based on the needs and characteristics of the target pesticide, and each sample will have its own features, which will depend on their physicochemical properties (Martins *et al.*, 2013).

Biological and Chemical analysis

Biological and chemical analysis involves the isolation of compounds which is commonly used to monitor environmental pollution, but such analyses can be limited, expensive and cannot indicate the biological effects. In contrast, biological tests indicate the toxicity of a wide range of compounds or environmental samples, and are therefore essential to determine the environmental impacts of the presence of these chemicals (Olivera *et al.*, 2012).

Immunoassays and biosensors are methods related to the biological factor. Such that they are powerful tools in clinical laboratories and one of the most widely applied analytical techniques. It can detect a wide range of compounds including drugs, proteins, and hormones; they can also identify and quantify the presence of pesticide residues in various samples such as natural water, food, and blood, among others (Andreu and Pico, 2012).

RESULTS AND DISCUSSION

The Effect of Pesticide Residue

The effects of pesticide residue cannot be over-emphasized as they affect human health, pollute atmospheric air, water land and other living organisms.

Effect of Pesticide Residue in Air

Pesticides can increase when they volatilize and may be blown by wind speeds into close proximity and areas. Subsequent factors influence the diffusion of pesticide in the air, along with the weather conditions at the time of application, temperature and relative humidity (Van den Berg *et al.*, 1999). Ground spraying generates a reduced amount of spread than aerial spraying.

Effect of Pesticide Residue on Water

There are four major paths through which pesticides get into the water. First is to contaminate water during spraying. A good example is in rice cultivation – it may infiltrate, or percolate, through the soil. Secondly, it may be carried to the water as runoff carried to water by eroding soil. After the contamination of the water, it makes countless problems. Application of herbicides to bodies of water can cause fish kills, reduce the quality of drinking water, and reduce



the amount of water available for cultivation and also changing by and large the physical characteristics of water bodies. Insecticides are characteristically more lethal to aquatic life in comparison to herbicides and fungicides.

Effect of Pesticide Residue on Ground water

Pesticides residue can leach into the soil and contaminate groundwater through surface runoff from agricultural fields where pesticides are applied (Kole and Bagchi, 1995). It will result to the pollution of ground water, which are consumed by the people in the area which may be hazardous to their health. When the ground water is polluted with toxic chemicals, it might take years around for the contamination to fritter away or else be uncontaminated.

Effect of Pesticide Residues on Soil Environment

The accumulation of pesticides in the soil also resulted due to the application of pesticides in agriculture and in other areas. Unsystematic use of pesticides further deteriorates the physical and chemical properties of soil and stressed soils to the much greater extent. The fate of pesticides in soil is determined by soil properties such as degradation, transportation, and adsorption and desorption. Effects of pesticides in soil include alterations of soil microbial diversity and bio-mass, affects soil vital biochemical reactions, influence mineralization of soil organic matter along with affecting and disturbing local metabolism and also alter soil enzymatic activity (Deepa *et al.*, 2011).

Effects of Pesticide Residues on Animals

Pesticides application can result in reduction of some animals' necessary food resources. The Residues of these chemicals can have property to travel up to the food chains. An earthworm plays a major role in digesting organic matter and increase nutrient content in the top layer of soil. Pesticides have detrimental effects on development and reproduction of earthworm's population. The extended limits of the pesticides can pose serious impact on the human survival and give birth to many defects and diseases in animals as well as in humans. At a larger extent, exposed species or persons can be associated with cancer, endocrine disturbance, reproductive defects, neurological disorders and toxicity, kidney and liver diseases, birth deficiencies, developmental changes and genetic alterations (Jayaraj *et al.*, 2016).

Effects of Pesticide Residue on Man

Health effects of pesticide exposure can have both immediate and long-term health effects on people (EPA 2007). Human exposure to excessive pesticides can result into various harmful health consequences which includes mild eye and skin irritation to more severe ones including effects on the brain system, hormone mimics that can cause reproductive problems, and even cancer (EPA, 2006). Acute effects due to the exposure of the pesticide's application may be abdominal pain, dizziness, headaches, nausea, vomiting, with skin and eye problems as the Pyrethrins, insecticides frequently used to kill common bug, can cause a potentially deadly circumstances if inhaled during the application (Evans *et al.*, 2010).

Many studies have examined the development of the cancerous cases in the exposed population. The epidemiological studies also reflect that the reason of almost more than 2 % of the cancer is the widespread use of pesticides (Kolaczinski and Curtis, 2004). It can be associated with different types of cancer, such as leukemia, lymphoma, brain, kidney, breast, prostate, pancreas, liver, lung, and skin cancers (Fucic, 2012).

The risk of developing Parkinson's disease is 70% larger in those exposed to even lower intensity of pesticides. Inhabitants with Parkinson's were 61% more expected to report direct cases of pesticide application. Reproductive effects due to pesticides have also strong evidence which

links pesticide exposure to birth defects, fetal death and altered fetal growth. It was also found that fetuses that were at any time exposed to pesticides had a stumpy birth weight and had imperfect growth and development. From past studies, some pesticides such as di-bromo-chlorophane and 2, 4-D has been related with impaired fertility in males (Recena *et al.*, 2006).

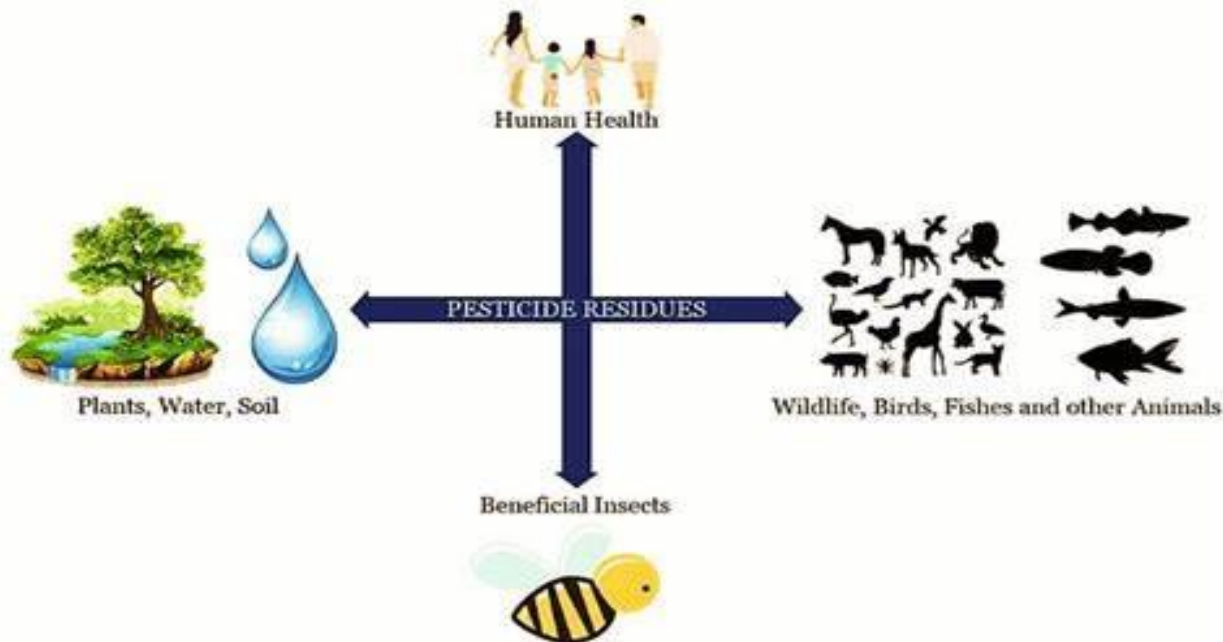


Figure 1: *Impact of pesticide residues on environment and different life forms*

Source: Muzafar Riyaz, 2021

Ecological effects of Pesticide Residues

The extreme ecological impact due to pesticides is loss of species diversity between the food chains and food webs. These impact covers a wide range of effects on pollinators, nutrient cycling in ecosystem, soil erosion, structure and fertility, water quality, human beings, birds along with this food contamination and harmful impact on aquatic life (Blacquiere *et al.*, 2012). Over and above these chemical formulations can disrupt the natural equilibrium among the pest and predators and also result bounce back of some pest population. The outbreak of the secondary pest and pest resistance are some of the major drawbacks of the pesticide's application. Moreover, all these collective disruptions in ecological system pesticides are known to be very harmful for overall ecosystem and ecological components including soil, air and water (Henry *et al.*, 2012).

Measures to Reduce Pesticide Residues in Crops

Reducing pesticide residues in food commodities requires conscious and concerted efforts on the part of the public and the government, given the presence of these residues may affect human health. As international commerce has increased, more foods that have been pesticide-treated are being imported into other countries. Because of this global trade, the public is worried about the rising levels of pesticide residues in diverse regions of the world. Several steps may be taken to lessen insect and disease problems as well as the quantity of pesticide residues in grains, vegetables, and fruits (Gale *et al.*, 2009).



The following approaches will go a long way in stemming the incidences of pesticide poisoning and other health related crises associated with the ingestion of food contaminated with pesticides.

Organic farming

One strategy to decrease the effects of pesticide residue in food is to consume organic foods rather than non-organic ones. According to common meta-analyses, non-organic crops contained detectable pesticide residues four times more frequently than organic ones (Baranski *et al.*, 2014). Consuming organic foods may help reduce your exposure to pesticide residues in food, according to the evidence (Smith-Spangler *et al.*, 2014). Organic crops typically contain greater antioxidant concentrations and fewer instances of pesticide residues than non-organic foods in all regions and production seasons. By inhibiting oxidative activity, eating foods strong in antioxidants is recommended to minimize the effects of chronic illness.

Washing food products

Studies have demonstrated that thorough washing or rinsing of food with different solvents may help reduce pesticide residues (Bhagirathi *et al.*, 2001). Cleaning may lessen the amount of pesticide residue on food products. For both domestic and commercial use, it's crucial to wash with water and various chemical treatments to eliminate pesticide residues.

Public sensitization

Public sensitization and capacity building programs for farmers, agricultural extension workers, food wholesalers/retailers on good agricultural practices (GAPs) are critical for agricultural resilience and a safe environment (Ojo, 2016).

Training and sensitization programs on the judicious use of pesticides must be done at the village or community level to ensure grass-root participation while the cost of training and demonstrations may be shouldered by the manufacturer of these pesticides. The public should be enlightened on how to carefully dispose of empty pesticide containers and how important good personal hygiene is, such as washing their hands with soap after the use of pesticides (Adesuyi *et al.*, 2018)

Processing food products

Most foods undergo processing steps before consumption, such as washing, peeling, canning, and cooking, which are essential in minimizing residues left on crops at harvest. The amount of pesticide residue in fruits and vegetables can vary depending on the processing methods used, such as peeling, boiling, frying, fermentation, and grinding (Claeys *et al.*, 2011). Cooking also reduces food residues; for instance, boiling can reduce organochlorine residues by 20 to 25 percent and organophosphate residues by 35 to 60 percent. By being husked and immersed, fruit and vegetables are allegedly able to reduce pesticide residues, particularly organophosphates (Neme *et al.*, 2016).

The inspection of registered pesticides and monitoring of pesticide residues in locally-consumed products:

The average Nigerian consumer is unaware of the number of pesticides in the food they consume. But Nigeria's food exports are tested regularly, and pesticide residues far exceed maximum limits on some crops. These regulatory lapses have blocked export opportunities. Since 2015, the European Union has banned agricultural products from Nigeria that contain pesticide residues. These include groundnut, palm oil, sesame seed and beans.

Weak regulations also make Nigeria vulnerable to becoming a dumping ground for internationally banned and counterfeit pesticides. The effective post-marketing surveillance of registered



pesticides will help to monitor the safety of pesticides after they have been released to the market. Prior to the use of any pesticides, the marketing authorization holder must submit a risk assessment plan to the regulator, which does not excise plans for post-authorization studies. The post-marketing surveillance of registered pesticides is critical in ensuring that newly marketed pesticides achieve the highest safety standards (Gill and Garg, 2014).

Rational use of pesticides and proper pesticide labeling

The rational use of pesticides includes the appropriate selection of pesticides; dose rates, dilutions; timing; frequency of application; treatment intervals; mode of administration, precautions, and restrictions. By using pesticides wisely, pesticide residues in food items may be reduced. Many times, especially when cultural or biological methods are effective, a pesticide may not even be required (Adesuyi *et al.*, 2018).

Use of biopesticides

Bio-pesticides don't leave behind any hazardous residues and are harmless for the environment. The term "bio-pesticides" refers to a broad class of microbial pesticides that provide protection against insect damage via the use of biochemical derived from microbes and other natural sources. To prevent the accumulation of pesticide residues in grains, vegetables, and fruits, certain insect repellents can also be employed (Gupta and Dikshit, 2010). Natural insecticides are also very efficient in preventing the accumulation of pesticide residues in food items, such as those made from chemicals and neem tree extracts (Schmutterer *et al.*, 1990).

The use of Postharvest Technologies in replacement of the use of Pesticides:

Post-harvest technologies have played essential roles in assisting farmers, by providing various technologies that is used to process harvested crops, so as to prevent infestation of pest, spoilage and to increase their financial stability. Postharvest technologies mostly use is: Hermetic steel drum, silo, pics bag and zero fly bag.

The regulation, adoption and implementation of harmonized guidelines for the registration of pesticides:

Poor legislation and lack of enforcement of available legislation on pesticide use and distribution are a major cause of pesticide poisoning in Nigeria and even transcend beyond Nigeria (Ojo, 2016). Hazards arising during the application of pesticides are mainly due to lack of information, knowledge and awareness, poor legislation or enforcement of legislation, and sales in the open market of pesticides (WHO, 2009). Governments of developing countries are beleaguered with pesticide mismanagement and handling by unlicensed retailers and smuggling across porous land borders (Keri, 2009).

Integrated pest management (IPM):

IPM coordinates practices that reduce the quantity of pesticide use and exposure to chemicals. Since it is impractical to ban a large number of pesticides right now, implementing programs to reduce pesticide use is critical and IPM represents the most effective way to control and manage pests because it uses cultural, mechanical, and biological pest controls where possible (Raven and Berg, 2004).

CONCLUSION AND RECOMMENDATIONS

Conclusively, although pesticides have the propensity to boost agricultural output, their residues are a significant contributor to a wide range of environmental degradation (air, land, and water). Pesticides have been implicated with numerous diseases, including asthma, anxiety, leukemia, and attention deficit hyperactivity disorder (ADHD) and cancer. Consequently, it is



imperative to enforce regulations guiding pesticide usage, strictly adhere to good hygiene practices (GHP) at personal and industrial levels and most importantly sensitizing the public on hazards associated with misuse of pesticides; employing can be brought on by either form of pesticide residue. Certain pesticide residues can cause cancer, whereas others do not (ADHD). Before eating or processing food crops, we should carefully wash them to prevent them. By employing biodegradable pesticides are encouraged while ensuring that organic farming is embraced.

Most importantly, there is need to call to action for stakeholders to work towards reducing pesticide residue in foods for the protection of public health and the environment. Also, Governments should encourage and support farmers to adopt IPM practices that reduce total reliance on chemical pesticides; development of alternative pest control methods. Governments should invest in research and development of alternative pest control methods. Such as biopesticides, natural predators and physical barriers and invest in educational campaigns to raise awareness about the health and environmental risk associated with the use of pesticide residues in agricultural practices.

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