WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

The Impact of Pesticide Residues on Human Health: A Study on Contamination Levels in Chhattisgarh

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ABSTRACT -

In agricultural techniques, pesticides are frequently employed to boost crop yields and provide disease and pest protection. But because of their overuse and carelessness, pesticide residues have accumulated in food, water, and soil, creating major health hazards. The influence of pesticide residues on human health in Chhattisgarh, a state with a sizable agricultural economy, is the main emphasis of this study. The origins of pesticide pollution, human exposure pathways, and related health risks are all examined in this research. It also outlines possible tactics and legislative actions to lessen the dangers associated with pesticide residues.

Keywords – Pesticide residues, human health, Chhattisgarh, agricultural pollution, exposure pathways, health hazards

Introduction

In contemporary agriculture, pesticides are essential since they greatly increase crop yields and the world's food output. But its widespread use has sparked worries about possible effects on the environment, human health, food safety, and agricultural quality. In order to encourage safe and sustainable pesticide usage, this research article will examine how pesticides affect crop quality and food safety, highlight related concerns, evaluate current regulatory measures, and review monitoring methods. The extensive use of pesticides has revolutionised farming methods by enabling farmers to successfully eradicate weeds, illnesses, and pests. This has boosted food availability and raised agricultural output, which has helped solve issues with global food security. In order to fulfil the increasing needs, farmers now need pesticides to cultivate a wide variety of crops. In order to protect crops from pests and diseases while increasing yield, pesticide treatment is a basic technique in modern agriculture. But the effects of pesticide use go beyond protecting crops; they also pose serious health hazards to people(1-3). Most afalou and Abdollahi (2013) conducted a thorough review that emphasised the risks of long-term pesticide exposure, citing neurotoxicity, carcinogenicity, and reproductive problems as the main health issues. Because organophosphates and organochlorines have been connected to negative effects on the nervous system, neurotoxicity is a serious problem with pesticides. Cognitive impairment, such as memory loss and attention span reduction, has been linked to exposure to certain substances. Additionally, research suggests that exposure to pesticides may raise the risk of neurological illnesses including Alzheimer's and Parkinson's(4-6).

A number of pesticides have been categorised as Group 2A or 2B carcinogens by the International Agency for Research on Cancer (IARC), a part of the World Health Organisation (WHO), indicating their potential to cause cancer in humans. These categories highlight the serious health hazards associated with extended exposure to pesticides. Additionally, pesticides have been connected to problems with reproductive health, such as decreased fertility and increased miscarriage rates. Some pesticides cause hormonal abnormalities that can harm reproductive health by upsetting the endocrine system. Acute pesticide poisoning is still a major problem worldwide, especially in areas where pesticide use is widespread. The prevalence and effects of severe pesticide toxicity, particularly in poor nations, are examined in a study by Eddleston et al. that was published in The Lancet(7-10). The type and extent of pesticide exposure determines the severity of poisoning symptoms, which can range from headaches, nausea, vomiting, and dizziness to more serious consequences like seizures, respiratory distress, and unconsciousness. Due to restricted access to medical care, agricultural communities are disproportionately affected by the millions of pesticide poisoning incidents that occur each year, which result in thousands of fatalities, according to the report(11-14).

A comprehensive strategy is needed to prevent acute pesticide poisoning, which includes adopting safer pesticide application methods, providing farmworkers with the necessary training and instruction, and utilising personal protective equipment. Additionally, minimising the symptoms of poisoning requires prompt medical attention. Developing public health regulations, enhancing treatment methods, and increasing public knowledge of the dangers of pesticide usage all depend on ongoing study into the origins and effects of pesticide toxicity(15-17).

Regulatory and Mitigation Strategies

- **Strict Enforcement:** Strengthening regulatory frameworks to monitor pesticide use.
- **Consumer Awareness:** Educating the public about washing and processing methods to reduce residue intake.
- **Sustainable Practices:** Encouraging organic farming and integrated pest management to minimize reliance on chemical pesticides(18-19).

Pesticide Residue Detection Data Platform A comprehensive platform integrating high-resolution mass spectrometry, internet connectivity, and data science to automate detection reporting and provide real-time traceability and early warning. Filed April 13, 2018, and granted February 22, 2022. Methods for Determination of Polar Pesticides by Chromatograph Introduces optimized chromatographic techniques for detecting polar pesticides (like glyphosate) with enhanced sensitivity using specialized columns and MS/MS workflows Mass Spectrometry Imaging for Residue Detection Presents a mass spectrometry imaging approach using paired spiked and unspiked extractions. It pairs chromatography with DART-TOF-MS for fast, quantitative pesticide analysis without the need for matrix-matched calibration curves . C-Q-Orbitrap Detection in Agro-products Details a method using GC coupled to Q-Orbitrap mass spectrometry, along with an electronic identification database. Employs retention indices and accurate mass fragments to profile residues in edible products(20-23).

Methodology

Study Area

The research was conducted across key agricultural districts in Chhattisgarh, namely Raipur, Durg, Bilaspur, Pendra, and Korba, which are prominent for their cultivation of vegetables like tomato, brinjal, spinach, and rice. These regions were selected due to their intensive pesticide usage and high agricultural productivity(24-25).

Sample collection

Vegetable samples (tomato, brinjal, and spinach) were collected from local markets and agricultural fields across major districts, including Raipur, Durg, and Bilaspur(26-27).

Vegetable Samples

Fresh vegetable samples, including tomato, brinjal, spinach, and cabbage, were collected from:

  - Local retail markets
  - Farm fields directly from growers

- Collection took place over a span of 3 month**s**, ensuring representative seasonal exposure.
- Each sample (approx. 500 grams) was stored in clean, airtight polyethylene bags and transported under cool conditions to avoid degradation of pesticide residues(28-29).

Water Samples

Groundwater samples were collected from agricultural areas near farms and irrigation wells. Samples were collected using acid-washed glass bottles (500 mL) and stored at 4°C during transportation (30).

Rice Samples

- Paddy samples were collected post-harvest from storage facilities and directly from farmers.
- Each rice sample was approximately 500 grams and placed in sterile, labeled containers.

Sample Preparation

Vegetable and Rice Samples

Samples were washed with distilled water, air-dried, and then chopped into small pieces. A representative homogenized portion was used for extraction. Extraction of pesticide residues was done using the QuEChERS method (Quick, Easy, Cheap, Effective, Rugged, and Safe)**:** Acetonitrile was used as a solvent for extraction. Clean-up was performed using dispersive solid-phase extraction (d-SPE) with PSA and magnesium sulfate(31-32).

Water Samples

Water samples were filtered using Whatman filter paper**.** Solid-phase extraction (SPE) cartridges were used to isolate pesticide residues. Elution was done with a suitable solvent such as methanol or dichloromethane(33-35).

Table 01 Pesticide Residue Levels in Chhattisgarh

Sample Type	Location (District)	Pesticides Detected	Concentration (ppm)	WHO/FAO Limits (ppm)
Water (Groundwater)	Bilaspur	Malathion, Atrazine	0.02 - 0.09	0.01
Vegetables (Tomato, Brinjal, Spinach)	Pendra	Cypermethrin, DDT	0.05 - 0.20	0.01 - 0.05
Rice Samples	Korba	Carbofuran, Monocrotophos	0.07 - 0.12	0.05

Table 02 Pesticide Residue Levels of vegetables in Chhattisgarh

Vegetable Type	Location (District)	Pesticides Detected	Concentration (ppm)	WHO/FAO Limits (ppm)
Brinjal	Bilaspur	Malathion, Chlorpyrifos	0.05-0.1	0.05
Spinach	Pendra	Endosulfan, DDT	0.08-0.20	0.01-0.05
Cabbage	Korba	Carbofuran, Monocrotophos	0.06-0.14	0.05

Result and discussion

Groundwater samples from Bilaspur showed pesticide concentrations ranging from 0.02 to 0.09 ppm, surpassing the WHO/FAO limit of 0.01 ppm. The presence of Malathion and Atrazine indicates significant leaching from agricultural fields into water sources, making water unsafe for consumption and increasing the risk of long-term health effects. Vegetable samples from Pendra were found to contain Cypermethrin and DDT, with concentrations between 0.05 and 0.20 ppm exceeding the permissible limit of 0.01–0.05 ppm. Consumption of such contaminated vegetables can lead to chronic health conditions, including endocrine disorders and neurological impairments. Rice samples from Korba exhibited Carbofuran and Monocrotophos residues ranging from 0.07 to 0.12 ppm, exceeding the 0.05 ppm safety threshold. These chemicals are known for their toxic effects on the nervous system and potential carcinogenicity, raising serious food safety concerns. The findings highlight a significant risk of pesticide contamination in Chhattisgarh's agricultural products and natural resources. The excessive use of pesticides beyond regulatory limits suggests a need for immediate intervention through improved pesticide management, alternative pest control methods, and stricter regulatory enforcement. Furthermore, consumer health awareness and regular monitoring programs should be strengthened to ensure food and water safety. Conclusion The presence of pesticide residues in Chhattisgarh poses a significant threat to human health. Stringent regulatory measures, sustainable agricultural practices, and public awareness are essential to mitigate the risks. Further research is needed to develop safer alternatives and policy frameworks to reduce pesticide dependence and protect public health. The highest pesticide accumulation, especially DDT (up to 0.20 ppm), was found in Pendra spinach, surpassing WHO/FAO standards. Cypermethrin and malathion levels in Bilaspur brinjal were higher than allowed. Concerns regarding food safety were raised by the pesticide residues found in Korba cabbage that were over safety limits. Excessive and uncontrolled pesticide use in some districts is indicated by high pesticide levels.

Because of its broadleaf structure, which better absorbs pesticide residues, spinach displayed the greatest levels of contamination. Neurotoxicity, endocrine disruption, and carcinogenicity are among the possible health hazards associated with pesticide residues that beyond WHO/FAO guidelines.

Conclusion –

The study's conclusions demonstrate the serious pesticide contamination of vegetables throughout Chhattisgarh. There are major worries about food safety and public health due to the high pesticide levels, especially in spinach. Serious health hazards, such as neurotoxicity, hormone abnormalities, and an increased risk of cancer, can result from exposure to these chemical residues, particularly DDT and cypermethrin. The study emphasises how urgent it is to enact stronger laws, enhance chemical monitoring, and encourage sustainable farming methods. Reducing pesticide exposure and shielding consumers from any health risks require quick action. Long-term health impacts, awareness campaigns, and the creation of eco-friendly, alternative pest control techniques should be the main areas of future research.

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