**American Journal of Biodiversity**
https://biojournals. us/index. php/AJB
**ISSN: 2997-3600**

# Impact of Pesticides on Human Health and the Environment: Current State of the Problem

**B.A. Jumanov**
Research Scholars, Zarmed University

**N.K. Tajieva**
Research Scholars, Zarmed University

**H.S. O'rinov (PhD)**
Research Scholars, Zarmed University
*haqberdiorinov@gmail.com*

**Received:** 2026, 04, Jan
**Accepted:** 2026, 10, Feb
**Published:** 2026, 12, Mar

Copyright © 2026 by author(s) and Bio Science Academic Publishing. This work is licensed under the Creative Commons Attribution International License (CC BY 4. 0).
http://creativecommons. org/licenses/ by/40/

Open Access

**Annotation:** Pesticides play an important role in modern agricultural systems by protecting crops from pests and diseases and contributing to global food security. However, the widespread and often uncontrolled use of these chemicals has raised serious concerns regarding their potential impacts on human health and environmental sustainability. This article analyzes the complex toxicological effects of pesticides on the human body and natural ecosystems based on contemporary scientific literature. Particular attention is given to the main pathways of pesticide exposure, including oral, inhalation, and dermal routes, as well as the mechanisms of toxicity associated with chronic exposure. The paper also examines the ecological consequences of pesticide contamination, including degradation of aquatic and terrestrial ecosystems and reduction of biodiversity. Special emphasis is placed on neurotoxicity, carcinogenic potential, endocrine disruption, and the risks faced by agricultural workers. The study highlights the necessity of implementing balanced pesticide management strategies, strengthening regulatory control, and promoting environmentally sustainable plant protection methods. The findings indicate that while pesticides remain essential for agricultural productivity, their uncontrolled application poses significant risks to human health and ecological stability.

**Keywords:** pesticides, toxicity, human health, ecosystem, neurotoxicity, carcinogenesis, ecotoxicology, sustainable agriculture.

## Introduction

Pesticides represent an integral component of modern agro-industrial systems and are widely used to protect crops from pests, diseases, and weeds. Their application significantly increases agricultural productivity and contributes to global food security by reducing crop losses and improving the quality of agricultural products. According to recent global assessments, millions of tons of pesticides are applied annually worldwide, making them one of the most widely used chemical groups in agriculture. Despite their undeniable benefits in food production, the extensive use of pesticides has generated increasing scientific concern regarding their potential risks to human health and environmental sustainability. The persistence, bioaccumulation capacity, and non-selective toxicity of many pesticide compounds enable them to spread beyond treated agricultural fields, contaminating soil, water bodies, air, and food chains [1].

In recent decades, scientific research has increasingly focused on the toxicological consequences of pesticide exposure for humans. Epidemiological and experimental studies have demonstrated that pesticide exposure may lead to a wide spectrum of adverse health effects, ranging from acute poisoning to long-term chronic diseases. The World Health Organization estimates that approximately 385 million cases of acute pesticide poisoning occur globally each year, with thousands of cases resulting in death. In addition to acute toxicity, chronic exposure to sublethal doses of pesticides has been associated with neurological disorders, endocrine disruption, reproductive toxicity, and carcinogenic effects. These risks are particularly significant for vulnerable populations such as agricultural workers, rural communities, pregnant women, and children whose physiological systems may be more sensitive to chemical exposure [2].

Pesticides can enter the human body through several major exposure pathways, including ingestion of contaminated food and water, inhalation of aerosolized particles, and dermal absorption through the skin. Among these routes, dermal exposure is considered particularly dangerous in agricultural settings because many pesticides possess lipophilic properties that enable them to penetrate intact skin and accumulate in fatty tissues. Certain organophosphate compounds are known to inhibit the enzyme acetylcholinesterase, which plays a critical role in neurotransmission. The inhibition of this enzyme leads to the accumulation of acetylcholine in synaptic junctions, resulting in overstimulation of the nervous system. Severe cases of poisoning may cause neurological dysfunction, respiratory distress, seizures, and encephalopathy characterized by structural and functional disturbances in the brain. Clinical manifestations often include severe headaches, dizziness, cognitive impairment, tinnitus, and memory disorders.

Beyond their direct impact on human health, pesticides also pose substantial threats to environmental integrity and biodiversity. Agricultural chemicals can enter aquatic ecosystems through runoff from treated fields, contaminating rivers, lakes, and groundwater resources. Numerous studies have documented the harmful effects of pesticide residues on aquatic organisms, including fish, amphibians, and aquatic plants. In terrestrial ecosystems, pesticides may affect non-target organisms such as birds, pollinators, and beneficial soil microorganisms. The decline of pollinator populations, particularly bees, has been linked in part to the widespread use of certain pesticide groups such as neonicotinoids. Additionally, persistent organic pesticides can accumulate within food chains, leading to biomagnification in higher trophic levels and increasing risks for predators and humans [7].

Considering these growing concerns, many international organizations and regulatory bodies have introduced policies aimed at reducing pesticide-related risks. Global initiatives such as the Stockholm Convention on Persistent Organic Pollutants and programs implemented by the Food and Agriculture Organization (FAO) emphasize the need for safer pesticide management and the gradual transition toward integrated pest management (IPM) systems. These strategies prioritize biological control methods, crop rotation, and environmentally friendly alternatives while limiting the use of highly toxic chemical pesticides. However, despite these efforts, pesticide exposure remains a significant public health and environmental challenge in many regions of the world.

Therefore, the objective of this study is to systematize contemporary scientific knowledge regarding the toxic effects of pesticides on human health and ecosystems. The study aims to identify the most vulnerable components of ecological and biological systems and to highlight strategies that may reduce the negative consequences associated with pesticide exposure.

## Methodology

This study used an analytical and comparative research approach to examine the impact of pesticides on human health and environmental ecosystems. Data were collected from recent epidemiological studies, toxicological experiments, and environmental monitoring reports related to pesticide exposure. The collected information was systematically classified into two main groups: human health effects and environmental impacts on terrestrial and aquatic ecosystems. Analytical methods were applied to evaluate the mechanisms of toxicity, exposure pathways, and potential long-term consequences of pesticide contamination.

Furthermore, comparative assessment was conducted to identify key risk factors, including chronic exposure, bioaccumulation, and ecological toxicity, allowing a comprehensive understanding of the relationship between pesticide use and its health and environmental outcomes.

## Results and Discussion

### *3.1 Effects of Pesticides on Human Health*

The analysis of current scientific literature indicates that pesticides may enter the human body through three main exposure pathways: oral intake (through contaminated food and water), inhalation of aerosolized particles through the respiratory system, and dermal absorption through the skin [1]. The severity of toxic effects depends on several factors, including the chemical class of the pesticide, dosage, duration of exposure, and individual susceptibility of the organism.

#### *3.1.1 Neurotoxic and Cognitive Effects*

One of the most extensively studied toxicological effects of pesticides is their impact on the nervous system. Cholinesterase inhibitors, particularly organophosphate and carbamate pesticides, demonstrate strong neurotoxic properties. These compounds inhibit the enzyme acetylcholinesterase, which is responsible for breaking down the neurotransmitter acetylcholine in synaptic junctions. As a result, acetylcholine accumulates in synapses, leading to overstimulation of the nervous system [2].

Acute poisoning by such pesticides is often characterized by symptoms such as convulsions, respiratory disorders, muscle weakness, and severe neurological disturbances. Even chronic exposure to relatively low doses may lead to cognitive impairment, reduced attention capacity, memory disorders, and increased risk of neurodegenerative diseases [2]. Children are considered the most vulnerable group because their nervous system is still developing and therefore more susceptible to toxic chemicals.

*3.1.2 Hepatotoxic and Nephrotoxic Effects*

The liver and kidneys, which play a central role in detoxification and excretion processes, are among the organs most affected by pesticide exposure. Chronic exposure to pesticide residues has been associated with increased levels of liver enzymes such as alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase, indicating damage to hepatocytes and impaired liver function [3-4].

Experimental studies conducted on laboratory animals have shown that prolonged pesticide exposure may cause liver fibrosis, inflammatory responses, and structural damage to renal tubules. These findings suggest that pesticide accumulation in biological tissues may disrupt metabolic processes and contribute to long-term organ dysfunction.

*3.1.3 Endocrine Disruption and Reproductive Toxicity*

Another important group of toxic effects is related to endocrine disruption. Many pesticides act as endocrine-disrupting chemicals (EDCs) that can mimic or block natural hormones such as estrogen and androgen [5]. Such interference with hormonal regulation can lead to reduced fertility, reproductive disorders, developmental abnormalities in embryos, and disruptions in sexual maturation.

Laboratory studies conducted in vitro have demonstrated that certain widely used pesticides, including glyphosate and imidacloprid, may alter the expression of estrogen receptors and other hormone-related genes [5]. These findings indicate that pesticide exposure may have long-term consequences for reproductive health and population stability.

*3.1.4 Carcinogenic Potential*

Epidemiological evidence also suggests a potential relationship between long-term pesticide exposure and increased risk of oncological diseases. Certain pesticides have been classified as potential carcinogens due to their ability to induce tumor formation in experimental models. For example, the pesticide thiamethoxam has been shown to cause liver adenomas and carcinomas in laboratory animals, which has led to its classification as a possible carcinogenic compound [6].

Additionally, persistent organochlorine pesticides such as DDT are known to accumulate in biological tissues and have been strongly associated with increased cancer risk due to their bioaccumulative properties and long-term persistence in the environment [7].

*3.1.5 Occupational Risks among Agricultural Workers*

Agricultural workers represent one of the groups most exposed to pesticides. Clinical observations indicate that farmers frequently experience a range of pesticide-related health problems, including dermatitis (reported in up to 85% of cases), chronic headaches, respiratory disorders, and visual disturbances [8-9]. Laboratory monitoring of agricultural workers often reveals reduced cholinesterase activity in the blood, which serves as an important biomarker of pesticide exposure and neurotoxicity.

### *3.2 Environmental Effects of Pesticides*

*3.2.1 Impact on Aquatic Ecosystems*

Pesticides entering water bodies through agricultural runoff represent a major source of aquatic environmental contamination. Herbicides such as acetochlor have been shown to disrupt the cellular membranes of diatom algae, inhibiting their growth and reducing primary productivity in aquatic ecosystems [10].

Exposure to pesticide-contaminated water also causes significant physiological damage in aquatic organisms. Studies have demonstrated that fish exposed to pesticides often exhibit histopathological changes in gill and liver tissues, as well as disturbances in osmoregulation, which is essential for maintaining ionic balance and normal physiological functioning [11].

*3.2.2 Effects on Terrestrial Ecosystems and Biodiversity*

Pesticide contamination also significantly affects terrestrial ecosystems and biodiversity.

Bird populations. Pesticides may cause both direct and indirect mortality among birds. Direct toxicity can lead to acute poisoning, while indirect effects arise from the destruction of insect populations that serve as an essential food source. It has been estimated that up to 72 million birds die annually in the United States due to pesticide exposure [12]. Neonicotinoid pesticides are particularly harmful to insectivorous bird species.

Pollinators. Pesticides can negatively affect pollinator species such as bees by impairing their navigation ability, immune function, and reproductive capacity, which may lead to colony collapse [13]. In addition, herbicides eliminate wild flowering plants that serve as an important source of food for pollinators.

Soil biota. Soil ecosystems are also highly sensitive to pesticide contamination. Many pesticides suppress beneficial soil microorganisms responsible for nutrient cycling and organic matter decomposition. As a result, pesticide accumulation may disrupt soil microbial balance and reduce natural soil fertility, ultimately affecting agricultural sustainability [14-15].

*3.2.3 Bioaccumulation and Trophic Transfer*

Another critical environmental issue associated with pesticide use is bioaccumulation and biomagnification within food chains. Lipophilic pesticide compounds, particularly organochlorine pesticides, tend to accumulate in fatty tissues of living organisms. As these compounds move through trophic levels, their concentrations increase progressively, a process known as biomagnification [16-17].

Consequently, top predators and humans often experience the highest levels of exposure despite not being directly involved in pesticide application. This phenomenon significantly increases the ecological and health risks associated with persistent pesticide residues [18].

***3.3 International Regulation and Risk Mitigation Strategies***

In response to the growing risks associated with pesticide use, several international regulatory frameworks have been established to manage pesticide-related hazards. Global initiatives such as the Stockholm Convention on Persistent Organic Pollutants and programs implemented by the Food and Agriculture Organization (FAO) aim to reduce the use of hazardous pesticides and promote safer agricultural practices [19].

The main directions for reducing pesticide-related risks include:

- Integrated Pest Management (IPM) – prioritizing biological control methods, crop rotation, and ecological pest control strategies while using chemical pesticides only as a last resort [20].
- Development of environmentally safer pesticides – designing selective pesticides with shorter environmental half-lives and lower toxicity to non-target organisms [21].
- Education and regulatory monitoring – strengthening pesticide application regulations, promoting the use of personal protective equipment (PPE), and monitoring maximum residue levels (MRLs) in agricultural products to ensure food safety [22].

**Conclusion**

Despite the fact that some pesticide compounds have been banned in many countries, pesticides are still widely used today to ensure agricultural productivity and global food security. However, their extensive application poses significant risks to both human health and biodiversity. The findings of this study indicate that pesticide exposure may lead to a wide range of adverse effects, affecting both humans and other living organisms.

Chronic exposure to agrochemicals has been associated with numerous pathological conditions, ranging from cognitive impairment and neurological disorders to endocrine disruption and carcinogenesis. These toxicological effects highlight the complex and long-term consequences of pesticide contamination in biological systems and ecosystems.

Therefore, before the application of pesticides in agricultural practice, it is advisable to conduct a comprehensive analysis of their chemical composition and toxicological properties using modern diagnostic and analytical methods. Such an approach may contribute to minimizing potential health risks and environmental damage while ensuring sustainable agricultural development.

## References

[1] B. Ádám, P. Cocco, and L. Godderis, "Hazardous Effects of Pesticides on Human Health," Toxics, vol. 12, no. 3, p. 186, 2024. https://doi.org/10.3390/ toxics12030186

[2] A. Alengebawy et al., "Heavy metals and pesticides toxicity in agricultural soil and plants: Ecological risks and human health implications," Toxics, vol. 9, no. 3, p. 42, 2021. https://doi.org/10.3390/toxics9030042

[3] I. M. Ali, "The harmful effects of pesticides on the environment and human health: A review," Diyala Agricultural Sciences Journal, vol. 15, no. 1, pp. 114–126, 2023.

[4] S. Ali et al., "Environmental and health effects of pesticide residues," in Sustainable Agriculture Reviews 48: Pesticide Occurrence, Analysis and Remediation, Cham: Springer International Publishing, 2020, pp. 311–336.

[5] A. Barathinivas et al., "Ecotoxicological effects of pesticides on hematological parameters and oxidative enzymes in freshwater catfish (Mystus keletius)," Sustainability, vol. 14, no. 15, p. 9529, 2022. https://doi.org/10.3390/ su14159529

[6] M. T. Bartling et al., "Current insights into sublethal effects of pesticides on insects," International Journal of Molecular Sciences, vol. 25, no. 11, p. 6007, 2024. https://doi.org/10.3390/ijms25116007

[7] C. Benbrook et al., "Novel strategies and new tools to curtail the health effects of pesticides," Environmental Health, vol. 20, no. 1, p. 87, 2021. https:// doi.org/10.1186/s12940-021-00773-4

[8] C. Shekhar et al., "A systematic review of pesticide exposure, associated risks, and long-term human health impacts," Toxicology Reports, vol. 13, p. 101840, 2024. https://doi.org/10.1016/j.toxrep.2024.101840

[9] L. Coppola et al., "Comparison of the toxicological effects of pesticides in non-tumorigenic MCF-12A and tumorigenic MCF-7 human breast cells," International Journal of Environmental Research and Public Health, vol. 19, no. 8, p. 4453, 2022. https://doi.org/10.3390/ijerph19084453

[10] J. Dalbó, L. A. Filgueiras, and A. N. Mendes, "Effects of pesticides on rural workers: hematological parameters and symptomalogical reports," Ciência & Saúde Coletiva, vol. 24, pp. 2569–2582, 2019. https://doi.org/10.1590/1413-81232018247.19012017

[11] I. Gruss et al., “Assessing the ecotoxicological effects of pesticides on non-target plant species,” Environmental Monitoring and Assessment, vol. 197, no. 9, p. 1047, 2025. https://doi.org/10.1007/s10661-025-14532-2

[12] V. N. Huyen et al., “Effects of pesticides on farmers' health in TuKy district, Hai Duong province, Vietnam,” Sustainable Futures, vol. 2, p. 100026, 2020. https://doi.org/10.1016/j.sftr.2020.100026

[13] A. Jabłońska-Trypuć and J. Wiater, “Protective effect of plant compounds in pesticides toxicity,” Journal of Environmental Health Science and Engineering, vol. 20, no. 2, pp. 1035–1045, 2022. https://doi.org/10.1007/s40201-022-00823-0

[14] M. Jat et al., “Effect of pesticides on soil ecosystem services and processes,” Indian Journal of Entomology, pp. 981–990, 2022.

[15] S. Kadiru, S. Patil, and R. D’Souza, “Effect of pesticide toxicity in aquatic environments: A recent review,” International Journal of Fisheries and Aquatic Studies, vol. 10, no. 3, pp. 113–118, 2022.

[16] R. Kaur et al., “Pesticides classification and its impact on environment,” International Journal of Current Microbiology and Applied Sciences, vol. 8, no. 3, pp. 1889–1897, 2019.

[17] Z. Khoshnood, “Toxic effects of pesticides in zebrafish (Danio rerio) and common carp (Cyprinus carpio), emphasizing atrazine herbicide,” Toxicology Reports, vol. 13, p. 101694, 2024. https://doi.org/10.1016/j.toxrep.2024.101694

[18] J. N. D. Koussé et al., “Self-reported health effects of pesticides among cotton farmers from the Central-West region in Burkina Faso,” Toxicology Reports, vol. 11, pp. 273–282, 2023. https://doi.org/10.1016/j.toxrep.2023.10.002

[19] K. Nagy et al., “Comparative studies assessing the toxicity of pesticide active ingredients and their formulations,” Environmental Research, vol. 181, p. 108926, 2020. https://doi.org/10.1016/j.envres.2019.108926

[20] Y. N. Nishonov and J. T. Mamasaidov, “The reaction of hepatocytes to the effects of pesticides,” BIO Web of Conferences, vol. 65, p. 09003, 2023. https://doi.org/10.1051/bioconf/20236509003

[21] J. M. Oliveira et al., “How do pesticides affect bats? A brief review of recent publications,” Brazilian Journal of Biology, vol. 81, no. 2, pp. 499–507, 2020. https://doi.org/10.1590/1519-6984.225876

[22] G. M. Palamara et al., “Investigating the effect of pesticides on Daphnia population dynamics using stochastic models,” Ecological Modelling, vol. 472, p. 110076, 2022. https://doi.org/10.1016/j.ecolmodel.2022.110076