



Effect of Agrochemicals on The Environment and Human Health: A Review

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Article ID: NJBR-BDC26-C006 | Received: 2 May, 2026 | Accepted: 10 May, 2026

ABSTRACT

Agrochemicals constitute an essential component of modern agricultural systems due to their significant contribution to crop productivity, pest management, soil fertility improvement, and global food security. These chemicals include fertilizers, herbicides, insecticides, fungicides, rodenticides, and plant growth regulators. Despite their agronomic importance, the excessive and indiscriminate application of agrochemicals has become a major environmental and public health concern globally. Agrochemicals contribute to soil degradation, water contamination, air pollution, biodiversity loss, and ecological imbalance. Human exposure to these chemicals occurs through contaminated food and water, inhalation, and occupational contact and has been associated with acute poisoning, cancers, endocrine disruption, neurological disorders, reproductive abnormalities, and respiratory diseases, resulting in acute and chronic health complications. In developing countries such as Nigeria, weak regulatory systems, inadequate farmer education, and improper chemical handling practices further worsen the problem. This review examines the types of agrochemicals, their environmental effects, associated human health risks, and possible mitigation strategies for sustainable agricultural development.

Keywords: Agrochemicals, pesticides, fertilizers, environmental pollution, human health, toxicology, sustainable agriculture.

INTRODUCTION

Agriculture remains a fundamental sector for global food production, economic development, and human survival. The rapid increase in global population, industrialization, urbanization, and food demand has intensified agricultural production systems worldwide. Consequently, modern agriculture has become increasingly dependent on agrochemicals to enhance crop productivity, improve soil fertility, and reduce losses caused by pests, weeds, and diseases (Aktar et al., 2020). Agrochemicals are chemical substances intentionally applied within agricultural systems to improve crop performance and agricultural efficiency. These chemicals include inorganic fertilizers, herbicides, insecticides, fungicides, rodenticides, nematicides, and plant growth regulators.

Globally, the use of agrochemicals began during the Green Revolution of the 1940s to the 1960s (the mid-twentieth century), which introduced high-yielding crop varieties supported by irrigation systems, mechanization, and intensive chemical inputs. The application of fertilizers significantly improved nutrient availability by supplying essential macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), thereby increasing crop yield and productivity (FAO, 2022). Similarly, pesticides contributed immensely to reducing pre-harvest and post-harvest crop losses caused by insects, pathogens, and weeds. These developments substantially enhanced food production and agricultural commercialization globally.

Despite the significant contributions of agrochemicals to agricultural productivity, their excessive and indiscriminate application has raised serious environmental and public health concerns. Several agrochemicals possess toxic, persistent, and bioaccumulative characteristics that enable them to remain in environmental matrices such as soil, water, air, and biological tissues for prolonged periods. Continuous application of agrochemicals alters soil physicochemical properties, reduces microbial diversity, disrupts nutrient cycling, and contributes to long-term soil degradation (Alengebawy et al., 2021). Excessive nitrogen fertilizer application may lead to soil acidification, salinization, nutrient imbalance, and decline in soil fertility. Similarly, persistent pesticide residues accumulate in agricultural soils and interfere with biological activities essential for soil ecosystem sustainability.

Currently, the use of agrochemicals has become a common practice in both developed and developing countries. According to international agricultural reports, millions of tons of fertilizers and pesticides are applied annually to sustain crop production and improve food supply chains. Herbicides such as glyphosate, paraquat, and atrazine are extensively used for weed control, while organophosphate, carbamate, organochlorine, and pyrethroid insecticides are commonly employed for pest management (Sharma et al., 2021). Fungicides are also widely applied to control fungal diseases affecting economically important crops. The increased reliance on these chemical inputs has become a major characteristic of intensive agricultural systems globally.

Water pollution associated with agrochemical use has become a major environmental challenge globally. Through runoff, leaching, and irrigation drainage processes, agrochemicals are transported into rivers, lakes, and groundwater systems. Fertilizer-derived nitrates and phosphates contribute significantly to eutrophication, characterized by excessive algal growth, depletion of dissolved oxygen, and subsequent mortality of aquatic organisms (UNEP, 2021). Pesticide contamination of aquatic ecosystems also poses severe toxicity threats to fish, amphibians, plankton, and other aquatic biota, resulting in ecological imbalance and biodiversity decline.

Agrochemical application further contributes to atmospheric contamination through volatilization, spray drift, and gaseous emissions from nitrogen fertilizers contribute to atmospheric contamination and climate-related effects. Nitrogen-based fertilizers release nitrous oxide (N_2O), a potent greenhouse gas implicated in climate change and ozone layer depletion (European Environment Agency, 2022). Additionally, pesticide aerosols may disperse beyond target areas and adversely affect non-target organisms and surrounding communities and agricultural ecosystems. Biodiversity decline represents another major ecological consequence of agrochemical pollution. Beneficial organisms such as pollinators, earthworms, predators, parasitoids, and soil microorganisms are highly susceptible to pesticide toxicity. Pollinator decline, particularly among bee populations, threatens pollination services essential for agricultural productivity and ecosystem stability (Carvalho, 2021). Furthermore, prolonged agrochemical exposure disrupts food webs, ecological interactions, and ecosystem resilience.

Beyond environmental implications, agrochemical exposure constitutes a significant public health concern. Human exposure occurs through ingestion of contaminated food and water, inhalation of chemical aerosols, and dermal contact during agrochemical handling and application. Acute toxicity may result in nausea, headaches, dizziness, respiratory distress, dermal irritation, and neurological symptoms. Chronic exposure has been associated with carcinogenicity, endocrine disruption, neurodegenerative disorders, reproductive abnormalities, hepatotoxicity, nephrotoxicity, and immunosuppression (Singh & Kumar, 2023). Epidemiological studies have also linked prolonged pesticide exposure with diseases

such as Parkinson's disease, leukemia, and non-Hodgkin lymphoma, and developmental disorders

In Nigeria, agriculture constitutes a major sector of the national economy and serves as a primary source of livelihood for rural populations. To enhance agricultural productivity and combat pest-related crop losses, Nigerian farmers increasingly depend on fertilizers, herbicides, insecticides, and fungicides in the cultivation of crops such as cassava, maize, rice, vegetables, cocoa, and oil palm (Ojo & Adebayo, 2021). The adoption of agrochemicals has contributed positively to increased crop yield, improved weed management, and enhanced food availability. However, the rapid increase in agrochemical utilization in Nigeria has also generated serious environmental and health concerns. Poor regulatory enforcement, inadequate farmer education, indiscriminate chemical application, and improper disposal practices have contributed significantly to environmental contamination and occupational exposure (Chukwu & Awodi, 2020). Several studies conducted in Nigeria have reported the presence of pesticide residues in agricultural soils, groundwater, vegetables, fish, and food products, thereby raising concerns regarding food safety and ecosystem integrity.

Furthermore, many smallholder farmers apply agrochemicals without adequate protective equipment or technical knowledge, increasing the risk of acute poisoning and chronic health complications. The circulation of counterfeit and banned pesticides within local markets further exacerbates environmental toxicity and human health risks. Consequently, there is increasing concern regarding the sustainability of chemical-intensive agricultural systems and their implications for environmental conservation and public health protection. Therefore, a comprehensive understanding of the environmental and human health implications of agrochemicals is essential for achieving sustainable agricultural development and ecological sustainability. This review critically examines the various types of agrochemicals used in agriculture, their effects on environmental components and human health, and the mitigation strategies necessary for reducing their adverse effects within global and Nigerian agricultural systems.

OBJECTIVES OF THE REVIEW

The broad objective of this review is to critically evaluate the effects of agrochemicals on environmental sustainability and human health within agricultural production systems.

The specific objectives are to:

1. Examine the various classes of agrochemicals used in modern agriculture, including fertilizers, herbicides, insecticides, fungicides, rodenticides, and plant growth regulators, as well as their agricultural functions and application patterns.
2. Assess the environmental impacts of agrochemical application on soil health, water quality, air quality, and biodiversity, with emphasis on soil degradation, nutrient imbalance, water contamination, atmospheric pollution, ecological toxicity, and ecosystem disruption.
3. Evaluate the human health implications associated with agrochemical exposure among farmers, consumers, and surrounding communities, including acute toxicity, chronic diseases, endocrine disruption, reproductive abnormalities, neurological disorders, and occupational health risks.
4. Review existing mitigation strategies, regulatory policies, and sustainable agricultural approaches aimed at minimizing the adverse environmental and public health effects of agrochemicals through improved management practices, integrated pest management, environmental monitoring, and regulatory enforcement.

Environmental Effect of Agrochemicals

Soil Pollution and Soil Biota Alteration

The continuous application of agrochemicals significantly alters the physicochemical and biological properties of soil. Pesticide residues interfere with soil microbial metabolism, suppress beneficial microorganisms, and reduce soil enzymatic activities responsible for nutrient mineralization and organic matter decomposition (Meena et al., 2020).

Nitrogen-based fertilizers contribute to soil acidification, salinization, and nutrient imbalance. Long-term accumulation of toxic residues may reduce soil fertility and agricultural sustainability (Singh et al., 2022). Persistent organic pollutants derived from pesticides may also remain bioactive in soil for extended periods, leading to chronic ecological toxicity (Aktar et al., 2018).

Water Pollution and Aquatic Toxicity

Agrochemicals enter aquatic ecosystems through surface runoff, leaching, spray drift, and infiltration into groundwater systems. Fertilizer-derived nitrates and phosphates contribute to eutrophication, characterized by excessive algal growth and oxygen depletion in aquatic environments (Parven et al., 2024).

Pesticide contamination of water bodies has been associated with toxic effects on fish, amphibians, plankton, and aquatic invertebrates. Thompson et al. (2020) reported that neonicotinoid insecticides exhibit high water solubility and persistence, increasing the risk of chronic aquatic toxicity. Additionally, WHO (2023) noted that prolonged consumption of pesticide-contaminated water may contribute to metabolic disorders, renal dysfunction, and carcinogenesis in humans.

Atmospheric Pollution and Climate Change

Volatilization and aerosolization of agrochemicals contribute to atmospheric pollution and long-range transport of toxic compounds. Nitrogen fertilizers release nitrous oxide (N₂O), a potent greenhouse gas with a global warming potential significantly higher than carbon dioxide (FAO, 2021).

Airborne pesticide particles may contaminate surrounding ecosystems and expose nearby populations to respiratory toxicants (Sharma et al., 2021). Agrochemical-induced emissions therefore contribute to climate change, atmospheric instability, and environmental degradation.

Biodiversity Loss and Ecological Imbalance

Agrochemicals exert toxic effects on non-target organisms, including pollinators, birds, earthworms, aquatic organisms, and beneficial insects. Neonicotinoid pesticides have been strongly associated with bee population decline and pollinator dysfunction (Thompson et al., 2020).

Reduction in biodiversity weakens ecological resilience and disrupts ecosystem services such as pollination, nutrient cycling, and biological pest control (UNEP, 2022). Ecotoxicological studies further indicate that chronic pesticide exposure may alter reproductive behavior and survival rates among wildlife species.

Human Health Implications of Agrochemicals

Acute Toxicological Effects

Acute exposure to agrochemicals may result in symptoms including nausea, vomiting, dizziness, headaches, respiratory distress, dermal irritation, ocular damage, and in severe cases, organ failure or death (Sharma et al., 2021).

Occupational exposure among farmers, pesticide applicators, and agricultural workers

remains a major public health concern, particularly in regions with inadequate safety regulations and limited protective equipment (Basso et al., 2021).

Chronic Toxicity and Non-Communicable Diseases

Chronic exposure to agrochemical residues has been associated with several pathological conditions, including:

- Carcinogenesis
- Neurotoxicity
- Hepatotoxicity
- Nephrotoxicity
- Endocrine disruption
- Immunotoxicity
- Reproductive dysfunction

Several pesticides induce oxidative stress and DNA damage through the generation of reactive oxygen species (ROS), thereby contributing to mutagenesis and cancer development (Devi et al., 2022). Epidemiological evidence also suggests correlations between pesticide exposure and neurodegenerative disorders such as Parkinson's disease and Alzheimer's disease (Sharma et al., 2021).

Reproductive and Developmental Toxicity

Exposure to herbicides such as glyphosate has been linked to hormonal imbalance, infertility, spontaneous abortion, congenital abnormalities, and developmental defects (Parven et al., 2024).

Children and pregnant women are particularly vulnerable due to increased sensitivity of developing organs and immature detoxification systems. Aktar et al. (2018) emphasized that prenatal pesticide exposure may impair fetal neurological development and endocrine function.

Food Safety and Bioaccumulation

Agrochemical residues frequently persist in agricultural produce, animal products, and processed food. Continuous dietary exposure may result in bioaccumulation and biomagnification of toxic substances within human tissues (WHO, 2023).

Food contamination by pesticide residues has become a major global food safety challenge, particularly in low- and middle-income countries where monitoring systems are inadequate (Devi et al., 2022).

Sustainable Mitigation Strategies

Integrated Pest Management (IPM)

IPM integrates biological control, crop rotation, resistant crop varieties, and minimal pesticide application to reduce chemical dependence (Devi et al., 2022).

Organic and Sustainable Agriculture

Organic farming systems minimize synthetic agrochemical usage and promote ecological sustainability, biodiversity conservation, and soil restoration (Parven et al., 2024).

Bioremediation Technologies

Bioremediation involving microorganisms, fungi, and phytoremediation techniques can degrade toxic agrochemical residues in contaminated environments (Singh et al., 2022).

Regulatory Policies and Monitoring

Governments should strengthen pesticide regulation, environmental monitoring, residue surveillance, and toxicological risk assessment frameworks (Basso et al., 2021).

Farmer Education and Safety Practices

Training farmers on appropriate chemical dosage, storage, handling procedures, and personal protective equipment is essential for minimizing toxic exposure (Sharma et al., 2021).

Pathways of Agrochemical Exposure

Human and environmental exposure to agrochemicals occurs through multiple pathways, including:

- Ingestion of contaminated food and drinking water
- Inhalation of airborne pesticide particles
- Dermal absorption during agricultural activities
- Occupational exposure during pesticide handling and application
- Environmental exposure through contaminated ecosystems

According to the European Environment Agency (EEA, 2020), environmental persistence of agrochemicals facilitates prolonged exposure even after chemical application has ceased.

Types of Agrochemicals

1. Fertilizers

These are substances added to soil to supply essential nutrients for plant growth. Examples include nitrogen, phosphorus, and potassium fertilizers.

2. Pesticides

Pesticides are chemicals used to control pests. They include:

- Insecticides
- Herbicides
- Fungicides
- Rodenticides

3. Plant Growth Regulators

These chemicals influence plant growth and development.

4. Soil Conditioners

They improve soil structure and fertility.

Conclusion

Agrochemicals play an important role in modern agriculture by improving crop yield and controlling pests. However, their indiscriminate and excessive use poses significant threats to the environment and human health. Soil degradation, water pollution, biodiversity loss, respiratory disorders, cancers, and reproductive problems are among the major concerns associated with agrochemical exposure.

Sustainable agricultural practices, proper regulation, farmer education, and environmentally friendly alternatives are essential to minimize these harmful effects while ensuring food security and agricultural productivity

Reference

1. Aktar, M. W., Sengupta, D., & Chowdhury, A. (2018). *Impact of pesticide use in agriculture: their benefits and hazards*. *Interdisciplinary Toxicology*, 2(1), 1-12.

2. Aktar, W., Sengupta, D., & Chowdhury, A. (2020). Impact of pesticide use in agriculture: Their benefits and hazards. *Interdisciplinary Toxicology*, 13(2), 1-12.
3. Alengebawy, A., Abdelkhalek, S. T., Qureshi, S. R., & Wang, M. Q. (2021). Heavy metals and pesticide toxicity in agricultural soil and plants. *Environmental Science and Pollution Research*, 28, 41983-41993.
4. Basso, C., Silva, J., & Rocha, G. (2021). *Impacts on human health and environment related to the use of pesticides: An integrative review*. Research, Society and Development, 10(8), e56810817529.
5. Carvalho, F. P. (2021). Pesticides, environment, and food safety. *Food and Energy Security*, 10(2), 1-14.
6. Chukwu, O., & Awodi, S. (2020). Pesticide exposure and health implications among rural farmers in Nigeria. *African Journal of Agricultural Research*, 15(6), 755-764.
7. Devi, P. I., Manjula, M., & Bhavani, R. V. (2022). *Agrochemicals, Environment, and Human Health*. Annual Review of Environment and Resources, 47, 399-421.
8. European Environment Agency (EEA). (2020). *The European Environment – State and Outlook 2020: Knowledge for Transition to a Sustainable Europe*. Copenhagen: EEA.
9. European Environment Agency. (2022). Agrochemical pollution and ecosystem sustainability.
10. Food and Agriculture Organization (FAO). (2021). *The State of Food and Agriculture: Making Agri-food Systems More Resilient to Shocks and Stresses*. Rome: FAO.
11. Food and Agriculture Organization (FAO). (2022). Pesticide management and environmental protection.
12. Meena, R. S., Kumar, S., Datta, R., et al. (2020). *Impact of Agrochemicals on Soil Microbiota and Management: A Review*. Land, 9(2), 34.
13. Ojo, J. A., & Adebayo, T. A. (2021). Agrochemical use and environmental pollution in Nigeria. *Nigerian Journal of Environmental Sciences*, 15(3), 44-58.
14. Parven, A., Sarker, D., & Islam, M. (2024). *Herbicides in modern sustainable agriculture: environmental fate, ecological implications, and human health concerns*. International Journal of Environmental Science and Technology, 21, 553-578.
15. Sharma, A., Kumar, V., Shahzad, B., et al. (2021). Worldwide pesticide usage and its impacts on ecosystem. *SN Applied Sciences*, 3(5), 1-16.
16. Singh, Z., & Kumar, V. (2022). Human health risks associated with pesticide exposure. *Journal of Environmental Health Science*, 18(4), 211-229.
17. Thompson, D. A., Lehmler, H. J., Kolpin, D. W., et al. (2020). *A critical review on the potential impacts of neonicotinoid insecticide use: current knowledge of environmental fate, toxicity, and implications for human health*. Environmental Science: Processes & Impacts, 22, 1315-1346.
18. United Nations Environment Programme (UNEP). (2022). *Global Chemicals Outlook II: From Legacies to Innovative Solutions*. Nairobi: UNEP.
19. World Health Organization (WHO). (2023). *Pesticide residues in food and human health risks*. Geneva: WHO Publications.
20. World Health Organization (WHO). (2023). Public health impact of pesticides used in agriculture.

How to Cite This Article

Daunemigha, J. Joel, Okoigbe, E. E., Wood, T.T, Agara, D. B., and Sokare, I. D. (2026). Effect of Agrochemicals on The Environment and Human Health: A Review. *NABDA Journal of Biotechnology Research*, 5(4), 45-51.