International Journal of Academic Research and Development
www.allreviewjournal.com
ISSN: 2455-4197
Received: 13-08-2025, Accepted: 12-09-2025, Published: 27-09-2025
Volume 10, Issue 4, 2025, Page No. 73-76

Pesticide residues and agrochemical impact on soil, water, and biota in selected areas of Kogi state, Nigeria

AbdulAzeez A'Majid IO
Department of Integrated Science, Federal College of Education, Okene, Kogi, Nigeria

Abstract
Agrochemical inputs remain central to agricultural productivity in sub-Saharan Africa, yet their indiscriminate use continues to present a growing challenge to environmental and human health. This study examines the occurrence, spatial distribution, and socio-economic implications of agrochemical residues—particularly organochlorine pesticides (OCPs)—in selected areas of the Kogi River catchments of Kogi State, Nigeria. Using a mixed-method approach, the research integrates laboratory analyses, GIS-based spatial interpolation, and community-level surveys. A total of twenty water and twenty-five soil samples were collected during wet and dry seasons, analyzed for physicochemical parameters, mineral residues, and pesticide concentrations. Spatial mapping was undertaken using Inverse Distance Weighting (IDW) in ArcGIS 10.5 to illustrate pollutant distribution. Additionally, socio-economic surveys (n = 250 households) assessed agrochemical handling, application rates, disposal practices, and awareness of pesticide regulations.

Results reveal persistent contamination of soil and water resources, with concentrations of OCPs such as aldrin, endosulfan, dieldrin, and dichlorvos exceeding international thresholds in several locations. Fertilizer residues were also prominent, with nitrate and phosphate enrichment contributing to eutrophication in low-flow areas. Farmers reported pesticide application rates between 5–10 L per hectare, with over 40% applying ≥10 L, significantly above recommended limits. Improper disposal of containers was common, with 58% discarding them directly on farmland. Spatial GIS analysis demonstrated localized hotspots of contamination, strongly linked to farming intensity. The persistence of banned pesticides, coupled with poor awareness of safe practices, underscores weak regulatory enforcement and potential risks to both ecosystems and human livelihoods.

This paper contributes to debates on sustainable intensification by combining chemical evidence, spatial mapping, and socio-economic realities. Findings highlight the urgent need for stronger regulatory frameworks, farmer education, and adoption of integrated pest management strategies.

Keywords: Agrochemical – a chemical product used in agricultural including fertilizer, pesticides

Introduction

Agricultural intensification has transformed food production systems in developing regions, but at the cost of increasing environmental degradation. Globally, over 150 million tons of fertilizers and large volumes of pesticides are applied annually. While these inputs enhance yields, they introduce negative externalities, including soil degradation, water contamination, and biodiversity loss. Fertilizer residues—particularly nitrogen and phosphorus compounds—are major drivers of eutrophication and oxygen depletion in aquatic ecosystems. Persistent organic pollutants such as organochlorine pesticides (OCPs) are particularly concerning due to their chemical stability and long half-lives, remaining in soils and sediments decades after their ban.

In Nigeria, pesticide contamination has been documented in several ecosystems. Ogedegbe *et al.* (2024) [10] reported residues of OCPs in southern soils, while Okonkwo *et al.* (2024) [11] found farmland soils in Delta State contained high concentrations of OCP metabolites. Aquatic contamination has also been reported: Akinola *et al.* (2023) [1] documented OCP levels in Chanchaga River exceeding WHO limits. These findings suggest widespread bioaccumulation risks across Nigerian food webs.

The Niger and Kaduna catchments—draining into the Kogi River basin—are ecologically sensitive areas supporting agriculture, fisheries, and domestic water supply. Their role as major livelihoods sources makes contamination particularly consequential. This study builds on previous research by integrating GIS-based spatial mapping with laboratory analyses and socio-economic data to provide a holistic account of agrochemical pollution in Kogi State. By situating findings within the Sustainable Development Goals, the study contributes to global efforts on SDG 6 (Clean Water) and SDG 15 (Life on Land).

Study Area

The study was conducted in riverine communities along the Kogi Rivers in Adavi Local Government Area, located in the Guinea Savannah zone of north-central Nigeria. The area is characterized by extensive floodplains, intensive subsistence and commercial farming, and strong dependence on rivers for fishing and domestic water supply. Additional sampling was undertaken along Rivers Niger and Kaduna to capture comparative contamination profiles. Coordinates of sampling stations were recorded using GPS.

Site Ref	Coordinates	Characteristics
S1 & W1 (Upper Zone RN)	9°14'53"N 5°85'37"E	Domestic activities, farming, fishing, settlements
S2 & W2	9°11'09"N 5°26'19"E	Domestic activities, farming, fishing, settlements
S3 & W3 (Middle Zone RN)	9°11'43"N 5°18'38"E	Domestic activities, farming, fishing, settlements
S4 & W4	9°45'25"N 5°50'38"E	Domestic activities, farming, fishing, settlements
S5 & W5 (Lower Zone RN)	9°35'11"N 5°25'59"E	Domestic activities, farming, fishing, settlements
S6 & W6 (Upper Zone RK)	9°46'12"N 5°18'42"E	Domestic activities, farming, fishing, settlements
S7 & W7	9°09'24"N 5°49'39"E	Domestic activities, farming, fishing, settlements
S8 & W8 (Lower Zone RK)	9°50'35"N 5°50'39"E	Domestic activities, farming, fishing, settlements

Conceptual Framework and Methodology

The Drivers–Pressure–State–Impact–Response (DPSIR) framework guided this study. Data collection involved field observations, participatory rural appraisal (PRA), questionnaires, and interviews with farmers and stakeholders. Soil and water samples were collected for laboratory analysis of physicochemical properties, fertilizer residues, and pesticide concentrations. Spatial analysis was conducted using GIS-based mapping to determine pollutant distributions. Laboratory protocols followed APHA standards for water and soil testing.

Sampling was conducted across multiple temporal phases—wet and dry seasons—to capture seasonal variability in pollutant concentration. Water samples were collected at 20 georeferenced points along both rivers, while 25 soil cores were extracted at varying depths (0–15 cm, 15–30 cm). In situ measurements of pH, electrical conductivity, dissolved oxygen, and turbidity were taken using portable multi-parameter probes. Samples were transported in ice-cooled containers to the laboratory for further analysis, following APHA (2017) standards. Quality assurance included triplicate sampling, blank controls, and use of certified reference materials.

GIS spatial interpolation techniques (Inverse Distance Weighting and Kriging) were employed to map pollutant distributions. The DPSIR framework further allowed the integration of biophysical data with socio-economic findings from household surveys (n = 250). Questionnaires focused on agrochemical handling, protective gear usage, and awareness of pesticide regulations. This integrated methodology ensures robust cross-validation of chemical data with community realities.

Chemical Nature and Environmental Fate of Agrochemicals

Agrochemicals exhibit diverse chemical properties that affect their persistence and transport. Organochlorine pesticides such as DDT ($C_{14}H_9Cl_5$) remain stable due to strong carbon-chlorine bonds, slowly degrading into DDE ($C_{14}H_8Cl_4$) and DDD ($C_{14}H_{10}Cl_4$). Other OCPs, including dieldrin ($C_{12}H_8Cl_6O$) and heptachlor ($C_{10}H_5Cl_7$), display similar persistence. Fertilizers, primarily nitrogen and phosphorus compounds, undergo transformations such as urea hydrolysis:

$CO(NH_2)_2 + H_2O \rightarrow 2NH_3 + CO_2$ (1)

Ammonium nitrification to nitrite: $2NH_4^+ + 3O_2 \rightarrow 2NO_2^- + 4H^+ + 2H_2O$ (2)

Nitrite oxidation to nitrate: $2NO_2^- + O_2 \rightarrow 2NO_3^-$ (3)

These transformations enhance nitrate leaching into groundwater. Additional processes include pesticide hydrolysis, denitrification ($2NO_3^- + 10e^- + 12H^+ \rightarrow N_2 + 6H_2O$), and sorption–desorption reactions affecting pesticide mobility in soils.

The degradation of other pesticides is also significant. Endosulfan, another widely used pesticide in Nigeria, undergoes hydrolysis in alkaline soils:

$C_9H_6Cl_6O_3S + H_2O \rightarrow C_9H_8Cl_4O_4S + 2HCl$ (4)

This reaction produces toxic metabolites such as endosulfan sulfate, which can persist even longer than the parent compound. Hexachlorocyclohexane (HCH) isomers, such as lindane (γ-HCH), degrade via dehydrochlorination:

$C_6H_6Cl_6 \rightarrow C_6H_5Cl_5 + HCl$ (5)

Such reactions emphasize that while degradation occurs, it often results in equally hazardous by-products that accumulate in soils and sediments.

Results

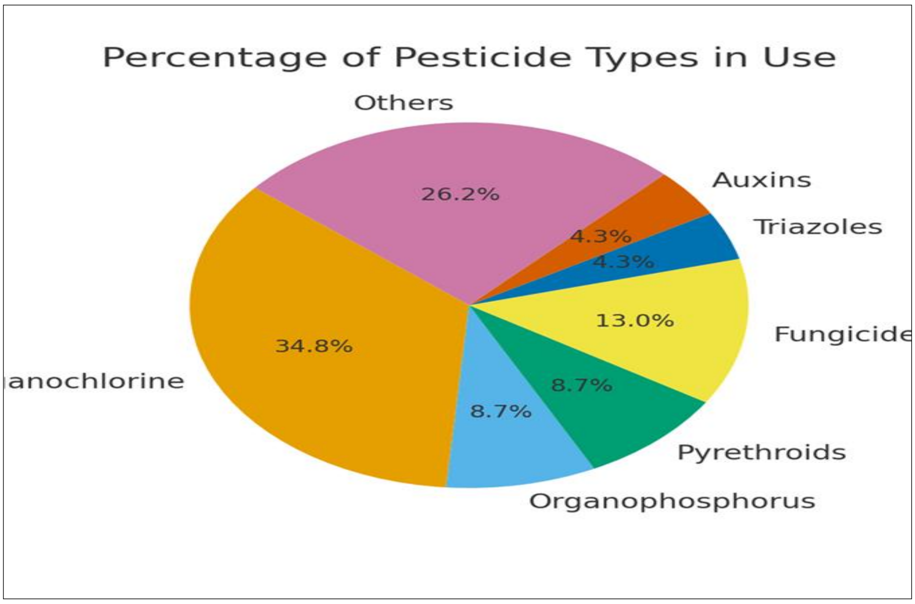

Fig 1: shows the distribution of pesticide types in the study area.

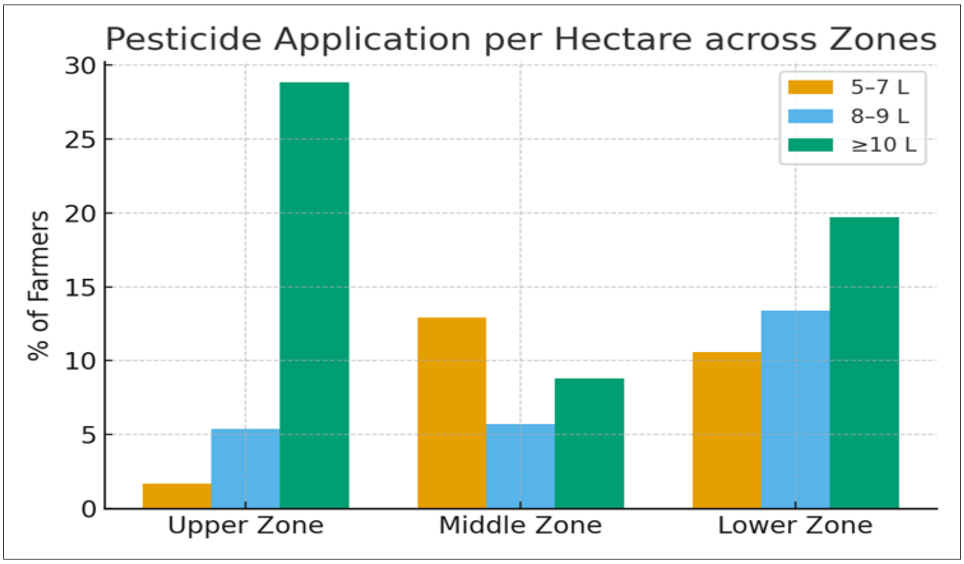

Fig 2: illustrates pesticide application levels across zones.

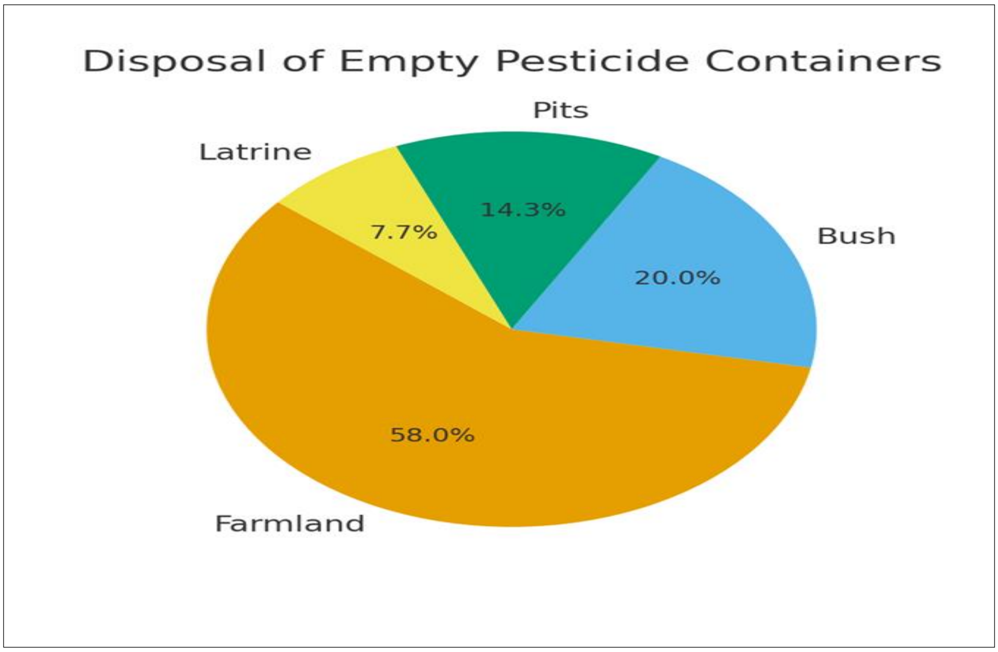

Fig 3: shows how empty pesticide containers are disposed of by farmers.

Discussion

The results confirm the widespread persistence of agrochemical residues in soil and water of the Kogi catchments. The dominance of organochlorine compounds illustrates the continued circulation of banned pesticides, reflecting poor regulatory enforcement. This aligns with global findings that OCPs persist long after use. High application rates of ≥10 L per hectare increase both cost and environmental risk. Disposal practices, with over half of farmers discarding containers on farmland, introduce plastics and residues into soils, compounding long-term degradation. Compared with Ghana and Uganda, Nigerian farmers show similar dependence on pesticides with little awareness of regulatory restrictions. The DPSIR framework demonstrates how farmer-driven intensification (Drivers) exerts Pressure through overuse, alters the State of water/soil, generates Impacts such as eutrophication and health effects, and calls for a Response via improved regulation and education.

Policy Implications

The findings highlight urgent needs: stronger enforcement of bans on OCPs, regulation of imports, and farmer education. NAFDAC and NESREA must strengthen monitoring. Adoption of integrated pest management and organic alternatives can reduce reliance on hazardous chemicals. Aligning policies with FAO and UNEP guidelines will support sustainable agriculture. Additionally, integrating GIS monitoring into water management will help track pollution hotspots in real time.

Conclusion

Agrochemical misuse in Kogi State leads to persistent residues, nutrient overloading, and socio-economic risks. GIS mapping confirmed localized hotspots linked to farming. The continued use of banned pesticides, unsafe disposal, and high application rates reflect weak regulation and poor awareness. Without urgent intervention, these practices will undermine ecosystem health, biodiversity, and food security.

Recommendations
1. Enforce pesticide bans and regulate imports.
2. Promote farmer education on safe handling and integrated pest management.
3. Subsidize organic inputs and alternatives.
4. Establish community-based monitoring committees.
5. Integrate GIS-based real-time monitoring into environmental management.
6. Strengthen farmer cooperatives for shared resources and sustainable practices.

References

1. Akinola O, Musa A, Bello T. Organochlorine pesticide residues and macroinvertebrate responses in Chanchaga River, Nigeria. Environmental Monitoring and Assessment,2023:195(4):321–335.
2. Bertrand M. Pesticide use and environmental health in developing countries. Journal of Environmental Studies,2019:45(3):201–215.
3. Chapman D, World Health Organization. Water quality assessments: A guide to the use of biota, sediments and water in environmental monitoring. 2nd ed. E & FN Spon, 1996.
4. Chatterjee S, Lataye D. Application of GIS in environmental pollution studies: A case study of water resources. Environmental Geoinformatics Journal,2020:12(2):87–95.
5. Knauer K. Eutrophication and its effects on aquatic ecosystems. In: Water Quality and Management. Springer, 2016, 87–101.
6. Leong L, Tan W, Yeo C. Agrochemicals: Impacts on human health and the environment. Annual Review of Environment and Resources,2020:45(1):345–367.
7. Machekano H, Sibanda T, Chitata T. Smallholder farmers and pesticide misuse: Evidence from rural Africa. African Journal of Agricultural Research,2019:14(5):217–227.
8. Mensah PK, Sraku-Lartey DB, Frimpong KO, Mensah CA. Agrochemicals and the environment in Ghana. Environmental Monitoring and Assessment,2014:186(10):6311–6320.
9. Nabulo G, *et al*. Pesticide contamination in vegetable-growing regions of Uganda. Journal of Environmental Science and Health,2022:57(3):211–223.
10. Ogedegbe O, Adeyemi A, Ibe C. Residual organochlorine pesticides in agricultural soils of Southern Nigeria. Environmental Science and Pollution Research,2024:31(7):2214–2230.
11. Okonkwo C, Edeh C, Akhigbe O. Occurrence and ecological risk assessment of organochlorine pesticides in farmland soils of Delta State, Nigeria. International Journal of Recent Research,2024:11(2):228–236.
12. Ogwueleka TC. Identification of pollution sources and water quality in Kaduna River, Niger State, Nigeria. Journal of Environmental Management,2014:98(1):45–51.
13. Sánchez-Bayo F, Tennekes HA. Impacts of systemic pesticides on biodiversity and ecosystem services. Environmental Science and Pollution Research,2017:24(1):1–21.
14. Adeshina F, Oladele A, Omotayo J. Pesticide handling and safety awareness among rural farmers in Nigeria. Nigerian Journal of Environmental Sciences,2019:13(2):89–101.