Current Situation of Pesticide Use and Its Impact on Aquatic Ecosystems and Fish Resources in West Africa: A Systematic Review

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***Abstract*—West Africa is a major consumer of pesticides used in agriculture, healthcare, and industry, raising growing concerns about freshwater ecosystem contamination. This review aims to (i) highlight research gaps regarding pesticide contamination in West African freshwater ecosystems to inform ecological risk assessment and environmental management, and (ii) summarize current knowledge on pesticide occurrence, affected fish species, and organ-specific impacts. A systematic search of Google Scholar, Web of Science, Scopus, Access to Global Online Research in Agriculture (AGORA), and PubMed identified 121 relevant studies, predominantly from Nigeria (37.2%), Benin (21.5%), and Ghana (19.8%). Organochlorine pesticides dominated reported contamination (51%), followed by organophosphates (9%) and pyrethroids (2%). Residue concentrations ranged from non-detectable to 80.1 µg/L in water and from non-detectable to 84.1 µg/g in fish tissues (Dry weight), frequently exceeding international Maximum Residue Limits. Bioaccumulation in liver, gills, and muscle was consistently associated with histopathological damage, raising concerns for aquatic biodiversity and food safety. Critical knowledge gaps include the near-total absence of studies from Sahelian river basins (the upper Niger, Senegal, and Volta rivers), the lack of long-term time-series data that prevents trend analysis, and the absence of harmonized biomarker protocols across studies, which limits cross-regional comparisons. Recommended actions include banning persistent organochlorine compounds still in use in violation of the Stockholm Convention, establishing a regional monitoring network under the Economic Community of West African States with standardized sampling and biomarker protocols, and prioritizing surveillance in rapidly expanding agricultural areas such as Burkina Faso, where pesticide imports have increased substantially in recent years.**

***Keywords*—persistent organic pollutants, pesticide contamination, freshwater fish, bioaccumulation, West Africa**

I. Introduction

Anthropogenic activities, such as agro-sylvo-pastoral practices and industrial development, have led to the release of pollutants that threaten both human health and the environment [1, 2]. Among these pollutants, pesticides are of particular concern due to their persistence, bioaccumulation, and documented toxicity to freshwater fish and other aquatic organisms [3]. Pesticides are widely recognized as some of the most harmful environmental contaminants [4].

Widely used in agriculture, pesticides increase crop yields by controlling insect pests, plant diseases, and weeds [5]. It has been estimated that pests and diseases are responsible for approximately 40% of annual global agricultural production losses [6]. Consequently, pesticides are often considered essential for safeguarding food production and ensuring economic benefits for farmers [7]. However, their extensive use also increases the risk of environmental contamination, particularly in aquatic ecosystems located downstream of agricultural areas [5].

Global pesticide use reached approximately 3.5 million tons of active compounds in 2021, corresponding to an average of 2.26 kg per hectare of agricultural land. In Africa, pesticide use accounted for 105,000 tons, and although this represents a smaller share of global use, application rates have increased sharply in several subregions relevant to West African freshwater ecosystems [8]. Reported residue concentrations in freshwater fish from these ecosystems range from 0.1 to 84 µg/g in liver, gills, and muscle, depending on the ecosystem and pesticide type [9]. These data highlight the growing concern about pesticide contamination in West African aquatic fauna. Pesticides are typically classified according to their primary function, including herbicides, fungicides, and insecticides [10]. Particular attention is warranted for persistent organic pesticides, which resist degradation and have been linked to long-term toxic effects in aquatic species and to bioaccumulation in food webs [10, 11].

In West Africa, pesticide use has increased substantially in recent decades, with the highest usage reported in Nigeria, Ghana, and Benin [12]. Previous studies have documented organochlorine contamination in several major West African water bodies, including the Ouémé River (Benin), the Niger River, Ivorian lagoons, and coastal waters of Ghana and Benin [1, 3, 9]. Organochlorines, organophosphates, and pyrethroids have been reported in fish tissues across these systems, with concentration ranges of 0.1 to 84.1 µg/g depending on the organ, species, and site [9, 13]. Nonetheless, studies have primarily focused on rivers, lakes, and aquaculture ponds in a few countries, whereas ecosystems in the Sahelian region remain largely under-represented. Although several studies have reported pesticide residues in freshwater fish across West Africa, the available data remain fragmented across countries, ecosystems, and fish species, limiting the possibility of obtaining a comprehensive regional overview [14].

Several important gaps persist in the West African literature [14, 15]. First, Sahelian river systems (e.g., upper Niger, Senegal, and Volta basins) are substantially under-represented. Second, long-term time series monitoring is nearly absent, preventing the assessment of temporal trends. Third, few studies employ standardized histopathological or biochemical biomarker protocols, limiting cross-study comparison. Fourth, sublethal endpoints such as reproductive toxicity, endocrine disruption, and behavioral changes have received little attention. Fifth, countries with rapidly increasing pesticide imports, such as Burkina Faso and Mali, remain among the least studied. This review differs from earlier regional assessments by providing an organ-specific synthesis of pesticide impacts across multiple compounds and sites, applying a Relative Frequency of Occurrence (RFO)-based mapping approach, and incorporating literature published up to 2024.

This review provides a comprehensive synthesis of the literature on pesticide contamination and its impacts on freshwater fish in West Africa. The objectives of this review are to: (i) highlight research gaps on pesticide contamination in West African freshwater ecosystems to support ecological risk assessment and environmental management; and (ii) summarize key knowledge on pesticide occurrence, affected fish species, and organ-specific impacts.

II. Methods of The Review

A. Study Area

West Africa was chosen as the study area to provide a better understanding of the issues that might arise from the use of pesticides and their effects on aquatic ecosystems. It is characterized by a high agricultural potential and diverse agro-pastoral practices, covering an area of approximately 5,112,903 km^2. It spans approximately 4° N to 22° N latitude and 17° W to 15° E longitude, with an estimated population of 456 million in 2024. Fig. 1 shows the geographical area.

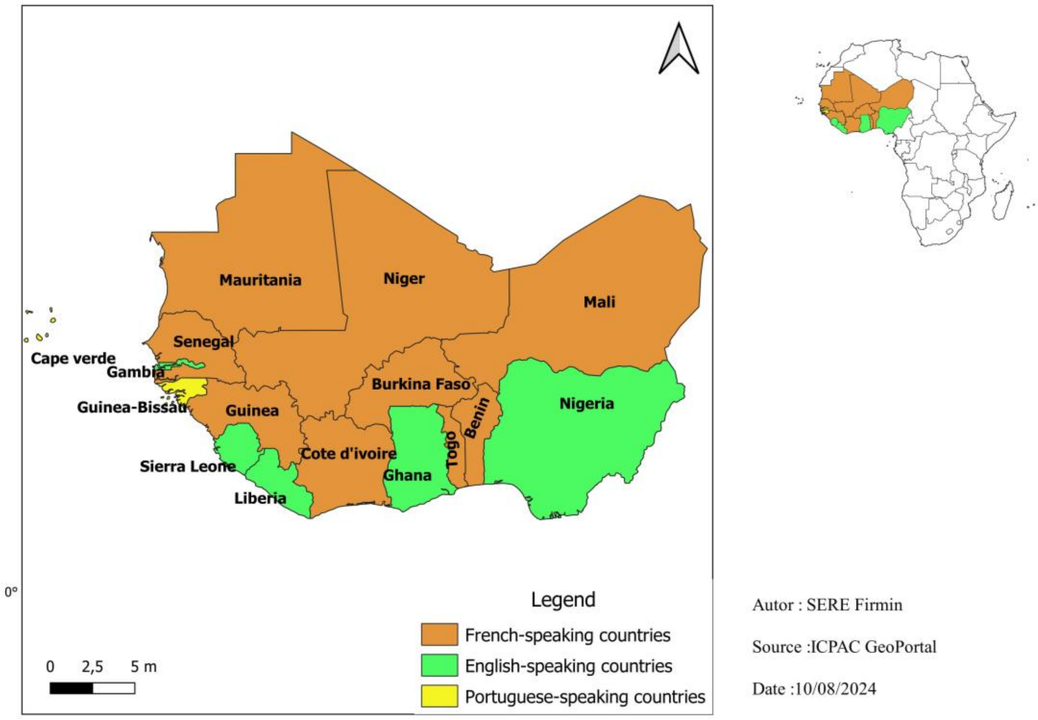

Fig. 1. Location of the study area.

B. Search Strategy

This study is a systematic review aimed at synthesizing published evidence on pesticide contamination in freshwater fish and ecosystems in West Africa. The literature search covered studies published between 1990 and 2024, the period when research on pesticide contamination in West Africa began [16], and searches were conducted from January 2025 to April 2025. Documentary sources included peer-reviewed articles, scientific study reports, theses, and dissertations written in English and French. Literature published in other languages was excluded; this is acknowledged as a limitation. Data were obtained from online databases including Google Scholar, PubMed, Web of Science, Scopus, and AGORA, selected to ensure comprehensive coverage of both peer-reviewed and grey literature relevant to freshwater ecosystems and pesticide contamination in West Africa. Both field and experimental studies were included. The document search was conducted using a combination of keywords related to the topic, study area, and period. Boolean operators and the following syntax were applied in both English and French: TS = ((“aquatic ecosystems” OR “aquatic organisms”) AND (“pesticides” OR “insecticides” OR “herbicides” OR “fungicides” OR “acaricides”) AND (“fish” OR “fishery resources”) AND (“West Africa” OR “Burkina Faso” OR “Togo” OR “Mali” OR “Niger” OR “Senegal” OR “Ivory Coast” OR “Mauritania” OR “Guinea” OR “Benin” OR “Nigeria” OR “Ghana” OR “Gambia” OR “Sierra Leone” OR “Liberia” OR “Cape Verde” OR “Guinea-Bissau”)). Exclusion criteria included non-West African studies, non-aquatic or estuarine/marine studies, studies without pesticide data, duplicates, and studies in languages other than English or French. Only studies meeting minimum methodological quality (clear identification of sampling and analytical methods) were included. The initial screening of titles and abstracts was performed independently by 2 reviewers. Discrepancies between reviewers were discussed and resolved through consensus. This procedure ensures objectivity and transparency in study selection. A total of 197 documents were initially identified. After removing 47 duplicates, 150 documents were screened based on titles and abstracts, with 11 excluded for being outside the scope. Full texts (*n* = 139) were assessed for eligibility, and 18 were further excluded for non-aquatic focus or absence of pesticide data, resulting in a final inclusion of 121 studies. A Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)-style flow diagram summarizing the selection process is provided in Fig. 2. This rigorous selection process ensures that only studies relevant to pesticide contamination in freshwater fish and ecosystems in West Africa were included.

Each downloaded document was carefully read and rigorously analyzed. The quality of each included document was evaluated using pre-defined criteria, and studies with serious methodological flaws were noted and considered in the interpretation of the results. No formal risk-of-bias scoring was applied; this review is therefore descriptive and semi-quantitative. No weighting by sample size, year, or exposure level was applied. This study employed a descriptive and semi-quantitative synthesis to summarize patterns of pesticide contamination across West African countries, freshwater ecosystems, and fish species. The analysis enabled identification of spatio-temporal trends in pesticide contamination and the recording of fish species and pesticide families. For each extracted variable, the Relative Frequency of Occurrence (RFO, expressed as %) was calculated using the formula [17]:

$$RFO(\%) = \left({}^{NO}/_{TP}\right) \times 100$$

where,

RFO: Relative Frequency of Occurrence (%),

NO: Number of occurrences of the variable shown in the figure (e.g., number of studies reporting a given pesticide family, a fish species, or a country)

TP: Total number of publications considered for that variable

RFO allows comparison across studies even when sample sizes and concentrations differ, making it suitable for this systematic review. All studies were considered equally, without weighting by year, sample size, or exposure level; the analysis is purely descriptive.

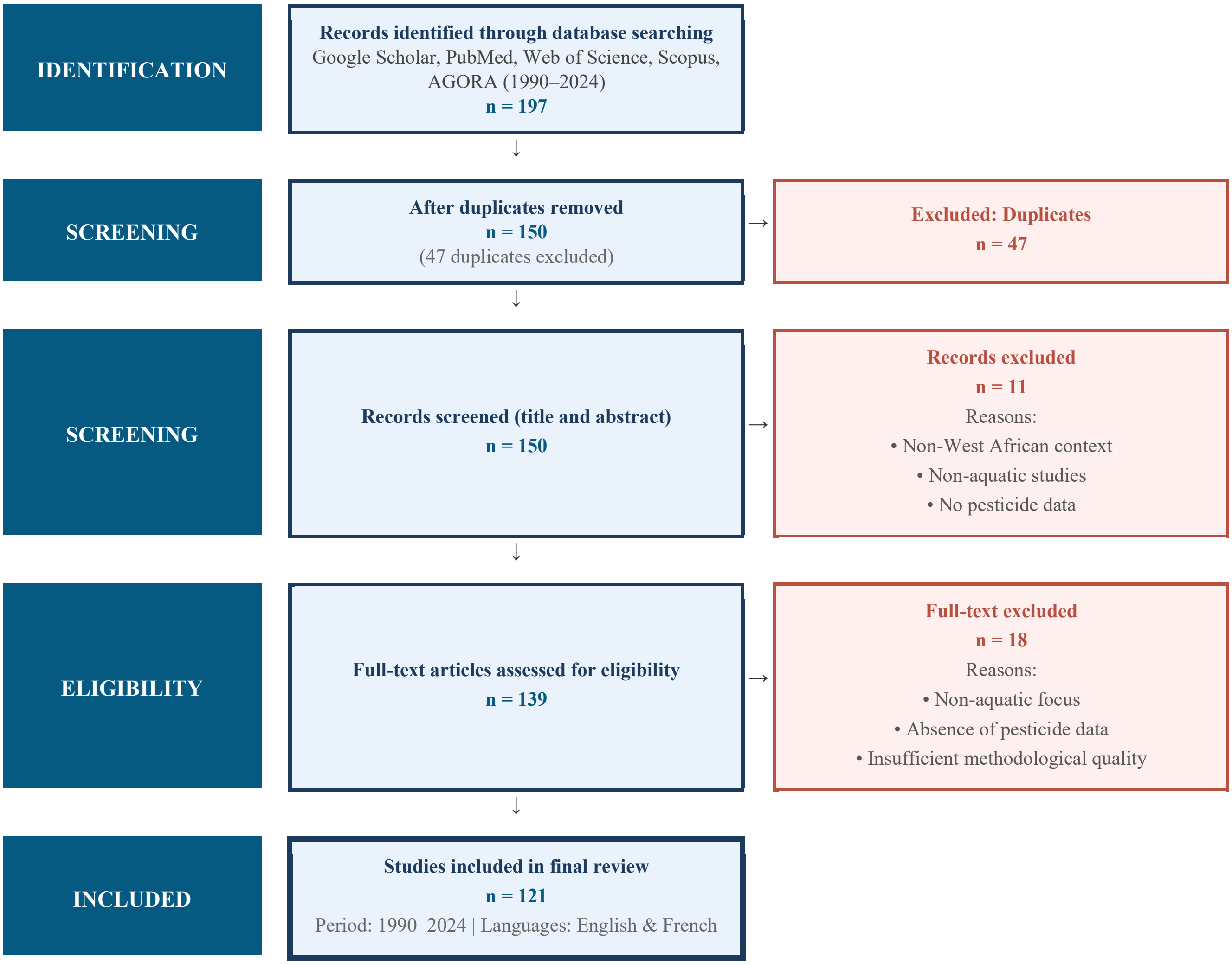

Fig. 2. PRISMA flow diagram of the literature selection and screening data analysis.

III. Results-Discussion

A. Pesticide Uses in West Africa

The use of pesticides in agriculture in West Africa accounts for only 2–4% of global consumption, but this can still exert significant local pressures on aquatic ecosystems, particularly in sensitive river basins [18, 19]. This low rate could be explained by the lack of agricultural modernization, poverty, and irregular rainy seasons [20]. Nonetheless, even at low usage, improper application can have environmental consequences [21]. In recent years, prices of generic herbicides have decreased, while rural wages have increased [22], making herbicide use increasingly economically attractive to farmers in Africa [23]. Studies in Mali have revealed that manual weeding costs could be reduced by 50% through herbicide application [23]. Pesticide imports in West Africa doubled over 5 years, rising from 218,948 tons in 2015 to 437,930 tons in 2020 (Fig. 3). In 2020, imports from Nigeria (69.45 million arable hectares) alone (147,446 tons) exceeded total imports from Southern Africa (87,403 tons) and North Africa (109,561 tons) [24]. Imported pesticides mainly include herbicides, insecticides, fungicides, and acaricides [25]. In Burkina Faso, the quantities of imported liquid pesticides increased from 222,156 liters to 3,133,289 liters between 2010 and 2016 [26]. Critically, high-import and high-use countries are also often those with the most documented evidence of pesticide contamination and environmental risk. For example, a global assessment found that 64 % of agricultural land in 168 countries is at risk of pesticide pollution, with high-risk regions including large pesticide users such as China, India, Australia, and Argentina [27].

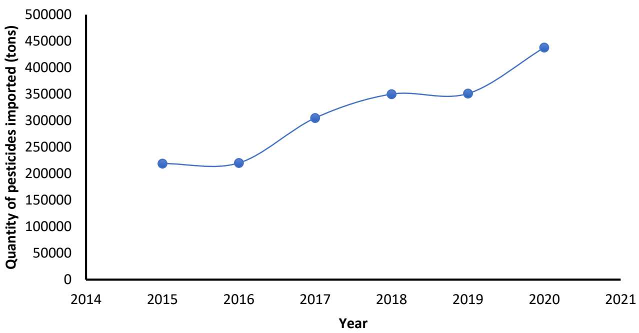

Fig. 3. Evolution of pesticide imports in West Africa. (Figure created by the authors using data from Ref. [24]).

B. Cultivated Area in West Africa

The largest areas are cultivated in Nigeria, Niger, and Côte d'Ivoire, with 44,636,246.3; 17,813,000; and 13,561,866.4 ha, respectively (Fig. 4). Nigeria is the largest producer in West Africa, which explains its position as the leading importer of pesticides [12]. Considering Nigeria's prominent role in both production and importation, as well as its high publication output on pesticide impacts, aquatic ecosystems in this country are likely exposed to higher levels of pesticide contamination [28, 29]. This exposure may have potential impacts on fish community structure and population health [30, 31]. Countries such as Niger and Côte d'Ivoire, despite large cultivated areas, show comparatively fewer studies on pesticide contamination, highlighting potential high-risk but data-poor regions [32]. This observation suggests that cultivated area and pesticide import volume alone do not fully predict research coverage or detected contamination, emphasizing the need for targeted monitoring in underrepresented countries [33].

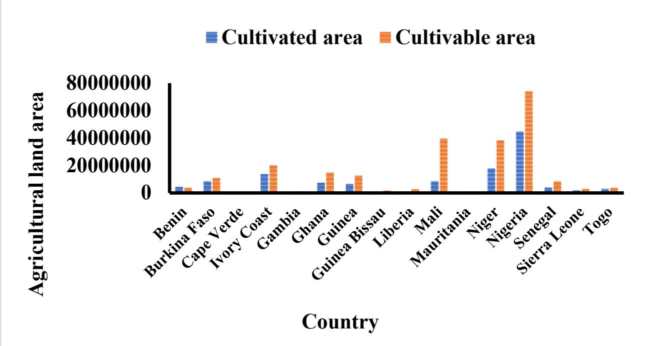

Fig. 4. Agricultural area in West Africa. (Figure created by the authors using data from Ref. [7].)

C. Mapping Pesticides Co-Contamination

At the global level, several regions are already recognized as hotspots of co-contamination in aquatic ecosystems. Well-documented examples include the Huang He Basin in China, the Indus in India, the Paraná in Argentina, the Orange River in South Africa, the Murray in Australia, and some parts of Latin America such as Mexico and Ecuador [27]. These areas are typically associated with intensive agriculture and heavy pesticide use [34]. In Africa, most global assessments mainly emphasize Southern Africa, especially the Orange Basin [27]. By contrast, West Africa is largely absent from these maps, not due to lower contamination risks but because comprehensive data remain limited, as noted in the methodology section [27]. Despite this, the widespread use of pesticides in West African agriculture, particularly in rice fields, vegetable production, cotton, and export crops like cocoa and coffee, indicates that aquatic ecosystems are likely under significant chemical stress. Evidence of contamination has already been reported in rivers such as the Niger, Ivorian lagoons, and coastal waters of Ghana and Benin [35, 36]. These aquatic systems can thus be considered regional hotspots based on the 121 studies included in this review [27].

Analysis of the 121 publications shows that research has concentrated on specific systems, including the Niger River, the Volta River, Ivorian lagoon systems, and coastal waters in Ghana and Benin [32, 37]. Other water bodies remain underrepresented, highlighting spatial gaps in the evidence. Research intensity varies with national research capacity, pesticide import volumes, and donor-funded projects [20]. Countries such as Nigeria, Benin, and Ghana contributed the most to publications (37.2% (45), 21.5% (26), and 19.8% (24)), whereas Cape Verde, Guinea Bissau, Equatorial Guinea, Liberia, Gambia, and Burkina Faso remain data-poor despite significant agricultural activity, identifying high-risk but understudied regions (Fig. 5).

Temporal analysis indicates studies began in 1996 and increased from 2008 (3.4%) to 2015 (12.4%), with most publications (60.33%) appearing over the last 10 years (2014–2024) (Fig. 6). Peaks in 2003, 2015, and 2022 partly mirror increases in pesticide imports, particularly in Nigeria between 2015–2020. Comparing import trends, cultivated area, and publication frequency highlights significant mismatches, distinguishing overstudied countries (e.g., Nigeria) from data-poor but potentially high-risk countries (e.g., Niger, Côte d'Ivoire, Burkina Faso) [14, 38] (Fig. 5).

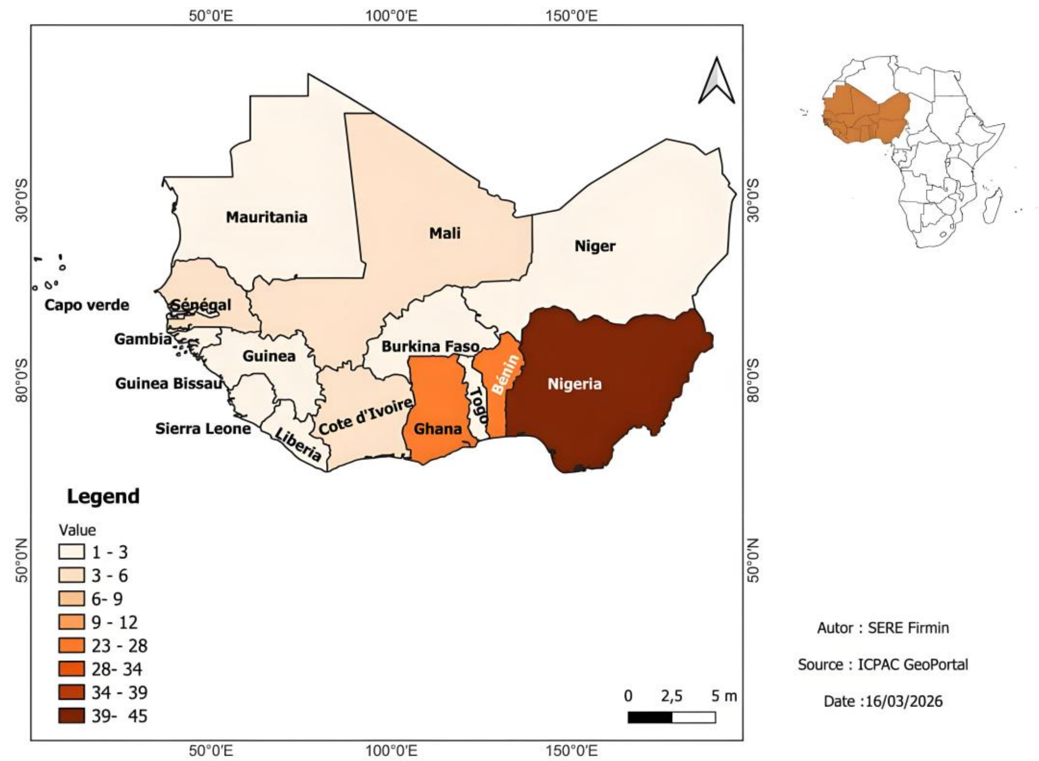

Fig. 5. Scientific publications on pesticides by country.

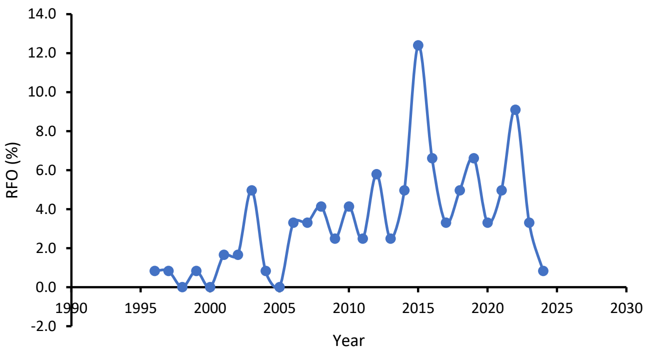

Fig. 6. Evolution of relative frequency of occurrence (RFO) of scientific publications on pesticides in relation to fish from 1990 to 2024 in West Africa.

These discrepancies suggest that countries with expanding agricultural activities and increasing pesticide inputs may experience substantial pressure on aquatic ecosystems, despite limited scientific attention. In such contexts, the lack of monitoring data may mask ongoing pesticide contamination and associated risks to freshwater biodiversity, particularly fish communities. Overall, these observations highlight that research on pesticide impacts in West Africa is unevenly distributed. Despite these gaps, analyzing the chemical composition of the pesticides most frequently studied is essential for understanding their ecological and health impacts.

D. Persistent Organic Pesticides

Since the advent of pesticide use in West Africa, several studies have investigated their chemical composition. The most frequently detected pesticide families in West Africa are organochlorines, organophosphates, and pyrethroids, with proportions of 51%, 9%, and 2%, respectively (Fig. 7).

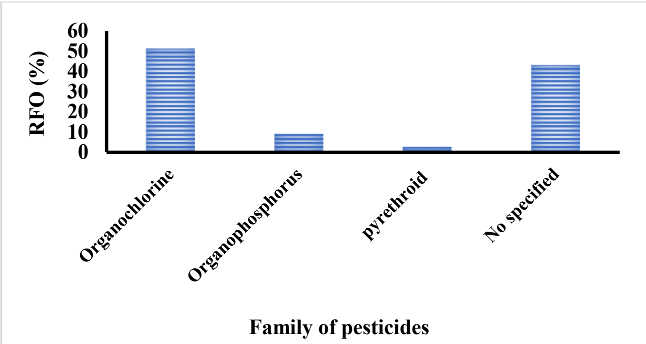

Fig. 7. Relative frequency of occurrence (RFO) of scientific publications according to pesticide families in West Africa.

This highlights the dominance of older-generation pesticides and their potential long-term effects on aquatic ecosystems [39]. It is important to distinguish between legacy contamination (residues from historical applications) and ongoing illegal or unregulated use of banned organochlorines. Evidence from post-2010 studies confirms that both mechanisms contribute to current environmental contamination, with dichlorodiphenyltrichloroethane (DDT) and endosulfan detected at levels exceeding World Health Organization/Food and Agriculture Organization (WHO/FAO) safety thresholds [40]. Organochlorines, also known as "first-generation pesticides", have dominated the agricultural market for decades, explaining their widespread detection in West Africa and worldwide [41]. Their use began in the 1940s with DDT spraying and increased in the 1960s. Most organochlorines detected are classified as Persistent

Organic Pollutants (POPs), which persist in soil and water, bioaccumulate in fish, and pose ecological and human health risks. For example, concentrations measured in freshwater fish include DDT, dieldrin, and endosulfan, sometimes exceeding recommended safety limits [42, 43]. Other POPs such as lindane and hexachlorobenzene (HCB) have also been detected in water, sediments, and fish in Niger, Ghana, and Benin (Table 1). These findings indicate that some POPs continue to persist in the environment either due to legacy residues or continued illegal use.

Synthetic organic pesticides are the most widely used, and the best-known chemical groups are organochlorines, organophosphates, carbamates, and synthetic pyrethroids [3, 46]. Pesticide choice depends on crop type: cotton uses mainly insecticides, cereals use herbicides, and vegetables often combine insecticides and fungicides, resulting in distinct pesticide mixtures entering freshwater systems [47]. Notably, organochlorines such as DDT, lindane, and endosulfan have been widely applied in West Africa, despite their ban under the Stockholm Convention [48], and post-2010 studies confirm their continued detection in aquatic ecosystems.

Table 1. Persistent organic pesticides detected in West African aquatic ecosystems

POP	Formula	Site (West Africa)	Concentration Range	WHO/FAO Guideline	Exceeds	Reference
DDT	$C_{14}H_9Cl_5$	Ouémé R. (Benin), Niger R. (Nigeria)	0–1364 µg/g lipid (fish); ND–1.61 µg/L (water)	0.001–0.01 µg/g (fish)	Frequently	[1]
Dieldrin	$C_{12}H_8Cl_6O$	Ouémé R. (Benin)	0–1364 µg/g lipid (fish)	0.001 µg/g (fish)	Yes (some sites)	[1]
Endosulfan	$C_9H_6Cl_6O_3S$	Ouémé R. (Benin), BF sites	ND–3.08 µg/L (water)	0.001–0.01 µg/L	Yes	[44]
Lindane (HCH)	$C_6H_6Cl_6$	Tono Res. (Ghana), BF	ND–0.39 µg/L (water); ND–8.34 µg/g (fish)	0.001–0.01 µg/g	Yes (some sites)	[45]

BF = Burkina Faso; ND = Not Detected; HCB = Hexachlorobenzene; HCH = Hexachlorocyclohexane. Concentration comparisons based on Codex Alimentarius/EU MRL standards and WHO drinking-water guidelines.

E. Impacts of Pesticides on Aquatic Ecosystems

Water pollution by pesticides alters aquatic environments, potentially affecting fish and other biotic communities [49]. Although concentrations vary, measured pesticide levels in West African freshwater systems can reach up to 80.1 µg/L (Table 2), sometimes exceeding ecological guideline values, indicating potential risks for aquatic life [2]. It is important to distinguish between evidence of association and established causal relationships. Observations of declining fish diversity coinciding with pesticide contamination suggest an association rather than a proven causal effect [50]. Multiple environmental factors, including overfishing, eutrophication, and habitat alteration, likely contribute simultaneously [51]. Nevertheless, experimental and mechanistic studies confirm that certain pesticides impair fish physiology, including growth, reproduction, and immune responses, at concentrations measured in West African freshwater systems [45, 52]. These studies provide toxicological evidence supporting causal effects at the individual level.

Table 2. Assessment of pesticide residues in aquatic ecosystems

Pesticide Family	Residues in Water (µg/L)	Exceeds Ecological Threshold (WHO/FAO)	Reference
Organochlorines, organophosphorus	ND–0.359	No	[53]
Organochlorines, organophosphorus	ND–1.502	Borderline	[4]
Organochlorine	ND–3.08	Yes (DDT)	[44]
Organochlorine	ND–1.61	Yes (DDT)	[54]
Organochlorines, organophosphorus	0.01–0.39	Borderline	[45]
Organochlorine	ND–60.18	Yes	[55]
Organochlorines, organophosphorus, carbamate	ND–80.1	Yes	[9]
Organochlorines, organophosphorus	0.025–23.4	Yes	[56]

ND: Not Detected. Ecological thresholds based on EU Environmental Quality Standards and WHO Drinking Water Guidelines

F. Impact of Pesticides on Fish

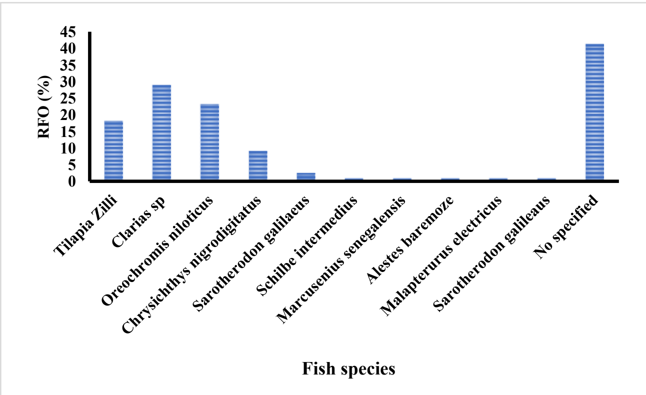

Fig. 8. Relative frequency of occurrence (RFO) of publications on pesticides according to fish species in West Africa.

In West Africa, the impact of pesticides has been studied for several species (Fig. 8). The most studied species were *Clarias sp*. (28%), *Oreochromis niloticus* (23%), Tilapia zillii (18%), and *Chrysichthys nigrodigitatus* (9%). These species are of particular economic, ecological, and scientific importance as primary sources of animal protein across the region [45, 57]. Predatory fish bioaccumulate persistent organic pesticides through trophic chains; the degree of bioaccumulation depends on feeding habits and the physicochemical properties of the compounds, with bioconcentration factors particularly high for lipophilic organochlorines [58, 59].

1) Impact on the liver

The liver, as the main detoxification organ, shows the highest pesticide accumulation [60]. Maximum Residue Limits (MRLs) referred to in this section are food safety standards for human consumption, based on Codex Alimentarius and EU standards (0.001–0.01 µg/g for most organochlorines) [61]. Organochlorines are most frequently detected (Table 3) and cause hepatocyte degeneration, necrosis, vacuolization, and sinusoidal dilation. The highest liver concentrations have been consistently reported in Nigerian and Beninese populations of Clarias gariepinus and Oreochromis niloticus, reaching up to 62 µg/g, which far exceed Maximum Residue Limits [4, 62]. These hepatic lesions directly reduce detoxification capacity, impair metabolic functions, and ultimately decrease fish survival and reproductive success [63, 64].

2) Impact on gills

Gills are directly exposed to contaminated water, leading to accumulation of organochlorines and organophosphates [65, 66]. Among the organs studied, gills show the broadest range of detected concentrations (non-detectable to 49 µg/g), with MRL exceedances most severe in Nigerian and Beninese studies (Table 4). Elevated residues correlate with epithelial lifting, haemorrhage, and lamellar degeneration, impairing respiration, ion regulation, and overall physiological performance [67]. These gill lesions directly reduce respiratory efficiency, limit oxygen uptake, and exacerbate physiological stress responses [67]. Gills therefore serve as sensitive biomarkers for monitoring pesticide pollution, although the adoption of standardized protocols remains inconsistent across reviewed studies, representing a key methodological gap [68].

3) Impact on muscles

Muscle tissue is the main edible portion; pesticide accumulation poses food safety risks [71]. Muscle tissue shows the highest maximum concentrations among the three organs (up to 84.1 µg/g), carrying the most direct implications for human food safety (Table 5). MRL exceedances are most frequent with organochlorine and organophosphorus compounds in fish (Table 5). Pesticide accumulation can alter nutritional quality and weaken immune function [72].

4) Synthesis of pesticide impacts

A synthesis of the 3 organ-specific analyses reveals a consistent pattern: organochlorine compounds dominate across all organs and countries, with the most frequent and severe MRL exceedances recorded in liver and muscle from Nigerian and Beninese fish populations [4, 57]. The liver shows the highest accumulation, reflecting its central detoxification role; gills show the broadest concentration range due to direct waterborne exposure; muscle carries the most critical food safety implications [68]. Table 6 cross-tabulates main pesticide families, the most affected organs, typical histopathological lesions, and functional consequences.

Table 3. Assessments of pesticide residues in fish liver

Species	Pesticide Family	Residues in Liver (µg/g)	MRL (µg/g)	Reference
Tilapia zillii, Clarias anguillaris, Heterotis niloticus, Oreochromis niloticus	Organochlorines, organophosphorus	1.56–**8.34**	0.001–0.01	[57]
Clarias gariepinus, Oreochromis niloticus	Organochlorines, organophosphorus	ND–**62**	0.001–0.01	[62]
Tilapia guineensis, Clarias gariepinus	Organochlorine	ND–**11.68**	0.001–0.01	[4]
Oreochromis niloticus	Organochlorine	ND–0.3348	0.001–0.01	[44]

MRL: Maximum Residue Limit (Codex Alimentarius/EU food safety standards). ND: Not Detected. Values in bold exceed MRL.

Table 4. Assessments of pesticide residues in fish gills

Species	Pesticide Family	Residues in Gills (µg/g)	MRL (µg/g)	Reference
Tilapia zillii, Clarias anguillaris, Heterotis niloticus, Oreochromis niloticus	Organochlorines, organophosphorus	1.56–**8.34**	0.001–0.01	[57]
Clarias gariepinus, Oreochromis niloticus	Organochlorines, organophosphorus	ND–**11.68**	0.001–0.01	[62]
Tilapia zillii, Chrysichthys nigrodigitatus	Organochlorine	0.004–0.038	0.001–0.01	[69]
Mugil cephalus, Pomadasys commersonnii	Organochlorine	ND–**2.429**	0.001–0.01	[70]
Oreochromis niloticus	Organochlorine	ND–**49.00**	0.001–0.01	[44]

MRL: Maximum Residue Limit. ND: Not Detected. Values in bold exceed MRL.

Table 5. Assessments of pesticide residues in fish muscle

Species	Pesticide family	Residues in Muscle (µg/g)	MRL (µg/g)	Reference
Tilapia zillii, Clarias anguillaris, Heterotis niloticus, Oreochromis niloticus	Organochlorines, organophosphorus	1.0–**3.73**	0.001–0.01	[58]
Clarias gariepinus, Oreochromis niloticus	Organochlorines, organophosphorus	ND–**19**	0.001–0.01	[59]
Oreochromis niloticus	Organochlorine	ND–0.055	0.001–0.01	[45]
Tilapia zillii, Clarias lazera	Organochlorine	0.001–0.064	0.001–0.01	[47]
Clarias gariepinus, Oreochromis niloticus, Tilapia zillii	Organochlorines, organophosphorus, carbamates	ND–**84.1**	0.001–0.01	[13]

MRL: Maximum Residue Limit. ND: Not Detected. Values in bold exceed MRL.

Table 6. Summary of organ-specific pesticide impacts on freshwater fish

Pesticide Family	Most Affected Organs	Typical Histopathological Lesions	Functional Consequences
Organochlorines	Liver, gills, muscle	Hepatocyte degeneration, necrosis, vacuolization, sinusoidal dilation, epithelial lifting	Reduced detoxification, metabolic disruption, impaired respiration, food safety risks [68 ,73]
Organophosphates	Gills, liver	Haemorrhage, cellular degeneration, oedema, epithelial lifting	Impaired respiration, physiological stress, reduced growth and survival [74]
Carbamates	Liver, gills	Cellular degeneration, tissue inflammation	Metabolic disturbances, reduced detoxification efficiency [75]
Pyrethroids	Gills	Lamellar damage, epithelial hyperplasia, haemorrhage	Reduced oxygen uptake, respiratory dysfunction [76]

IV. Conclusion

The synthesis of available studies indicates that organochlorine pesticides dominate contamination in West African freshwater fish, with frequent exceedances of Maximum Residue Limits (MRLs) in liver, gills, and muscle tissues. Reported concentrations vary substantially across species and basins, reaching up to 62 µg/g in liver and 84.1 µg/g in muscle, suggesting significant bioaccumulation and potential biomagnification within aquatic food webs, with implications for ecosystem and human health.

Despite the extensive dataset reviewed, several limitations should be acknowledged. Research coverage across West Africa is uneven, with most studies concentrated in Nigeria, Benin, and Ghana, leaving countries such as Burkina Faso, Mali, and Niger insufficiently represented despite their potential risk. Temporal monitoring remains limited, as few longitudinal studies are available to assess trends in pesticide accumulation and ecosystem impacts over time. Methodological variability, including differences in sampling strategies, analytical detection limits, and the inconsistent use of histopathological or biomarker protocols, reduces comparability among studies. The search was restricted to English and French literature, potentially missing relevant studies in other languages such as Portuguese, which is relevant for countries like Guinea-Bissau and Cape Verde. No formal risk-of-bias assessment was applied to the included studies, and variability in methodological rigour may affect the reliability of reported concentration data. Finally, although associations between pesticide contamination and fish health are evident, establishing causal relationships remains challenging due to the influence of multiple interacting stressors.

To address these limitations, it is recommended to strengthen regional monitoring networks, particularly within ECOWAS, to improve coverage of underrepresented areas and harmonize data collection. Standardization of analytical and biological assessment protocols should be promoted to enhance comparability across studies. Furthermore, the development of long-term monitoring programs is essential to better understand temporal trends and ecosystem responses. Finally, reinforcing regulations on persistent pesticides and adopting integrated multi-stressor approaches will improve ecological risk assessment and management in West African aquatic systems

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Firmin Sere: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Visualization, Writing–Original Draft, Writing–Review and Editing. Inoussa Compaore: Conceptualization, Methodology, Data Curation, Formal Analysis, Visualization, Writing–Original Draft, Writing–Review and Editing. Sylvain Ilboudo: Conceptualization, Methodology, Writing–Review and Editing. Aurelie Goutte: Conceptualization, Methodology, Writing–Review and Editing. Hassan Bismark Nacro: Conceptualization, Methodology, Writing–Review and Editing. Salam Sawadogo: Methodology, Writing–Review and Editing. Frederic S. Bere: Methodology, Writing–Review and Editing. All authors had approved the final version.

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