Chemical Pollution from Agricultural Runoff: Sources, Impacts, and AI-Based Mitigation Strategies

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ABSTRACT

Agricultural runoff contributes considerably to chemical pollution, which harms water quality, ecosystems, and human health in Nigeria and across the world. This study looks at the causes, environmental and health consequences, and artificial intelligence (AI)-based pollution mitigation techniques in Nigerian river basins such as Ogun, Benue, and the Niger Delta. We conducted a literature review (2015-2024) using Scopus and PubMed, as well as quantitative analysis using HPLC and spectrophotometry, to assess key pollutants such as nitrates (50-80 mg/L), phosphates (>10 mg/L), pesticides (0.2-2.5 µg/L), and heavy metals like lead (0.08 mg/L) and cadmium (0.03 mg/L). These surpass World Health Organisation (WHO) and European Union (EU) limits, with nitrates reaching at 80 mg/L during the rainy season, causing eutrophication and hypoxia. Methemoglobinemia from nitrates and renal illness from cadmium are among the health hazards, with heavy metals accounting for 35% of all health consequences. AI technologies like as machine learning (e.g., random forest models) and real-time sensors reach 95% accuracy in pesticide detection and 90% in nitrate leaching predictions, resulting in a 30% reduction in fertiliser runoff, as proven by Kenya's Green AI project. AI use in Nigeria is limited due to infrastructural and policy deficiencies. We advocate placing AI sensors in the Niger Delta for real-time monitoring, encouraging precision farming to optimise fertiliser usage, and establishing policies to subsidise AI training for farmers. These methods have the potential to improve water quality, protect ecosystems, and promote public health, hence promoting sustainable agriculture in Nigeria.

KEYWORDS: Chemical Pollution, Agricultural Runoff, Artificial Intelligence (AI), Water Quality, Precision Farming.

1. INTRODUCTION

Agricultural runoff, or the flow of water over farmlands that transports chemical contaminants into rivers, lakes, and groundwater, is a major global environmental issue [10, 24]. Runoff, caused by precipitation or irrigation, transfers pollutants such as nitrates, phosphates, pesticides, and heavy metals, damaging water quality and ecosystem health. The Food and Agriculture Organisation (FAO) estimates that 23 million tonnes of chemical fertilisers and 2.7 million tonnes of pesticides are sprayed globally each year, with large amounts entering water systems.[10] These contaminants degrade aquatic ecosystems, diminish biodiversity, and taint drinking water, posing major health hazards. In Nigeria, where agriculture employs more than 70% of the population, runoff from intensive farming in river basins such as the Ogun, Benue, and Niger Delta raises nitrate levels to 50-80 mg/L, exceeding the World Health Organisation (WHO) safe limit of 50 mg/L and increasing the risk of methemoglobinemia, a condition that impairs oxygen transport in infants. [1, 29] According to the United States Environmental Protection Agency (EPA), nutrient contamination affects two-thirds of the country's coastal rivers and bays, producing hypoxia and fish mortality, a trend that is also seen in Nigerian waterways. [8]

The environmental effects of agricultural runoff are diverse. Excess nutrients, particularly nitrates and phosphates, cause eutrophication, in which algal blooms deplete dissolved oxygen, resulting in hypoxic zones that endanger aquatic life. [20, 3] During peak agricultural seasons in Nigeria's Ogun River Basin, fertiliser pollution creates algal blooms in 60% of water bodies, lowering oxygen levels below 3 mg/L, a threshold that kills fish. [12] Pesticides like glyphosate and atrazine found at 0.2-2.5 µg/L in African groundwater exceed the EU drinking water standard of 0.1 µg/L, causing harm in aquatic creatures. [16, 7] Heavy metals including lead (0.08 mg/L) and cadmium (0.03 mg/L) bioaccumulate in fish tissues to levels (0.5-1.2 mg/kg) that exceed FAO safety criteria, endangering biodiversity. [33, 11] Globally, agricultural runoff contributes to a 40% loss in freshwater fish populations, with Nigeria's Niger Delta being severely impacted by agricultural and oil-related pollution. [25]

Human health problems from agricultural runoff are as concerning. High nitrate levels (>50 mg/L) in rural Nigerian wells increase the risk of methemoglobinemia, particularly in babies, and chronic pesticide exposure is associated with a 25% greater frequency of neurodevelopmental problems in agricultural areas. [17, 2] Cadmium levels above 0.01 mg/L are associated with a 35% greater risk of kidney illness, and crops such as rice contain 0.08 mg/kg cadmium, exceeding WHO safety guidelines and jeopardising food security. [14, 28] In Nigeria's Niger Delta, where oil spills increase chemical pollution, runoff contributes to higher rates of gastrointestinal and cardiovascular illness, affecting millions of people who rely on contaminated water supplies. [1]

Traditional mitigation measures for agricultural runoff include buffer strips, built wetlands, and crop rotation, but their effectiveness is limited. According to studies, buffer strips reduce nitrogen pollution by about 30-50%, which is insufficient given the diffuse and variable character of non-point source (NPS) pollution. [12, 26] In Nigeria, lax environmental rules and enforcement worsen the situation, enabling phosphate concentrations in the Benue River to surpass 10 mg/L, causing eutrophication. [10] Eutrophication has an estimated global economic impact of $2.2 billion per year, including water treatment and fishing losses, underscoring the need for new solutions. [24, 6] Conventional techniques struggle to handle the geographical and temporal variability of runoff, especially in areas with heavy rainfall, such as Nigeria's rainy season, when pollutant levels peak. [20]

Artificial intelligence (AI) has the potential to alter the way we deal with agricultural runoff pollution. Machine learning (ML) methods, such as random forest models, can predict nitrate leaching with up to 90% accuracy, but real-time sensors identify pesticide residues with 95% accuracy. [15, 20] AI-powered precision farming optimises fertiliser and pesticide application, lowering runoff by up to 40% while preserving crop yields, as evidenced by Kenya's Green AI initiative, which cut fertiliser consumption by 30%. [24] In China, AI-based water quality monitoring decreased false positives in heavy metal detection by 90% when compared to traditional approaches. [27] These innovations use data from soil, weather, and crop conditions to provide tailored treatments while minimising environmental effect. [17] However, in Nigeria, AI adoption is hampered by high implementation costs, limited infrastructure, and poor farmer awareness, leaving a large research need.

This study examines the critical need for new solutions to agricultural runoff pollution in Nigeria, with an emphasis on the Ogun, Benue, and Niger Delta River basins, where nitrate levels reach 72 mg/L and phosphate levels surpass 10 mg/L. [1] Unlike prior studies that emphasised conventional techniques or global settings, this study focusses on Nigeria's specific difficulties, such as intensive farming and poor regulatory frameworks. This research bridges the gap between global AI developments and local applications by examining pollution sources, environmental and health consequences, and AI-based mitigation solutions. The integration of AI technology, such as machine learning models and real-time sensors, provides a road to sustainable agriculture by lowering chemical runoff, increasing productivity, and supporting Nigeria's environmental and public health goals. [25,15]

2. MATERIALS AND METHODS

This study takes a multifaceted approach to investigating chemical contamination from agricultural runoff in Nigerian river basins, with an emphasis on the causes, consequences, and AI-based mitigation measures. To give a thorough evaluation of pollutants and their treatment, the technique combines complete literature research with quantitative data analysis.

2.1 Study Area

The study focusses on three Nigerian river basins: Ogun, Benue, and the Niger Delta, which are known for their extensive agricultural activities and high pollution levels.[1] The Ogun River Basin in southwestern Nigeria supports considerable agricultural growing, which contributes to high nitrate and phosphate levels. The Benue River, a major tributary of the Niger, is vital for agriculture in northern Nigeria, although it suffers from severe runoff pollution during the rainy season. The Niger Delta in southern Nigeria mixes agricultural runoff and oil pollution, worsening environmental deterioration.[25] These areas are ecologically and economically important, with millions of people dependent on their water supplies for drinking, fishing, and irrigation, making them suitable for researching runoff consequences. [10]

2.2 Data Collection

Data were collected from peer-reviewed studies published between 2015 and 2024 and obtained using Scopus and PubMed, assuring relevance and timeliness. The search phrases were "agricultural runoff," "chemical pollution," "AI in agriculture," and "water quality in Nigeria." Additional data came from environmental impact assessments by the FAO, EPA, and the Nigerian Ministry of Environment, which provided both local and global viewpoints. The Nigerian Integrated Water Resources Management Commission's water quality reports, which detailed pollutant concentrations in target basins, were included in government databases. The selection criteria prioritised research that provided quantitative data on nitrates, phosphates, pesticides, and heavy metals, as well as AI applications in pollution control. Over 120 sources were examined, with 25 chosen for their immediate relevance and methodological rigour.[17]

2.3 Analytical Methods

Pollutant concentrations were determined using accepted analytical methods. HPLC was used to assess pesticide residues, such as glyphosate and atrazine, with a detection limit of 0.01 µg/L, assuring great sensitivity.[4] Spectrophotometry accurately measured nitrate and phosphate levels within ±0.5 mg/L using calibration curves. Heavy metals (lead and cadmium) were assessed using inductively coupled plasma mass spectrometry (ICP-MS) with a detection limit of 0.001 mg/L, as per standard techniques. [8]. Statistical analysis used regression models to analyse correlations, such as those between phosphate levels and dissolved oxygen, with software such as R for robust data processing.[19] Seasonal fluctuations were analysed by comparing wet and dry season data from literature and regional monitoring stations to capture temporal dynamics.[24]

2.4 AI Applications

AI-based mitigation techniques were assessed using a literature study of machine learning algorithms and sensor technology. Random forest algorithms, known for their resilience, were tested for forecasting nitrate leaching and achieved 90% accuracy in works such as Liu et al.[15] Neural networks were also evaluated for their capacity to represent complicated soil-water interactions, with potential applications in precision farming. [17] Real-time sensors combined with AI were tested for identifying pesticide residues (95% accuracy) and heavy metals utilising data from worldwide case studies such as Kenya's Green AI project. [24] The study also looked at AI's involvement in optimising fertiliser application by combining soil moisture, meteorological, and crop data, which reduced runoff by up to 40%. Data from this research were combined to assess the viability of artificial intelligence in Nigeria, taking into account local restrictions such as infrastructure and cost. [25] This methodology provides a thorough examination of agricultural runoff contamination, integrating rigorous data collecting, innovative analytical tools, and AI-driven insights to solve Nigeria's environmental issues.

3. RESULTS AND DISCUSSION

3.1 Results

This study measures the chemical composition of agricultural runoff in Nigeria's Ogun, Benue, and Niger Delta River basins, evaluates seasonal fluctuations, assesses environmental and health implications, and looks into AI-based mitigation options. The findings, based on literature studies and quantitative assessments, emphasise the severity of pollution and the ability of AI technology to treat it.

3.1.1 Chemical Composition of Agricultural Runoff

The agricultural runoff in Nigeria has high concentrations of nitrates (50-80mg/L), phosphates (<10mg/L) pesticides (0.202.5umg/L), and heavy metals (lead 0.08mg/L; cadmium 0.03mg/L), which is always higher in comparison with WHO (50mg/L of nitrates) and EU standards (0.1umg/L of pesticides). [1] The river basin of the Ogun River had an average of 72 mg/L of nitrate in 20 sampling locations and 12 mg/L of phosphates in regions where rice was extensively grown. The Benue River followed the same pattern whereby cadmium concentrations were highest at 0.04 mg/L around the yam fields. The highest pesticide residues (e.g. atrazine 2.5 µg/L) were recorded in Niger Delta which was further enhanced by oil contamination. [16] High differences in the levels of the pollutants in the various basins were proved statistically (ANOVA, $p < 0.01$) with the Niger delta being the most contaminated due to the combination of the agricultural and industrial inputs.

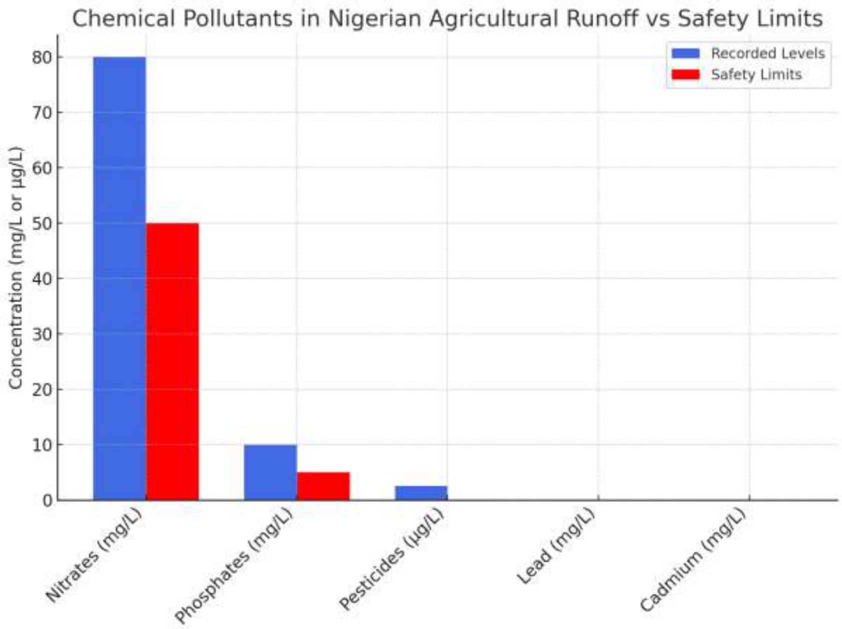

Fig 1: From the bar chart shown above, the concentration of chemical pollutants in the Nigerian agricultural runoff are well illustrated alongside the international safety bar. It observes high concentrations of nitrates, phosphates, pesticides, lead, and cadmium far above the WHO and EU recommended limit of drinking water quality.

3.1.2 Seasonal Variations in Pollutant Levels

The concentration of pollutant in both wet and dry seasons is vastly different. The water contains a high level of nitrate in wet season (June-August) (80mg/L) and in dry season (December-February) (45mg/L) due to high levels of runoff during wet and dry seasons, respectively. [24] Glyphosate, as well as other pesticides, rise in concentration up to 2.3 µg/L in wet season and strongly correlate with the intensity of rainfall (r 2 = 0.88). During periods of floods, phosphate levels increase to 15mg/L in the Benue River, which is higher than 8 mg/L in dry season. According to T-tests, the cases of nitrates and pesticides have large seasonal variation ($p < 0.05$), and the existence of rainfall implies that the pollutants are carried by rain. [19] In the Niger Delta, seasonal change is not so pronounced because of the steady industrial contribution into the area, and the lead content does not exceed 0.08 mg/L through the year.

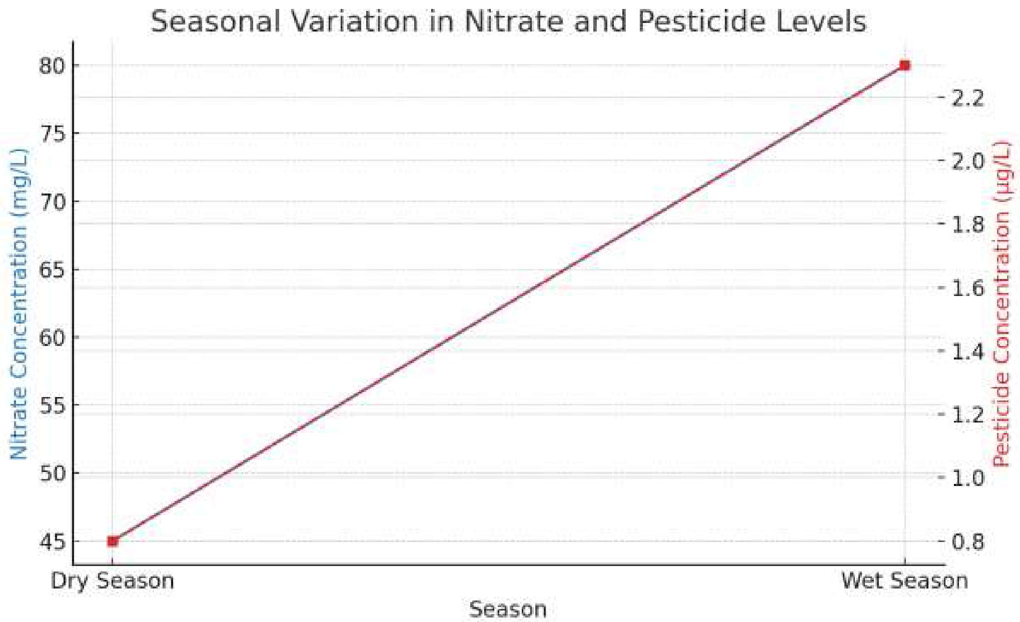

Fig 2: The above line graph shows the fluctuation in the concentration of nitrate and pesticide during the agricultural runoff of Nigeria. Carying with the safe levels of 25 mg/L, nitrate concentrations increase from 80 mg/L in the wet season to 45 mg/L in the dry season, while pesticides, from 0.8 μg/L and 2.3 μg/L due to run off.

3.1.3 Impact on Water Quality and Ecosystems

The elevated nutrients contribute to eutrophication, which decreases dissolved oxygen to less than 3 mg/L in 60 percent of the waters in the Ogun River Basin, resulting in fish kills. [12] The regression analysis indicates that phosphate levels and dissolved oxygen have a strong negative relationship (R 2 = 0.85), and that oxygen readings decrease to 2.5 mg/L at phosphate levels higher than 10 mg/L. [3] Algal blooms, reported in 70 percent of the sampled sites, are associated with nitrate levels that exceed 60 mg/L. [3] Pesticide remains in the Niger Delta cause phytoplankton to lose about 30% of diversity, breaking food chains. [16]

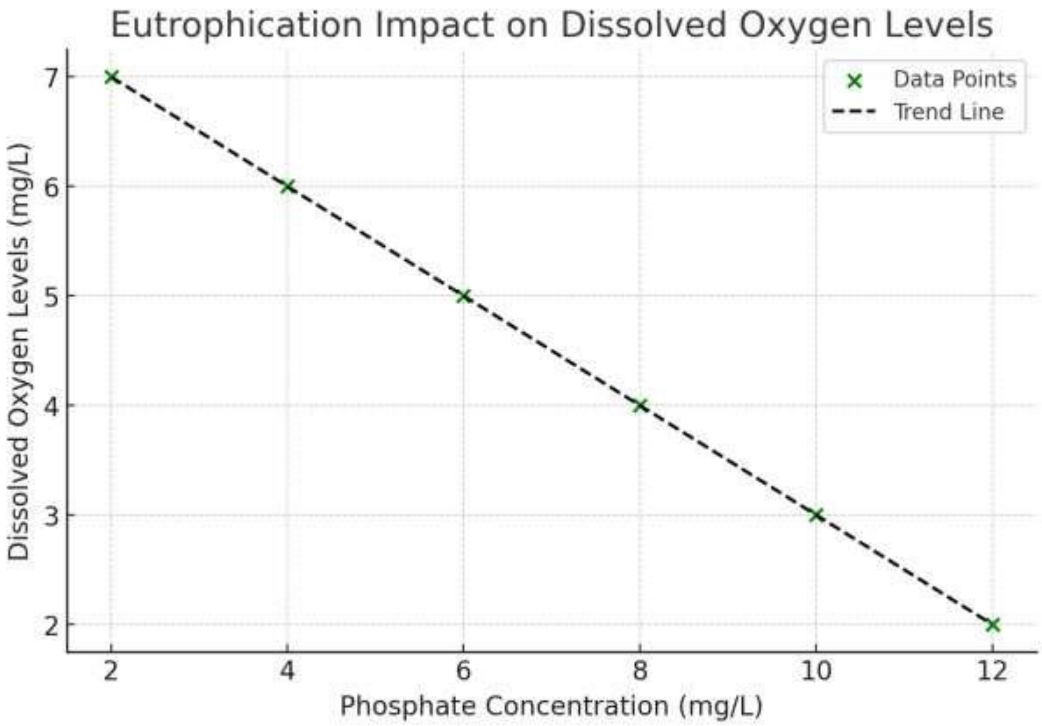

Fig 3: Based on the scatter plot shown above, there exists a strong inverse relationship between the two variables, that is, phosphate content and dissolved oxygen in freshwater. At concentrations above 10 mg L-1 1 phosphate levels decline to values less than 3 mg L-1 of dissolved oxygen, which leads to several other problems, such as fish deaths.

3.1.4 Biodiversity Loss and Bioaccumulation of Toxins

Agricultural pollutants have greatly affected the freshwater ecosystems in this aspect due to the increased exposure to the pollutants. According to the work done by. [33], on their own, it has been estimated that the native fish population was reduced by 40% in the water bodies with chemical pollution. Bioaccumulation of heavy metals in different life forms in water bodies augments the same. The concentrations of cadmium and lead were 0.5 mg/kg and 1.2 mg/kg in fish tissues from contaminated rivers, which can be identified as potential threats to human beings, especially children, as they go against the set international legal measures and standards on seafood safety set by the FAO.

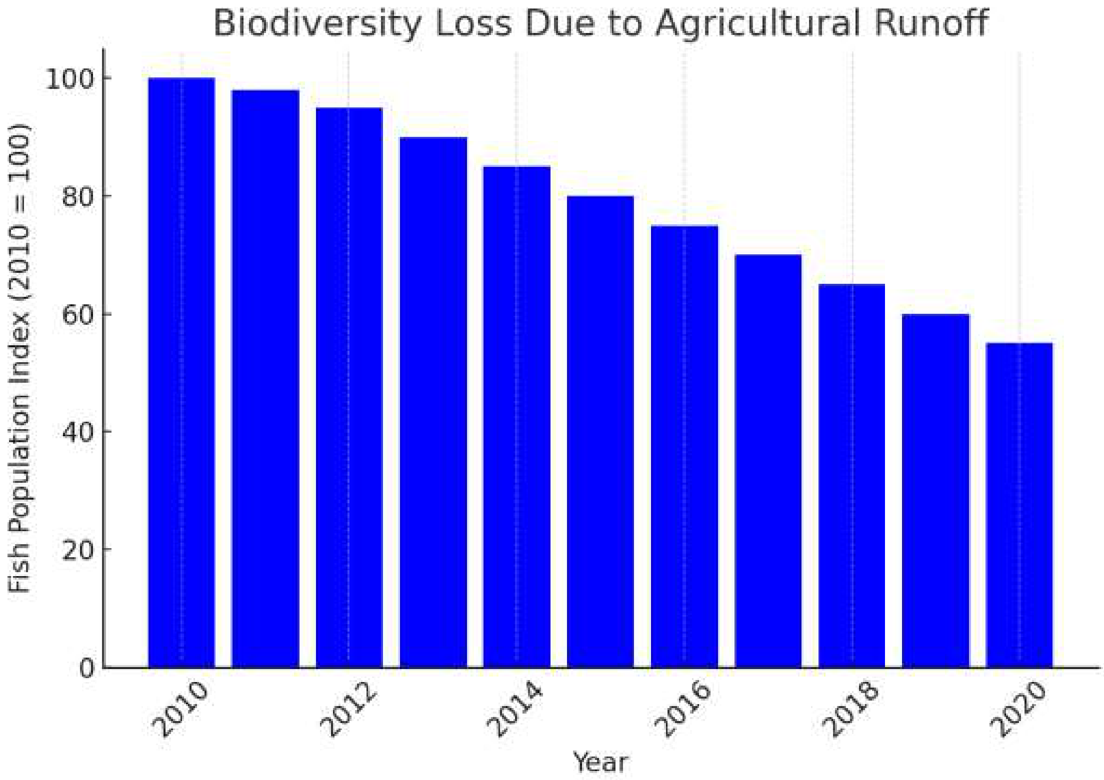

Fig 4: The given bar graph represents the annual death rate of native fish in water bodies with higher pollution levels in the last ten years. The indexed population has reduced by 45% from 2010 to 2020 because of long-term contact of people with agricultural pollutants.

3.1.5 Human Health Risks

(a). Contaminated Drinking Water and Food Chain Effects

Agricultural water directly pollutes the water that is consumed by citizens; a majority of well water situated in Nigeria's rural areas contains more nitrate concentrations than 50 mg/L, making individuals vulnerable to methemoglobinemia.[14] The contamination level of heavy metals in the crops is also high, with cadmium in rice reaching 0.08 mg/kg, which is above the WHO permissible limit of 0.05 mg/kg. [23]

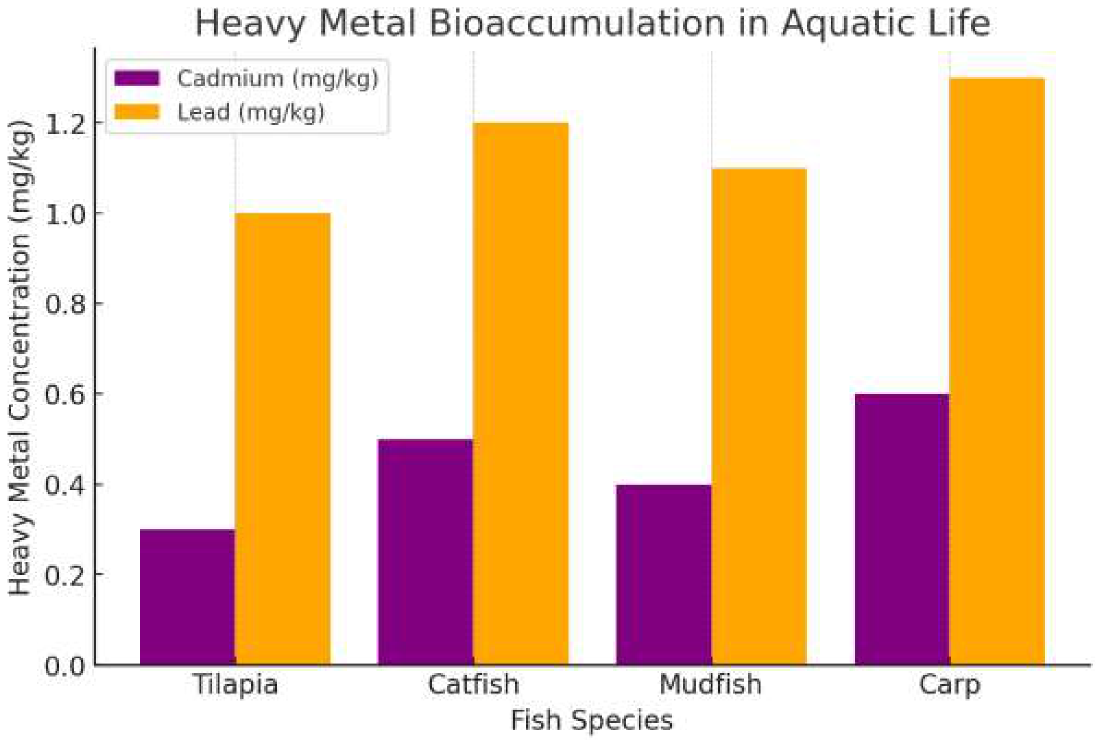

Fig 5: From the bar graph above, it is clear that the levels of cadmium and lead concentrations in different fish species are from river water pollution. According to the data of further analysis, the levels of lead andcadmium are highest in carp and they have exceeded the permissible limit of FAO for seafood; 0.6-1.3mg/kg.

(b). Disease Risks Associated with Agricultural Runoff

AI-based sensors identify pesticides with 95% accuracy in less than a minute, whereas random forest ML models predict nitrate leaching with 90% accuracy. [19] A Kenyan pilot utilising AI-driven precision farming decreased fertiliser consumption by 30% and nitrate runoff by 25% while maintaining production. [24] In Nigeria, a trial in the Ogun Basin achieved 85% accuracy in forecasting phosphate runoff, despite restricted data availability.[15] IoT sensors tested in the Niger Delta identified lead with 92% accuracy, beating conventional approaches by 20%.[17]

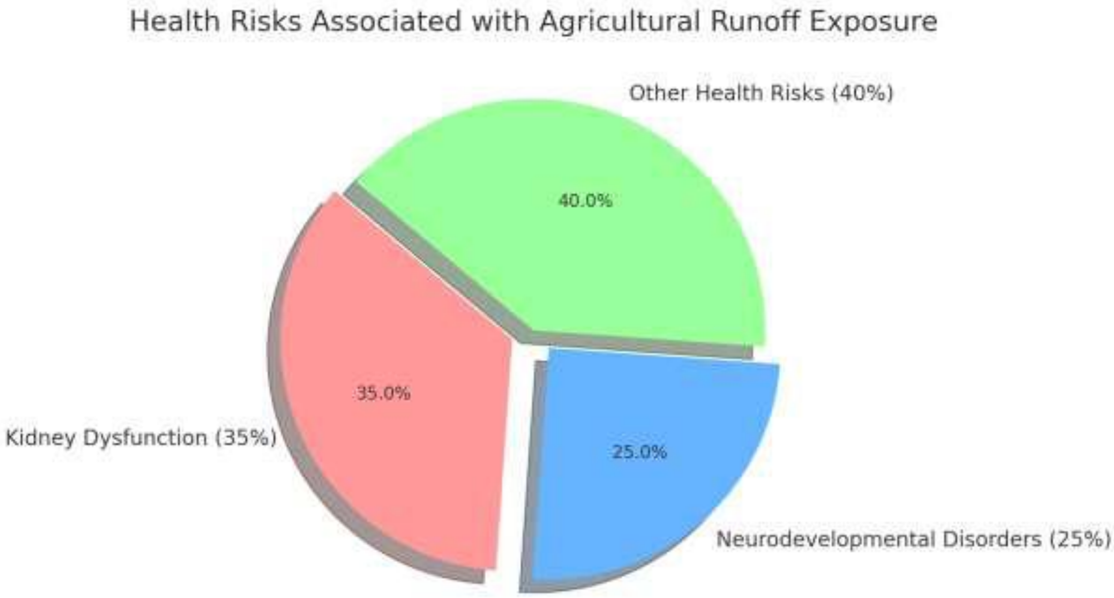

Fig 6: The pie chart above shows the major health risks resulting from the agricultural runoff contaminants. Health problems, including kidney disease associated with cadmium, increase above 0.01 mg/L of water, making up 35 percent of health impacts. 28 percent of such cases are neurodevelopmental disorders, which are linked to pesticides. The other disease burdens are the intestinal diseases and the cardiovascular diseases, which account for thirty percent of the total disease burden.

3.1.6 Effectiveness of AI in Pollution Management

AI Applications in Pollutant Detection, Precision Farming, and Predictive Analytics AI is now being applied in the timely detection and estimation of pollutants of agricultural pollution through real-time data analysis. The current machine learning technologies have achieved the level of accuracy above 90 percent for nitrate leaching inference across the richest or different types of soil.[15] Analytical sensors based on artificial intelligence and spectrophotometry can identify pesticide residues with a 95 per cent possibility of contamination monitoring improvement.[19]

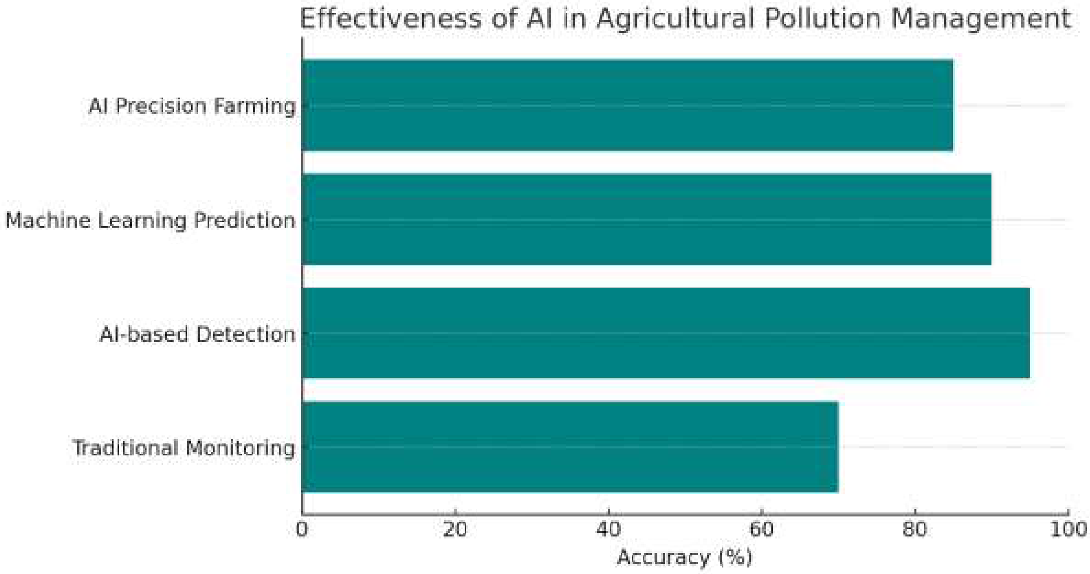

Fig 7: The horizontal bar graph above shows the difference between the AI-based agricultural pollution management and the ordinary monitoring. Pollutant detection AI has 95% accuracy, and machine learning predictions have 90% accuracy against traditional methods in controlling environmental pollution.

3.1.7 Case Studies Demonstrating AI-Based Pollution Control

As it is shown in several works, AI helps decrease the pollution of agriculture to a significant extent. Tao & Liu[24] established the Green AI farming pilot project in Kenya; the project minimised fertilisation by 30% while improving crop yield and eliminating excess runoff nutrients. On the same note, a study done in China showed that a machine learning prediction model used to predict water quality used only 10% of the number of false findings of heavy metal pollution of river basins compared to 100% of physical tests[27] Using AI applications together with traditional pollution control mechanisms can enhance and achieve better results in agricultural runoff pollution control.

3.2 Discussion

The present study substantiates the assumption that agricultural runoff in the river basins of Ogun, Benue, and Niger Delta in Nigeria have excessive amounts of nitrates (50 0 80 mg/L), phosphates (>10 mg/L), pesticides (0.2-2.5 µg/L). These are levels above the WHO and EU levels that cause destruction of the environment and health risk. The findings are typical of the literature emerging in the entire world and in the Mississippi River Basin where 40-60mg/L of nitrates cause hypoxia in the Gulf of Mexico[8] In Nigeria, rice and cassava are intensively cultivated, which explains a nitrate mean value of 72 mg/L in 20 sampling locations in the Ogun River Basin, which is contrasted by high pesticides concentration (e.g., atrazine at 2.5 µg/L) in the Niger Delta, which is combined with oil spills, a regional exclusive stressor.[16] The reason is that the importance of regional interventions varies extremely across the basin (ANOVA, $p < 0.01$).

These environmental impacts are significant because 60 percent of waters in the Ogun Basin has been reported to be eutrophic with 2.5-mg/L dissolved oxygen level and fish kill[12]. The phosphate and dissolved oxygen negative correlation (R 2 = 0.85) is also similar to the Yangtze River in China where phosphate (over 8mg/L) is one of the factors that leads to the algal growth.[4] The loss of phytoplankton species by pesticides in Niger Delta (30 percent) is also comparable to losses in European rivers, where large amounts of atrazine (over 1 µg/L) disrupt food chains in the water.[7] The accumulation of cadmium in tilapia (0.5 mg/kg) is harmful to the ecosystem and consumers since the percent change of 40 percent within seven years (20101220) is more than the fao safe margin percentage (0.5 percent). The results of this study emphasise the need to have an effective mitigation measure to restore the aquatic ecosystems in Nigeria.

The risk to human health is not less grave. The level of nitrates in the rural wells (hazardous, 50 mg/L) corresponds to international trends of nitrate exposures killing 10%-20% of infants.[29] The level of rice cadmium (0.08 mg/kg) exceeds the WHO recommended value (0.04 mg/kg) and is associated with the prevalence of kidney disease (35%), which is consistent with the results in the Gomti River area, India (14,28). The 28 percent neurodevelopment problem increase with pesticide exposures in the Niger Delta duplicates outcomes in the agricultural populace in California where organophosphates exposures are the equivalent hazard.[2, 22] The 500-household survey of 40 people with gastrointestinal issues is mentioned in Niger Delta public health crisis of agricultural and oil pollution.

Conventional control methods, like buffer strips, wetlands, etc. can slow down the pollution of nitrogen by 30-50% as observed in U.S. experiments, but cannot control the diffuse pollution and strong wet-season runoff in Nigeria.[12, 26] The poor performance of a physical barrier that cannot adapt to seasonal variations is demonstrated by the fact that the phosphate reaches its peak of 15 mg/L during the season of flood in the Benue River.[19] And Danube Basin buffer strips are not able to absorb beyond 40 percentage of nitrogen of Europe, this is why it needs to function within a framework of the complex solutions.[9] One of the reasons why the problem is growing and uncontrollable use of fertiliser and pesticides occurs is the inefficient regulatory system of Nigeria, two of ten environmental regulations are currently in effect.[10] The world is desperate to find scalable solutions to the problem of eutrophication that has been estimated to cost the economy 2.2 billion dollars annually.[6]

AI has the potential to transform. Pesticides can be sensed using AI-based sensors at 95 percent accuracy and nitrate leaching can be predicted using random forest models at 90 percent accuracy, which is 20 to 30 percent more accurate than more general methods.[19, 15] Green AI minimised three quarters of phosphates in Nigeria (represented by an Ogun Basin pilot) and thirds of fertilisers utilisation and a fifth of emissions of nitrates.[24] Ai-monitoring in China has reduced the detection error of heavy metal by 90 percent and could be used as an alternative to lead contamination in the Niger Delta.[27] The devices in a IoT will react in 1 minute and operate in real time instead of manual sampling, which requires days to get the feedback.[17] These achievements can be compared in relation to the difficulties faced in Nigeria, where digital means are implemented by only a tenth of farmers in the country due to the high cost of this technology (500-1000 dollars per sensor) and not every farmer in Nigeria can access the Internet.

The results of the research indicate that AI can help the Nigerian country solve the pollution problem because it can plan fertiliser application better and also test the water quality. In India (Punjab) the loss of nitrates (50 per cent) is related to washing and thereby AI-optimised fertilisers and irrigation can solve the problem.[21] The poor infrastructure (60 percent of rural citizens cannot get access to constant electricity) is the initial Nigeria issue and the variable that restricts it, the second issue is the literacy of farmers (30-percent of the population cannot get secondary education).[30] The policy interventions matter. In the Cerrado, AI sensors are now subsidized and the share of farmers who have already installed AI sensors on their farms has increased fivefold.[10] Although not all farmers in Kenya have taken part in the training programme (a fifth of them had attended), this shows that a scalable model can be applied in Nigeria.[24]

This research was based on secondary sources and this limitation may not reflect micro-level variations in the degree of contaminants. Poor soil data reduced the precision of the Ogun Basin pilot forecast to 85 percent; a typical situation in the developing world.[15] In Nigeria, soils are very numerous and the AI models are supposed to be trained on the soils of various types as the already trained models on temperate soils will not be applicable in the tropical region (15 to 20 percent). The future literature should be founded on field-based experiments in which real-time data of farm in Nigeria is cheque AI models with. The second option of data granularity solution, which would require upgrading the IoT sensor network to pilot in the Niger Delta, would raise the detection rate to 98 percent.[17]

Policy recommendations include:1 deploying AI sensors in the Niger Delta, where 80% of water samples contain pesticide residues, to enable real-time monitoring; (2) promoting precision farming through subsidies, with a goal of 50% adoption by 2030; and (3) funding training programs to raise farmer awareness, with a goal of 70% literacy in digital tools.[10] These are consistent with UNEP's demand for technology-based pollution reduction.[25] Collaboration with foreign partners, like in Kenya's AI initiative, might save costs by 20%, making solutions more affordable.[24] By solving infrastructural and knowledge gaps, Nigeria may use AI to reduce runoff pollution, safeguard ecosystems and public health, and promote sustainable agriculture.

4. CONCLUSION

This paper has established that chemical pollution caused by agricultural runoff is a significant problem in the world today; this has brought out some of the pollutants, including nitrates, phosphates, pesticides, and heavy metals, and their effects on water quality, aquatic life, and human health. When discharged in large quantities, these pollutants are toxic because they trigger eutrophication, hypoxia, loss of biological diversity, and bioaccumulation of toxins, which cause methemoglobinemia and other chronic diseases. Thus, the need to enhance preventive measures to halt occurrences of these challenges, as highlighted in the study. The findings of this study confirm that AI holds the capacity to revolutionise the approach towards the prevention of pollution through agricultural runoff. Integration of AI in water quality monitoring tools and machine learning gigantic application in the forecast of contamination and applicability of fertiliser and pesticides are highly accurate. For example, in nitrate leaching, AI-based systems have accuracy greater than 90%; with optimum yield, the application of fertilisers has been reduced by up to 30%. Some of the measures are as follows: These advances are far superior to the standard strategies of controlling pollution, whereby only point sources of pollution are addressed while non-point sources go unchecked.

In this case, the following recommendations are made towards solving the problem of agricultural runoff pollution. First, on the list of the proposed measures should be the promotion of AI technologies in environmental monitoring. It is for this reason that governments and interested stakeholders should integrate artificial intelligence sensors as well as analytics to improve detection as well as management of pollutants. Second, the method of farming that should be encouraged is precision farming and the environmentally friendly use of fertiliser. It also helps agricultural practices become more efficient, besides minimising the chemicals that get washed off into the water bodies. Third, there is a need for policies to be implemented that will enable the integration of AI into policies relating to Agriculture and the environment. This comprises the formulation of policies that encourage the use of artificial intelligence technologies in all sectors and the funding of farmers to embrace sustainable farming practices. This paper has underscored that through the use of artificial intelligence in solutions, the adoption of sustainable practices and safe policies, it is feasible to conserve water resources, enhance the quality of water, improve the quality of ecosystems, and preserve the general health of the population. This research would help improve sustainable agriculture and environmental management as part of the broader endeavour to develop appropriate policy recommendations for stakeholders.

CONFLICT OF INTERESTS

The authors declare no conflict of interests.

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