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The Impact of Agricultural Activities and Wastewater Discharge From Ogbujiriekwe Stream Nimo on Water Suitability For Domestic and Agricultural Purposes

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Abstract

Water quality at the surface of small tropical streams is extremely vulnerable to diffuse runoff from agriculture and untreated household wastewater. Over six months, this research assessed the physico-chemical quality of Ogbujiriekwe Stream in Nimo, Anambra State, Nigeria, at four sampling stations (rainy season: June–August 2025; dry season: November 2025–January 2026). The parameters examined comprised pH, electrical conductivity (EC), total dissolved solids (TDS), nitrate-nitrogen (NO_3-N), phosphate-phosphorus (PO_4-P), sulphate, carbonate, bicarbonate, chloride, major cations (Ca^{2+}, Mg^{2+}, Na^+, K^+), boron, and ammonium-nitrogen (NH_4-N). The Weighted Arithmetic Water Quality Index (WQI) was calculated, and the findings were compared against WHO guidelines. Mean NH_4-N levels (2.6–4.6 mg L^{-1}) persistently surpassed the WHO threshold of 1.5 mg L^{-1}, and potassium was likewise elevated, pointing to inputs from agricultural fertilizers and organic waste. Every other major ion stayed within acceptable limits. WQI values spanned 132.9–159.2 (rainy season) to 173.4–244.6 (dry season), rating the water as "unsuitable for human consumption" at all stations and in both seasons.

Keywords: Wastewater, Agricultural activities, Ogbujiriekwe stream, Sampling points.

Introduction

Agricultural land use modifies the natural landscape and can seriously compromise the biological integrity of rivers and streams by transferring nutrients, sediments, and pesticides into waterways through runoff, infiltration, and erosion. For example, agricultural runoff has been found to be the primary cause of water quality degradation in rivers and streams in the United States. This is primarily because livestock manure, pesticides, and large amounts of nitrogen and phosphorus fertilizers enter water bodies through runoff pathways. Aquatic life and water usefulness may suffer as a result of eutrophication, toxic algal blooms, and decreased dissolved oxygen levels (U.S. EPA, 2016). The effects of agricultural activities on water quality have been demonstrated worldwide in a variety of river basins. A thorough examination highlights how agricultural practices are important diffuse sources of pesticides, phosphates, and nitrates that degrade surface and groundwater quality,

endangering ecosystem services and water supply. Increased farming techniques and the unchecked use of chemical inputs are linked to these toxins, particularly in areas with lax or non-existent regulatory frameworks and monitoring systems (Gavrilaş et al., 2025).

A major source of pollutant loads in rivers, aside from agricultural sources, is wastewater discharge from both municipal and industrial sources. Organic debris, fertilizers, pathogens, and chemical contaminants are directly introduced into watercourses by untreated or inadequately treated effluents, changing the physico-chemical conditions downstream of discharge stations. Wastewater imports can increase turbidity, biochemical oxygen demand (BOD), and microbiological contamination like E. coli, making water unfit for human consumption without adequate treatment, according to studies conducted in a variety of settings, including impoverished nations. For instance, studies of Nigerian abattoir effluents along the River Benue showed elevated bacterial populations and physico-chemical characteristics that were beyond suggested limits downstream of effluent discharge locations (Omoni et al., 2022).

Particular studies conducted in Nigeria support the connection between human activity and the deterioration of river water quality. An evaluation of the Asa River in Ilorin, Kwara State, found that human activity had a major impact on the water quality of the river, with downstream sites exhibiting higher concentrations of contaminants than upstream locations, making the water less suitable for intended uses (Solihu et al., 2022). The fragility of riverine ecosystems where farming is common is highlighted by research on the Ofu River in Kogi State, which revealed that agricultural growth and related activities contributed to nutrient and sediment influxes that degrade water quality (Daniel et al., 2023).

The Ogbujiriekwe stream in Nimo is becoming more and more vulnerable to human pressures due to growing agricultural activity along its banks and the discharge of untreated or improperly managed domestic wastewater from neighbouring communities. Conditions for nutrient and sediment flow into the stream are created by farming practices such fertilizer application, soil disturbance, and cultivation near the river channel, especially during rainstorm events. At the same time, residential effluents are being dumped directly into the stream due to the lack of organized wastewater collection and treatment infrastructure. Despite the stream's significance for domestic use, irrigation, and other livelihood activities, its water quality status has not been regularly monitored or documented.

Together, agricultural practices and wastewater discharge create intricate difficulties for managing water quality. Enrichment with nutrients, sedimentation, and contamination from organic and microbial sources can render rivers unfit for household use, irrigation, and ecosystem support unless they are treated or mitigated. This context underscores why it is relevant to study the Ogbujiriekwe stream at Nimo, a river probably affected by adjacent farmland and human wastewater, in order to gain a clearer picture of how such activities influence local water quality patterns and to guide strategies for sustainable water resource management.

2.0 Materials and Methods

2.1 Study Area

The Ogbujiriekwe stream is a freshwater river situated in Nimo town, within the Njikoka Local Government Area of Anambra State, in southeastern Nigeria. Anambra State is situated within the Anambra Basin, a sedimentary basin marked by lowland floodplains, alluvial deposits, and a network of interconnected rivers that flow into the lower Niger River system. The Ogbujiriekwe stream forms part of this fluvial network and acts as a significant surface water resource for the communities around it. In geographical terms, the study area is located roughly between latitudes 6°05′N–6°15′N and longitudes 6°55′E–7°05′E. The area has a humid tropical climate marked by clearly defined wet and dry seasons. Yearly rainfall ranges from roughly 1,500 mm to 2,000 mm, with the heaviest precipitation falling between July and September. The wet season encourages surface runoff and erosion, which are major forces driving the movement of pollutants from farmland and residential areas into the river. The land around the Ogbujiriekwe stream is mostly flat to gently undulating, which supports widespread agricultural activity. The river shows seasonal changes in discharge, with faster flow velocities and greater sediment loads during the rainy season. Because of these hydrological traits, the river is especially vulnerable to contamination from diffuse agricultural runoff and point-source wastewater discharge. Figure 2.1 shows the geographical location of the Ogbujiriekwe stream within Anambra State, Nigeria, and depicts how the established sampling stations used in this study are spatially arranged.

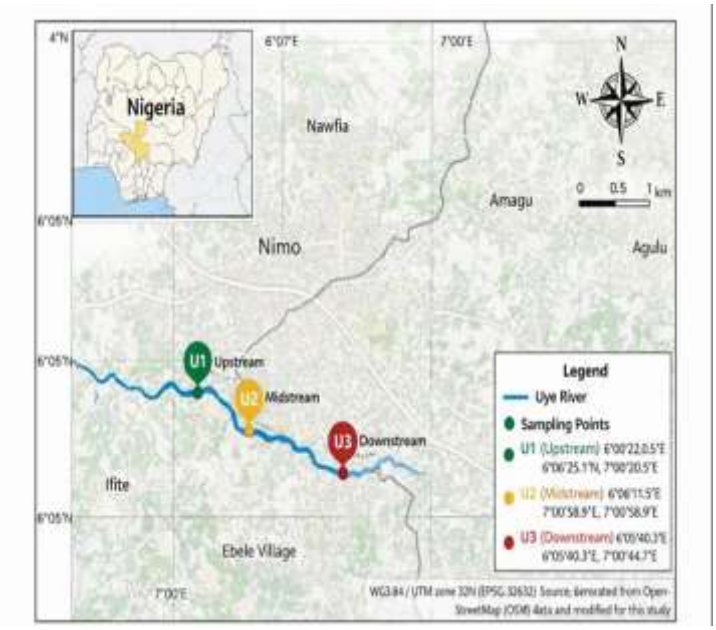


Fig 2.1 Map of Ogbujiriekwe stream (Source: Openstreet map, 2016)

2.2 Land Use activities around the stream

Small-scale subsistence farming and residential settlements are the primary land uses in the Ogbujiriekwe stream catchment. Crops grown along the riverbanks include cassava, yam, maize, vegetables, and rice. Such activities typically entail clearing land, tilling the soil, and applying fertilizer very near the stream channel, which raises the chance that nutrients and sediment will be carried into the stream, particularly when it rains. Beyond farming, the discharge of domestic wastewater represents a significant human-induced stress on the stream. Because there is no centralized sewage

system, household effluents, grey water, and other wastes are frequently released, directly or indirectly, into the stream. Water quality is further degraded by the open dumping of solid waste and by informal sanitation practices. Given the combined effects of agricultural runoff and domestic wastewater inputs, a systematic assessment of the river's water quality is needed to establish the degree of anthropogenic impact.

2.3 Sample Collection Procedure

2.3.1 Sampling point selection

During preliminary survey, the sampling points were divided randomly into 4 places along the Ogbujiriekwe stream using an impact-based approach. The water sample collection was done seasonally, three months during rainy season (June to August, 2025) and three months during dry season (November 2025 to January, 2026).

2.3.2 Water sample collection procedure

Water samples were collected randomly and seasonally using sterile bottles. Sampling was carried out at a depth of approximately 20–30 cm below the water surface to avoid surface films and bottom sediment interference. Prior to sample collection, the bottles were rinsed three times with river water from the respective sampling locations. Samples were properly labeled, stored in ice-packed containers, and transported to Laboratories for analysis within 24 hours of collection. Appropriate preservation techniques were applied for specific parameters in accordance with APHA guidelines to ensure sample integrity.

2.4 Water Quality Parameters Analysis

The assessment of Ogbujiriekwe stream water quality focused on selected physico-chemical parameters that are sensitive to agricultural runoff and wastewater discharge. These parameters provide critical information on water suitability for domestic use, irrigation, and ecological sustainability.

2.5 Research design

This study employed a field-based, cross-sectional design for water quality assessment, intended to evaluate how agricultural practices and wastewater discharge affect the physico-chemical quality of the Ogbujiriekwe stream. The design was arranged to meet the study's objectives by allowing spatial comparison of water quality parameters among locations subject to differing levels of anthropogenic influence. Sampling took place along a longitudinal gradient of the river, covering upstream, midstream, and downstream sections. The upstream section served as a representation of baseline conditions with minimal human interference, the midstream section reflected areas mainly influenced by agricultural activities, and the downstream section captured zones impacted by domestic wastewater discharge from nearby settlements. This spatial design supports engineering-based analysis of source impacts and helps identify pollution trends along the river course.

3. Results and Discussion

3.1 Results

3.1.1 Surface Water Quality Analysis

The water samples from Ogbujiriekwe stream were collected for six months randomly at four sampling stations as discussed in chapter three. The six months data collection was seasonal covering June 2025 to August 2025 for the rainy season data and November 2025 to January 2026 for the dry season data. The sampling points for the rainy season were presented as RP1, RP2, RP3 and RP4 while that of dry season were presented as DP1, DP2, DP3 and DP4.

3.2 Water Quality Analysis

A water quality analysis was carried out in Ogbujiriekwe Stream, Nimo, to assess whether it is suitable for drinking and irrigation purposes when compared with the World Health Organization (WHO) standard. The stream is exposed to ongoing human activities, including the washing of bitter leaf, which adds organic matter, plant residues, suspended solids, and nutrients to the water, potentially changing its physical, chemical, and microbiological properties. When done often and on a large scale, this practice may raise the organic load of the stream, increase turbidity, lower dissolved oxygen levels through microbial decomposition, and encourage nutrient enrichment, which could result in the deterioration of water quality. The stream additionally acts as a water source for irrigation. Water intended for irrigation should have acceptable physicochemical characteristics so as to avoid soil degradation, salinity issues, nutrient imbalance, and harmful effects on crop growth and yield.

Assessing parameters such as pH, Electric conductivity, total dissolved solids, Ammonium Nitrogen, Chloride, Sulphate, Calcium, Magnessium, Sodium and potassium are therefore necessary to determine whether the water meets established irrigation water quality standards. Below (Table 3.1 and Table 3.2) shows the results of the water quality analysis for the rainy and dry season in comparison with WHO standard.

Table 3.1: Weight Calibration, Standards, and Raw Field Data

Parameter	Sn (WHO)	1/Sn	Wi	RP1	RP2	RP3	RP4	DP1	DP2	DP3	DP4
pH	8.5	0.117647	0.12646	6.8	7.6	7.2	7.0	7.6	8.7	7.4	7.2
EC	1000	0.001	0.001075	99.3	102.9	97.0	93.8	80.97	91.56	80.41	79.32
TDS	500	0.002	0.00215	60.8	84.5	80.8	81.1	67.1	70.8	67.1	63.1
NH_4-N	1.5	0.666667	0.716604	2.9	3.0	2.8	2.6	3.8	4.6	3.6	3.4
Cl^-	250	0.004	0.0043	109.0	111.0	109.0	107.0	88.7	90.7	88.0	87.0
SO_4^{2-}	250	0.004	0.0043	38.9	42.3	39.9	39.9	42.7	41.4	40.6	39.9
Ca^{2+}	75	0.013333	0.014332	7.5	9.8	7.7	7.4	9.1	9.8	7.5	7.1

Mg^{2+}	30	0.033333	0.03583	7.8	8.5	7.2	7.3	9.6	9.8	8.4	7.6
Na^{+}	200	0.005	0.005375	6.8	7.6	6.8	6.7	8.7	9.3	8.4	8.2
K^{+}	12	0.083333	0.089576	10.1	12.5	10.4	9.9	9.6	11.9	11.2	10.7
Sum		**0.930314**	**1**								

Table 3.2: Calculated Parameter Sub-Indices (Qi) and Final Aggregated WQI

Parameter Sub-Index (Qi)	**RP1**	**RP2**	**RP3**	**RP4**	**DP1**	**DP2**	**DP3**	**DP4**
Q_pH	-13.3333	40.0000	13.3333	0.0000	40.0000	113.3333	26.6667	13.3333
Q_EC	9.9300	10.2900	9.7000	9.3800	8.0970	9.1560	8.0410	7.9320
Q_TDS	12.1600	16.9000	16.1600	16.2200	13.4200	14.1600	13.4200	12.6200
Q_NH_4-N	193.3333	200.0000	186.6667	173.3333	253.3333	306.6667	240.0000	226.6667
Q_Cl^{-}	43.6000	44.4000	43.6000	42.8000	35.4800	36.2800	35.2000	34.8000
Q_SO_4^{2-}	15.5600	16.9200	15.9600	15.9600	17.0800	16.5600	16.2400	15.9600
Q_Ca^{2+}	10.0000	13.0667	10.2667	9.8667	12.1333	13.0667	10.0000	9.4667
Q_Mg^{2+}	26.0000	28.3333	24.0000	24.3333	32.0000	32.6667	28.0000	25.3333
Q_Na^{+}	3.4000	3.8000	3.4000	3.3500	4.3500	4.6500	4.2000	4.1000
Q_K^{+}	84.1667	104.1667	86.6667	82.5000	80.0000	99.1667	93.3333	89.1667
Final WQI Score	**145.7810**	**159.2439**	**144.5420**	**132.9302**	**195.3715**	**244.6238**	**185.1454**	**173.4229**
Water Quality Status	***Unsuitable***	***Unsuitable***	***Unsuitable***	***Unsuitable***	***Unsuitable***	***Unsuitable***	***Unsuitable***	***Unsuitable***

The findings showed that water from the Ogbujiriekwe Stream is not safe for human consumption at every station and in both seasons. Ammonium-Nitrogen (NH_4-N), with a WHO guideline value of 1.5 mg/L, is the strongest mathematical contributor. Laboratory data reveals values between 2.6 mg/L and 4.6 mg/L. Since these figures are roughly two to three times the safe limit, the individual Ammonium quality ratings (Qi) climbed to between 173.3 and 306.6. This one parameter alone is ruining the stream's water quality score. Potassium (K^{+}) levels were also significantly raised, driving sub-index scores (Qi)) to near or above 100. This offers conclusive evidence of agricultural runoff from nearby farms that use NPK chemical fertilizers. Although the stream was heavily polluted in the rainy season (WQI scores of about 132 to 159), it turns into a severe toxic hotspot in the dry season, reaching a peak of 244.62 at station DP2. This is probably caused by the following: in the dry season, rainwater no longer dilutes the stream, and point-source pollution (such as untreated municipal sewage and domestic wastewater) becomes highly concentrated. Further confirmation came from DP2's pH, which peaked at 8.7, indicating highly alkaline chemical discharge or intense algal activity driven by wastewater nutrients. Parameters including Salinity, Boron, Carbonate, and Bicarbonate were left out of the final aggregated Water Quality Index (WQI) calculation because no official numeric drinking water threshold limits ((Sn) are given in the WHO guidelines, which prevented

the mathematical evaluation of individual sub-index quality ratings (Qi). The water quality analysis of Ogbujiriekwe Stream in Nimo was carried out because the stream is a vital community water resource that faces continuous bitter leaf washing and other human activities while also serving irrigation and domestic uses.

Moreover, water quality monitoring supplies baseline information on the environmental condition of the stream, pinpoints the impacts of human activities on the aquatic ecosystem, and aids in developing suitable management strategies. The results can help local authorities, environmental agencies, and community stakeholders put pollution control measures in place, regulate activities around the stream, and encourage sustainable use of the water resource. The water quality analysis of Ogbujiriekwe Stream in Nimo was carried out because this stream serves as a vital community water source, being subjected to ongoing bitter leaf washing and other human activities while also meeting irrigation and domestic demands. Comprehensive monitoring of water quality provides baseline data that indicates the state of aquatic systems, just as Anozie et al. (2020) and Akinyele and Ibeh (2020) demonstrated through their work on growth responses and seed treatments for improved early plant development. Similar to Salami et al. (2020), who evaluated the direct effects of anthropogenic structural change in tropical rainforests, and Rotowa et al. (2020), who concentrated on management within agroforestry systems, stream assessments shed light on the consequences of anthropogenic changes. Furthermore, as Nweke et al. (2021), Nweke et al. (2020), and Okenmuo et al. (2023) previously did, water data reveals environmental weaknesses so that strategic interventions can be informed. Finally, these combined monitoring results allow local governments, environmental organizations, and community members to put into practice effective measures to reduce pollution, regulate activities near essential water resources, and take proactive action to guarantee their sustainable and long-term use, as illustrated by Alegbeleye et al. (2025), Ibeh and Akinyele (2024) and Aguma et al. (2026).

3.3 Human Risk Assessment

A health risk assessment was carried out on Ogbujiriekwe Stream in Nimo to determine the possible health effects linked to human contact with contaminants in the stream, given the many human activities taking place within its catchment area. For the nearby communities, the stream is a vital water source, providing water for domestic use and irrigation. Its location and the various sources of pollution, however, give rise to worries about whether it is suitable for these uses and about the possible dangers it presents to human health. A key activity occurring in the stream is the ongoing washing of bitter leaf (Vernonia amygdalina). This process introduces substantial amounts of plant residues, suspended solids, organic matter, and microorganisms into the water. Moreover, runoff from nearby farmlands carries pesticide and herbicide residues, fertilizers, and soil particles away from the fields where they were applied. The steady release of these materials into the stream may raise turbidity, nutrient levels, and microbial numbers, thus lowering the water's overall quality.

Moreover, Ogbujiriekwe Stream sits in a lowland area that naturally collects drainage from the surrounding uplands. As a result, wastewater and industrial effluents released by nearby industries located at higher elevations can reach the stream via gravity flow and surface drainage. Depending on

the kinds of human activities involved, these effluents may carry heavy metals along with oils, grease, solvents, detergents, and other hazardous chemicals. Such contaminants can build up in the stream's water and sediments, raising the likelihood of chronic exposure for those who use the stream. Runoff from the surrounding agricultural lands is another significant pollution source. To boost crop yields, farmers in the watershed use both organic manures, including poultry droppings and livestock manure, and inorganic fertilizers. When it rains, surface runoff carries surplus nutrients, sediments, pesticides, herbicides, pathogens, and fertilizer residues into the stream. High concentrations of nutrients like nitrate and phosphate can encourage eutrophication, while pesticide residues and heavy metals found in some fertilizers may remain in the aquatic environment and create toxicological hazards for humans and aquatic life. The results of the human health risk assessment conducted on the stream are presented below. The baseline dose entering the human metabolic system through the direct oral ingestion pathway is defined by the following multi-factor equation:

$$CDI\ \frac{(C\ X\ IR\ X\ EF\ X\ ED)}{(BW\ X\ AT)} \ldots\ldots\ldots\ldots\ldots\ldots \text{ eqn. 3.1}$$

Where C represents the measured nitrate toxicant concentration (mg/L) (1.1.2). Because the default tracking exposure frequency (EF = 365 days/year) and exposure duration (ED) cancel out precisely against the average life expectancy tracking timeline (AT = ED × 365 days), the equation reduces directly to:

$$CDI\ \frac{(C\ x\ IR)}{BW} \ldots\ldots\ldots\ldots\ldots\ldots \text{ eqn. 3.2}$$

The combined impact of bitter leaf washing, industrial effluent release, and agricultural runoff produces several routes by which contaminants can enter Ogbujiriekwe Stream. Because some residents drink directly from the stream, they may be exposed to these contaminants through ingestion. Drinking contaminated water can cause both acute and chronic health problems, such as gastrointestinal infections, neurological disorders, kidney and liver damage, developmental abnormalities, cardiovascular diseases, and a higher risk of cancer, depending on the type, concentration, and length of exposure to the contaminants. The stream is also used as a source of irrigation water for agricultural production. Irrigating with contaminated water can lead to the buildup of heavy metals and other pollutants in agricultural soils and edible crops. These contaminants may then enter the human food chain when contaminated vegetables and other agricultural produce are eaten, thus forming an indirect pathway of human exposure. Continued use of polluted irrigation water can also harm soil quality, lower crop productivity, and jeopardize food safety. A health risk assessment was therefore carried out to quantify both the non-carcinogenic and carcinogenic risks linked to exposure to contaminants in the stream. Non-carcinogenic risk assessment requires estimating the Hazard Quotient (HQ) and Hazard Index (HI) to establish whether exposure surpasses established safe limits. Values below unity (HQ or HI < 1) typically signify negligible health risks, while values above one indicates the possibility of adverse health effects. Carcinogenic risk assessment estimates the lifetime probability of developing cancer from exposure to carcinogenic substances and compares the estimated risk against internationally accepted guideline values. The assessment also offers valuable scientific information for environmental management by identifying contaminants of concern, determining the extent of pollution, and evaluating whether the stream is safe for drinking

and irrigation. The findings provide a basis for recommending suitable mitigation measures, such as better wastewater treatment, regulation of industrial effluent discharge, adoption of sustainable agricultural practices, routine water quality monitoring, and public health interventions designed to protect communities that rely on the stream.

4.0 Conclusion

When the water quality assessment results are compared with the WHO standard, they show that Ogbujiriekwe Stream is heavily polluted, as Ammonium-Nitrogen and agricultural runoff make the water unsafe to drink in every season, especially during the peak of the dry season. In addition, this study assessed the non-carcinogenic human health risks linked to nitrate-nitrogen (NO_3-N) and boron (B) in the stream water of Nimo by applying the Human Health Risk Assessment (HHRA) approach. The assessment found that nitrate is the main contaminant driving potential health risks, whereas boron is present at concentrations that add only a minor contribution to the overall toxicological concerns. The consistently high nitrate concentrations observed in both the rainy and dry seasons point to ongoing contamination of the stream, most probably caused by runoff from agricultural fertilizers, leaking septic tanks, and discharges of domestic wastewater. By contrast, boron concentrations stayed low, even though the small rise seen in the dry season pointed to localized human inputs from household greywater. The chronic daily intake (CDI) analysis revealed distinct differences in contaminant exposure between adults and infants. Adults had comparatively low exposure owing to their higher body weight, which kept the hazard quotient (HQ) values for both nitrate and boron below the acceptable threshold set by USEPA. As a result, the cumulative Hazard Index (HI) for adults showed that the present water quality is unlikely to cause adverse non-carcinogenic health effects from long-term consumption, although it is not advisable to drink, as indicated in the water quality assessment and regulated by WHO. Infants, however, were found to be the most vulnerable group because they consume more water relative to their body weight; therefore, the water is not safe for infants to drink. These findings indicate that any rise in nitrate concentration or extended exposure could push the health risk above acceptable levels, leaving infants especially susceptible to nitrate-induced health effects.

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