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Research Article

INVESTIGATION OF ENVIRONMENTAL WATER QUALITY IN SOMBRERO AND ORASHI RIVERS, NIGER DELTA

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Abstract

Water quality is fundamental to environmental sustainability, ecosystem integrity, and human well-being. It is determined by the interplay of physical, chemical, and biological parameters that collectively indicate the suitability of water for drinking, agriculture, recreation, and industrial activities. In the Niger Delta, a region renowned for its rich biodiversity and complex hydrological networks, maintaining high water quality is critical. The delta's intricate system of rivers, estuaries, and wetlands supports diverse flora and fauna, including numerous fish species and aquatic plants that are essential for nutrient cycling and ecological balance. These water bodies also provide vital services for local communities, such as potable water, fisheries, transportation, and irrigation. However, pressures from population growth, industrial activities, and environmental pollution threaten the ecological and socio-economic functions of these rivers. Understanding and monitoring the physico-chemical characteristics of the Niger Delta's rivers are therefore crucial for sustainable management, conservation of biodiversity, and safeguarding public health. This study focuses on the physico-chemical analysis of the Sombrero and Orashi Rivers to evaluate their water quality and identify potential environmental risks.

Keywords: Water quality, Niger Delta, Rivers, Physico-chemical analysis, Environmental sustainability

INTRODUCTION

Water quality is a cornerstone of environmental sustainability and public health, serving as a critical determinant of ecosystem health, biodiversity, and human well-being (Carpenter et al., 2021; Huang et al., 2019). It encompasses a broad range of physical, chemical, and biological parameters that collectively assess the suitability of water for various uses, including drinking, agriculture, recreation, and industrial applications. In the Niger Delta, a region rich in biodiversity and natural resources, the significance of maintaining high water quality cannot be overstated. This delta, formed by the confluence of several rivers, is not only a vital ecological zone but also a lifeline for millions of people whose livelihoods depend on its water bodies (Adeleke et al., 2022; Efe et al., 2020).

The Niger Delta is one of the largest delta systems globally, characterized by its intricate network of rivers, estuaries, and wetlands. This unique hydrological environment supports a diverse array of flora and fauna, contributing to its ecological richness (Mmom et al., 2022). The region is known for its high biodiversity, with numerous fish species and aquatic plants that play critical roles in nutrient cycling and food webs. Furthermore, the delta's rivers serve multiple functions: they provide drinking water, sustain fisheries, enable transportation, and support agriculture. For many communities, these water bodies are integral to their cultural identity and economic activities, making the maintenance of water quality essential for social and economic stability (Adeleke et al., 2022).

However, the rivers of the Niger Delta are increasingly under threat from various anthropogenic activities. Oil exploration and extraction, a major economic driver in the region, have resulted in widespread pollution, including oil spills and the release of toxic waste into water bodies (Nwankwoala et al., 2020). Furthermore, urbanization and agricultural practices introduce contaminants such as fertilizers and pesticides, which can significantly alter the chemical composition of river water (Efe et al., 2020). These factors have led to concerns regarding the degradation of water quality, posing risks not only to aquatic ecosystems but also to the health and livelihoods of communities that rely on these rivers for survival.

To assess the current state of water quality in these rivers, this study focuses on a detailed analysis of various physio-chemical parameters over a three-month period (June to August 2024). Key parameters such as turbidity, total suspended solids, dissolved oxygen, biological oxygen demand (BOD), and nutrient concentrations were examined to identify significant differences in water quality between the two rivers. Understanding these parameters is essential for recognizing potential sources of pollution and developing targeted management strategies to safeguard these critical water resources.

The importance of this research underscore the implications for water resource management and public health. Poor water quality can lead to adverse health outcomes, including waterborne diseases and reduced fish populations, which directly affect local communities' livelihoods (Huang et al., 2019).

This study highlights the significance of water quality in the Niger Delta and sets the stage for an investigation into their physico-chemical characteristics. This research aims to contribute to a greater understanding of the complex interplay between human activities and water quality, ultimately advocating for the protection and preservation of the Niger Delta's invaluable water resources.

Study area

The study was conducted in the Sombero River at Agba –Ndele and Ikiri Rivers, Rivers State in the lower Niger Delta. Agba –Ndele River shares a geographical boundary with Rumuewhor by the North, Rumuekpe by the South, and Abua odual by the East. The Niger Delta basin, covers all the land between latitude 04'88'10" and 0.06' 642.45' down stream, middle stream latitude 04,888'10"78" and upstream at 0.06'642.45" and longitude of 006.692.41". the Sombrero River is one of the major sources of water for the Agba-Ndele community. With numerous human activities such as bathing, washing, fishing, oil mil –effluent, agricultural waste, dredging and transportation taking place. These may be a potential source of pollution to the environment, while the Ikiri River is a cross-section of the Sombrero River that lies between latitudes $05.283,04^{0}$, 05.288.05, $05.283.05^{0}$, $05.282.46^{0}$ and 05.282.45 and longitude 006.701.75, 006.701.88', 006.70204 and 006.70182' down stream, middle stream of latitude, $05.234.48^{0}$. The Ikiri River is one of the series of the Niger Delta Rivers which drains into the Atlantic ocean and is connected to other Rivers via creecks in the coastal areas of the Niger Delta (Ezekiel 1986). The climate of the study area is a tropical climate with raining and dry seasons (Nwilo & Badejo, 2006) The stretch of the Sombrero River is one of the most important River system in the Niger Delta providing nursery and breeding grounds for a large variety of fish species (Ezekiel, et al., 2011).

The Niger Delta, one of the world's most significant and biodiverse delta systems, spans approximately 70,000 square kilometers in southern Nigeria, where the Niger River meets the Atlantic Ocean (Dahunsi et al., 2021). This region is characterized by its unique geographical features, including extensive mangrove forests, swamps, and numerous interconnected rivers and creeks, which contribute to its rich biodiversity and complex ecosystems (Nwankwoala et al., 2020). The delta supports a wide variety of flora and fauna, with numerous species of fish, birds, and plants that are adapted to its humid tropical climate (Mmom et al., 2022).

Materials & Methods

Water samples were collected monthly from designated sampling sites along the Agba-Ndele and Ikiri Rivers over a three-month period (June to August). The selection of sampling sites was based on the accessibility and representativeness of different river locations (downstream, mid-stream, and upstream) to account for diurnal variations in water quality.

Laboratory Analysis of Physico-Chemical Parameters of Surface Water Determination of pH

The pH electrode of (pH meter Model PHS-3C Serial number YK-041908131) was calibrated with two standard buffer solutions of pH4 and 9. The electrode was then thoroughly rinsed in distilled water and then dipped into the water sample. A steady pH reading was recorded as the pH of the water.

Determination of Salinity

Salinity was measured with a digital salinity meter, Hanna Instruments model number HI 9142. When the probe of the meter was dipped into the water body and the switch turned to the salinity position, a steady reading display was recorded as the salinity of the water (APHA,
1998).

Conductivity (usmc-^{1})

The electrical conductivity of the water samples was measured with a digital conductivity meter (Hanna product model number HI 9142). The probe of the meter was inserted in the water sample and the control was turned to conductivity; a steady reading displayed was recorded as the conductivity of the water sample (APHA, 1998).

Turbidity (NTU)

The turbidity meter is used for this determination after it has been calibrated with calibration solutions. The water sample was then inserted into the meter and turbidity was read directly in NTU units. Turbidity was done with the turbidity meter from Wagtech. Hanna Instruments model number HI 9142 (APHA, 1998).

Total Dissolved Solids (TDS)

An evaporating dish was washed and oven-dried until a constant weight was obtained. 100ml of water sample was poured into the dish and placed on a 6-hole water bath and heated until the water evaporated to dryness. The dish was then placed in a desiccator and allowed to cool to room temperature. The evaporating dish and residue were then weighed. The difference in weight before and after evaporation gives the amount of TDS in the water sample in mg/l (or ppm) (APHA, 1998).

Total Suspended Solids (TSS)

The total suspended solids (TSS) in the water samples were measured gravimetrically. A precipitated gauged filter paper was utilized to channel 100ml of the water sample. The combined filter paper and filtered solids were dried at 105^{0}C and reweighed. This was done until a constant value was reached. The weight of suspended solids was computed using the formulae below:

$$TSS = \frac{(W_c - W_t)}{V} \times 106 \text{ (mg/l)}$$

Where: TSS = Total Suspended Solids, W_t = Weight of pre-combusted filter (mg), constant weight of filter + residue (mg), V = Volume of water sample used (ml).

Nitrate Test (NO_3)

10ml of water sample was placed in the sample holder of the Nitrate kit. One nitrate test tablet was crushed poured into the hold and mixed. The sample holder was left to stand on the bench for 10 minutes. For colour development, the spectrophotometer was set on transmittance and wavelength set at 470mm. the transmittance was read directly on a concentrating chart in mg/l (ppm). (APHA, 1998).

Determination of Phosphate (By Ascorbic acid mtd) APHA 4500 – P P04

Procedure: 5ml of the sample in a test tube added 0.8ml of the combined reagent. Combined reagent was prepared by mixing 50ml 5N H_2SO_4, 5ml potassium Antimony tartrate, 15ml Ammonium motybdate solution, 30ml Ascorbic acid solution, ensuring mixing upon each addition. Phosphate standard, solution was prepared using potassium dehydrogen phosphate. From calibration curve of absorbance agent corresponding concentrations, slow was obtained. Phosphate value was obtained as absorbance value obtained multiplied by the slope of the curve. Absorbance was determined at 380nm.

Hardness (By EDTA Titrimetric mtd) Procedure:

1. 50ml of sample was transferred into an Erienmeyer flask.
2. A pinch of Enchrome black T indicator was added.
3. Titration was done from burette containing 0.01m EDTA solution.
4. A change of the deep crime red colour to a deep blue colour indicates the endpoint.
5. The colour change is better viewed in daylight for accuracy.
6. Sufficient sample volume helps to improve accuracy.

Hardness was determined as follows:

$$\text{Hardness Cas caco}_3\text{ mg/l)} = \left[\frac{100(v_1-v_2) \times CF}{V_3} \right]$$

V1 = Vol. in 1ml of EDTA std solution used in the titration of the sample

V2 = Vol. in ml of the EDTA std. solution used in the titration for the blank

V3 = Vol. in ml of the sample taken for the test

CF = X_1/X_2 = correction factor = 1

Total Alkalinity

The total alkalinity in the water samples was determined titrimetrically, by directly titrating 100ml of the sample against 0.02N sulphuric acid with methyl orange as an indicator and the endpoint was golden yellow (faint pink) (APHA, 1998)

Preparation of Reagent

Sulphuric acid (0.02N) was prepared by diluting 1.98ml (approximately 2.0ml) of the concentrated sulphuric acid 98.10% pure. (sp-gr 1.84g cm) in 1 litre of distilled water. Total alkalinity was calculated as:

$$\text{Total Alkalinity } (\text{mg/K. Co3}) = \frac{\text{AXNX50,000}}{\text{V.S}}$$

Where

A = Volume of acid used
N = Normality of the acid (0.02N)
V.S = Volume of sample used (100ml)

Dissolved Oxygen (DO)

The dissolved oxygen meter (DO meter) Hanna Instrument, model number HI 9142 was used to determine the dissolved oxygen in the water body. The DO meter probe was zeroed and then rinsed in distilled water and dipped into the water body and a steady read out displayed was recorded as the dissolved oxygen in the sample.

Determination of Biological Oxygen Demand (BOD)

BOD is defined as the amount of oxygen required by bacteria for breaking down the decomposable organic matter present in any water, wastewater, treated or untreated effluent. BOD can also be taken as the measure of the concentration of organic matter present in water. The greater the BOD the greater the oxygen demand. The tests are generally carried out by measuring the amount of dissolved oxygen.

DO present in the sample before and after the incubation in the dark for 5 days at 25^0C. the water was diluted by 2% into the 125ml BOD bottles.100ml of the 2% water sample was added using a long 50ml pipette. 25ml dilution water was added bringing the solution in the bottle to the brim.

An initial DO was taken from one of the duplicate bottles. The stoppers were now inserted into the bottles leaving no air space or bubbles in the bottles.

The bottles were then incubated in the incubator in the dark at 25^0C for 5 days. On the fifth (5th) day, the DO was again taken, and that of the blank bottle. The 5 days BODs are computed from the DO values DO_0 and DO_5 and the % dilution

$$\text{BOD}_5 \text{ mg/l} = \frac{DO_0\text{-}DO_0 1}{\%\ \text{Dilution}}$$

OR

$$\text{BOD5 mg/l} = (DO_0 – DO_d) \times \frac{\text{Vol BOD bottle}}{\text{Vol. of sample}}$$

Where

DO_0 = DO initial (Before Dilution)

DO_d = DO after 5 days incubation (APHA, 1998)

Determination of Chemical Oxygen Demand (COD) by Titration

Chemical oxygen demand (COD) is a measured parameter used to determine the pollution strength of domestic and industrial wastewater. This determination is achieved by using a strong oxidizing agent under acidic conditions.

An excess amount of the oxidizing agent is used. Oxygen is released, some are used to oxidize an equivalent amount of the waste to carbon dioxide (Carbon iv Oxide), and the unused fraction is determined by titration with a reducing agent of known strength. The amount used for the oxidation of the waste is known by difference.

Procedure:

0.4g mercury II Sulphate (H_2SO_4) was weighed into a refluxing flask and 20ml of water sample was added. 10 ml of $K_2Cr_4O_7$ was added using a pipette. Slowly and with gentle swirling, 30ml of AgSO4 solution was added. The refluxing condenser was then put in place. The mixture was refluxed for 2 hours. The system was then cooled and the condenser was washed into a conical flask containing the refluxed sample.

With the aid of 0.05m ferrous ammonium sulphate (FAS) solution, the excess dichromate ($Kr_2Cr_4O_7$) solution was titrated using FERROIN as the indicator. A blank titration was also taken.

$$\text{Mg/L COD} = \frac{(Vb - Va) \times M \times 16{,}000}{\text{Vol of sample used}}$$

Vb = Blank titre

Va = Sample titre

M = Molarity of (FAS)

16,000 = Oxygen conversion factor (APHA, 1998)

RESULTS AND DISCUSSION

Results

An analysis of the physico-chemical characteristics of the Agba-Ndele and Ikiri Rivers was carried out based on data collected over three months (June to August). The results highlight significant variations in water quality parameters, underscoring the impacts of anthropogenic activities and natural environmental factors.

Physico-Chemical Parameters

Turbidity and Total Suspended Solids (TSS)

Turbidity levels were assessed to determine the clarity of the water, which is influenced by the presence of suspended particles. In June, the Agba-Ndele River recorded a turbidity of 2.43 NTU as shown in Table 1, which decreased to 1.67 NTU in July (Table 2) but increased again to 2.04 NTU in August (Table 3). In contrast, the Ikiri River exhibited lower turbidity values throughout the study, with measurements of 0.80 NTU in June, 0.93

NTU in July as shown in Table 2, and 1.86 NTU (Table 3) in August. The relatively high turbidity in the Agba-Ndele River may be attributed to agricultural runoff, which is consistent with findings from Adeleke et al. (2022), who noted similar trends in rural agricultural watersheds. The distribution of the parameters for each month is shown in Figures 1 to 3 respectively.

Table 1. JUNE SURFACE WATER ANALYSIS

PARAMETER	METHOD	Agba-Ndele River	Ikiri River
PHYSIO-CHEMICAL			
Turbidity Ntu	APHA 2130B	2.43	0.80
Total Suspended Solid mg/l	APHA 2540	3.41	1.60
Alkalinity mg/l	APHA 2320B	8	9.85
Chemical Oxygen Demand mg/l	APHA 5220	0.873	0.813
PH	ASTMD 1	8.86	9.98
Electrical Conductivity µs	ASTMD 1125	12.36	4.56
Total Dissolved Oxygen ppm	ASTMD 1125	6.29	27.2
Temperature ®c	ASTMD 1293B	27.3	0.01
Salinity ppt	ASTMD 1293B	0.03	27.2
Hardness mg/l	EDTA	2.0	1.4
Biological Oxygen Demand mg/l	WALKEY BLACK	0.7	1,5
Phosphate mg/l	APHA 4500	5.582	5.083
Nitrate mg/l	HACH 8171	0.950	1.373
Sulphate mg/l	EPA 375.4	1.065	1.937
Dissolved Oxygen mg/l	WALKEY BLACK	3.3	6.3

The total suspended solids (TSS) followed a similar trend, with the Agba-Ndele River showing higher values than the Ikiri River. The recorded TSS for Agba-Ndele were 3.41 mg/l in June,
3.89 mg/l in July, and 4.12 mg/l in August, while the Ikiri River values were notably lower at
1.60 mg/l, 2.42 mg/l, and 3.88 mg/l, respectively. These findings indicate that the Agba-Ndele River is more susceptible to sedimentation issues, potentially affecting aquatic habitats and reducing light penetration, which can impact photosynthetic activity (Kumar et al., 2020).

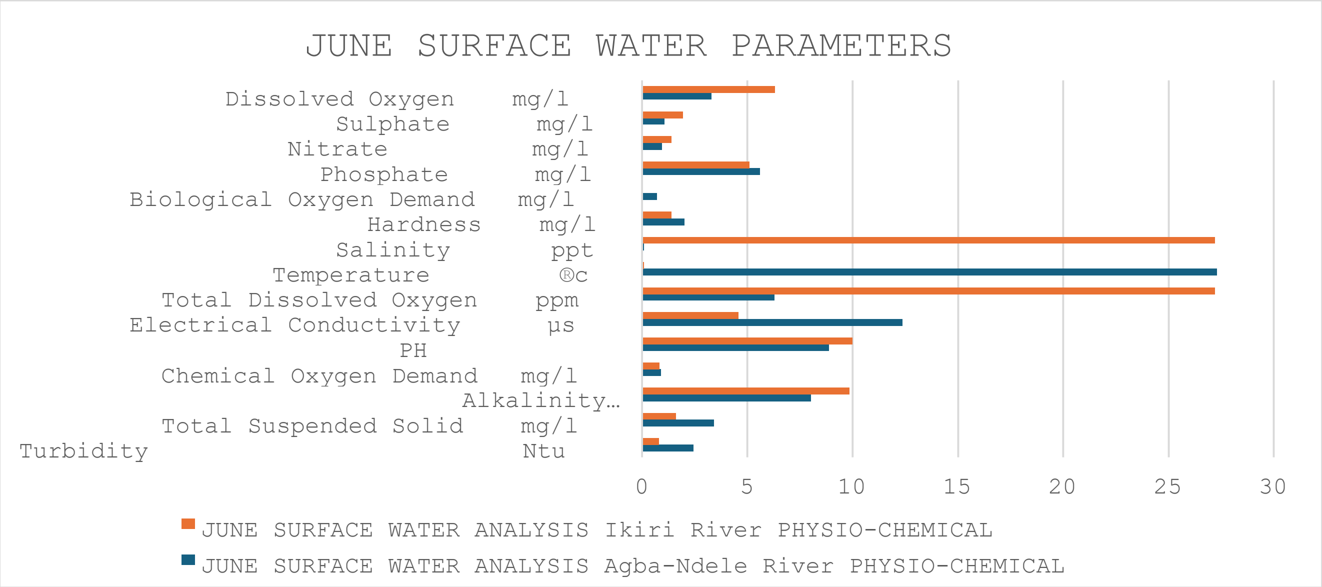


FIGURE 1. JUNE SURFACE WATER PARAMETER DISTRIBUTION

Table 2. JULY SURFACE WATER ANALYSIS

PARAMETER PHYSIO-CHEMICAL	METHOD	Agba-Ndele River	Ikiri River
Turbidity Ntu	APHA 2130B	1.67	0.93
Total Suspended Solid mg/l	APHA 2540	3.89	2.42
Alkalinity mg/l	APHA 2320B	9	10
Chemical Oxygen Demand mg/l	APHA 5220	0.438	1.875
PH	ASTMD 1	8.43	9.67
Electrical Conductivity µs	ASTMD 1125	11.63	10.36
Total Dissolved Oxygen ppm	ASTMD 1125	5.58	4.94
Temperature ®c	ASTMD 1293B	27.2	27.3
Salinity ppt	ASTMD 1293B	0.01	0.01
Hardness mg/l	EDTA	3	2
Biological Oxygen Demand mg/l	WALKEY BLACK	1.6	2.1
Phosphate mg/l	APHA 4500	6.098	7.011
Nitrate mg/l	HACH 8171	2.271	3.469
Sulphate mg/l	EPA 375.4	3.620	2.924
Dissolved Oxygen mg/l	WALKEY BLACK	3.7	5.6

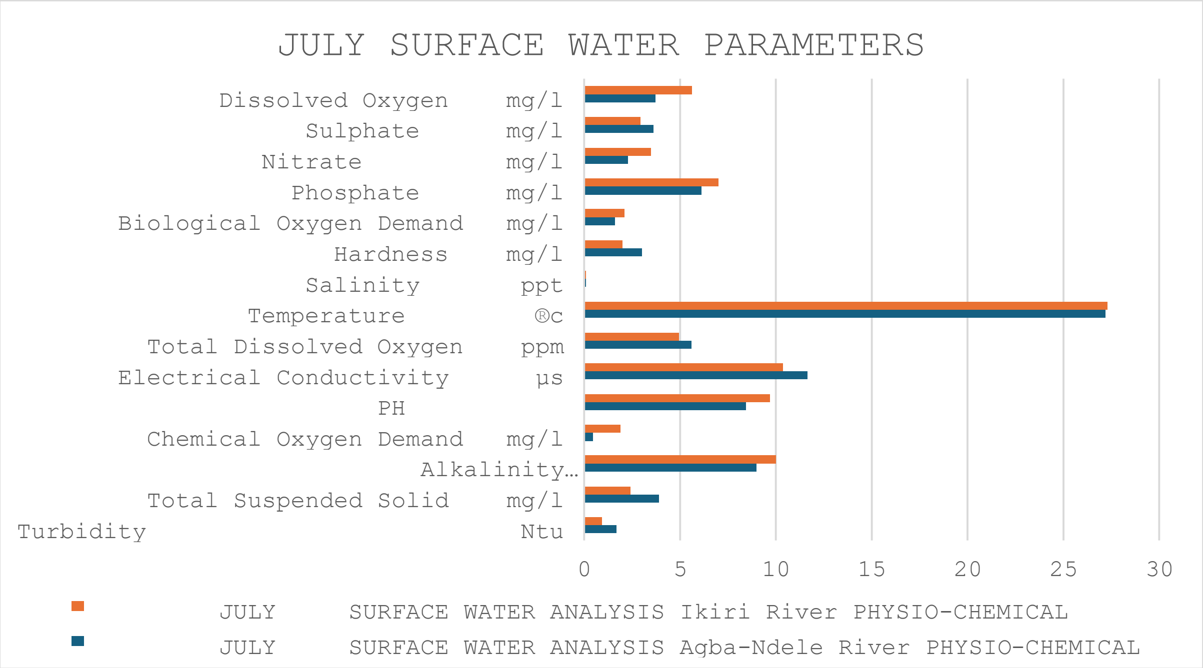


FIGURE 2. JULY SURFACE WATER PARAMETER DISTRIBUTION

Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD)

Dissolved oxygen is a crucial indicator of water quality, influencing the survival and growth of aquatic organisms. In June, the Agba-Ndele River exhibited a DO concentration of 3.3 mg/l, significantly lower than the Ikiri River's 6.3 mg/l (Table 1). This disparity suggests that the Agba-Ndele River may be experiencing higher organic pollution, as reflected by its higher BOD levels, which were 0.7 mg/l in June compared to the Ikiri River's 1.5 mg/l. In July, the Agba-Ndele River recorded a slight improvement in DO at 3.7 mg/l, while the Ikiri River maintained a higher concentration of 5.6 mg/l (Table 2). The consistently low DO levels in the Agba-Ndele River may be attributed to organic matter decomposition due to agricultural runoff, which aligns with the conclusions of Efe et al. (2020) regarding the detrimental effects of agricultural practices on aquatic ecosystems.

Nutrient Concentrations: Nitrate and Phosphate

Nutrient enrichment in river systems is a significant concern, particularly regarding the potential for eutrophication. Phosphate levels in the Agba-Ndele River ranged from 5.582 mg/l in June to 6.740 mg/l in August, while the Ikiri River exhibited slightly higher values of 5.083 mg/l to 7.011 mg/l over the same period (Table 3). The elevated phosphate concentrations in both rivers indicate a potential risk for algal blooms, particularly in the Ikiri River, which is influenced by urban runoff (Chikwendu et al., 2021).

Table 3. AUGUST SURFACE WATER ANALYSIS

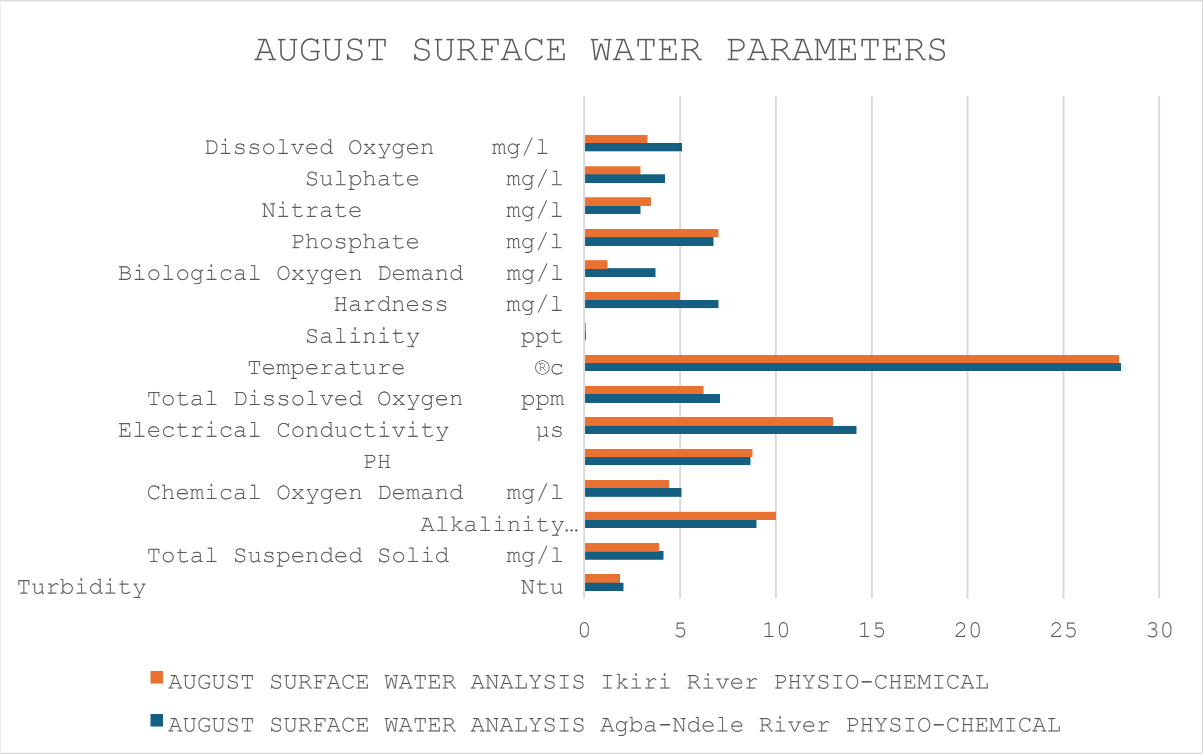
PARAMETER	METHOD	Agba-Ndele River	Ikiri River
PHYSIO-CHEMICAL			

Turbidity	Ntu	APHA 2130B	2.04	1.86
Total Suspended Solid	mg/l	APHA 2540	4.12	3.88
Alkalinity	mg/l	APHA 2320B	9	10
Chemical Oxygen Demand	mg/l	APHA 5220	5.06	4.42
PH		ASTMD 1	8.66	8.78
Electrical Conductivity	µs	ASTMD 1125	14.20	12.99
Total Dissolved Oxygen	ppm	ASTMD 1125	7.07	6.22
Temperature	®c	ASTMD 1293B	28.0	27.9
Salinity	ppt	ASTMD 1293B	0.01	0.01
Hardness	mg/l	EDTA	7	5
Biological Oxygen Demand	mg/l	WALKEY BLACK	3.7	1.2
Phosphate	mg/l	APHA 4500	6.740	7.011
Nitrate	mg/l	HACH 8171	2.927	3.469
Sulphate	mg/l	EPA 375.4	4.211	2.924
Dissolved Oxygen	mg/l	WALKEY BLACK	5.1	3.3

Nitrate levels also reflected significant differences between the two rivers. The Agba-Ndele River had nitrate concentrations of 0.950 mg/l, 2.271 mg/l, and 2.927 mg/l across the study months, while the Ikiri River's levels were consistently higher, measuring 1.373 mg/l, 3.469 mg/l, and remaining stable in August. This trend emphasizes the impact of urbanization on nutrient loading in the Ikiri River, corroborating findings by Mmom et al. (2022) regarding the correlation between urban development and increased nutrient input into water bodies.

pH and Electrical Conductivity

The pH levels of both rivers remained within a relatively neutral range throughout the study period. The Agba-Ndele River exhibited pH values of 8.86, 8.43, and 8.66, while the Ikiri River recorded slightly higher values of 9.98, 9.67, and 8.78. These results suggest that both rivers may be experiencing some degree of alkalinity, potentially influenced by the surrounding geological formations and agricultural practices (Adeleke et al., 2022). Woke and Wokoma (2006) reported pH as an important ecological parameter that has a strong relationship with the physiology of most aquatic organisms.



Electrical conductivity (EC) serves as an indicator of ion concentration in water, reflecting the presence of dissolved salts. The Agba-Ndele River's EC was relatively stable at 12.36 µS, 11.63 µS, and increased to 14.20 µS, while the Ikiri River showed lower values of 4.56 µS, 10.36 µS, and 12.99 µS. The higher conductivity in the Agba-Ndele River could suggest increased salinity or pollution, supporting the concerns raised by Nwankwoala et al. (2020) regarding the impacts of agricultural runoff on water quality.

Discussion

The findings of this study provide critical insights into the physio-chemical quality of the AgbaNdele and Ikiri Rivers, highlighting the varying impacts of anthropogenic activities in the Niger Delta region. strategies. The results indicate that the Agba-Ndele and Ikiri Rivers exhibit distinct water quality profiles, influenced by their differing land uses and environmental conditions. The Agba-Ndele River, primarily affected by agricultural runoff, demonstrates higher turbidity, TSS, and lower DO levels. In contrast, the Ikiri River faces challenges from urbanization, as evidenced by elevated nutrient concentrations and a more stable water quality profile. These findings highlight the need for targeted management strategies that account for the unique characteristics and pressures faced by each river system.

Impacts of Turbidity and Total Suspended Solids

The Agba-Ndele River's turbidity levels consistently exceeded those of the Ikiri River, raising concerns about water quality. The observed turbidity levels of 2.43 NTU in June and a peak of

2.04 NTU in August indicate substantial amounts of suspended particles likely stemming from agricultural runoff (Ola et al., 2023). Elevated turbidity can significantly impact aquatic ecosystems by reducing light penetration, which is crucial for photosynthesis in aquatic plants (Liu et al., 2022). The negative effects on primary productivity can cascade through the food web, affecting herbivorous and predatory species alike (Kumar et al., 2023).

Total suspended solids (TSS) in the Agba-Ndele River ranged from 3.41 mg/l to 4.12 mg/l, which can lead to sedimentation issues that smother habitats for aquatic organisms (Adesina et al., 2023). In contrast, the Ikiri River's lower TSS values suggest a more stable aquatic environment, potentially due to more effective land management practices in urban areas. The higher sediment loads in the Agba-Ndele River can disrupt spawning habitats for fish, significantly impacting biodiversity and the health of fish populations (Sharma et al., 2021).

Dissolved Oxygen and Biological Oxygen Demand

The substantial difference in dissolved oxygen (DO) levels between the two rivers raises serious ecological concerns. The Agba-Ndele River recorded alarming low DO concentrations, notably 3.3 mg/l in June, which could severely threaten aquatic life (Adesina et al., 2023). Low DO is often indicative of organic pollution, as evidenced by the river’s higher biological oxygen demand (BOD) levels, which were 0.7 mg/l in June (Mmom et al., 2022). The decomposition of organic matter consumes available oxygen, leading to hypoxic conditions detrimental to fish and other aquatic organisms (Chikwendu et al., 2021).

Conversely, the Ikiri River maintained higher DO levels, averaging around 5.6 mg/l. This suggests that urban management practices, such as improved wastewater treatment, may mitigate organic pollution (Efe et al., 2020). However, ongoing urbanization poses risks that could alter this balance if nutrient loading continues to increase, necessitating ongoing monitoring and management strategies.

Nutrient Enrichment and Eutrophication

The nutrient concentrations in both rivers raise important concerns regarding eutrophication. Phosphate levels in the Agba-Ndele River peaked at 6.740 mg/l, while the Ikiri River maintained slightly higher phosphate levels of 7.011 mg/l (Adesina et al., 2023). Elevated nutrient concentrations can lead to algal blooms, which not only consume oxygen but can also produce toxins harmful to aquatic life and human health (Ola et al., 2023).

Nitrate concentrations further exemplified this concern, with the Agba-Ndele River showing values of 2.927 mg/l compared to the Ikiri River's 3.469 mg/l. These nutrient loads, particularly in the context of agricultural runoff, can accelerate the eutrophication process, resulting in shifts in species composition and a decline in overall water quality (Mmom et al., 2022). This aligns with the findings by Liu et al. (2022), who emphasized that nutrient enrichment from agricultural activities significantly impacts aquatic ecosystems.

pH and Electrical Conductivity

The pH levels recorded in both rivers indicate a slightly alkaline environment, which is common in freshwater systems influenced by fertilizer runoffs (Ola et al., 2023). While the pH values fell within acceptable ranges for aquatic life, any shifts toward more extreme pH levels could jeopardize the health of fish and invertebrates (Efe et al., 2020; Woke and Wokoma, 2006). Continuous monitoring of pH is essential, especially considering the potential impact of ongoing agricultural activities in the watershed.

Electrical conductivity (EC) serves as a proxy for ion concentration in the water. The AgbaNdele River’s higher EC levels suggest a greater presence of dissolved salts or pollutants, likely due to agricultural practices (Chikwendu et al., 2021). Conversely, the Ikiri River's lower EC levels could indicate better water quality management practices, although urban runoff can introduce new challenges (Adesina et al., 2023).

Implications for Water Quality Management

The disparities in water quality between the Agba-Ndele and Ikiri Rivers highlight the urgent need for targeted water management strategies. For the Agba-Ndele River, the implementation of best management practices (BMPs) in agriculture can significantly reduce nutrient and sediment runoff, ultimately improving water quality (Mmom et al., 2022). BMPs such as cover cropping, crop rotation, and buffer strips can help mitigate the impacts of agricultural runoff, promoting healthier water systems.

For the Ikiri River, enhancing urban wastewater treatment facilities and developing sustainable drainage systems is crucial to minimize nutrient loading from urban sources (Liu et al., 2022). Public education and community involvement are also vital components in promoting conservation practices that protect water quality. Collaborative efforts between governmental agencies, local communities, and researchers can lead to more sustainable management of these critical water resources (Efe et al., 2020).

In summary, the comparative analysis of the Agba-Ndele and Ikiri Rivers reveals significant disparities in water quality driven by differing land-use practices. The results underscore the complexities of managing water resources in a biodiverse and economically vital region like the Niger Delta. As anthropogenic pressures continue to evolve, ongoing monitoring and adaptive management strategies will be essential to ensure the health of these aquatic ecosystems.

CONCLUSION

This study offers an assessment of the physio-chemical parameters of the Agba-Ndele and Ikiri Rivers within the Niger Delta region of Nigeria, highlighting variations in water quality linked to various anthropogenic influences. The results reveal that the Agba-Ndele River exhibits elevated turbidity, total suspended solids, and biological oxygen demand, primarily due to agricultural runoff and related activities (Adeleke et al., 2021). Conversely, the Ikiri River demonstrates comparatively better water quality, likely attributable to effective urban water management practices that mitigate pollution from domestic sources (Nwankwoala et al., 2020).

The critical concern for aquatic ecosystems is underscored by the consistently low dissolved oxygen levels observed in the Agba-Ndele River, with a peak of 3.3 mg/l, indicating potential hypoxic conditions that threaten aquatic life (Mmom et al., 2022). In contrast, the Ikiri River maintained higher dissolved oxygen levels, averaging around 5.6 mg/l, suggesting a healthier ecosystem bolstered by improved wastewater management practices (Efe et al., 2020).

Nutrient enrichment, particularly in phosphates and nitrates, was notable in both rivers, raising concerns about eutrophication, especially in the Agba-Ndele River (Obogu et al., 2022). The phosphate levels, peaking at 6.740 mg/l, highlight a nutrient loading that can lead to harmful algal blooms and other ecological disturbances.

The analysis of pH levels revealed slightly alkaline conditions in both rivers, typical for freshwater systems influenced by agricultural runoff (Adeleke et al., 2021). Additionally, the higher electrical conductivity recorded in the Agba-Ndele River suggests increased concentrations of dissolved salts and potential pollutants, indicating a more stressed aquatic environment compared to the Ikiri River (Chikwendu et al., 2021).

In summary, the findings underscore an urgent need for targeted water quality management initiatives in the Niger Delta. Implementing best management practices in agriculture and enhancing urban wastewater treatment facilities are essential to mitigate the adverse effects of nutrient loading and sedimentation (Efe et al., 2020). Furthermore, fostering community involvement and public awareness about conservation practices is crucial for protecting these vital water resources. As anthropogenic pressures continue to evolve, ongoing monitoring and adaptive management strategies will be critical to ensure the sustainability and ecological integrity of these aquatic ecosystems for future generations (Mmom et al., 2022).

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