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Water Quality of the Okpare Community River Ughelli South LGA, Delta State, Nigeria

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ABSTRACT
The Okpare Community River in Ughelli South LGA, Delta State, Nigeria, faces severe threats from oil exploration, bunkering, and illegal refineries, resulting in oil spillages that endanger aquatic life, the environment, and human health. This research evaluates the water quality of the river, focusing on environmental conditions and potential health risks associated with heavy metal contamination. Results from in-situ water analysis reveal pH values between 6.03 and 6.96, indicating suitable conditions for aquatic life but potential ecosystem impacts due to pH fluctuations. Stable thermal conditions (28.9°C to 29.2°C) and low Total Dissolved Solids (TDS) suggest relatively unpolluted water. Turbidity values (107.10 NTU to 561.30 NTU) indicate varying degrees of water cloudiness, potentially due to sediments or pollutants. Dissolved Oxygen (DO) levels (2.10 mg/l to 5.20 mg/l) fall within acceptable ranges but highlight potential oxygen depletion risks. Ex-situ physicochemical parameters reveal varying total hardness (7.96 mg/l to 16.70 mg/l), total suspended solids (100.00 mg/l to 600.00 mg/l), and biological oxygen demand (1.20 mg/l to 3.40 mg/l). Significant heavy metal variations include notable levels of Fe, Zn, Cu, Pb, and Ni at different sampling points. Pearson's correlation analysis indicates strong relationships between turbidity and heavy metals, emphasizing potential pollution sources. Comparison with World Health Organization (WHO) standards reveals elevated zinc and copper levels, posing a moderate to high risk of adverse health effects. Elevated lead levels signal notable risks, necessitating urgent intervention. These results contribute valuable insights into the Okpare Community River's water quality, which emphasizes the importance of monitoring and managing water quality to ensure safe drinking water and safeguard the river's ecosystem.

Keywords: *Water Quality, Heavy Metal Contamination, Environmental Health, River Pollution, Okpare Olomu.*

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I. Introduction

Pollution has emerged as a pervasive global concern, particularly with the exponential growth of urban centers and industrial activities. The Industrial Revolution and subsequent technological advancements, notably in oil exploration, have significantly contributed to the escalation of pollution levels worldwide (Ite et al., 2013; Carpenter, 2019; Mahmod et al., 2020). Environmental pollution encompasses the contamination of the earth's physical and biological components to an extent that disrupts normal environmental processes (Arihilam and Arihilam, 2019). Human and natural activities introduce harmful substances into the environment, adversely affecting land, water, air, and the acoustic environment (Akhtar et al., 2021). This pollution, whether from natural or anthropogenic sources, poses threats to human and ecosystem health, urging a critical evaluation of water quality in specific locales such as the Okpare Community River in Ughelli South LGA, Delta State.

The escalating challenges of environmental pollution have transformed it into an enduring menace, posing threats to both livelihoods and sustainable development (Babatunde, 2020). The air, water, and soil, fundamental components of our environment, are indispensable to human survival, yet human activities, driven by technological and industrial progress, have led to environmental degradation (Richard et al., 2022). Of particular concern are pollutants like carbon monoxide, particulate matter, sulfur dioxide, hydrocarbons, and nitrogen oxides released into the air through various anthropogenic activities, including agricultural combustion and petroleum refining (Osuji and Avwiri, 2005). Such pollutants can have severe implications for human health and the ecological balance, making a comprehensive evaluation of water quality imperative.

The aquatic ecosystem, a crucial resource sustaining life, is linked to the Okpare Community River. This river not only serves as a habitat for diverse fish species but also provides domestic water, transportation, and construction materials, emphasizing its pivotal role in the community (Aghalino, 2015; Ogunkeyede et al., 2022). However, human activities, especially heavy metal pollution, have led to the depletion of aquatic biodiversity and threatened endemic fish species globally (Bashir et al., 2020). The Niger Delta, encompassing

the Okpare Community River, faces substantial environmental challenges due to oil and gas exploration, industrial production, and urbanization, resulting in heavy metal contamination (McGranahan et al., 2004; Ikelegbe et al., 2013; Ezeonyejiaku et al., 2017). This research aims to address these critical issues by evaluating the water quality of the Okpare Community River, focusing on heavy metal contamination and its potential impact on the ecosystem and human health. Through comprehensive in-situ and ex-situ analyses, the study aims to provide actionable insights for effective environmental management and sustainable development in the region.

The Okpare Community River, integral to the cultural, economic, and ecological fabric of Okpare, faces imminent threats from oil exploration, bunkering activities, and illegal local refineries, leading to oil spillages that jeopardize aquatic life, the environment, and human health. The river's significance in the community's identity, livelihoods, and ecosystem health calls for urgent attention to assess and address the deteriorating water quality. This research seeks to investigate the extent of heavy metal contamination resulting from land-based activities along the Okpare Community River, shedding light on potential risks and providing a scientific basis for sustainable environmental management strategies. The aim of this research is to assess and evaluate the water quality of the Okpare Community River in Ughelli South LGA, Delta State, with a specific focus on understanding the environmental conditions and potential health risks associated with heavy metal contamination.

II. Materials and Method

Study Area

Okpare River, located within the Olomu clan of Ughelli South Local Government Area, Delta State, Nigeria, is a vital natural water resource. Flowing through multiple communities, including Out-Jeremi and Okwagbe, it eventually joins the Forcados River. The area has experienced series of crude oil pollution and has experienced years of environmental pollution due to crude oil bunkering and illegal refining (Edjere and Asibor, 2020). During refining, residues are disposed of into the nearby water body thereby impacting the quality of the water which is often used for domestic, fishing and recreation purposes like swimming by indigenes of the community (Idibie and Idibie, 2021). There is a need for monitoring of the river to avoid public health implications hence, the need of this study. Samples were collected from 5 points in the Okpare-Olomu river, and tagges S1, S2, S3, S5 and S10.

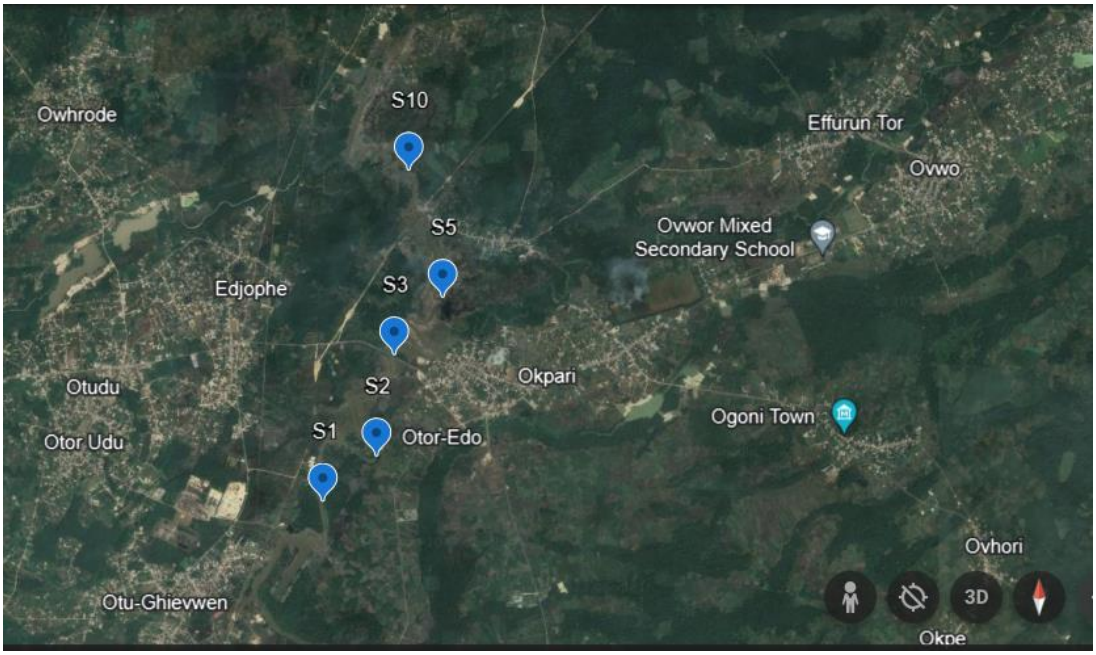

Figure 1: Map of study area showing the sampling coordinates

Sample Collection

Samples were collected in the month of April, 2022, with the aid of plastic containers. Surface water samples intended for heavy metal analysis were immediately treated with 1ml of nitric acid (HNO3) after field collection and stored in plastic bottles. Surface water samples designated for Biochemical Oxygen Demand (BOD) analysis were collected in glass bottles and preserved in ice packs to maintain their integrity during

transportation. Surface water samples allocated for physicochemical analysis were also collected in plastic bottles and preserved in ice packs to ensure accurate assessment.

In-situ Assessment of Physicochemical Parameters

In-situ measurements were taken for temperature (°C) using a Hanna Temperature Meter, with 50 ml of water in a 100 ml plastic beaker. The meter's probe was used for readings. For electrical conductivity and Total Dissolved Solids (TDS), a versatile Extech Instrument (4-in-1) was employed, with the probe immersed for 3 minutes before recording µS/cm for conductivity and mg/l for TDS. Dissolved Oxygen (DO) concentration was determined in-situ via the Winkler method (Titrimetric) using a standard DO bottle, and Turbidity (NTU) was measured in-situ with a Turbidity Meter (Model 800) after calibration. The water sample was placed in a turbidity bottle, inserted into the instrument's chamber, and the recorded value obtained after stabilization following a 30-minute warm-up period.

Ex Situ Assessment of Water Quality Parameters

Biological Oxygen Demand (BOD), an indicator of organic matter, was assessed using the dilution method (APHA 5210 B), measuring oxygen consumption over a fixed 5-day period. Chemical Oxygen Demand (COD) was determined through the Open Reflux Method (APHA 508), calculating mg/l from titration results. Total Suspended Solids (TSS) were obtained via filtration (APHA 208). Bicarbonate Alkalinity was determined using a titrimetric method with H_2SO_4, expressed as mg/l. Salinity, measured as chloride (Cl-), utilized $AgNO_3$ titration with results expressed in mg/l. Total Hardness, Calcium Hardness, and Magnesium Hardness were determined through EDTA titration, with magnesium hardness derived by subtracting calcium hardness from total hardness. Sulphate levels were determined turbidimetrically. Nitrate levels were assessed by evaporating water samples and measuring absorbance at 410 nm. Phosphate levels were determined by measuring absorbance at 880 nm after chemical treatment. Ammonium levels were assessed through a phenate method using spectrophotometry. For Heavy Metals analysis, wet oxidation and Atomic Absorption Spectrophotometry (AAS) were employed, with prior digestion using a 1:1 portion of HNO_3 and HCl before AAS analysis.

Statistical Analysis

Descriptive statistics were applied to the replicates of the concentrations determined using Microsoft Excel 2016.

III. Results and Discussion

Concentration of Physicochemical Parameters in Water Samples from the Okpare Olomu River

The samples collected were subjected to in-situ water analysis. The concentrations of pH, salinity, turbidity, electrical conductivity (EC), dissolved oxygen (DO), total dissolved solids (TDS), and temperature are all shown in Figure at the sampling points (S1, S2, S3, S5, and S10) within the Okpare Community River in Ughelli South LGA, Delta State.

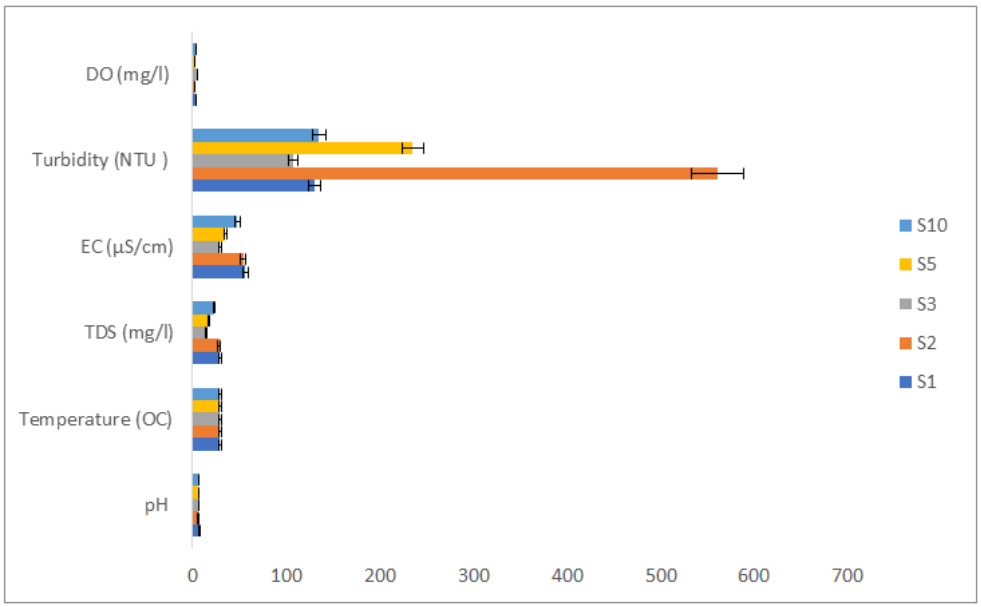

Figure 3: In situ parameters conducted on the sample in-situ

The pH values of the water samples range from 6.03 to 6.96, indicating slightly acidic to near-neutral conditions, generally suitable for aquatic life but highlighting the potential for ecosystem impact with pH fluctuations. Water temperature at the sampling points shows consistency, ranging from 28.9°C to 29.2°C, suggesting stable thermal conditions in the river, crucial for various aquatic processes. The concentration of TDS was recorded to between 15.00 mg/l and 29.00 mg/l, indicate a relatively low presence of dissolved solids in the water. EC, ranging from 29.00 µS/cm to 56.00 µS/cm, reveals moderate electrical conductivity, offering insights into overall ion concentration. Turbidity values, reported between 107.10 NTU and 561.30 NTU, suggest varying degrees of water cloudiness, potentially indicating the presence of sediments or pollutants that could impact water quality and aquatic life. Dissolved Oxygen (DO) levels ranging from 2.10 mg/l to 5.20 mg/l fall within acceptable ranges for aquatic life but signal the importance of monitoring potential oxygen depletion risks.

The micronutrients in the study

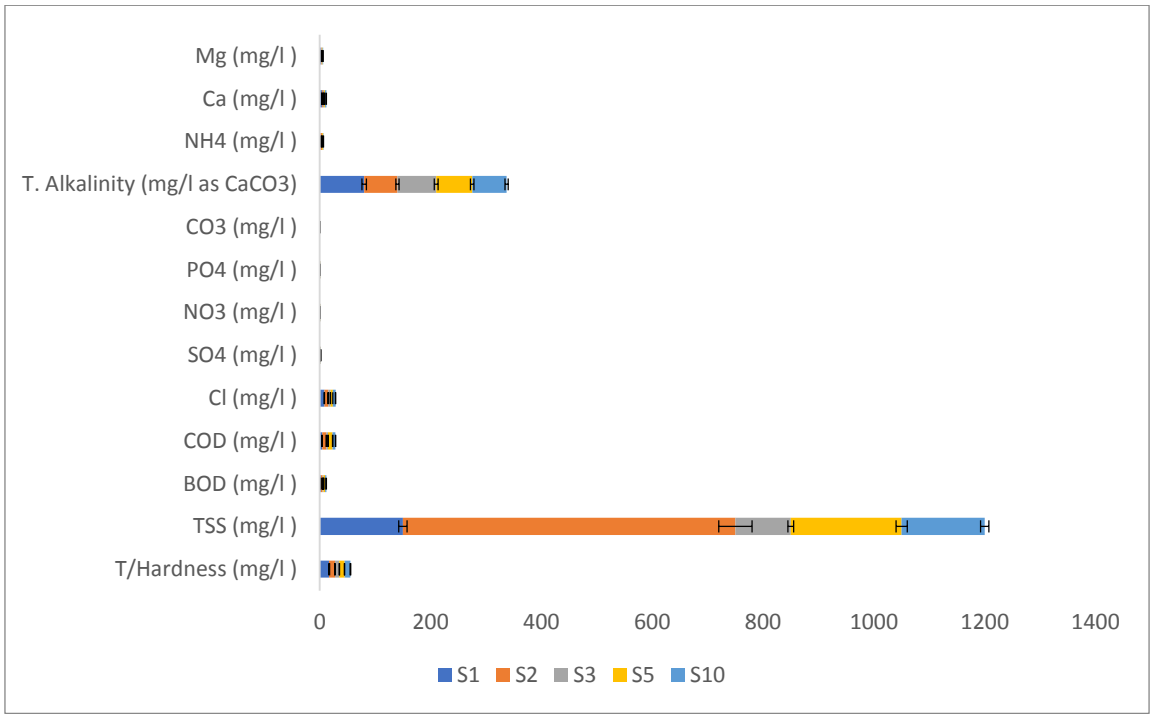

Figure 4: Ex-situ physicochemical Parameters of water samples from Okpare Olomu

The ex situ water quality parameters in the Okpare Community River reveals varying levels of total hardness (T/Hardness) across samples, ranging from 7.96 mg/l to 16.70 mg/l (S3 and S1, respectively). Total hardness, influenced by calcium and magnesium ion concentrations, is a critical factor for assessing water suitability for drinking or industrial use. Lower hardness levels are generally preferable for drinking water, while higher levels may require additional treatment. Additionally, significant disparities in total suspended solids (TSS) are evident, with values ranging from 100.00 mg/l to 600.00 mg/l (S3 and S2, respectively). Elevated TSS levels can indicate poor water clarity, potentially stemming from sedimentation, pollution, or other environmental factors. Such conditions pose challenges for water treatment processes and can have detrimental effects on aquatic ecosystems, emphasizing the need for measures to mitigate TSS levels in the Okpare Community River and preserve its ecological balance. Lastly, the assessment of biological oxygen demand (BOD) reveals values ranging from 1.20 mg/l to 3.40 mg/l (S3 and S2, respectively). Elevated BOD levels suggest the presence of organic pollution, potentially leading to oxygen depletion in the water and endangering aquatic life. Managing and reducing sources of organic pollution is crucial to safeguarding the Okpare Community River's water quality and ecosystem health.

Concentration of Heavy Metals in Water Samples from the Okpare Olomu River

The results of heavy metal analysis in water samples from the Okpare-Olomu river is shown in figure 5 below. As, Ba, V, Co, and Hg all had concentrations beyond detectable limit in the study which was (<0.001), with the exclusion of S5, which had concentrations of 0.013 and 0.008 mg/L for As and Co respectively.

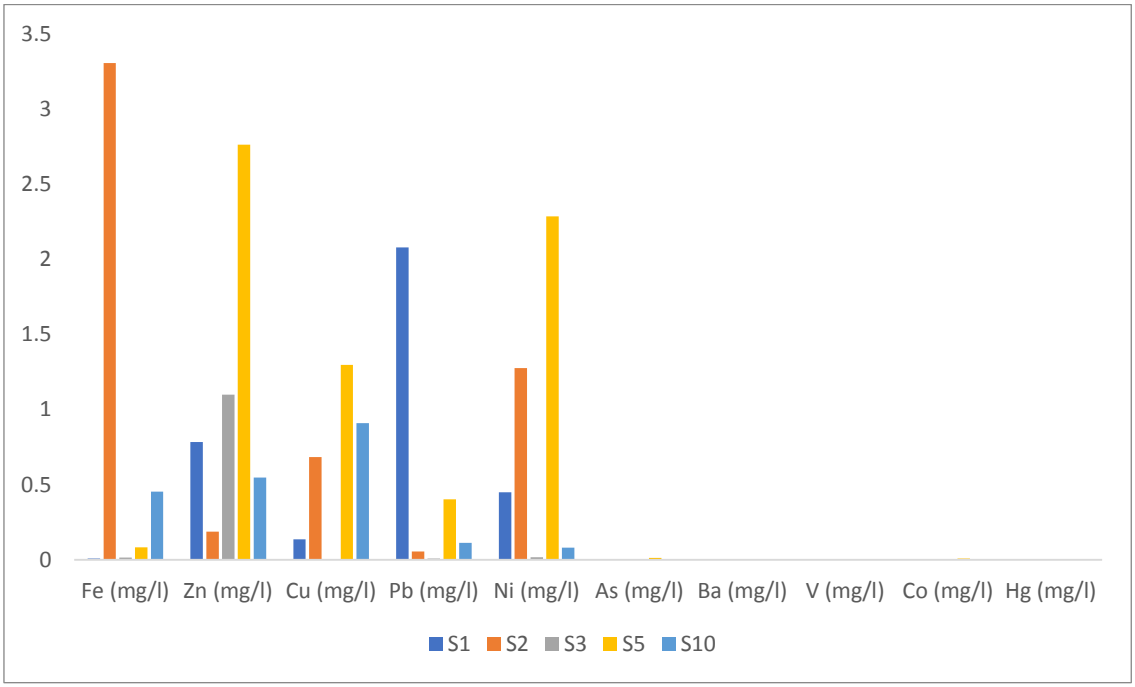

Figure 5: Heavy Metal concentrations of water samples in Okpare Olomu river.

The assessment of heavy metal concentrations in the Okpare Community River water samples reveals variations at the different sampling points. Notably, at sampling point S2, Fe concentration was relatively high, measuring 3.305 mg/l, suggesting potential contamination sources in the vicinity that warrant further investigation. Zn concentrations also varied, with the highest level recorded at S5 (2.762 mg/l), indicating a potential pollution source upstream and emphasizing the need for environmental management practices. Cu exhibited detectable levels at S1 (0.136 mg/l), necessitating further assessment of potential pollution sources in the upstream areas. Pb concentrations were generally low, yet the highest level was found at S1 (2.079 mg/l), highlighting the importance of continued monitoring and mitigation efforts to prevent harm to the environment and public health. Ni concentrations varied, reaching the highest level at S5 (2.285 mg/l), underscoring the importance of identifying and managing potential pollution sources. As mentioned earlier, As, Ba, V, Co, and Hg were mostly not detected or found at concentrations well below 0.01 mg/l and 0.001 mg/l, indicating minimal or absent presence, which is favorable for water quality and environmental health.

Pearson's Correlation Analysis

The Pearson's correlation analysis of the water samples from the water samples in table 1 below.

Table 1: Pearsons correlation analysis

	Turbidity	Zn	Cu	Fe	Pb	Ni	Ba	V	TDS	EC	DO	pH	Temperature
S2	0.99	0.87	0.86	-0.85	-0.8	0.89	-0.8	-0.79	-0.87	-0.86	0.83	-0.89	1
S5	-0.97	-0.86	-0.95	0.85	0.83	-0.91	0.8	0.77	0.86	0.95	-0.87	0.95	-0.96
S1	-0.96	-0.82	0.91	-0.84	-0.8	0.87	-0.77	-0.75	0.82	0.95	0.83	0.93	-0.97
S3	-0.9	-0.84	-0.95	0.84	0.83	-0.9	0.78	-0.76	0.84	0.99	-0.88	0.79	-0.89
S10	-0.94	0.61	-0.71	0.66	0.61	-0.76	0.48	0.44	0.57	0.58	-0.79	1	-0.9

The Pearson's correlation analysis on water quality parameters in the Okpare Community River, Ughelli South LGA, Delta State, reveals significant insights. Turbidity shows strong positive correlations with Zn, Cu, and Ni, suggesting that elevated turbidity links to higher concentrations of these heavy metals. Conversely, Fe exhibits a strong negative correlation with turbidity. DO correlates significantly with pH, temperature, and EC, indicating positive influences of higher pH and temperature on DO, while EC is negatively associated. Additionally, pH is strongly negatively correlated with turbidity, implying that higher pH corresponds to reduced turbidity. Temperature is positively correlated with DO and negatively with turbidity, suggesting higher temperatures associate with increased DO and reduced turbidity. These findings highlight the

relationships between water quality parameters and underscore the need for targeted pollution mitigation efforts to protect the aquatic ecosystem and public health in the Okpare Community River. Understanding these correlations is crucial for predicting and managing fluctuations in water quality, emphasizing the importance of monitoring and managing water quality to ensure safe drinking water and safeguard the river's ecosystem and biodiversity.

The assessment of heavy metal concentrations at different sampling points further adds depth to the study. Notably, elevated levels of Fe at S2 and Zn at S5 suggest potential contamination sources which could possibly be from crude oil pollution, emphasizing the need for environmental management practices. Detectable levels of Cu at S1 and the highest Pb concentration at S1 underscore the importance of continued monitoring and mitigation efforts. Ni concentrations vary, reaching the highest at S5, while the absence or minimal presence of As, Ba, V, Co, and Hg is favorable for water quality and environmental health. Comparatively, this study as well as that conducted by Onajite and Ovie (2022), contributes valuable insights into the Okpare Community River's water quality, providing a baseline for future comparisons with other studies in river bodies experiencing crude oil pollution. The unique parameters assessed here offer an understanding of the ecological dynamics, enabling an evaluation of the river's health and potential pollution sources.

While the in-situ analysis indicates generally suitable conditions for aquatic life, the presence of elevated levels of zinc, copper, lead, vanadium, and mercury, as compared to World Health Organization (WHO) standards in table 2 below, poses significant health risks for the community.

Table 2: Comparison of Heavy metals in this study to WHO standards (Fewtrell and Bartram, 2001)

Parameter	Heavy metals range (mg/l)	WHO Guideline Value (mg/l)	Risk Classification	Potential Health Effects
Fe	0.009-3.305	0.3	Low	Minimal health risk, essential nutrient
Zn	0.187-2.762	0.05	Moderate	Potential adverse health effects at high levels
Cu	0.001-1.297	0.02	High	Risk of toxicity and adverse health effects
Pb	0.008-2.079	0.01	High	Significant risk of toxicity and health impacts
Ni	0.017-2.285	0.02	Moderate	Moderate risk of adverse health effects
As	<0.001-0.013	0.005	Low	Minimal health risk, but long-term exposure concern
Ba	<0.001	0.01	Low	Minimal health risk, naturally occurring
V	<0.001	0.03	Moderate	Potential adverse health effects at high levels
Co	<0.001-0.008	0.01	Low	Minimal health risk, essential nutrient
Hg	<0.001	0.001	High	Significant risk of toxicity and health impacts

Zinc and copper concentrations exceeding WHO guidelines indicate a moderate to high risk of adverse health effects, urging immediate investigation and monitoring. High lead levels signal a notable risk, necessitating urgent intervention to prevent severe health impacts.

IV. Conclusion

In conclusion, the assessment of water quality in Okpare Community River, situated within Ughelli South LGA, Delta State, has shed light on significant concerns that warrant immediate attention. The findings of this assessment underscore the critical importance of maintaining and improving the quality of this vital water resource. The results of the assessment have revealed deviations from established water quality standards in several parameters, indicating the presence of pollution sources that have impacted the river's ecosystem and pose potential health risks to the local community. The contamination sources, including agricultural runoff, potential industrial discharges, oil exploration activities that causes oil spillage and illegal bunkering, such demand prompt mitigation strategies to prevent further degradation of water quality. The implications of poor water quality extend beyond the immediate ecosystem, affecting both the ecological balance and the well-being of the community that relies on the river for various purposes. It is imperative that community engagement and awareness initiatives are undertaken to educate residents about responsible water use practices and the importance of preserving water quality. Sustained monitoring efforts are essential to track progress and adapt strategies as conditions evolve. By taking proactive measures guided by this assessment's insights, Okpare Community River can be on a path toward restoration and sustained water quality. Ultimately, the successful

rehabilitation of the river's water quality will safeguard the environment, protect public health, and secure the well-being of both present and future generations.

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