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Comparative Physico- Chemical Parameters of Selected Water Bodies in Warri and its Environment

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ABSTRACT

This study aimed to assess the physicochemical parameters and the degree of water degradation in selected water bodies in Warri and its environment. The water samples were collected from four strategic locations (DSC Aladja, NPA, NNPC Terminal, and Ekpan) and labeled A, B, C, and D, respectively. The samples were analyzed for physico-chemical parameters using standard analytical techniques, including an Atomic Absorption Spectrophotometer (AAS) in accordance with regulatory standards. Key findings revealed elevated concentrations of Turbidity (82 – 135 NTU), COD (153.55 – 260.50 mg/L), BOD (24.10 – 35.00 mg/L), and DO (2.80 – 5.40 mg/L). The results for the heavy metals Lead (Pb) and iron (Fe) are 0.00 ± 0.50 mg/L and 1.003 ± 1.951 mg/L, respectively. Comparison of results with FMENV and NUPRC standards indicates that key parameters such as BOD, COD, Oil and grease for sample C, and turbidity are at high concentrations, indicating a high pollution load in the Warri River. High ammonia concentrations further suggest potential harm to aquatic life. Also, the high concentration of oil and grease at the NNPC terminal, due to oil loading and spills, causes the oil film to coat and destroy algae and other plankton. Therefore, the river water is not fit for consumption or swimming, especially at the NNPC terminal sites, due to its severely high impurity levels compared to other sites, and is thus highly degraded.

Keywords: Water pollution; Physicochemical parameters; Heavy metals; Surface water quality; Oil contamination.

1.0. Introduction

Water is the most crucial requirement for human existence (Anderson et al., 2023). It is a renewable resource that holds significant value in the sustenance of all kinds of life on earth, economic development, and general well-being (Jurczynski et al., 2024; Ochuko et al., 2023). Water pollution is a widespread issue in many parts of the world (Nguyen et al., 2023). Water pollution has been increasing, posing a growing danger to inhabitants. This has permeated our water system, especially with wastewater dumps. This problem causes various forms of environmental pollution, particularly in water, in Warri and Its Environs. The entry of

pollutants into water bodies has degraded the quality of clean water, leading to water pollution (Aghoghovwia et al., 2011). River water sources can be influenced by natural and anthropogenic factors, including agricultural activities and urbanization (Nguyen et al., 2023; Singh et al., 2024). A prominent risk of oil is the environmental degradation associated with its production and use (Ambrose et al., 2020). In Nigeria, oil field pollution presents the greatest risk from the oil industry. Nigerian waters are polluted by well blowouts (Ifesinachi, 2018), various discharges of production wastes and refinery effluents on land and into water, leaks from pipelines and storage tanks, and spills during storage and loading operations at terminals (Audu et al., 2024; Chinedu et al., 2018).

Communities residing near production sites, refineries, and pipelines have had to deal with polluted rivers. Oil, like many other pollutants in water, consumes dissolved oxygen during degradation, and a lack of oxygen could be deadly to the organisms living in water (Ambrose et al., 2020). More so than in developed nations, the results in Nigeria indicate that waste from oil fields, refineries, pipelines, and storage tanks increases the risk to human health due to greater contamination of drinking water by petroleum (Oyeyemi et al., 2024 & Jiang et al., 2021). Anthropogenic heavy metals are typically present at higher concentrations and may have toxic effects on aquatic biota (Yi et al., 2016; Ikpesu et al., 2021). Heavy metals are highly fatal when consumed even at low concentrations (Adewumi et al., 2023).

This study, therefore, aims to conduct comparative physicochemical studies of the river waters in Warri and its environment, to suggest possible remedial measures for such pollution, and to apply, where possible, necessary Governmental and industrial policies.

2.0. Materials and Methods

2.1. Sampling

2.1.1. Sample locations from the study area

The Warri River originates from Utagba-Uno in the Ndokwa Local Government Area and flows through Agbarho, Warri, and Ekpan, traversing the rainforest belt of Forcados before ultimately discharging into the Atlantic Ocean. Important landmarks along this stretch of the river are Ovwian and Aladja (DSC steel town) and Warri ports (NPA) (Aghoghovwia et al., 2011).

2.1.2. Sampling Collection and Preparation

Four sampling points were selected for this study: DSC Aladja River, NPA River, NNPC Terminal, and Ekpan River, labelled A, B, C, and D, respectively. Water samples were collected using a calibrated water sampler into clear containers. To prevent contamination, all sampling materials and containers were sterilized using an autoclave and rinsed with the river water before collection. For heavy metals determination, sampling bottles were rinsed with solutions of one part nitric acid to four parts of water, followed by a substantial amount of distilled water, and samples were preserved with a 1:1 Nitric acid solution (Lukubye and Andama, 2017; Shi et al., 2025).

2.2. Physicochemical Analysis

Temperature, pH, Turbidity, TDS (Total Dissolved Solids), DO (Dissolved Oxygen), and Conductivity were determined in situ due to their ease of measurement and their tendency to vary with time and environmental conditions (Abhijeet, 2025). DO bottles were used to collect samples for DO analysis and fixed with winker A and winker B solutions. Samples were kept in a cooler with an ice pack and transported to the laboratory. Several calibrated standard

instruments in accordance with the American Society for Testing and Materials (ASTM) were used. Other water parameters not determined on the spot were sent for laboratory analysis. These parameters included BOD, COD, Oil and grease, Ammonia, and heavy metals, such as zinc (Zn), iron (Fe), lead (Pb), and copper (Cu) (Lebbie et al., 2025). Water analysis was carried out in a standard analytical laboratory. Physicochemical parameters. Dark and transparent bottles were used for BOD and oil-and-grease collection, respectively. Water samples for BOD_5 determination were collected in black polythene bags and incubated for 5 days at 20ºC prior to analysis. Field instruments were frequently calibrated against international standards (Olorunda et al., 2026). Physicochemical parameters (Ibe et al., 2026) determined in the surface water samples include temperature, Electrical Conductivity and pH (electrometric method), turbidity (Nephelometric method), Dissolved Oxygen, DO and Biochemical Oxygen Demand, BOD_5 (Winker Azide Modification Titrimetric Method), Oil and Grease (Extraction Method) Total Suspended Solids TSS (Photometric Method), Total Dissolved Solid, TDS (Electrical Conductivity), Ammonia (Direct Nesslerization Method), Sulphate (Turbimetric Method), Total iron (Phenanthroline Method), and Heavy Metals (Atomic Absorption Spectrophotometer).

3.0. Results and Discussion

3.1. Physico-Chemical Parameters of Surface Water

Table 1 shows a range of values of some physicochemical parameters obtained in analyzing selected sampled surface water within Warri and environs

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Table 1: Physico-Chemical characteristics of sampled surface water.

Parameters	Unit	A	B	C	D	Mean ± δ	WHO (2022)	FMENV/ NUPRC
pH	-	6.42	6.55	5.81	6.35	6.28±0.28	6.50-8.50	6.5-8.5
Temperature	ºC	27.10	27.50	28.80	27.90	27.83±0.63	30.00	40
Turbidity	NTU	135.00	120.00	26.50	82.00	90.88±41.89	5 – 25	15
TDS	mg/L	29.32	31.05	26.90	47.60	33.72±8.15	1000.00	<2000
Conductivity	µS/cm	43.20	47.10	77.00	111.60	69.73±27.49	200-1000	-
BOD	mg/L	24.10	25.55	35.00	27.00	27.91±4.22	4.00	10.00
COD	mg/L	153.55	159.65	260.50	157.65	182.84±44.89	40.00	40.00
DO	mg/L	2.80	3.80	4.40	5.40	4.10±0.94	4.00	6.00
Oil & Grease	mg/L	3.22	4.72	34.65	8.86	12.86±12.75	-	10.00
TSS	mg/L	0.283	0.311	0.401	0.284	0.320±0.048	20.000	30.000
Ammonia	mg/L	2.047	2.359	2.627	0.878	1.978±0.667	1.500	0.200
Sulphate	mg/L	7.159	11.606	4.899	6.255	7.480±2.514	200.000	200.000

The pH values ranged from 5.81 to 6.55 across sample locations (Table 1). The pH of sample B (6.55) falls within acceptable limits, whereas A (6.42), C (5.81), and D (6.35) are below the lower limit permissible limits of 6.5 – 8.5 as shown in Table 1. The

reduced mean pH (6.28±0.28) values across all three locations may result from an acid-forming industrial deposit. A river with an acidic pH could negatively impact aquatic habitats intolerant of low pH and may also pose health risks to humans if the water is consumed. WHO (2022) emphasizes that pH outside the recommended range can affect taste, corrosion potential, and treatment efficiency (Okobiebi et al*.,* 2021).

The minimum temperature of 27.1ºC was recorded at river A, while the maximum temperature was recorded at river C, with an average temperature of 27.83±0.63 °C across locations (Table 1). The observed temperature levels were found within the recommended standard.

The mean (90.88±41.89 NTU) and individual turbidity values exceed WHO and FMENV/NUPRC limits (Table 1). Sample C (26.50 NTU) is slightly above the WHO upper limit, while A, B, and D show very high turbidity. Increased turbidity reduces the penetration of sunlight into river water, hampering phytoplankton photosynthesis.

When the obtained values are compared with the WHO and FMENV/NUPRC guidelines, all samples fall within the limits, with an average TDS of 33.72±8.15 mg/L. This demonstrates that the surface water has a low concentration of dissolved solids. A comparable range for TDS has been documented (Aderemi et al., 2011).

The conductivity of the surface water sample falls within the WHO acceptable limits (Table 1). These relatively low average values (69.73±27.49 µS/cm) correspond to low TDS levels, as dissolved salt ions are responsible for electrical Conductivity (Aliyu et al., 2018; Nguyen et al., 2023).

The BOD values of A to D ranged between 24.10mg/L to 35.00mg/L. These values exceed the WHO and FMEVN/NUPRC permissible limits (Table 1). The elevated BOD levels (27.91±4.22 mg/L) indicate the presence of substantial organic contaminants in surface water. Such conditions may pose a health risk to humans who consume the river water, as the water is significantly polluted, particularly at the NNPC terminal sampling point (sample C).

COD values are extremely high (182.84±44.89 mg/L) in all samples (Table 1), especially in sample C (260.5 mg/L), indicating a high concentration of oxidizable pollutants. The elevated COD values relative to BOD suggest the presence of non-biodegradable chemical contaminants, including petroleum residues, detergents, industrial organics, and other chemically stable pollutants. In oil-producing environments, elevated COD is often strongly linked to hydrocarbon contamination (Popoola et al., 2023).

A comparison of the obtained Dissolved Oxygen (DO) values (4.10±0.94 mg/L) with the WHO and FMENV/NUPRC standard threshold indicates that samples A and B fall within an acceptable range, whereas samples C and D slightly exceed the WHO permissible limit (Table 1). The low DO reflects high organic pollution, elevated microbial respiration, and temperature. Studies show that DO decreases as turbidity and organic load increase (Kumar et al., 2019; Adestina et al., 2024).

Based on the analytical results, the oil and grease concentration ranged from 3.22 mg/L to 34.65 mg/L (Table 1). The surface water sample from the NNPC terminal contains a higher proportion of oily matter, primarily due to oil-loading activities in the vicinity. The concentration of sample C exceeds the FMENV/ NUPRC permissible standard of 10mg/L. The presence of such oily matter imparts undesirable colour, unpleasant taste and offensive odour to the surface water.

Therefore, the water is unfit for human consumption due to high contamination.

A comparison of the obtained values with the WHO and FMENV/NUPRC standards of 20 mg/L and 30 mg/L indicates that all TSS values are far below both limits (Table 1), indicating a low mass of suspended solids. However, turbidity is high, suggesting the presence of fine colloidal particles rather than heavy sediments.

The concentrations of heavy metals, including Zinc (Zn), Iron (Fe), Lead (Pb), and Copper (Cu), in the surface water samples are presented in Table 2.

3.2. Heavy Metals Analysis

Table 2: Levels of Heavy metals (mg/L) in Surface water across Locations

Heavy Metal	Unit	A	B	C	D	Mean ± δ	WHO (2022)	FMENV/ NUPRC
Lead	mg/L	<0.001	<0.001	0.500	<0.001	0.126±0.216	0.100	0.05
Zinc	mg/L	<0.001	0.048	0.131	0.179	0.090±0.070	3.000	1.000
Total Iron	mg/L	1.840	1.951	0.686	1.003	1.370±0.539	0.300	1.000
Copper	mg/L	<0.001	<0.001	0.100	<0.001	0.026±0.043	2.000	1.500

The measured Zn value was below the permissible limit relative to the standard guideline values, indicating it would have no significant impact on the river water due to its relatively low concentration. The observed Fe values (1.370±0.539 mg/L) exceeded the WHO limit across all locations, as shown in Table 2. This indicates that the river water contains high levels of iron, which could pose a challenge for certain industrial operations. The analysis further revealed that Pb concentrations were below detectable limits in three locations and at 0.5 mg/L in C. The NNPC terminal surface water sample (Sample C) exceeded the standard limit. This shows that Pb concentration exists in the surface water, indicating contamination from industrial waste, fuel residues, or metal corrosion (Abali et al., 2023; Paul, 2017). Conversely, Cu concentrations had no significant negative effect on surface water quality, as they remained below the FMEVN/NUPRE and WHO permissible limits of 1.500 mg/L and 2.000 mg/L (Varol, 2020).

4.0. Conclusions

The study revealed that not all parameters were within the WHO permissible limits. From the results, the water in Warri and its environment are highly polluted and very turbid, and thus could be destructive to aquatic life. The NNPC terminal has a severity greater than that of any other and is thus highly degraded.

Stricter enforcement of environmental regulations and improved industrial wastewater treatment are essential to reduce pollution. Regular water quality monitoring and the adoption of remediation techniques, such as bioremediation, are recommended. Public awareness and further research on contamination trends and ecological risks are also necessary for sustainable water management.

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