World Journal of Environmental Biosciences
Available Online at: **www.environmentaljournals.org**

Volume 14, Issue 1: 21-28

https://doi.org/10.51847/MCmrpuO9Qe

ISSN 2277- 8047

Microbial and Physicochemical Quality of River Water in Delta State, Nigeria

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ABSTRACT

Water is essential to man as a source of life and well-being. Water make up 70% of the body mass index. Over 71% of the earth is made up of water but only a little is potable and available for man's use. The sources of water to man include ground water, surface water and so on. River water is a vital source of water to the rural and urban communities and need to be preserved from pollution. The study investigated the microbial load and physicochemical parameters of ten rivers across Delta State. Microbial quality and Physicochemical analyses were determined by standard methods. Results showed that the total bacterial count of water samples were within the range of 5 ×10^{-4} cfu/ml, and the least was 1.0 ×10^{-3} cfu/ml. Bacteria isolated included Bacillus spp, Klebsiella pneumoniae, Staphylococcus aureus, Proteus spp Escherichia coli, Pseudomonas aeruginosa, Streptococcus spp and Enterobacter spp. Coliform count varied with the rivers sampled. Physiochemical results also varied with the river. Temperature ranged from 27-28 °C, pH (6.30-7.9), Dissolved Oxygen (5.3-7.40mg/L), B.O.D (2.11-3.60mg/L), Conductivity (15-37 µs/cm), Colour (from cloudy to clear), TDS (2.14-8.41mg/L), S.S (0.19-4.46 mg/L), Hardness (0.11-16.1 mg/L), Pb (0.11-0.28 ppm), chloride (0.96-3.03), Zn (0.32-2.80 ppm), Cu (0.32-2.16 ppm), Nitrate (0.90-2,61 ppm), Cd (0.01-0.04 ppm) and Cr (0.01-0.07 ppm). Pathogenic bacteria were detected in the river samples. Though physicochemical results show that water is safe for domestic use apart from a few that had heavy metals content above the standard limit, there is a need for the population to be educated on pollution control and water disinfection before use.

Keywords: *River water, Microbial quality, Physicochemical parameters, Delta State, Nigeria*

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Received: 07 January 2025
Accepted: 17 March 2025

INTRODUCTION

Water is required by man for nourishment and recreation. Water is fundamental to life on this planet and there is no substitute as it serves man in different ways. Water is significant for mankind's survival and societal progression (Alico & Dragonjac, 2018; Dhanasekar *et al*., 2022). Water is essential to life functions, as it is important for cooling irrigation systems in agricultural practices, movement of humans and goods and services and food production. Natural waters serve as sources of recreational waters and their potability is usually improved by the frequency with which the water is changed and disinfected with chlorine. Minimal quantity, about 1 ppm chlorine is used to avoid irritation of skin and eyes (Cairns & Dickson, 2021; Sheshadri *et al*., 2024).

Water is very important for the survival of human beings, yet also serve as a medium for the transmission of diseases. It is difficult to maintain the potability of surface water, and as, such are prone to microbial and chemical contamination. River water is polluted due to non-functional septic tank systems and inadequate solid waste disposal methods (Arnone & Walling, 2021; Weerasinghe *et al*., 2023; Figueroa-Valverde *et al.*, 2024). Records show that water borne diseases are responsible for more than two million deaths yearly, protozoa, bacteria and viruses are the major water-borne pathogenic microorganisms. While typhoid fever, *Escherichia coli* infections, bacillary dysentery, salmonellosis, Campylobacteriosis, Legionnaires' disease, cholera, leptospirosis, botulism and typhoid fever are common water-borne microbial diseases (Lee *et al.,* 2022; Pushkin *et al.*, 2023).

The development of dams led to the creation of reservoirs which in turn have provided water for agricultural purposes, domestic needs and industries. The use of rivers as dumping sites for industrial and domestic waste and use of river banks for open defecation might lead to microbial contamination. It became necessary to evaluate the quality (microbial and physicochemical) of selected surface water in Delta State, especially when the microbial and physicochemical of soil had been initially investigated (Adomi & Morka, 2020; Zhang *et al*., 2022; Jiang *et al*., 2024).This investigation may provide data for future research since people are using water collected from these sources directly without disinfection for domestic and agricultural purposes due to a shortage of water (Olatunde & Ayandele, 2018).

MATERIALS AND METHODS

This study was carried out in five communities in Delta State. The sampled communities were; Abraka, Obiaruku, Eku, Kwale and Warri at geometric locations which include, 5°44'46N 6°7'43E, 5°50'46N 6°7'43N, 5.7361°N 5.9357°E respectively

(Figure 1) during raining season in May and June The rivers are surrounded with vast vegetation and exposed to direct sunlight. The major occupations of the indigenes of these communities are fishing, crop farming, trading and other industrial activities in Warri.

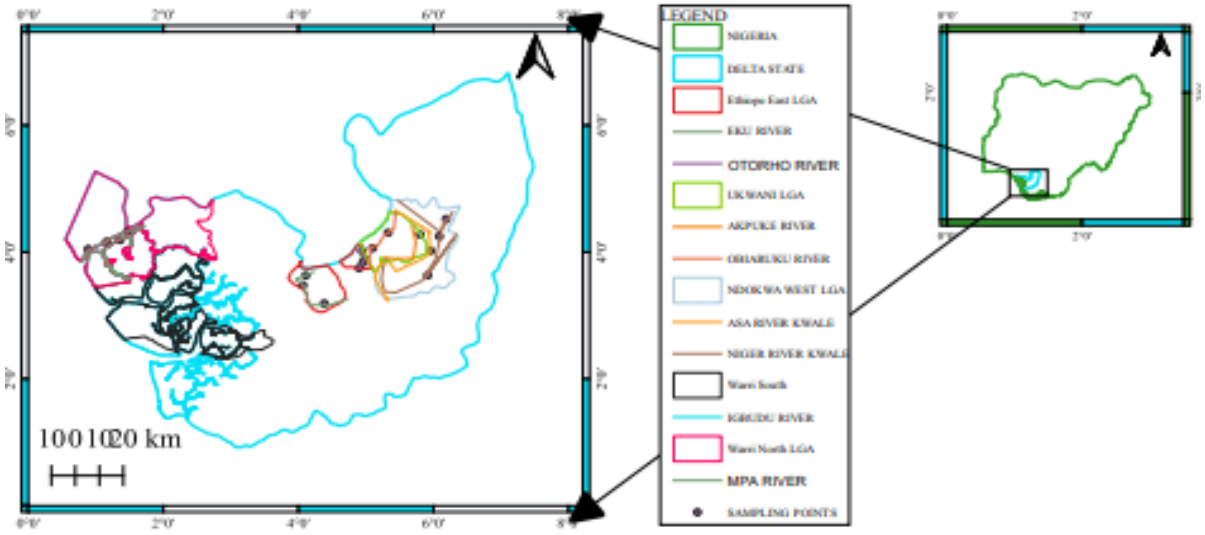

Figure 1. Map of Delta State showing the study area

Collection of samples

A total of ten (10) river samples were collected. Each was collected from four points of the rivers aseptically into sterile cans and pooled together to make a representative sample and labelled as sample A to J respectively. The sterile cans were covered immediately, placed in ice packs and taken to the laboratory for analysis.

Determination of microbial load

Serial dilution

This was carried out following the procedure reported by Cheesbrough (2006). A nine-fold serial dilution was carried out using standard procedures. The sterile test tubes, each contained 9ml of normal saline. One milliliter of the water sample each was drawn with a sterile pipette and placed in each of the test tubes containing 9ml of the sterile normal saline and shaken, one milliliter of mixture from the first test tube was drawn and transferred to the second test tube and rocked. This procedure was repeated aseptically until the ninth test tube (10^{-9}). There after 1ml was withdrawn from the last test tube and discarded. Dilution factors of 10^3, 10^6 and 10^8 were used in each set of water samples. Each set of sample was inoculated onto freshly prepared media using the pour-plating technique. Nutrient and MacConkey agar plates were labelled and incubated at 37^0c for 24h. for the total heterotrophic count and Coliform count of the sample.

Most probable number

2This method is mostly used to detect the presence of coliforms in water (Fewtrell & Bartram, 2001; Shenoy *et al*., 2023). The MPN procedure used involved using three sets of test tubes of MacConkey Broth for the estimation of the coliforms population. A 0.1 ml, 1.0 ml, and 10 ml volume are added to the MacConkey Broth medium and incubated at 37^oC for 24 hours. The level of contamination is indicated by a maximum of one positive tube out of three tubes containing 10 ml of water sample per tube. The test result for the 3 test tubes is matched with the Standard MPN Table to estimate the total coliform

Presumptive test

In the initial phase, the presumptive test was conducted to assess the presence of coliform bacteria in the river water samples. The process began with the serial dilution of the samples, followed by inoculation into a series of tubes containing lactose broth. These tubes were incubated at a temperature of 35-37°C for 24-48 hours. After incubation, the tubes were closely examined for any signs of gas production, turbidity, or colour change, which would indicate the potential presence of lactose-fermenting bacteria. The occurrence of positive results was recorded based on the number of tubes showing these signs at each dilution level.

Confirmed test

To verify the findings from the presumptive test, a confirmed test was carried out. In this step, samples from the positive presumptive tubes were transferred into tubes containing Brilliant Green Lactose Bile (BGLB) broth. The inoculated tubes were then incubated at 35-37°C for an additional 24-48 hours. The presence of gas production in these tubes served as confirmation of coliform bacteria, thereby affirming the initial detection.

Completed test

Following the confirmed test, the completed test was performed to ensure the accurate identification of the detected organisms. Samples from the confirmed test tubes that showed positive

results were streaked onto Eosin Methylene Blue (EMB) agar. The plates were incubated at 35-37°C for 24-48 hours. After incubation, the plates were examined for colonies exhibiting characteristics typical of coliforms. Further identification was conducted through additional tests, including Gram staining and biochemical assays, to conclusively determine the bacterial identity.

Isolation of bacterial isolates

After the incubation period, morphologically distinct colonies from inoculated nutrient agar plates and colonies from inoculated MacConkey agar plates were picked using a sterile wire loop, subcultured and streaked on freshly prepared nutrient agar plates to produce pure colonies after an incubation period of 24h at 37°C. Pure isolates were gram-stained and biochemical tests were done for the identification.

Physiochemical analysis

pH

pH was measured by calibrating the pH meter using buffer solutions (pH 4.7 and 9.2) before measurement. The electrode was rinsed with distilled water and immersed into the water sample. The pH value was read after stabilizing

Hardness

Each water sample was titrated with a standard EDTA solution using an appropriate indicator (such as Eriochrome Black T for total hardness) until the colour changed. The amount of EDTA used corresponded to the concentration of calcium and magnesium ions (APHA, 2017).

Turbidity

After calibration using standard turbidity solutions (e.g. Formazin standards). Fill a clean, turbidity-free cuvette with the water sample, ensuring no air bubbles. Place the cuvette in the turbidity meter and record the turbidity value in Nephelometric Turbidity Units (NTU).

Salinity as Chloride (Cl-)

Salinity is measured as the salt content in water. The salinitywas determined as described in the Horiba Instruction Manual Horiba (1991).

Total dissolved solids

Total dissolved solids were measured by filtering 100ml of water in an initially weighed filter paper. The filter paper was oven-dried for one hour. The filter paper was re-weighed to obtain the difference between initial and final (APHA, 2005).

Sulphate and nitrate

These were determined using the spectrophotometer (APHA, 2005).

Lead

5ml of water was placed in the reaction cell and some drops of lead reagent was included and mixed with it. Concentration was then taken with a spectrophotometer at 620nm.

Chromate

6 drops (0.6ml) of chromate reagent cr-3k was included to reaction cell and shaken to blend. This was permitted to stand for about 60 seconds, 5ml of sample was included and allowed to stand for another 60 seconds after mixing. Reading was taken from the spectrophotometer at a wavelength of 560nm.

Iron

A water sample (5ml) was introduced into a test tube and 0.30ml iron reagent Fe-1 was added mixed and permitted to stand for 180 seconds. Readings were taken at a wavelength of 420nm with the spectrophotometer.

Zinc

0.5ml of Zn-1k was placed in a reaction cell and mixed and after that, 0.5ml of the water test was included and shaken, Zn-2k was included, mixed and allowed to stand for 15 minutes. The zinc concentration was read at a wavelength of 720nm.

Copper

5ml of each water sample was put in a WTW spectrophotometer reaction cell and 5 drops of copper reagent cu-1k, were included into it and shaken. After 5 minutes, the reading was then taken at 450 nm

RESULTS AND DISCUSSION

The total bacterial count of water samples is presented in **Table 1**. It was observed that sample A had the highest bacterial plate count of 5×10^4 cfu/ml, followed by sample F (3.4 cfu/ml) while samples D and E had the least bacterial plate count of 1.0×10^3 cfu/ml each.

Bacteria isolates were identified using several morphological and biochemical characterizations as shown in **Table 2**. Bacteria isolates identified were; *Bacillus subtilis, Klebsiella pneumoniae, Escherichia coli, Proteus* spp, *Pseudomonas aeruginosa Staphylococcus aureus*., *Streptococcus* spp *and Enterobacter* spp.

The percentage prevalence of isolates in river water is presented in **Table 3**. It was observed that *Klebsiella pneumoniae* had the highest percentage prevalence of 30.20%, followed by *Bacillus subtilis* (19.7%), while *Pseudomonas aeruginosa* and *Streptococcus spp* were the least prevalent bacterial isolates.

Table 4 showed that the water samples contained the most probable number (MPN) of bacteria ranging from 11 to more than 18 bacteria per 100 ml. Water samples labelled F, G and E yielded relatively low coliform counts compared with samples labelled A, C and D which had over 18 bacteria each. *Escherichia coli* was confirmed to be present in samples A, B, C and D **(Table 5)**.

Presented in **Table 5** are the mean physiochemical parameters of the selected river waters in the study. The result showed Temperature ranged from 27-28 °C, pH (6.30-7.9), Dissolved Oxygen (5.3-7.40mg/L), B.O.D (2.11-3.60mg/L), Conductivity (15-37 µs/cm), Colour (from cloudy to clear), Turbidity (14-31NTU), TDS (2.14-8.41mg/L), S.S (0.19-4.46mg/L), Hardness (0.11-16.1mg/L), Pb (0.11-0.28ppm), chloride (0.96-3.03), Zn (0.32-2.80ppm), Cu (0.32-2.16ppm), Nitrate (0.90-2,61ppm), Cd (0.01-0.04ppm) and Cr (0.01-0.07ppm).

Table 1. Total heterotrophic, total coliform and faecal count of river water samples

Sample site	THB (cfu/ml)	TCC (MPN/100ml)	FCC (MPN/100ml)
A	5.0×10^4	18	3
B	3.6×10^3	11	5
C	1.0×10^3	18	6
D	1.0×10^3	18	6
E	1.0×10^4	14	0
F	3.4×10^4	15	0
G	1.7×10^3	11	0
H	1.3×10^3	14	0
I	2.6×10^3	15	0
J	1.6×10^3	13	0
WHO STANDARD	1.0×10^2	0	0
USEPA STANDARD	1.0×10^2	0	0

Key: A=Otorho, B= Abraka, C= Eku, D= Obiaruko, E= Obiaruko, F=Kwale, G=kwale, H= Igbudu, I= Ugbagwe, J= Warri river

Table 2. Bacterial characteristics of bacterial isolates from River isolates

Morphology	Gram reaction	Catalase	Oxidase	Indole	Citrate	H_2S	Acid	Gas	Lactose	Glucose	Motility	Organism identified
Rod	+	+	-	-	+	+	+	-	+	+	+	*Bacillus* spp
Rod	-	+	-	-	+	-	+	+	+	+	-	*Klebsiella pneumoniae*
Rod	-	+	-	+	-	-	+	+	+	+	+	*Escherichia coli*
Rod	-	+	-	-	+	+	+	+	-	+	+	*Proteus spp*
Cocci	+	+	-	-	+	-	+	-	+	+	-	*Staphylococcus aureus*
Cocci	+	+	-	-	+	-	+	-	+	+	-	*Streptococcus* spp
Rod	+	+	-	-	+	+	+	-	+	+	+	*Pseudomonas aeruginosa*
Rod	+	+	-	-	-	+	+	-	+	+	+	*Enterobacter* spp

Table 3. Frequency of occurrence of bacterial isolates

Isolates	Occurrence	Frequency of Occurrence(%)
Bacillus spp	19	19.7
Escherichia coli	12	12.5
Streptococcus spp	2	2.0
Staphylococcus aureus	9	9.3
Pseudomonas aeruginosa	5	5.2
Klebsiella pneumonia	29	30.20
Proteus spp	12	12.5
Enterobacter spp	8	8.33
Total	96	100

Table 4. Distribution of bacteria solates from river samples

Sample site	*Bacillus* spp	*Escherichia coli*	*Streptococcus* spp	*Staphylococcus aureus*	*Klebsiella pneumoniae*	*Proteus* sp	*Pseudomonas aeruginosa*	*Enterobacter* spp
A	+	+	-	-	+	-	+	-
B	-	+	-	+	+	-	-	+
C	+	+	-	-	+	+	+	+

D	-	+	-	-	+	+	-	+
E	+	+	-	-	+	-	-	+
F	+	-	-	-	+	+	-	-
G	+	-	-	+	+	-	+	-
H	+	-	-	-	+	+	+	-
I	-	-	-	+	+	+	+	-
J	+	-	+	+	+	+	-	-

Key: A=Otorho, B= Abraka, C= Eku, D= Obiaruko, E= Obiaruko, F=Kwale, G=kwale, H= Igbudu, I+ Ugbuwangue, J= Warri river (NPA)

Table 5. Physicochemical Properties of the River Water from Delta State

Physicochemical Parameters	A	B	C	D	E	F	G	H	I	J	WHO(PLS)	US EPA
Temp	28	28.00	27,5	28.00	27.00	28.00	27.00	27.00	27.5	28	< 25	<25
pH	7,80	6.30	6.70	6.80	7.90	7.50	6.80	7.90	7.70	7.80	6.5-8.2	6.5-8.5
D.O (mg/L)	6.40	5.20	5.79	7.40	5.30	5.70	5.80	6.70	7.40	7.10		
B.O.D(mg/L)	2.60	2.11	3.06	2.90	2.20	2.60	2.20	2.70	3.40	3.60	14	-
E.C (us/cm)	18/00	15.00	17.00	17.60	21.00	28.00	19.00	3.40	26.40	37.00	Unobjectional	Unobjectional
Colour	Cloudy	Colourless	Clear	Cloudy	Cloudy	brown	Slightly brown	Cloudy	Cloudy	cloudy		
Turbidity	14.00	12.00	20.10	18.00	24.00	24.70	31.60	21.80	19.00	31.00	5	5
TDC(mg/L)	4.81	2.14	3.80	3.76	5.81	5.63	6.11	7.43	8.41	6.11	<600	No limit
SS(mg/L)	3.81	0.19	4.08	3.90	4.81	2.98	3.11	4.11	4.46	4.10		
Hardness	0.30	0.60	0.20	0.11	0.30	0.40	0.28	0.70	0.40	1.16	100	-
Pb (mg/)	ND	ND	0.07	0.04	ND	0.16	0.11	ND	0.07	0.28	0/01	-
Chloride (mg/L)	1.36	0,98	2.72	3.11	0.95	2.61	1.89	2.16	3.03	1.67		
Zn (ppm)	1.63	2.11	0.84	1.77	2.08	1.44	1.81	0.92	0.32	0.78	3.0	-
Cu (ppm)	2.00	1.08	2.10	1.94	1.46	1.09	1.16	0.32	1.18	2.16	2.0	-
Nitrate	1.41	1.01	1.71	0.90	2.61	1.84	1.16	2.08	1.74	2.92	50	-
Cd (ppm)	ND	ND	0,01	ND	ND	0.02	0.30	0.03	ND	0.04	-	-
Cr (ppm)	0.06	0.01	ND	ND	0.02	0.30	0.03	ND	0.06	0.03	0.07	-

Key: Temp – Temperature, pH - Potential of Hydrogen, D.O - Dissolved Oxygen, B.O.D - Biochemical Oxygen Demand, Colour, Turbidity, TDS - Total Dissolved Solids, S.S - Suspended Solids, Hardness, Pb – Lead, expressed in parts per million, Chloride, Zn – Zinc, Cu – Copper, Nitrate, Cd – Cadmium, Cr – Chromium. Ppm – parts per million, NTU - Nephelometric Turbidity Units.

The comprehensive bacteriological and physiochemical analysis of the selected river waters in Delta State, Nigeria, provides significant insights into the water quality and potential health risks posed by microbial contamination. This study focused on the ten rivers (Otorho River (Abraka), Eku River (Eku), Ethiope River (Abraka), Umuebu River (Obiaruku) and Amukpw River (Obiaruku). Igbudu river, Ugbuwangue and NPA river. The results reveal the presence of multiple bacterial species and highlight critical water quality parameters that necessitate immediate attention and intervention. The microbial load of the water sample after 24 hrs of incubation showed that Otorho and Ase river (Kwale) had the highest total viable count while river Ugbuwangue had the least total viable count. This could be due to contamination arising from constant use of the river by many persons. The high presence of bacterial load may indicates that water from these rivers may require treatment before domestic usage as they contain pathogenic organisms. This corresponds with the findings by Ashoka *et al.* (2015) who worked on the study of biofilm in bacteria from water and reported that rivers contained varying degrees of bacterial count.

The bacteriological analysis identified eight bacterial species across the selected rivers: ***Escherichia coli*, *Streptococcus* sp., *Staphylococcus* aureus., *Bacillus* sp., *Enterobacter* sp., *Klebsiella* pneumoniae., *Pseudomonas* aeruginosa.**, and ***Proteus* sp. (Table 2)**. The prevalence data **(Table 4)** show that ***Klebsiella pneumoniae*** had the highest prevalence at 30.2%, followed by ***Bacillus* spp** at 19.7% and both ***Escherichia coli*** and ***Proteus spp.***. These bacteria are known to be pathogenic and their presence in river water is of great concern due to the potential health risks for individuals using the water for drinking, cooking, and recreational activities.

Escherichia coli is a common indicator of fecal contamination, suggesting that the rivers are receiving untreated sewage or animal waste. ***Klebsiella* pneumoniae** and ***Proteus* sp.** are also associated with waterborne diseases and are often found in

polluted waters. The presence of these bacteria aligns with findings from other studies in similar regions, such as Adesuyi *et al.* (2015), Bratt and Fagerström (2023), Lassmann *et al*. (2022) and Chigor *et al.* (2012), who reported significant bacterial contamination in Nigerian water bodies, highlighting the widespread issue of water pollution.

The findings from this research revealed that all the water samples examined from the various locations had high total coliform counts. The presence of these organisms in the river water samples is undesirable especially when the limit is above the permitted by standard. In this study the counts are more than the WHO permissible limit.

This aligns with the findings of Ego *et al.* (2013) where the total coliform count from water sources in River Ogun exceeded the limit permitted by WHO. The bacterial species identified from the water samples could be as a result of farming activities occurring near the surface water by the habitat of the community living around these water bodies. Anyanwu and Okoli (2012) reported that river water contamination arises from farming, washing, bathing and seepages from feaces during run-off. The bacteria identified in this study may cause diarrhea, pneumonia and urinary tract infections in consumers. Feacal coliforms and other coliforms were isolated from water. These indicated feacal pollution which stresses the need for disinfection before use.

pH is one of the important parameters that can reveal water as alkaline or acidic. It conditions the physico-chemical equilibria, especially the calco-carbonic equilibrium (the action of water vis-à-vis carbonates) (Dan *et al.,* 2018). All the river waters except Ethiope River (Abraka, 6.30) were within the acceptable range for domestic water as shown by WHO Guidelines for Drinking Water (WHO, 2017). Consumption of water with low pH may lead to acidosis, resulting in peptic ulcers (Obeta *et al*., 2023; Egbomuche *et al.,* 2024) The analysis revealed that the different water samples tested were acidic but within the acceptable limit which makes this study a contrast to the findings of Williams *et al.* (2021) and Shrestha *et al*. (2024), which found an acidic pH in their study ranging from 5.15 to 5.73. However, agrees with the work carried out by Bello *et al.* (2023) with a pH value of 6.6 to 7.1. The slightly low pH as seen in this study may be due to human activities. These activities may have caused the death of some living things leading to the release of proteins including ammonia upon death and decay.

In this study, the dissolved oxygen (DO) of the sampled water was within the range of 6.27-8.70mg/L which was higher than the minimum concentration of 3.0 mg/L required for the survival of lives in water bodies (Harmouche *et al*., 2022; Ağaçkıran *et al*., 2023). Nevertheless, the DO levels found in the examined river water were within the ideal range for high-quality drinking water intended for residential use and recreational activities. Water designated for such uses should always have DO levels above 3.0 mg/L (WHO, 2017). The dissolved oxygen amounts exceeding 5.0 mg/L indicates a capability to support fish populations and aerobic life forms

The turbidity measurements ranged from 14 to 31 NTU. This corresponds with findings by Bello *et al*. (2023), which noted turbidity levels exceeding typical values. Typically, water with high turbidity is seen as having an increased quantity of microorganisms and elevated turbidity can hinder effective disinfection. The high turbidity levels in the river waters may be linked to soil erosion and runoff, particularly prevalent during the rainy season. Intense rainfall can lead to flooding, which washes dirt, nutrients, and domestic waste into water sources, thus causing variation in the turbidity of these bodies (Sila, 2019; Seceleanu *et al*., 2024).

The electrical conductivity (EC) readings of the river water samples ranged from 15 to 37 µS/cm, although most samples fell into the WHO's acceptable range of 50 to 100 µS/cm for household water. This could relate to the increased rainfall during the observation period. According to Amin *et al*. (2018), conductivity was found to be elevated in dry months, whereas lower values were noted during periods of heavy rainfall. This study corresponds with that of Egbomuche *et al.* (2024) that reported a normal range value of EC (85.07±0.52 µS/cm).

Solids found in a water body can either exist as dissolved or suspended (Elijah, 2023; Ghati *et al*., 2023). In the studied rivers sample, some of the observed solids existed as undissolved suspended solids, with a relative value of TDS 2.14-8.41mg/L. The maximum concentration allowed by the WHO is 1000 mg/L. According to FAO/EIFAC (1992), a TSS of 25-80 mg/l in European waters is not harmful to the fishery, but waters with a TSS of 80-100mg/l are unlikely to support a good freshwater fishery in the tropics. Consumption of water with high solids could lead to gastrointestinal discomfort, which could lead to other gastrointestinal diseases (APHA, 2005). The chlorine content in the water was within the WHO limits.

The nitrate and lead values shown in water samples from the respective sampling locations indicated low contamination of organic matter. Heavy metals concentrations were below SON permissible value except cadmium and lead. The reason may be due to the indiscriminate washing of cars and farm implements as well as the release from the exhaust of cars. This study is similar to that of Ifi *et al*. (2019). The Biological Oxygen Demand (BOD) values reported ranged from 1.20 to 2.10 mg/l, which were lower than the SON (2007) permissible limit, indicating water samples from rivers are fit for consumption. These findings conform with what was obtained by Olatunji and Anani (2020) and Omonigho (2018) but are not similar to that of Ifi *et al*. (2019).

CONCLUSION

The bacteriological and physiochemical analysis of river water from the selected sites in Delta State indicated severe contamination with pathogenic bacteria and unacceptable levels of coliforms. The high prevalence of ***Klebsiella* pneumonie, Bacillus spp, *Proteus* sp., *Enterococcus* sp. And *Escherichia coli***, points to fecal contamination and potential health hazards for communities relying on these water sources. The physiochemical analysis further highlights moderate organic pollution and the presence of hazardous heavy metals, particularly cadmium and lead which exceeds WHO permissible limits (≤ 0.003). These findings underscore the urgent need for effective water quality management to mitigate health risks.

Recommendations

Based on the findings of the study the following is recommended;

i. Implement routine and systematic water quality testing to identify and address contamination sources promptly.

ii. Enlighten the communities about the importance of keeping rivers and encourage practices like reducing littering, proper waste disposal and limits of harmful chemicals.
iii. Ensure all wastewater from homes, industries and businesses is properly treated before introduction into rivers using advanced treatment technologies when necessary.
iv. Implement continuous monitoring of river water for pollutants like nitrates, phosphates, heavy metals and pathogens to detect and address any quality issues promptly.
v. Encourage farmers to use practices like cover cropping, reduced pesticides application and organic farming to prevent runoff of chemicals into rivers.

ACKNOWLEDGMENTS: The reasearchers wish to acknowledge the support received from Staff of the laboratories in Departments of Microbiology and Chemistry as well as research assistants during the course of this study.

CONFLICT OF INTEREST: None

FINANCIAL SUPPORT: None

ETHICS STATEMENT: None

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