Bima Journal of Science and Technology, Vol. 8(3) Sept, 2024 ISSN: 2536-6041

DOI: 10.56892/bima.v8i3A.806

Limnological and Bacteriological Properties of Agba-Ndele Segment of Sombriero River, Rivers State, Nigeria

Otene B. B.*, Ukwe, I. O. K. and Fibika S. C.

Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Nigeria

Corresponding Author: benjaminotene56@yahoo.com

ABSTRACT

The quality of our surface waters has deteriorated significantly in many countries in the past few decades due to anthropogenic activities resulting from population growth, urbanization and industrialization. This study was carried out for four Months in Agba-Ndele, Segment of Sombriero River to assess the bacteriological and limnological properties of the water. Water and sediment samples were collected from four sampling stations and analyzed in the laboratory for the bacterial and some other water variables using standard method of APHA. A one-way analysis of variance (ANOVA) was used to ascertain the spatial variation while Duncan Multiple Range Test (DMRT) was used to separate the means where there was significant difference at $p<0.05$. The results showed that some of the mean values of the water variables studied were, Temperature, 28.44 ± 0.93ºC,pH, 6.42 ± 0.65, DO, 6.05 ± 0.37mg/l, Conductivity, 2471.06 ± 569.73us/cm, nitrate, 591.78±41.33 etc some of which were above the permissible limits of WHO, SON, EPA and USEPA guidelines. There were spatial variations with Station 3 significantly different from others while temperature, Dissolved oxygen (DO), conductivity and phosphate exhibited seasonal variations at $p<0.05$. The mean value of Total Heterotrophic Bacteria in water (THBw) was 5058.13±9286.625 cfu/ml while that of sediment (THBs) was 4132.5±7345.808cfu/g.Total Coliform Bacteria in water (TCBw) was 1743.75 ± 852.423 cfu/ml while that of sediment (TCBs) was 2162.50±709.812 cfu/g with water coliform value lower than the sediment. The bacterial load/count in Station 3 was significantly different from the other stations. Out of the total of 13 bacteria isolated one (1) was absent from the sediment. Agba-Ndele segment of Sombriero river is therefore under threat. Adequate measures should be taken in regulating the level of anthropogenic activities in the area thereby avoiding further deterioration of water.

Keywords: Limnological, Bacteriological, Agba-Ndele Segment, Sombriero River, Rivers State.

INTRODUCTION

Water is the most important and indispensable fundamental need and natural resource for human beings; owing to the fact that it is responsible for evolving life in our planet (Otene *et al.,* 2023). According to Ewulonu *et al*. (2019) highlight the critical role of microbiological quality in water used for human consumption and domestic activities. They emphasize that monitoring this quality is essential for protecting human health. Microbiological assessments can reveal contamination levels that might be overlooked in chemical sampling programs, underscoring the need for comprehensive water quality evaluations to ensure safety and public health. Studies showed that microorganisms in sediment are sensitive to changes in the ecosystem as opined by Wang *et al*., (2018) and that microbes in river ecosystems are involved in processes such as decomposition of organic matter and migration of inorganic substances (Wu *et al*., 2013).

The quality of our surface waters have deteriorated significantly in many countries in the past few decades due to anthropogenic activities resulting from population growth, urbanization and industrialization (Otene and Alfred-ockiya, 2019aandb, Otene *et al*, 2022). Otene *et al* (2021) opined that the quantum of microbes found in water to some extent is a function of that on the sediment which act as a sink in the aquatic ecosystem. Sediment in most cases serves as the abode for microbial degradation of organic matter. Research revealed (Cheesbrough, 2000) that surface water contains more quantum of harmful microbes compared to other sources such as groundwater and rain water due to indiscriminate disposal of waste water from anthropogenic activities known to be sources of bacteria and other pathogenic microbes. Faecal coliforms are usually known to be indicator of faecal contamination in water just like *Aeromonas* and *Pseudomonas* and the presence of these pathogen stand the risk of health challenge for unsuspecting consumers Pavlor *et al.,* (2004). A number of processes such as natural gravitation, hyporheic exchange with the water-bed, attachment to suspended particles and aquatic vegetation and filtration within the bed sediment has led to the settling of microorganisms and their subsequent re-suspension from the bed sediment (Drummond *et al*, 2014).

Limnological and bacteriological evaluation of water and sediment became a necessity due to the importance attached to water and sediment. There has been a paucity of knowledge in Agba-Ndele River especially in the area of limnological and bacteriological properties of water and sediment hence this research.

MATERIALS AND METHODS

Study Area

This research was carried out in Agba-Ndele River which is a mangrove intertidal wetland and a thickly populated municipal environment. The study was carried out at middle reaches of Sombreiro river at Agba-Ndele, Rivers State, Nigeria with the coordinate 4.8976°E and 6.6990°N (Fig.1). The water is a tidal fresh water part of the Sombreiro river which serves as a boundary between Agba-Ndele in Emohua Local Government Area and Abua, Rivers State. Human activities within and around this water body include sewage disposal, laundry, transportation, dredging, waste dump site by the river bank, washing of clothes, bathing and illegal refineries.

Sample Collection

Water samples for physicochemical and microbiological analysis were collected separately from four (4) stations, labelled appropriately as sample A and B respectively and conveyed to the laboratory for analysis. Sediments samples were also collected from the respective stations with Ekman grab and labeled as sample C for microbiological analysis. The water samples were preserved at 4^{o}C in the refrigerator until required (Nweke *et al*, 2007).

Physicochemical Analysis of Water

The analysis of the physicochemical parameters such as temperature, pH, electrical conductivity, dissolved oxygen, biochemical oxygen demand, turbidity, sulphate, phosphate and nitrate were carried out as described in APHA (2012).

Bacteriological Analysis (Water and Sediment)

A gram (1g) of the sediment sample was suspended in 9ml of sterile water contained in a 100ml Erlenmeyer flask and shook vigorously for 1 minute then allowed to stand for about 10 minutes (Fawole and Oso, 2004). Ten folds serial dilutions of both samples were carried out. About 0.1ml of 10^{-5} and 10^{-3} dilutions of sediment and water samples were inoculated aseptically onto sterile nutrient agar plates in duplicates using Pasteur pipette

DOI: 10.56892/bima.v8i3A.806

(sterile) and then spread with sterile glass rod and incubated for 24 hours at 37°C. Bacteria colonies were counted then total heterotrophic count (THB) of samples were ascertained. Discrete colonies were subcultured on nutrient agar plates to obtain pure culture and stored on agar slants in the refrigerator at 4°C. Obtained isolates were identified using morphological features and biochemical tests (Chessbrough, 2005).

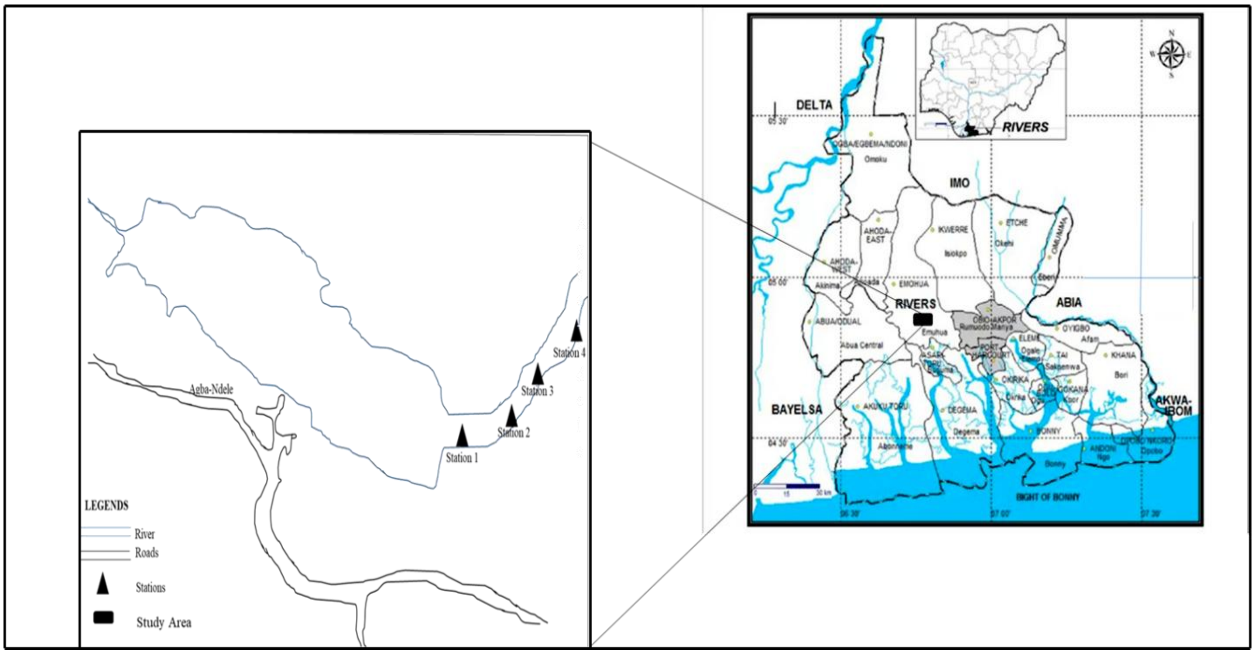

Figure 1: Map of the Study area showing the sampling Stations.

Data Analysis

A PAST Software Version 4 was used in carrying out the statistical analysis of the bacteria data for descriptive and inferential statistics at $p<0.05$. The Analysis of Variance (ANOVA) was determined while the spatial means were subjected to Duncan Multiple Range Test (DMRT) for mean differences at $p<0.05$.

RESULTS

Limnological Properties

The results of the limnological properties of Agba-Ndele river is presented in Tables 1-2 and Figures 2-4. Temperature ranged between 27.00 and 30.00°C with the overall mean value of 28.44 ± 0.93°C with observed significant difference across the stations and season (Table 1-4) The highest (30.0°C) and lowest (27.90°C) temperature were observed in December and September, 2021 respectively and in station 3 (Table 1-3). It exhibited seasonality (Table 4). pH value ranged between 5.50 and 7.50 with the mean value of 6.42 ± 0.65 (Table 1). There was observed significant spatial variation and non-seasonality with the lowest pH (5.55 ± 0.10) in station 3 (Table 2 and 4) at $P<0.05$. The water pH was slightly acidic across the stations and below the permissible limits of WHO, Environmental Protection Agency (EPA) and Standard Organisation of Nigeria (SON)Table 1).

Dissolved oxygen (DO) ranged from 5.50 to 6.66mg/l with the overall mean value of 6.05 ± 0.37mg/l with significant spatial variation and non-seasonality at $P<0.05$ (Table 1-4). DO values were highest (6.30 ± 0.25mg/l) and

Bima Journal of Science and Technology, Vol. 8(3) Sept, 2024 ISSN: 2536-6041

DOI: 10.56892/bima.v8i3A.806

lowest (5.55 ± 0.10mg/l) in stations 4 and 3 respectively (Table 3-4). DO values were lowest in October and November but highest in September. Biological Oxygen Demand (BOD) ranged from 9.30 and 12.60mg/l with the overall mean value of 10.75 ± 1.03mg/l with the observed significant spatial variations across the stations and non-seasonality (Table 1 and 4).

Electrical conductivity ranged between 1005 and 3310 us/cm with the overall mean value of 2471.06 ± 569.73us/cm and observed significant spatial difference and seasonality (Tables 1-4). EC value was above the permissible limits of WHO, EPA and SON with exhibited seasonality.

Turbidity value ranged from 6.00 to 9.50 NTU with the mean value of 7.48 ± 0.93 NTU (Table 1). There was observed significant spatial difference across the stations without non-seasonality (Table 2 and 4). Turbidity value was highest in station 3 (8.60 ± 0.638 NTU) but lowest in station 4 (6.75 ± 0.52 NTU) Table 2). Temporally, turbidity value was highest in October (8.30 NTU) but lowest in September (6.50 NTU) and November (6.50NTU) (Table 3). The water nutrients (SO_4 and PO_4) were all above the permissible limits of WHO, EPA and SON) except NO_3 (Table 1). SO_4,PO_4, and NO_3 all showed spatial significant difference across the stations with the highest values observed in station 3 (Table 2). There was observed seasonality among the nutrients (SO_4 and PO_4) except NO_3 (Table 4).

Table 1: Overall Mean Value of Physiochemical Parameters in the study Area

S/No	Parameters	(Mean ±SD)	Mini	Max	WHO 2011	EPA (2002)	SON (2007)	USEPA (2000)
1.	Temperature (O^c)	28.944±0.93	25.00	30.20	25	NA	30	40
2.	D O (mg/l)	6.050±0.37	5.50	6.60	7.5	NA	7.5	40-60
3.	pH	6.05± 0.34	5.40	6.60	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
4.	BOD (mg/l)	10.75±1.03	9.30	12.60	2-6	NA	6.00	10
5.	Conductivity(µs/cm)	2471.06 ± 569	1005	3310	250	NA	1000	400
6.	Turbidity (NTU)	7.48±0.93	6.00	9.50	5	NA	NA	NA
7.	Sulphate (mg/l)	591.78±41.33	502.20	650.10	250	250	150	NA
8.	Phosphate (mg/l)	0.55±0.22	0.05	0.85	0.50	0.50	0.01-0.03	NA
9.	Nitrate(mg/l)	0.64±0.10	0.40	0.80	50	1.0	50	NA

Key: DO= Dissolved Oxygen, BOD= Biological Oxygen Demand, NA Mean Not available, WHO= World Health Organization, US/EPA=United State Environmental Protection Agency, SON= Standard Organization of Nigeria.

Table 2: Spatial Mean Value of physicochemical Parameters of the study Area

S/No	Parameters	Station 1	Station 2	Station 3	Station 4
1.	Temperature (0^C)	28.450 ±1.13c	28.825±0.71a	29.925±0.299a	28.57±0.78b
2.	DO (mg/l)	6.225±0.15a	6.125±0.36b	5.55±0.10c	6.30±0.245a
3.	pH	6.250±0.24a	6.30±0.08a	5.55±0.17c	6.125±0.10b
4.	BOD (mg/l)	1045±0.40b	10.38±0.63	12.288±.36a	9.88±0.39c
5.	Conductivity(µs/cm-	2142.50±145.459c	2285.00±86.99b	3095.50±188.79a	2361.25±912.44b
6.	Turbidity (NTU)	6.975±0.885c	7.58±0.298b	8.60±0.638a	6.75±0.52b
7.	Sulphate (mg/l)	586.075±56.78b	585.55±32.58b	625.253±17.19a	570.253±41.89b
8.	Phosphate(mg/l)	0.405±0.11b	0..501±0.12c	0.805±0.04a	0.475±0.284b
9.	Nitrate (mg/l)	0.538±0.095c	0.595±0.07b	0.76±0.04a	0.65±6.041b

Key: Difference in Superscript across the column shows significant difference at $p< 0.05$.

Table 3: Temporal Mean Value of Physiochemical parameters.

S/No	Parameters	September	October	November	December
1.	Temperature (0^C)	27.90	28.20	27.60	30.10
2.	Dissolved Oxygen (mg/l)	6.40	6.10	6.10	6.30
3.	pH	6.60	6.10	6.20	6.10
4.	BOD (mg/l)	10.20	10.50	11.00	10.10
5.	Conductivity (us/cm)	2010.00	2100	2.350	2.110
6.	Turbidity (NTU)	6.50	8.30	6.50	6.60
7.	Sulphate (mg/l)	502.20	621.50	620.50	600.10
8.	Phosphate (mg/l)	0.36	0.56	0.30	0.40
9.	Nitrate (mg/l)	0.56	0.60	0.60	0.40

Table 4: Seasonal Mean Value of Limnological Parameters in the Stud Area.

S/No	Parameters	Wet	Dry
1.	Temperature (0^C)	28.975a	26.912b
2.	Dissolved Oxygen (mg/l)	6.025b	6.075a
3.	pH	6.075a	6.038a
4.	BOD (mg/l)	10.763a	10.731a
5.	Conductivity (us/cm)	2527.56a	2414.63b
6.	Turbidity (NTU)	7.675a	7..275a
7.	Sulphate (mg/l)	574.429b	609.138a
8.	Phosphate (mg/l)	0.615a	0.479b
9.	Nitrate (mg/l)	0.654a	0.619a

Differences in Superscript across the column shows significant difference at p< 0.05.

Table 5-7 showed the overall, temporal and spatial mean value of bacteria in water and sediment. THBw ranged between $1.1x10^2$ (Station 1, November, and $3.4x10^3$ (Station 3, December) with the overall mean of 5058.13±9286.625 cfu/ml while THBs ranged between $0.6x10^3$ (Station 4 September) and $2.9x10^3$ (Station 3 December) with the overall mean of 4132.5± 7345.808 cfu (Table 5 and 6). The mean values of THBw was higher than the THBs. The spatial mean value of heterotrophic bacteria in water and sediment were both significantly highest in station 3 but lowest in station 4 at p<0.05(Table 7). Figures 2 and 3 showed the temporal and seasonal mean values of THBw and THBs. The values of THBw and THBs were both highest in December but lowest in November and October respectively. There was seasonality in the mean values of THBw and THBs with higher values observed in the wet season at p<0.05 (Figure 3).

TCBw ranged between $0.4x10^2$ **(**Station 1 September) and $3.3x10^3$ cfu/ml (Station 3, October) with the overall mean value of 1743.75±852.423cfu/ml while TCBs ranged between $0.9x10^3$ (Station 4 November) and $3.4x10^4$ cfu/g (Station 3 October) with the overall mean value of 2162.50±709.812 cfu/g (Table 5 and 6). The spatial mean value of TCBw and TCBs were both significantly highest in station 3 but lowest in stations 1 and 4 respectively for TCBw and TCBs (Table 7). TCBs was higher than TCBw. The values of TCBw and TCBs were highest in October and September respectively but were both lowest in December (Figure 2). There was seasonality in the mean values of TCBw and TCBs with higher values observed in the wet season at p<0.05 (Figure 3).

Bima Journal of Science and Technology, Vol. 8(3) Sept, 2024 ISSN: 2536-6041

DOI: 10.56892/bima.v8i3A.806

Table 5: Overall Mean Values of Bacterial 1solates in the Area

S/No	Isolate Parameters	Mean	Mini	Max	WHO
1.	Total Heterotrophic Bacteria in Water (THBw	5058.13±9286.625	110	32,000	1x10^{2}/ml
2.	Total Heterotrophic Bacteria in Sediment(THBs)	4132.50±7345.808	3,120	28,000	--
3.	Total Coliform Bacteria in Water (TCBw)	1743.75±852.423	200	3,300	0/100ml
4.	Total Coliform Bacteria in Sediment (TCBs)	2162.50±709.812	900	3400	---

Table 6: Monthly and Spatial Value of Bacteria in the Study Area

Month	Station	Season	THBw	THBs	TCBw	TCBs
September	1	Wet	1.3x10^{3}	1.1x10^{3}	0.4x10^{3}	3.x10^{3}
	2	Wet	1.1X10^{3}	1.2X10^{3}	1.4X10^{3}	2..0X10^{3}
	3	Wet	2.5x10^{4}	2.6x10^{3}	1.6x10^{3}	2.4x10^{3}
	4	Wet	1.0x10^{3}	0.6x10^{3}	1.2x10^{3}	1.6x10^{3}
October	1	Wet	2.1x10^{3}	1.2x10^{2}	2.0x10^{3}	2.0x10^{3}
	2	Wet	2.4x10^{3}	1.0x10^{3}	2.2x10^{3}	1.9x10^{3}
	3	Wet	3.2x10^{4}	2.8x10^{4}	3.3.x10^{3}	3.4x10^{3}
	4	Wet	1.1x10^{3}	1.3x10^{3}	2.1x10^{3}	2x10^{3}
November	1	Dry	1.1X10^{2}	2.1x10^{3}	1.1x10^{3}	2.0x10^{3}
	2	Dry	1.2X10^{2}	1.8x10^{3}	1.3x10^{3}	2.1x10^{2}
	3	Dry	2.2X10^{3}	1.6x10^{4}	1.9x10^{3}	3.1x10^{3}
	4	Dry	2.6X10^{3}	1.3x10^{3}	1.4x10^{3}	0.9x10^{3}
December.	1	Dry	2.3X10^{2}	2.1x10^{3}	2.0x10^{2}	1.1x10^{3}
	2	Dry	2.1X10^{3}	1.9x10^{3}	2.6x10^{3}	2.0x10^{3}
	3	Dry	3.4x10^{3}	2.9x10^{3}	3.1x10^{3}	3.1x10^{3}
	4	Dry	1.4x10^{3}	2.1x10^{3}	2.1x10^{3}	1.9x10^{3}

Table 7: Spatial Mean Value of Bacteria in the Study Area

S/No	Parameters	Station 1	Station 2	Station 3	Station 4
1.	Total Heterotrophic Bacteria in Water (THBw)	1452.50±993.83^{c}	1430±1035.18^{c}	15825±14913.61^{a}	525±736.55^{b}
2.	Total Heterotrophic Bacteria in Sediment (THBs)	1355±948.74^{c}	1475±442.53^{b}	12375±12146.43^{a}	1325±613.05^{c}
3.	Total Coliform Bacteria in Water (TCBW)	925±813.94^{c}	1875±629.15^{b}	2475±850^{a}	1700±469.04^{b}
4.	Total Coliform Bacteria in Water (TCBW)	2025±776.21^{b}	2000±81.650^{b}	3025±434.93^{a}	1600±496.66^{c}

Differences in Superscript across the column shows significant difference at $p< 0.05$.

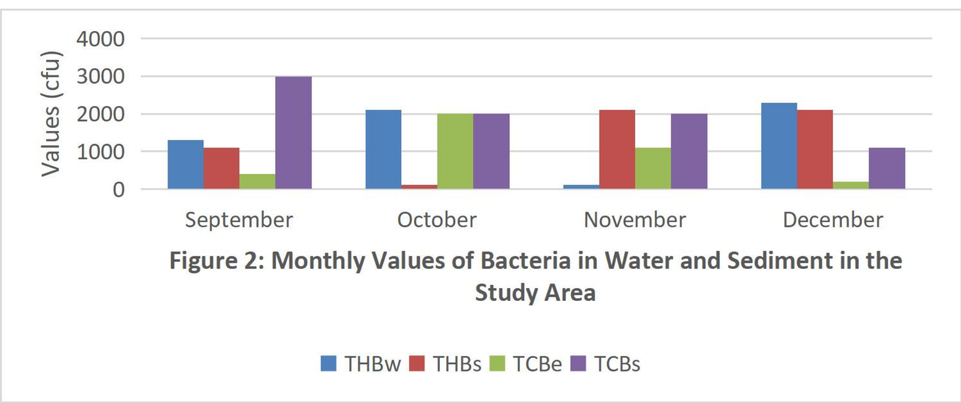

Figure 2: Monthly Values of Bacteria in Water and Sediment from the Study Area.

Bima Journal of Science and Technology, Vol. 8(3) Sept, 2024 ISSN: 2536-6041

DOI: 10.56892/bima.v8i3A.806

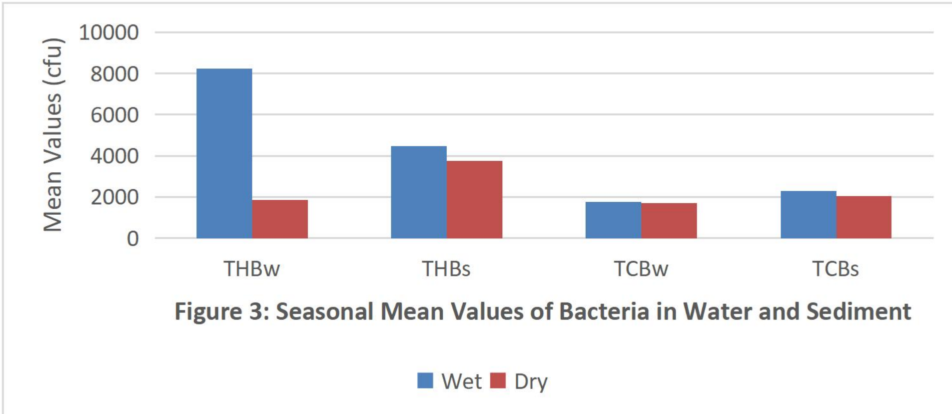

Figure 3: Seasonal Mean Values of Bacteria in Water and Sediment

Figure 3: Seasonal Mean Values of Bacteria in Water and Sediment from the Study Area.

Table 8 and 9 showed the morphological and biochemical Test of Bacteria Isolate and the species per station in water and sediment sample. A total of 13 species of bacteria were observed in the study area which include *streptococcus spp, Pseudomonas spp, Enterobacter spp, Bacillus spp, Staphylococcus spp, Bacillus areus, Bacillus substilis, Escheria coli, Micrococcus spp, Vibrio spp, Klebsella spp, Proteus mirabilis and Aeromonas hydrophila*.. The 13 species of bacteria isolated were consistently present in station 3 while only *Bacillus species* is absent in station 2 in water unlike sediment sample where many species were consistently absent. *Micrococcus spp* was completely absent in all the stations in sediment but consistently present in the Water. Station 3 had the highest diversity of bacteria species in both water and sediment

Table 8: Morphological and Biochemical Test of Bacteria Isolate in Water Sample

Iso	Gram Rxn	Cat	Oxi	Moti	Ind	MR	VP	Suc	Gluc	Lact	Suspected Organisms
1.	Gram **+ve**	+ve	+ve	– ve	– ve	– ve	– ve	+ ve	– ve	– ve	*Streptococcus spp*
2.	–ve	+ve	+ve	+ve	+ve	– ve	– ve	– ve	A	A	*Pseudomonas spp*
3.	–ve	+ve	+ve	+ve	– ve	+ve	+ve	– ve	A	– ve	*Enterobacter spp*
4.	+ve	+ve	+ve	+ve	– ve	+ve	+ ve	+ ve	A	– ve	*Bacillus spp*
5.	+ve	+ve	+ve	+ve	– ve	+ve	+ ve	+ ve	A	+ve	*Micrococcus spp*
6.	+ve cocci	+ve	+ve	–ve	–ve	+ve	+ ve	+ ve	A	A	*Staphylococcus spp*
7.	+ve	+ve	+ve	+ve	– ve	– ve	+ ve	– ve	A	– ve	*Bacillus circus*
8.	+ve rod	+ve	+ve	+ve	– ve	– ve	+ ve	+ ve	A	– ve	*Bacillus substilis*
9	-ve	+ve	+ve	+ve	+ve	+ve	– ve	+ ve	AG	A	*Escherichia coli*
10.	– ve	+ve	–ve	–ve	–ve	–ve	+ ve	+ ve	AG	+ve	*Klebsella pneumonia*
11.	– ve	+ve	+ve	–ve	+ve	+ve	– ve	+ ve	AG	– ve	*Vibrio specie*
12.	– ve	+ve	–ve	+ve	+ve	+ve	+ ve	+ ve	AG	– ve	*Proteus mirabilis*
13.	– ve	+ve	+ve	+ve	+ve	– ve	– ve	+ ve	AG	+ve	*Aeromonas hydrophila*

Key: +ve = positive, -ve =negative, A=acid, A/G=absence of gas, INDL represent Indole Test, MR = Methyl Red, VP = Voges Proskaauel, CAT= Catalase, OXI = Oxidase, MOL= Motility, SUC = Sucrose, FRU = Fructose, GLU = Glucose and LAC = Lactose.

DOI: 10.56892/bima.v8i3A.806

Table 9: Bacteria Isolates Per Station

S/No.	Isolates/Station	Sediment				Water			
		Stn1	Stn2	Stn3	Stn4	Stn1	Stn2	Stn3	Stn4
1	*Streptococcus spp*	+	+	-	+	+	+	+	+
2	*Pseudomonas spp*	-	+	+	-	-	+	+	+
3	*Enterobacter spp*	+	+	+	-	-	+	+	+
4	*Bacillus spp*	+	-	+	-	-	-	+	-
5	*Micrococcus spp*	-	-	-	-	+	+	+	+
6	*Staphylococcus spp*	+	-	+	-	+	+	+	-
7	*Bacillus circus*	+	+	-	+	-	+	+	-
8	*Bacillus substilis*	+	+	+	-	+	+	+	-
9	*Escherichia coli*	-	+	+	+	+	+	+	-
10	*Klebsella pneumonia*	-	+	+	+	+	+	+	+
11	*Vibrio spp*	+	+	+	-	-	+	+	-
12	*Proteus mirabilis*	-	-	+	-	-	+	+	+
13	*Aeromonas hydrophila*	-	-	+	+	+	+	+	+

Key: + mean present, - mean absent

DISCUSSION

The observed temperature range in this study falls within the safe and acceptable limits of 25°C and 30°C) (WHO, 2011, SON, 2007). This temperature range is within the range of 28.52 ± 1.19 to 28.27 ± 29°C reported by Agbazue *et al* (2017) and Aliyu *et al* (2006) from Oro-obor and Ayo Rivers in Enugu South, Southern Nigeria and Otene *et al.* (2022) also reported range of 29.50-30.50°C from Sombriero river in Rivers State. The DO range in this study falls slightly below the permissible limits (7.5mg/l) of WHO (2011) and SON (2007). Mgbemena and Okwunodulu (2015) opined that DO is an essential measure of the extent of pollution and that the lower its value, the higher the pollution concentration and vice versa. Obodo (2002) disclosed that a portable water should at least contain DO value of 5.0mgl. DO has been known to be an indicator of biological health of a water body, nevertheless, it fluctuates in value throughout the day and are affected by changes in water temperature and the organic matters such as industrial or municipal wastes which increase organic matter concentration. Alagoa and Aleleye-Wokoma (2012) reported that organic load influences aerobic biodegradation resulting to oxygen depletion. The observed spatial and seasonal variation in DO values in this study could be attributed to the level of anthropogenic activities in the area. BOD values exceeded the permissible limits of 2-6.0mg/l (WHO, 2011) probably due to discharge of domestic wastes (sewage) and poorly executed agricultural activities near the river bank. Unpolluted waters typically have BOD value of 2mg/l or less where as those receiving wastes may have up to 10mg/l or more.

The pH mean value ranged between acidic level which is within the acceptable limit of WHO (2011), EPA (2002), SON 2007) and USEPA (2000). This pH range in this study is comparable with the 6.20 and 7.90 reported by Otene and Iorchor (2013) in Amadi-Ama Bonny estuary. This pH range is also in tandem with that reported by Ewulonu *et al.* (2019) in a fresh water in Isiokpo which was attributed to influx of biodegradable materials and further biodegradation process leading to release of acidic gases as by-products into the water. The range of conductivity values in this study is contrary to the (140.50-1500us/cm) reported by Otene *et al* (2022) from Sombrier river. The observed spatial significant difference across the stations could be attributed to difference in anthropogenic activity in the areas. Electrical conductivity is a variable used as water quality parameters especially in the coastal area which is an indicator of salinity level making it useful in studying sea water intrusion (Rusydi, 2018).

The water nutrients (SO_4, PO_4 and NO_3) observed in this study were all above the permissible limits that permit productivity in the aquatic ecosystem. The observed spatial significant difference across the stations with the highest values in station 3 at $P<0.05$ could be attributed to increased human faeces and high level of utilization of detergent by the inhabitants. The observed significant difference in phosphate across the stations is in tandem with the finding of Otene *et al*. (2023) in Okamini stream which could be attributed to difference in anthropogenic activities in the areas.

The observed higher mean values of total heterotrophic bacteria in water (THBw) than that of the sediment (THBs) is contrary to the findings of Otene *et al.* (2021) who reported higher THBs than THBw in the New Calabar River, Port Harcourt Zhao *et al* (2017) who reported higher abundance of bacteria in sediment than water and was attributed to higher degradation of organic matter in the sediment than the water during the period. The range of total heterotrophic bacteria in the sediment ($0.6x10^3$ – $2.9x10^3$fu/g) observed in this study is far lower than the 1.08–1.60(x 10^6cfu/g) reported by Edet *et al.* (2018) from Iko river estuary. The result also contradicts the range (1.1 to $5.1x10^7$cfu/g) reported from the benthic sediment by Udotong *et al.* (2015) from the same water body. This could be attributed to difference in environmental factors. This result is however comparable with the range ($2.02x10^4$cfu/ml and $5.1x10^4$cfu/ml) reported by Okere *et al* 2021) from rivers Otamiri and Nworie in Owerri, Nigeria. Similarly, Okere *et al.* (2021) reported higher mean value of THB in water than sediment which is in line with this study. The higher values and range of TCB in sediment than water in this study is contrary to that reported by Otene *et al.* (2021) from the New Calabar River, Port Harcourt. The observed highest values of both THB and TCB in water and sediment in this study in station 3 could be attributed to high rate of decomposition in the area. These variations could also be attributed to difference in degrees of anthropogenic activities in station 3. The range of TCB in water in this study is also in line with the (7.8x10to $2.3x10^4$cfu/ml) reported by Ejiko and Otene (2019) in Trans-Amadi, Woji Creek, Port Harcourt. Ibinabo *et al* (2022) reported higher THB in the surface water than the sediment at the five locations (Ogan Ama George Ama, Kalio Ama, Abam Ama, Okari-Ama and Edeme-biri) all in Okrika Creek, Port Harcourt which is in line with this study but contrary to the higher TCB in sediment than surface water in Okari-Ama and Edeme-biri in Okrika Creek. The observed consistent high values of bacteria (THB and TCB) in water and sediment in the wet season than the dry season in this study could be attributed to low salinity, high turbidity and low temperature which are said to be typical of wet season months (Solo-Gabriel *et al,* 2000). This observation is in agreement with the findings of Ejiko and Otene (2019) and Ibinabo *et al.* (2022) in Okrika Creek. Ejiko and Otene (2019) attributed seasonal changes in microbial groups in creeks/waters bodies to the influence of physicochemical properties and anthropogenic activities in the area.

Comparing the observed values of THB and TCB with the international guidelines' levels for drinking water (WHO, SON) the water is considered poor and unsuitable for drinking since they exceeded the permissible limits of $1x10^2$cfu and 0 respectively for THB and TCB (WHO, 2011). According to Edberg and Allen (2004) and Pavlor *et al.* (2004) water contaminated with total heterotrophic bacteria is dangerous to human health and may cause

Bima Journal of Science and Technology, Vol. 8(3) Sept, 2024 ISSN: 2536-6041

DOI: 10.56892/bima.v8i3A.806

acute gastrointestinal illness which can result to fever, nausea and diarrhea as well as vomiting. The contamination of the sediment samples in both seasons with THB and TCB could be attributed to the discharge of unscreened industrial wastes and household garbage into the area. The presence of total coliform bacteria (TCB) in this study shows pollution hence according to Ibinabo *et al.* (2022) coliform bacteria are indicators to measure the degree of pollution and sanitary quality of water.

The 13 species of bacteria observed in this study is in agreement with the 12 reported by Ejiko and Otene (2019) from Trans-Amadi/Woji Creek, 13 species reported by Ibinabo *et al* (2022) from Okrika Creek and 12 species by Robert and Dirk (2017) from Otamiri River but contrary to the 33 species reported by Amadi and Wemedo (2020) from Krakrama water, River State, 6 species reported by Josiah *et al* (2014) from Okada water sources in Edo State and 6 species reported by Reuben *et al.* (2018) from Keffi river, central Nigeria.

The presence of the members of Enterobacteriaccae family such as *Enterobacter spp, Bacillus spp, E.coli, Klebsiclla spp, Proteus sp, Pseudomonas spp*, which are considered pathogenic portray danger as reported by other researchers such as Aliyu *et al.* (2006), Bisi-Johnson *et al.* (2017), Choudhury *et al.* (2016) and Edama *et al.* (2001). The presence of specific indicators species such as *Escherichic coli, Staphylococcus aureus* and *Streptococcus spp* in this study is in line with that of Aina *et al.* (2012) from different borehole waters from different towns in Ogun State, Nigeria. Robert and Dirk (2017) opined that bacteria contamination in water is measured using indicator organisms such as *Escherichia Coli and Enterococci spp* which are primary indicators of contamination in freshwater and marine water quality rather than the total coliforms present. EPA (2002), EPA (2003) and WHO (2011) opined that presence of coliforms bacteria such as *E. Coli* especially in the sediment is of health importance since it indicates recent pollution of water source by human/animal feces, wastes and sewage.

CONCLUSION

The exceeding values of some physicochemical variables such as BOD, conductivity, sulphate, and phosphates as well as Total heterotrophic bacteria (THB) and Total coliform bacteria (TCB) in water above the permissible limits of the regulatory agencies such as WHO, SON, EPA and USEPA signifies stress/threat in the water body. Adequate measures should be taken in regulating the anthropogenic activities in the area.

REFERENCES

Agbazue,V.E.,Ewoh,J.C.,Madu,C.N.,Ngang,B. U(2017).Comparativeanalysis of physicochemical and microbial parameters of water samples from Oro-Obor and Ayo Rivers in Enugu South, Enugu State, Nigeria. *IOSR J Appl Chem.,*10(9):49-54. DOI: 10.9790/5736-1009 034954

Aina, D. A., Olawuyi, O. J., Coker, O. A., Ojelabi, D. O. and Alatise, F. A (2012). Bacteriological analysis of borehole water from different towns in Ogun State, Nigeria. *African Journal of Microbiology Research* Vol. 6(10), pp. 2462-2468.

Alagoa, K. J., Aleleye-Wokoma, I. P. (2012): Human Induced Variations of Selected Physicochemical Parameters of Taylor Creek in the Niger Delta, Bayelsa State, Nigeria. *Resources and Environment* 2(2), 45-5

Aliyu, H.S.A., Ekhaise, F.O.,Adelusi, D and Oviasogie, F.E(2006). Effect of human activities and oil pollution on the microbiological and physicochemical quality of Udu river, Warri, Nigeria. *Estud Biol.*28(62):35-43.

Amadi,L.O and Wemedo,S.A (2020).Microbiological and Physicochemical Properties of Krakrama (Brackish) Waterin Rivers State, Niger Delta, Nigeria. *Acta Scientific Microbiology* 3.5123-132

American Public Health Association (APHA) (2012). Standard Methods for the Examination of Water and Wastewater, 22nd edition edited by E. W. Rice, R. B. Baird, A.D. Eaton and L. S. Clesceri. American Water Works Association (AWWA) and Water Pollution Control Federation (WPCF). Washington, D.C.

Bisi-Johnson, M.A., Kehinde, O., Adediran, S.A., Akinola, E.O.P and Anthony, I.O (2006) Comparative physicochemical and microbiological qualities of source and stored household waters in some selected communities in Southwestern Nigeria. Sustainability. 9:454.

Bisi-Johnson, M.A., Kehinde, O., Adediran, S.A., Akinola, E.O.P and Anthony, I.O (2017). Comparative physicochemical and microbiological qualities of source and stored household waters in some selected communities in Southwestern Nigeria. Sustainability; 9:454.

Bukola C A-T and Abiodun A O (2008) Screening of Lactic Acid Bacteria Strains Isolated from Some Nigerian Fermented Foods for EPS Production. World Applied Sci J 4 (5): 741- 747. http://www.idosi.org/wasj/wasj4(5)/20.pdf

Cheesebrough M (2000). District laboratory practice in tropical countries, Part 2. Cambridge Univ. Press, UK.35-38:62-69. 14.

Chessbrough, M (2005). Biochemical Test to Identify Bacteria: District Laboratory Practice in Tropical Countries.2nd edn. Cambridge University Press, London. 2: 62-70.

Cheesbrough M (2006). "District laboratory practices in Tropical countries". Volume 2 Part 2. Cambridge University Press, UK 24.

Choudhury, S.S.,Ajay,K.,Hiramoni,D and Mukutamoni, D (2016). Preliminary physicochemical and microbiological analysis of Bahini river water of Guwahati, Assam, India. *Intnl J. Current Microbiol Appl Sci*,5(2):684-692.

Drummond J.D., Davies-Colley R.J., Stott R., Sukias J.P., Nagels J.W., Sharp A., Packman A.I. (2014). Retention and remobilization dynamics of fine particles and microorganisms in pastoral streams. Water Res. 66:459–472. doi: 10.1016/j.watres.2014.08.025.

Edama, M.D., Omemu, A.M and Fapetu, O.M (2016). Microbiological and physicochemical analysis of different sources of drinking water in Abeokuta, Nigeria. *Niger J Microbial.* 15(1):57-61.

Edema, M. O., Omemu, A. M. and Fapetu,O. M. (2001): Microbiology and Physicochemical Analysis of different sources of drinking water in Abeokuta, Nigeria. Niger. *J. Microbiol*. 57- 61.

Edet, U, Antai, S.P., Asitok, A and Broom A (2018). Comparative Evaluation of Microbial Diversity of Epipellic and Benthic Sediments using Cultural and Metagenomics Techniques Article *in Asian Journal of Environment and Ecology*.

Edberg, S and Allen, M.J (2004). Virulence and risk from drinking water of heterotrophic plate count bacteria in human population groups. *International Journal of Food Microbiology*. 92(3):255-63.

Ejiko, E.S and Otene, B.B(2019). Microbiological Characteristics of Water and Seafood (Oyster Tissue) from Trans-Amadiwoji Creek, Port Harcourt, Nigeria.*Research and Reviews: Journal of Ecology* , Volume 8, Issue 3 ISSN: 2278-2230

EPA (2003). US Environmental Protection Agency Safe Drinking Water Act. EPA 816-F- 03- 016.

Ewulonu, C. C., Obire, O. and Akani, N. P. (2019). Microbiological and Physiochemical Quality of Freshwater in Isiokpo Community, Rivers State, Nigeria. *South Asian Journal of Research in Microbiology*, 3(1): 1-8.DOI: 10.9734/SAJRM/2019/v3i130078

Fawole, M. O and Oso, B. A. (2004). *Laboratory Manual of Microbiology.* 2nd edn. University Press Plc, Ibadan. 21.

Ibinabo, O., David,O and Tamunoene, K.S.A (2022). Evaluation of Microbiological Quality of Water, Sediment and Soil Characteristics in Okrika Local Government Area, Rivers State, Nigeria. *South Asian Journal of Research in Microbiology* . ***12(1): 32-49***

Josiah, J. Sunday1, Nwangwu C. O. Spencer1, Omage Kingsley, Akpanyung O. Edet and Dike D. Amaka (2014). Physico-chemical and microbiological properties of water samples used for domestic purposes in Okada town, Edo state, Nigeria *Int.J. Curr. Microbiol. App.Sci* 3(6):886-894

Mgbemena, N.M, Okwunodulu, F.U(2015). Physicochemical and microbiological assessment of borehole waters in Umudike, Ikwuano L.G.A., Abia State, Nigeria. *Adv Appl Sci Res.* ;6(4):210-214.

Nweke, C. O., Alisi, C. S., Okolo, J. C and Nwanyanwu, C. E.(2007a). Toxicity of Zinc to Heterotrophic Bacteria from a Tropical River Sediment. *Applied Ecology and Environmental Research*, 5 (1): 123-132.

Obodo GA (2002). Pollution Estimates of Rivers Nworie, Otamiri, Imo, Aba and Mbaa. *J Physical Sc*i. 1(1):27.

Okere, K., Azorji, J.N., Iheagwam S. K.,Emeka J. E and Nzenwa P. O (2021). Assessment of Microbial Load in Water and Sediments of Rivers Otamiri and Nworie in Owerri, South Eastern Nigeria.*International Journal of Pathogen Research 6(3): 27-39,*

Otene, B.B, J.F. Alfred-Ockiya, J.F and Ejiko, E.O (2020). Bio-Indices of Bacteria Loads in Water and Mangrove Oyster (Crassostrea Gasar) of Woji/ Trans-Amadi Creek, Port Harcourt, Nigeria. *International Journal of Research and Innovation in Applied Science* (IJRIAS), 5(3) 2454-6194.

Otene, B.B. and Alfre-Ockiya, J.F. (2019a). Assessment of water Quality Index (WQI) and Suitability for Consumption of Elele-Alimini Stream, Port Harcourt. *Global Scientific Journal*, 7 (2) 2320-91-86. www.globalscientificjournal.com.

Otene,B.B and J.F.Alfred-Ockiya (2019b**)**. Human and Ecological Risk Assessment of Heavy Metals in Water and Sediment of Elechi Creek, Port Harcourt, Nigeria. *IOSR Journal of Environmental Science, Toxicology, and Food Technology (IOSR- JESTFT),13(3):,pp01-07*. www. iosrjournals.org

Otene, B.B, Simbi-Wellington,W.S and Robinson,N(2023).Limnological properties and phytoplankton as indicator of pollution, Choba segment, New Calabar River, Port Harcourt

Nigeria. *World Journal of Advanced Research and Reviews*, 17(02), 500–511

Otene,B.B.Chukwu,K.O and Pepple, F.S (2021a). Microbiological Properties of Water and Sediment of New Calabar River, Port Harcourt, Nigeria. *Journal of Aquatic Sciences*, 36(2),199-222.

Otene, B.B., I. Thornhill and J. Amadi (2023). A comparison of the water quality and plankton diversity of the Okamini Stream to the freshwater systems within the New Calabar River catchment, Port Harcourt, Nigeria. *African Journal of Aquatic Science*, 48 (1), 97-104

Otene,B.B.,Ejiko,E.O and Deekae, S.N.(2021b). Fungal Diversity In Water And Mangrove Oyster (Crassostrea Gasar), Woji/Trans-Amadi Creek, Port Harcourt, Nigeria. ***International Journal of Research and Innovation in Applied Science*** **(IJRIAS) 6(2)ISSN 2454-6194.**

Otene, B.B and Iorchor, S.I (2013). Seasonal Variability in Some Parameters of Water of Amadi-Ama Creek, Upper Bonny Estuary, Niger Delta. *Scientific Journal of Zoology,* 2 (1):1-5

Otene, B.B, O.M.G.,Abu, D. Amachree and M.C. Asawo (2022). Limnological Properties and Water Quality of Sombreiro River, Port Harcourt, Nigeria. *International Journal of Agriculture and Earth Science (IJAES)* 8(7) 2695-1894

Pavlov, D, De Wet, M.E, Grabow, W.O.K and Ehlers, M.M (2004). Potentially Pathogen Features of heterotrophic plate count bacteria isolated from treated and untreated drinking water. *International Journal of Food Microbiology*.92:275-287.

Reuben, R.C, Gyar,S.D and Yakubu,A (2018). Physicochemical and Microbiological Parameters of water from Keffi Rivers, North Central. *Microbiology Research Journal International,* 24(3): 1-12

Robert, G and Dirk*,* W (2017). *E. coli* as an Indicator of Contamination and Health Risk in Environmental Waters. Open access peer-reviewed chapter

Rusydi, A.F (2018). "Correlation between conductivity and total dissolved solid in various type of water: A review". *IOP Conference Series: Earth and Environmental Science* 118: 012019. 33.

Solo-Gabrielle, H. M., Wolfert, M. A., Desmaris, T. R., and Palmer, C. J. (2000). Sources of *Escherichia coli* in a coastal subtropical environment. *Applied and Environmental Microbiolology*, *66*(1), 230-7.http://dx.doi.org/10.1128/AEM.66.1.230-237.2000

SON (2007). Nigerian standards for drinking water quality. Pg 1-30.

Udotong, I.R., Uko, M.P and Udotong, J.I.R (2015). Microbial diversity of a remote aviation fuel contaminated sediment of a lentic ecosystem in Ibeno, Nigeria. *Journal of Environmental and Analytical Toxicology*.5(320):1-7.

United State Environmental Protection Agency (USEPA,2000). "Ambient aquatic life water quality criteria for dissolved oxygen (saltwater): Cape Cod to Cape Hatteras".

UnitedStateEnvironmentalProtectionAgencyEPA.(2002).Ground wateranddrinkingwater.Current Drinking Standard United State Environmental Protection Agency(EPA).1-5.

Wang, P., Wang, T. Y., Giesy, J. P and Lu, Y. L. (2013). Perfluorinated Compounds in Soils from Liaodong Bay with Concentrated Fluorine Industry Park in China, *Chemosphere*, 91: 751-757.

Wang, C.Y.; Li, W.J.; Chen, S.; Li, D.; Wang, D., and Liu, J., (2018). The spatial and temporal variation of total suspended solid concentra- tion in Pearl River estuary during 1987– 2015 based on remote sensing. *Science of the Total Environment,* 618, 1124–1137.

WHO (2011). Guideline for Drinking Water Quality. First Addendum to the Third Edition Volume 1 recommendations.491 – 493.

World Health Organisation (WHO) (2012). Guidelines for Standard Operating Procedures for Microbiology: In Bacteriological Examination of Water. World Health Organization Regional Office for South-East Asia.

World Health Organization (WHO)(2019).Drinking Water. WHO international; 2019. Available :http // www.who.into.World Health Organization. 2021WHO.

Wu, G.F.; Cui, L.; Duan, H.; Fei, T., and Liu, Y.,(2013). An approach for developing Landsat-5 TM-based retrieval models of suspended particulate matter concentration with the assistance of MODIS. ISPRS Journal of Photogrammetry and Remote Sensing, 85, 84– 92.

Zhao1, D, Xinyi C.1, Rui H, Jin Z, Qinglong L. W (2017). Variation of bacterial communities in water and sediments during the decomposition of *Microcystis* biomass. PLoS ONE 12(4): e 01 7 6397.https://doi.org/10.1371/journal.pone. 0176397.