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Assessment of Njaba River Quality Using Physico-Chemical Parameters

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study analyzed the physico-chemical parameters of Njaba River in Imo State, Nigeria. Triplicate water samples were collected in May, 2023 at five sampling points for physico-chemical analysis using standard methods. Mean concentrations of turbidity (15.60±2.86 NTU), TSS (83.48±7.26

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mg/L), Pb (0.078±0.030 mg/L), Zn (0.225±0.054 mg/L) and Ni (0.254±0.012 mg/L) exceeded the Federal Ministry of Environment's maximum permissible limits. Narrow variation was recorded for temperature while wide variations were recorded for turbidity, TS, TSS and Pb. These were a clear indication of human activities such as sand excavation runoff, agricultural runoff as well as effluent discharge from a brewery into the river. The One-Way ANOVA test revealed that mean concentrations of DO, BOD, COD, turbidity, TS, TDS, TSS, NO_3^-, PO_4^3, Pb, Zn and Ni ions (Sig.values=0.000 each), as well as those of water temperature (Sig.value=0.003) all differed significantly across the sampling locations at $p<0.05$. Post-hoc Duncan Multiple Range test revealed that the difference in concentrations of BOD, TS, TSS, Zn and Ni occurred mainly between the impacted and control locations. It was observed that the water was slightly polluted giving the high levels of turbidity and total suspended solids, as well as those of heavy metals (Zn and Ni) resulting from discharge of brewery effluent, sand excavation, solid waste dumping and agricultural practices in and around the water body.

Keywords: Njaba River; water quality; anthropogenic activities; effluent; sand excavation.

1. INTRODUCTION

The major resource required by all creatures for their survival is water and the desire of quality water has been reduced due to anthropogenic activities. However, these activities (such as bathing and washing of clothes, sand excavation and agricultural runoffs) when discharged into water bodies contributes significantly to water pollution which in turn makes clean water a scarce commodity. Singh and Deepika, [1] classified all these activities as point and non-point sources of pollution which deteriorates the quality of water sources through nutrient enrichment, destruction of spawning grounds for aquatic and marine life and eventually, killing of aquatic lives. The study area Njaba River is a major river of economic, agricultural and environmental significance in Awo- Omamma, Oru-East Local Government Area of Imo State, Nigeria. Njaba River, Awo-omamma receives effluents from the Nigerian Breweries Plc, as well as contaminants from agricultural runoff and other sources that could contribute to its pollution. Some studies [2,3] revealed that untreated effluent from factories which are directly or indirectly discharged into rivers causes pollution of surface water. On the other hand, effluents from the food (brewery) industry are not particularly toxic but their organic content and large volume can exert a considerable oxygen demand on the environment in the region where they are discharged [4]. These organic contents together with agricultural runoff, sand excavation runoff etc., when combined, alters the ecological niche resulting in stressors like increased turbidity which limits light penetration and prohibits healthy plant growth on the river bed. The quality of water is usually influenced by myriads of parameters such as temperature, power of the concentration of hydrogen ion (pH), Electrical conductivity, turbidity, dissolved oxygen, chemical oxygen demand, biological oxygen demand, total dissolved solids, total suspended solid, and some heavy metals (APEC). Thus, a regular monitoring of some of them not only prevents diseases and hazards but also checks the water resources from further pollution [5]. Sequel to the above, the present study assessed the water quality of Njaba River by analyzing some physico-chemical parameters of the water.

2. MATERIALS AND METHODS

Njaba River in Awo-Omamma community Oru-East Local Government Area originated from the north-western part of Isu at Isunjaba, flows south-westwards through Njaba and Oguta territories towards Oguta lake, passing through the southern parts of Ukworji, Umunnoha and Oguta Local Government Areas in Imo State of Nigeria (Fig. 1). The river is located between latitude N 5°44' longitude 6°49' E and latitude 5°47' longitude 7°03'. The climate around the river area has a mean rainfall season that falls between the month of May and October and the river is adequately recharged by precipitation during rainy season, [6]. The region is a rainforest belt. The river serves as a source of water for both domestic and agricultural purposes to the poor, and the entire local population [7].

Aside sand excavation, other human activities such as washing, farming and fishing also take place along the river banks [8].

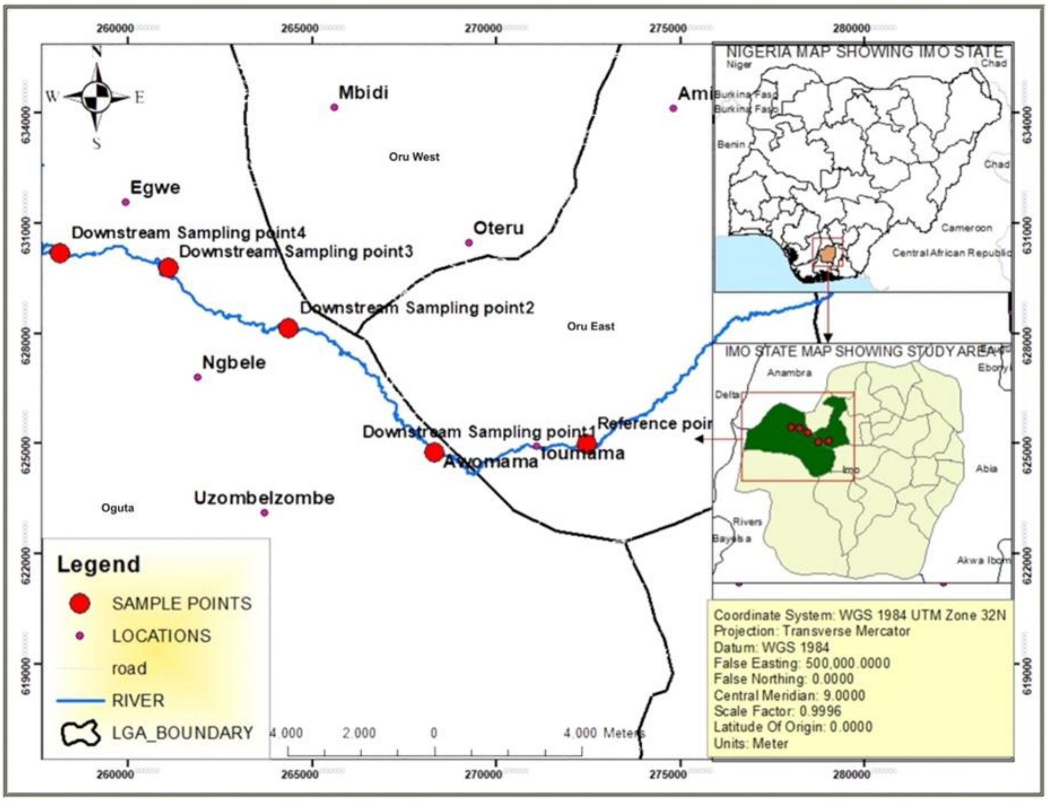

Fig. 1. Study area showing the sampling points along Njaba River in Imo State, Nigeria
(Source: Current Research, 2023)

The study was carried out during the month of May, 2023. Water and sediment samples were collected at different sampling points. At each sampling point, the sterile sample container was dipped inside the river counter current to the flow of the river in collection of the sample. The in-situ parameters such as pH, Temperature, Conductivity, Dissolved Oxygen (DO) and Total Dissolved Solids (TDS) were measured using the following equipments: pH meter, Temperature Probe, Conductivity meter, DO meter and TDS meter respectively and their readings recorded accordingly.

Biological Oxygen Demand (BOD) samples were also collected immediately after the in-situ measurement of the DO at each sampling points. The water sample was fixed in the 250ml Winklers bottle at each sampling point and corked. Afterwards, it was placed in an ice chest alongside the water samples and transported to the laboratory for further analysis. The physico-chemical parameters of the water samples were analysed in the laboratory using standard methods. Duncan Multiple Range test was used to differentiate the concentrations of Zn and Ni across the sampling points.

3. RESULTS

3.1 Spatial Variations in physico-chemical parameters of Njaba River

Numerical variations were observed in concentrations of the physico-chemical parameters measured across the sampling point control in the Njaba River during the study period. Mean ±SE values of EC, temperature and Turbidity were 12.33±0.66 µS/cm, 27.63±0.28 °C and 6.60±0.70 NTU. At sampling points (SP 1) their respective mean ±SE concentrations were 13.67±0.33 µS/cm, 29.50±0.05 °C and 33.47±0.56 NTU. At SP 2, their mean concentrations were 12.67±0.33 µS/cm, 28.73±0.28 °C and 22.33±1.51 NTU. At SP 3 they were 12.33±0.66 µS/cm, 28.10±0.05°C and 7.77±0.08 NTU. The mean spatial variations recorded at SP 4 were 12.67±0.33 µS/cm, 27.77±0.43 °C and 7.83±0.38 NTU (Fig. 2).

Table 1. Descriptive of the physico-chemical parameters of Njaba River in Imo State

	Concentrations				
Parameters	**Minimum**	**Maximum**	**Mean**	**SE**	**FMEnv**
pH	3.00	5.80	5.02	0.26	6.50-8.50
Temp. (°C)	27.00	29.60	28.35	0.21	30.00
EC (µS/cm)	11.00	14.00	12.73	0.22	1000.00
DO (mg/L)	7.40	8.70	8.31	0.12	>7.50
BOD (mg/L)	3.50	5.70	4.61	0.18	NS
COD (mg/L)	560.00	704.00	651.20	13.54	NS
Turbidity (NTU)	5.80	34.60	15.60	2.86	10.00
TS (mg/L)	50.00	128.00	91.87	7.41	500-1000
TDS (mg/L)	8.30	9.10	8.55	0.07	500.00
TSS (mg/L)	43.00	118.90	83.48	7.26	<10.00
NO_3^- (mg/L)	0.40	3.74	1.16	0.34	50.00
PO_4^{3-} (mg/L)	0.40	0.56	0.47	0.01	5.00
Pb (mg/L)	0.008	0.305	0.078	0.030	0.05
Zn (mg/L)	0.040	0.598	0.225	0.054	0.01
Ni (mg/L)	0.180	0.308	0.254	0.012	0.02

NS=Not Specified, FMEnv=Federal Ministry of Environment, SE=Standard error of mean, Temp=Temperature, EC=Electrical Conductivity, DO=Dissolved oxygen, BOD=Biological oxygen demand, COD=Chemical oxygen demand, TS=Total solids, TDS=Total dissolved solids, TSS=Total suspended solids, NO_3^-=Nitrate, PO_4^{3-}=Phosphate, Pb=Lead, Zn=Zinc, Ni=Nickel

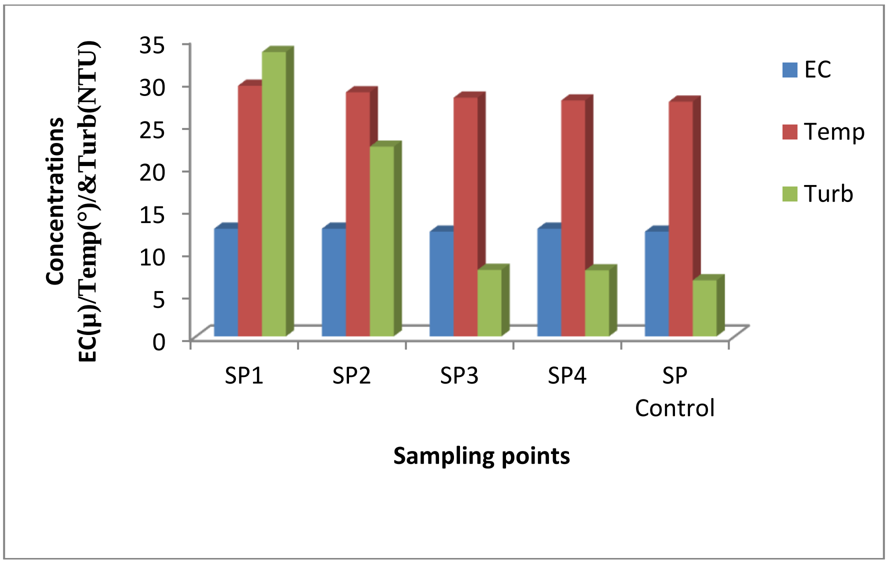

Fig. 2. Spatial variation in mean Electrical conductivity, Water Temperature and Turbidity across the sampling points

Mean concentrations of COD, TS and TSS for SP control were 567.33±4.66, 51.33±0.66 and 43.37±0.18 (mg/L) respectively while that recorded at SP 1 were 694.00±5.03, 123.33±2.40 and 113.93±2.50(mg/L) respectively. At SP 2 their spatial values were recorded as 686.67±15.37, 122.67±1.76 and 113.70±1.92 (mg/L) respectively. Numerical variations in mean concentration observed at SP 3 were 680.00±16.01, 81.33±0.66 and 73.37±0.18 (mg/L) respectively. However, the spatial variations in mean concentrations of these parameters at SP 4 were 627.33±9.82, 80.67±1.76 and 73.03±1.79 (mg/L) respectively (Fig. 2).

Mean concentrations of DO, BOD, TDS and pH at SP Control were 8.67±0.03, 3.57±0.03, 8.40±0.05 (mg/L) respectively and 5.43±0.01. At the SP 1 the spatial variations in mean DO, BOD, TDS and pH were 7.47±0.03, 4.83±0.28, 9.07±0.03 (mg/L) respectively and 5.73±0.03. At

SP 2, the respective parameter mean concentrations were 8.27±0.03 mg/L, 5.57±0.08mg/L, 8.43±0.01mg/L and 4.55±0.79 while that of SP 3 recorded 8.57±0.03mg/L, 4.73±0.08mg/L, 8.41±0.04mg/L and 4.73±0.81. At SP 4 the mean concentrations were 8.60±0.05 mg/L, 4.37±0.08 mg/L, 8.43±0.01 mg/L and 4.65±0.77 (Fig. 3).

The Mean ±SE values of NO_3^-, PO_4^{3-}, Pb, Zn and Ni ions at the SP Control were 0.49±0.01 mg/L, 0.45±0.02,mg/L, 0.011±0.000 mg/L, 0.041±0.000 mg/L and 0.2707±0.000 mg/L. The spatial mean variation recorded for these parameters at SP 1 were 0.53±0.01, 0.43±0.01, 0.3033±0.001, 0.5953±0.002, 0.2247±0.002 and at SP 2 the recorded mean concentration were 0.63±0.01, 0.54±0.01, 0.053±0.001, 0.282±0.001, 0.285±0.002. At SP 3, they were 3.69±0.02, 0.52±0.01, 0.015±0.002, 0.145±0.002 and 0.185±0.002 (mg/L) respectively. However, at SP 4 they were 0.45±0.02, 0.41±0.01, 0.0087±0.000, 0.0633±0.001, 0.3053±0.002 (mg/L) respectively (Fig. 4).

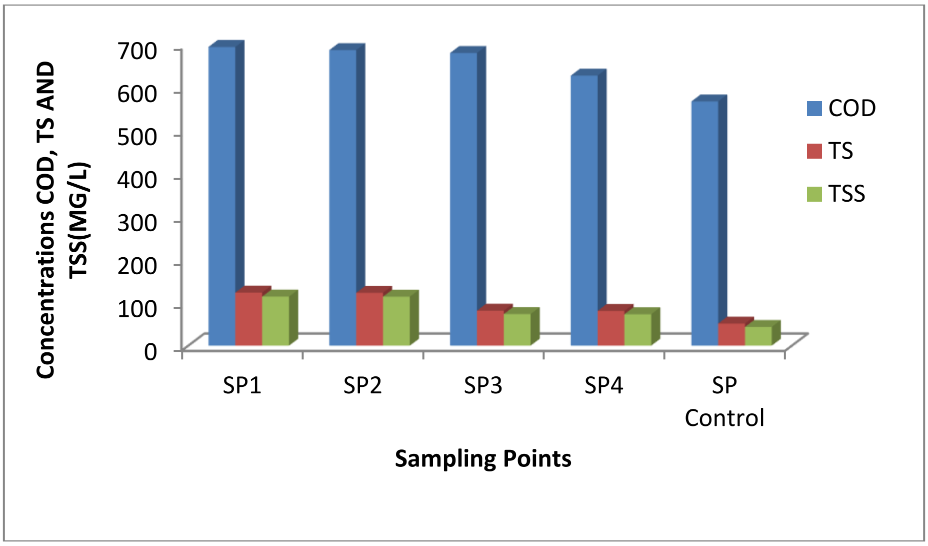

Fig. 3. spatial variations in mean Chemical Oxygen Demand, Total Solids and Total Suspended Solids across the sampling points

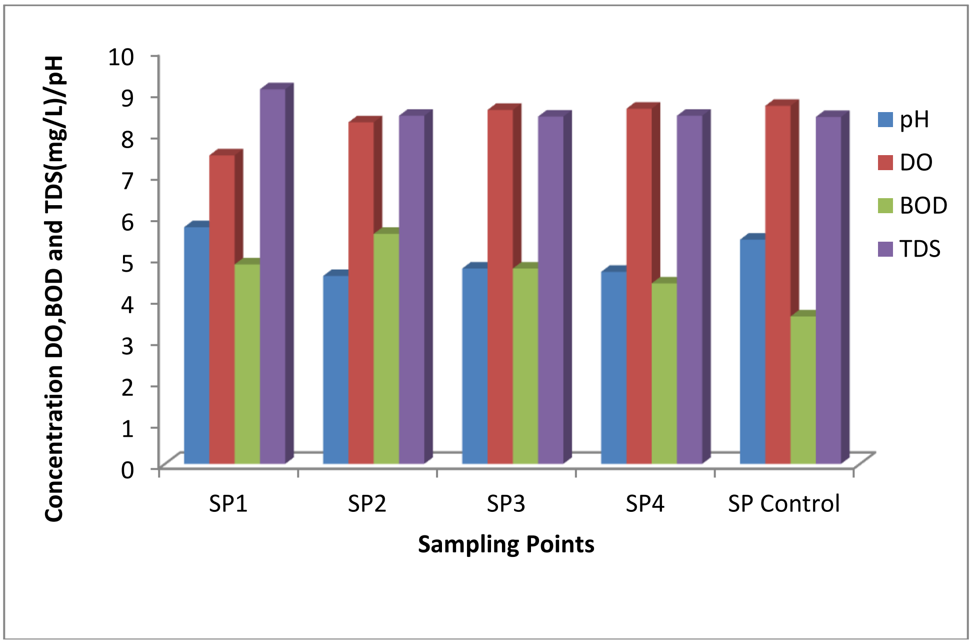

Fig. 4. Spatial Variation in mean pH, Dissolved Oxygen, Biological Oxygen Demand and Total Dissoved Oxygen

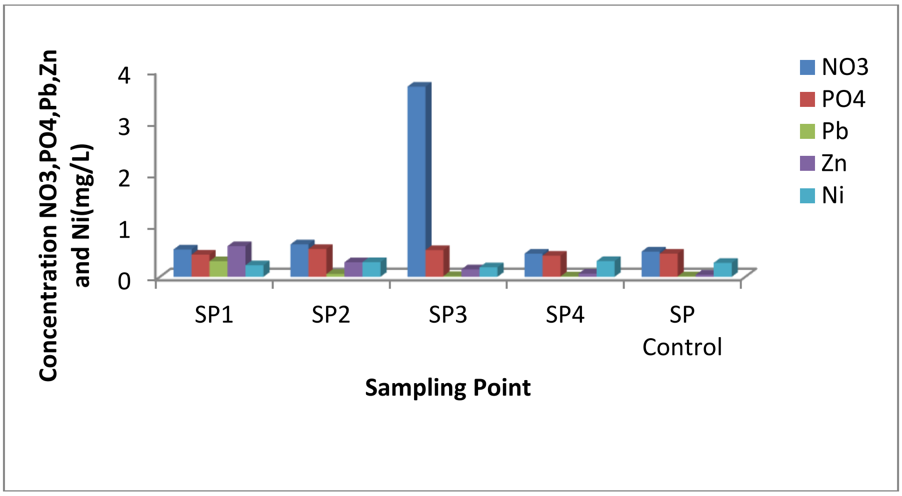

Fig. 5. Spatial variation in mean Nitrate, Phosphate, Lead,zinc and Nickel across sampling points

Table 2. Mean separation in physicochemical parameters of Njaba River across the locations using Duncan Multiple Range Test (p<0.05)

	Sampling points				
Parameters (units)	**SP 1**	**SP 2**	**SP 3**	**SP 4**	**SP Control**
pH	5.73^a	4.55^a	4.73^a	4.65^a	5.43^a
Temp. (°C)	29.50^{bc}	28.73^{ab}	28.10^a	27.77^a	27.63^c
EC (µS/cm)	13.67^a	12.67^a	12.33^a	12.67^a	12.33^a
DO (mg/L)	7.47^a	8.27^b	8.57^c	8.60^c	8.67^c
BOD (mg/L)	4.83^b	5.57^c	4.73^b	4.37^b	3.57^a
COD (mg/L)	694.00^c	686.67^a	680.00^c	627.33^c	567.33^b
Turbidity (NTU)	33.47^b	22.33^a	7.77^c	7.83^a	6.6^a
TS (mg/L)	123.33^c	122.67^b	81.33^c	80.67^b	51.33^a
TDS (mg/L)	9.07^b	8.43^a	8.41^a	8.43^a	8.40^a
TSS (mg/L)	113.93^c	113.7^b	73.37^c	73.03^b	43.37^a
NO_3^- (mg/L)	0.53^b	0.63^c	3.69^d	0.45^a	0.49^{ab}
PO_4^{3-} (mg/L)	0.43^a	0.54^b	0.52^a	0.41^a	0.45^b
Pb (mg/L)	0.303^d	0.053^c	0.015^b	0.009^a	0.011^{ab}
Zn (mg/L)	0.595^e	0.282^d	0.145^c	0.063^b	0.041^a
Ni (mg/L)	0.225^b	0.285^d	0.185^a	0.305^e	0.271^c

Values with same superscript along same row are not significantly different at p<0.05; Temp=Temperature; EC=Electrical conductivity; DO=Dissolved Oxygen; BOD=Biological Oxygen Demand; COD=Chemical Oxygen Demand; TS=Total Solids; TDS=Total Dissolved Solids; TSS=Total Suspended Solids

The One-Way Analysis of Variance (ANOVA) test revealed that mean concentrations of DO, BOD, COD, turbidity, TS, TDS, TSS, NO_3^-, PO_4^3, Pb, Zn and Ni ions (Sig.values=0.000), as well as those of water temperature (Sig.value=0.003) all differed significantly across the sampling locations at $p<0.05$.

A post-hoc mean separation with the Duncan Multiple Range test revealed that the observed difference in concentrations of Zn and Ni was between all the sampling points.

4. DISCUSSION

Temperature values reported in the current work were below the maximum permissible limit by Federal Ministry of Environment (FMEnv). Al-Janabi et al. [9] in their study stated that though, water bodies have the ability to buffer against atmospheric temperature extremes, even moderate changes in water temperature can have serious impacts on aquatic life.

The pH of the study area was lower than the minimum permissible limit of the FMEnv across all the sampling points. The slightly acidic pH condition recorded across the sampling points of this study is in consonance with the findings of Enuneku et al. [10] in Obueyinomo River. They opined that this is typical of tropical aquatic bodies. However, the pH values across the stations did not fall within the FMEnv recommended range of 6.50–8.50 for surface water. According to Enuneku et al. [10] and Rim-Rukeh et al. [11], acidic conditions in an aquatic body could be attributable to humic acid formed from decaying organic matter.

The mean value of Electrical conductivity EC obtained were significantly below FMEnv guideline limit of 1000µS/cm. Okoye et al. [12] in their work reported that change in conductivity values during the rainy season might be due to dilution by rainfall which is in consonance with this study. EC is related to the concentration of TDS. In this study, the TDS value recorded across the sampling points were below recommended guideline of 500mg/l for drinking water and conforms to the findings obtained by Onwona et al. [13] who reported that the low values of EC and TDS recorded in their work indicated low salt contents in the study area. However, this finding is not in tandem with the study of Keke et al. [14] who reported a high conductivity value range of 32.00-72.00 µS/cm in surface water of downstream Kaduna River, in Zungeru.

The FMEnv guideline for DO is greater than 7.50 mg/L. Other than in SP1, all other SPs have DO values that were above this guideline limit. Low DOs in SP1 is attributed to the decomposition of organic matter, dissolved gases, sand excavation runoff into the river as well as brewery effluent. The SP1 DO recorded for this study is in tandem with the findings of Dimowo [15], who reported DO range of 2.9-7.7 mg/L in his work on River Ogun Southwestern Nigeria and Keke et al. [14] also reported a DO range of 3.5-8.2 mg/L from surface water of Kaduna River Zungeru Niger state, Nigeria which is also in consonance to the SP2 DO recorded for this work. The BOD recorded at SP Control is lower than BOD recorded at other sampling points.The mean value of BOD recorded in this work conforms to values recorded by Okoye et al. [12] and Ude [16]. On the other hand, high COD indicated presence of all forms of organic matter, biodegradable and non-biodegradables, and hence the degree of pollution in water. The COD of the study area were high across the sampling points. The mean COD value 651.20±13.54 mg/L was in consonance to the findings of Akaahan and Azua [17] who obtained highest value of COD in river Benue. They observed that the seasonal variation of COD during their study was increasing during the rainy season and decreasing during the dry seasons. Thus, they opined that, reduced water quantity during the dry season decreases COD value. This result agreed with the high COD findings of earlier studies in River Benue by Eneji et al. [18], Longe and Omole [19] in River Illo, Ota Nigeria and Edokpayi et al. [20] in a coastal ecosystem impacted by land based activities.

There was a wide variation recorded for turbidity, TS, TSS, and Pb in this study. The wide variations in turbidity, TS and TSS reflected significant increases in levels of particulate materials constituting turbidity, especially after rainfalls. Turbidity values of the present study were higher than FMEnv standard at SP1 and SP3. The observed high values were clear indication of the influence of human activities in such perturbations as sand excavation, as well as runoff from farm lands into the river. The area is located in the rain forest region of Nigeria, where annual precipitations has been noted to be as high as 2500 mm; most of which falls between the months of May and October, [6]. Consumption of water with high total suspended solids is harmful to the human body [8]. Low nitrate and phosphate were recorded during the study period. Phosphate and nitrate were one of the limiting factors of environmental variables because when used up, aquatic environment becomes unproductive [21].

Suspended solid materials appeared to increase the concentrations of ions such as sulphate in our water bodies [22].

The Pb did not exceed the set standard across most of the SPs, except SP1 that recorded a value far above the regulatory standard. High concentrations of Lead in the body can cause death or permanent damage to the central nervous system, the brain, and kidneys [14]. Nickel was high across all the sampling points when compared to the set standard. This can be attributed to anthropogenic activities. In small quantities nickel is essential, but when the uptake is too high, it can be dangerous to human health. The value of Zinc recorded in the study was far above FMEnv limit [23,24].

5. CONCLUSION

In conclusion it was observed that the water was slightly polluted as deduced mainly from the high levels of turbidity and total suspended solids, as well as those of heavy metals (Zn and Ni) arising from such anthropogenic activities, including discharge of brewery effluent, sand excavation, solid waste dumping and from agricultural farmlands into the water body. Therefore, Government Agencies should put in place stringent measures to tackle discharges of effluents from industries as well as other anthropogenic activities.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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