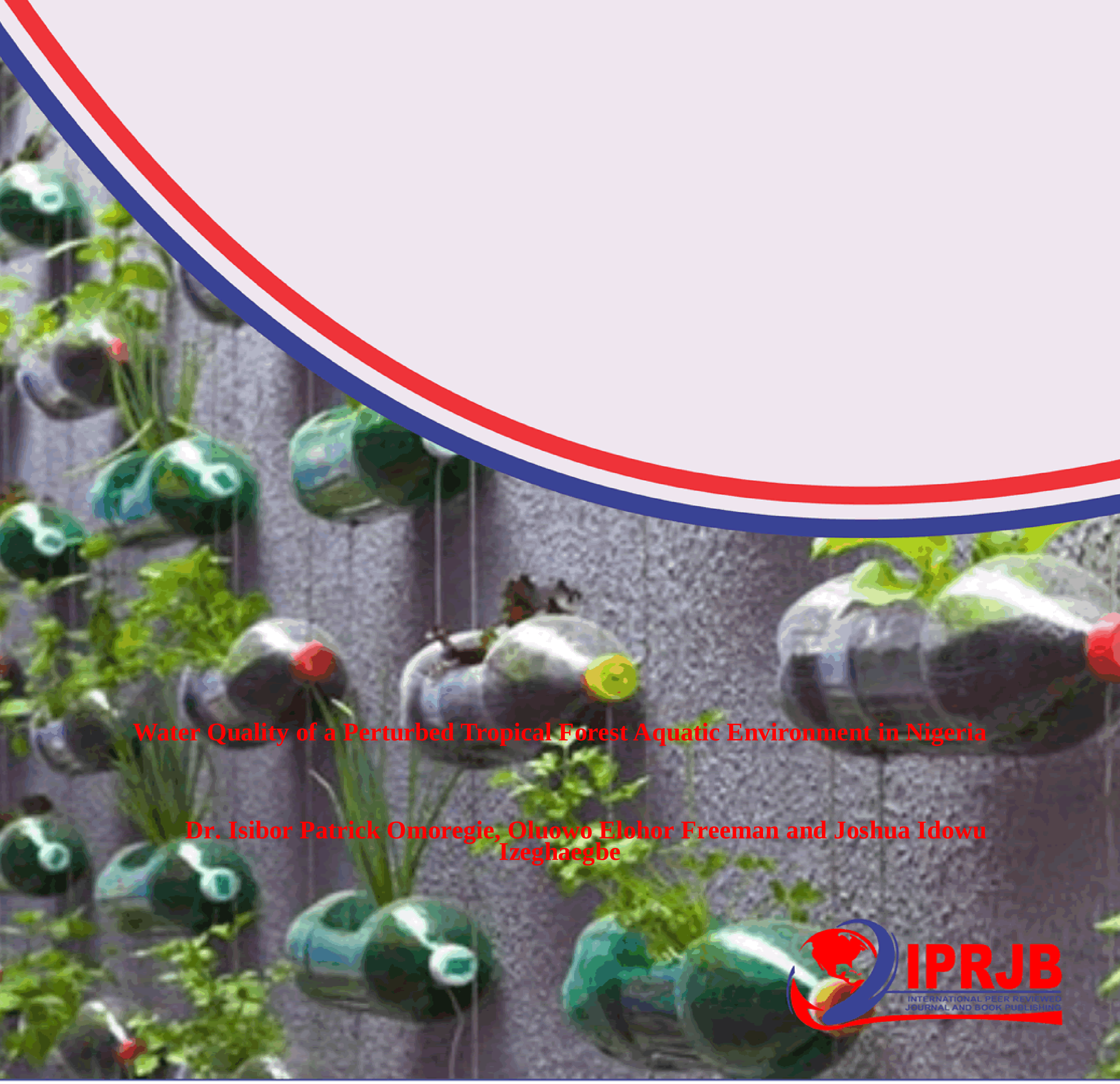
International Journal of
Environmental Science
(IJES)



Water Quality of a Perturbed Tropical Forest Aquatic Environment in Nigeria

Dr. Isibor Patrick Omoregie, Oluowo Elohor Freeman and Joshua Idowu Izeghaegbe

IPRJB
INTERNATIONAL PEER REVIEWED JOURNAL AND BOOK PUBLISHING

International Journal of Environmental Sciences
ISSN xxxx-xxxx (Paper) ISSN XXXX-XXXX (Online)
Vol.1, Issue 1 No.1, pp 54-68, 2016

Water Quality of a Perturbed Tropical Forest Aquatic Environment in Nigeria

[1*]Dr. Isibor Patrick Omoregie

Animal and Environmental Biology Department, University of Benin, Nigeria

***Corresponding Author's E-mail: patrickisibor007@gmail.com**

PHONE: +2347035790793

[2]Oluowo Elohor Freeman

Animal and Environmental Biology Department, University of Benin, Nigeria

[3]Joshua Idowu Izegaegbe

Zoology Department, Ambrose Alli University, Edo State, Nigeria

Abstract

Purpose: Egbokodo River was surveyed from November, 2014 to February, 2016 (covering wet and dry seasons); on monthly basis. 10 samples of surface water were collected at 10 sub-stations randomly around each station; labelled Stations 1, 2, 3, 4, and 5 using 250 litres sampling bottles. **Methodology:** Two-way ANOVA was used to test for significant differences across the months and across the stations. High conductivity in the dry season was coeval with high salinity; indicating a substantial contribution of the dissolved salts to the conductivity of the river. The outstandingly high levels of total dissolved solids and turbidity at Station 3 can be attributed to the intense dredging activities carried out at this location. The high values of BOD observed at Station 2 was accompanied by low dissolved oxygen (DO). This can be attributed to disposal of organic wastes at this section of the river. The DO at Station 3 was significantly higher than other stations throughout the study period ($P < 0.05$). This can be attributed to the surface turbulence by dredging agitation and high standing aquatic macrophytes. The levels of the essential primary productivity nutrients such as nitrate, phosphate and sulphate in the river indicate that the river is oligotrophic. Results show that anthropogenic activities around the river are of higher impacts on the ecological equilibrium than neighbouring rivers. The river is supports aquatic life, it is also suitable for agriculture and domestic use; though not without proper water treatment before drinking.

Conclusion and Recommendation: Dredging is the most impactful anthropogenic disruption in this environment, hence amelioration of the activity is suggested.

Key words: *Allocthonous, authoctonous, anthropogenic activities, pollution, seasonal variation, physico-chemical properties.*

International Journal of Environmental Sciences
ISSN xxxx-xxxx (Paper) ISSN XXXX-XXXX (Online)
Vol.1, Issue 1 No.1, pp 54-68, 2016

1.0 INTRODUCTION

The physico-chemical properties of a water body is the basis of the aquatic ecosystem quality; hence a reflection of the conditions of the aquatic biota. However, the quality of rivers and lakes are in constant moderation by allocthonous and authoctonus influences. In the event of pollution of a water body, contaminants released into the aqueous phase are adsorbed on surfaces of particulate matter; which settle them quickly to the bottom of the river where they create the potential for continued environmental degradation, even when the concentrations in the water medium comply with established water quality criteria (DiToro *et al.*, 1991). The physico-chemical properties of the river influences the metal bioavailability to the biota (i.e. finfish and shellfish); hence an impact on the health of the consumers. However, the variability of the physico-chemical parameters of an aquatic environment is a function of the varied degrees of anthropogenic activities. Hence, constant biomonitoring study of aquatic environments is very paramount in assessing the impacts of anthropogenic activities on the receiving water bodies and impact on public health (Ogbeibu & Ezeunara, 2002).

Egbokodo River has been disturbed by several anthropogenic activities such as oil production, agricultural practices and domestic perturbations. These activities are potential allochthonous sources of contaminants which might have risen to concentrations of eco-toxicological significance (Oyewo & Don-Pedro, 2003). The fate of these contaminants can be monitored by measuring their concentrations in water at strategic locations (Camusso *et al.*, 1995). There is dearth information on the baseline data of physico-chemical properties of Egbokodo River. Ikejimba and Sakpa (2013) recommended a detailed study of the physico-chemical properties of the river; with a view to providing a baseline data information of the aquatic environment. There is need for an extensive and intensive biological survey of this aquatic environment; which is of nutrition, ecological and economic importance to the public.

The research was aimed at surveying the aquatic environment with a view to assessing the spatial and temporal variations of the surface water quality of the river through rainy and dry seasons.

2.0 MATERIALS AND METHODS

2.1 Study area

An aquatic ecological survey was carried out across the stretch of Egbokodo River; located in Warri South Local Government Area of Delta State, Nigeria. It lies between 5° 37' and 5° 42' N; 5°38' and 5°42' E (Figure 1).The study area is dominated by bamboo trees (*Bambusa species*), oil palm trees (*Elaeisguinensis*), water hyacinths (*Eichhorniacrassipes*) and few grasses and shrubs. The area has tropical wet climate which is regulated by rainfall. The climate of the area comprises the wet season (April to October) and the dry season (November to March); followed by a cold harmattan spell from December to January. Occupations of the dwellers of the communities around the catchment areas include farming, fishing, trading and transportation of goods and passengers along the course of the river.

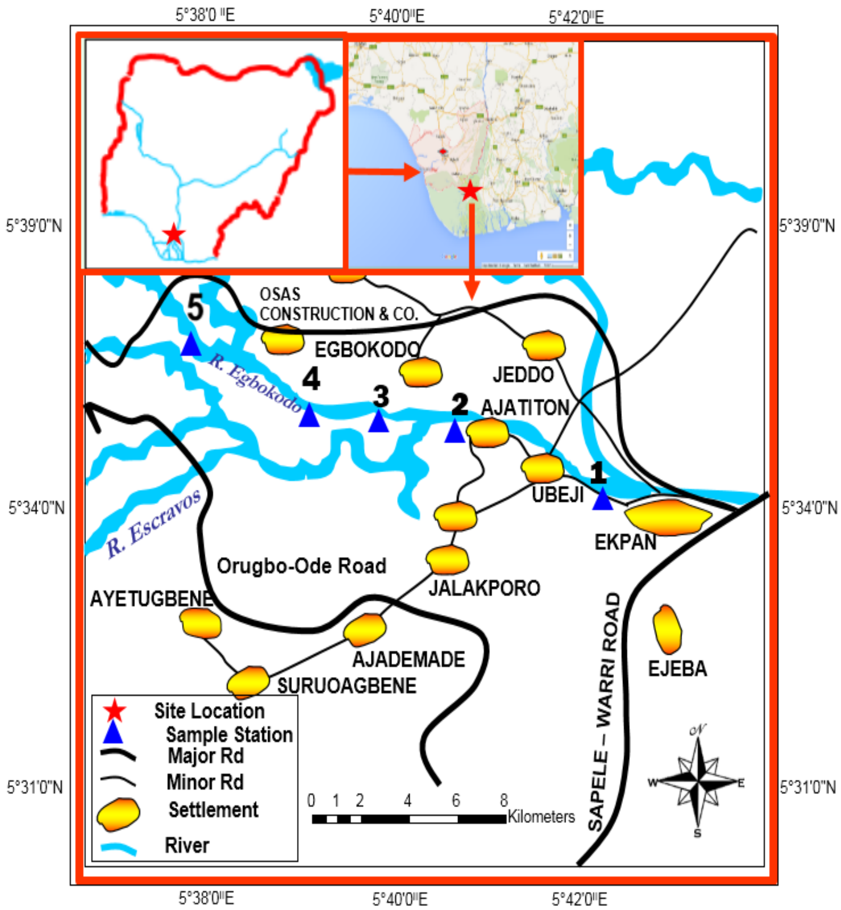


Figure 1: Map of study area showing sampling sampled stations

Five (5) stations were chosen at relevant points of anthropogenic activities along the stretch of the river. Station 1 was located far upstream; away from the disturbed locations. Minimal anthropogenic activities were observed at this location; hence labelled as the control station. Station 2 was located about 430 metres downstream from Station 1. Inhabitants of the surrounding communities use water of the river for washing, bathing and laundering. It was observed that the dwellers of the surrounding communities also dump faeces, kitchen wastes, and other organic domestic wastes at this section of the river. Station 3 was located about 180 metres downstream from Station 2. Manual dredging activities was constantly carried out by a company called Osas Construction Company at this section of the river during the period of sampling. Station 4 was located about 150 metres downstream from Station 3. A vandalized oil pipline (point source pollution) is located at this section of the river. Station 5 was chosen about 430 metres downstream from Station 4. Immense fishing activities predominate this section of the river.

2.2 Sample collection and analysis

Biomonitoring survey of the river was carried out around important sections along the river. 10 samples of surface water were collected at 10 sub-stations; marked using the Global Positioning System device (GPS); randomly around each station (1, 2, 3, 4, and 5) using 250 litres sampling bottles which were rinsed with distilled water, and then with water from each sampling point. The sampling regime was from November, 2014 to February, 2016 (16 months); on monthly basis between 0700 h and 1100 h of each sampling day. The pH of water was taken and recorded in-situ using a WTW water sampler probe. All samples were transported immediately to the laboratory for analysis of the physico-chemical variables using standard methods (APHA, 1998).

Turbidity was measured with the aid of a DR/2000 HACH spectrophotometer and was recorded in Nephelometric Turbidity Units (NTU). Conductivity was determined using conductivity meter and was recorded in µS/cm. Total dissolved solid was determined using a total dissolved meter and was recorded in mg/L. Salinity was determined spectrophotometrically and recorded in mg/L.

Dissolved oxygen (DO) was determined using Winkler's method. Water samples were fixed immediately after collected at the field with 1ml each of Winkler's solution A ($MnSO_4$) and B (alkali- iodide-azide) and determined titrimetrically in the laboratory using Azide modification method (APHA, 1998) and recorded in mg/L. Water samples for biological oxygen demand (BOD) were incubated at 200 ºC for five days, after when BOD_5 was determined using Winkler's method and recorded in mg/L.

2.3 Statistical analysis

The mean and standard error values of 10 samples collected from each station were subjected to a two-way analysis of variance (ANOVA) to analyse the differences across the stations and the months; using SPSS version 19.2 at probability level of 0.05. Duncan Multiple Range test (DMR) to ascertain the actual locations of the significant differences across the stations and among the months.

3.0 RESULTS AND DISCUSSION

The pH of an aquatic environment is a vital physico-chemical characteristic. It determines the bioavailability of contaminants to the aquatic biota; hence it is worthy of much attention. Table 1 shows no significant difference occurred in the pH of Station 1 throughout the study period ($P > 0.05$). The values observed were within Federal Ministry of Environment (FMEnv) established standard limit (6 – 8). This is quite supportive of aquatic ecological system and shows the suitability of the station as control.

At Station 2, significantly higher pH was recorded from November, 2014 to February, 2015 and July, 2015 than the remaining part of the study period ($P < 0.05$). Slightly acidic pH was recorded at this Station in the months of May and October, 2015 and January, 2016 (Table 1). These periods may expose the finfish and shell fish of the river to higher bioavailability of metals; which may culminate in higher bioaccumulation of the metals in their tissue. At Station 3, the pH was significantly higher in January, 2015 than other months in the study period ($P < 0.05$). The pH was within regulatory limits during January, March and December, 2015; and January, 2016; and became slightly acidic in August, 2015. There was no discernible pattern in the temporal rhythmic fluctuations in the pH at this station. Slightly acidic pH recorded in the river is typical of African rivers (Ekhator *et al.,* 2012); which might probably be due to high content of humic acid in the groundwater (Olajire & Imeopkaria, 2001). After Station 1, Station 5 was the most stable in terms of the pH levels throughout the period of study. The overall pH (4.12 – 7.07) of the river was wider in range than that observed in Ovia River: 6.58 -6.60 (Imoobe and Adeyinka, 2009) and Ikpoba River: 5.44 – 6.67 (Ekhator *et al.,* 2012). The high variability in the pH of the river can be attributed to the intense disturbances of the river floor.

Conductivity; which is the measure of the amount of matter in the water; which can conduct electricity was generally higher in the dry season compared to the rainy season in all the stations; except Stations 2 and 4 (Table 2). The higher conductivity in dry season can be attributed to lower water volume due to reduced water input from rain; hence higher concentration of aqueous ions. The general conductivity was Stations 2 > Station 5 > Station 3 > Station 4 > Station 1 ($P < 0.05$). The entire conductivity was below the Federal Ministry of Environment regulatory limit (80 mg/L) throughout the study period. The conductivity of the entire river ranged from 2.4 µS/cm (Station 1 in June and July, 2015) to 48.9 µS/cm (Station 2 in November, 2014). This range is however lower than the conductivities observed by Ekhator *et al.* (2012) in Okhuaihe River (51 – 78 µS/cm), Ikpoba River (38 – 83 µS/cm), Ossiomo River (41 – 94 µS/cm), Siluko River (28 – 68 µS/cm) and Ogba River (46 – 85 µS/cm).High conductivity in the dry season was coeval with high salinity (Table 7) i.e. the levels of conductivity was directly proportional to the salinity throughout the period of study. This indicates a substantial contribution of the dissolved salts to the conductivity of the river.

Table 1: Seasonal variation in pH of water

STATION	2014		2015												2016	
	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
1	6.89* ± 0.02	6.12* ± 0.04	6.05 ± 0.02	6.78 ± 0.12	6.81* ± 0.11	6.21 ± 0.13	6.01* ± 0.02	6.25* ± 0.01	6.23* ± 1.21	6.08* ± 0.22	6.22* ± 0.11	6.03* ± 0.02	6.06* ± 0.02	6.02* ± 0.03	6.01* ± 0.02	6.01* ± 1.12
2	6.81^{A*} ± 0.04	6.8^{A*} ± 0.03	6.78^{A} ± 0.41	7.07^{A} ± 0.03	5.67^{B*} ± 0.04	5.81^{B} ± 0.21	4.77^{C} ± 0.32	5.72^{B*} ± 0.31	6.81^{A*} ± 0.21	5.46^{B} ± 0.22	5.39^{B} ± 1.21	4.58^{C} ± 0.33	5.78^{B*} ± 0.41	5.67^{B*} ± 0.23	4.81^{C} ± 0.41	5.59^{B*} ± 0.21
3	5.08^{B} ± 0.11	5.07^{B} ± 0.41	6.86^{A} ± 0.22	5.84^{B} ± 0.31	6.08^{B*} ± 0.17	5.86^{B} ± 0.16	5.67^{B} ± 0.22	5.77^{B*} ± 0.01	5.79^{B*} ± 0.03	4.82^{C} ± 0.04	5.81^{B*} ± 0.08	5.8^{B*} ± 0.04	5.81^{B*} ± 0.02	6.09^{B*} ± 0.14	6.12^{B*} ± 0.03	5.58^{B*} ± 0.02
4	4.44^{C} ± 0.02	5.34^{B} ± 0.02	5.78^{B} ± 0.04	6.78^{A} ± 0.02	5.23^{B} ± 0.33	6.44^{A} ± 0.02	6.86^{A*} ± 0.11	6.23^{A*} ± 0.22	4.21^{C} ± 0.21	6.87^{A*} ± 0.02	6.34^{A*} ± 0.44	5.41^{B} ± 0.21	5.67^{B*} ± 0.11	4.77^{C} ± 0.22	5.02^{B} ± 0.71	4.12^{C} ± 0.11
5	5.11^{B} ± 0.22	5.67^{B} ± 0.42	6.11^{A} ± 2.1	6.44^{A} ± 1.43	6.22^{A*} ± 2.11	5.87^{A} ± 0.67	5.67^{B} ± 0.87	5.22^{B} ± 1.22	6.66^{A*} ± 1.61	6.75^{A*} ± 1.77	6.02^{A*} ± 1.22	5.88^{A*} ± 1.11	5.12^{B} ± 1.11	6.12^{A*} ± 0.77	6.02^{A*} ± 1.22	6.34* ± 1.44

Note: Along each row, figures with same superscript = No temporal significant difference (P> 0.05), those with different superscripts = significant difference (P<0.05). Down each column, figures with asterisks are significantly higher than others. Sample size (N) = 10.

STATION	2014		2015												2016	
	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
1	25.5^{A} ± 0.02	15.2^{B} ± 0.04	16.3^{B} ± 0.02	7.5^{C} ± 0.12	4.2^{C} ± 0.11	5.5^{C} ± 0.13	6.5^{C} ± 0.02	2.4^{C} ± 0.01	8.2^{C} ± 1.21	2.4^{C} ± 0.22	5.5^{C} ± 0.11	4.5^{C} ± 0.02	5.6^{C} ± 0.02	32.2^{A} ± 0.03	4.8^{C} ± 0.02	13.6^{B} ± 1.12
2	48.9^{A*} ± 0.04	26^{B} ± 0.03	42.8^{A*} ± 0.41	6.5^{C} ± 0.03	12.6^{C} ± 0.04	12^{C} ± 0.21	8.5^{C} ± 0.32	5.8^{C} ± 0.31	6.7^{C} ± 0.21	5.7^{C} ± 0.22	22^{B*} ± 1.21	24^{B*} ± 0.33	13.9^{B*} ± 0.41	48^{A*} ± 0.23	41^{A*} ± 0.41	19.5^{B*} ± 0.21
3	21^{A} ± 0.11	35^{A*} ± 0.41	21^{A} ± 0.22	5.6^{C} ± 0.31	7.5^{C*} ± 0.17	5.3^{C} ± 0.16	8.2^{C} ± 0.22	12.5^{B*} ± 0.01	5.2^{C} ± 0.03	4.8^{C*} ± 0.04	4.2^{C} ± 0.08	2.6^{C} ± 0.04	4.6^{C} ± 0.02	22^{B} ± 0.14	4.5^{C} ± 0.03	5.8^{C} ± 0.02
4	14.5^{B} ± 0.02	22.1^{A} ± 0.02	12.8^{A} ± 0.04	22^{A*} ± 0.02	11.3^{B} ± 0.33	6.8^{C} ± 0.02	4.6^{C} ± 0.11	4.1^{C*} ± 0.22	4.2^{C} ± 0.21	7.4^{C} ± 0.02	4.1^{C} ± 0.44	8.2^{C} ± 0.21	12.7^{B} ± 0.11	17.7^{B} ± 0.22	15.8^{B} ± 0.71	4.2^{C} ± 0.11
5	21.6^{B} ± 0.22	23.3^{B} ± 0.42	15.5^{C} ± 2.1	13.5^{C} ± 1.43	22.2^{B*} ± 2.11	21^{B*} ± 0.67	15^{C*} ± 0.87	12.5^{C*} ± 1.22	11.2^{C*} ± 1.61	8.8^{C} ± 1.77	11^{C} ± 1.22	22^{B*} ± 1.11	11.1^{C} ± 1.11	31^{B} ± 0.77	42^{A} ± 1.22	12.1^{C} ± 1.44

Table 2: Seasonal variation in conductivity (µS/cm) of water

Note: Along each row, figures with same superscript = No temporal significant difference (P> 0.05), those with different superscripts = significant difference (P<0.05). Down each column, figures with asterisks are significantly higher than others. Sample size (N) = 10.

Total dissolved solids (TDS); which is the amount of filterable and non-filterable components of the water was higher across the length of the river in the rainy season than the dry season; contrary to the seasonal rhythm of the conductivity. This suggests that the dissolved solids in the water is not associated with the high conductivity observed in dry season. However the levels of total dissolved solid (Table 3) was directly proportional to the turbidity (Table 6); especially at Station 3; which recorded significantly higher concentrations in both parameters than other stations. The outstandingly high levels of total dissolved solids and turbidity at Station 3 can be attributed to the intense dredging activities carried out at this location. The overall total dissolved solid (15 – 88.4 mg/L) and turbidity (0.21 – 26.8 NTU) of the river were lower than the FMEnv regulatory, but much higher than the levels reported in Okhuaihe River: 25.10 – 37.5 mg/L and 0.5 – 4.84 NTU, Siluko River: 15.5 – 34.0 mg/L and 2.29 – 9.94 NTU); and Ossiomo River: 18.4 – 45.0 mg/L and 5.38 – 18.88 NTU (Ekhator *et al.*, 2012).

The lowest biological oxygen demand (BOD) was recorded at Station 1 throughout the study period (Table 4). There was stability in the BOD of Station 3; which had a significant reduction only in November and December, 2014; and August, 2015 ($P < 0.05$). Stability was also observed in Station 5; which also showed significant drop only in November, 2014; and May and November, 2015 ($P < 0.05$). Highest BOD was observed in Station 2, particularly in December, 2015; January and February, 2016 ($P < 0.05$) during which extreme BOD levels were observed. This abrupt upsurge in BOD can be attributed to disposal of organic wastes at this section of the river; which is the predominant activity during the end of the year; a period of festivity when much organic wastes are generated from nearby kitchens. The high values of BOD observed at Station 2 was accompanied by low dissolved oxygen (DO) (Table 5). The DO at Station 3 was significantly higher than other stations throughout the study period ($P < 0.05$). This can be attributed to the dredging disturbances; which may lead to exchange of oxygen gas between the air-water interface through diffusion of oxygen at water surface due to surface water agitation and turbulence (Omaigberale & Ogbeibu, 2007). The numerous standing aquatic macrophytes at this station might have also contributed to the substantially higher oxygen observed at the station. Only Station 1 (control) and Station 4 maintained DO concentrations within regulatory limits. The overall dissolved oxygen of the river (1.2 – 8.8 mg/L) was within close range with that observed in Siluko River (5.6 – 8.8 mg/L) (Ekhator *et al.*, 2012).

Table 3: Seasonal variation in total dissolved solids; TDS (mg/L) of water

STATION	2014		2015												2016	
	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
1	18.5^{D} ± 0.02	16.1^{D} ± 0.04	15.0^{D} ± 0.02	16.7^{D} ± 0.12	21.3^{C} ± 0.11	22.5^{C} ± 0.13	28.2^{A} ± 0.02	22.4^{C} ± 0.01	28.6^{A} ± 1.21	26.7^{B} ± 0.22	23.4^{C} ± 0.11	24.6^{B} ± 0.02	32.1^{A} ± 0.02	21.3^{C} ± 0.03	22.4^{C} ± 0.02	29.3^{A} ± 1.12
2	17.2^{F} ± 0.04	23.3^{E} ± 0.03	26.8^{D} ± 0.41	27.4^{D} ± 0.03	18.4^{F} ± 0.04	22.3^{E} ± 0.21	32.5^{A} ± 0.32	31.3^{C} ± 0.31	36.7^{A} ± 0.21	38.2^{A} ± 0.22	33.2^{A} ± 1.21	23.5^{C} ± 0.33	34.4^{A} ± 0.41	28.9^{D} ± 0.23	18.5^{C} ± 0.41	19.7^{F} ± 0.21
3	32.5^{D*} ± 0.11	33.4^{D*} ± 0.41	41.9^{C*} ± 0.22	31.5^{D*} ± 0.31	35.2^{C*} ± 0.17	33.8^{D*} ± 0.16	68.3^{B*} ± 0.22	48.5^{C*} ± 0.01	62.4^{B*} ± 0.03	71.6^{A*} ± 0.04	88.4^{A*} ± 0.08	53.6^{C*} ± 0.04	66.7^{B*} ± 0.02	72.5^{A*} ± 0.14	42.5^{C*} ± 0.03	33.4^{D*} ± 0.02
4	25.8^{B} ± 0.02	28.2^{A*} ± 0.02	26.7^{B} ± 0.04	32.4^{A*} ± 0.02	18.5^{C} ± 0.33	28.7^{A} ± 0.02	33.8^{A} ± 0.11	32.6^{A} ± 0.22	34.3^{A} ± 0.21	36.7^{A} ± 0.02	38.7^{A} ± 0.44	31.5^{A} ± 0.21	28.7^{B} ± 0.11	26.9^{B} ± 0.22	21.3^{B} ± 0.71	17.9^{C} ± 0.11
5	24.8^{B} ± 0.22	28.9^{A*} ± 0.42	33.2^{A} ± 2.1	29.7^{A} ± 1.43	25.5^{B} ± 2.11	27.8^{A} ± 0.67	31.2^{A} ± 0.87	28.7^{A} ± 1.22	26.8^{A} ± 1.61	32.4^{A} ± 1.77	33.2^{A} ± 1.22	22.8^{B} ± 1.11	31.5^{A} ± 1.11	34.1^{A} ± 0.77	25.9^{B} ± 1.22	24.3^{B} ± 1.44

Note: Along each row, figures with same superscript = No temporal significant difference ($P > 0.05$), those with different superscripts = significant difference ($P < 0.05$). Down each column, figures with asterisks are significantly higher than others. Sample size (N) = 10.

Table 4: Seasonal variation in biological oxygen demand; BOD (mg/L) of water

STATION	2014		2015												2016	
	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
1	$1.81^{C} \pm 0.02$	$1.21^{C} \pm 0.04$	$2.61^{A} \pm 0.02$	$2.72^{A} \pm 0.12$	$3.82^{A} \pm 0.11$	$2.22^{B} \pm 0.13$	$2.52^{B} \pm 0.02$	$2.21^{B} \pm 0.01$	$3.21^{A} \pm 1.21$	$1.81^{C} \pm 0.22$	$2.21^{B} \pm 0.11$	$1.31^{C} \pm 0.02$	$2.61^{A} \pm 0.02$	$3.22^{A} \pm 0.03$	$1.22^{C} \pm 0.02$	$1.23^{C} \pm 1.12$
2	$6.82^{D*} \pm 0.04$	$6.81^{D*} \pm 0.03$	$6.71^{D*} \pm 0.41$	$7.11^{D*} \pm 0.03$	$5.63^{D*} \pm 0.04$	$5.83^{D*} \pm 0.21$	$4.23^{E} \pm 0.32$	$5.2^{E*} \pm 0.31$	$4.21^{E} \pm 0.21$	$3.18^{E} \pm 0.22$	$3.16^{E} \pm 1.21$	$4.15^{E} \pm 0.33$	$8.17^{C*} \pm 0.41$	$22.16^{B*} \pm 0.23$	$42.3^{A*} \pm 0.41$	$48^{A*} \pm 0.21$
3	$5.08^{B} \pm 0.11$	$5.07^{B} \pm 0.41$	$6.86^{A*} \pm 0.22$	$5.84^{A*} \pm 0.31$	$6.08^{A*} \pm 0.17$	$5.86^{A*} \pm 0.16$	$5.67^{A} \pm 0.22$	$5.7^{A*} \pm 0.01$	$5.79^{A*} \pm 0.03$	$4.8^{B} \pm 0.04$	$5.81^{A*} \pm 0.08$	$5.8^{A*} \pm 0.04$	$5.81^{A} \pm 0.02$	$6.09^{A} \pm 0.14$	$6.12^{A} \pm 0.03$	$5.58^{A} \pm 0.02$
4	$4.44^{C} \pm 0.02$	$5.34^{B} \pm 0.02$	$5.78^{B*} \pm 0.04$	$6.78^{A*} \pm 0.02$	$5.23^{B} \pm 0.33$	$6.44^{A*} \pm 0.02$	$6.86^{A*} \pm 0.11$	$6.23^{A*} \pm 0.22$	$4.21^{C} \pm 0.21$	$6.87^{A*} \pm 0.02$	$6.34^{A*} \pm 0.44$	$5.41^{B*} \pm 0.21$	$5.67^{B} \pm 0.11$	$4.77^{C} \pm 0.22$	$5.02^{B} \pm 0.71$	$4.12^{C} \pm 0.11$
5	$5.11^{B} \pm 0.22$	$5.67^{A*} \pm 0.42$	$6.11^{A*} \pm 2.1$	$6.44^{A*} \pm 1.43$	$6.22^{A*} \pm 2.11$	$5.87^{A*} \pm 0.67$	$5.67^{A} \pm 0.87$	$5.22^{B*} \pm 1.22$	$6.66^{A*} \pm 1.61$	$6.75^{A*} \pm 1.77$	$6.02^{A*} \pm 1.22$	$5.88^{A*} \pm 1.11$	$5.12^{B} \pm 1.11$	$6.12^{A} \pm 0.77$	$6.02^{A} \pm 1.22$	$6.34^{A} \pm 1.44$

Note: Along each row, figures with same superscript = No temporal significant difference (P> 0.05), those with different superscripts = significant difference (P<0.05). Down each column, figures with asterisks are significantly higher than others. Sample size (N) = 10.

STATION	2014		2015												2016	
	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
1	$3.8^{C} \pm 0.02$	$4.2^{B} \pm 0.04$	$3.6^{C} \pm 0.02$	$4.7^{A} \pm 0.12$	$3.8^{C} \pm 0.11$	$6.2^{A} \pm 0.13$	$4.5^{B} \pm 0.02$	$3.2^{C} \pm 0.01$	$3.2^{C} \pm 1.21$	$4.8^{A} \pm 0.22$	$5.2^{A} \pm 0.11$	$3.3^{C} \pm 0.02$	$5.6^{A} \pm 0.02$	$6.2^{A} \pm 0.03$	$5.2^{A} \pm 0.02$	$3.3^{A} \pm 1.12$
2	$1.2^{D} \pm 0.04$	$2.2^{C} \pm 0.03$	$2.7^{C} \pm 0.41$	$2.1^{C} \pm 0.03$	$2.6^{C} \pm 0.04$	$1.3^{D} \pm 0.21$	$2.1^{C} \pm 0.32$	$3.1^{B} \pm 0.31$	$2.1^{C} \pm 0.21$	$1.4^{D} \pm 0.22$	$3.6^{B} \pm 1.21$	$4.5^{A} \pm 0.33$	$1.7^{D} \pm 0.41$	$2.6^{C} \pm 0.23$	$2.3^{C} \pm 0.41$	$1.5^{D} \pm 0.21$
3	$7.2^{A*} \pm 0.11$	$5.3^{C*} \pm 0.41$	$6.8^{B*} \pm 0.22$	$8.2^{A*} \pm 0.31$	$6.2^{B*} \pm 0.17$	$8.2^{A*} \pm 0.16$	$5.6^{C*} \pm 0.22$	$5.7^{C*} \pm 0.01$	$5.7^{C*} \pm 0.03$	$8.8^{A*} \pm 0.04$	$7.8^{A*} \pm 0.08$	$5.8^{C*} \pm 0.04$	$5.2^{C*} \pm 0.02$	$6.9^{B*} \pm 0.14$	$6.8^{B*} \pm 0.03$	$7.5^{C*} \pm 0.02$
4	$4.4^{B} \pm 0.02$	$5.3^{A*} \pm 0.02$	$3.4^{C} \pm 0.04$	$3.8^{C} \pm 0.02$	$4.2^{B} \pm 0.33$	$3.4^{C} \pm 0.02$	$3.5^{C} \pm 0.11$	$4.2^{B} \pm 0.22$	$4.2^{B} \pm 0.21$	$6.2^{A} \pm 0.02$	$5.2^{A} \pm 0.44$	$4.2^{B} \pm 0.21$	$3.8^{C} \pm 0.11$	$3.6^{C} \pm 0.22$	$4.2^{B} \pm 0.71$	$4.1^{B} \pm 0.11$
5	$3.6^{D} \pm 0.22$	$5.2^{B*} \pm 0.42$	$3.4^{D} \pm 2.1$	$6.4^{A} \pm 1.43$	$6.2^{A*} \pm 2.11$	$5.7^{A} \pm 0.67$	$4.6^{C} \pm 0.87$	$4.2^{C} \pm 1.22$	$3.4^{D} \pm 1.61$	$4.5^{C} \pm 1.77$	$6.4^{A} \pm 1.22$	$5.8^{A*} \pm 1.11$	$5.1^{B*} \pm 1.11$	$6.1^{A*} \pm 0.77$	$4.4^{A} \pm 1.22$	$3.3^{A} \pm 1.44$

Table 5: Seasonal variation in dissolved oxygen; DO concentrations (mg/L) in water

Note: Along each row, figures with same superscript = No temporal significant difference (P> 0.05), those with different superscripts = significant difference (P<0.05). Down each column, figures with asterisks are significantly higher than others. Sample size (N) = 10.

International Journal of Environmental Sciences
ISSN xxxx-xxxx (Paper) ISSN XXXX-XXXX (Online)
Vol.1, Issue 1 No.1, pp 54-68, 2016

Results show that the turbidity of the river is fairly within expected range throughout the study period; except at Station 3 (location of dredging activities) where significantly high levels were observed, particularly in the wet season (Table 6). The observed turbidity is typical of an oligotrophic freshwater. Values obtained during most part of the study period are quite similar to that observed by Ogbeibu *et al.*, (2014) in water of Ikpoba River.

STATION	2014		2015												2016	
	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
1	0.82^{C} ± 0.02	0.21^{C} ± 0.04	1.61^{C} ± 0.02	1.72^{C} ± 0.12	1.82^{C} ± 0.11	1.22^{C} ± 0.13	4.52^{A} ± 0.02	3.21^{A} ± 0.01	3.21^{A} ± 1.21	2.82^{A} ± 0.22	2.21^{A} ± 0.11	3.32^{A} ± 0.02	2.61^{B} ± 0.02	1.22^{C} ± 0.03	1.21^{C} ± 0.02	1.32^{C} ± 1.12
2	3.22^{B} ± 0.04	2.21^{C} ± 0.03	2.72^{C} ± 0.41	2.11^{C} ± 0.03	2.62^{C} ± 0.04	3.31^{B} ± 0.21	2.11^{C} ± 0.32	4.11^{A} ± 0.31	4.11^{A} ± 0.21	3.41^{B} ± 0.22	3.62^{B} ± 1.21	4.52^{A} ± 0.33	2.72^{C} ± 0.41	2.62^{C} ± 0.23	2.32^{C} ± 0.41	3.52^{B} ± 0.21
3	7.21^{C*} ± 0.11	5.31^{C*} ± 0.41	26.8^{A*} ± 0.22	17.2^{A*} ± 0.31	16.2^{B*} ± 0.17	8.2^{C*} ± 0.16	15.6^{B*} ± 0.22	5.71^{C*} ± 0.01	5.71^{C*} ± 0.03	18.8^{B*} ± 0.04	7.8^{C*} ± 0.08	15.8^{B*} ± 0.04	15.2^{B*} ± 0.02	12.9^{B*} ± 0.14	16.8^{B*} ± 0.03	7.5^{C*} ± 0.02
4	4.41 ± 0.02	5.32* ± 0.02	3.42 ± 0.04	3.81 ± 0.02	5.24 ± 0.33	3.44 ± 0.02	3.54 ± 0.11	4.24 ± 0.22	4.24 ± 0.21	6.23 ± 0.02	5.23 ± 0.44	4.32 ± 0.21	3.83± 0.11	3.63 ± 0.22	4.23 ± 0.71	4.31 ± 0.11
5	3.63 ± 0.22	5.23* ± 0.42	3.42 ± 2.1	6.24 ± 1.43	6.22 ± 2.11	5.72 ± 0.67	4.62 ± 0.87	4.22 ± 1.22	3.14 ± 1.61	4.52 ± 1.77	6.42 ± 1.22	5.82 ± 1.11	5.12 ± 1.11	6.21 ± 0.77	4.42 ± 1.22	3.23 ± 1.44

Table 6: Seasonal variation inturbidity (NTU) of water

Note: Along each row, figures with same superscript = No temporal significant difference (P> 0.05), those with different superscripts = significant difference (P<0.05). Down each column, figures with asterisks are significantly higher than others. Sample size (N) = 10.

Salinity of the entire study area ranged from 0.01 to 0.82 $^{0}/_{00}$ throughout the period of study (Table 7). The low salinity characterizes a freshwater aquatic environment and it is supportive of freshwater finfish and shellfish lives.

Table 7: Seasonal variation in salinity ($^{0}/_{00}$) of water

STATION	2014		2015												2016	
	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
1	0.52^{A} ± 0.02	0.42^{A} ± 0.04	0.42^{A*} ± 0.02	0.32^{A*} ± 0.12	0.42^{A*} ± 0.11	0.02^{B} ± 0.13	0.03^{B} ± 0.02	0.02^{B} ± 0.01	0.03^{B} ± 1.21	0.04^{B} ± 0.22	0.02^{B} ± 0.11	0.03^{B} ± 0.02	0.61^{A*} ± 0.02	0.22^{A} ± 0.03	0.11^{A} ± 0.02	0.32^{A} ± 1.12
2	0.22 ± 0.04	0.21 ± 0.03	0.22* ± 0.41	0.11 ± 0.03	0.32* ± 0.04	0.31* ± 0.21	0.11 ± 0.32	0.11 ± 0.31	0.11* ± 0.21	0.41* ± 0.22	0.62* ± 1.21	0.52 ± 0.33	0.32 ± 0.41	0.62* ± 0.23	0.32 ± 0.41	0.52* ± 0.21
3	0.21^{A} ± 0.11	0.31^{A} ± 0.41	0.08^{B} ± 0.22	0.02^{B} ± 0.31	0.03^{B} ± 0.17	0.2^{A*} ± 0.16	0.36^{A} ± 0.22	0.31^{A*} ± 0.01	0.01^{B} ± 0.03	0.08^{B} ± 0.04	0.28^{A} ± 0.08	0.08^{B} ± 0.04	0.2^{A} ± 0.02	0.39^{A} ± 0.14	0.5^{A*} ± 0.03	0.52^{A*} ± 0.02
4	0.41 ± 0.02	0.32 ± 0.02	0.42* ± 0.04	0.21* ± 0.02	0.24* ± 0.33	0.44* ± 0.02	0.24 ± 0.11	0.24* ± 0.22	0.24* ± 0.21	0.23* ± 0.02	0.23 ± 0.44	0.32 ± 0.21	0.33 ± 0.11	0.63* ± 0.22	0.23 ± 0.71	0.31 ± 0.11
5	0.63^{A*} ± 0.22	0.53^{A*} ± 0.42	0.42^{A*} ± 2.1	0.24^{B*} ± 1.43	0.22^{B*} ± 2.11	0.32^{B*} ± 0.67	0.62^{A*} ± 0.87	0.22^{B*} ± 1.22	0.14^{B*} ± 1.61	0.52^{A*} ± 1.77	0.42^{A*} ± 1.22	0.82^{A*} ± 1.11	0.82^{A*} ± 1.11	0.21^{B} ± 0.77	0.42^{A} ± 1.22	0.23^{B} ± 1.44

Note: Along each row, figures with same superscript = No temporal significant difference (P> 0.05), those with different superscripts = significant difference (P<0.05). Down each column, figures with asterisks are significantly higher than others. Sample size (N) = 10.

The ranges of the essential primary productivity nutrients nitrate: 0.11 – 2.52 mg/L (Table 8), phosphate: 0.01 – 1.68 mg/L (Table 9), and sulphate: 0.01 – 0.81 mg/L (Table 10) indicate that the river is an oligotrophic aquatic ecosystem. The relatively high levels of these essential nutrients at Station 2 is traceable to the release of organic domestic wastes into this section of the river. The upsurge in the nitrate, sulphate and phosphate concentrations is associated with the allocthonous sources of high organic waste from nearby kitchens; particularly towards the end of each year.

International Journal of Environmental Sciences
ISSN xxxx-xxxx (Paper) ISSN XXXX-XXXX (Online)
Vol.1, Issue 1 No.1, pp 54-68, 2016

Table 8: Seasonal variation in nitrate (mg/L) of water

STATION	2014		2015												2016	
	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
1	0.21 ± 0.02	0.22 ± 0.04	0.22 ± 0.02	0.32 ± 0.12	0.32 ± 0.11	0.32 ± 0.13	0.23 ± 0.02	0.32 ± 0.01	0.13 ± 1.21	0.34 ± 0.22	0.22 ± 0.11	0.33 ± 0.02	0.21 ± 0.02	0.22 ± 0.03	0.11 ± 0.02	0.32 ± 1.12
2	2.24^{A*} ± 0.04	2.81^{A*} ± 0.03	1.22^{B*} ± 0.41	0.71^{C*} ± 0.03	0.32^{D} ± 0.04	0.81^{C*} ± 0.21	0.12^{D} ± 0.32	0.11^{D} ± 0.31	0.12^{D} ± 0.21	0.41^{D} ± 0.22	0.62^{C*} ± 1.21	2.52^{A*} ± 0.33	2.38^{A*} ± 0.41	1.62^{B*} ± 0.23	2.32^{A*} ± 0.41	1.52^{B*} ± 0.21
3	0.21 ± 0.11	0.31 ± 0.41	0.38 ± 0.22	0.32 ± 0.31	0.23 ± 0.17	0.21 ± 0.16	0.36 ± 0.22	0.31 ± 0.01	0.21 ± 0.03	0.28 ± 0.04	0.28 ± 0.08	0.38 ± 0.04	0.22 ± 0.02	0.39 ± 0.14	0.51 ± 0.03	0.52 ± 0.02
4	0.41^{B} ± 0.02	0.32^{B} ± 0.02	0.42^{B} ± 0.04	0.21^{C} ± 0.02	0.24^{C} ± 0.33	0.44^{B} ± 0.02	0.74^{A*} ± 0.11	0.84^{A*} ± 0.22	0.78^{A*} ± 0.21	0.73^{A*} ± 0.02	0.43^{B} ± 0.44	0.82^{A} ± 0.21	0.33^{C} ± 0.11	0.63^{A} ± 0.22	0.23^{C} ± 0.71	0.31^{C} ± 0.11
5	0.52^{B} ± 0.22	0.53^{B} ± 0.42	0.42^{B} ± 2.1	0.24^{C} ± 1.43	0.22^{C} ± 2.11	0.32^{C} ± 0.67	0.62^{A*} ± 0.87	0.22^{C} ± 1.22	0.79^{A*} ± 1.61	0.52^{B} ± 1.77	0.42^{B} ± 1.22	0.82^{A} ± 1.11	0.82^{A} ± 1.11	0.21^{C} ± 0.77	0.42^{C} ± 1.22	0.23^{C} ± 1.44

Note: Along each row, figures with same superscript = No temporal significant difference (P> 0.05), those with different superscripts = significant difference (P<0.05). Down each column, figures with asterisks are significantly higher than others. Sample size (N) = 10.

STATION	2014		2015												2016	
	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
1	0.32 ± 0.02	0.41 ± 0.04	0.42 ± 0.02	0.3* ± 0.12	0.42* ± 0.11	0.23 ± 0.13	0.33 ± 0.02	0.21 ± 0.01	0.12 ± 1.21	0.4 ± 0.22	0.22 ± 0.11	0.23 ± 0.02	0.31 ± 0.02	0.22 ± 0.03	0.11 ± 0.02	0.32 ± 1.12
2	0.62^{B*} ± 0.04	1.21^{A*} ± 0.03	0.82^{B*} ± 0.41	0.3^{*C} ± 0.03	0.3^{*C} ± 0.04	1.31^{A*} ± 0.21	1.68^{A*} ± 0.32	0.81^{B} ± 0.31	1.87^{A*} ± 0.21	0.71^{B*} ± 0.22	0.6^{B*} ± 1.21	1.5^{A*} ± 0.33	1.42^{A*} ± 0.41	0.82^{B*} ± 0.23	1.72^{A*} ± 0.41	0.82^{B*} ± 0.21
3	0.21^{B} ± 0.11	0.31^{B} ± 0.41	0.08^{C} ± 0.22	0.3^{B*} ± 0.31	0.2^{B*} ± 0.17	0.2^{B} ± 0.16	0.36^{B} ± 0.22	0.31^{B} ± 0.01	0.01^{C} ± 0.03	0.08^{C} ± 0.04	0.28^{B} ± 0.08	0.18^{B} ± 0.04	0.32^{A} ± 0.02	0.39^{A} ± 0.14	0.5^{A} ± 0.03	0.52^{A} ± 0.02
4	0.41^{C} ± 0.02	0.32^{C} ± 0.02	0.42^{C} ± 0.04	0.2^{C*} ± 0.02	0.2^{*C} ± 0.33	0.44^{C} ± 0.02	0.84^{B} ± 0.11	1.24^{A*} ± 0.22	1.24^{A*} ± 0.21	1.23^{A*} ± 0.02	1.22^{A*} ± 0.44	0.7^{B*} ± 0.21	0.33^{C} ± 0.11	0.23^{C} ± 0.22	0.33^{C} ± 0.71	0.31^{C} ± 0.11
5	0.01^{C} ± 0.22	0.02^{C} ± 0.42	0.08^{C} ± 2.1	0.07^{C} ± 1.43	0.02^{C} ± 2.11	0.32^{B} ± 0.67	0.62^{A} ± 0.87	0.2^{B} ± 1.22	0.4^{B} ± 1.61	0.2^{B} ± 1.77	0.42^{B} ± 1.22	0.02^{C} ± 1.11	0.02^{C} ± 1.11	0.01^{C} ± 0.77	0.02^{C} ± 1.22	0.08^{C} ± 1.44

Table 9: Seasonal variation in phosphate (mg/L) of water

Note: Along each row, figures with same superscript = No temporal significant difference (P> 0.05), those with different superscripts = significant difference (P<0.05). Down each column, figures with asterisks are significantly higher than others. Sample size (N) = 10.

International Journal of Environmental Sciences
ISSN xxxx-xxxx (Paper) ISSN XXXX-XXXX (Online)
Vol.1, Issue 1 No.1, pp 54-68, 2016

Table 10: Seasonal variation in sulphate (mg/L) of water

STATION	2014		2015												2016	
	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
1	0.02 ± 0.02	0.03 ± 0.04	0.02 ± 0.02	0.04^{A} ± 0.12	0.02^{A} ± 0.11	0.02 ± 0.13	0.03 ± 0.02	0.02^{B} ± 0.01	0.03 ± 1.21	0.04 ± 0.22	0.02 ± 0.11	0.03 ± 0.02	0.03 ± 0.02	0.02 ± 0.03	0.01 ± 0.02	0.02 ± 1.12
2	0.22^{C} ± 0.04	0.21^{C} ± 0.03	0.42^{C*} ± 0.41	0.81^{A*} ± 0.03	0.32^{C} ± 0.04	0.31^{C*} ± 0.21	0.71^{A*} ± 0.32	0.76^{A*} ± 0.31	0.75^{A*} ± 0.21	0.41^{C*} ± 0.22	0.62^{B*} ± 1.21	0.52^{B} ± 0.33	0.32^{C} ± 0.41	0.62^{B*} ± 0.23	0.32^{C} ± 0.41	0.52^{B*} ± 0.21
3	0.02 ± 0.11	0.03 ± 0.41	0.05 ± 0.22	0.02 ± 0.31	0.03 ± 0.17	0.04 ± 0.16	0.02 ± 0.22	0.04 ± 0.01	0.01 ± 0.03	0.04 ± 0.04	0.03 ± 0.08	0.04 ± 0.04	0.03 ± 0.02	0.03 ± 0.14	0.03 ± 0.03	0.05 ± 0.02
4	0.41 ± 0.02	0.32 ± 0.02	0.42* ± 0.04	0.21 ± 0.02	0.24 ± 0.33	0.44 ± 0.02	0.24 ± 0.11	0.24 ± 0.22	0.24 ± 0.21	0.23 ± 0.02	0.23 ± 0.44	0.32 ± 0.21	0.33 ± 0.11	0.22 ± 0.22	0.23 ± 0.71	0.31 ± 0.11
5	0.63^{A*} ± 0.22	0.53^{B*} ± 0.42	0.42^{B*} ± 2.1	0.24^{C} ± 1.43	0.22^{C} ± 2.11	0.32^{BC*} ± 0.67	0.62^{A*} ± 0.87	0.22^{C} ± 1.22	0.14^{C} ± 1.61	0.52^{B*} ± 1.77	0.42^{B} ± 1.22	0.82^{A*} ± 1.11	0.82^{A*} ± 1.11	0.21^{C} ± 0.77	0.42^{B*} ± 1.22	0.23^{C} ± 1.44

Note: Along each row, figures with same superscript = No temporal significant difference ($P > 0.05$), those with different superscripts = significant difference ($P < 0.05$). Down each column, figures with asterisks are significantly higher than others. Sample size (N) = 10.

4.0 CONCLUSION

The study has provided a general picture of the aquatic environment over an extended period of time; a database useful for reference in future studies and local environment governmental decision making.

Results show that anthropogenic activities around the river are of higher impacts on the ecological equilibrium than neighbouring rivers. The river is supports aquatic life, it is also suitable for agriculture and domestic use; though not without proper water treatment before drinking. Dredging is the most impactful anthropogenic disruption in this environment, hence amelioration of the activity is suggested. Dredging was the most impactful anthropogenic disruption in this environment, hence amelioration of the activity is suggested.

REFERENCES

American Public Health Association (APHA). (1998). Standard Methods for Examination of Water and Waste water. 20th edition APHA – AWNA- WPCF. New York, USA,pp 1134.

Camusso, M. Vigano, L. &Baistrini, R. (1995). Bioaccumulation of trace metals in rainbow trout. *Ecotoxicology and Environmental Safety*, Vol31: 133 – 141.

Di Toro, D. M. Zarba, C. S. Hansen, D. J. Berry, W. J. Swartz, R. C. Cowan, C. E. Pavlou, S. P. Allen, H. E. Thomas, N. A.& Paquin, P. R. (1991). Technical basis for establishing sediment quality criteria for nonionic organic chemicals by using equilibrium partitioning. *Environ. Toxicol. Chem*. Vol 10. Issue 12. pp 1541-1583.

Ekhator, O.Akoma, O. C.&Ogie-Odia, E. (2012). A comparative limnological and water quality assessment of some rivers in Benin City and Perı-urban areas, Edo State, Nıgerıa**.** *Global Research Journal of Microbiology*. Vol. 2. Issue 1. pp 090 – 095.

Ikejimba, C. C. &Sakpa, S. (2013). Comparative study of some heavy metals' concentrations in water and Tympanotonusfuscatusvar radula samples of Egbokodo River, Warri, Nigeria. *International Journal of Modern Biological Research (Int. Mod. Biol. Res.). IJMBR*. Vol. 2. Issue 2014. pp 7 – 15.

Imoobe, T. O. T. &Adeyinka, M. L. (2009). Zooplankton-based assessment of the trophic state of a tropical forest river in Nigeria. *Arch. Biol. Sci. Belgrade*. Vol. 61. Issue 4. pp 733- 740.

Ogbeibu, A. E.Oriabure, P. A.Oboh, I. P.&Edogun, I. S. (2014). The effects of brewery effluent discharge on the water quality and sediment of the Ikpoba River, Benin City, Nigeria. *Journal of Aquatic Sciences*. Vol. 29. Issue 1A. pp 43 – 58.

Olajire, A. A. &Imeokparia, F. E. (2001). Water quality assessment of Osun River: Studies on inorganic nutrients. *Environmental Monitoring and Assessment*. Vol. 2. Issue 69. pp17-28.

Omoigberale, M. O.&Ogbeibu, A. E. (2007). Assessing the environmental impacts of oil exploration and production on the water quality of Osse River, Southern Nigeria. *Global Journal ofEnv.Sc.* Vol. 6. Issue 1. pp 1-13.

Oyewo, E. O.& Don-Pedro, K. N. (2003). Lethal and Sub lethal effects of copper to the African Catfish (*Clariasgarienpnus*). *West Africa Journal of Applied Ecology*. Vol. 4. Issue 2. pp115 – 123.

Pavlou, H. E., Allen, N. A. T., and Paquin, R. N. (1991). Technical basis for establishing sediment quality criteria for nonionic organic chemicals by using equilibrium partitioning. *Environ. Toxicol. Chem.*Vol. 10. Issue 12. pp 1541-1583.