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Impacts of Anthropogenic Perturbation On Water Quality Characteristics of Ikpe Ikot Nkon River, Southern Nigeria

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Abstract: A study to investigate the impacts of anthropogenic perturbation on water quality of Ikpe Ikot Nkon River was carried out between October, 2017 and September, 2018. Surface water samples were collected monthly from three sampling stations along the river course and they were analyzed using standard laboratory procedures. The mean range values of water temperature was 26.42 to 28.70 ^{0}C, EC 6.73 to 22.17 µs/cm**,** pH 6.33 to 7.02, DO 3.45 to 7.50 mg/L, BOD 1.85 to 3.80 mg/L, alkalinity 58.40 to 102.17 mg/L, COD 125.45 to 261.92 mg/L, TDS 9.62 to 22.65 mg/L, TSS 14.41 to 60.83 mg/L, PO_4^{3-} 1.54 to 4.18 mg/L, NO_3^- 2.39 to 8.21 mg/L and Cl^- 14.14 to 32.59 mg/L. Analysis of variance (ANOVA) showed significant difference across the stations ($p<0.05$) while Paired sample t-test showed significant difference between dry and wet season ($p<0.05$). The result revealed that anthropogenic perturbations in Ikpe Ikot Nkon River have negative impacts on water quality seasonally. However, the mean value of the parameters studied were within the recommended limits for portable water by World Health Organization in some of the stations. Although, the values were also found to be higher than the threshold limit in some stations. The study recommends continuous monitoring of the river in order to forestall any significant variation that may arise due to intensified human activities within the study area.
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1. Introduction

Aquatic ecosystem is one of the most and important natural resources that support the existence of life. It also served as medium for the survival, reproduction, growth of aquatic biota, and recycling of nutrients. The health of aquatic ecosystem is degraded when the capacity to absorb a stress has been exceeded. Stresses on aquatic ecosystems are as a result of physical, chemicals and biological alteration of the aquatic environment. However, several studies in Nigeria have identified anthropogenic alteration of environment as the major source of water pollution (Obasi and Balogun, 2001; Ogidiaka *et al*., 2012, and Adjarho *et al*., 2013). Available literature on environmental monitoring of surface water indicated that streams and rivers in Nigeria are showing increasing trend of water pollution, due to increase in human population, industrialization, urbanization and agricultural activities in the water ways.

Wastes generated by the industries, untreated waste waters, agrochemicals use in agricultural activities, commercial and household's wastes are indiscriminately disposed-off into the water bodies. Therefore, the increase in anthropogenic inputs, through erosion and leaching has contributed to the pollution load of inland water bodies and subsequently increase in water quality parameters like heavy metals, nutrients, organic and Poly-Nuclear Aromatic Hydrocarbons (PAHSs) (Esoka and Umara, 2006; Adebayo *et al*., 2007; Solomon, 2009), thus rendered the water unsuitable for domestic use. The case is not different in Ikpe Ikot Nkon River, where it's subjected to various anthropogenic activities and input of allochthonous organic materials from the catchment areas during rainfall, which may likely alter certain water quality parameters. There is a dearth of information in relation to physicochemical parameters in this river. However, this work is aim at investigating the influences of anthropogenic perturbation on water quality parameters of Ikpe Ikot Nkon River, which will help in the sustainable management of aquatic ecosystem.

2. Material and Methods

2.1Study Area

The Ikpe Ikot Nkon River is one of the major rivers in tropical coastal regions. It located in Ini Local Government Area, Akwa Ibom State, Southern, Nigeria. Geographically, the River lies between Latitude 5^0 24.0’’ 59.0’ N and Longitude of 7^0 46’’55.7 E (Figure 1). The river takes its course from Nkari River, flows in North-West direction to Ikpa Nya River and discharged into Eniong River in Cross River State. The region is characterized by tropical humid climate with distinct dry season between November and March and wet season between April and October, with a seasonal flooding regime. The banks of the rivers are mostly covered with grasses and other riparian vegetation like *Rhizophora racemosa, Nypa fruticans, Pandamus, Elaeis guineensis.* The river received allochtonous inputs of organic and inorganic wastes from anthropogenic sources through surface run-off from the surrounding farm lands.

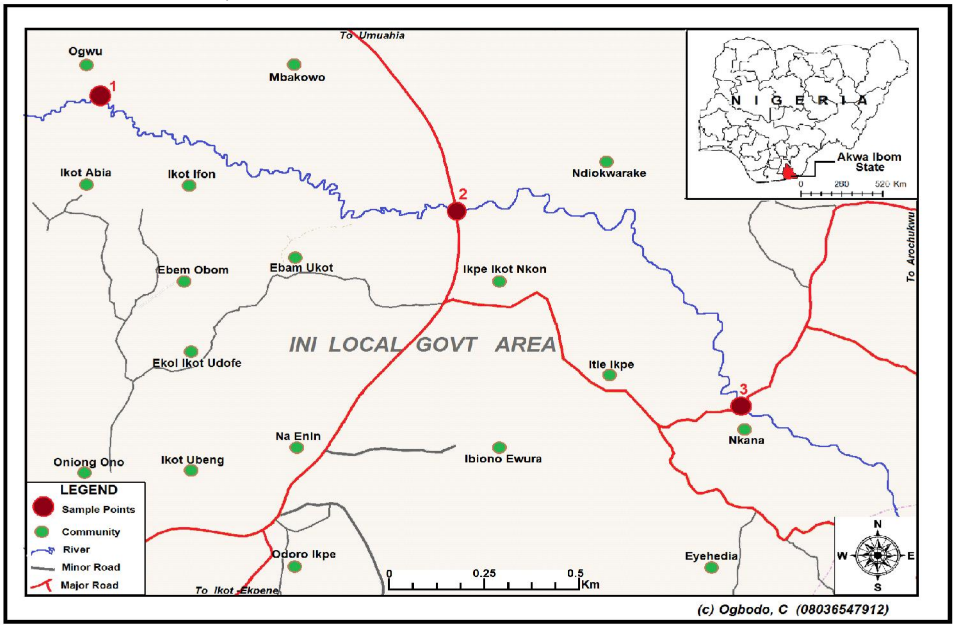

Figure 1: Map of the Study Area Showing the Sampling Stations

2.2 Sampling Stations

The experimental sites were selected along the river course with high, medium and low anthropogenic activities. Station 1 is located upstream, where there are no human activities; station 2 (midstream) is located 2km down away from station 1, and its characterized by high anthropogenic activities, while station 3 (downstream) is 2km away from station 2 and its characterized by having low agricultural landscape where run-off is high, with minimum human activities.

2.3 Collection of Water Samples / Determination

Water sample from each sampling stations were collected at the depth of 30cm below the surface water on a monthly basis for a period of twelve months (October, 2017 to September, 2018). The water samples were collected between the hours of 8.00am and 12.00 noon, using clean plastic bottles (one litre) for physicochemical analysis. The collected water samples were stored in ice chest and transported to the laboratory and kept frozen at 4^0C to preserve the integrity of the samples priorto analysis for physicochemical parameters such as nitrate, phosphate, chloride, total alkalinity, total suspended solid, Biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD). These parameters were determined based on the principles and procedure outlined in standard methods for the examination of physicochemical parameters in water (APHA, 2005, AOAC, 2000). Water temperature, dissolved oxygen (DO), hydrogen ion concentration (pH), electrical conductivity (EC), total dissolved solid (TDS) were determined *in situ* using test kits with sensitive probes. (APHA, 2005).

2.4 Statistical Analysis

Statistical package for Social Sciences (SPSS) version 20 was employed to compute Mean, variance and standard error in the data. Also, two-way analysis of variance (ANOVA) and Least Significant Difference (LSD) test were employed to separate significant differences in mean values computed for stations while t-test was employ to test for seasonal variation. The probability level was set at p = 0.05.

3. Results

The mean spatial variations and standard error of physicochemical parameters across the sampling stations is shown in Table 1. Seasonal variation of physicochemical characteristics in each sampling stations are shown in Table 2, 3 and 4; while Table 5 show the range values of physicochemical parameters of water samples compared with WHO standards.

The mean temperature of the water samples varied slightly across the stations, ranging from 26.42 to 28.70^{0}C. The highest mean value was recorded in station 1 (28.70±0.32 ^{0}C) during dry season, while the lowest value was recorded in station 2 (26.42±0.49 ^{0}C) during wet season, and there were seasonal variations between dry and wet season values in all the stations ($p<0.05$).

The mean values of EC had its range from 6.73 to 22.17 (µs/cm). Highest mean value was recorded in wet season (22.17±2.32) in station 2, while the lowest was recorded during dry season (6.73±0.55) in station 1. There was significant variation between dry and wet seasons values across the stations ($p<0.05$).

The pH values of the water samples were observed to have varied across each sampling stations. The values recorded were slightly acidic to slightly alkaline. Highest mean value was 7.02±0.24, recorded in station 2 during dry season, while the lowest was recorded in wet season (6.33±0.08). There were no seasonal variations in pH values obtained in this study.

The mean DO values obtained in this study ranged from 3.45 to 7.50 mg/L and the highest mean value were recorded during dry season (7.50±0.74 mg/L) in station 1, while lowest of 3.45±0.39 mg/L were recorded during wet season in station 3. There was seasonal variation between the mean value of DO in station 2(t=-2.330, $p<0.05$) and station 3 (t=4.016, $p<0.05$).

The mean values for total alkalinity were higher in the dry season than wet season with significant differences observed seasonally in station 2 (t= 3.407, $p<0.05$) and station 3 (t = 3.616, $p<0.05$). The highest mean value (102.17±7.08) were recorded in station 3, while the lowest value of 58.40±5.11 were recorded in station 1 during the wet season of the study.

Chemical oxygen demand (COD) is the measure of organic waste concentration in a water body. It was observed that COD values were generally higher in all the stations during wet season. The highest value was recorded in station 3 (261.92 ±22.40 mg/L), while the lowest value of 125.45±9.79 mg/L was recorded in station 1. There was a significant different in station 2(t = -2.937, $p<0.05$) and in station 3(t= -3.132, $p<0.05$).

Total Dissolved solids (TDS) mean values range from 9.62±0.42 to 22.65±2.63. The lowest mean value was recorded in station 1, while the highest was recorded in station 2 during wet season of the study period. There was a significant difference in TDS value between dry and wet season in station 2(t=-3.517, $p<0.05$) and 3 (t=-2.895, $p<0.05$).

The total suspended solids (TSS) value were higher in station 2 (60.83±3.51) during dry season when compared with other stations. The lowest mean value of 14.41±2.27 was recorded in station 1 during the wet season of the study and there was no significant difference observed across the stations between the two seasons.

Phosphate had its mean values range from 1.54±0.35 to 4.18± 0.32 mg/L. The highest value was obtained in station 2 during wet season, while the lowest was recorded also in station 2 during dry season with significant differences observed seasonally (t= -2.773, $p<0.05$).

Nitrate mean values were ranged from 2.39±0.09 to 8.21±0.61. The highest value was recorded in station 2 during wet season, while the lowest was in station 1 during dry season. Nitrate was observed to be significantly different between the seasons in station 1 (t= - 4.474, $p<0.05$), station 2 (t= - 3.92, $p<0.05$) and station 3 (t = -2.371, $p<0.05$).

Table 1: Mean spatial variations of physicochemical characteristics of Ikpe Ikot Nkon River during the study period

Parameters	Station 1	Station 2	Station 3
Temp.	27.59^a± 0.45	27.53^a±0.44	27.52^a± 0.45
EC	7.96^a±0.51	16.69^b±2.01	15.98^b±1.93
Ph	6.79^a±0.04	6.70^b±0.15	6.58^a±0.15
DO	6.87^a±0.47	2.36^b±0.43	2.38^b±0.35
BOD	2.07^a±0.16	6.37^b±0.23	6.45^b±0.22
TA	62.95^a±3.02	84.58^b±5.57	86.33^b±6.67
COD	134.20^a±6.24	298.84^b±23.37	272.300^b±19.52
TDS	10.53^a±0.37	17.88^b±1.92	16.50^b±1.85
TSS	15.88^a±1.74	57.83^b±2.41	55.53^b±1.72
PO_4^{3-}	1.77^a±0.23	4.74^b±0.33	3.34^b±0.21
NO_3^-	3.40^a±0.37	6.82^b±0.53	5.58^b±0.39
Cl^-	15.94^a±0.77	31.01^b±4.96	22.17^b±4.51

±Standard error, means with different superscripts along the same row are significantly different at $p<0.05$.

Table 2: Seasonal variations of physicochemical characteristics in station 1

Parameters	Wet Season	Dry Season	t-value
Temp.	26.48±0.54	28.70±0.32	2.842*
EC	9.18±0.49	6.73±0.55	-2.720*
Ph	9.18±0.49	6.88±0.04	1.659
DO	6.23±0.52	7.50±0.74	1.196
BOD	2.28±0.20	1.85±0.22	-1.188
TA	58.40±5.11	67.50±2.45	2.359
COD	142.95±6.72	125.45±9.79	-1.183
TDS	9.62±0.42	10.45±0.29	-2.301
TSS	14.41±2.27	17.36±2.68	0.938
PO_4^{3-}	1.99±0.31	1.54±0.35	-.803
NO_3^-	4.41±0.42	2.39±0.09	-4.474*
Cl^-	14.14±0.77	17.76±0.87	-2.991*

± Standard error, *significant at p<0.05

Table 3: Seasonal variations of physicochemical characteristics in station 2

Parameters	Wet Season	Dry Season	t-value
Temp.	26.42±0.49	28.63±0.35	2.965*
EC	22.17±2.32	11.22±0.68	-4.432*
Ph	6.38±0.08	7.02±0.24	2.146
DO	3.58±0.56	5.13±0.51	-2.330*
BOD	3.67±0.29	3.07±0.42	-1.063
TA	71.48±5.29	97.67±6.33	3.407*
COD	250.40±21.88	173.28±10.24	-2.937*
TDS	22.65±2.63	13.12±0.38	-3.517*
TSS	54.84±3.13	60.83±3.51	-1.151
PO_4^{3-}	4.18±0.32	3.29±0.25	-2.773*
NO_3^-	8.21±0.61	5.44±0.34	-3.924*
Cl^-	29.44±2.55	32.59±10.03	0.287

± Standard error, *significant at p<0.05

Table 4: Seasonal variations of physicochemical characteristics in station 3.

Parameters	Wet Season	Dry Season	t-value
Temp.	26.43±0.52	28.62±0.36	2.842*
EC	21.03±2.09	10.93±1.34	-3.570*
Ph	6.33±0.08	6.83±0.25	1.775
DO	3.45±0.39	4.98±0.39	4.016*
BOD	3.80±0.33	3.10±024	-1.862
TA	70.50±6.72	102.17±7.08	3.616*
COD	261.92±22.40	182.68±14.89	-3.132*
TDS	20.82±2.74	12.18±0.33	-2.895*
TSS	52.17±1.80	58.89±2.30	-2.051
PO_4^{3-}	3.52±0.37	3.17±0.19	-.686
NO_3^-	7.48±0.78	5.68±0.38	-2.371*
Cl-	27.26±1.24	31.09±9.29	.410

± Standard error, *significant at p<0.05

Table 5: Mean range values of physicochemical parameters compared with WHO standard

Parameters	Range Values (mg/L)	WHO Standards 2011
Temp.	26.42 – 28.70	24 – 30^{0}c
EC	6.73 - 22.17	1200 µs/cm
pH	6.33 - 7.02	6.5 - 9.0
DO	3.45 – 7.50	>5.0 mg/L
BOD	1.85 – 3.80	3.0mg/L
TA	58.40 - 102.17	100mg/L
COD	125.45 – 261.92	Nl
TDS	9.62 – 22.65	0-500 mg/L
TSS	14.41 – 60.83	50 mg/L
PO_4^{3-}	1.54 – 4.18	<5 mg/L
NO_3^-	2.39 – 8.21	10 mg/L
Cl^-	14.14 – 32.59	50 mg/L

WHO – World Health Organization. NI = Not indicated

4. Discussion

The results obtained in this study revealed that anthropogenic perturbations influenced the physico-chemical parameters of the study area. Temperature values obtained were in the range reported by Okorafor *et al.* (2013) for Calabar River, Nigeria. The high mean values of water temperature obtained during dry season across the sampling stations could be attributed to the location and time of sample collection, which indicate that the cold weather condition reduces the above-mentioned parameter during the wet season. A similar trend was reported by Ekpo *et al.* (2012) in Ikpa River, Nigeria. This also affirms the reports of Sowmyashree *et al.* (2012) that heat generated during the dry season resulted in rising surface water temperature. The values of temperature obtained in this study were within the permissible limit of WHO.

Electrical Conductivity (EC) is a measure of the total concentration of ions present in a water sample, which mostly is influenced by inorganic dissolved salts. The seasonal regime in the levels of EC showed higher values during the wet season than dry season. This trend agrees with the reports of Ekpo *et al.* (2012) for Ikpa River and contradicts with the reports of George and Atakpa (2015) for Cross River Estuary, and Essien-Ibok *et al.* (2010) for Mbo River. The positive increased of EC value in wet season may be ascribed to the positive effect of rainfall which leads to subsequent runoff of nutrients and salt-rich substances from the inundated lands into the water body. The range recorded during the study period was within the permissible limits of WHO.

The mean pH values between dry and wet seasons showed no significant differences ($p<0.05$) in all the stations. The pH was observed to have slight variations between stations and in seasons. During the study period, slightly acidic pH value was obtained in station 2 and 3 during wet season, and slightly alkaline in station 2 during dry season. Low pH mean value during wet season of station 2 and 3 could be attributed to the consistent influx of more acidic forming substances into the water body through surface runoff. This trend agrees with the reports of Clement *et al.* (2010) for urban draining Creek, Nigeria and George and Atakpa (2015) for Cross River Estuary.

The mean DO values were higher during the dry season over the wet season in all the stations. This report is in consonance with the findings of Ekpo *et al.* (2012) and Ezra and Nwankwo (2001). The high value of this parameter during the dry season may be attributed to high photosynthetic activities by green plants which released oxygen into the water body. Also, the absence of flood that would have transported organic and inorganic wastes into the river. Low value of DO during the wet season may be attributed to high rainfall, which transported pollutants of anthropogenic source into the river, which in turned reduced the value of this parameter. Statistical analysis showed no significant differences in DO mean value between dry and wet season in station 1, significant difference was observed in stations 2 and 3. The range of DO value especially in station 3 was below the acceptable limits by WHO.

The mean values of BOD obtained were higher in stations 2 and 3 when compared to station 1. Seasonally, the values were higher in wet season in all the stations. This may be attributed to high precipitation which caused the increased input of decomposable organic matter requiring oxygen for their biodegradation into the river through surface runoff. This view coincides with the findings of Akpan (1993) for Qua Iboe River and Essien-Ibok (2010) for Mbo River, Nigeria. There was no significant difference in BOD mean value between dry and wet season during the study period in all the stations. The BOD value reported in station 1 was within the permissible limits of WHO, while station 2 and 3 were above the recommended limits.

Alkalinity of a water body is a measure of the capacity to neutralize acids to a designated pH (Edokpayi, 2005). Seasonal regime of total alkalinity value obtained in this study shows that high alkalinity value was recorded in dry season over the wet season. The low values in wet season was linked to high rainfall which resulted in the dilution of this parameter. The value obtained is consistent with the finding of Akpan (1993), Ali *et al*. (2003), Essien-Ibok *et al*. (2010) and Deekae *et al*. (2010). According to the authors, they attributed the low values of alkalinity in wet season to high volume of water during the season which resulted in diluting the acidic content of the water. Significant difference in value between the both seasons were observed in station 2 and 3 only, and the ranged values were within the permissible limits of WHO, exception of station 3 during the dry season which was above the recommended WHO limits.

Chemical oxygen demand was higher in the wet season than in the dry season across the stations. This may be connected to the fact that rainfall through surface runoff transported inorganic and organic pollutants from the surrounding environment into the river. These seasonal differences in COD value contradicts with the findings of Jonah *et al*. (2015) for Ohii Miri River and Essien-Ibok *et al.* (2010), where they recorded high value in dry season over the wet season. Statistic shows significantly difference in station 2 and 3 between the two seasons.

The mean wet season values for TDS were higher than dry season which can be attributed to high influx of allochthonous inputs into the river through surface run-off. This result is consistent with the reports of Akpan (2004) and George and Atakpa (2015) in Cross River Estuary. Fatoki *et al.* (2001) also reported an increase in TDS in Umtata River (South Africa), but different from the findings of Akpan (1991) and Essien-Ibok *et al.* (2010). However, the mean difference between the dry and wet seasons values of TDS was statistically significant ($p<0.05$) in station 2 and 3 during the study period, and the range obtained was within the permissible limits of WHO.

The seasonal regimes in TSS showed high dry season values than wet season. This result is in contrast with the findings of Ekpo *et al*. (2012). These scholars reported higher wet season's values for TSS and attributed it to the influx of suspended materials and organic matter debris into the system through surface run-off. However, the low values of TSS recorded in the wet season may be as a result of the increase in water level which reduced the amount of organic debris. Comparatively, higher values were considerably observed for all the stations in the dry than wet season, and they were no significant difference between the dry and wet season values of TSS in all the stations during the study period.

Phosphate contents showed a marked seasonal regime with higher values in the wet than in the dry season which may be linked to precipitation which carries wastes rich in phosphate through surface runoff from the surrounding agricultural farm lands into the river. The low values during the dry season could probably be as a result of the absence of above factors and may be their utilization by aquatic biota. The seasonal value of phosphate recorded in this study is supportive of the claims of clement *et al.* (2010) and contrary with the findings of Heleen *et al.* (1995) and Ibrahim *et al*. (2009) for Kontagora reservoir, Niger State where they recorded high values of this parameters during the dry season.

The mean values of nitrate were increased downstream in wet season, which may be attributed to high surface run-off of nutrients from the surrounding fertilized farm lands into the river. This is supported by the report of Commins *et al.* (1983) and Ufodike *et al*. (2001) for Dokowa Vine Lake, but contrary with the reports of Akpan and Akpan (1994), Jonah *et al.* (2015) where they observed a higher nitrate concentration in dry season. Statistic showed significant difference between the two seasons in all the stations. The mean values of nitrate obtained in this study were within the desirable limits by WHO for drinking water.

Chloride contents were recorded high in dry season, which may be credited to the absent of precipitation which could have caused a dilution of chemical substance rich in chloride salt. This may be explained further to mean that high rainfall evidenced during the wet season diluted this parameter. Jonah *et al*. (2015) reported high level of chloride in the dry season for Ohii Miri River, Nigeria. The value obtained was below the permissible limits set by WHO.

5.0 Conclusion

Variation in seasonal regime of values in physicochemical parameters obtained in this study was associated with the seasonal anthropogenic activities and high precipitation during the study period. The levels of the parameters obtained were within the acceptable ranges for domestic water purposes and fish production. Although, some of the parameters were slightly above the WHO threshold limit in some of the stations. The results of the present study show evidence of human perturbations in Ikpe Ikot Nkon River. This study vindicates the essence of continuous monitoring of our water bodies as this will help to give vital information on the status of water bodies in Nigeria and to expedite remedial measures in the event of pollution.

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