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By

Okorafor K. A.
Effanga E. O.
Andem A. B.
George U. U
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Research Article

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***Okorafor K. A., Effanga E. O., Andem A. B., George U. U. and Amos D. I.**

Department of Zoology and Environmental Biology, University of Calabar, Calabar, Cross River State, Nigeria.

*Corresponding Author's Email: okoraforka@yahoo.com, Tel: +2348037930542

ABSTRACT

The study of spatial variation in physical and chemical water quality and macro-invertebrates in the intertidal regions of Calabar River was carried out in Adiabo Community for a period of four months (September to December, 2012). The surface water was collected from four different stations along the river. The mean values of triplicate samples of all the water parameters include temperature of 28.69 ± 0.03^{0}C, pH of 6.60 ± 0.02, dissolved oxygen (DO_2) of 4.06 ± 0.21 mgO2/L, Total Suspended Solid (TSS) of 535.63 ± 39.8mg/L, Turbidity of 0.020 ± 0.0025mg/L, Conductivity of 8.87 ± 0.26 Sμ/Cm, Chemical Oxygen Demand (COD) of 1.82 ± 0.013mgO_2/L, Biochemical Oxygen Demand (BOD), of 1.23 ± 0.04mg/L, Phosphate of 0.49 ± 0.0025mg/L, Sulphate of 0.022 ± 0.00 mg/L, Nitrate of 0.020 ± 0.0025mg/L, Iron of 0.53 ± 0.0025mg/L, Lead of 0.45 ± 0.0025mg/L, Zinc of 0.48 ± 0.0025mg/L. The analysis of variance (ANOVA) showed significant differences ($P<0.05$) in the mean values of Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and Turbidity. Ten macro-invertebrate fauna: *Uca tangeri, Hemigrapsus sp, Penaeus notialis, Macrobranchium vollenhovenii, Machrobranchium felicium, Machromia sp, Pachymelania fusca, Pachymelania byronensis, Pachymelania aurita* and *Neritina rubricata* were recorded. The results showed that Calabar River is moderately polluted. Analysis of metals showed that phosphate, iron, lead and zinc levels are slightly high in the River. Spatial variation showed some stations to be more polluted than others. All the macro-invertebrates recorded were clean water and pollution tolerant species.

Keywords: Spatial Variation, Physical, chemical, Calabar River, Macro-invertebrates, Intertidal Region, Nigeria.

INTRODUCTION

In recent years, both anthropogenic influence such as urban, industrial and agricultural activities have increased exploitation of water resources as well as natural processes such as precipitation inputs, erosion, weathering of crystal materials, degradation of surface waters and rendering the water unsuitable for both primary and secondary uses (Agbaire and Basaran, 2009).

Pollution status of aquatic ecosystems determines the health condition of all organisms that depend partly or wholly on such ecosystems for survival. Aquatic pollution has great ecological impacts on all the components of the ecosystem. The impacts created by aquatic pollution do not only affect the health of organisms, but also developmental processes. Therefore, the need for researches on aquatic pollution and the way out can never be overemphasised.

Calabar River runs through farmlands, industrial, commercial and recreational areas such as Nsidung Beach, Itiat Ekpe Beach, Addax Petroleum Company, Nigerian Port Authority (NPA), Marina Resort, Tinapa Resort and Peri-urban areas before it finally confluences at the Delta River. Calabar Municipality has no waste treatment facilities and heavy rains wash human and industrial wastes into the river. Despite increasing anthropogenic influences due to the rapid development of Calabar town in recent times, there is dearth of information regarding the limnology of the river.

Water, an essential natural resource that sustains life is used up by all living organisms. Therefore the knowledge of the status of water bodies in terms of contamination or pollution is quite essential for proper management of water environments. Although water is important to life, it is one of the most poorly managed resources in the world (Fakayode, 2005). The quality of water resources in any ecosystem provides significant information about the available resources for supporting life in the ecosystem (Rajesh et al. 2007). In recent years, both anthropogenic influence such as urban, industrial and agricultural activities have increased exploitation of water resources as well as natural processes such as precipitation inputs, erosion, weathering of crystal materials, degradation of surface waters and rendering the water unsuitable for both primary and secondary uses (Agbaire and Basaran, 2009).

The assessment of water resources quality for any region is an important aspect for the development activities of the region, because the rivers, lakes and reserviours are used for domestic, industrial, agricultural and fish culture (Jakher and Rawat, 2003). The dynamics of aquatic ecosystem depends on the properties of water, and the ultimate objective of limnology is to understand the factors upon which the continued existence of the organisms depends and also to find out causes of reduction and in some cases extinction of the organisms (Kolo and Oladimeji, 2004). The dynamics of water quality may also present complex patterns and variability which are dependent on a number of unpredictable factors. Some of the factors may be hydrological, meteorological and anthropogenic (Shrestha and Kazama, 2007; Bu *et al,* 2010).

The composition and structure of macro-invertebrates communities has been the subject of much research in river systems. Benefits of research on macro-invertebrates include the quick assessment of biological resources for the conservation purpose and the detection of pollution through the differences between predicted and actual faunal assemblages (Miserendino, 2001). Benthic organisms are known to be one of the bio-indicators of water qualities. In aquatic ecosystems where there are inputs from anthropogenic activities, the standing crop of the benthic community may be negatively affected unlike in pristine environment. The pollution status of any river will likely influence the population of the benthic invertebrates of the river system. It is on this background that this study is going to be carried out.

2.0 MATERIALS AND METHODS

2.1 Description of Sampling Area

Calabar River is a freshwater river which flows through the city of Calabar in a South-eastern direction. It is located at latitude 050-3.365’N and longitude 0080-18.379’E of the Greenwich Meridian. The basin is about 43 kilometres wide and 62 kilometres long, with an area of 1,514 square kilometres (Eze and Effiong, 2010). The Calabar River drains part of the Oban Hills in the Cross River National Park (Cross River National Park, 2010) and empties into the Atlantic Ocean. The River is a tidal river which is characterized by a long wet and dry seasons. Wet season starts from April till October, during which 80% of the annual rain falls, with peak of the rainfall in June and September. Annual rainfall averages 1,830 millimetres. Average temperatures range from 24 ℃ (75 ℉) in August to 30 ℃ (86 ℉) in February. Relative humidity is high, between 80% and 100% (Eze and Effiong, 2010). It consists of vegetation rainforest climate which is close to the mangrove belts, with major species such as Avecinia Africana, Rhizophora, racemosa, Nypa fruitciaus (nipa palm) and a tropical rainforest climate which is influenced by temperature and rainfall. The human activities of the people living around the river includes: fishing, farming, hunting, wood logging and sand mining. The geology of the river basin includes the Pre-Cambrian Oban Massif, Cretaceous sediments of the Calabar flank and the recent Niger Delta sedimentary basin (Eze and Effiong, 2010). At one time it was entirely covered by tropical rainforest (Effiong, 2011).

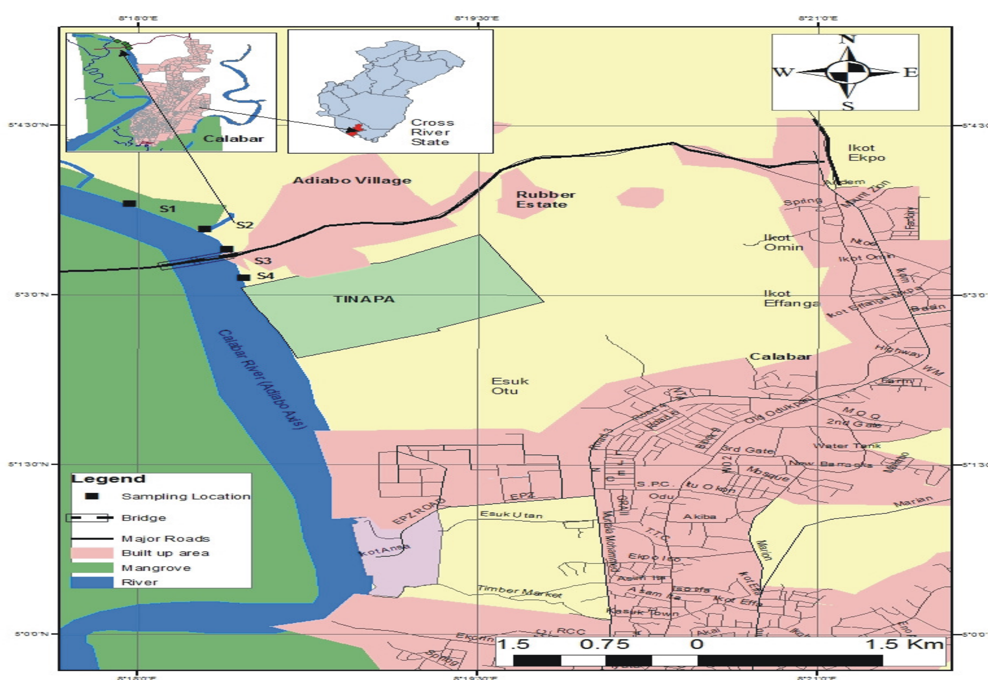

Fig. 1: Map of the study area showing sampling stations.

2.2 Sampling Stations

For the purpose of this study, four locations were chosen. The sampling locations of the river were based on the ecological settings, vegetation and human activities in the area. Station 1 which formed the starting point where other locations began their distances from has a water dredge and the water here is transparent. No farm lands are located at the river bank in this station. Station 2 is located 1km from station 1. This is the narrow creek. It is covered by mangrove vegetations such as the *racemosa, Rhizophora, Nypa fruticaus* (nipa palm), which is used in roofing local houses. The river drains over a sandy substratum and contaminated with human waste during down pour which makes the water in this part of the river very dark with low transparency. Station 3 is within the head bridge of the river. This is the landing site of fishermen and where aquatic life like fishes, shrimps, crayfish, etc are sold. The intertidal region of this station is sandy and the water is very transparent. No vegetation is found here. Station 4 is near the slaughter, where animals like cow, goat etc are been butchered. During rainy season, the wastes and dung from the slaughter are washed into the river. The water in this part of the river has a low transparency. The vegetation in this location includes; Aquatic macrophytes such as *Pomea aquatic, Lemna Sp* (duck weed), *Utricularia sp, Nympaea sp* and *Pistia stratiotes* (Water lettuce).

2.3 Collection of Samples

Samples were collected within a period of four months (from September to December, 2012). Triplicate samples were collected and the mean and standard error recorded after analysis. Water samples were collected into four plastic sampling bottles measuring 1 liter each. The bottles were immersed into the river 6cm below the water surface, filled to capacity and properly closed. The water samples in the bottles were transported in an ice-chest box to the laboratory of pure and applied Chemistry, University of Calabar, Calabar for analysis.

Sampling of macro-invertebrates was done between 7.00 and 12.00 hours on each sampling day. Kick sampling techniques described by Lenat *et al,* (1981) and modified by Kellog (1994) was used in collecting macro-invertebrates from the river banks. The method involved vigorously disturbing the substratum and the emergent vegetation by kicking method. The disturbed animals from the bed were dislodged by the current and a net of mesh size (0.05µ) held downstream was used to collect them. Some of the macro-invertebrates were also collected by hand-picking at the intertidal regions during low tide. Collected samples were preserved in 10% formalin and taken to the Zoology Laboratory in the Faculty of Science, University of Calabar for further studies.

2.4 Samples Analysis/Laboratory Studies

Water temperature was measured with a Jenway 430 thermometer at the site. The pH of the sample was determined in situ with a Jenway 430 pH meter. Conductivity was determined with a Jenway 4510 conductivity meter. Dissolved oxygen (DO) was determined using Jenway 970 dissolved oxygen meter at the site. Turbidity was also determined in situ with a spectrophotometer model 121D. Biochemical Oxygen Demand (BOD) was determined using Dissolved Oxygen meter after incubating for five days at 20^0C in BOD bottle. DO of first day minus DO of fifth day gave the BOD, i.e. DO_1- DO_5= BOD.

Chemical Oxygen Demand (COD) was determined by titration method. The Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and Total Solids (TS) were determined by filtration method. Nitrate, sulphate and phosphate were determined using Jenway 6405 ultra violet spectrometric (Screening) method. Lead, Iron and Zinc were determined using Buck Scientific model 210 VGP Atomic Absorption Spectrophotometer (AAS).

In the laboratory, macro-invertebrates were stained with Rose Bengal solution following Narita *et al.,* (2003). Rose Bengal solution enhances the benthic organisms to be clearly seen even with the naked eyes (Narita *et al*., 2003; Hart, 1999). The respective macro-invertebrates species was sorted using identification guides of Olaniyan (1978); Edmunds (1978); Castro and Huber (2005).

Data were presented in tables and graphs with mean values and standard deviations recorded. Analysis of variance (ANOVA) was used to test for statistical differences between the means of the physical and chemical parameters of the four sampling stations.

3.0 RESULTS

A summary of the physical and chemical parameters of the surface water of Calabar River is shown in Table 1. Water temperature ranged between 27.4 - 30.6 ^{0}C with mean and standard error values of 28.78 ± 0.37; 28.55 ± 1.33; 28.78 ± 1.39 and 28.65 ± 1.23^0C for first station, second station, third station and forth station respectively. The highest mean values of temperature (28.780C) were recorded at stations 1 and 3 respectively and the lowest value was recorded at station 4. Water temperature did not differ significantly between the stations (P > 0.05). The pH was near-neutral throughout the study. The values were within the range 6.32 - 7.24 with mean and standard error values of 6.77 ± 0.37, 6.62 ± 0.22, 6.65 ± 0.03 and 6.72±0.33 from station one to four accordingly. The highest pH value (6.77) was recorded at station 1 while the lowest value was recorded at station

2. The Hydrogen concentration (pH) variation was also not significantly different between stations ($P > 0.05$). Dissolved oxygen values were within the range of 3.89- 4.42mg/L with mean and standard error values accounting for 4.07 ± 0.22, 4.04 ± 0.15, 4.04 ± 0.17 and 4.09 ± 0.23mg/L for the four stations respectively. Dissolved oxygen did not show significant difference between the stations ($P > 0.05$). The lowest mean values (4.04mg/L) of DO were recorded at stations 2 and 3 respectively while the highest value (4.09mg/L) was recorded at station 4. Biochemical oxygen demand (BOD) was generally low during the study period. The values ranged between 1.01- 2.18mgL. The mean and standard error values were 1.21 ± 0.35, 1.23 ± 0.24, 1.38 ± 0.54 and 1.08 ± 0.09mg/L respectively. The highest mean value (1.38mg/L) was recorded at station 3 while the lowest value (1.08mg/L) was recorded at station 4. Biochemical oxygen demand shows significant difference between the stations ($P<0.05$). Total suspended solids, Total dissolved solids and Total solids were between the ranges of 60-100mg/L, 100-800mg/L and 160-1400mg/L. Total suspended solids and total dissolved solids showed statistically significant difference ($P < 0.05$). The mean and standard error values of total solids were 767.50 ± 38.91, 1142.50 ± 63.32, 692.50 ± 102.00, 637.50 ± 98.96mg/L for the four stations with the highest mean value (1142.50mg/L) recorded at station 2 and the lowest value (637.50mg/L) recorded at station 4. Total solids did not show significant difference between the stations ($P>0.05$). Conductivity values ranged between 6.15-16.48µS/cm, it was generally low during the study period. The mean and standard error values were 7.99 ± 2.26, 10.19 ± 2.44, 8.11 ± 2.45, 9.24 ± 4.88µS/cm respectively. The highest mean value (10.19µS/cm) of conductivity was recorded at station 2 while the lowest value (7.99µS/cm) was recorded at station 3. Conductivity did not show significant difference between the stations ($P>0.05$). Turbidity shows significant difference between the stations ($P<0.05$).

The ranges in the mean levels of Chemical Oxygen Demand (COD) recorded at the four stations in the river were (1.87mg/L), (1.84mg/L), (1.79mg/L) and (1.77mg/L) respectively. The lowest mean value (1.77mg/L) was recorded at station 4 while the highest value (1.87mg/L) was recorded at station 1. The mean values of metals (phosphate, sulphate, nitrate, Iron, Lead and Zinc) recorded at the four stations in the river were 0.30-0.81mg/L, 0.13-0.28mg/L, 0.13-0.22mg/L, 0.01-0.84mg/L, 0.01-1.80mg/L and 0.29-0.65mg/L. The lowest mean value of nitrate (0.18mg/L) was recorded at station 1 while the highest mean value was recorded at station 4. All the metals have their highest mean values at station 4 and these chemical variables did not show significant difference between the stations ($P>0.05$).

Table 1: Mean variations and F-values of the Analysis of Variance (ANOVA) of physical and chemical parameters measured at the four stations along Calabar River.

Station	Station 1 (Water dredge)	Station 2 (Narrow Creek)	Station 3 (Bridge)	Station 4 (Slaughter)	Total		Analysis of Variance	
Physico-chemical Parameters	Mean	Mean	Mean	Mean	Mean	Standard Error	Cal F-value	Tab F-value
PH	6.77 (6.37-7.24)	6.62 (6.32-6.81)	6.65 (6.62-6.68)	6.72 (6.52-7.21)	6.69	0.02	0.65	3.05
Temperature (^{0}C)	28.78 (27.4-30.4)	28.55 (27.5-30.5)	28.78 (27.6-30.6)	28.65 (27.4-30.1)	28.69	0.03	0.78	3.03
Dissolved Oxygen (mg/L)	4.07 (3.90-4.39)	4.04 (3.91-4.26)	4.04 (3.89-4.28)	4.09 (3.91-4.42)	4.06	0.21	1.05	3.01
Biochemical Oxygen demand (mg/L)	1.21 (1.01-1.74)	1.23 (1.01-1.54)	1.38 (1.03-2.18)	1.08 (1.01-1.21)	1.23	0.04	6.18*	5.18
Total Suspended Solid(mg/L)	512.50 (370-700)	767.50 (600-1000)	435.00 (60-1000)	427.50 (110-1000)	535.63	39.8	3.49*	3.03
Total Dissolved Solid (mg/L)	255.00 (100-320)	375.00 (100-800)	257.50 (100-430)	210.00 (180-260)	274.38	17.64	7.63*	5.19
Total Solid (mg/L)	767.50 (670-1000)	1142.50 (810-1400)	692.50 (160-1100)	637.50 (290-1200)	810	56.99	1.03	5.16
Turbidity (mg/L)	0.19 (0.10-0.43)	0.20 (0.1-0.47)	0.19 (0.10-0.43)	0.19 (0.098-0.43)	0.20	0.0025	6.43*	5.17
Conductivity (Sµ/cm)	7.99 (6.24-11.58)	10.19 (8.08-12.8)	8.11 (6.15-11.56)	9.24 (6.18-16.48)	8.87	0.26	0.12	3.03
Chemical Oxygen Demand (mg/L)	1.87 (1.43-2.47)	1.84 (1.46-2.38)	1.79 (1.45-2.35)	1.77 (1.33-2.30)	1.82	0.013	0.20	5.16
Phosphate (mg/L)	0.48 (0.30-0.81)	0.49 (0.31-0.81)	0.49 (0.31-0.81)	0.49 (0.30-0.81)	0.49	0.0025	3.03	0.00
Sulphate (mg/L)	0.22 (0.15-0.28)	0.22 (0.13-0.27)	0.22 (0.13-0.27)	0.22 (0.13-0.28)	0.22	0.00	0.00	5.16
Nitrate (mg/L)	0.18 (0.13-0.21)	0.20 (0.17-0.22)	0.20 (0.19-0.21)	0.21 (0.19-0.22)	0.20	0.0025	3.01	5.16
Iron (mg/L)	0.53 (0.004-0.81)	0.53 (0.003-0.80)	0.53 (0.01-0.81)	0.54 (0.002-0.84)	0.53	0.0025	3.04	5.16
Lead (mg/L)	0.45 (0.04-1.77)	0.45 (0.002-1.76)	0.45 (0.01-1.75)	0.46 (0.001-1.79)	0.45	0.0025	3.00	5.16
Zinc (mg/L)	0.48 (0.29-0.64)	0.49 (0.30-0.63)	0.49 (0.29-0.64)	0.49 (0.29-0.64)	0.48	0.0025	3.02	

*Significant at p<0.05, Minimum - Maximum values in Parenthesis

Table 2: Physical and chemical parameters that show significant difference in Mean values at the stations along Calabar River.

	STATIONS			
Physico-chemical Parameters	**Station 1 (Water dredge)**	**Station 2 (Narrow Creek)**	**Station 3 (Bridge)**	**Station 4 (Near Slaughter)**
Biochemical Oxygen Demand (mg/L)	0.21^{ab}	0.23^{b}	0.38^{ab}	0.08^{a}
Total Suspended Solid(mg/L)	512.50^{a}	767.50^{ab}	435.00^{b}	427.50^{ab}
Total Dissolved Solid (mg/L)	255.00^{bc}	375.00^{a}	257.50^{a}	210.00^{ac}
Turbidity (mg/L)	0.19^{b}	0.20^{a}	0.19^{ab}	0.19^{ab}

Mean with the same letter along the row (Stations) for a particular parameter are not significantly different (Duncan's test) $P<0.05$.

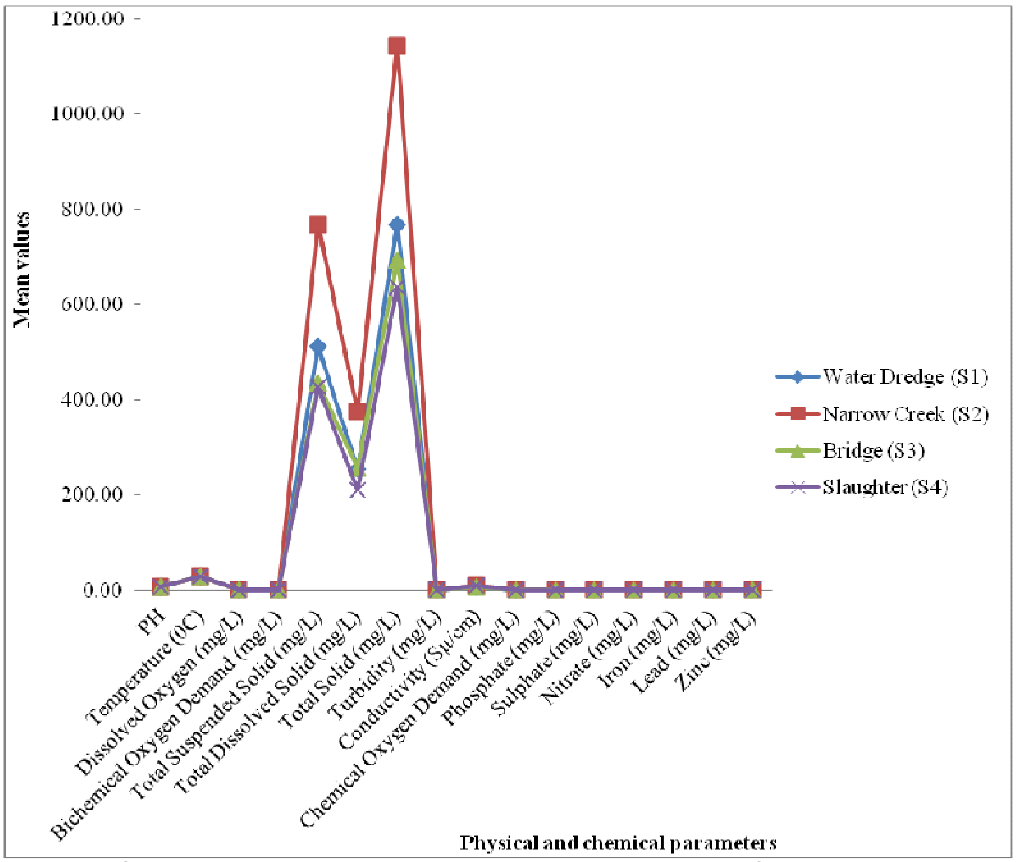

Figure 2: Spatial variation of Physical and chemical Parameters of Calabar River.

Table 3 shows the different species of the macro-invertebrates identified at the different stations. Altogether, ten macro-invertebrate species (taxa) belonging to ten genera and three orders were encountered during the study. They included *Uca tangeri, Hemigrapsus sp, Penaeus notialis, Macrobranchium vollenhovenii, Machrobranchium felicium, Machromia sp, Pachymelania fusca, Pachymelania byronensis, Pachymelania aurita* and *Neritina rubricata.* The gastropods: *Uca tangeri, Hemigrapsus sp, Machrobranchium felicium,* and the gastropods*: Pachymelania aurita* and *Neritina rubricate* were found at all the stations. The decopods: *Penaeus notialis, Macrobranchium vollenhovenii,* and the gastropods: *Pachymelania fusca* and *Pachymelania byronensis,* were absent at station four while the *Machromia sp (*order odonata) was found only at stations one and two.

Table 3: Distribution of Macro-invertebrates at the four stations long the intertidal regions of Calabar River

		Stations			
S/N	**Organisms**	**1**	**2**	**3**	**4**
1.	*Uca tangeri*	+	+	+	+
2.	*Hemigrapsus sp*	+	+	+	+
3.	*Penaeus notialis*	+	+	+	-
4.	*Macrobranchium vollenhovenii*	+	+	+	-
5.	*Machrobranchium felicium*	+	+	+	+
6.	*Machromia sp*	+	+	-	-
7.	*Pachymelania fusca*	+	+	+	-
8.	*Pachymelania byronensis*	+	+	+	-
9.	*Pachymelania aurita*	+	+	+	+
10.	*Neritina rubricata*	+	+	+	+

+ Present
- Absent

4.0 DISCUSSION

The temperature values were within the range for a tropical climate in accordance with Federal ministry of environment (FMENV, 1999) effluent permissible limit of <40˚C. An increase in temperature will lead to an increase rate of chemical reactions and formation of toxic complexes which may have profound effect on aquatic organisms. The near-alkaline pH values recorded throughout the study period falls within the recommended range (6.5- 9) as suitable for aquatic life by FMENV and alkaline pH has been reported in some fluvial ecosystems (Beecroft *et al.,* 1987; Adekola and Annune, 2003; Emere and Nasiru, 2005). The pH of an aquatic system is an indicator of the water quality and the extent of pollution in the water shed (Jonnalagadda and Mhere, 2001). The alkalinity of pH during the study period may be due to the influx and decay of debris in the area as well as imbalance level of hydrogen ions input from surface run-offs during the rains. Change in pH may hold dire consequences for the health of aquatic organisms since most of their metabolic activities are pH dependent (Morgan and McManhon, 1982; Chen and Lin, 1995).

Dissolved oxygen (DO) concentration in natural waters depends on the physical, chemical and biochemical activities in the water body. DO values recorded during the study period were lower than FMENV permissible limit of 5.0mg/l. This was not surprising considering the high levels of nutrients and total suspended solids contents of the effluent from the slaughter. The depletion of DO at the lower stations could also be due to enormous amount of organic loads which required high levels of oxygen for chemical oxidation, decomposition or break down. Similar findings have been reported by some authors (Morenikeji and Raheem, 2008; Chukwu *et al*., 2008 and Andem *et al.,* 2012). DO is very crucial for the survival of aquatic life and it is also used to evaluate the degree of freshness of a river. A DO level as low as between 1-5mg/L will slow down the growth of fishes when continuously exposed, while levels below 1mg/L are reported to be lethal to fish when exposed more than a few hours (Miroslav and Valadimir, 1999; Andem, *et al.,* 2012).

BOD values were below the FMENV permissible limit of 50mg/l. The low level of BOD values recorded in this study could be due to the volume and surface area of the rivers or streams receiving these effluents. DO values were higher than BOD values in all the stations. Moreover, low BOD values at the downstream stations compared to DO values could be attributed to the high DO level, since low DO will result in high BOD and this is a good indication of pollution (Fagade, 1981; Chukwu *et al*., 2007 and Andem *et al.,* 2012).

The chemical oxygen demand (COD) during the study period was very low when compared to permissible limit of 80mg/L set by (FMENV, 1999). The high COD compared to BOD values recorded in this study may be as a result of the fact that some organic substances which are not oxidized biologically can be oxidized chemically as COD measures all the oxidizable organics while BOD measures the oxygen available for biological activities. Also, high COD value compared to BOD values across the stations could be due to high organic load of total solid and total suspended solid from the activities surrounding the River. This affirms the linear relationship between solids and COD (Osibanjo and Adie, 2007). There was no noticeable impact of wastes from the slaughter house at station 4. Moreover, the size of the slaughter house is small compared to the size of the river. Secondly the river flows in both directions (tidal river). These could be the reasons why wastes from the slaughter did not have noticeable impact on the BOD and COD of the river.

Total solid (TS) is the sum total of the suspended solid particles and dissolved materials. TS values were low when compared to the maximum permissible limit of 2000 mg/l set by (FMENV, 1999). The levels of TS, TDS and TSS were generally low. This could be as a result of tidal influence of the river.

Conductivity is a measure of conducting ionic species in a sample solution. Low level of conductivity recorded during the study period could be attributed to the low levels of conducting species such as chloride, phosphate and heavy metals present in the stations. This affirms the study of Fakayode (2005) in Alaro stream , Ibadan. Nitrate values during the study period were below 20 mg/L permissible limit by (FMENV, 1999). The source of nitrate could be from oxidation of other forms of nitrogen compounds like ammonia and nitrite into nitrate. Phosphate values were lower than the maximum permissible level of <5mg/L by (FMENV, 1999). The level of phosphate in the water could relatively be due to the leaching of fertilizer residues from agricultural farms along the river. Sulphate and phosphate levels in the water is likely from phosphate and sulphate containing compounds employed in the manufacturing of detergents which is employed by the abattoir in washing of roasted slaughtered animals. Also, the presence of sulphate and phosphate may be attributed to the washing activities from residents and discharge of house hold effluents into the river.

Lead values ranged between 0.00-1.80mg/L during the study period and were above the permissible limit of 0.05mg/L by (FMENV, 1999). Concentration of lead could be attributed to the leaching from tires employed in roasting of slaughtered animals. These tires are made of tetraethyl lead (TEL) (Horsfall, 2001). Zinc values ranged between 0.29-0.65mg/L were slightly above the maximum permissible limit. The high zinc value observed at the discharge point could be attributed to the high concentrations of Iron in that Zinc which occurs in nature with other metals of which Iron is the most common (Dallars and Day, 1993). The high level of Iron could be attributed to high organic matter and low dissolved oxygen content in that Iron which can be easily absorbed on particulate organic matter or complexes with colloidal organic matter in aquatic environment as pointed out by (Bryan, 1975; Sanders, 1997). It is pointers to the fact that naturally, these trace metals are distributed in surface water due to weathering of minerals and atmospheric deposition (Merian, 1991; Robinson, 1996).

Ten macro-invertebrates belonging to three orders were encountered during the period of this study. All the macro invertebrates encountered are known to be commonly occurring in tropical riverine areas. The occurrence of an organism or species group in a particular environment has been explained by the ability of the species to adapt to the various ecological influences on the organism (Ndome *et al*, 2011). All the stations appeared to be apparently uniform. Little wonder almost all the species of macro-invertebrates encountered could be found at all the stations during the study. Neira et al., (2006) reported variability in the occurrence and distribution of macro-invertebrates in a flowing tidal flat in California, as was previously reported by Straughan (1972) in Ross River Estuary, Australia. Variability in the occurrence and distribution of organisms in a habitat has also been linked with recruitment and reproduction pattern which vary among different organisms. This again, corroborates with the observation of Ombu (1987) and Narita et al., (2003) who worked on some macro-fauna of the central Bonny Estuary, Nigeria and the seasonal and inter-annual variation in biomass and abundance of mega benthos in Ise Bay, central Japan.

All the macro-invertebrates recorded were clean water and pollution tolerant species. The uniformity in the distribution of these organisms could be as a result of apparent uniformity in local environmental conditions. The Calabar River generally showed the presence of common macro-invertebrate composition as in other tropical river systems.

5.0 CONCLUSION/ RECOMMENDATION

The results show that effluent from the slaughter house did not make much impact on the physico-chemical parameters of the river. This could be due to the large size of the river. Also, the river is tidal and there should be high level of mixing and natural purification that could reduce the impact of effluent from the slaughter house. On the other hand, the highest mean values of all the metals were recorded at station 4. This shows that the effluent from the slaughter house could have high metallic constituents.

The quality of an aquatic habitat as describable by physical and chemical properties of the water goes a long way to help assess the stress conditions and thus the survival potentials of organisms present in it. But early detection of unfavorable changes in water quality will allow for proper management of the water resource and the fauna living in it. The common practice of using natural water bodies as disposal media for wastes/effluents in Nigeria poses a serious threat to the aquatic ecosystems. In order to ensure sustainable management and conservation of aquatic environment and enhance biodiversity, there is need to regulate and prevent untreated effluent discharged from industries into the natural water bodies. The following regulatory measures are therefore recommended:

I. There is need to provide adequate waste disposal facilities that will prevent the indiscriminate dumping of wastes into Calabar River.
II. There is also the need for public enlightenment campaigns to raise the level of awareness and re-orienting the attitude of large and small scale industries as well as individuals with respect to environmental pollution problems which may result from discharge of untreated wastes/ effluents into the natural water bodies.
III. Offenders of Environmental laws/legislations should be duly punished so that it will serve as a deterrent to others.
IV. Existing environmental laws should be reinforced.

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