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Heavy Metals, Nutrients, Total Hydrocarbons and Zooplankton Community Structure of Osse River, Edo State, Nigeria

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Abstract

An aquatic ecological survey was carried out across Osse River from April, 2013 to September, 2014. The study was aimed at assessing the heavy metals, nutrients and total hydrocarbons in the water and sediment in conjunction with the zooplankton biodiversity. Surface water, sediment and zooplankton samples were collected from four (4) selected stations. Station 1 was chosen as control station upstream, far away from perturbations; while Stations 2, 3 and 4 were chosen at locations of distinct anthropogenic activities. Surface water and bottom sediment samples were analyzed for heavy metals, nutrients and total hydrocarbons using Atomic Absorption Spectrophotometer (AAS) and Gas Chromatograph-Flame Ionization Detector (GC-FID), respectively. Zooplankton specimens were sorted and dissected where necessary under a binocular dissecting microscope (American Optical Corporation, Model 570), while counting and identifications were done with an Olympus Vanox Research Microscope (mag X60) Model 230485. Results showed that the river is an oligotrophic aquatic ecosystem. The significant Varimax rotated matrices of manganese (0.947), copper (0.883) and zinc (0.817) revealed that these parameters were the active components in the water; while that of copper (0.896) was the active component in the sediment. This revealed that essential metals were the active components in both media. This is consistent with the fact that concentrations of manganese in the water at Stations 3 (0.97 mg/l) and Station 4 (1.26 mg/l), and copper at Station 4 (1.05 mg/l) slightly exceeded the regulatory limits. The zooplankton individuals were spatially distributed in the following order: Station 1 (923) > Station 4 (385) > Station 3 (191) > Station 2 (123). The lowest number of zooplankton individuals were recorded at Stations 2 and 3, i.e., locations of highest perturbations where high concentrations of manganese, nickel and THC were recorded in the water, and nickel, lead, copper and THC were recorded in the sediment. The high concentrations of manganese and THC; particularly Ni which was higher than other stations and FEPA limit, can be attributed to oil exploration activities, such as gas flaring, petrochemical production, storage and transit. Perturbation in zooplankton community structure is prognostic of possible impacts on other aquatic biota of economic relevance. There are indications that anthropogenic activities at Osse River are liable to cause severe ecological perturbations in future if not put in constant check. Continuous stringent bio-monitoring study of the aquatic environment is recommended to put the levels of heavy metals, nutrients and total hydrocarbons in constant check.

Keywords: Zooplankton, surface water, sediment, heavy metals, nutrients, total hydrocarbons.

1. Introduction

Osse River is a major source of water, finfish and shellfish for the populace within communities in the watershed. However, incessant perturbations due to anthropogenic activities are potential threats to the aquatic biota which hold substantial economic values. The activities include oil exploration and exploitation, agricultural practices, discharge of domestic and industrial wastes, laundering and logging. These pollutants are released into the aquatic environments through different pathways, such as point source discharges, surface run-offs, leaching and atmospheric deposition. These activities are capable of disrupting the delicate aquatic ecological equilibrium. Unfortunately, water and sediment are receptors of anthropogenic chemicals as well as habitats to aquatic organisms.

Variability in water and sediment properties is a function of a number of factors which have been reported in previous studies by numerous authors. Generally, these factors can be categorized as authoctonous and allothonous factors working in tandem. Ogbeibu and Victor (1989) reported that perturbations from road and bridge construction across Ikpoba River, Benin City, Nigeria, had a significant impact on the sediment which in turn had impacts on the vital benthic invertebrates. Benka-Coker and Ohiomian (1995) reported on the significant effect of slaughter house waste on the water and sediment qualities of Ikpoba River and warned against threats to the aquatic fauna which are of nutritional relevance to the dependent populace.

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Tukura *et al*. (2012) attributed variation of physico-chemical properties of water and sediment of Mada River, Nasarawa State, Nigeria to seasonal variation, i.e., higher concentrations of most parameters observed in dry season was attributed to increase in concentration as a result of reduced water volume in the dry season.

The water matrix of an aquatic ecosystem is the first receptor of the contaminants released from anthropogenic activities. The sediment of the river eventually serves as repository to these contaminants (Adams *et al.*, 1992; Camusso *et al.*, 1995). However, the rate of deposition of these contaminants is a function of the sorption capacity, which varies among contaminants. Ogbeibu *et al*. (2014) observed that manganese, zinc, copper, cadmium, lead and total hydrocarbons had very high sorption capacities from water into the sediment of Ikpoba River. They therefore strictly recommended biomonitoring of the parameters.

The distinct anthropogenic activities at Osse River are capable of releasing toxicants into the aquatic environment (water and sediment). These toxicants can be readily accumulated by the fauna and flora through processes of bioconcentration, bioaccumulation and biomagnification (Isibor and Oluowo, 2016). Toxicants rise to significant concentrations as they are transferred from one trophic level to the higher, up the pyramid of biomasses through food chain. This might ultimately culminate in public health concerns.

Zooplanktons are a unique group which are suitable bio-indicators in biomonitoring studies. This is due to their unique position in the food chain; as the primary consumers and their high sensitivity to physico-chemical alterations in their ambience. Several researchers have sought to use zooplanktons as bio-indicators of aquatic perturbations. Innumerable studies have been carried on zooplankton using the water quality as the basic background reference. Some detailed zooplankton study in the Niger Delta areas of Nigeria include Imoobe and Adeyinka (2010), Ezekiel *et al* (2011), Ogbuagu and Ayoade (2012), Iloba and Ruejoma (2014), Mandu and Imaobong (2015) to mention a few. However, no existing holistic study has been done on water, sediment and zooplankton biodiversity; with a view to providing the picture of the entire aquatic environment at a glance. Therefore the study was aimed at assessing the heavy metals, nutrients and total hydrocarbons in the water and sediment; in conjunction with the zooplankton biodiversity.

2. Material and Methods

2.1. The Study Area

The research was conducted on a stretch of Osse River, which traverses Nikorowa, through Ekehuan and Gelegele and terminates at Iziedema community. It lies between latitude 5° 90' - 6° 60' N and longitude 5° 18' - 5° 23' E (Figure 1). It is a lotic freshwater with a thick vegetation canopy along its bank. The predominant vegetation around the river includes palm trees (*Elaeis guinensis*), shrubs, floating *Salvinia* species, *Lemna*s pecies and water hyacinth (*Eichorrnia crassipes*). The river is located in the Ovia North- East Local GovernmentArea, Edo State, within the tropical rainforest belt, in the southern part of Nigeria. Water flows in south-westerly direction into the river from Akpata Hills in Ekiti State. It then flows further downstream through the Gwato creeks; into the Benin River, which empties into the Atlantic Ocean. For the purpose of the current study, four Four (4) stations were chosen along the stretch of the river based on distinct anthropogenic activities. Station 1 (control station) was upstream, located at Nikorowa upstream, far away from perturbations, while Stations 2 was located at (Ekehuan, about 4,135 metres downstream from of Station 1), Station 3 (Gelegele, 4, 441 metres downstream from Station 2), and Station 4 (Iziedema, 1, 400 metres downstream from Station 3) were chosen at locations of distinct anthropogenic activities. At the Ekehuan section (Station2) of the river, innumerable drums of crude oil were stored at the bank of the river. An oil company named Dubri Oil Company carries out oil exploration activities at the Gelegele section (Station 3) of the river. Constant gas flaring was also observed at this section. Immense lumbering activities were observed at the bank of Iziedema section (Station 4). These activities are potential perturbation sources to the aquatic environment.

Figure 1. Map of the study area

2.2. Collection and Analysis of Samples

The samples were collected monthly from April 2013 to September 2014 at all the stations. Surface water samples were collected in 250 ml glass containers with lid and properly labelled. Sediment samples were collected using a Birge-Ekman grab. The sediment samples were collected in foil papers and wrapped with labelled polythene. Qualitative plankton samples were collected by towing a 55 µm mesh hydrobios plankton net tied to a 25 HP engine-powered boat driven at about 2 knots just below the water surface for 5 minutes. Quantitative samples on the other hand were collected by filtering 100 liters of water fetched with a bucket through a 55 µm mesh hydrobios net. Both samples were preserved separately in 4% buffered formalin solution. All samples were preserved in ice coolers and transported immediately to the laboratory for analysis. For quality control and standardization measures, these laboratory procedures were repeated at least 3 times and mean values were compared with standards set by FEPA (2003).

2.2.1. Analysis of Water and Sediment

2.2.1.1. Heavy Metals and Nutrients

Water samples were pretreated and digested using the wet oxidation method (Martin *et al*., 1992). The varian Techron spectra AA- 10 Atomic Absorption Spectrometer (Serial No. 9021318) with an attached printer was used for the qualitative determination of heavy metals and nutrients. The sample was fixed with 2 ml of 0.05 M Nitric acid (Martin *et al*., 1992). The mixture was filtered through Whatman filter paper number 1 and aspirated directly into the Atomic Absorption Spectrometer (AAS) for metals and nutrients determination, having prepared the blanks accordingly. For qualitative assurance purposes the purpose the AAS was calibrated for each parameter by dissolving 1 gram analar grade of each element in 1 liter of distilled water. Standard and corresponding blanks were run with each set of experimental digest to ascertain quality control. The results of the analysis were cross checked using standards set by FEPA (2003).

1 gram air-dry sediment sample was placed in a 300-mlL calibrated digestion tube. 3ml concentrated nitric acid (HNO3) was added, swirled carefully and placed in a rack to settle. The mixture was slowly heat up by gradually increasing temperature to about 145 °C for 1 hour (Estefan *et al*. 2013). 4 ml concentrated Perchloric acid (HClO4) was added and heated to 240°Cfor another 1 hour. Mixture was allowed to cool to room temperature. It was filtered through Whatman No. 42 filter paper and the volume was made up to 50 ml with de-ionized water. Heavy metals were then determined by Atomic Absorption Spectrophotometer (model-analyst 200 PerkinElmer).

2.2.1.2. Total Hydrocarbons (THC)

50 ml of water sample was collected in a conical flask. 20 ml of dichloromethane was also added into the flask. The flask was shaken and pressure released at intervals. The sample was allowed to stand for few minutes. Consequently, two layers were formed in the flask. The lower layer (extract) of the sample was collected into a beaker through a filter paper. The filtrate was concentrated to 1 ml by evaporation at room temperature overnight in a fume cupboard (LAWI, 2011).

10g of air-dried sediment sample was added into an amber glass bottle. 20g of anhydrous sodium sulfate (Na2SO4) was also added into the glass bottle containing the soil sample and stirred to remove moisture from the sample. 300 µg/ml of surrogate (1-chlorooctadecane) standard was added to the soil sample. 30 ml of dichloromethane (extracting solvent) was added to the sample and the bottle was corked. The bottle containing the mixture was agitated for about 6 hours at room temperature using a mechanical shaker (LAWI, 2011). After agitation, the sample was allowed to settle for 1 hour and then filtered through 110 mm filter paper into a clean beaker. The filtrate was allowed to concentrate to 1 ml by evaporation overnight in a fume cupboard.

The separation and detection of compounds in sediment and water samples were carried out using Agilent 6890N Gas Chromatograph-Flame Ionization Detector (GC-FID) instrument according to LAWI (2011), which was slightly modified by Cortes *et al*. (2012). 3 µl of concentrated sample was injected into Gas Chromatography (GC) vial. The blank dichloromethane was injected into micro-syringe of GC to clean the syringe (3 times) before taking the sample for analysis. The micro-syringe was further rinsed with the sample. Then, the sample was injected into the column for separation of compounds in the sample. After separation the compounds were passed through a Flame Ionization Detector (FID). FID detected the compounds in the sample. The amount of total hydrocarbons was ascertained at a particular chromatogram in mg/kg for sediment samples and in mg/l for water samples.

2.2.2. Analysis of zooplankton

In the laboratory, specimens were sorted and dissected where necessary under a binocular dissecting microscope (American Optical Corporation, Model 570), while counting and identifications were done with an Olympus Vanox Research Microscope (magX60) Model 230485. Identification of specimens was carried out at the University of Benin, Zooplankton laboratory using identification keys provided by Van de Velde (1984), Jeje and Fernando (1986) and Boxshall and Braide (1991).

2.2.3. Statistical Computations

In order to discern the major parameters of key importance, i.e., responsible for alterations in the environmental matrices analyzed, the principal components of the water and sediment samples were analyzed using descriptive statistics such as communalities, total variance, percentage variance and rotated component matrix. Parameters with communality values less than 0.75 were considered insignificant while components with Eigen values less than 1 were also considered insignificant; hence eliminated so that fewer components were further subjected to the Varimax rotation stage using Keiser normalization method. The descriptive statistics such as the mean, range and standard error were for significant differences in the heavy metals, nutrients and total hydrocarbons in water and sediment samples was done using ANOVA ($P < 0.05$). Duncan Multiple Range (DMR) test was used to identify the source of variance.

The percentage relative abundance of the zooplankton was estimated by direct count. Each quantitative sample was concentrated to 10 ml and1 ml of sample was taken and all individual taxa present were counted. Relative abundance was calculated as the number of individuals per 100litres.The diversity of the zooplankton was expressed using biodiversity indices such as taxa Richness (R), Evenness (E), Dominance (D) and Shannon-Weiner diversity (H), which were computed using Paleontological Statistics Software (PAST). The sorption capacities of heavy metals and THC were assessed using the Distribution co-efficient (Kd).

$$(Kd) = \frac{M_{ads}}{M_{sol}}$$ (Soares and Alleoni, 2006)

; where M_{ads} = metals adsorbed into the soil and M_{sol} = metal concentration in water.

3. Results and Discussion

3.1. Heavy Metal, Nutrients and THC in Water and Sediment

3.1.1. Water

In the water, spatially heterogeneous patterns of some of the parameters analyzed were apparent in the result. As shown in Table 1, concentrations of iron in water of Stations 2, 3 and 4 were much significantly higher than that of Station 1 ($P < 0.001$). The levels of iron though slightly above the control station were however within FEPA (2003) acceptable limit for aquaculture. The concentrations of manganese and lead in the water of Stations 3 and 4 were significantly higher than Stations 1 and 2 ($P < 0.001$). Omoigberale and Ikponmwosa- Eweka (2010) also reported that the level of manganese in water at Gelegele (Station 3) was higher than limit within the period of July, 2000 to June, 2002. Oguzie and Ehigiator (2011) observed a reduction in the level of manganese from July to September, 2007 at same location below the acceptable limits. The periodical variability in the levels of manganese can be at-tributed to varying anthropogenic activities. At Station 2; the location of most severe crude oil activities and illegal operations, the concentrations of nickel and total hydrocarbons (THC) in water were very much significantly higher than other stations and even established standard limits. Table 2 show high spatial heterogeneity in metal, nutrients and THC loads in sediment across all stations. This evidence of repository nature of sediment was earlier reported by Camusso et al. (1995).

Table 1. Summary of heavy metal, nutrients and total hydrocarbons (in mg/l) in water of Osse River

PARAMETERS	**STATION 1** **MEAN±S.E(RANGE)**	**STATION 2** **MEAN±S.E(RANGE)**	**STATION 3** **MEAN±S.E(RANGE)**	**STATION 4** **MEAN±S.E(RANGE)**	**P value**	FEPA (2003)
Fe	**0.45 ± 0.16^{B} (0 – 2.4)**	**1.71 ± 0.25^{A} (0 – 3.5)**	**1.44 ± 0.19^{A} (0 – 2.9)**	**1.38 ± 0.27^{A}(0.2 – 5.4)**	**P<0.001**	20
Mn	**0.02 ± 0.01^{B} (0 – 0.1)**	**0.24 ± 0.06^{B} (0 – 0.7)**	**0.97 ± 0.22^{A} (0 – 2.3)**	**1.26 ± 0.34^{A} (0 – 3.7)**	**P<0.001**	0.5
Ni	**0.004 ± 0.03^{C}(0 – 0.4)**	**2.59 ± 0.15^{A} (0.1 – 2.6)**	**3.92 ± 0.3^{B}(0.2 – 5.2)**	**0.09 ± 0.25^{C}(0 – 3.3)**	**P<0.05**	1
Pb	**0.001 ± 0.003^{B}(0 – 0.1)**	**0.08 ± 0.01^{A}(0 – 0.2)**	**0.83 ± 0.24^{A} (0 – 2.7)**	**0.03 ± 0.26^{A} (0 – 2.7)**	**P<0.001**	< 1
Cu	**0.02 ± 0.01^{B}(0 – 0.1)**	**0.14 ± 0.03^{B} (0 – 0.5)**	**0.13 ± 0.02^{B} (0 – 0.4)**	**2.05 ± 0.26^{A} (0 – 2.76)**	**P<0.001**	< 1
SO_4	**2.5 ± 0.4^{B}(0 – 5.2)**	**5.4 ± 1.1^{A}(0.1 – 13.5)**	**3.5 ± 0.5^{B}(0.1 – 7.5)**	**2.2 ± 2.8^{B}(0.1 – 5)**	**P<0.01**	-
NO3	**0.68 ± 0.18^{C}(0 – 2.1)**	**2.67 ± 0.53^{A}(0 – 6.5)**	**1.93 ± 0.24^{B}(0 – 3.4)**	**1.36 ± 0.33^{B}(0 – 3.1)**	**P<0.001**	20
PO_4	2.17±0.14(1.5 – 3.4)	2.57±0.28(0.5 – 4.5)	2.15±0.19(0.7 – 3.9)	1.74±0.21(0.6 – 3.3)	P>0.05	<5
THC	**0.02 ± 0.01^{D} (0 – 0.1)**	**6.19 ± 0.6^{A} (0 – 10.5)**	**4.77 ± 0.2^{B} (0- 1.89)**	**1.26 ± 0.28^{C} (0 – 3.2)**	**P<0.001**	10

Note: Values with similar superscripts indicate no significant difference. Number of samples= 18. P>0.05 impliesthere is no significant difference, **P<0.05** means there is significant difference, **P<0.01** means there is much significant difference, and **P<0.001** means there is very much significant difference

3.1.2. Sediment

The levels of iron in the sediment at Stations 2, 3 and 4 were very much higher than that of the control station and FEPA limit for aquatic aquaculture. Concentration of copper was also higher in the water at Station 4 than other stations including regulatory limit. The levels of primary productivity nutrients (sulfate, nitrate and phosphate) show that Osse River is an oligotrophic aquatic ecosystem. This agrees with the findings of Imoobe and Adeyinka (2010). Concentrations of copper and total hydrocarbons were also higher in the sediment of other stations than the control station. High concentrations of manganese, nickel, copper and THC observed in the water may result in chronic sub-lethal effects and de-creased biodiversity of the biota in the water column.

Manganese could cause nervous system disruptions in finfish and shellfish, which may result in inefficiency in escape from predators and search for food and mates; and ultimately reduced biodiversity (Isibor *et al*., 2016). At the highest trophic level, manganese concentrations may rise through the processes of bio-magnification and could ultimately elicit neurological disorders similar to Parkinson's disease in man (ATSDR, 2005). High concentrations of some heavy metals in the water and sediment of the perturbed locations may cause severe ecological disruptions in Osse River. THC in the water and sediment may elicit teratogenic, carcinogenic, mutagenic and immunosuppressive effects both in biota and man (ATSDR, 2010). Relatively higher concentrations of nickel, lead and THC observed in the water and sediment at Station 2 can be attributed to the reckless crude oil handling which was prominent at this station. Relatively higher concentrations of iron, nickel, lead and total hydrocarbons; particularly in the sediment samples of Stations 3 and can be attributed to the significant sorption capacities of the metals (Table 3). Figures 2 and 3 further showed at a glance that most of the parameters analyzed were deposited in the sediment. These deposited pollutants can be released back into the water column; causing perpetual rise in the aqueous phase.

Table 2. Summary of heavy metal, nutrients and total hydrocarbons (in mg/kg) in sediment of Osse River

	STATION 1	STATION 2	STATION 3	STATION 4		FEPA (2003)
PARAMETERS	MEAN±S.E(RANGE)	MEAN±S.E(RANGE)	MEAN±S.E(RANGE)	MEAN±S.E(RANGE)	P value	
Fe	0.3 ± 0.06^{D}(0- 0.9)	1.91 ± 0.2^{A}(0.9- 3.8)	2.28 ± 0.2^{B}(0.6- 3.4)	1.4 ± 0.5^{C}(0.4- 3.4)	P<0.001	1
Mn	0.1 ± 0.05^{D}(0- 0.9)	1.01 ± 0.21^{B}(0- 2.6)	5.67 ± 0.23^{A}(0.1- 4.2)	0.97 ± 0.36^{C}(0.2- 2.4)	P<0.001	0.4
Ni	0.35 ± 0.06^{D}(0- 0.9)	19.58 ± 0.28^{A}(0.2- 4.1)	6.19 ± 0.19^{B}(0.7- 3.2)	1.1 ± 0.3^{C}(0.1- 2.3)	P<0.001	-
Pb	0.01 ± 0.001^{C}(0- 0.03)	6.04 ± 0.01^{A}(0- 0.08)	2.04 ± 0.01^{B}(0- 0.2)	0.04 ± 0.08^{C}(0- 0.1)	P<0.001	0.05
Cu	0.05 ± 0.015^{C}(0- 0.2)	2.72 ± 0.248^{A}(0- 3.6)	2.16 ± 0.219^{A}(0- 2.6)	0.56 ± 0.37^{B}(0.1- 1.3)	P<0.001	0.3
SO_4	0.49 ± 0.08^{C}(0.1 – 1.7)	2.27 ± 0.356^{A}(1.1- 6.1)	2.11 ± 0.17^{A}(1.3- 3.4)	1.86 ± 0.58^{B}(0.5- 3.2)	P<0.001	240
NO_3	1.41 ± 0.17^{C}(0.4 – 2.7)	3 ± 0.27^{A}(1.7- 5.2)	3.49 ± 0.18^{A}(2.3- 4.6)	2.88 ± 0.1^{B}(1.8- 4.4)	P<0.001	40
PO_4	2.05 ± 0.17^{D}(1.1 – 3.6)	3.54 ± 0.23^{C}(2.3- 5.5)	5.07 ± 0.31^{A}(3.1- 7.8)	4.07 ± 0.82^{B}(2.5- 6.7)	P<0.001	5
THC	0.24 ± 0.05^{D}(0- 0.6)	68.435 ± 0.165^{A}(0.3- 2.4)	14.15 ± 0.52^{B}(0.4-8.3)	2.09 ± 0.3^{C}(0.3- 3.8)	P<0.001	-

Note: Values with similar superscripts indicate no significant difference. Number of samples= 18. P>0.05 means there is no significant difference, **P<0.05** means there is significant difference, **P<0.01** means there is much significant difference, and **P<0.001** means there is very much significant difference

Table 3. Distribution co-efficient of heavy metals, nutrients and total hydrocarbons

Fe	Mn	Ni	Pb	Cu	SO_4	NO_3	PO_4	THC
11.18	3.13	**24.61**	**13.41**	2.66	1.33	2.59	1.7	**66.51**

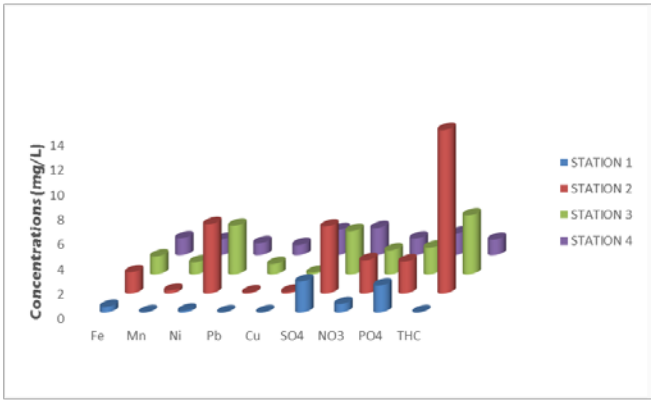

Figure 2. Concentrations of heavy metals, nutrients and THC in water

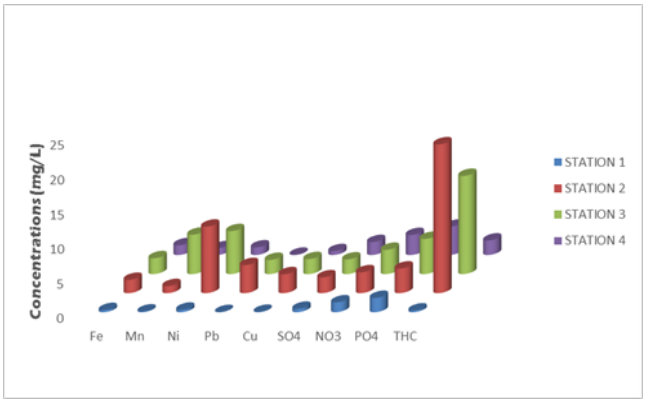

Figure 3. Concentrations of heavy metals, nutrients and THC in sediment

3.2. Zooplankton Community Structure

The relative percentage composition of the taxonomic groups recorded during the study period was Rotifera (41.12%) > Copepoda (30.64%) > Cladocera (20.72%) > Calanoida (7.52 %).This conforms to the trend observed at Ekpan River by Iloba and Ruejoma (2014). Rotifers (represented by 13 taxa) were the most represented among all the groups observed. The group was dominated by *Conochilus unicornis* which constituted 88 individuals.

Cladocerans were also well represented by 10 taxa in the zooplankton community with *Ilvocryptus spinifer* having the highest number of individuals (53). Copepoda was represented by 9 taxa and it was dominated by *Microcyclops varicans*; having 69 individuals. The least represented was Calanoida, which had 3 taxa, dominated by *Thermodiaptomus galebi*; 44 individuals. The presence of tropical Freshwater species such *Synchaeta longipes* and *Conochilus dossuarius*, coupled with the absence of *Pompholyx sulcata, Proales sp., Keratella tropica, Keratella quadrata*, *Bronchionus anguilaris*, and *Trichocera pusilla* indicates an oligotrophic to mesotrophic aquatic system. This can be attributed to the moderate concentrations of nitrate, phosphate and sulfate observed in the water of the aquatic environment throughout the period of study (Imoobe and Adeyinka, 2010). Furthermore, the absence of *Diaptomus minutus* at Stations 2 and 3 can be linked to high concentrations of manganese, nickel and THC (Mohammed, 2006).

The zooplankton individuals were spatially distributed in the following order: Station 1 (923) > Station 4 (385) > Station 3 (191) > Station 2 (123). The lowest number of zooplankton individuals were recorded at Stations 2 and 3, i.e., locations of highest perturbations where high concentrations of manganese, nickel and THC were recorded in the water (Table 1), and nickel, lead, copper and THC were recorded in the sediment (Table 2). The high concentrations of manganese and THC; particularly Ni which were higher than other stations and FEPA limit (Table 1) can be attributed to oil exploration activities such as gas flaring, petrochemical production, storage and transit. Mortality of zooplankton due to perturbations from anthropogenic activities has been reported in many literatures. Almeda *et al*. (2013) reported the mortality of innumerable zooplankton species due to exposure to crude oil.

The Taxa Richness (R) and Shannon-Wienner Diversity (D) of zooplankton at Station 2 and 3 were significantly lower than that of Station 4, which was higher than that of Station 1 (Table 5). The Copepoda group comprises of individuals with adaptive resilience to oil-associated environmental stressors. Of the four groups at Stations 2 and 3 Copepods have an outstanding number (Table 4); particularly *Thermocyclops neglectus* which dominated Station 2 (18 individuals) and Station 3 (16 individuals). Other Copepods which dominate the impacted stations include *Afrocyclops curticonis, Diacyclops thomasi, Ectocyclops phaleratus, Eucyclops agiloides, Halicyclops korodiensis, Mesocyclops minutues, and Micocyclops varicans* (Table 4). The dominance of the Copepods is reflected in the relatively high Dominance Indices at Station 2 (1.02) and Station 3 (0.98), coupled with the relatively low Taxa Richness (R) which are 1.14 and 1.89 respectively (Table 5). The percentage distribution of zooplanktons is in the order of Station 1 (57%) > Station 4 (24%) Station 3 (12%) > Station 2 (7%). The significantly lower numbers of individuals at Stations 2 and 3, compared to Stations 1 and 4 are additional evidences of significant spatial impacts of anthropogenic activities.

Table 4. Species composition and percentage occurrence of Osse River Zooplankton. Sample size (N) = 18

SPECIES COMPOSITION	STATION 1	STATON 2	STATION 3	STATION 4	TOTAL	% OCCURRENCE
Cladocera						
Alona rectangula	28	1	1	12	42	2.65
Bomina longirostris	18	0	2	11	31	1.96
Bosminopsis deitersi	22	9	2	12	45	2.84
Ceriodaphnia cornuta	28	0	1	4	33	2.08
Chydorus sphaericus	18	1	1	6	27	1.71
Diaphanosoma excisum	21	0	1	3	25	1.58
Echinisca triseralis	24	2	2	4	32	2.02
Ilyocryptus spinifer	42	1	3	7	53	3.35
Kurzia longirostris	19	0	1	4	24	1.52
Macrothrix spinosa	14	0	0	2	16	1.01
Copepoda						
Afrocyclop curticornis	22	3	1	14	40	2.53
Diacyclops thomasi	12	4	1	12	29	1.83
Ectocyclops phaleratus	18	11	12	8	49	3.10
Eucyclops agiloides	22	8	18	14	62	3.92
Halicyclops korodiensis	23	13	19	12	67	4.23
Mesocyclops leukarti	28	4	22	11	65	4.11
Metacyclops minutus	21	8	13	3	45	2.84
Microcyclops varicans	28	14	15	12	69	4.36
Thermocyclops neglectus	15	18	16	10	59	3.73

Calanoida						
Diaptomus minutus	22	0	0	12	34	2.15
Thermodiaptomus galebi	26	2	6	10	44	2.78
Tropodiaptomus incognitus	18	1	8	14	41	2.59
Rotifera						
Ascomorpha ovalis	17	3	9	12	41	2.59
Asplanchna priodonta	19	2	4	8	33	2.08
Brachionus diversicornis	12	0	3	6	21	1.33
Collotheca sp	10	1	2	6	19	1.22
Conochilus dossuarius	56	0	1	8	65	4.11
Conochilus unicornis	68	0	2	18	88	5.56
Euchlanis dilatata	71	0	6	15	52	3.28
Kellicottia longispina	42	1	0	28	71	4.49
Keratella cochlearis cochlearis	32	4	0	16	52	3.28
Keratella longispina	28	3	8	14	53	3.28
Synchaeta longipes	31	9	7	19	66	4.17
Trichocerca cylindrica chattoni	26	0	4	21	51	3.22
Trichocerca similis	22	0	0	17	39	2.46
TOTAL=	**923**	**123**	**191**	**385**	**1583**	**100**

Table 5. Biodiversity of the zooplankton community of Osse River between April, 2013 and September, 2014

Descriptive Indices	STATION 1	STATION 2	STATION 3	STATION 4	P VALUE
No. of Species	35	23	30	35	P>0.05
No. of Taxa	4	4	4	4	P>0.05
No. of Individuals	923^{A}	123^{C}	191^{C}	385^{B}	P<0.001
Taxa Richness (R)	6.32^{A}	1.14^{B}	1.89^{B}	5.87^{A}	P<0.05
S. Wienner Diversity (D)	3.32^{A}	0.24^{B}	0.45^{B}	3.42^{A}	P<0.05
Eveness (E)	0.876^{A}	0.132^{B}	0.334^{B}	0.89^{A}	P<0.01
Dominance Index (C)	0.75^{B}	1.02^{A}	0.98^{A}	0.45^{C}	P<0.05

Note: Values with similar superscripts indicate no significant difference. Number of sample replicates = 18. P>0.05 means there is no significant difference, **P<0.05** means there is significant difference, **P<0.01** means there is much significant difference, and **P<0.001** means there is very much significant difference

4. Conclusion

The present study showed a detailed proactive investigation of suspected anthropogenic disruptions using the zooplankton community as a predictive tool. Anthropogenic activities had a significant impact on the community structure of the zooplankton. This necessitates further detailed research to ascertain the possible ecological and public health risks nickel, copper, manganese and total hydrocarbons may pose. Impacts on zooplankton community structure are prognostic of possible impacts on other aquatic biota of economic relevance. We recommend a continuous stringent bio-monitoring study of the aquatic environment to put the levels of heavy metal, nutrients and total hydrocarbons in constant check.

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