The International Journal Of Engineering And Science (IJES)
||Volume||2 ||Issue|| 4 ||Pages|| 13-21||2013||
ISSN(e): 2319 – 1813 ISSN(p): 2319 – 1805

Effect of Physico-Chemical Parameters on Zooplankton Species and Density of a Tropical Rainforest River in Niger Delta, Nigeria Using Canonical Cluster Analysis

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--Abstract--
Investigations on physico-chemical features and zooplankton species were conducted forthnightly using standard methods in three sampling stations in Ikpa River between March 2009 and February 2010. Among others, the data were subjected to Canonical Cluster Analysis (CCA) to determine the effect of the environmental factors on the zooplankton species. The results of zooplankton revealed that all the sampling stations were significantly different (CV=17.72; F=46.09; p=<0.0001). The total number of classes, genera and species of zooplankton sampled were 4, 41 and 53 respectively. Zooplankton species composition was highest in station 3 (37 species; 69.81%) and lowest in station 2 (24 species; 45.28%), station 1 had 29 species (54.72%). Zooplankton classes in their descending order made the following contributions: rotifers (20 species; 37.74%), cladocera (14 species; 26.42%), protozoa (10 species; 18.87%) and copepods (9 species; 16.98%). Clean water species were observed to cluster in upper course where the most important environmental factor was transparency while pollution-tolerant species clustered in the downstream station which had nutrients, water level, total dissolved solids and biochemical oxygen demand as determinant environmental vectors. Middle course had fewer species clustered with the vectors of dissolved oxygen and total hardness. The observed trends which deviate remarkably from normal could be attributed to anthropogenic perturbations in STN 2 which alter the ecosystem stability and cause a shift in the longitudinal pattern downstream.

Keywords: *species composition, rainforest, zooplankton, Copepoda, Ikpa River*

Date of Submission: 12, February, 2013 ⟺ Date of Publication: 10 April 2013

1. INTRODUCTION

Zooplankton are microscopic drifting animal-like organisms found either at or near the surface of water bodies. Ovie (2011) defined zooplankton as the free-floating, aquatic invertebrates, often described as microscopic because of their usual small sizes that range from a few to several micrometers and are rarely exceeding a millimeter. Economically, they are the major mode of energy transfer between phytoplankton and other aquatic animals including fish. Ecologically, zooplankton are the most important biotic components influencing all the functional aspects of all aquatic ecosystems, viz; food chains, food webs, energy flow/transfer and cycling of matter. Generally, they play an important role in fish nutrition, both in aquaculture and capture fisheries. Suresh *et al.*, (2011) reported that different environmental factors that determine the characters of water have great importance upon the growth and abundance of zooplankton. Thus, water quality influences zooplankton abundance, clustering and biomass. Water quality assessment generally involves analysis of physico-chemical, biological and microbiological parameters and reflects on abiotic and biotic status of the ecosystem (Rajagopal *et al.*, 2011).

Most of the species are cosmopolitan in distribution. The distribution of zooplankton communities depends on many factors, some of which are change of climatic conditions, physico-chemical parameters and vegetation cover. According to Rajagopal *et al.*, (2011) zooplankton plays an integral role and serves as bio-indicator and it is a well-suited tool for understanding water pollution status. A few research works have been carried out in Ikpa River, Nigeria: fish species of Ikpa River (Onuoha *et al.*, 2010, Ekpo 2012 and Ekpo *et al.*, 2012_b); diversity and variability of aquatic macrophytes (Ekpo *et al.*, 2011); studies on the physico-chemical characteristics and nutrients (Ekpo *et al.*, 2012_a and Ekpo *et al.*, 2012_c); women's participation in lower Ikpa River fisheries of Akwa Ibom State Nigeria: A case-study of Ifiayong (Ekpo 2013). Therefore, the present investigation attempts to present benchmark information on zooplankton abundance, seasonality and effect of physico-chemical parameters on zooplankton species using CCA in Ikpa River, Nigeria.

II. MATERIALS AND METHODS

Ikpa River is situated in Akwa Ibom State within the rainforest zone of southeastern Nigeria (Fig. 1). It is a small perennial rainforest tributary located west of the lower reaches of the Cross River system. It drains a catchment area of 516.5km^2, 14.8% (76.5km^2) of which is prone to annual flooding. The stream has a main channel with total length of 53.5km between its source in Ikono Local Government Area and where it discharges into the Cross River creek close to Nwaniba in Uruan Local Government Area. The length of the main channel lies at the interface of two different geological deposits: tertiary sedimentary rocks and cretaceous deposits (Ekpo *et al.*, 2011). The lower reaches are susceptible to annual flooding of the fringing low land riparian zone during the rainy season. The non-flooded zones of the upper reaches have a basin area of 440km^2 (85.2%) and mean depth and width of 2.0m and 12.5m respectively.

Most of the stream is considerably shaded by overhanging canopy of riparian vegetation (mostly *Elaeis guineensis, Pandanus, Raphia hookeri, R. vinifera* and other tropical forest trees). The aquatic macrophytes are mainly *Nymphaea, Vossia, Utricularia and Musanga crinium* species. The climate of the area is typical of tropical rain forests: it comprises dry (November–March) and wet (April–October) seasons. The dry season is characterized by prevalence of dry tropical continental winds from the Sahara desert, and low mean monthly precipitation (3.5–13.6cm). Peak dry season occurs in December–February. The wet season also was typified by moist tropical maritime winds from the Atlantic Ocean and high mean monthly rainfall (23.0–39.2cm; ±31.1cm) with a double maximum in July and September. The mean annual rainfall is 255.8cm. Hydrological observations revealed that fluctuations in stream level and flow rate (current velocity) are determined by intensity of precipitation and contribution from runoff from the riparian zone. These produce a cyclic hydrological regime, typified by high water level and flow rate during the rains and vice versa in the dry season. Its substrate is made up of fine sand, mud/sand organic debris. The depth ranges from 1–6m; ±3.5m. The maximum transparency varies from 1.0–1.3m; ±1.15m.

The Eastings and Northings of the three sampling stations selected are as follow: 379437.913mE and 572840.203mN for STN 1 in Ikot Ebom; 380881.324mE and 561822.998mN for STN 2 in Ntak Inyang, and 394252.669mE and 558778.199mN for STN 3 in Nwaniba respectively. Along Ikpa River, the human anthropogenic perturbations include reintroduction of wastewater from the oil palm mill sited at the bank of the river at the upper course; new bridge and road constructions and riverbed dredging at the middle course; and introduction of wastewater from Le Meriden Hotel and Golf Resort together with beach activities (Ekpo *et al.*, 2011and Ekpo, 2012$_c$). Sampling for physico-chemical parameters and zooplankton species were carried out at forthnightly interval for twelve calendar months from March 2009 to February 2010 to cover both the dry and wet seasons.

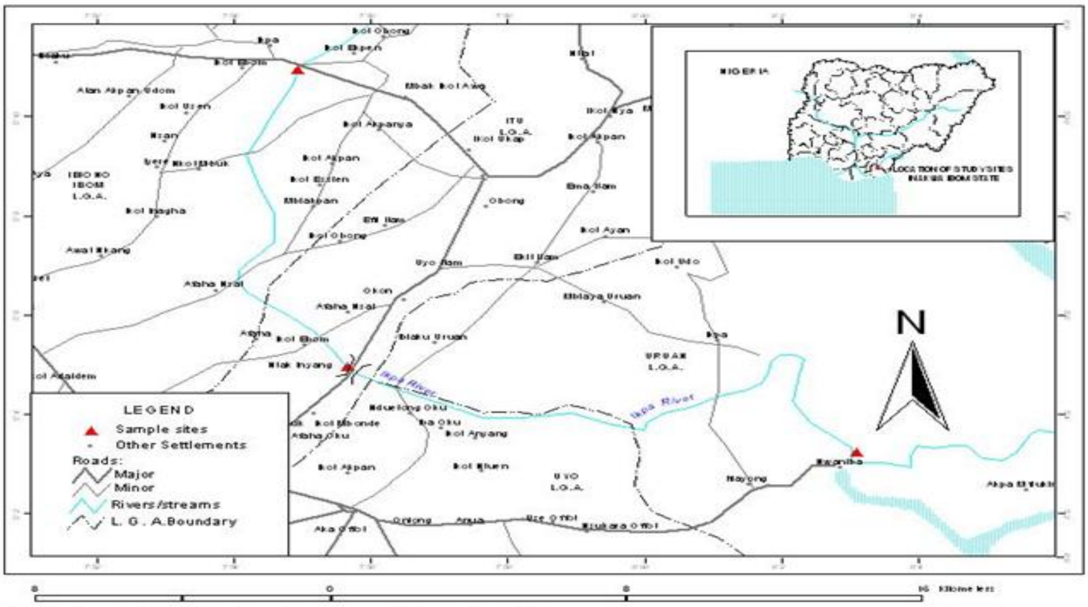

Fig. 1: Ikpa River showing Locations of Sampling Sites

2.1 Physico - chemical parameters

Fifteen physico-chemical parameters (current velocity (CV), water level (WL), air temperature (AT), water temperature (WT), transparency (Trans), total dissolved solids (TDS), total suspended solids (TSS), total hardness (TH), total alkalinity (TA), conductivity (Condu), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), free carbondioxide (FCO_2) and hydrogen ion concentration (pH)) and three nutrients (nitrates-nitrogen (NO_3-N), phosphate-phosphorus (PO_4-P) and sulphate (SO_4^{2-})) were sampled and analyzed using field kit with sensitive probes and standard and analytical methods of water analysis (Schlosser, 1983 and APHA-AWWA-WPCF, 2005).

2.2 Zooplankton species sampling

Water samples (100L) were compositely collected from approximately 15–20cm below the water surface at each sampling site in new clean buckets. This was filtered through a 55μm mesh size plankton net into an attached 100ml sample bottle. The collected samples were fixed with approximately 5ml of 4% formalin solution and were taken to the laboratory for analysis of zooplankton. The concentrated samples were homogenized by centrifugation before 1ml of sub-sample from the original stock was collected with Stempe 1ml pipette. The pipette content was transferred unto a Sedgewick–Rafter counting chamber for species enumeration (each sample having three replicates of the concentrate) which were examined under the Leitz Wetzler binocular microscope using the scanning, low-power and high-power objectives at 100-200x, 100-400x magnifications. The composite species were identified with the aid of keys, descriptions and illustrations such as Durand and Léveque (1980) and APHA, 2005). The different organisms identified were classified into different families and species and their frequencies were noted.

2.3 Statistical analysis

Generated data were subjected to analysis of variance (ANOVA) to assess the effect of sampling stations on the physico-chemical parameters. Measures of dispersion were used on the zooplankton species to determine abundance and seasonality. These data from each sampling station and zooplankton species were analyzed using PROC Generalized Linear Module (GLM) in Statistical Analysis System (SAS) (2003) to determine their clustering. Multivariate analysis such as CCA has been used to determine the effect of one environmental factor on one or more biota (Tabachnick and Fidell, 1983; Tan and Beklioglu, 2005 and Li *et al.*, 2009). CCA represented by the triplot is made up of two main axes and four quadrants. The effect of a parameter on the species and sampling stations in a quadrant shows a positive correlation but negative in the adjacent quadrant. The environmental factors are represented by the arrows which show that the longer the arrows, the more the effect of the factors on zooplankton species in a particular sampling station.

III. RESULTS

The result of zooplankton in the three sampling stations revealed that all the sampling stations were significantly different (CV=17.72; F=46.09; p=<0.0001). The total number of classes, genera and species of zooplankton sampled were 4, 41 and 53 respectively. Table 1 shows zooplankton species composition and relative abundance showing seasonal variations in the three sampling stations. *C. staphylinus* was the dominant species with 39 cell m^{-1} whereas *Paramecium caudatum* was the least with 4 cell m^{-1} in STN 1. In the classes Cladocera, Copepoda, Protozoa and Rotifera, the species with the highest number of cells were *D. magna* (30 cell m^{-1}), *C. staphylinus* (37 cell m^{-1}), *T. lacustris* (20 cell m^{-1}) and *B. diversicornis* (30 cell m^{-1}) while those with the least were *A. rectangula* (10 cell m^{-1}), *N. schmackeri* (10 cell m^{-1}), *P. caudatum* (4 cell m^{-1}) and *C. unicornis* (8 cell m^{-1}) respectively. In STN 2, the dominant species was *A. priodonta* having 34cell m^{-1} while the least was *M. spinosa* with 7 cell m^{-1}. Among the classes Cladocera, Copepoda, Protozoa and Rotifera, the species with the highest number of cells were *G. cornuta* (26 cell m^{-1}), *Cyclopoida sp* (20cell m^{-1}), *Cyclidium* (14cell m^{-1}) and *A. priodonta* (34cell m^{-1}) whereas the least number of cells were observed in *M. spinosa* (7cell m^{-1}), *E. speratus* and *Nauplii* (14cell m^{-1}), *A. eichorni, S. fockei and T. lacustris* (13cell m^{-1}) and *F. maior* and *P. erythrophthalma* (8cell m^{-1}) respectively.

In STN 3, the dominant species was *B. longirostris* with 44 cell m^{-1} while the least was *D. oblonga* with 5 cell m^{-}1. In the classes Cladocera, Copepoda, Protozoa and Rotifera, the species with the highest number of cells were *B. longirostris* (44cell m^{-1}), *M. leukarti* (33cell m^{-1}), *V. mayerii* (29cell m^{-1}) and *K. cochlearis* (30cell m^{-1}) whereas those with the least number of cells were *M. micrura* (8cell m^{-1}), *M. albidus* (11cell m^{-1}), *D. oblonga* (5cell m^{-1}) and *R. neptunia* (15cell m^{-1}) respectively. The overall zooplankton class with the least number of species was Copepoda having 9 species whereas the highest number of species was encountered in the class Rotifera having 20 species.The overall individual annual contribution on species basis revealed that the lowest abundance was obtained in *P. caudatum* with 4 cell m^{-1} and the highest was *D. magna* with 75 cell m^{-1}. Among the Cladocera, *D. aspinosum* was the lowest abounded species (15 cell m^{-1}) and *D. magna* was the highest (75 cell m^{-1}) abounded species. The lowest and highest species abundance was *M. albidus* (11 cell m^{-1})

and *Nauplii* (52 cell m^{-1}) respectively in the class Copepoda. *P. caudatum* was the least abounded Protozoan with 4 cell m^{-1} and the highest was *A. eicorni* (59 cell m^{-1}). In the class Rotifera, the lowest abundance was recorded in *F. maior* and *P. erythrophthalma* (8 cell m^{-1} each) and the highest was *A. priodonta* (72 cell m^{-1}).

A total of 1681 zooplankton cells were sampled, with abundance of 1158 cells in the wet season being higher than that of the dry season (524 cells). The result of the annual abundance of zooplankton showed that the least abundant family with respect to number of cells ml^{-1} sampled and number of species was Protozoa (226 cells ml^{-1}; 13.44%) and Protozoa (10 cells ml^{-1}; 18.87%) while the highest was Rotifera (633 cells ml^{-1}; 37.66%) and Rotifera (20 cells ml^{-1}; 37.74%). The annual seasonal abundance of zooplankton cells m^{-1} was lowest during the dry season (230 cells ml^{-1}; 30.07%) and highest during the wet season (535 cells ml^{-1}; 69.93%), giving a total of 765 cells ml^{-1} of zooplanktonts. In the wet season, the lowest number of zooplankton cells m^{-1} contribution in a family was from Protozoa (141 cells ml^{-1}; 12.18%) and the highest was obtained in Rotifera (455 cells ml^{-1}; 22.79%). In the dry season, the lowest number of cell contribution was in Protozoa (85 cells ml^{-1}; 16.22%) and the highest was in Cladocera (168 cells ml^{-1}; 32.06%). Seasonal variations were observed among the different classes of zooplankton with a general lower abundance and occurrence in the dry season and higher abundance and occurrence during the wet season. Cladocera had lowest abundance of 168 cells ml^{-1} during dry season and highest abundance of 204 cells ml^{-1} during the wet season. The lowest and highest abundance in Copepoda were observed to be 99 cells ml^{-1} during the dry season and 217 cells ml^{-1} during the wet season respectively. Protozoa had its lowest and highest abundance of 85 cells ml^{-1} during the dry season and 141 cells ml^{-1} during the wet season respectively. The lowest and highest abundance were observed in Rotifera were 167 cells ml^{-1} during the dry season and 455 cells ml^{-1} during the wet season respectively.

3.1 Canonical Cluster Analysis of physico-chemical parameters and zooplankton species

The results of the CCA for physico-chemical parameters and zooplankton species in relation to the three sampling stations are presented in Fig. 3. In CCV 1, which accounted for 18.5% of the total variance, was positively influenced by TH, DO, FCO_2, pH and CV and negatively by PO_4-P, TDS, COD and BOD. In CCV 2, which contributed 34.0% of the total variance, WL, SO_4^{2-}, NO_3-N, conductivity, WT and AT were positively loaded and transparency was negatively loaded. In quadrat 1, the most important loading was DO, followed by TH, current velocity, FCO_2 and pH with eigenvalue of 0.40 influenced 18.5% of total variance in the CCV 1 axis. These were observed in sampling stations such as $S_{13, 14, 16, 17, 18, 19, 20, 21}$ and $_{23}$, where clusters of the zooplankton: *F. maior, Dia. paucispinosum, K. quadrata, Cyclopoida sp, B. capsuliflorus, S. fockei, P. erythrophthalma, E. dilata* and *S. vetulus* were found. S_{15} and $_{24}$ were isolated on their own. Water level was the most important vector with the highest loading, which was followed by NO_3-N, WT, AT, SO_4^{2-} and conductivity together with an eigenvalue of 0.24 caused 29.7% of total variance in CCV 2 axis. These were observed in the downstream stations of $S_{25, 30, 31, 33 \text{ and } 35.}$ *K. longispina, P. militaris, M. albidus, N. schmackeri, S. exspinosus and R. neptunia* were the zooplankton that formed clusters there. In quadrat 3, the most important environmental vector with the highest loading was PO_4-P, followed by TDS, COD and BOD with an eigenvalue of 0.09 contributing 34.0% of total variance in CCV 3. These were observed in the following sampling stations: $S_{27, 28, 29, 33, 34}$ and $_{36}$ and the following species of zooplankton were found clustering there: *S. pectinata, I. pocillum, D. oblonga, M. leukarti, T. lineare, C. hippocrepis, V. mayerii, T. prasinus, L. bulla, T. cylindrica, D. acuminata,* and *D. bolbanii.* The only environmental vector with eigenvalue loading of 0.08 in quadrat 4 was transparency, contributing 37.5% of total variance in CCV 4. Zooplankton species (*T. lacustris, B. diversicornis, D. longis, M. micrura, D. caudatus, M. varicans, P. caudatum, C. unicornis, A. aspinosum, A. affinis and C. staphylinus*) formed clusters in the following sampling stations: $S_{1, 2, 3, 4, 5, 6, 9, 10}$ and $_{12,}$ while S_7 and $_8$ were isolated stations. Test of significance for all the four CCA axes was positive (Trace=1.30; F=1.39; P<0.005).

IV. DISCUSSION

The total number of 53 species made up of a total of 1681 cells m^{-1} of zooplankton recorded in Ikpa River, Nigeria is relatively high and competes favourably when compared to other tropical rivers and even in temperate inland water systems. Different numbers of zooplankton species and populations have been reported by different researchers: 8 species (Aguigwo (1998); 49 species made up of 32 Rotifera, 6 Cladocera and Protozoa and 4 Copepoda (Akin-Oriola, 2003); Cladocera 31 (30.10%) and 4 species, Rotifera 50 (48.54%) and 7 species and Copepoda 22 (21.36%); 4 species (Abdullahi *et al.*, 2007); 19 rotifer species (Ogbeibu and Edutie, 2009); Protozoa (43.30%), Rotifera (37.40%), Copepoda (17.0%) and Cladocera (2.30%) (Adeyemi *et al*., 2009); 51 species and 4 taxa (Davis *et al.*, 2009); 7 species (Saidu *et al.*, 2009); 40 species made up of 16 rotifers, 12 cladocerans, 12 copepods and 10 calanoids (Imoobe and Adeyinka, 2010). It had been observed that based on the available information on zooplankton in rivers in the tropics is rather sparse but existing studies indicate that similar factors influencing zooplankton densities as those influencing phytoplankton. Variations in zooplankton abundance according to Welcomme (1975) have been attributed to differences in flow, with a number of other factors including turbidity, DO concentration, temperature and conductivity and (Akin-Oriola, 2003) added the density of fish population. Imoobe and Adeyinka (2010) noted that the rivers watershed, combined with the lack of residential housing or farms surrounding the river, probably limited nutrients input which limit zooplankton abundance. The highest occurring class of zooplankton in all the sampling stations was rotifers. Similar observations had been made by some researchers such as: Akin-Oriola (2003) and Imoobe and Adeyinka (2010). They reported that seasonal pulses in total zooplankton numbers seem to arise mainly by increases in rotifers, their parthenogenetic reproductive pattern, short development rates under favourable conditions and fish predation on larger zooplankton; they have the shortest life cycle with peak reproductive period of 12 days at 20°C and 5 days at 25°C. The rotifers are normally considered as good indicators of good water quality and Vladimir (1983) suggested that the high occurrence of rotifers in any body of water indicates an aerobic condition.

However, other authors have contrasting results: Kemdirim (2000) reported that the most abundant zooplankters were Copepoda and Cladocera; Akin-Oriola (2003); Saidu *et al.*,(2009) reported that copepods dominated the total population with the highest number of occurrence as cyclopoid species; Adeyemi *et al.*, (2009) reported that the most abundant zooplankton taxon was protozoa and that abundance and diversity of zooplankton varied according to limnological features and the trophic state of the water body and may increase with increasing eutrophication. Hence, composition and diversity of zooplankton provided information on the characteristics and quality of the water body. However, Imoobe and Adeyinka (2010) differed in opinion based on their report that the zooplankton community was dominated by numerous species of rotifers and crustaceans, which were typical of oligotrophic to mesotrophic systems such species included *Conochilus dossaurius* and *Synchaeta longipes.* However, the most dominant zooplankton species in West African freshwater ecosystems, viz; *Keratella tropica, K. quadrata, Brachionus angularis, Trichocera pusilla, Filinia longiseta, Pompholyx sulcata* and *Proales* sp and others that are indicator species of high trophic levels were not recorded in the river. The authors concluded that the river was very clear and could be used for all manner of recreational activities. Imoobe and Adeyinka (2010) studying the usefulness of zooplankton as a tool for assessing the trophic status of Ovia River, Nigeria reported that the trophic status of the river evaluated from the zooplankton community (rotifers and crustaceans) indicated that the river was oligotrophic to mesotrophic system.

Higher abundance of zooplankton was observed during the wet season than the dry season which confirms the results of Aguigwo (1998); Kemdirim (2000) and Davies *et al.,* (2009) whose zooplankton peak was during the wet season. The zooplankton abundance increased with increase in the rains and nutrient (such as organic manures) levels as also observed by Aguigwo (1998) and Saidu *et al.,* 2009. This is in contrast to the findings of Welcomme (1975) where maxima of both conductivity and zooplankton numbers occurred during the dry season. Both parameters were minimal during the peak flood when zooplankton was nearly absent. The author reported that the survival of the adverse conditions of the flood poses certain problems for planktonic organisms which are easily washed away by increased flows which reappear rapidly when more favourable low flow patterns are re-established but Moghraby (1977) showed the problems to be lowered temperatures and increased silt concentrations which make adults and eggs of many species to enter diapauses awaiting favourable conditions. The lowest occurred species was *P. caudatum*. This is in contrast with the findings of Aguigwo (1998) where *Conochilus* sp was the least occurred species; Davies *et al.*, (2009) reported that *Frontonia leucus* (Protozoa), *Philodina roseola* and *Rotaria* (Rotifera) were the least observed zooplankton species in the dry season.

Most of the species identified in this study were typical tropical assemblages but interestingly and surprisingly, predominant temperate genera like *Synchaeta* and *Notholca* were also recorded. Akin-Oriola (2003) and Imoobe and Adeyinka (2010) had earlier reported on similar observations of temperate zooplankton species in tropical waters. Also, contrary to the observations of Imoobe and Adeyinka (2010) that the genus *Daphnia* was absent, which they said was typical of most tropical waters; the genus was present in all the sampling stations in the river course. This may be attributed to differences in the nutrient levels (since the former had been described as oligotrophic), stream order and tributary and distance of linkage to the marine environment (if any). Zooplankton community structure has been used as indicator of the nutrient and pollution status of water bodies (Ogbeibu *et al.*, 2001and Imoobe and Adeyinka, 2010). Several species of rotifers are considered as good indicators of the trophic state of rivers. The regularly most dominant species in West African freshwater ecosystems according to Imoobe and Adeyinka (2010) include *Keratella tropica, K. quadrata, Brachionus angularis, Trichocera pusilla, Filinia longiseta, Pompholyx sulcata* and *Proales* sp are indicator species of high trophic levels; some of which were encountered in this work.

The results show that the main source of anthropogenic perturbation in river system is nutrients (inputs) enrichment. In unpolluted systems, ecological indicators show discrete arrangement or pattern downstream with the concentrations of most dissolved salts, levels of most nutrients and number of species tending to increase progressively downstream (Giller and Malmqvist, 2002 and Vannote *et al.*, 1980). However, the observed trends deviate remarkably from those previously established. Such deviations could be attributed to anthropogenic perturbations in STN 2 which alter the ecosystem stability and cause a shift in the longitudinal pattern downstream. Lower values were therefore, observed in TDS, TSS, BOD, COD, TA and PO_4-P whereas higher values were observed in CV, WT, FCO_2, TH and pH in STN 2 than in the other two stations. Some these parameters are pollution indicators (Allan, 2001). This suggests that the river at STN 2 is impacted by human interferences more than STNs 1 and 3. Also, there was reduction in number of species composition zooplankton (24 species; 45.28%) in this station than in other stations.

The information on environmental status, structure and functioning of communities is used in preparing management plan and minimizing adverse effects of unsustainable development and pollution. Clean water species were observed to cluster in upper course where the most important environmental factor was transparency while pollution-tolerant species clustered in the downstream station which had nutrients, water level, TDS and BOD as determinant environmental vectors. Middle course had fewer species clustered with the environmental vectors of DO and TH. The observed trends in this study could be attributed to anthropogenic perturbations in STN 2 which have altered the ecosystem stability and caused a shift in the longitudinal pattern downstream. Thus, this system needs restoration and sustainable developmental programmes.

V. ACKNOWLEDGEMENTS

This paper is an excerpt from a Ph. D research supervised by Prof. G. C. Onuoha and Dr. L. A. Chude to whom I am very grateful. This study was possible by a Staff Development Award from the University of Uyo, Uyo; she deserves immense gratitude. My sincere thanks also go to the Department of Fisheries and Aquaculture, University of Uyo, Uyo, for providing the necessary facilities used in this work.

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BIOGRAPHY

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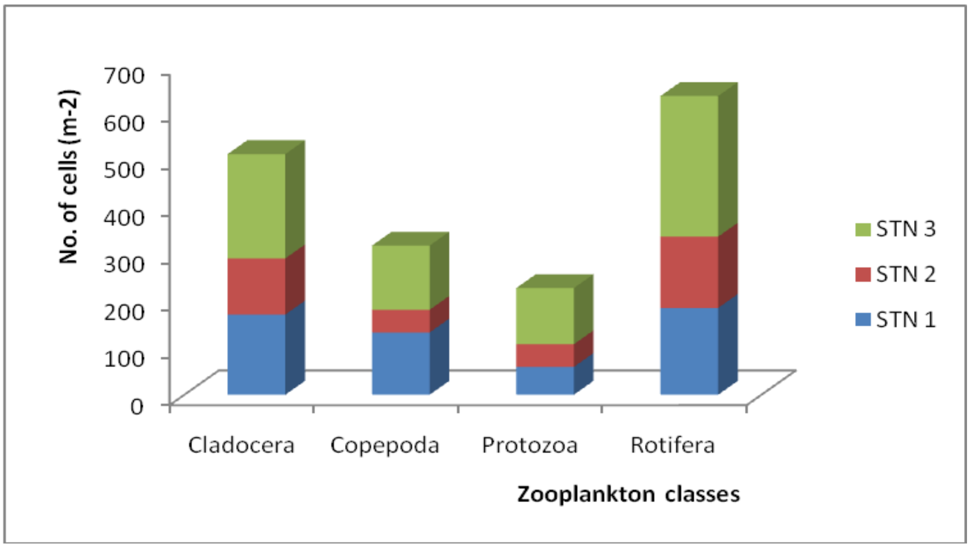

Fig. 2: Zooplankton abundance (cell m^{-1}) in the different classes in all the sampling stations in Ikpa River, Nigeria.

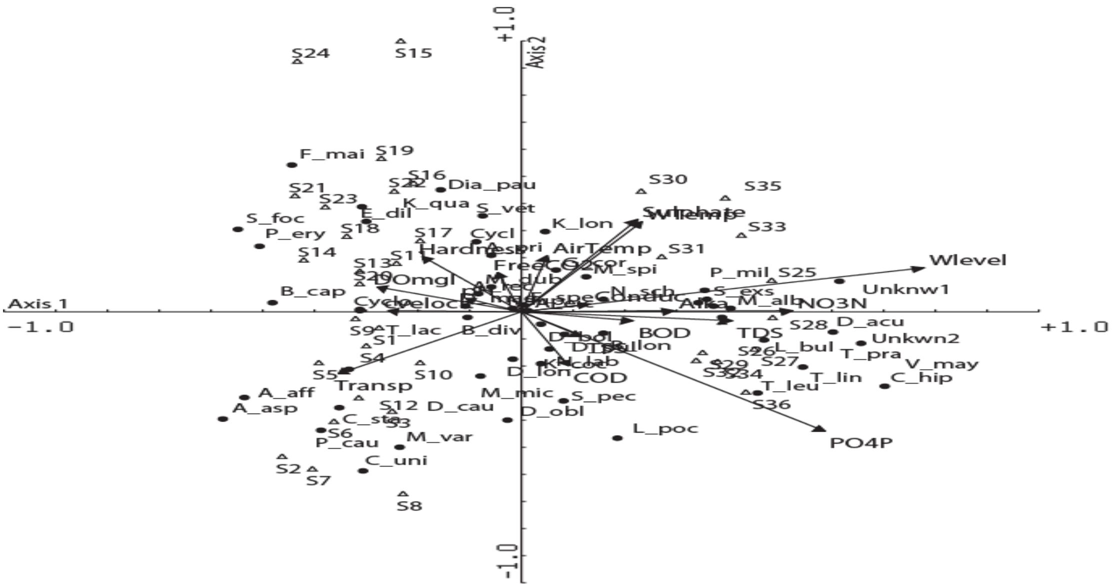

Fig. 3: An ordination diagram of the first two CCA triplot for zooplankton species illustrating substantial taxonomic overlap among sampling stations in Ikpa River, Nigeria.

Table 1: Zooplankton species composition and relative abundance (No. of cells ml^{-1}) showing seasonal variations in the three sampling stations in Ikpa River, Nigeria.

Class/ species	Sampling stations (No. of cells ml^{-1})											
	STN 1			STN 2			STN 3			Total		
	WS	DS	TO	WS	DS	TO	WS	DS	TO	WS	DS	TO
Cladocera												
Alona affinis	24	3	27	-	-	-	-	-	-	24	3	27
A. rectangular	7	3	10	10	7	17	10	4	14	27	17	44
Bosmina longirostris	13	7	20	-	-	-	26	18	44	39	25	64
Daphnia longis	20	8	28	-	-	-	16	6	22	36	14	50
D. magna	16	14	30	19	5	24	17	4	21	52	23	75
D. pulex	12	8	20	-	-	-	20	8	28	32	16	48
Diaphanosoma aspinosum	12	3	15	-	-	-	-	-	-	12	3	15
D. paucispinosum	-	-	-	15	3	18	-	-	-	15	3	18
Geriodaphnia cornuta	-	-	-	17	9	26	23	7	30	40	16	56
Macrothrix spinosa	-	-	-	5	2	7	9	3	12	14	5	19
Moina dubia	3	9	12	6	3	9	8	4	12	14	22	36
M. micrura	12	6	18	-	-	-	6	2	8	18	8	26
Simocephalus expinosus	-	-	-	-	-	-	12	8	20	12	8	20
S. vetulus	-	-	-	13	5	18	5	4	9	18	9	27
TOTAL	**109**	**61**	**170**	**80**	**39**	**119**	**153**	**68**	**221**	**204**	**168**	**372**
Copepoda												
Canthocamptus staphylinus	31	6	37	-	-	-	-	-	-	31	6	37
Cyclopoida sp	21	10	31	13	7	20	-	-	-	34	17	51
Eucyclops speratus	8	3	11	6	8	14	15	7	22	29	18	47
Microcyclops albidus	-	-	-	-	-	-	6	5	11	6	5	11
M. leukarti	-	-	-	-	-	-	22	9	33	22	9	33
M. varicans	12	4	16	-	-	-	-	-	-	12	4	16
Nauplii	8	9	17	10	4	14	14	7	21	32	20	52
Neodiaptomus schmackeri	4	6	10	-	-	-	23	4	27	27	10	37
T. prasinus	-	-	-	-	-	-	12	10	22	12	10	22
TOTAL	**94**	**38**	**132**	**29**	**19**	**48**	**94**	**42**	**136**	**217**	**99**	**316**
Protozoa												
Actinohaerium eichorni	6	6	12	8	5	13	17	7	22	31	28	59
Cyclidium sp	-	-	-	7	7	14	3	5	8	10	12	22
Didinium bolbanii	5	10	15	-	-	-	10	6	16	15	16	31
D. accuminata	-	-	-	-	-	-	20	8	28	20	8	28
Dilugiaff oblonga	6	2	8	-	-	-	3	2	5	9	4	13
Paramecium caudatum	3	1	4	-	-	-	-	-	-	3	1	4
Sphaerastrum fockei	-	-	-	8	5	13	-	-	-	8	5	13
Tintinnopsis lacustris	12	8	20	9	4	13	-	-	-	21	12	33

T. lineare	-	-	-	-	-	-	9	4	13	9	4	13
Vorticella mayerii	-	-	-	-	-	-	22	7	29	22	7	29
TOTAL	**32**	**27**	**59**	**29**	**19**	**48**	**80**	**39**	**119**	**141**	**85**	**226**
ROTIFERA												
Asplanchna priodonta	8	5	13	23	9	34	19	8	27	50	22	72
Brachionus capisuliflorus	18	6	24	21	4	25	-	-	-	39	10	49
B. diversicornis	27	3	30	-	-	-	17	7	24	44	10	54
Conochilus hippocrepis	-	-	-	-	-	-	18	5	23	18	5	23
C. unicornis	6	2	8	11	8	19	-	-	-	17	10	17
Dicranophorus caudatus	19	9	28	-	-	-	-	-	-	19	9	28
Euchlanis dilatata	-	-	-	15	6	21	-	-	-	15	6	21
Filinia maior	-	-	-	6	2	8	-	-	-	6	2	8
Keratella cochlearis	19	8	27	-	-	-	23	7	30	42	15	57
K. longispina	-	-	-	17	5	22	17	7	24	34	12	46
K. quadrata	-	-	-	7	7	14	-	-	-	7	7	14
Lecane bulla	-	-	-	-	-	-	11	9	20	11	9	20
Notholca labis	10	3	13	-	-	-	10	6	16	20	9	29
Philodina erythrophthalma	-	-	-	7	1	8	-	-	-	7	1	8
P. militaris	-	-	-	-	-	-	12	8	20	12	8	20
R. neptunia	-	-	-	-	-	-	11	4	15	11	4	15
Synchaeta pectinata	19	4	23	-	-	-	15	8	29	34	12	52
Trichotria cylindrica	-	-	-	-	-	-	16	2	18	16	2	18
T. similis	-	-	-	-	-	-	23	4	27	23	4	27
T. pocillum	12	6	18	-	-	-	11	6	17	23	12	35
TOTAL	**138**	**46**	**184**	**109**	**42**	**151**	**208**	**81**	**298**	**455**	**167**	**633**
GRAND TOTAL	**373**	**173**	**545**	**250**	**121**	**371**	**535**	**230**	**765**	**1158**	**524**	**1681**

- = Absence; DS = Dry season; WS = Wet season; TO = Total