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Studies on plankton diversity and water quality of a tropical rainforest River, Niger Delta, Nigeria

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Abstract
All physico-chemical parameters were analyzed in accordance with standard methods. The means values were in the following ranges: Water temperature (26.30-26.90^{0}c), DO (2.33-5.18mg/l), pH (6.21-6.91mg/l), TDS (12.34 – 18.33 mg/l), Turbidity (8.32-17.15 NTU), EC (57.03 - 62.61µS/cm), PO_4^{3-} (5.30-18.80 mg/l), NO_3^- (8.90 – 24.33mg/l), BOD (1.10-3.80mg/l) and TSS (46.60 – 69.34mg/l). A total of 30 taxa, 858 individual species from eight taxonomic groups of plankton species were identified. Rotifera was the dominant group (24.3%). Station 1 had a total of 325 individual species, Station 2 (235), and Station 3 (298) respectively. The low species of plankton and diversity indices noticed in station 2 and 3 reflect poor water quality due to cumulative impacts of anthropogenic activities, which had an influenced on the plankton diversity.

Keywords: Plankton, diversity, water quality, anthropogenic, pollution, hydrobiology

1. Introduction

Plankton is a collective term used for the description of plants and animals floating in the water, whose power of movement are insufficient to prevent them from being moved by water current. It also a community of organisms that drift in the water column, with low capacity to counteract the movement of water current during swimming. In aquatic ecosystem, plankton constitute myriad species of organisms, which some are planktonic during the larvae, and become nektonic in adult stage. The abundance, distribution and productivity of plankton are controlled by water quality characteristics, availability of food, geomorphologic nature of the environment and biotic factor [1]. However, plankton played an important role in aquatic ecosystems; diatoms and dinoflagellates serves as a basis of nutritional cycles and primary producers in the water bodies. Phytoplankton formed an important source of energy and basis for life in aquatic ecosystem [2]. Unlike phytoplankton, zooplankton serves as a linked between the primary producers and large aquatic animals like fishes, as it's formed the second step in aquatic food chains. Moreover, plankton has been reported as a tool used for assessing of water quality [3-5]. Kutama *et al.* (2014) [6] reported that the quality of water determined by the available plankton (phytoplankton), as it give more information on changes in water quality parameters than the nutrient concentrations [7]. In a similar study, which reported that trophic changes in lake environments could be highlighted through the study of the structure and composition of the planktonic communities [8], and Dorak [9] affirm that zooplankton are said to be a tool to monitor water quality in terms of pollution states, since their abundance are strongly influenced by the environmental modifications. The present work aim at assessing the distribution and abundance of plankton and hydrochemistry profiles of Ikpe Ikot Nkon River. The anthropogenic activities identify within the study area during investigation were laundry, bathing, farming and sand mining which are capable of deteriorating the water quality and impose negative impact on the plankton in term of abundance and distribution.

2. Materials and Methods

2.1 Study area and Sampling stations

Ikpe Ikot Nton River is among the major tropical rainforest river, located in Ini local Government Area, Akwa Ibom State. The river is lying within the Latitude 5^0 24'59.0'' North and Longitude 7^0 46' 55.7'' East (Figure 1). The river flows in North-west direction from Nkari River and transverse across many communities to Eniong River in Udokpani Local

Government Area in Cross River State, Nigeria [10]. The region in characterized by tropical humid climate with distinct dry and wet seasons. The sampling stations were chosen along the stretch of the river using the level and nature of human activities as a criterion for selection. Station 1 was located upstream, close to Ikot Abia community; human activities at this station are minimal with only bathing and laundry. Station 2 was located downstream, 2km away from station 1. The observed human activities were farming at the left and right edges of the river, sand, mining, loading of sand, lumbering, bathing, laundry and other domestic activities. Station 3 was downstream, located at Nkana Ikpe community, about 2km away from station 2 and 4km from station 1. The station is noted for different land use which includes bridge construction and agriculture use, other observed activities were fish production, laundry and bathing.

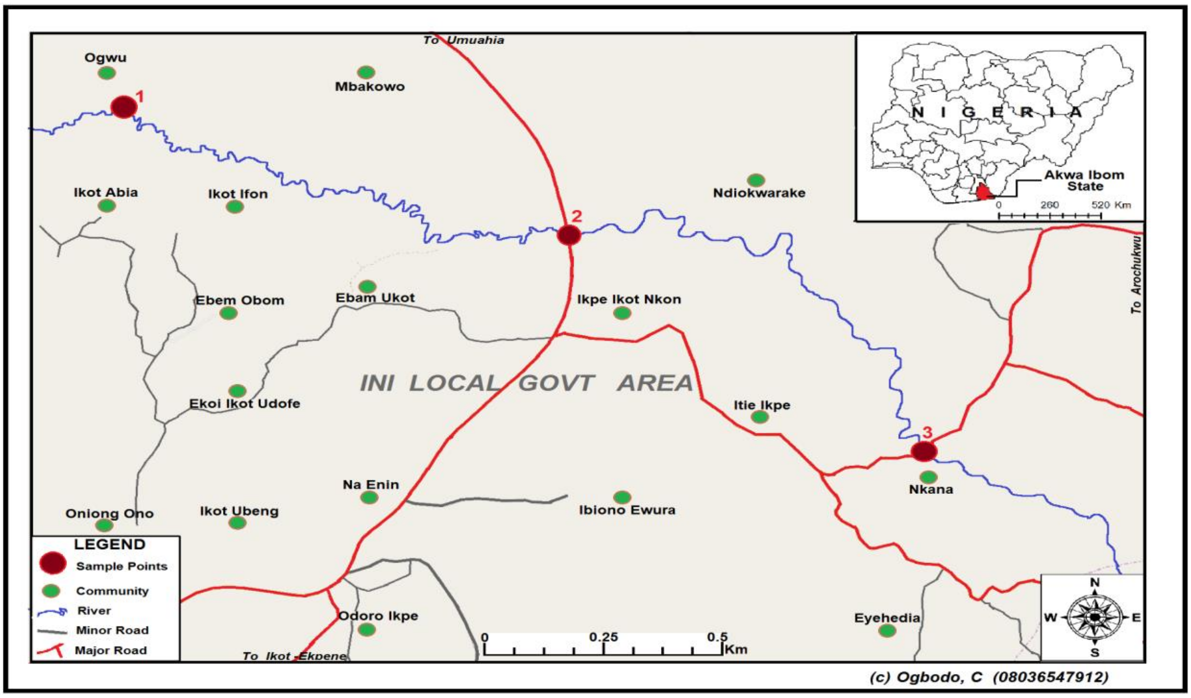

Fig 1: Map of Ini Local Government Area Showing the Sampling Stations

2.2 Samples collection and Analysis

Water samples: Water samples for physical and chemical analysis were collected from the three (3) sampling stations. The samples were collected in monthly basis, between the hours of 8.00am and 12.00noon, between April, 2019 and March, 2020. Samples were collected in sterilized plastic bottles and placed in ice-packed container which later transferred to the Laboratory unit of Akwa State Ministry of Science and Technology, Uyo for analysis. Water parameters like temperature, Dissolved Oxygen (DO), Hydrogen –ion concentration (pH), Total Dissolve Solids (TDS), Total Suspended Solids (TSS), Electrical Conductivity (EC) and Turbidity were determined and recorded right at the sampling stations using test kits and sensitive probes. All parameters were determined in accordance with the standard methods [11, 12]. The data obtained were summarized with micro-soft Excel; while test for significant difference *P*<0.05 among the stations was carried out with One-way analysis of variance (ANOVA) and significant variations were isolated using Least Significant Difference (LSD) test.

Plankton samples: Plankton samples were collected by filtering 100 litres of water fetched with a rubber bucket through a 55µm (micro) mesh size standard plankton net [13]. The filtered samples were preserved in 4% formalin with a few drops of lugol's solution. The quantitative plankton samples from the sampling stations were concentrated to 10ml; 1 ml from the 10ml for each sampling station was pipette into counting chamber for analysis under an inverted microscope. Identification of species was with the aid of key manuals [14-21]. Biological indices like Shannon -wiener index (H); Margalef's index (D) and Evenness (E) were employed to determine the species diversity, richness and uniformity in distribution. All the calculations of diversity indices were made using PAST (Paleontological Statistics, Version 3.0) Software.

3. Results and Discussion

The mean values and standard error of physico-chemical parameters analyzed presented in Table 1, while the plankton composition are showed in Table 2. The mean value of water temperature was ranged between 26.30 and 26.90 ^{0}C. The values were similar with the ranged documented from other tropical rain forest river [22]. Dissolved Oxygen mean values were observed to be high in station 1 (5.18mg/l) when compared with values station 2 and 3 (2.33mg/l and 2.80mg/l) respectively. The low values recorded may be attributed to high and nature of human activities like dredging, wastes discharged and surface runoff which transported organic pollutants into the water body at these stations. ANOVA showed significant different *P*<0.05; and values obtained from all the stations fall below the recommended value (>6.0mg/l) of FMENV (2011) [23, 24]. Hydrogen-ion (pH) concentration was slightly acidic to alkaline range. Acidic range was recorded in station 2 and 3 (6.21 and 6.33mg/l). This could be as a result of agricultural and domestic wastes discharge into the water body directly and via surface runoff. Total dissolved solids values were in the same trend with pH, with higher mean value in station 2 and 3 (18.33mg/l and 18.23mg/l), while station 1 had the lowest mean value (12.34mg/l). The higher mean values could be linked to domestic activities in these stations. ANOVA indicate that station 1 is significantly lower than other stations $P<0.05$. Electrical conductivity had it's ranged from 57.03 to 61.24 µs/cm, which the lowest value (57.03µs/cm) was observed in station 1. The high values may be as s result of available inorganic pollutants [25]. Phosphate and Nitrate values were on the trend; the mean value of phosphate was between 5.30mg/l and 18.80mg/l, while nitrate ranged from 8.90mg/l to 24.33mg/l. High values of these parameters were obtained in station 2 and 3, when checked with station 1. Organic and inorganic wastes from point and non-point source could be responsible for the high values of these parameters observed in station 2 and 3. Chapman [26], reported that nitrate values above 5mg/l are indicators of pollution resulting from organic sources. All the mean values of phosphate were above the acceptable limit (3.5mg/l) of FMENV (2011), while nitrate means values falls within acceptable limit (3.5mg/l).

ANOVA showed that station 1 was significantly lower than the values in station 2 and 3 $P<0.05$. Biochemical Oxygen demand values ranged between 1.10mg/l and 3.80mg/l; the highest value was recorded in station 2 and 3 above the FMENV acceptable value (3.0mg/l). This could be ascribed to consistent in deposition of organic and inorganic wastes substances possibly via surface runoff, re-suspension and circulation of inorganic matters through sand mining [27, 28]. One -way analysis of variance (ANOVA) revealed that station 1 was significantly lower than values in station 2 and 3 $P<0.05$. The mean values of Total Suspended Solid (TSS) and Turbidity was observed to be high in station 3 (69.34mg/l and 17.15 NTU) when compared with station 2 and 1 respectively. Increases in TSS are proportional to the corresponding increase in turbidity and reduction in amount of photosynthetic activities by green plants. The high values of these parameters recorded in station 3 may be confirmed to be as a result of sand mining activities (dredging) and allochthonous substance brought in via surface runoff. ANOVA showed significant different between the mean values between the station $P<0.05$.

Table 1: Mean values of physico-chemical parameters obtained from (April, 2019 -March, 2020)

Parameters	STN 1	STN 2	STN 3	P–value	FMENV (2011)
Temperature. ºC	26.30 ± 0.07^a	26.90 ± 0.02^a	26.60 ± 0.03^a	$P>0.05$	< 40 ºC
Dissolved Oxygen mg/l	5.18 ± 0.13^a	2.33 ± 0.26^b	2.80 ± 0.29^b	$P<0.05$	> 6.0 mg/l
Hydrogen-ion mg/l	6.91 ± 0.07^a	6.21 ± 0.14^b	6.33 ± 0.23^b	$P<0.05$	6.5 – 8.5 mg/l
Tot. Dissol. Solids mg/l	12.34 ± 0.028^a	18.33 ± 1.49^b	18.23 ± 1.23^b	$P<0.05$	-
Elect. Conduct. µs/cm	$57.03 \pm 0.14_a$	$62.61 \pm 0.20_a$	$61.24 \pm 0.28_a$	$P>0.05$	-
Phosphate mg/l	5.30 ± 0.13^a	12.50 ± 0.13^b	18.80 ± 0.24^b	$P<0.05$	3.5mg/l
Nitrate mg/l	8.90 ± 0.04^a	19.80 ± 0.33^b	24.33 ± 0.17^b	$P<0.05$	50mg/l
Bio.Oxy Deman. mg/l	1.10 ± 0.04^a	3.80 ± 0.33^b	3.33 ± 0.27^b	$P<0.05$	3.0mg/l
Tot.Sus.Solids mg/l	46.60 ± 1.33^a	60.41 ± 2.21^b	69.34 ± 2.21^b	$P<0.05$	-
Total Hardness. mg/l	58.34 ± 0.13^a	53.16 ± 0.11^a	53.10 ± 0.19^a	$P>0.05$	-
Turbidity NTU	8.32 ± 0.21^a	15.33 ± 0.31^b	17.15 ± 0.39^b	$P<0.05$	<5 NTU

a,b = means with different superscripts across the rows are significantly different at $p<0.05$., FMENV (2011) – National Environmental (surface and Groundwater quality) Regulations.

The diversity of plankton of the water bodies provides sustainable information about the environmental status, since their abundance is influenced by the prevailing physical, chemical characteristics and biological factors. In this study, a total of 30 taxa, comprising of a total of 858 individual species of plankton (zooplankton and phytoplankton) belonging to eight (8) taxonomic groups were encountered. Rotifera had the higher species composition 208 cells/ml (24.3%), followed by *chlorophyceae* 155 cells/ml (18.0%), *Bacillariophycae* 146 cells/ml (17.0%), *Cyanophyceae* 112 cells/ml (13.0%), Cladocera 81 cells/ml (9.5%), Copepoda 74 cells/ml (8.6%), Protozoa 72 cells/ml (8.4%) and the least was *Euglenophyceae* (10 cells/ml) with the relative abundance of 1.2%. The percentage composition of taxa revealed that *Micrateria radiate and Volvox sp.* were the most occurrence species (74 and 72), with relative abundance of 8.6% and 8.4% respectively. Spatially, station 1 had the highest number of individual species (325 cells/ml), station 2 (235 cells/ml) and station 3 (298 cells/ml) with their relative abundance of 37.8%, 27.4% and 34.8% respectively. Rotifera recorded the highest dominant group in station 1 (114 cells/ml); in station 2, *Cyanophyceae* had the highest (49 cells/ml) and the lowest was protozoa (7 cells/ml), while *Bacillariophyceae* was the most abundance group in station 3 (61 cells/ml), and the least was *Euglenophyceae* (2 cells/ml). In this study, 30 taxa of plankton recorded is lower than 98 taxa reported by Komala *et al*. (2013) [29] from Arkavathi River and greater than 22 reported by Kather *et al*. (2015) [30] from Ambattur Lake, Tamil Nadu. The dominant of Rotifera evidenced in this study is accordance with the reports of similar studies [31-34]. Variations in population spatially may be attributed to inability of some species to adapt to the prevailing ecological conditions of the station, which include habitat structure, water quality characteristic, location of stations, period of investigation, food availability and anthropogenic activities. Instability of the sampling stations may also contribute to observed variations in species composition. Low species of protozoa and cladocera recorded in station 2 and 3 may be ascribed to the abundance of *Cyanophycea* species like *Anabaena spiroides*, *Chroococcus minor* and *Oscillatoria sp.* in these stations Tillmans *et al*. (2008) [35]. The presence of *Oscillatoria curviceps*, *Oscillatoria tenus*, *Oscillatoria subbrevis*, *Diatomella sp.* and *Anabaena spiroides* mostly in station 2 and 3 indicate that the station is moderately polluted with nutrient concentrations.

Table 2: Checklist of plankton composition identified during the study period (April, 2019-March, 2020).

Series Composition	STN.T	STN.2	STN.3	TOTAL
Zooplankton				
Rotifera				
Brachionus caudatus	44	-	-	44
Asplanchna priodonta	-	-	10	10
Colourell obtuse	11	-	-	11
Notholca labis	27	16	8	51
Trichocera similis	2	-	13	15
Keretella quadrata	19	12	9	40
K. tropica	8	6	9	23
Lecane scutata	3	11	-	14
Copepoda				
Mesocyclops leukati	5	5	3	13
Tropocyclops prasinus	-	7	3	10
Cyclops nauplii	5	15	12	32
Phyllodiaptomus	-	-	13	13
Neuplius sp.	6	-	-	6
Protozoa				
Euclypha ciliate	8	7	27	42
Trintinnopsis lacustris	27	-	3	30
Cladocgera				
Moina micrura	-	-	21	21
Bosmina longirotris	28	13	-	41
Daphnia rosea	11	2	6	19
Phytoplankton				
Bacillariophyceae				
Melosira granulate	12	18	31	61
Diatomella sp.	10	20	-	30
Tabellaria sp.	25	-	30	55
Euglenophyceae				
Euglena convolute	-	8	2	10
Chlorophyceae				
Chlorella ellipsoidea	9	-	-	9
Micrateria radiate	33	24	17	74
Volvox sp.	13	22	37	72
Cyanophyceae				
Anabaena spiroides	3	10	7	20
Chroococcus minor	-	10	14	24
Oscillatoria curviceps	3	9	-	12
O. subbrevis	2	18	8	28
O. tenus	11	2	15	28
Number of Individual	325	235	298	858
Number of species (taxa)	24	20	21	30
Maigalef's Index (D)	3.963	3.454	3.508	
Shannon – Weiner (H)	2.993	2.246	2.349	
Evenness Index (E)	0.935	0.774	0.783	

Diversity indices have been applied in plankton assessments in order to evaluate the environmental stability. Shekhar *et al.* (2008) [36], proposed a Shannon-Weiner diversity index classification; value > 4 was for clean water bodies; 3 to 4 was for slightly polluted water, while severely polluted waters falls below 2. The Shannon-Weiner index values recorded were ranged from 2.246 to 2.993; Margalef's index values were between 3.454 and 3.965. The low values of these diversity indices recorded in station 2 and 3 may be attributed to severe stress of anthropogenic impact on water quality which in turn affect the abundance of plankton in these stations. High values recorded in station 1 revealed that the station is stress free and devoid of anthropogenic impact. However, the higher value of Evenness index recorded in station 1 (0.935) showed that the plankton in this station are evenly distributed due to constancy in water quality.

4. Conclusion

Based on the present findings, the nefarious activities of humans in the environment interfere with the water quality characteristics, which in turned influenced the abundant and distribution of plankton. The variations in species composition spatially indicate that the river is polluted and hit with human activities. The ecological index values obtained portray moderately polluted system. It is on this note that this study recommends the needs to create educational awareness to the inhabitants of the study area and the general public on the need for effect of anthropogenic activities in aquatic ecosystems for sustainable management and healthy productivity.

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6. Authors' contribution

Jonah, UE., Nnana, GP and Hanson, HE participated in sampling collection, coding of data, analyzing, statistical analysis and the discussion**;** Avoaja, DA supervised the work and corrected the manuscript. All the authors read and approved the final manuscript for publication.

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