Original Research Article

Comment [YM1]: Check the punctuation and spaces in sentence

The Physico-chemical Characteristics and Plankton Diversity of Nwaniba River, Akwa Ibom State, Nigeria.

ABSTRACT

The physico-chemical characteristics and plankton diversity of Nwaniba River, Uruan, Akwa Ibom, Nigeria were studied between April and Sptember 2013. Surface water samples were collected for physico-chemical parameter and plankton analysis according to standard methods. The results of the physico-chemical parameters were within recommended limits of the National Environmental Standards and Regulations Enforcement Agencies (NESREA) for aquatic life. Twenty plankton species belonging to five taxa were encountered in the following order of dominance; Bacillariophyceae (69.23%) > Chlorophyceae (18.38%) > Cyanophyceae (11.97%) > Dinophyceae (0.85%) > Rotifera (0.43%). The most abundant phytoplankton was *Coscinodiscus radiates*, accounting for 47.7%, the least were *Peridinium bipes, Pediastrum duplex, Rivularia spp, Gonatozon monalaenum, Navicular peroltelti, Tabelaria spp, Epithemia zebra* and accounting for less than 1% respectively, while *Lacane bulla* was the only species for zooplankton. High Diversity indices values was recorded for Chlorophyceae =1.36 while the least was Cyanophyceae = 1-21. The presence of certain plankton-pollution tolerance species such as *Anabaena circularis*, *Navicula peroltelti*, and *Peridinium bipes* suggests a low level of organic pollution in the river.

Keywords: Physico-chemical, Plankton, Diversity, Nwaniba River.

INTRODUCTION

Water is an essential element to life on earth. It covers about 70% of the earth surface, providing habitat to numerous species of organisms. Though water is very important to life, it is one of the most poorly managed resources in the world (Fakayode, 2005; Shittu *et al*., 2008).

Several studies in Nigeria had identified anthropogenic activities as easy source of water pollution (Obasi and Balogun, 2001; Ogidiaka *et al*., 2012; Adjarho *et al*., 2013), as natural water bodies are constantly used as receptacles for untreated waste water or poorly treated effluents from industrial, agricultural, commercial or domestic activities, (Adeyemi-Ale *et al*., 2014). Thus, the increase in anthropogenic inputs, through erosion, leeching and weathering of crystal materials, has led to the rapid degradation of surface water and has thus rendered most water bodies unsuitable for their multipurposes such as artisanal fishing and domestic purposes (Tharme, 2003).

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The use of algae as biomonitors for fresh water bodies had already been recognized in the mid-19th century (Cohn, 1853). The relation of these organisms to water quality was more clearly defined by Kolkuritz and Marsson (1902). Since then, several methods of deducing water quality have been used in the laboratory, such as the bio-assay (Dakulil, 2003). The presence of an algae species in an aquatic habitat readily reflects the characteristics of the environment which they exist, showing that one or more ecological variables are within its tolerance range, (Dokuhil, 2003).

The plankton community is a dynamic system that would quickly respond to changes in the physical and chemical properties of the water environment, as they represent the base-line of food chain in the aquatic ecosystem (Adeyinka and Imoobe, 2009). The position they occupy in the trophic level makes them more vulnerable and highly sensitive to the slightest environmental changes, hence they act as indicators of water quality (Wetzel, 1983). The concept of employing planktons indicator species is extended beyond the presence/absence of a given species, to also include their abundance and biomass or growth (blooms) of algal species as a result of anthropogenic activities (Adeyemi-Ale *et al*., 2014).

Due to several favorable features such as small size, short generation time and a relatively homogenous habitat, plankton organisms are considered ideal for theoretical and experimental population ecology (Rothhaupt, 2000). The physico-chemical characteristics of water bodies in the south-south Nigeria are well reported (Akpan, 1991; Akpan and Offem, 1993; Akpan and Akpan, 1994), but there is dearth of information on the physico-chemical characteristics and plankton diversity of Nwaniba River, hence the need for this study.

Materials and Methods

Study Area: This study was carried out between April and September in Nwaniba River located in Uruan Local Government Area of Akwa Ibom State, Nigeria. (Fig.1). Nwaniba River lies between latitude $5^0$2’51”N and longitude $8^0$2’41”E. The annual rainfall received here is about 2500mm with a mean annual temperature of 32 ^oC and a relative humidity of 75%. The banks of the river were mostly covered with grass and other tropical marginal vegetations.

Comment [YM2]: Year?

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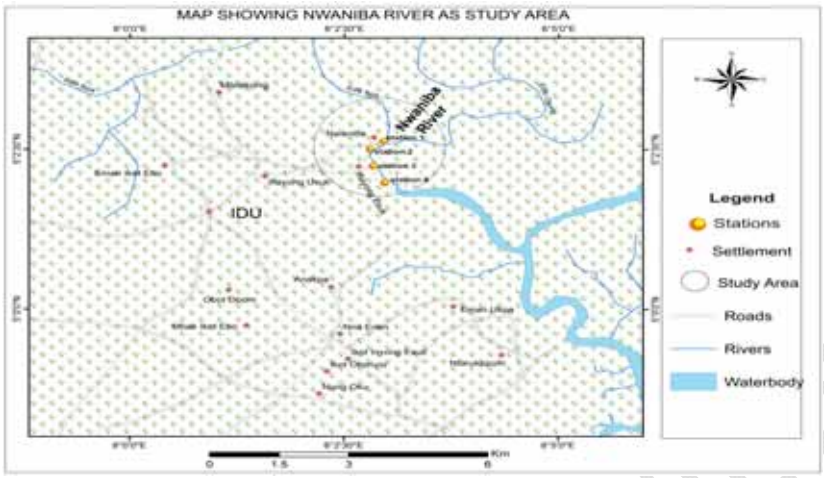

FIGURE 1: MAP OF STUDY AREA SHOWING SAMPLING STATIONS (●)

Samples collection: Water sample for physico-chemical parameters were collected with 250ml bottles, while data for water temperature, transparency and water depth were measured in-situ, using a digital thermometer for temperature, an Extect meter model Extik EC400 for conductivity, TDS, and salinity. A locally fabricated metal Scchi disc with a diameter of 20cm and an improvised metal pole of total length 10m was used for the determination of transparency and depth respectively. Dissolved oxygen concentration was determined using using the azide modification of the iodometric method. Plankton samples were collected using plankton net with mesh size of 55mm. The water samples were stored in plastic bottles and fixed with 4% formalin in the field immediately before it was taken to the laboratory for identification and analysis. Key guides provided by Nedham and Nedham (1962), Jeje and Fernando (1986, 1991), APHA/AWWA/WEF (1998), Nwankwo (2004), were used for identification of the plankton specimen encountered.

Comment [YM3]: How many liters of water do you filter?

Data analysis: Microsoft excel (2007) was used for Data analysis**,** while version 3 of PAST Software Design was used to determine the Diversity index of the plankton community and Canonical Correspondence Analysis (CCA) to determine the pattern of distribution of plankton groups related to physical and chemical parameters.

Comment [YM4]: Analysis

Results

Physico-chemical parameters: The mean, standard error and range of the physico-chemical parameters of Nwaniba River measured during the study period is shown in Table 1, while table 2 shows the spatial variation in the physico-chemical parameters.

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Table 1: The Range, Mean and Std. Error of Physico-chemical parameters of Nwaniba River.

Physico-chemical parameters	Range	Mean ±Std Error
Water Temperature (˚C)	26 - 31	28.02 ±0.33
Dissolved Oxygen (mg/L)	1.4 – 4.95	4.00 ±0.22
Biological Oxygen Demand (mg/L)	00 – 0.96	0.66 ±0.64
Ph	5.7 – 8.1	6.61 ±0.12
Salinity (ppt)	0.01 – 0.04	0.02 ±0.001
Conductivity (µS/cm)	16.6 – 74.4	25.27 ±2.28
Total Dissolved Solute (mg/L)	9.10 – 31.0	12.67 ±0.89
Transparency (m)	0.1 - 0.9	0.63 ±0.04
Water depth (m)	0.2 - 8.4	3.75 ±0.57

Comment [YM5]: pH

Table 2: The Mean variation in Physico-chemical Variables across the Sampling stations in Nwaniba River

Physico-chemical variables	Station 1	Station 2	Station 3	Station 4
Water Temperature (˚C)	27.83 ±0.70	27.91 ±0.78	28.16 ±0.65	28.02 ±0.70
Dissolved Oxygen (mg/L)	4.01 ±0.48	4.06 ±0.41	3.92 ±0.43	3.93 ±0.52
Biological Oxygen Demand (mg/L)	0.65 ±0.13	0.68 ±0.14	0.60 ±0.12	0.69 ±0.14
pH	6.53 ±0.21	6.60 ±0.21	6.60 ±0.24	6.74 ±0.35
Salinity (ppt)	0.014 ±0.001	0.013 ±0.001	0.014 ±0.001	0.02±0.005
Conductivity (µS/cm)	20.97 ±1.5	23.52 ±1.91	23.29 ±1.31	33.31 ±8.36
Total Dissolved Solute (mg/L)	11.23 ±0.51	12.62 ±0.75	12.11 ±0.84	14.73 ±3.40
Transparency (m)	0.65 ±0.07	0.65 ±0.09	0.62 ±0.07	0.63 ±0.11
Water depth (m)	4.70 ±1.05	6.0 ±1.45	2.54 ±0.60	1.8 ±0.47

Plankton composition and abundance: A total of twenty species of plankton belonging to four taxa were encountered (Table 3). The abundance of phytoplankton was in the following order; Bacillariophyceae (69.23%) > Chlorophyceae (18.38%) > Cyanophyceae (11.97%) > Dinophyceae (0.85%) > Rotifera (0.43). The most abundant phytoplankton specie was *Coscinodiscus radiates*, accounting for 47.7% while the least were *Peridinium bipes, Pediastrum duplex, Rivularia spp, Gonatozygon monalaenum, Navicular peroltelti, Tabelaria spp and Epithemia zebra*, accounting for less than 1% respectively. Only one taxa of zooplankton was recorded.

Diversity indices: High values of Shannon-Wiener Index_**H** were recorded for Chlorophyceae (1.36) and low values for Cyanophyceae (1.20). Highest values for species dominance_**D** were recorded for Dinophyceae and Rotifer (1.0) respectively and lowest for Chlorophyceae (0.27). Evenness range from (0.84) in Cyanophyceae to (1) in Dinophyceae and Rotifer (Table 4).

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Table 3: Percentage Abundance of Plankton species encountered during the study period.

	Stations						
Plankton Diversity	**1**	**2**	**3**	**4**	**Total**	**% Composition**	
CYANOPHYCEAE							
Phomidium spp	105	35	-	-	140	1.71	
Aphanizomenon spp	245	105	-	70	420	5.56	
Dactylococcopsis acicularis	35	105	105	-	245	2.99	11.97%
Anabaena circularis	70	-	35	-	105	1.28	
Rivularia spp	-	-	35	-	35	0.43	
Sub-total	**455**	**245**	**175**	**70**	**945**		
CHLOROPHYCEAE							
Closterium kuetzingii	105	175	490	210	980	11.97	
Pediastrum duplex	-	35	-	-	35	0.43	
Arthrodeamum subulalus	-	70	-	-	70	0.85	
Gonatozogon monotaenum	-	-	-	35	35	0.43	18.38%
Mongeotia spp	105	35	-	-	140	1.71	
Tribonema spp	175	-	35	35	245	2.99	
Sub-total	**385**	**315**	**525**	**280**	**1505**		
BACILLARIOPHYCEAE							
Coscinodiscus radiates	60	490	2065	770	3885	47.44	
Pinnularia mayor	-	105	210	-	315	3.85	
Pleurosigma elongatum	-	-	-	70	70	0.85	
Gyrosigma atternutum	385	140	210	280	1015	12.39	
Navicula peroltelti	-	-	35	-	35	0.43	
Tabellaria spp.	35	-	-	-	35	0.43	69.23%
Epithemia zebra	-	-	-	35	35	0.43	
Grammatophora angulosa	-	175	-	105	280	3.42	
Sub-total	**980**	**910**	**2520**	**1260**	**5670**		
DINOPHYCEAE							
Peridinium bipes	-	70	-	-	**70**	0.85	0.85%
ROTIFER							
Lacane bulla	-	35	-	-	**35**	0.43	0.43%
Grand Total	**1,820**	**1,540**	**3,220**	**1,610**	**8,190**		

Table 4: Diversity index

S/n	Iindex	BACC.	CHLORO.	CYANO.	DINO.	ROTIFER.
1.	**Shannon_H**	1.29	1.36	1.21	-	-
2	**Dominance_D**	0.30	0.27	0.34	1	1
3.	**Evenness_e^H/S**	0.91	0.97	0.84	1	1

The relationship between Physico-chemical variables and plankton abundance: The Canonical correspondence analysis (CCA) ordination diagram was employed to show the relationships existing between biological assemblage and the physic-chemical variables. The CCA triplot ordination diagram consist of four (4) sampling site-points with different colors labeled ST_1 (Blue), ST_2 (Yellow), ST_3 (Pink), ST_4 (Green); Plankton groups are

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labeled by abbreviation of their first few letters, and the arrow points of the various physicochemical variables that were measure during the course of the study (Fig 2).

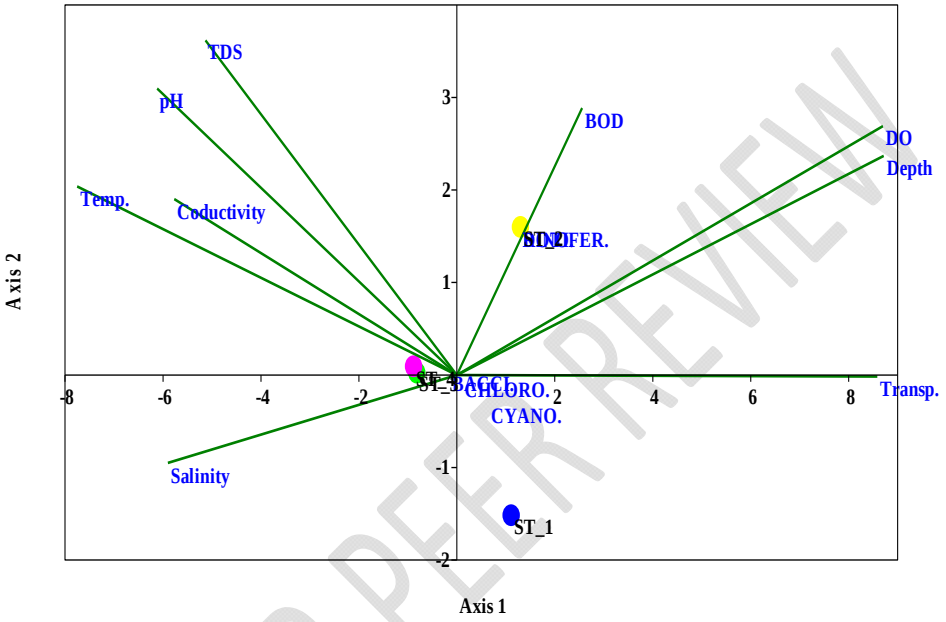

Fig. 2: Canonical correspondence analysis (CCA) triplot ordination diagram with 5 plankton groups (Bacilariophycea, Chlorophycea, Cyanophycea, Dinophyceae and Rotifera), 9 quantitative environmental variables (lines). The environmental factors are: Temperature, DO, BOD, pH, Salinity, Conductivity, TDS, Transparency, Water Depth and Four sampling station labeled 1 to 4.

Discussion

Physico-chemical parameters: The mean value of the water temperature of Nwaniba River was within the NESREA recommended range limits of 25^0C - 31^0C for surface water in the tropical region, but the observed monthly variation during the study period could be attributed to seasonal variation and rainfall pattern, as also reported by Akpan and Offem, (1993). The Dissolved Oxygen value of 4.0 ±0.22mg/l was slightly lower as compared to NESREA limits of 5.0mg/l for surface water. Thus, indicating a less oxidized aquatic

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ecosystem. According to Anago *et al.,* (2013), the depression in dissolved oxygen level could be due to chemical and biological oxidation processes in water. This may also depend on the rate of solubility, respiration processes by aquatic organisms, decay processes by aerobic bacteria and decomposition of dead decaying sediments (Gupta and Gupta, 2006). Rani *et al*., (2004) also reported lower values of dissolved oxygen in summer season due to high rate of decomposition of organic matter and limited flow of water in low holding environments due to higher temperature. The lower dissolved oxygen level in the river may also be attributed to vegetative decomposition of plants that have been excerbated by heavy point source of fresh water inflows carrying excess nutrients into this river system (EPA, 2000).

Biological oxygen demand is an important parameter that is required for the degradation of organic matter. The value of the biological oxygen demand of Nwaniba River ranged between 0 and 0.86mg/l, with a mean 0.66 ±0.64mg/L. However, other physico-chemical parameters of the river such as pH, salinity conductivity, TDS and transparency were within recommended limits as stipulated by NESREA for aquatic life.

Plankton Community Structure: The diversity and abundance of plankton in Nwaniba River show spatial variations. The percentage abundance of the phytoplankton groups was in the following order of Bacillariophyceae(diatoms) (69.23%) > Chlorophyceae (18.38%) > Cyanophyceae (11.97%) > Dinophyceae (4.2 %.). Similar trends in abundance of plankton groups were also reported by Abowei *et al*., (2011) and Ogbuagu *et al.,* (2012) in Koluama River, Bayelsa State and Imo River, in Etche Local Government Area, Rivers State, Nigeria respectively.

The dorminance of Bacillariophyceae (Diatoms) in this present study agrees with the reports of Onyema (2008) and Esenowo and Ugwumba (2010) that diatoms are the most obvious representatives of the phytoplankton in rivers, seas and lakes. The more frequent occuring plankton species encountered during the study was *Coscinodiscus radiatus*. This shows consistency with the work of Adeyemi-ale *et al*., (2014) who reported the prominence of *Coscinodiscus radiates* in Osere Stream, Ilorin, Kwara, Nigeria. Several other researchers have added to the impresive array of the cosmopolitan nature of these species which are prevalent in prominent Nigerian water bodies (Okusami and Odu, 1992; Akpan and Akpan, 1994; Onyema and Nwankwo, 2006; Onyema, 2008).

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Onyema *et al.,* (2003) reported the presence of some phytoplankton species such as *Navicula spp, Nitzchiz spp, Anabana spp and Synedra Spp*., as good indicators of organic pollution in any aquatic ecosystem. Thus, lower percentage abundance of *Navicula* and *Anabaena* species in Nwaniba River may suggest a mild level of organic pollution. These may also be a clear indication that the river may be undergoing a gradual pollution stress as a result of anthropogenic activities such as effluents from lundary, bathing, and saw-milling which may pose severe negative impact on the water parameters.

Comment [YM6]: spp

An important application of diversity indices in phytoplankton studies is in the assessment of pollution. According to Shekhar *et al*., (2008) and Ganai and Parveen, (2013) the Shannon-Weiner diversity index for clean fresh water bodies is proposed as diversity index greater than (> 4); between 3-4 is proposed as mildly polluted water while less than 2 (< 2) as heavily polluted water. The Shannon-Weiner diversity index ranged between 1.36 and 1.21 indicating heavily polluted water.

The correlation between the plankton groups, the physico-chemical parameters and the sampling station (using the distance rule, which states that the site-points closer to the specie-point tends to have a higher effect on the abundance of the species in question than sites farther from the species points) shows that water transparency, temperature, DO, depth, TDS and pH, was found to have the greatest effect on the distribution of plankton diversity, while conductivity, BOD and salinity had lesser influences on the distribution of plankton group. According to ter Braak and Verdonschot, (1995), the difference in length of the environmental variable arrows is equal to the amount of their corresponding effect on the ordination scores (specie score or site score). The ordination diagram in Figure 2 reveals that the order of importance of the measured physicochemical parameter was as follows: Transparency >Depth > DO > Temperature > pH > TDS > Salinity > Conductivity > BOD with the following correlations with axis 1, (0.95, 0.97, 0.97, -0.86, -0.68, -0.57, -0.66, -0.64, 0.28) respectively.

Conclusion

The temporal variations in the physico-chemical parameters may be attributed to rainfall patterns, while the spatial variations are due to the influence of various anthropogenic activities around this area. Although the physico-chemical parameters were within limits as recommended by National Environment Standards and Regulations Agency (NESREA) for

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tropical aquatic life, the presence of certain plankton-pollution tolerance species such as *Anabaena circularis*, *Navicula peroltelti*, and *Peridinium bipes* suggests the low level of organic pollution in the river.

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