

Original Research Article

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 September 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).

38 The use of algae as biomonitors for fresh water bodies had already been recognized in
39 the mid-19th century (Cohn, 1853). The relation of these organisms to water quality was
40 more clearly defined by Kolkuritz and Marsson (1902). Since then, several methods of
41 deducing water quality have been used in the laboratory, such as the bio-assay (Dakulil,
42 2003). The presence of an algae species in an aquatic habitat readily reflects the
43 characteristics of the environment which they exist, showing that one or more ecological
44 variables are within its tolerance range, (Dokuhil, 2003).

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

53 Due to several favorable features such as small size, short generation time and a
54 relatively homogenous habitat, plankton organisms are considered ideal for theoretical and
55 experimental population ecology (Rothhaupt, 2000). The physico-chemical characteristics of
56 water bodies in the south-south Nigeria are well reported (Akpan, 1991; Akpan and Offem,
57 1993; Akpan and Akpan, 1994), but there is dearth of information on the physico-chemical
58 characteristics and plankton diversity of Nwaniba River, hence the need for this study.

60 **Materials and Methods**

61 **Study Area:** This study was carried out between April and September in Nwaniba River
62 located in Uruan Local Government Area of Akwa Ibom State, Nigeria. (Fig.1). Nwaniba
63 River lies between latitude $5^{\circ}2'51''\text{N}$ and longitude $8^{\circ}2'41''\text{E}$. The annual rainfall received
64 here is about 2500mm with a mean annual temperature of 32°C and a relative humidity of
65 75%. The banks of the river were mostly covered with grass and other tropical marginal
66 vegetations.

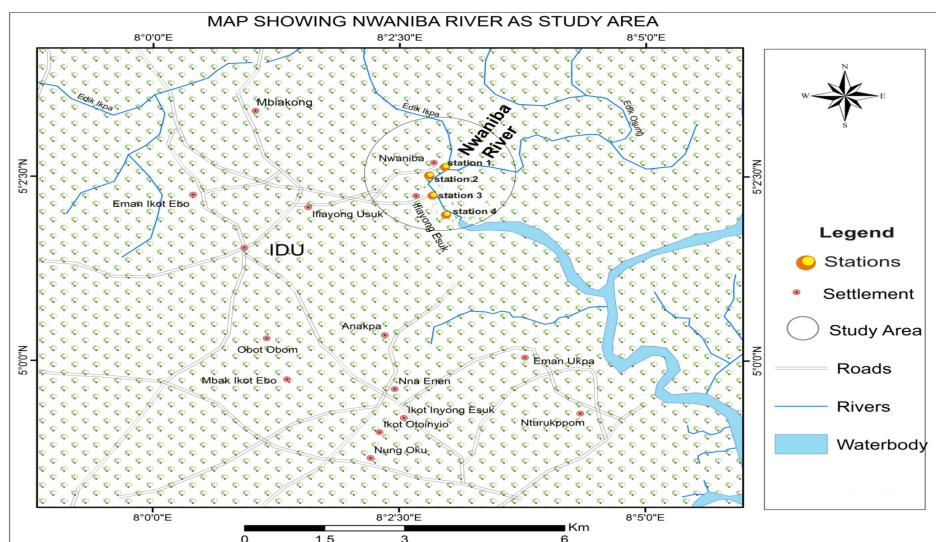


FIGURE 1: MAP OF STUDY AREA SHOWING SAMPLING STATIONS

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 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. 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.

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.

89

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

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

91

92 **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 ($^{\circ}$ C)	27.83 $\pm$ 0.70	27.91 $\pm$ 0.78	28.16 $\pm$ 0.65	28.02 $\pm$ 0.70
Dissolved Oxygen (mg/L)	4.01 $\pm$ 0.48	4.06 $\pm$ 0.41	3.92 $\pm$ 0.43	3.93 $\pm$ 0.52
Biological Oxygen Demand (mg/L)	0.65 $\pm$ 0.13	0.68 $\pm$ 0.14	0.60 $\pm$ 0.12	0.69 $\pm$ 0.14
pH	6.53 $\pm$ 0.21	6.60 $\pm$ 0.21	6.60 $\pm$ 0.24	6.74 $\pm$ 0.35
Salinity (ppt)	0.014 $\pm$ 0.001	0.013 $\pm$ 0.001	0.014 $\pm$ 0.001	0.02 $\pm$ 0.005
Conductivity (μ S/cm)	20.97 $\pm$ 1.5	23.52 $\pm$ 1.91	23.29 $\pm$ 1.31	33.31 $\pm$ 8.36
Total Dissolved Solute (mg/L)	11.23 $\pm$ 0.51	12.62 $\pm$ 0.75	12.11 $\pm$ 0.84	14.73 $\pm$ 3.40
Transparency (m)	0.65 $\pm$ 0.07	0.65 $\pm$ 0.09	0.62 $\pm$ 0.07	0.63 $\pm$ 0.11
Water depth (m)	4.70 $\pm$ 1.05	6.0 $\pm$ 1.45	2.54 $\pm$ 0.60	1.8 $\pm$ 0.47

93

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

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

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

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

108

109 **Table 4: Diversity index**

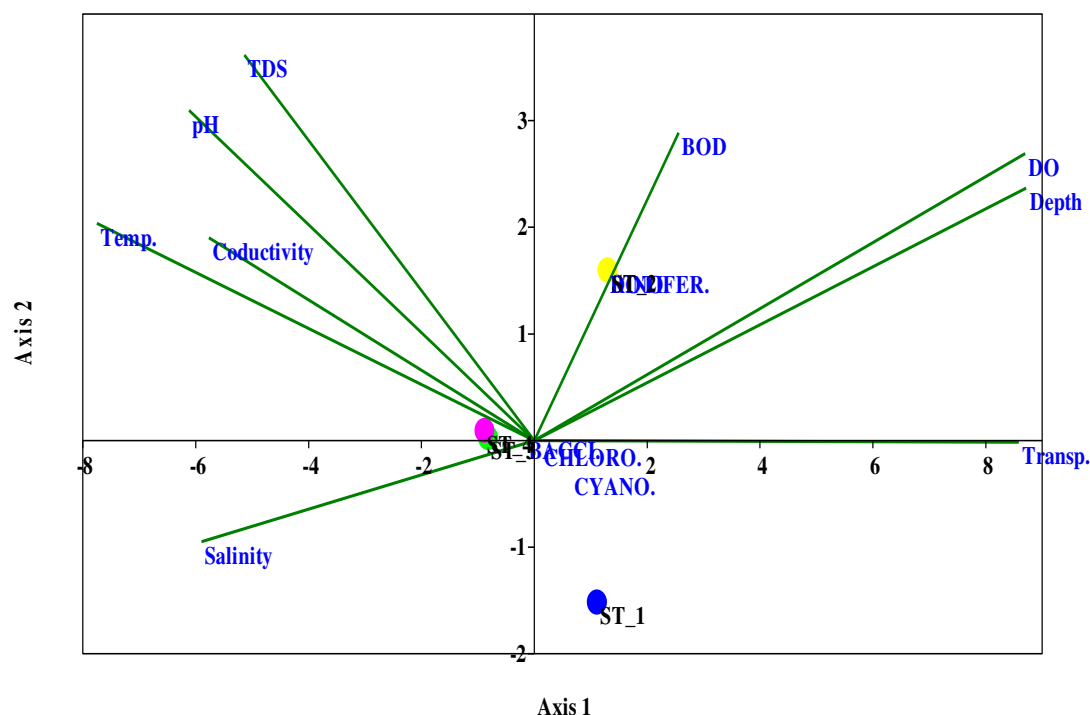
S/n	Index	BACC.	CHLORO.	CYANO.	DINO.	ROTIFER.
1.	Shannon_H	1.29	1.36	1.21	-	-
2	Dominance_D	0.30	0.27	0.34	1	1
3.	Evenness_e^H/S	0.91	0.97	0.84	1	1

110

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

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).

118



119

Fig. 2: Canonical correspondence analysis (CCA) triplot ordination diagram with 5 plankton groups (Bacilariophyceae, Chlorophyceae, Cyanophyceae, 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.

125 Discussion



Physico-chemical parameters: The mean value of the water temperature of Nwaniba River was within the NESREA recommended range limits of 25⁰C - 31⁰C 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

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 exacerbated 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 ± 0.64 mg/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).

Onyema *et al.*, (2003) reported the presence of some phytoplankton species such as *Navicula spp*, *Nitzschia spp*, *Anabaena 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 laundry, bathing, and saw-milling which may pose severe negative impact on the water parameters.

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 species 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 (species 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

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.

References



Abowei, J. F. N., Ezekiel, E. N., and Ogamba, E. N. (2011). Phytoplankton composition and Abundance in Sombreino river, Niger Delta, Nigeria. *Current Research Journal of Biological Sciences*, 3(3): 229-233

Adeyemi-ale, O. A., Aladesida, A. A., Esenowo I. K. (2014). The Effect of Detergent on the Physico-chemical characteristics and plankton Diversity of Osere Stream, Ilorin, Kwara, Nigeria. *J. Appl. Sci. Environ. Manage.*, 18(1): 109-113.

Adeyinka, M. I. and Imoobe, T.O.T. (2009). Zooplankton-based assessment of a tropical forest river in Nigeria. *Arch. Biol.*, 61(4): 733-740.

Adjarho, U. B., Esenowo, I.K. and Ugwumba, A.A.A. (2013) Physico-chemical Parameters and Macroinvertebrates Fauna of Ona River at Oluyole Estate, Ibadan, Nigeria. *Research Journal of Environmental and Earth Sciences* 5(11): 671-676, 2013

Akpan, E. R. (1991). Seasonal variation in Phytoplankton biomass and Pigments in relation to water quality in the Cross River System. Ph.D Thesis, University of Calabar. p 179.

Akpan E. R. and Offem, J. O. (1993). Seasonal variation in water quality of the Cross River, Nigeria. *Rev. Hydrobiol. trop.* 26 (2): pp 95-103.

Akpan A. W. and Akpan, B. E. (1994). Spatial and temporal heterogeneity in plankton distribution in a Nigerian tropical freshwater pond (southern Nigeria). *Acta Hydrobiol.* 36 (2): Pp 201-211.

Anago, I.J., Esenowo, I.K. and Ugwumba, A.A.A. (2013) The Physico-chemistry and Plankton Diversity of Awba Reservoir University of Ibadan, Ibadan Nigeria. *Research Journal of Environmental and Earth Sciences* 5(11): 638-644

APHA, AWWA and WEF, (1998). Standard Methods for the Examination of Water and Wastewater. 20th Edn., American Public Health Association, American Water Works Association and Water Environmental Federation, Washinton, DC, United States.

Cohn, F. (1853). Uber lebende organism in Trinkwasser. *Z. Klen. Mecizin* (4): 229-237.

- 242 Dokulil, M. T. (2003). Algae as Ecological biomonitors; Elsener Science Ltd. Pp 285-290.
- 243
- 244 Environmental Protection Agency, EPA (2000). Ambient water quality criteria
- 245 recommendations
- 246 information supporting the development of state and tribal nutrient criteria for
- 247 wetlands in ecoregion XIII. 2000. USEPA 822-B-00-023.
- 248
- 249 Esenowo I. K. and Ugwunba A. A. A. (2010). Composition and abundance of Macrobenthos
- 250 in Majidun
- 251 River Ikorodu Lagos State. Nigeria. *Research Journals of Biological Science*, 2010,
- 252 5(8): pp 556-560
- 253
- 254 Fakayode, S. O. (2005). Impact Assessment of Industrial Effluent on Water Quality of the
- 255 Receiving Alaro
- 256 River in Ibadan, Nigeria. *AJEAM-RAGEE*, (10): pp 1-13.
- 257
- 258 Ganai, A. H., and Parveen, S. (2013). Effect of physico-chemical conditions on the structure
- 259 and
- 260 composition of the phytoplankton community in Wular Lake at Lankrishipora,
- 261 Kashmir, India. *International Journal of Biodiversity and Conservation*. 6(1): 71 - 84.
- 262
- 263 Gupta, S.K. and R.C. Gupta, (2006). General and Applied Ichthyology (Fish and Fisheries).
- 264 S. Chand and
- 265 Company Ltd., Ram Nagar, New Delhi, pp 1130.
- 266
- 267 Jeje, C. Y. and C. H. Fernando, (1986). A Practical Guide to the Identification of Nigerian
- 268 Zooplankton
- 269 (Cladocera, Copepoda and Rotifera). Published by KLRI, New Bussa. pp 142.
- 270
- 271 Jeje, C. Y. and C. H. Fernando,(1991). An illustrated guide to identification of Nigerian
- 272 freshwater rotifers.
- 273 *Niger. J. Sci.*, 25: 77-95. Jost, L. (2006). Entropy and diversity. - *Oikos* 113: 363–374.
- 274
- 275 Kolkwitz. R. Marsson, M. (1902). Grundsätze für die biologische Beurteilung des wasser nach
- 276 seiner flora
- 277 und fauna. Mitteilungen der prüfungsanstalt für wasserversorgung und Abwasserreinigung
- 278 (1): 33-72.
- 279
- 280 Needham, J. G. and P.R. Needham, (1962). A Guide to the Study of Freshwater Biology. *2nd*
- 281 *Edn.*,
- 282 *Holden-Day Inc.*, San Francisco, C.A. pp 108.
- 283
- 284 Nwankwo, D. I. (2004). Studies on the Environmental preference of blue-green algae
- 285 (cyanophyta) in
- 286 Nigeria coastal waters. *Niger. Environ. Soc. J.*, 2(1): pp 44 -51.
- 287
- 288 Obasi, R. A. and Balogun, O. (2001) Water Quality and Environmental Impact Assessment of
- 289 Water Resources in Nigeria. *African Journal of Environmental Studies*, 2(2): pp 228-
- 290 231.

- Ogbuagu, D. H., Ayoade, A. A., and Chidiago, G. O. (2012). Seasonal variations in physico-chemical regime, Bacterioplankton and mycoplankton of Imo River in Etche, Nigeria. *J. Microbiol. Biotech. Res.*, 2(2): 289-297
- Ogidiaka, E., Esenowo, I. K. and Ugwumba, A. A. A. (2012). Physico-chemical Parameters and Benthic Macroinvertebrates of Ogunpa River at Bodija, Ibadan, Oyo State. *Eur. J. Sci. Res.*, 85(1): 89-97
- Okusami, V. B. and Odu E. A. (1992). Freshwater diatoms from Ile-Ife, Osun state. *The Nigerian field*, 57: 143 -163
- Onyema, I. C. (2008). A checklist of phytoplankton species of the Iyagbe lagoon, Lagos. *Journal of Fisheries and Aquatic Sciences*, 3(3): pp 167 – 175.
- Onyema, I.C. and Nwankwo, D.I. (2006). The epipellic assemblage of a polluted estuarine creek in Lagos, Nigeria. *Journal Pollution Research*. 25 (3): pp 459 – 468.
- Onyema, I.C, Otudeko, O.G. and Nwankwo, D. I. (2003). The distribution and composition of plankton around a sewage disposal site at Iddo, Nigeria. *Journal of Scientific Research Development*, (7):11 □26.
- Passy, I. S., Bodoie, R. W., Calson, D. M. and Novak, N. A., (2004). Comparative Environmental Assessment in the studies of Benthic Diatoms, Macro-invertebrate and fish community. *Intl. Rev. Hydrobiol.* (89): 121-138.
- Rani, R., Gupta, B. K. and Srivastava, K. B. L. (2004). Studies on water quality assessment in Satna city (M.P.): *Seasonal parametric variations. Nat. Env. Poll. Tech.*, 3(4): pp 563-565.
- Rothhaupt, K.O., (2000). Plankton population dynamics: Food web interactions and abiotic constraints. *Freshwater Biol.*, 45: pp 105-109.
- Shekhar, S. T. R., Kiran, B. B., Puttaiah, T., Shivraj, Y., Mahadevan, K. M. (2008). Phytoplankton as index of water quality with reference to industrial pollution. *J. Environ. Biol.* 29(2) : 233-236
- Shittu, O. B., Olaitan, J. O., and Amusa, T. S. (2008). Physico-chemical and Bacteriological Analysis of

339 water used for Drinking and Swimming purposes in Abeokuta, Nigeria. *African*
340 *Journal of Biomedical Research*, 11: 285-290.
341
342 ter Braak, C. J. AND Verdonschot, F. M. (1995). Canonical Corresponding analysis and
343 related multivariate
344 methods in aquatic ecology. *Aquatic Sciences* 57 (3): 255-289
345
346 Tharme, R. E. (2003). "A global perspective on environmental flow assessment: emerging
347 trends in the
348 development and application of environmental flow methodologies for rivers." *River*
349 *Research and*
350 *Applications* 19 (5-6): 397-441.
351
352 Wetzel, R.G. (1983). Limnology, 2nd Edition. Saunders College Publishing, Philadelphia,
353 PA. pp 36-47