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Assessment of Water Quality and Plankton Taxa of NworieRiver inOwerri, Southeastern Nigeria

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Abstract
The study assessed the physicochemical quality and plankton biotypes of Nworie River in a southeastern state of Nigeria. Water and Plankton samples were collected from 3 points along the course of the river for two months (February and July) to represent the dry and rainy season samples respectively. Maximum results (Mean ±SE) obtained were as follows, pH: (8.20±0.18); Turbidity: (155.13±3.57)NTU; Nitrates: (66.11±4.23)mg/l, Phosphates: (122.85±1.74)mg/l, Total suspended Solids: (155±49.71)mg/l; Total Dissolved Solids: (81.74±2.78)mg/l and Dissolved Oxygen: (1.65±0.13)mg/l. Twenty six species of phytoplankton belonging to six classes, and 5 species of zooplankton belonging to three classes were identified. The order of abundance of phytoplankton taxa was Bacillariophyceae (44%) >Cyanophyceae (37%) >Chlorophyceae (11%) >Chrysophyceae (4%) >Euglenophyceae (3%) >Xanthophyceae (1%) and that of the zooplankton was Cladocera (50%) > Protozoa (38.5%) >Copepoda (11.5%). The dominant phytoplankton species included Melosira granulate and Cyclotellasp, while the dominant zooplankton species included Peridiniumumbonatum, Ceriodaphniasetosa and Daphnia carinata spp. Species diversity highest values were recorded at Egbeada station for both phytoplankton and zooplankton. Spatial differences between stations were insignificant for most of the physicochemical parameters studied, except for significant variations between seasons. Findings from the study revealed that almost all physicochemical parameters were not within the National Environmental Standards and Regulations Enforcement Agency (NESREA) and World Health Organization (WHO) permissible limits for fresh water bodies and this seemed to have a negative impact on the species richness and diversity. Stricter measures need to be applied in managing the river to prevent loss of biodiversity.

Keywords: *Nworie River, Plankton, Diversity, Heavy metals, NESREA.*

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I. Introduction

In the aquatic ecosystem, plankton occupy the first trophic level (Frederiksen*et al*., 2006). Phytoplankton are the primary producers for all aquatic creatures and.their primary consumers are the zooplankton, the animal like plankton, which in turn become food for larger animals. Any upset in their healthy existence could result in a disruption of the balance in the ecosystem. Plankton also play a significant role in the carbon cycle as about a quarter of the carbon dioxide, a major greenhouse gas released into the atmosphere by humans are absorbed into the ocean and a large part of this is utilized by phytoplankton for their photosynthetic functions (Pavia *et al*., 2019). This places emphasis on the role of plankton in regulating global climate changes and its importance in ecological research (Blaschko*et al*, 2005). Plankton are also known bioindicators, as the predominance of certain species of zooplankton have been observed to be associated with changes in various physicochemical properties of aquatic environments such as temperature, chloride ions and pH. For example, some species of phytoplankton and zooplankton thrive in environments that are rich in nutrient content, which is an indication of high levels of organic pollution (Odiete, 1999). These properties make them useful for marine biologists in early detection of organic pollution and in monitoring water quality. The Physicochemical parameters of a water body are used to evaluate its quality as they provide information on the state of the ecosystem. When the rate of contamination of a river or stream is higher than its rate of recovery, its chemical, physical and biological properties gradually change until it gets to a point where it cannot sustain desirable biota or be useful for any purpose

The city of Owerri is fast developing and undergoing many urban expansion and renewal schemes. However, the schemes do not take into consideration the rivers that flow through the city, thereby resulting in the compromise of the water quality (Pat-Mbano*et al*., 2012). The Nworie River situated in Owerri, has its source at Ohi in Mbaitoli Local Government Area and empties into Otamiri River at the AbaRoad (Fig. 1). The river is used for various domestic purposes by inhabitants of Owerri, even as some people take their baths, swim and wash their clothes and cars in the river. Over the years, human activities including dredging, have relatively had negative effects on the river (Ummunakwe and Nnaji, 2015). The levels of heavy metals in the sediment of Nworie river were found to have increased after dredging (Udensi*et al.,* 2014). Dredging has also been found to affect the development of fish negatively (Seiyaboh*et al.*, 2013). Seiyaboh*et al.*, (2007) had observed that there is a correlation between water and sediment quality and fish resources. Nworie River receives a high load of wastes daily as the waste management authority in the state manages an open dump by the side of the river along the old Nekede Road (Pat-mbano*et al.*, 2012). Additional waste imputs come from the Amakohia axis where there are several open dumpsites by the river sides and all classes and types of waste and sewage are dumped into the river. Some institutions located along the banks of the river channel their untreated sewage which may likely contain hazardous substances directly into the river (Ogbomida and Emeribe, 2013). The waste disposal method for solid wastes practiced by these institutions and other residents around the river is open dumping (Ishaku and Ezeigbo 2010).

In Owerri, regular water supply is not constant and the communities have to augment during periods of water shortage with natural water sources like rivers and streams. Unfortunately, many of these water bodies are also sinks for waste as the absence of adequate waste disposal systems has remained a challenge facing the city. This study assessed physicochemical properties and plankton biotypes of Nworie River in order to ascertain the quality of the aquatic ecosystem.

II. Methodology

2.1 Study area

Nworie river is located in Owerri the capital of Imo State in south-eastern Nigeria.. The river is about 5km long and lies between latitudes 5^0 4' and 6^0 3' N and longitude 6^0 15'and 7^0 34' E (Fig.1). The river has its source at Ohi in Mbaitoli LGA and empties into Otamiri River at Aba Road (Amangabara, 2015). It flows through Egbeada and Amakohia environs and across Nekede Road all in Owerri Municipal. The watershed that feed the Nworieriver is subject to intensive anthropogenic and industrial activities which result in the discharge of a wide range of pollutants into the river (Umunnakwe and Nnaji, 2015).

The river is located in the lowland regions of the southern part of Imo State, with an elevation of less than 40m. Nworie River is a first order stream and a tributary of Otamiri watershed, which is one of the five major sub-basins of Imo State (Amangabara, 2015).

The climate of the area is humid and semi-hot equatorial type. The area falls within the rainforest zone, with an annual rainfall of between 1700 and 2500m which is concentrated almost entirely between the months of March and October. Relative humidity fluctuates between 55 and 85% during the dry and rainy seasons. Ambient temperature ranges between 28 and 35^0C (maximum) and 19 and 24^0C (minimum) (ISEPA/MPE, 2008). The hottest months are between January and March. Vegetation is typical of rainforest belts and about 45.4 % of the land cover of Imo State, representing 2256.7$Km^2$is covered by light vegetation, whereas 24.7 % of the land area representing 1229 Km^2 is covered by thick vegetation (Udokporo*et al.,* 2015).

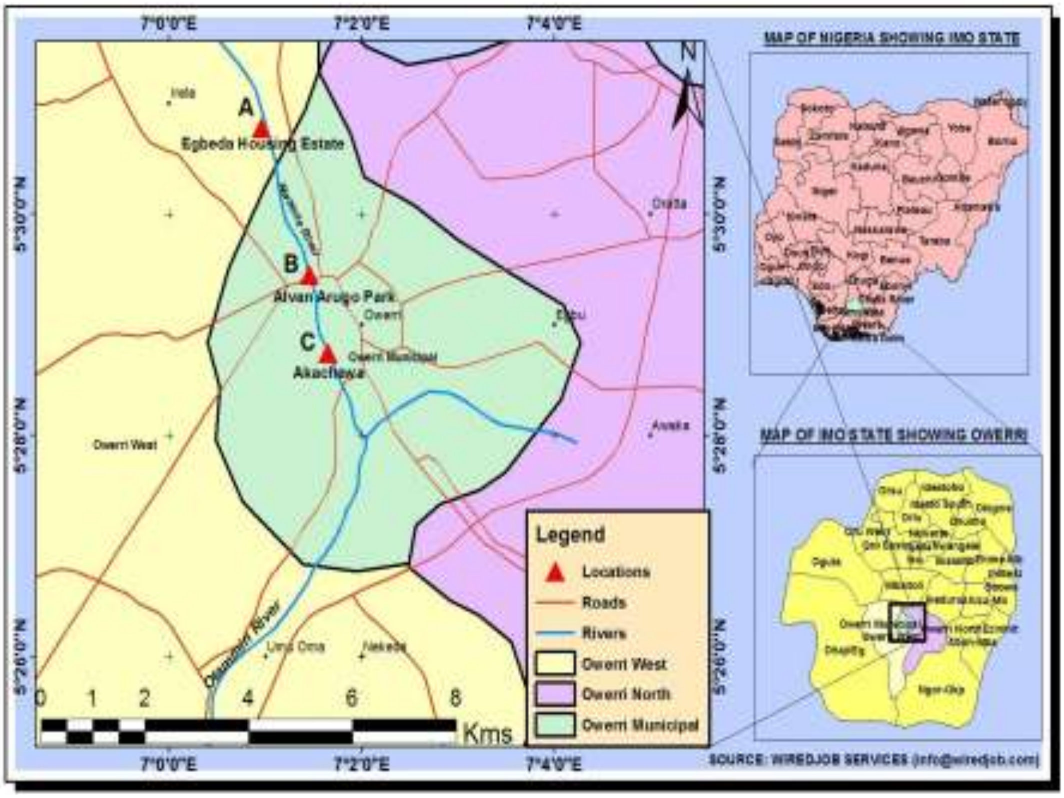

Fig .1: Map of Owerri showing the sampling points along Nworie River

2.2 Sample collection

Water samples for the analysis of physicochemical parameters were collected at 3 designated locations along the river, below the water surface in 500ml plastic bottles with screw caps. Location A was located at Egbeada Housing Estate, location B at Arugo Park, while location C was at the 2nd Mainland Bridge off Akanchawa Road (Fig.1) Samples were collected for two seasons; in February for the dry season and in July for the rainy season.

Plankton samples were collected in triplicates at each location according to the method described by Ogbuagu and Ayoade (2012). The samples were collected using 55µm mesh size standard plankton net that was towed horizontally for five minutes at a depth of about 0.5 metres. The samples were transferred into well labelled plastic containers with screw caps, and preserved with 4% formalin.

All samples were collected in the day between 10am and 3pm. and were taken to the laboratory on the same day for analysis. Results were compared to National Environmental Standards and Regulations Enforcement Agency (NESREA) and World Health Organisation (WHO) standards for fresh water.

2.3 *In situ* measurements

Temperature, pH, Conductivity, Turbidity and Dissolved oxygen (DO) were all measured *in-situ.* . pH was determined using hand held pH meter (model HI98107 HANNA) that was calibrated using pH buffer 7, and 4. Temperature was determined with the aid of an aquatic thermometer. Readings were taken below the water surface after insertion for 2 minutes. Conductivity was determined using a hand held Conductivity Meter (Model HI98302 HANNA) calibrated using conductivity solution at 25 ^{o} C. Turbidity was determined by photometric method using a HACH DR/2010 spectrometer at a wavelength of 860nm and programmed number 750. The DO was determined using a Jenway –Model 9500 DO meter calibrated with 5% sodium Sulphate solution.

2.4 Laboratory analyses

Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Nitrates, Phosphates and Heavy Metals (Cu, Cd, Pd and Fe) concentrations were all determined in the laboratory. TSS was determined by photometric methods using HACH DR/2010 spectrophotometer at a wavelength of 810nm and program number 630. TDS was determined using the conductivity/total dissolved solids HANNA meter (HI98302 model). Nitrate was determined by Cadmium reduction method using a HI83200 multi-parameter bench photometer at a wavelength of 525 nm. Phosphate was determined by Amino Acid methods using HI 83200 multi-parameter bench photometer at a wavelength of 525 nm. Heavy metal samples were first digested using 10ml of aqua regia which was added to 50ml of the sample in a 250ml conical flask. The mixture was heated and the digest filtered with filter paper, before being analysed with an Atomic Absorption Spectrophotometer.

2.5 Plankton Identification

Keys provided by Whitford and Schumacher (1973), Needham and Needham (1974), Jeje and Fernando (1986; 1991), Maosen (1978), APHA/AWWA/WEF (1998) and Nwankwo (2004) were used for identification of plankton species. Identifications and count of plankton per millilitre of water were organized using taxonomy.

2.6 Statistical Analysis

The SPSS V.22.0 was used to analyse data. Descriptive statistics was used to obtain mean, standard deviation and variance. Variation plots were used to represent the level of the physicochemical parameters and numerical abundances of plankton taxa across the sample locations and mean seperations were made with the Duncan multiple range test.. The one-way analysis of variance (ANOVA) was used to determine homogeneity in mean variance of the water parameters and plankton abundances across the sampling locations. The Pearson correlation coefficient (r) was used to evaluate possible relationships between the environmental variables and the plankton abundance. The Shannon-Wiener's index (H**)** was used to determine plankton diversity.

III. Results And Discussion

3.1 Physicochemical Parameters

Temperature values were all within normal limits for both seasons, ranging between 24.75 and 27.10^{0}C throughout the period showing slight variations between seasons. This is in conformity with the temperature ranges observed in other studies carried out in the region (Duru andNwanekwu, 2012). Turbidity levels were higher in the Rainy season (98.79 -109.340NTU) than in the dry season (57.65 -74.93NTU). This could be due to run-off from the catchment area during rainfalls which carry debris, pollutants and sediment into the waterways. The debris increases the sediment loading and the amount of suspended solids which in turn increase the turbidity of the water. Electrical conductivity fell within acceptable limits in all locations in July, but not in February. This is probably due to the increased concentration of dissolved ions in the river in the dry months when the river is stagnant.

pH levels were lower in the dry season; ranging between 5.87 and 6.81. This could be attributed to the formation of substances such as humic acid as a result of decomposition and other metabolic processes. The stagnant nature of the river in the dry season is also likely to cause an increase in the concentration of nutrients and other pollutants in the river. In a study carried out by Yamada and Ikeda (1999) on the effects of lowered pH on 10 different species of zooplankton, the ability of zooplankton to tolerate lowered pH was highly variable between and possibly within species. They observed that although tolerance toward low pH in freshwater zooplankton differed within species, this was dependent on the pH and the composition of potentially toxic elements (Ca, Na, CO_2 and heavy metals) in the water from which they originated. TDS values in February ranged between 51.39 and 81.74 mg/l and between 52 and 55.25 mg/l in July. The high TDS value recorded at Egbeada in the dry season was probably due to the stagnation of the river during the period. TSS values ranged between 14.09 and 28.75 mg/l in February and between 103 and 155 mg/l in July (Table 1). The increase in the rainy season was probably due to an increase in debris and suspended pollutants dumped or washed into the river. TDS is usually positively correlated with electrical conductivity as ions are released into the water system when particles are dissolved. All DO levels recorded were low, ranging between 0.23 and1.08mg/l in February, and 0.35 and 1.65 mg/l in July. This was probably due to the high rate of decomposition of organic matter and algal growth in the river throughout the year.

In February, Nitrate levels were as low as between 0.17 and 0.94 mg/l and in July, levels increased to 18.28 and 66.11mg/l, which did not conform with NESREA standards. The increase in Nitrate levels in the rainy season could be due to high inflow of sewage and other organic contents into the river as well as due to denitrification of decayed organic matter. Nitrate is a limiting factor for phytoplankton growth and its increase could lead to phytoplankton blooms. Levels of phosphate recorded in the month of July (24.45 - 122.85 mg/l) were several times higher than levels recorded in February (1.46 - 122.85 mg/l). The levels in the rainy season exceeded the allowable limits for phosphates in surface water bodies. Phosphate is also a limiting factor in phytoplankton growth but only after organisms have had enough Nitrates (Tyrell, 1999). Lead levels ranged between 0.03 and 0.27mg/l in February and between 0 and 8.89mg/l in July. The high lead levels recorded were attributed to the several auto mechanic workshops located at several point along the course of the river.

Iron values ranged between 0.69 and 0.76 mg/l in the rainy season and 0.27 and 0.67mg/l in the dry season. Copper values recorded in February (0.18 - 1.21 mg/l) were higher than those recorded in July (0 -

0.01mg.l). Cadmium levels ranged between 0.04 and 0.14mg/l in February and between 0.14 and 0.53mg/l in July. These results conform to those obtained by Udensi*et al*. (2014), but lower than that obtained by Ummunakwe and Nnaji (2015). This could be an indication of sedimentedheavy metals released into the water column after activities that generated some turbulence. However, Pb and Cd are very toxic to aquatic organisms even at very small concentrations (Bahnasawy, Khidr and Dheina, 2011). Cu on the other hand, is an essential element for aquatic organisms. Lead, Iron and Cadmium levels were not within WHO and NESREA standards throughout the period of the study. Copper levels were within the acceptable limits in the rainy season, but were not in the dry season. Alinnor and Obiji (2010) had observed some trace metal elements in fish tissues from Nworie River.

Some institutionslocated along the river banks channel their untreated sewage directly into the river and these may likely contain hazardous contents (Ogbomida and Emeribe, 2013). The waste disposal practiced by inhabitants of these institutions and other members of the public is open dumping for solid wastes (Ishaku and Ezeigbo 2010). This in addition to the presence of several small farms located along the course of the river could be responsible for the high levels of phosphates and nitrates recorded in July.

Table 1. Mean values of water parameters at sampling stations along Nworie River

Parameters	Month	Unit	Egbeada	Arugo park	Akanchawa Rd	NESREA Standards	WHO Standards
Temperature	**Feb**		27.03 ± 0.13^{c}	26.0 ± 0.16^{b}	24.75 ± 0.29^{a}		
	July	^{0}C	27.10 ± 0.27^{a}	26.60 ± 0.70^{a}	26.98 ± 0.17^{a}	NS	20-30
Turbidity	**Feb**		74.93 ± 30.19^{a}	57.65 ± 1.93^{a}	61.0 ± 6.30^{a}		
	July	NTU	98.79 ± 2.13^{a}	109.34 ± 2.43^{b}	105.36 ± 2.02^{c}	10	50
Conductivity	**Feb**		155.13 ± 3.57^{c}	87.77 ± 0.37^{a}	101.53 ± 1.38^{b}		
	July	µS/cm	85.00 ± 17.32^{ab}	80.00 ± 0.00^{a}	100.00 ± 0.00^{b}	NS	100
pH	**Feb**		5.97 ± 0.09^{a}	5.87 ± 0.05^{a}	6.81 ± 0.20^{b}		
	July		8.20 ± 0.18^{a}	7.50 ± 0.16^{a}	7.35 ± 0.39^{b}	6.5-8.5	6.5-8.5
Total Dissolve Solid	**Feb**		81.74 ± 2.78^{c}	51.39 ± 1.88^{a}	56.30 ± 1.00^{b}		
	July	mg/l	55.25 ± 10.70^{ab}	52.00 ± 0.82^{a}	65.0 ± 0.82^{b}	NS	250
Total Suspended solid	**Feb**		14.09 ± 0.15^{a}	19.13 ± 0.21^{b}	28.75 ± 0.52^{c}		
	July	mg/l	155 ± 49.71^{a}	124.00 ± 26.58^{a}	103.00 ± 20.82^{a}	0.25	50
Dissolved Oxygen	**Feb**		0.95 ± 0.24^{b}	1.08 ± 0.31^{b}	0.23 ± 0.05^{a}		
	July	mg/l	1.65 ± 0.13^{a}	1.50 ± 0.48^{b}	0.35 ± 0.06^{b}	6	10
Nitrate	**Feb**		0.17 ± 0.02^{a}	0.94 ± 0.03^{c}	0.22 ± 0.03^{b}		
	July	mg/l	18.28 ± 14.38^{a}	39.04 ± 1.72^{b}	66.11 ± 4.23^{c}	9.1	40
Phosphate	**Feb**		1.46 ± 0.49^{a}	2.62 ± 0.11^{b}	2.46 ± 0.05^{b}		
	July	mg/l	122.85 ± 1.74^{a}	76.65 ± 1.99^{b}	24.45 ± 2.27^{c}	3.5	5
Lead	**Feb**		0.12 ± 0.06^{a}	0.03 ± 0.01^{a}	0.27 ± 0.41^{a}		
	July	mg/l	1.45 ± 1.59^{a}	8.89 ± 10.27^{a}	0.00 ± 0.00^{a}	0.01	0.05
Iron	**Feb**		0.27 ± 0.06^{a}	0.67 ± 0.04^{b}	0.32 ± 0.03^{a}		
	July	mg/l	0.76 ± 0.13^{a}	0.69 ± 0.18^{a}	0.69 ± 0.15^{a}	0.05	0.3
Copper	**Feb**		0.18 ± 0.05^{a}	0.97 ± 0.12^{b}	1.21 ± 0.02^{c}		
	July	mg/l	0.01 ± 0.01^{a}	0.01 ± 0.01^{a}	0.00 ± 0.00^{b}	0.001	0.3
Cadmium	**Feb**		0.04 ± 0.04^{a}	0.14 ± 0.06^{b}	0.09 ± 0.09^{ab}		
	July	mg/l	0.63 ± 0.61^{a}	0.14 ± 0.01^{a}	0.20 ± 0.03^{a}	0.005	0.003

Means with different superscripts are significantly different at $p<0.05$.

The results of the physicochemical analysis of the river (Table 1) revealed that several of the parameters were not within the WHO and NESREA standards. This differs from the results obtained by Ummunakwe and Nnaji, (2015) in a similar study on the water quality of the same river. This is an indication that the river has gradually deteriorated in quality over the period.

3.2 Plankton Abundance and Diversity

Twenty three genera of phytoplankton,were identified (Table 2). This was less than the number of genera (43) recorded by Ogbuagu and Ayoade (2012) in Imo river. The numerical order of dominance of the families was Bacillariophyceae (44%) >Cyanophyceae (37%) >Chlorophyceae (11%) >Chrysophyceae (4%) >Euglenophyceae (3%) >Xanthophyceae (1%). Zooplankton was made up of 3 taxa with order of dominance as Cladocera (50%) >Protozoa (38.5%) >Copepoda (11.5%) (Table 3).Bacillariophyceae were present in all locations and comprised of 9 species present in both seasons. The predominant species of this family included *Diatom*spp*., Melosira granulate and Cyclotella*sp. Gharib*et al*. (2011), Ogbuagu and Ayoade (2012), Aldridge, *et al*. (2012), and Gulecal and Temel (2014) had also made similar observations in species abundance.

Cyanophyceae another dominant taxa in the phytoplankton community comprised of a total of 7 species in all. This group was also present in all sampling locations of the river and constituted about 37% of the population. *Aphanizomenonflos-aquae, Oscillatorialacustris*and *Anabaena spiroides*are the most predominant species in the group. The abundance of the pollution tolerant *Oscillatoria*sp. is an indication of excess nutrient enrichmnent (Nair *et al*., 2015; Abubakar, 2012). Chlorophyceae, the green algae was also present in all sampling locations and included *Chlamydomonas sp., Crucigenia fenestrate,* and *Spirogyra* sp. as dominant species. Chrysophyceae.present included *Mallamonas caudate* and *Dinobryon*spp. Euglenophyceae were also present at all sampling locations in both months covered during the study period. *Trachelomonas*sp. was the only species identified throughout the period. *Tribonemavulgare*was the only Xanthophyceae species spotted in the month of July. The zooplankton community was low in abundance and diversity, probably due to the low DO and high turbidity content of the river. 3 classes were identified during the period of the study (Table 3), comprising of 5 species. *Peridiniumumbonatum, Ceriodaphniasetosa*and *Daphnia carinata*spp. were the classes with the highest abundance. In both seasons, Cladocerans had the highest abundance while Copepods had the lowest abundance. The composition of zooplankton population comprised of Protozoa with 2 species, Cladocerans with 2 species and Copepods with only 1 species identified.

There were no observed significant differences in the means for all plankton taxa except bacilliarophyceae which had significant variations between samples collected at Egbeada and other stations.

Table 2. Plankton taxa across the sampling locations in Nworie River

Plankton taxa/species	Total occurrence A1	A2	B1	B2	C1	C2
PHYTOPLANKTON						
Bacillariophyceae (Diatoms)						
Asterionella formosa	x	x	x	x	x	x
Fragilaria virescens	-	-	x	-	x	-
Fragilaria capucina	-	x	-	x	-	x
Tabellaria flocculosa	x	-	x	-	x	-
Nitzschia closterium	x	x	x	x	x	x
Diatoma sp.	x	x	x	x	x	x
Melosira varians	-	x	-	x	-	x
Melosira granulate	x	x	x	x	x	x
Synedra ulna	-	-	-	x	-	x
Cyclotella meneghiniana	-	x	-	x	-	x
Cyclotella operculata	x	-	x	-	x	-
Cyanophyceae						
Microcystis aeruginosa	x	x	x	x	x	x
Anabaena spiroides	x	x	x	x	x	x
Aphanizomenon flos-aquae	x	x	x	x	x	x
Oscillatoria lacustris	x	x	x	x	x	x
Lyngbya limnetica	-	-	-	x	-	x
Chlorophyceae						
Chlamydomonas sp.	x	x	x	x	x	x
Volvox globator	-	x	x	x	-	-
Ankistrodesmus falcatus	x	-	x	-	x	-
Crucigenia fenestrate	x	-	x	-	x	-
Spirogyra spp.	-	x	-	-	-	x
Closterium gracile	-	x	-	x	-	x
Closterium parvulum	x	-	x	-	x	-
Euglenophyceae						
Trachelomonas sp.	x	x	x	x	x	x
Chrysophyceae						
Mallamonas caudate	x	-	x	-	x	-
Dinobryon sp.	x	x	x	x	x	-
ZOOPLANKTON						
Protozoa	-	x	-	-	-	x
Peridinium umbonatum	x	x	x	-	-	x
Cladocera						
Ceriodaphnia setosa	x	-	x	x	x	x
Copepoda						
Limnocalanus macrurus	-	x	-	x	-	-

X= Present, - = Absent

Table 3. Mean values of Plankton counts at sampling stations along Nworie River.

Plankton taxa (Cells/Organisms /ml)	Month	Nworie River at Egbeada	Nworie River at Arugo park	Nworie River at Akanchawa Rd
Bacillariophyceae	Feb	7.33±1.53[a]	20.00±5.29[b]	22.00±4.36[b]
	July	10.00±3.00[b]	12.67±3.79[ab]	17.33±3.51[a]
Cyanophyceae	Feb	7.33±5.03[a]	18.33±2.08[a]	15.00±10.44[a]
	July	9.00±4.58[a]	13.33±5.51[a]	10.67±9.87[a]
Chlorophyceae	Feb	2.33±0.58[a]	7.33±3.51[a]	4.67±3.00[a]
	July	2.33±0.58[a]	2.00±2.65[a]	3.67±0.58[a]
Chrysophyceae	Feb	1.67±1.15[a]	2.00±1.00[a]	3.00±1.73[a]
	July	0.33±0.58[a]	0.33±0.58[a]	0.00±0.00[a]
Euglenophyceae	Feb	0.67±0.58[a]	0.67±0.58[a]	1.33±1.15[a]
	July	1.33±1.15[a]	0.33±0.58[a]	0.67±1.15[a]
Xanthophyceae	Feb	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]
	July	0.33±0.58[a]	0.33±0.58[a]	1.67±2.08[a]
Protozoa	Feb	0.33±0.58[a]	0.67±1.15[a]	0.00±0.00[a]
	July	1.33±0.58[a]	0.00±0.00[a]	1.00±1.00[a]
Cladocera	Feb	1.33±0.58[a]	1.00±1.00[a]	1.33±0.58[a]
	July	1.33±2.31[a]	0.33±0.58[a]	1.00±1.00[a]
Copepoda	Feb	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]
	July	0.33±0.58[a]	0.67±1.15[a]	0.00±0.00[a]

Means with different superscripts are significantly different at $p<0.05$.

Shannon-Weiner's index (H) (Table 4), showed the highest diversityof phytoplankton at Egbeada and the lowest at Akanchawa. For Zooplankton, the lowest species diversity was recorded at Egbeada in July, while the highest was recorded at Akanchawa in February. All sites showed similar trends in species diversitywhich was low. This is an indication that the water quality of the Nworieriver is not able to support diverse plankton species.

Table 4. Shannon-Wiener's diversity index (H) for various sampling stations along Nworie River..

Plankton taxa		Sampling Locations		
		Nworie River at Egbeada	Nworie River at Arugo park	Nworie River at Akanchawa
Phytoplankton	Feb	0.88	0.84	0.79
	July	0.87	0.86	0.84
Zooplaankton	Feb	0.92	0.87	1.00
	July	0.91	0.94	0.95

IV. Summary

Nworieriver by virtue of its location, passes through a municipal and receives a large quantity of untreated waste daily into its waters. The results of the study revealed a large amount of nutrient enrichment in the rainy season. This can be controlled through proper channeling and treatment of sewage from homes and institutions, covering drainages with slabs and the use of drainage separators to trap refuse before it is washed into the river. There is a need to carry out a long term study of the water quality taking into consideration the biotic and abiotic components to confirm if the degradation of the river is progressing. The results of the physicochemical analysis show that the river may not sustain biota if left to deteriorate further. Though most of the predominant phytoplankton species in the river are characteristic of healthy freshwater bodies, their abundance and diversity was low. Any significant change in the plankton population would also have a significant impact on the ecosystem. These indicators are signs that the river quality has been compromised and the rate of inflow of contaminants that degrade the Nworieriver is much higher than the river's rate of recovery.

The Nworie river water quality is gradually deteriorating and if the present pollution pattern continues unchecked, may deteriorate to the point where it may be unable to sustain aquatic life and would be detrimental to human health.

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Lucy Chinomso Izunobi, et. al. "Assessment of Water Quality and Plankton Taxa of Nworie River InOwerri, Southeastern Nigeria." *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 14(9), (2020): pp43-51.