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Environmental characteristics, relative abundance and diversity of phytoplankton at river Taraba at Garbabi, Nigeria

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Abstract
The purpose of this study was to explore the environmental characteristics, relative abundance and diversity of phytoplankton at River Taraba, Taraba State, Nigeria. The study was carried out for a period of eight months (August 2021 to March 2022). The phytoplankton were sampled using a plankton net with a mesh size of 55µm, towed horizontally for five meters. The data on phytoplankton species composition and abundance were analyzed using frequency counts and percentages. The ComEcolPaC program (a Microsoft Excel 2003 based tool) was used to assess the diversity indices. The average water temperature of the River was 25.375 ºC. The pH of the water was slightly basic (pH = 6.2). The water transparency was 0.730, indicating that the water was relatively clear. Dissolved oxygen levels were low, at 3.82 mg/L. Alkalinity levels were 571.8 mg/L, while conductivity was 0.002278 µm hos/cm. Thirty-four (34) species from seven (7) families were identified and distributed across the study area. They include: Bacillariophyceae, Chlorophyceae, Dinophyceae, Euglenophyceae, Zygnematophyceae, Cyanophyceae and Xanthophyceae. Bacillariophyceae (n=13) was the most prevalent in terms of number of species followed by Chlorophyceae (n=12). Euglenophyceae, Cyanophyceae and Xanthophyceae were the least dominant with (n=1) specie each. In terms of species abundance, *Volvox* sp (31.02%) was the most abundant species followed by *Spirogyra longata* (27.99%) and the least was *Bulbochaete* spp. with 0.01%.

Keywords: Relative abundance, diversity, phytoplankton, river Taraba, Garbabi, Nigeria

Introduction
The quality of any river system is dependent on the complex interactions between biotic (Living organisms) and abiotic (non-living) conditions within the river environment. These conditions determine the types of flora and fauna that inhabit the river, and the services that the river provides to the surrounding ecosystems. Therefore, understanding and protecting the quality of rivers is essential for the health of the environment and the people who rely on them [1]. These rivers are major water resources, which are very diverse both in terms of size and fisheries potential [2]. Rivers provides most of earths' freshwater resources and also provide humans with enormous benefits in both domestic and irrigational activities [3]; therefore, the need for diversity and abundance of phytoplankton, as well as the physical and chemical properties of water, are key indicators of water quality and the effects of environmental change. Multiple groups of organisms have been studied to assess water quality, including phytoplankton, macrophytes, protozoa, fish and other animals [4, 5]. The relationship between physical and chemical parameters and phytoplankton production is crucial for effective management of aquatic ecosystems. These parameters influence phytoplankton growth and diversity, which in turn can affect the health and productivity of the ecosystem as a whole [2].
According to Abdullahi *et al.*, [2], Phytoplankton are key producers of oxygen and other nutrients in aquatic ecosystems, and they are also sensitive to pollution. For these reasons, they are used as indicators of water quality and pollution levels. Phytoplankton are particularly important for assessing the impact of pollution on aquatic ecosystems because they are at the bottom of the food chain and any adverse effects on them will have cascading effects on the rest of the ecosystem. They also play a vital role in the food web by producing the energy that sustains other organisms [6]. Some phytoplankton species can release harmful substances such as neurotoxins and hepatotoxins, which can negatively impact human and animal health. Nevertheless, the quantity and quality of phytoplankton in a body of water can serve as

important indicators of water quality and productivity. Thus, it is crucial to monitor phytoplankton populations in aquatic ecosystems [7]. Therefore, Studying the composition, abundance, diversity, and relationships between phytoplankton and water parameters is essential for understanding aquatic ecosystems and their productivity. The purpose of this study was to evaluate the phytoplankton community of River Taraba at Garbabi, as well as to understand the relationship between phytoplankton and the surrounding environment.

Materials and Methods

Study Area

River Taraba is located on latitude 8°34' N and longitude 10°15' E (Fig 1). The river has its source from the high altitude of the Alantica hills on the Nigeria-Cameroon border in the mideastern part of the State and flows westwards through Mambilla Plateau of Sardauna Local Government Area of Taraba state and covering a distance of about 265km before entering the River Benue [8].

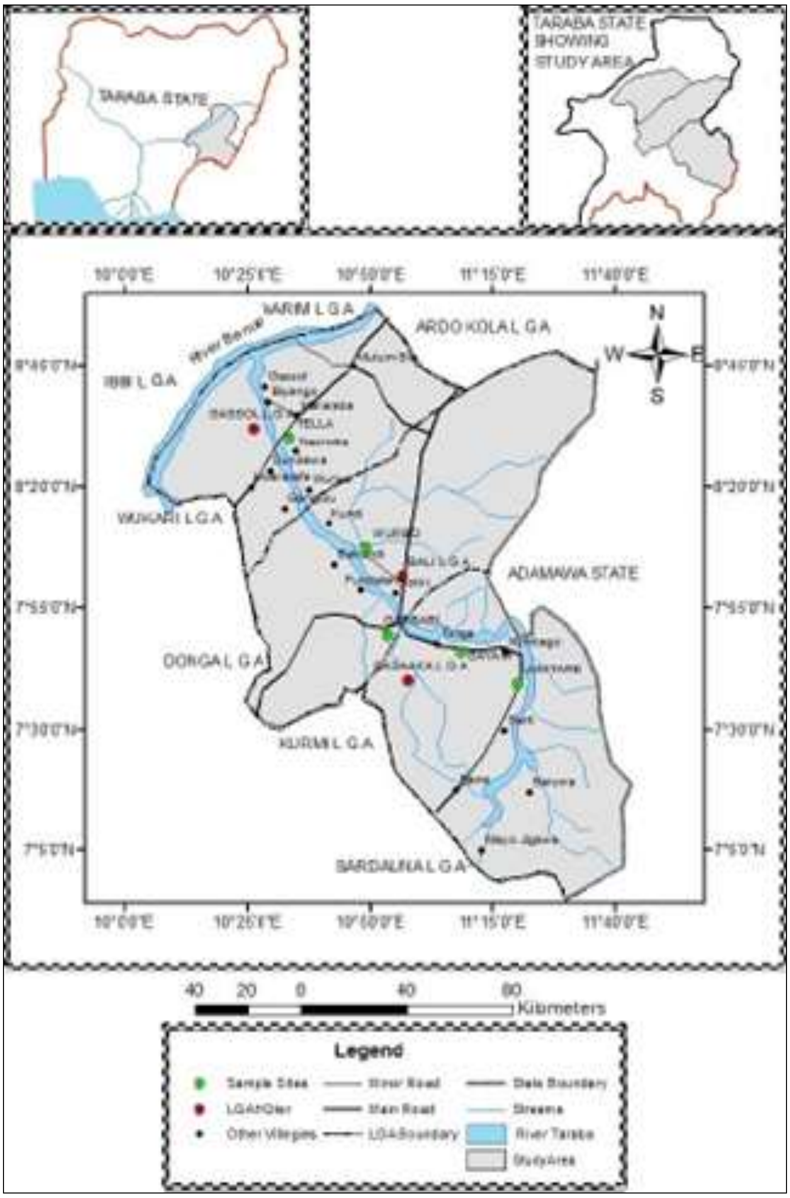

Fig 1: Location Map of the Study area

Sample Stations

The study was conducted over an 8-month period between August 2021 and March 2022, with data collected from three stations (A, B, and C) along the River Taraba in Garbabi. Station A was situated at the lower level of the river, where fishing, farming, bathing, and clothes washing activities occurred. Station B was surrounded by grazing land and characterized by activities such as irrigation farming, cattle rearing, bathing, and washing. Station C was downstream and had similar activities such as irrigation, farming, and cattle rearing.

Method of Data Collection

At each station, a plankton net with a 55-micrometer mesh size was used to collect samples by hauling it horizontally across each station for a distance of five meters, following the method described by Anene [9]. The concentrated plankton samples were transferred into plastic containers, preserved with 4% formalin and three drops of Lugol's solution, and then stored in an ice-filled cooler to prevent further biological activity. The samples were then analyzed. To identify and count the phytoplankton species, a binocular light microscope was used at 100x magnification (oil immersion). Slides were

prepared in triplicate for both qualitative and quantitative analyses, and the whole count method was used to determine the density of the phytoplankton. The Sedgwick-Rafter counting chamber was employed to count the phytoplankton [10]. The zooplankton species were identified using the Nguetsop *et al*., [11], Bellinger & Siegee [12] key, which are the standard reference for zooplankton taxonomy.
The following physical and chemical parameters were recorded on site: temperature (T), conductivity, and pH using a portable multi-parameter instrument. Other physicochemical parameters were analyzed at the Taraba State University laboratory using the APHA (American Public Health Association) standard methods [10].
Alkalinity: The alkalinity was measured using the titration method and the Gran function plot.
Ammonia: Ammonia levels were determined using the phenate method with standard colorimetric techniques.
Transparency: The transparency was determined using a Secchi disk.
BOD: The BOD was measured using the 5-day BOD incubation method, following standard procedures.

Data Analysis
The frequency counts and percentages were calculated using a Microsoft Excel 2003-based program, ComEcolPaC, which was also used to calculate species richness and diversity. Species richness measures the number of species present in a sample, while species diversity also considers the relative abundance of each species. Thus, species diversity provides a more nuanced picture of the community composition than species richness alone

D_{Ma} - Margalef Diversity Index

$$D_{Ma} = \frac{S-1}{\ln N}$$

S - Species richness,
N - Total abundance

D_{Me} – Menhinick Diversity Index

$$D_{Me} = \frac{S}{\sqrt{N}}$$

S - Species richness,
N - total abundance

D - Simpson's index

$$D = \sum_{i=1}^{s} p_i^2$$

S - Species richness, p_i - proportion of species *i*

H' - Shannon-Wiener diversity index

$$H' = \sum_{i=1}^{s} p_i \cdot \log_2 p_i$$

S - Species richness (number of species),
p_i - proportion of species *i*

E – Pielou Evenness Index

$$E = \frac{H'}{H_{\max}}$$

Results
Table 1 and Figure 2 – 9 shows the physical and chemical parameters at the River from August 2021 to March 2022. The mean water temperature was 25.375 °C, and the pH was 6.2, indicating slightly alkaline conditions. The transparency of the water was 0.730, and the dissolved oxygen level was 3.82 mg/L. The alkalinity was 571.8 mg/L, the conductivity was 438.84 µm hos/cm, and the ammonia and CO2 levels were 0.032 mg/L and 5.20 mg/L, respectively.
Table 2 showed thirty-four (34) species from seven (7) families were identified and distributed across the study area. They include: Bacillariophyceae, Chlorophyceae, Dinophyceae, Euglenophyceae, Zygnematophyceae, Cyanophyceae and Xanthophyceae. Bacillariophyceae (n=13) was the most dominant in terms of number of species followed by Chlorophyceae (n=12). Euglenophyceae, Cyanophyceae and Xanthophyceae were the least dominant with (n=1) specie each. In the context of species abundance, the most prevalent species was *Volvox* sp, accounting for 31.02% of the total. Following closely was *Spirogyra longata*, making up 27.99% of the species distribution. On the other hand, the least abundant species was *Bulbochaete* spp., comprising only 0.01% of the overall population.
Table 3 of the study revealed the Spatial Variation in the Diversity indices of the study.

Table 1: The mean, standard error of the physico-chemical parameters of River Taraba at Garbabi

Station	Means of physicochemical parameters							
	Alkalinity (mg/L)	**Ammonia (mg/L)**	**CO_2 (mg/L)**	**D.O (mg/L)**	**Ph**	**Temperature (°C)**	**Transparency (NTU)**	**Conductivity** µmhos/**cm**
A	566.3^a	0.0203^a	4.02^a	3.9625^a	6.2275^a	25.375^a	0.9050^a	504.79^a
B	571.8^a	0.0320^a	5.20^a	3.7875^a	5.9187^a	25.625^a	0.3900^b	438.84^a
C	689.6 ^{a}	0.0339^a	9.24^a	3.8250^a	5.9012^a	25.625^a	0.7300^{ab}	429.63^a
WHO	-	-	-	5.00	6.5 – 8.5	25	5.00	50 – 1500
USEPA	-	-	-	-	6.5 – 8.5	-	-	300
SE $\pm$	86.02	7.359	4.054	0.2087	0.2062	0.5428	0.1654	52.561

*abcd values with the same letter in a column were not significantly different at the P<0.05 level (One-way ANOVA and Tukey's HSD test)
*WHO: World Health Organization (2006)
*USEPA: United States Environmental Protection Agency (2017)

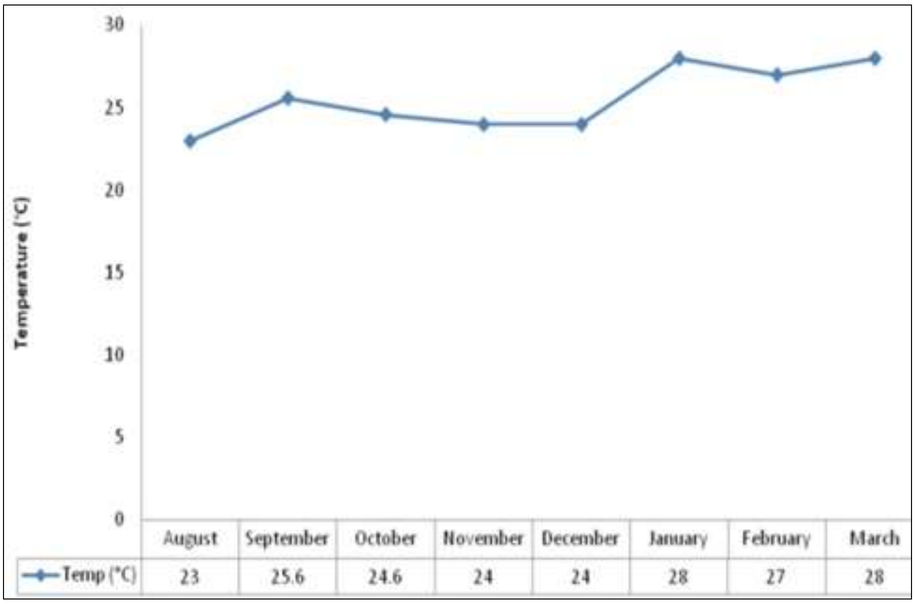

Fig 2: Monthly variation in levels of Temperature at River Taraba at Garbabi (Aug 2021 – March 2022

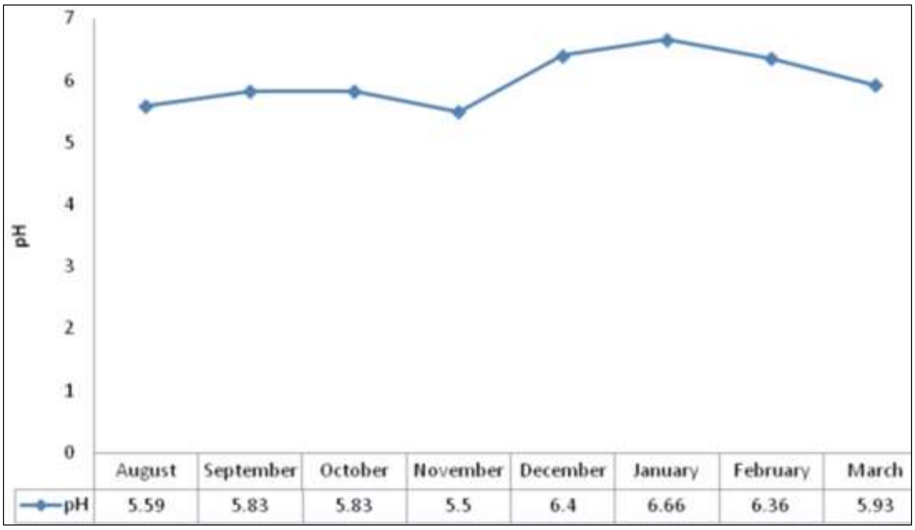

Fig 3: Monthly variation in levels of pH at River Taraba at Garbabi (Aug 2021 – March 2022

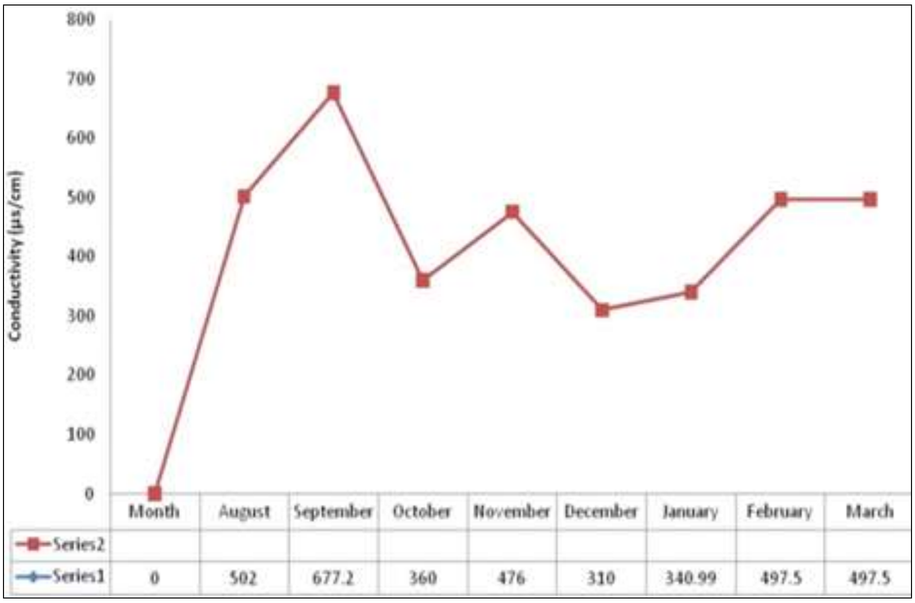

Fig 4: Monthly variation in levels of Conductivity at River Taraba at Garbabi (Aug 2021 – March 2022

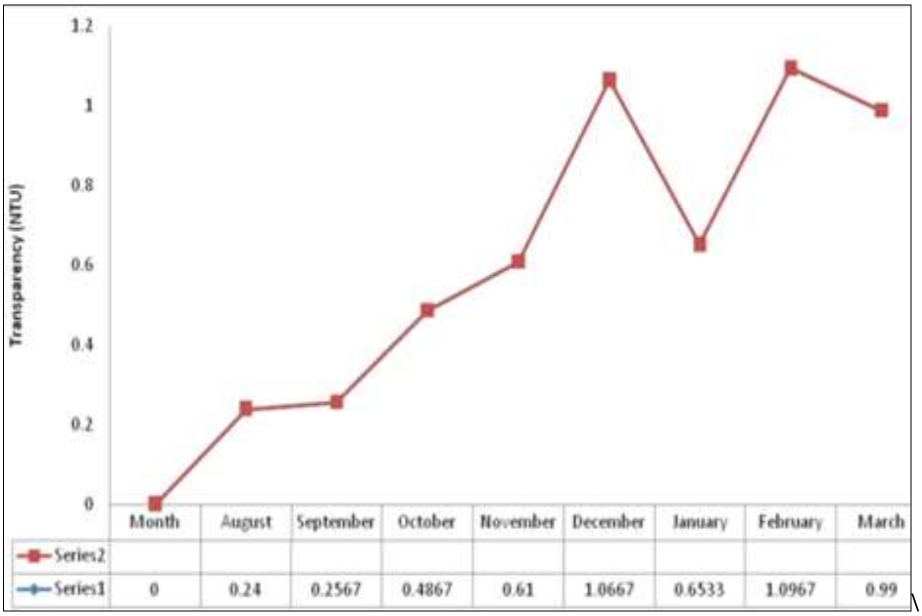

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Fig 5: Monthly variation in levels of Transparency at River Taraba at Garbabi (Aug 2021 – March 2022

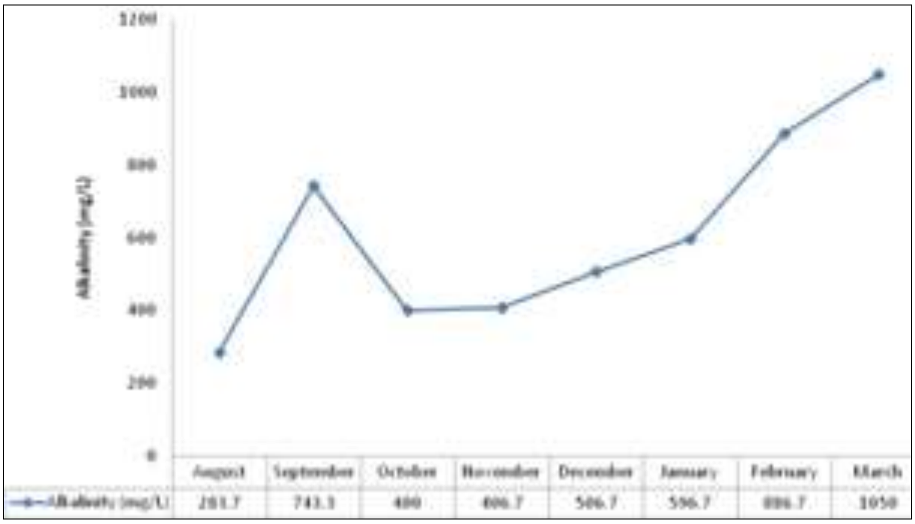

Fig 6: Monthly variation in levels of Alkalinity at River Taraba at Garbabi (Aug 2021 – March 2022

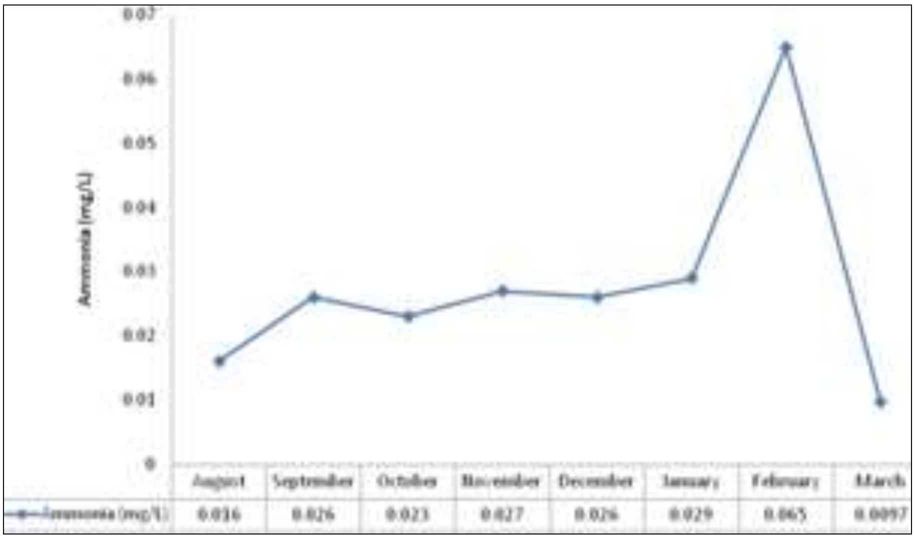

Fig 7: Monthly variation in levels of Ammonia at River Taraba at Garbabi (Aug 2021 – March 2022

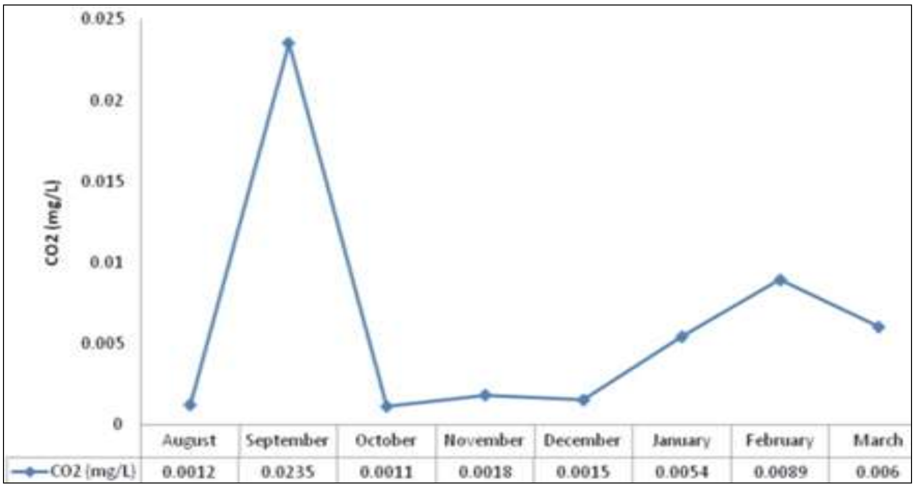

Fig 8: Monthly variation in levels of CO_2 at River Taraba at Garbabi (Aug 2021 – March 2022

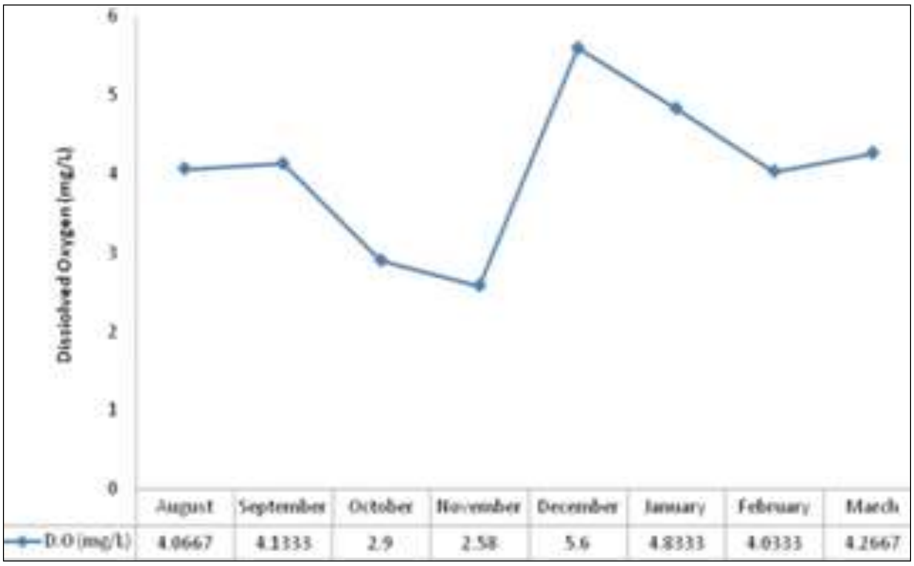

Fig 9:
Monthly variation in levels of D.O at River Taraba at Garbabi (Aug 2021 – March 2022

Table 2: Species Composition and Abundance of Phytoplankton from River Taraba at Garbabi

Taxa	Specie	Abundance	Percentage abundance
Bacillariophyceae	*Asterionella* spp.	15	0.09
	Asterionellopsis glacialis	04	0.03
	Bacillaria spp.	86	0.54
	Guinardia striata	24	0.15
	Gyrosigma acuminatum	51	0.32
	Licmophora ehrenbergii	06	0.04
	Meridion spp.	06	0.04
	Pennales centric	21	0.13
	Fragilaria spp.	24	0.15
	Rhizosolenia imbricate	04	0.03
	Pleurosigma spp.	05	0.03
	Tabellaria spp.	05	0.03
	Surirella ovalis	29	0.18
Chlorophyceae	*Bulbochaete* spp.	02	0.01
	Cosmarium spp.	138	0.87
	Hydrodictyon spp.	349	2.21
	Micrasterias jenner	128	0.81
	Chlamydomonas spp.	06	0.04
	Netrium spp.	08	0.05
	Pediastrum spp.	1309	8.28
	Rhizoclonium spp.	22	0.14
	Ulothrix spp.	21	0.13
	Volvox spp.	4902	31.02

	Scenedesmus spp.	557	3.52
	Spirogyra longata	4424	27.99
Dinophyceae	*Prorocentrum micans*	06	0.04
	Noctiluca scintillan	05	0.03
	Protoperidinium excentricum	07	0.04
	Protoperidinium obtusum	33	0.21
Euglenophyceae	*Euglena gracilis*	31	0.20
Zygnematophyceae	*Mougeotia* spp	2779	17.58
	Zygnema spp.	523	3.31
Cyanophyceae	*Microcystis* spp.	230	1.46
Xanthophyceae	*Vaucheria* spp.	45	0.28
			100.00

Table 3: Spatial Variation in Diversity indices of Phytoplankton population across the study stations

Stations	Richness indices		Diversity indices		Evenness indices
	Margalef (DMa)	**Menhinick (DMe)**	**Simpson (D)**	**Shannon-Wiener (H')**	**Pielou (J)**
A	3.420824	0.386385	0.331374	2.067018	0.409397
B	3.667505	0.575541	0.159385	3.011427	0.602612
C	3.180906	0.355594	0.238863	2.545285	0.518034

Discussion

The temperature range observed in this study was similar to the range reported by Usman *et al.*, [13] in Taraba River; Abdullahi *et al.*, [2] in Kanye Dam, Kano; Adelakun *et al.*, [6] in Jebba River Basin, Niger State. These results fall within the range of tropical temperatures [14]. He pH values ranged from 5.30 to 6.20 and were within the range recommended by the World Health Organization, WHO [15]. The pH values were within the WHO standards and showed a significant positive correlation with conductivity. The river water is slightly acidic and slightly alkaline, which is optimal for aquatic organisms including fish [6, 13, 15, 16]. Low transparency (NTU) levels were observed in September due to increased rainfall, leading to high turbidity. High turbidity reduces light penetration, which in turn decreases photosynthesis and primary productivity [10, 16]. High transparency was observed in December due to dry conditions, which allowed more light penetration and increased photosynthesis and primary productivity. This is consistent with the findings of Usman *et al.*, [13]; Fonge *et al.*, [15] and Adeyemi [16]. The dissolved oxygen content of the river water fell within the range of 3.76 to 3.96 mg/L, which is consistent with the findings of Usman *et al.*, [13] in Taraba River; Adeyemi [16] in Ajeko stream, Northern Nigeria; Indabawa and Abdullahi [2] in River Hadejia, Jigawa State, Nigeria and Adeyemi *et al.*, [17] in Gbedikere Lake, Kogi State, Nigeria.

The abundance of phytoplankton in River Taraba varied with the seasons and locations. Seasonal fluctuations in phytoplankton community structure are related to water circulation dynamics, nutrient concentrations, rainfall patterns, and local conditions. In tropical areas, these factors fluctuate with the dry and wet seasons [15]. The study recorded Bacillariophyceae (n=13) was the most dominant in terms of number of species followed by Chlorophyceae (n=12). This study corroborates the findings of Adeyemi [16] who conducted similar research in Ajeko Stream, Iyale, North Central Nigeria and find out that Bacillariophyceae and Chlorophyceae are the dominant species in the study area. Furthermore, Arimoro *et al*., [18] reported that in the Orogodo river in Nigeria, phytoplankton was in the order of Bacillariophyceae > Chlorophyceae > Cyanophyceae > Euglenophyceae. Bellinger and Siegee [12] reported that diatom (bacillariophyta) abundance is a characteristic feature of a eutrophic environment. Brraich and Kaur [19]; Tiwari and Chauhan [20]; Balasingh *et al.*, [21]; and Fonge *et al*., [15] reported that Diatoms are considered major indicators of water quality and environmental conditions, as they are well-adapted to a wide range of physical and chemical parameters. Their abundance in an aquatic ecosystem is influenced by high levels of sunlight, constant water temperature, and a large catchment area [22]. The abundance of phytoplankton in a river system increases with increased transparency, which typically occurs during the dry season (black flood). In contrast, high turbidity during the wet season (white flood) results in a decrease in phytoplankton abundance [22]. In the case of the River Taraba at Garbabi, *Asterionellopsis glacialis, Rhizosolenia imbricate, Pleurosigma* spp, *Tabellaria* spp, *Noctiluca scintillan and Bulbochaete* spp were the least abundant species. According to Reynolds [23], the growth of some species of phytoplankton is unlikely to be constrained by nitrogen availability

Table 3 of the study revealed the Spatial Variation in the Diversity indices of the study. The species richness were determined using Margalef Diversity Index (DMa) with range of 3.180906 – 3.667505 and Menhinick Diversity Index (DMe) ranged from 0.355594 - 0.386385 across the River. Diversity index was determined using the Simpson's Diversity Index (D) ranged between 0.159385 - 0.331274 and Shannon Weiner Diversity Index (H^{I}) ranged between 2.067018-3.011427 while the Evenness index was determined using the Pielou index (J) ranged between 0.409397 – 0.602612. Menhinick's and Margalef's indices provide information on the richness of species in an ecosystem. In the present study, the minimum species richness was 0.35 and the maximum was 0.38, which is consistent with the findings of Brraich and Kaur [19] who found out a similar result. The Simpson index is used to quantify the biodiversity of habitats by considering the number of species present and the relative abundance of each species. A higher value indicates greater biodiversity in the sample [23]. The Simpson index values (ranging from 0.15 to 0.33) in the study area indicate that species are evenly distributed. The Shannon-Weiner index (H′) reflects both species richness and evenness, with higher values indicating greater species diversity. This result conforms to the study conducted by Adelakun *et al.*, [6]; Brraich and Kaur, [19]; Azma & Siti [24]; Frutos *et al*., [25].

Conclusion

In conclusion, the study aimed to assess the environmental characteristics, relative abundance, and diversity of phytoplankton in the River Taraba at Garbabi, Nigeria. The results of the study revealed that the phytoplankton community was diverse, with a total of 34 species belonging to seven different classes. The river's environmental conditions, including water temperature, pH, and dissolved oxygen levels, were found to be within the optimal range for phytoplankton growth. The study also found that the abundance and diversity of phytoplankton in the river were influenced by various environmental factors, including water temperature, dissolved oxygen, phosphate, nitrate, and ammonia. Higher water temperature and phosphate levels were associated with higher phytoplankton abundance and diversity, while nitrate and ammonia levels had the opposite effect. Overall, the study found that the River Taraba at Garbabi provides a healthy habitat for phytoplankton, and that the abundance and diversity of these organisms is closely related to the environmental conditions of the river.

References

1. Gupta A, Rai DK, Pandey RS, Bechan S. Analysis of some heavy metals in the riverine water, sediments and fish from river Ganges at Allahabad. Environmental Monitoring and Assessment. 2009;157:449. https://doi.org/10.1007/s10661-008- 0547-4
2. Abdullahi Y, Mustapha Y, Indabawa II, Sindama A. The Relative Abundance, Distribution and Species Diversity of Phytoplanktons in Kanye Dam in Kano, North western-Nigeria. IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT). 2017;11(4):20-31.
3. Dirican S. Assessment of water quality using physico-chemical parameters of Çamlıgöze Dam Lake in Sivas, Turkey. Ecologia. 2015;5:1-7.
4. Spaak P, Bauchrowitz R, Eawag M. Swiss Federal Institute of Aquatic Science and Technology. 2010;69e:25-27.
5. Ogbuagu DH, Ayoade AA, Chukwuocha NBAC. Spatial dynamics in physicochemistry and bacterio and myco-plankton assemblages of Imo River in a Niger Delta community in Nigeria. African J Microbil. Resear. 2011;5(8):872-887.
6. Adelakun KM, Mu'azu MM, Amali RP, Omotayo OL. Diversity of Phytoplankton Communities in a Tropical River Basin, Nigeria. HYDRO NEPAL. 2016;19;52-56.
7. Sigee DC. Freshwater Microbiology: Diversity and Dynamic Interactions of Microorganisms in the Aquatic environment. Chichester, UK, John Wiley & Sons; c2004. p. 524.
8. Danba EP, Ja'afaru A, Abubakar KA, Zira JD, Kefas M, Barau BW, *et al*. Fish Biodiversity and Abundance In River Taraba, Taraba State, Nigeria. Ethiopian Journal of Environmental Studies & Management. 2020;13(5):535-544.
9. Anene A. Techniques in Hydrobiology. In: Eugene, N.O. and O.O. Julian, (Eds.), Research Techniques in Biological and Chemical Sciences. Springfield Publishers; c2003. p. 174-189.
10. American Public Health Association, APHA. Manual of Standard Methods for Examination of Water and Waste. 14th Edition, Washington DC; c2005. p. 121-132.
11. Nguetsop VF, Fonko UT, Assah VMD, Nangtson MN, Pinta JY. Relationships between algae taxa and physicochemical characteristics of water in wetlands and water bodies. Cameroon. J Exp. Biol. 2007;3(2):70-79.
12. Bellinger GE, Siegee DC. Fresh Water Algae: Identification and Use as Bio-indicators. First edition, John Wiley and Sons, Ltd; c2010; p. 271.
13. Usman B, Bingari MS, Peter DD, Vandi S. Survey of Zooplankton Diversity and Abundance and its Relationship with Physicochemical Parameters in River Taraba, Takum, Taraba State, Nigeria. International Research Journal of Natural Sciences. 2019;7(1):1-13.
14. Alabaster JS, Downing AL. A Field and Laboratory Investigation of Heated Effluents on Fish. Fish Invest. Ministry. Agric. Fish Food, (UK). 1966;6:42.
15. Fonge BA, Tening AS, Egbe EA, Yinda GS, Fongod AN, Achu RM, *et al*. Phytoplankton diversity and abundance in Ndop wetland plain, Cameroon. African Journal of Environmental Science and Technology. 2012;6(6):247-257.
16. Adeyemi, SO. Preliminary Census of Zooplanktons and Phytoplanktons Community of Ajeko Stream, Iyale, North Central Nigeria. Animal Research International. 2012;9(3):1638-1644.
17. Adeyemi SO, Adikwu IA, Akombu PM, Iyela JT. Survey of zooplanktons and macroinvertebrates of Gbedikere Lake, Bassa, Kogi State, Nigeria. International Journal of Lakes and Rivers. 2009b;1:55-62.
18. Arimoro FO, Noyo EE, Amaka RO. Phytoplankton community responses in a perturbed tropical streams in the Niger Delta, Nigeria. Trop. Freshwater Biol. 2008;17:37-52.
19. Brraich OS, Kaur R. Phytoplankton Community Structure and Species Diversity of Nangal Wetland, Punjab, India. International Research Journal of Biological Sciences. 2015;4(3):76-83.
20. Tiwari A, Chauhan SVS. Seasonal phytoplankton diversity of Kitham Lake, Agra, J Environ. Biol. 2006;27:35-38.
21. Balasingh GR, Shamal VPS. Phytoplankton diversity of a perennial pond in Kanyakumari District, J. Basic Appl. Biol. 2007;1:23-26.
22. Adeniyi HA. Diurnal vertical distribution of zooplankton during stratification in Kainji Lake, Nigeria. Int. J. Limnol. 2017;20:1677-1689.
23. Reynolds CS. Ecology of Phytoplankton. Cambridge University Press, Cambridge; c2006 p. 535.
24. Azma HI, Siti AZ. A comparative study of zooplankton diversity and abundance from three different types of water body. 2nd International Conference on Agriculture, Environment and Biological Sciences (ICAEBS'15), Bali (Indonesia); c2015. p. 12-18.
25. Frutos SM, Poi de Neiff AS, Neiff G. Zooplankton abundance and species diversity in two lakes with different trophic states (Corrientes, Argentina)," Acta Limnol. Bras. 2009;21(3):367-375.