Asian Journal of Fisheries and Aquatic Research

4(1): 1-7, 2019; Article no.AJFAR.49915

Phytoplankton Diversity and Abundance in Lake Ribadu, Adamawa State, Nigeria

E. I. Hassan[1], R. Bonjoru[2*] and V. R. Ndeham[3]

[1]Department of Zoology, Modibbo Adama University of Technology, P.M.B 2076, Yola, Adamawa State, Nigeria.
[2]Department of Biology, College of Education, P.M.B 1021, Zing, Taraba State, Nigeria.
[3]Department of Fisheries, Federal Polytechnic, Mubi, Adamawa State, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author EIH designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author RB managed the analyses of the study. Author VRN managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJFAR/2019/v4i130044
Editor(s):
(1) Dr. Telat Yanik, Professor, Department of Aquaculture, Faculty of Fisheries, Atatürk University, Turkey.
Reviewers:
(1) Yapo Michel Laurince, Université Peleforo Gon Coulibaly, Côte d'Ivoire.
(2) Sophia Barinova, University of Haifa, Israel.
(3) Dodo Juliet Dingtsen, University of Jos, Nigeria.
Complete Peer review History: http://www.sdiarticle3.com/review-history/49915

Original Research Article

Received 15 June 2019
Accepted 03 August 2019
Published 13 August 2019

ABSTRACT

This study was carried out to look at the phytoplankton diversity and abundance in Lake Ribadu, Fufore Local Government Area, Adamawa State, Nigeria. The study was carried out for a period of 6 months (July to December 2016). Phytoplanktons sampling was carried out by using the plankton net of mesh size 55µm by hauling horizontally for five meters. Frequency counts, percentages were used to analyzing the phytoplankton species composition and abundance while ComEcolPaC (a Microsoft Excel 2003 based program) was used to analyze the variation in the diversity indices. A total of Twenty one (21) species were observed in the study sites. *Bacillariophyceae* recorded the highest with the percentage abundance of 37.8% followed by *Chlorophyceae* with 35.12%, *Myxophyceae* with 25.82% while *Chrysophyceae* with 1.53% is the least abundant. The study recommends that Monitoring of the lake by the immediate community and regulation of all anthropogenic activities should be given topmost priority as part of the environmental management policy for the sustainability of aquatic resources of the lake.

**Corresponding author: Email: bonjoru13@gmail.com;*

Keywords: Diversity; abundance; phytoplankton; lakes; Ribadu.

1. INTRODUCTION

Lakes are a very important part of our natural heritage, they have widely been utilized by mankind over the centuries to the extent that very few, if not many are now in a natural condition [1,2]. Lakes and wetlands are dynamic ecosystems, continually undergoing natural changes due to infilling with sediments and nutrient subsidence and a rise in water levels during heavy floods. They sustain all life forms and perform some useful functions in the maintenance of the overall balance of nature. Subsequently, it was observed that rapid urbanization, burgeoning human population and their various activities have contributed to the decline of the quality and quantity of these lakes [3]. Change in the area (habitat loss), change in water regime, change in water quality, unsustainable exploitation of lake resources, interaction of alien species, Intensive farming practices along the lake plains causes changes in the lake soils, hydrology, vegetation condition and dynamics of the lakes or wetlands [3,4].

The maintenance of a healthy aquatic ecosystem is dependent on the quality of water and its biological diversity [5]. Ja'afaru et al. [6] pointed out that the productivity of an aquatic ecosystem is dependent on its physicochemical parameters and plankton diversity and distribution of the water. Physico-chemical parameters have been reported as one of the sources of the variations in species composition, abundance, diversity and distribution of plankton [7]. The phytoplankton is an important water quality indicator due to their shorter life spans combined with their different tolerance levels towards physicochemical parameters [8]. Research has also shown that phytoplankton species have different tolerance limits towards the physicochemical parameters. Hence, it is imperative to focus on the preservation of these endangered habitats to achieve ecological sustainability. Therefore, the present study aimed at assessing some physicochemical parameters and its relationship with the abundance of phytoplankton in Lake Ribadu. Furthermore, the knowledge of phytoplankton distribution with reference to the spatial pattern is important to determine the status of the ecosystem structure and functioning.

2. MATERIALS AND METHODS

2.1 Study Area

Lake Ribadu is located in Ribadu village of Fufore Local Government Area, Adamawa State, Nigeria. As shown in Fig. 1, Lake Ribadu is a perennial lake situated in latitude 9.12 – 16.51 N and longitude 12.28 – 12.43 E [9]. Lake Ribadu is a wet flood plain adjacent to the Upper Benue River Basin.

2.2 Methods of Data Collection

The samples were collected once every month from Lake Ribadu during morning hours of 7:00 am – 8:00 am for a period of six months (July – December 2016). The study area was categorized into three stations: A, B and C. Station A was located at the shore of the lake where human activities, like bathing, washing and other domestic activities are taking place. Station B was located in the middle of the lake where there are less human activities. Station C was located at the downstream of the lake where irrigation is the major activity. Plankton sampling was carried out by using the plankton net of mesh size 55µm by hauling horizontally for five meters according to the method. Filtered water samples were stored in the sample bottle and then preserved with Lugol's iodine solution of 10%. Identification of the phytoplankton species was according to Botes [10]; Emi and Andy [11].

2.3 Statistical Analysis

Frequency counts, Percentages and ComEcolPaC, a Microsoft Excel 2003 based program was used to calculate: Species richness and species diversity.

Phytoplankton Specie richness seeks to ascertain the number of species per sample while species diversity seeks to provides more information about community composition than simply species richness (i.e., the number of species present); they also take the relative abundances of different species into account.

2.3.1 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 - The proportion of species *i*

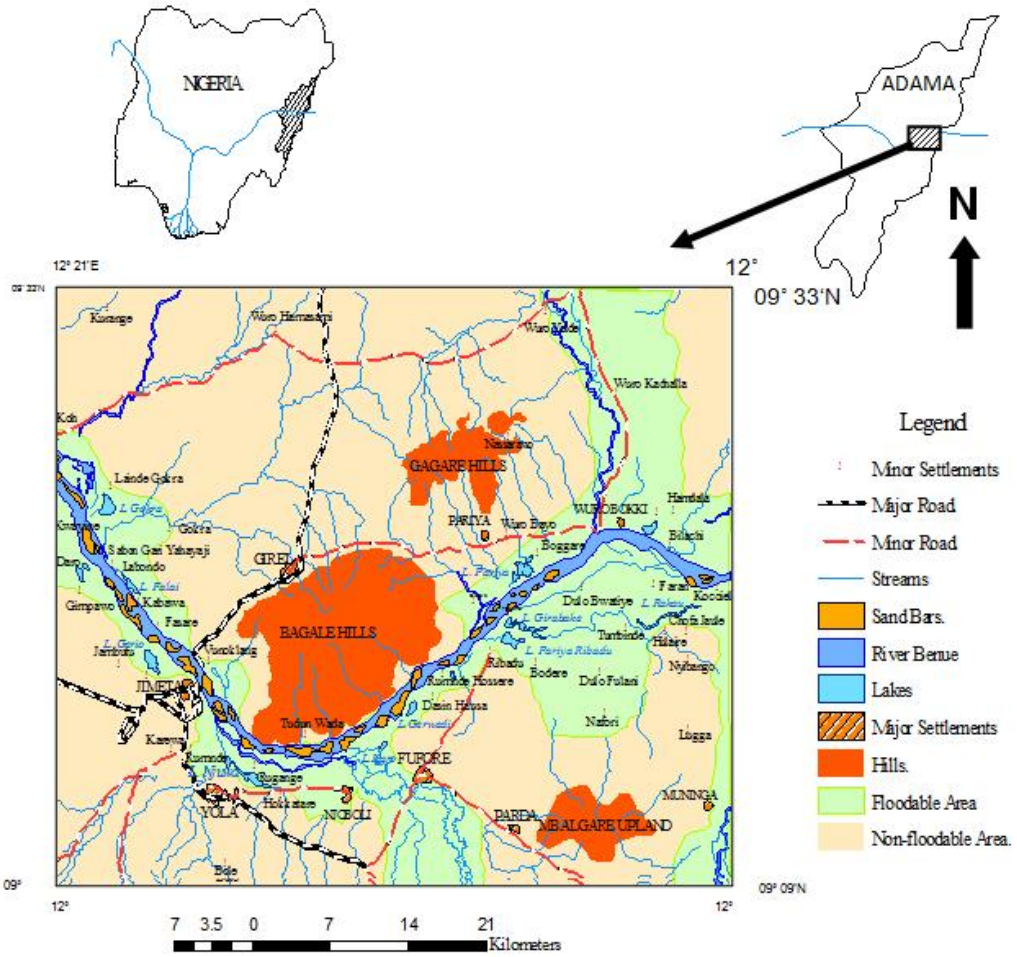

Fig. 1. Map of Fufore LGA showing the study area (Lake Ribadu)

2.3.2 E – Pielou evenness index

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

2.3.3 D - Simpson's index

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

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

2.3.4 D_{Ma} - Margalef diversity index

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

S - Species richness,

N - Total abundance

2.3.5 D_{Me} – Menhinick diversity index

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

S - Species richness,

N - Total abundance

3. RESULTS

At the end of the six-month-long survey, four families (*Bacillariophyceae, Chlorophyceae, Chrysophyceae,* and *Myxophyceae*) comprising of 21 phytoplankton species were identified. *Flagilaria* recorded the highest with the percentage abundance of 28.8% followed by

Ankistrodesmus with 22.54%, *Aphanocapsa* with 20.01% while *Synuva* with 0.05% is the least abundant (Table 1).

Tables 2 and 3 of the study revealed the Shannon-Wiener Diversity Index (H') and the Spatial Variation in the Diversity indices of the study.

4. DISCUSSION

Seasonal variation of phytoplankton community structure is generally understood to be driven by the water circulation dynamics, nutrient concentrations, rainfall patterns, location and the nature of the physical environment which varies mainly in accordance to the dry and wet periods in the tropical waters [3, 12]. A higher number of *Flagilaria* (28.8%), *Ankistrodesmus* (22.54%) was observed during the research period that lasted for six months (July-December, 2016). A total number of twenty-one (21) species of phytoplankton were identified during the study period. Generally, plankton species composition was similar in all three sites. This is similar with the findings of Mohammed *et al.,* [13], Anago *et al.,* [14] who reported phytoplankton and zooplankton abundance in a study of phytoplankton diversity from Koil Coastal waters India and Awba Reservoir Ibadan Nigeria respectively. Furthermore, a study conducted by Fonge *et al.,* [3] on Phytoplankton diversity and abundance in Ndop wetland plain, Cameroon showed a high diversity of phytoplankton in study areas. The high abundance of the phytoplankton in Station A may be attributed to the anthropogenic activities in the station. The findings agree with Fonge *et al.* [3] who pointed out that the high abundance of phytoplankton species may also be due to the constant addition of nutrient particularly through nitrate and phosphate fertilizers used close to the station.

Table 2 and 3 of the study revealed the Shannon-Wiener Diversity Index (H') and the Spatial Variation in the Diversity indices of the study. The Shannon-Wiener Diversity Index (H') ranged between 2.59 – 3.12 across the three study sites while the spatial variation in diversity indices of fish population across the three study sites are: Pielou Evenness Index (E) ranged between 0.70 - 0.74; Simpson's Diversity Index (D) ranged between 0.16 - 0.21; Others indices recorded included Margalef Diversity Index (DMa) with the range of 1.00 - 1.41 and Menhinick Diversity Index (DMe) ranged from 0.03 - 0.04. Species richness, diversity and evenness were observed to increase in all sites. This may be attributed to increased living space leading to an increased number of microhabitats. The study agrees with the findings of Azma [15] who shows that a Simpson Index value of 0.83 - 0.93 indicates that the communities are mature and stable as the dominance is shared by a large

Table 1. Species composition and abundance of phytoplankton in Lake Ribadu

Species	Total abundance	% Abundance
Flagilaria	124896	28.80
Tabellaria sp.	15235	3.51
Naviculales	4200	0.96
Nituschia	2456	0.56
Cyclotella	15896	3.66
Ankistrodesmus	97791	22.54
Chlorella	18741	4.32
Ulothrix	7358	1.69
Enteromorpha	1035	0.23
Closterium	5825	1.34
Eudorina	1053	0.24
Oocystis	13159	3.03
Zugrema	1579	0.36
Microspora	5791	1.33
Aphanocapsa	86801	20.01
Anabaena	14959	3.44
Oscillatoria	1594	0.36
Aphanizomenon	8637	1.99
Mallomonas	6415	1.47
Synuva	256	0.05
	433677	100

Table 2. Shannon-wiener diversity index of the phytoplankton species from the study sites

Specie	Site A				Site B				Site C			
	N	Pi	LnPi	PiLnPi	N	Pi	LnPi	PiLnPi	N	Pi	LnPi	PiLnPi
Flagilaria	40945	0.26	-1.36	-0.35	45067	0.31	-1.18	-0.36	38884	0.30	-1.19	-0.36
Tabellaria spp	11025	0.07	-2.67	-0.18	1578	0.01	-4.53	-0.05	2632	0.02	-3.89	-0.08
Naviculales	1568	0.01	-4.62	-0.05	526	0.00	-5.63	-0.02	2106	0.02	-4.11	-0.07
Nituschia	1831	0.01	-4.47	-0.05	625	0.00	-5.45	-0.02	-			
Cyclotella	4843	0.03	-3.49	-0.11	7368	0.05	-2.99	-0.15	3685	0.03	-3.55	-0.10
Ankistrodesmus	37516	0.24	-1.45	-0.34	35268	0.24	-1.42	-0.34	25007	0.20	-1.63	-0.32
Chlorella	7637	0.05	-3.04	-0.15	3826	0.03	-3.64	-0.10	7278	0.06	-2.87	-0.16
Ulothrix	6305	0.04	-3.23	-0.13	-	-	-	-	1053	0.01	-4.80	-0.04
Enteromorpha	-	-	-	-	-	-	-	-	1035	0.01	-4.82	-0.04
Closterium	3685	0.02	-3.77	-0.09	1088	0.01	-4.90	-0.04	1052	0.01	-4.80	-0.04
Eudorina	1053	0.01	-5.02	-0.03	-	-	-		-	-	-	-
Oocystis	4737	0.03	-3.52	-0.10	4211	0.03	-3.55	-0.10	4211	0.03	-3.42	-0.11
Zugrema	-	-	-	-	-				1579	0.01	-4.40	-0.05
Microspora	2106	0.01	-4.33	-0.06	2106	0.01	-4.24	-0.06	1579	0.01	-4.40	-0.05
Aphanocapsa	27509	0.17	-1.76	-0.30	35263	0.24	-1.42	-0.34	24029	0.19	-1.67	-0.31
Anabaena	4063	0.03	-3.67	-0.09	6317	0.04	-3.14	-0.14	4579	0.04	-3.33	-0.12
Oscillatoria	562	0.00	-5.65	-0.02	-	-	-	-	1032	0.01	-4.82	-0.04
Aphanizomenon	1795	0.01	-4.49	-0.05	-	-	-	-	6842	0.05	-2.93	-0.16
Mallomonas	2106	0.01	-4.33	-0.06	2730	0.02	-3.98	-0.07	1579	0.01	-4.40	-0.05
Synuva	256	0.00	-6.43	-0.01	-	-	-	-	-	-	-	-
	159542	1.00		3.12	145973	1.00		2.59	128162	1.00		3.04

Table 3. Spatial variation in diversity indices of phytoplankton population across the study sites

	Site		
	A	B	C
Shannon-Wiener Diversity Index (H')	3.12	2.59	3.04
Pielou Evenness Index (E)	0.74	0.70	0.74
Simpson's Density Index (D)	0.16	0.21	0.17
Margalef Density Index (DMa)	1.41	1.00	1.36
Menhinick Density Index (DMe)	0.04	0.03	0.04

number of species. The Pielou index values which are more than 0.5 indicated that the zooplankton community is balance during the study period. According to Azma [15] and Frutos *et al*., [16] pointed out that if the Pielou Index values are less than 0.5, it could be an indicator of the presence of ecological stress.

5. CONCLUSION

Phytoplankton diversity and abundance were influenced by season and by space. Thus, phytoplankton abundance and distribution were closely associated with environmental conditions. Hence further studies should be made to evaluate the physicochemical and phytoplankton abundance and composition in different parts of the water throughout the year.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/49915