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Research Article

Phytoplankton Abundance, Distribution and Diversity in Upper River Benue, Adamawa State, Nigeria

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Abstract

Phytoplankton Abundance, Distribution and Diversity of Upper River Benue were examined between January and June. Biological conditions of Upper River Benue were assessed at five selected sites on monthly basis between 6:00 – 10:00a.m. Water Samples were taken using standard procedure for the analysis of phytoplankton. A total of 1,803 organisms were recorded for phytoplankton abundance. Chlorophyceae was observed to have a total abundance of 34.28%, followed by Cyanophyceae contributed a total of 31.54%, while the least was Rhodophyceae that gave 4.93%. The number of taxa (19) was recorded across the sites. The abundance of individuals was highest at site V. Nineteen (19) species of phytoplankton were identified during the study period ranging from seven Chlorophyceae, five Cyanophyceae, four Bacillariophyceae, two Euglenophyceae and one Rhodophyceae. The order of dominance of the phytoplankton in Upper River Benue was Chlorophyceae > Cyanophyceae>Bacillariophyceae>Euglenophyceae>Rhodophyceae respectively with Oscillatoria splendid being the most dominant (8.54%) of the total phytoplankton in Upper River Benue. The study showed that the river was eutrophic with high ecological with diverse assemblages of phytoplankton. It was recommended that there should be continuous monitoring of the biological of the river to ascertain the long-term impact of anthropogenic inputs to take remedial measures so as to ensure the health of aquatic life.

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Introduction

Biological assessment is a useful alternative for assessing the ecological quality of aquatic ecosystems because biological communities integrate the environmental effects of river water and lakes [1]. To assess water quality and the impact of environmental change, many groups of organisms have been studied, including algae, macrophytes, protozoa, fish and other animals [2,3]. Phytoplanktons are the primary producers forming the first trophic level in the food chain [4,5]. According to [6], based on the distribution pattern of the phytoplankton the water quality of the environment can be assessed. Drinking water supply, recreational activities and fisheries can be impaired by high phytoplankton biomass [6]. Phytoplankton populations are highly dynamic and in many environments, they experience episodes of rapid biomass increase (blooms), often due to the recurrent changes of the environmental variables [7]. Phytoplankton has long been used as effective bioindicators of eutrophic water that is sensitive to environmental changes [8]. The rate of production of phytoplankton is determined by a host of environmental parameters like physicochemical properties of water and soil, meteorological characteristics of the region and hydrographic features of the water body [9]. According to [5], the distribution, abundance, species diversity and composition of the phytoplankton are used to assess the biological integrity of a water body. The present study aimed at assessing the Phytoplankton Abundance, Distribution and Diversity of Upper River Benue.

Materials and Methods

Study area

Adamawa State is located at the North Eastern part of Nigeria. It lies between latitude 7° and 11° N of the equator and between longitude 11° and 14° E of the Greenwich meridian. It has an altitude of 185.9 and covers a land area of about 38,741 km. It shares boundary with Taraba State in the south and west, Gombe state in its northwest and Borno state to the north. Adamawa state has an international boundary with Cameroon Republic along its Eastern border. The Benue which is the major river in the state rises from the highlands of Cameroon and flows south- ward to join the River Niger at Lokoja (Figure 1). Two seasonal periods are being experienced in the state: the wet and the dry seasons. The months of May to October constitute the wet season. During this period no place receives less than 60 mm of rain. The months of November to April constitute the dry season. It experiences harmattan between the months of November to February. March and April are the hottest months (42.78°), while November and December are the coldest months (11.11°) [10,11].

Upper River Benue is the main source of water for irrigation, fishing, domestic and industrial purposes in the state. The main sources of water apart from rainfall are surface and ground water. The river is well dissected by network of rivers. The river is approximately 1,400

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km long and it is almost navigable during the summer months [10]. This study was conducted in the Upper River Benue. Upper Benue River in this study was divided into five Sites (I, II, III, IV and V). Site I was Boronji, at this site, human activities such as fishing, irrigation, washing, sand collection and other domestic activities are taking place regularly. Site II was Opposite Customs Office, at this site, agricultural activities, domestic, industrial, fishing and other activities are taking place., Site III was Near the Bridge, at this site, agricultural activities, fishing, dumping of refuse and other activities are taking place., Site IV close to Inlet to Lake Geriyo, at this site, agricultural activities, fishing and other activities are taking place and Site V was One hundred fifty meters away from site IV, at this site, agricultural activities, fishing and other activities are taking place. The study was conducted at the Upper River Benue and the study sites were designated as sites (I, II, III, IV and V) phytoplankton was collected from the above mentioned sites.

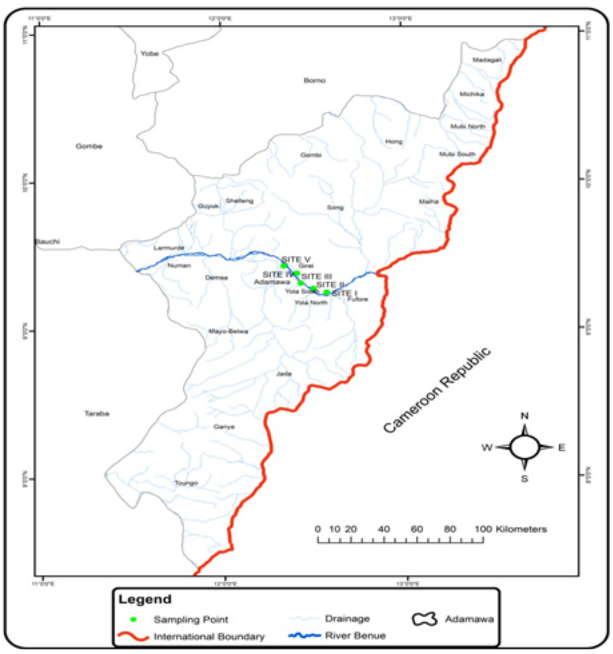

Figure 1: Map of Adamawa state showing study area and sampling sites.

Duration of sampling

The study was conducted for the period of six months (i.e. from January-June, 2023). Water and Phytoplankton samples were collected monthly for six months.

Phytoplankton samples collection

Phytoplankton samples were collected from five sites (sites I, II, III, IV and V) by towing a 55 µm mesh Hydrobios plankton net tied to a boat driven at low speed just below water surface for 5 minutes at the sampling stations. The samples were immediately fixed in 4% formalin and transported to the laboratory in labeled 250 ml bottles with screw caps where it was allowed to settle after which decantation method was used to reduce to 10 ml. In the laboratory, 0.1 ml was pipetted carefully into 50 x 9 mm petri dishes and carefully positioned over the chamber for viewing, specimens were sorted and examined under a binocular dissecting microscope (American Optical Corporation, Model 570) during which counting and identifications using taxonomic keys by [12-15].

Density was expressed as the number of individuals per sample volume (ind/l). The Phytoplankton Community composition was done by calculating the species diversity index (H) [16]. Density of organisms was estimated from the count records of the final concentrate volume in relation to the original volume of water sediment.

Cells/ml= N × 1000 ml × V

Where N=number of cells/unit counted, V= Volume of concentrate viewed.

Data analysis

Biological indices such as Margalef's index (d); Shannon-Weiner Index (H) and Evenness (E) were used in the calculation of taxa richness, diversity and evenness. Margalef's Index (D) is a measure of species richness and is expressed as;

$$D = \frac{S-1}{N} \quad \ldots\ldots\ldots\ldots (1)$$

Where;

S is the number of species in sample

N is the number of individuals in the sample

Shannon Weiner's Index (H'): is a species abundance and evenness and is expressed as;

$$H' = \frac{N \ln N - (ni \ln ni)}{N} \quad \ldots\ldots\ldots\ldots (2)$$

Where;

N is the total number of individuals in the sample,

ni is the total number of individual species in the samples,

ln is natural logarithm.

Species Equitability or Evenness (E) were determined by the equation

$$E = \frac{H'}{\ln S} \quad \ldots\ldots\ldots\ldots (3)$$

Where;

H is the Shannon and wiener's index

S is the number of species in sample [17,18].

PhytoPlankton composition, abundance and their range in Upper River Benue

Overall, 5 groups of Phytoplankton were seen in the Upper River Benue (Table 1). The Observed phytoplankton groups in this study were Chlorophyceae, Bacillariophyceae, Cyanophyceae, Euglenophyceae, Rhodophyceae. A total of 365, 360, 345, 364 and 369 species were recorded in Sites I, II, III, IV and V respectively with abundance values of 1803. Twenty (20) species of phytoplankton were identified during the study period ranging from seven Chlorophyceae, five Cyanophyceae, four Bacillariophyceae, two Euglenophyceae,

S/no	Taxa/Species Identified	ST-I	ST-II	ST-III	ST-IV	ST-V	Total	Percentage
1	**Chlorophyceae**							
	Spirogyra Sp	23	25	20	16	19	103	5.71
	Nitzchia Sp	15	19	13	16	19	82	4.54
	Chlorella Sp	17	18	17	16	21	89	4.93
	Cladophora oligoclonus	15	19	18	22	17	91	5.04
	Ulothrix tenuissim	14	17	19	16	18	84	4.65
	Mougeotia Sp	13	16	15	12	19	75	4.15
	Hormiclium sp	15	24	17	18	21	95	5.26
								-34.28%
2	**Bacillariophyceae**							
	Synedra Sp	21	15	17	22	24	99	5.49
	Fragillaria	14	17	16	20	13	80	4.43
	Ceradium Sp	17	18	24	15	19	93	5.15
	Diatomella sp.	22	14	16	19	18	89	4.93
								-21.00%
3	**Cyanophyceae**							
	Oscillatoria rubens	33	27	28	30	28	146	8.09
	Oscillatoria splendid	35	23	22	40	34	154	8.54
	Anabaena Sp	14	18	16	13	11	72	3.99
	Nostoc Sp	11	17	10	16	12	66	3.66
	Athrospira sp.	37	23	25	19	27	131	7.26
								-31.54%
4	**Euglenophyceae**							
	Euglena Sp	17	19	16	20	14	86	4.76
	Phacus SP	15	16	17	18	13	79	4.38
								-9.14%
5	**Rhodophyceae**							
	Batrachospermum Sp	17	15	19	16	22	89	. 4.93
								-4.93%
	Total	365	360	345	364	369	1,803	100
	Percentage	20.24%	19.97%	19.13%	20.19%	20.47%		

Table 1: Phytoplankton composition, abundance and distribution at the different sites of Upper River Benue.

SITES	Site I	Site II	Site III	Site IV	Site V	Total
Total number of species	19	19	19	19	19	
Total number of Individuals	365	360	345	364	369	1803
Margalef's Index (d)	3.6778	3.5765	3.8241	3.7922	3.6617	18.5323
Shannon-Wiener Index(H´)	1.41	1.3949	1.41	1.4173	1.4114	7.0436
Equitability Index (E)	0.2854	0.2785	0.2698	0.2861	0.2889	1.4087

Table 2: Diversity indices of Phytoplankton of Upper River Benue (Jan.-June, 2022).

and one Rhodophyceae. The Phytoplankton species are arranged in order of their abundance as summarised in Tables 1. The Table also presents the relative abundance and distribution of various phytoplankton species identified at the river. The high relative abundance of Phytoplankton species were observed in Site-V, Site-I, Site-III, with relative abundance of 369 (20.47%), 365 (20.24%) and 364 (20.19%) respectively while it's least relative abundance were in Site-II, Site-III with relative abundance of 360 (19.97%), 345 (19.13%) respectively.

Diversity indices of phytoplankton in Upper River Benue

A summary of the diversity and dominance indices calculated for the five sites is shown in Table 2. Taxa richness calculated as Margalef index (d) was least in site II (3.5765) followed by sites V and I which accounted for (3.6617) and (3.6778) respectively; while the sites IV and III accounted for the highest diversity (3.7922) and (3.8241) respectively. The pattern for Shannon diversity index (H) in site II was least (1.3949) followed by sites I and III that accounted for (1.4100) while sites V and IV accounted for the highest diversity (1.4114) and (v) respectively. Equitability was least in site III (0.2698) followed by site II and I (0.2785) and (0.2854) respectively; while sites IV and V had the highest diversity (0.2861) and (0.2889) respectively. The five sites had more or less equal dominance and diversity levels with insignificantly different indices values.

Discussion

Planktonic organisms are not evenly distributed in water. They exhibit what is called patchiness, which is a characteristic that reduces predator pressure. Plankton show variation in abundance, which likely depends on changes in water currents, water level transparency, and the amount of nutrient available [19-21]. The species composition and abundance order of dominance Chlorophyceae > Cyanophyceae> Bacillariophyceae>Euglenophyceae> Rhodophyceae respectively. The phytoplankton in this study followed the general pattern for most inland waters as reported by [22-24]. The observation of Chlorophyceae being the most abundant phytoplankton in this study corroborates the report of earlier researcher including [24-27] that Chlorophyceae are the most obvious representative of the phytoplankton in tropics. This is in agreement with the findings of [28] that blue algae, green algae and diatoms dominate the tropical lakes. Chlorophyceae are considered as one of the most common and dominant taxa in freshwater environment. Virtually all the observed Chlorophyceae in the river are not pollution indicator; hence the river could not be considered to be under pollution stress. The dominant Chlorophyceae in River was the filamentous nitrogen fixing genus Spirogyra. This might be explained by the generally low nitrate status of the river which necessitates an increase in the nitrogen fixing blue- greens to ensure maximum utilization of nutrients. The other Chlorophyceae equally found in appreciable quantities in river were Hormiclium sp, Cladophora oligoclonus and Ulothrix tenuissim which have been implicated as indicators of organic pollution in surface waters [29]. The presence of some Cyanophyceae which can tolerate various levels of organically polluted waters further suggest the presence of organic pollutants in river. Though bloom formation was not detected in the river during this period of study, but there is the possibility of bloom formation if there is excessive nutrient enrichment of the water, even as other bloom forming genera such as Oscillatoria are present in appreciable quantity in the river.

It was also observed that Chlorophyceae was observed to have a total abundance of 34.28%, followed by Cyanophyceae contributed a total of 31.54%, while the least was Rhodophyceae gave 4.93%. [30] studied the phytoplankton of Ajeko stream also observed that the Chlorophyta were the most dominant they accounted for approximately 79% within the phytoplanktons community of the stream during the period of study followed by the Bacillariophyta 17%, Euglenophyta 2% and the Cryptophyta 2%. The five flora groups recorded in this study are characteristics of tropical river systems and are also similar to that of [31] in their study of Egbe reservoir.

The number of phytoplankton taxa recorded in the sites are equal across the sites while the abundance pattern in these sites could be summarized as V>I>V>IV>II>III. The phytoplankton community composition, structure, density and diversity and horizontal distribution have been greatly affected by the presence of the less homogenous environment within the river, which reduces the number of colonizing taxa. The dominance of the Chlorophyceae in terms of taxa representation is attributable to the freshness of the river in the study area. This conforms to [32] in the Shore of Great Kwa River, Calabar, Nigeria.

The low Shannon-Weiner diversity value (7.0436) and a relatively high Margalef diversity level (18.5323) recorded were due to the fact that the former incorporates evenness of distribution while the later only measures species richness. Thus, the low Shannon-Weiner diversity value was as a result of the much higher relative abundance of the Chlorophyceae taxa than other phytoplankton taxa. The comparable number of phytoplankton taxa as well as insignificantly different phytoplankton abundance and diversity levels of sites indicated uniform distribution of phytoplankton in the study area. The low species diversity may be attributed to fluctuation in some physicochemical parameters. These factors could probably cause disruption of life cycle, reproductive cycle [33].

Conclusion

The study revealed that phytoplankton composition, abundance and diversity were influenced by changes in water quality as shown by changes in species composition, assemblages and abundance at the various sites. The recorded dominance of the pollution indicator taxa and intermediate bio-diversity indices suggested that the river is moderately polluted probably due to the accumulations of the suspended materials from the runoff and various human activities around the river. It is therefore suggested that anthropogenic activities around the river should be regulated.

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