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Spatio-temporal Assessment of Phytoplankton and Physicochemical Parameters of Dangana Lake, Lapai, Niger State Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Dangana Lake was constructed primarily to provide water for drinking, domestic activities and control flood. Phytoplankton assemblage and physicochemical parameters of Dangana Lake, Lapai, Niger State Nigeria were investigated monthly between March and October 2019 using standard methods and procedures. Water samples were collected from 3 different stations in the Lake. The result of the lake shows water temperature (23.2-29.5ºC), Biochemical oxygen Demand (2.30-3.91mg/l), Dissolved oxygen (3.40-4.70mg/l), water pH (6.10-7.5), Electrical conductivity (60.00-121µS/cm), Nitrates (0.30-1.05mg/l) and Phosphate (0.53-1.75mg/l). Temperature, DO, BOD_5, and pH shows no significant difference ($p>0.05$) among sampling sites, however, Electrical conductivity, Nitrate and Phosphate differs significantly among sampling sites ($p<0.05$). Seasonally there was a significant difference ($p<0.05$) among sampling months in all the physicochemical parameter measures. A total of Seventeen (17) species of phytoplankton in six (6) families were encountered. The percentage abundant of phytoplankton revealed Bacillariophyta (36.84%), Dinophyta (33.38%), Chlorophyta (17.05%), Heterokontophyta (6.93%) Cyanophyta, (4.76%), and Euglenophyta (1.02%). Phytoplankton population was significantly higher during the dry season than in the raining season. The Canonical Correspondence analysis (CCA) correlated positively

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between the measured physicochemical parameters and the observed organisms. The nutrient status of the lake shows a medium range as indicated by the measured environmental parameters.

Keywords: Planktons; phytoplankton; physicochemical parameters; dangana lake.

1. INTRODUCTION

In Nigeria, and many parts of the world, man-made lakes or reservoir is of great value to man. [1]. They are very beneficial to man in which they serve as a means of flood control, biodiversity life support, domestic water supply, irrigation and industrial water sources [1,2]. Lakes are widely utilized by Mankind over the centuries because they constitute a very important part of our heritage [2]. Interaction occurs between living and non-living components of an aquatic basis environment [3,4].

Biodiversity is heterogeneously distributed to biological communities varying in location, space, and time [5,6]. The assessment of the population of various organisms at any particular location and time form a basis of understanding the trophic state of that biological environment [7]. Species abundance and richness are important indicators in understanding changes in the aquatic environment [8]. Health status of aquatic ecosystem is dependent on the physico-chemical properties and biological diversity of the water body [9]. The physical and chemical characteristics of a lake determine the occurrence, diversity and density of both flora and fauna of any aquatic habitat [10,11]. Changes in the physicochemical characteristics of provide valuable information on water quality of an aquatic environment [10,12] In Nigeria, most aquatic ecosystem is threatened by different anthropogenic activities [4,6,10,13]. Planktons are sensitive to the environment in which they live and any change in the environment leads to change in their communities in view of tolerance abundance, diversity and dominance in a particular habitat [1]. Planktons are widely considered as an indicator of environmental health and productivity [14], they are also large consumed by fishes and other higher animals in food chains [3].

The productivity of any water body is determined by the amount of plankton it contains as they are the major primary and secondary producers [15]. Phytoplankton are among the most important biotic component influencing all the functional aspect of an aquatic ecosystem such as food web, food chains, energy flow and cycling matter [16]. The used of phytoplankton to evaluate the trophic state status of the aquatic environment is becoming a novel practice in water maintenance for both aquaculture and portable water [17,18]. This study evaluates the spatial and temporal variation in abundance of Phytoplankton in relation to environmental variables of man-made lake in Northcentral Nigeria.

2. MATERIALS AND METHODS

2.1 Description of Study Area

The study was carried out at Dangana lake, Lapai, Niger state, Nigeria. This lake is located within longitude 6°36’29.6′E and latitude 9°02′12.02N with elevation of 159m above the sea level. The vegetation of the area reflects that of Savannah zone, the vegetation is mixed, prominent ones include Malaina (*Gmeilana arborea*) Locust beans (*Parkia biglobosa*) Neem (*Azadirachta indica*) and other sparsely native trees and grasses. The climate presents two distinct seasons, a rainy season between April and October, and a dry season (November-March) completely devoid of rain.

2.2 Sampling Station

Station 1: This is the entry point of water into the lake, it is the place where the lake received its water sources from nearby wetlands and it has few human activities taking place such as fetching of water for drinking and other domestic use.

Station 2: This is a place with high anthropogenic activities. Human activities in this station vary which include laundry, car wash and other domestic activities.

Station 3: This station is free of human activities; it is the quiet region of the lake. It has an opening which allows water to move out of the lake when there is excess water in the lake due to flood or excessive rainfall.

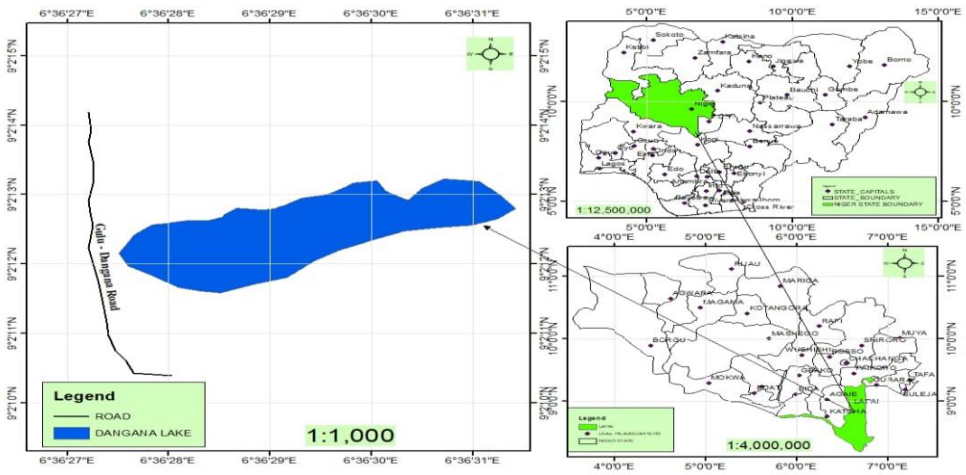

Fig. 1. Map of the study area showing Dangana Lake Lapai, Niger State Nigeria

2.3 Sampling Technique

2.3.1 Determination of physicochemical parameters

Water samples for physicochemical parameters were collected monthly between March and October, 2019 from three selected sampling sites in the lake. Sampling period covers both dry and wet season. On the sampling site physicochemical parameters including Water Temperature, Dissolved oxygen (DO), Conductivity and pH were measured using the multipurpose Meter (HANNA model 1910). BOD_5, Nitrate and Phosphate were determined by the methods described by APHA [19].

2.3.2 Phytoplankton Sample Collection

Phytoplankton samples were collected by horizontal towing using a standard plankton net with a mesh size of 20.0µm with a small bottle container attached of 50ml attached to its narrow end. The samples collected were immediately preserved in 4% formalin and transported to the laboratory for further analysis. In the laboratory, phytoplanktons were identified by pipetting 1ml of water sample from field samples and place on a slide which was mounted under light microscope and view under magnification (×40, ×100), counting of planktons was done by counting each cell as individual [20]. Identification was done by comparing the specimen with plankton identification charts [21-24].

2.4 Data Analyses

The physicochemical parameter data were subjected by descriptive statistical test, using Microsoft Excel 2010. The mean, range and standard error of each physicochemical characteristic were calculated per station. Physicochemical variables among all stations and months were compared using one way analysis of variance (ANOVA). Biological indices such as taxa richness, evenness indices, diversity index and dominance were also analyzed. Canonical correspondence analysis (CCA) was used to determine the relationship between phytoplankton communities and environmental variables using the paleontological statistical software (PAST).

3. RESULTS

3.1 Physicochemical Parameters

The physicochemical parameters of sampling sites of Dangana lake Lapai Niger state for a period of Eight months (March-October 2019) is presented in Table 1. From the entire sampling site, temperature ranged from 23.5±29.0 in site C to 26.65±0.74 in site B. Dissolved oxygen ranged from 3.98±0.5 in site B to 4.13±0.20 in site C. The Biochemical oxygen demand ranged from 3.00±0.14 in site A to 3.12±0.19 in site C. The pH ranges from 6.88±0.14 in site A to 7.05± in site B. The electrical conductivity ranges from 86.43±8.57 in site A to 94.8±8.54 in site C. Nitrate ranged 0.67±0.09 in site C to 0.76±0.08 in site B and Mean phosphate value of 0.85±0.11 in site C to 1.04±0.12 in site B. Temperature, DO, BOD_5, and pH shows no significant difference ($p>0.05$) among the sampling sites. However, electrical conductivity nitrate and phosphate differs significantly among sampling sites ($p<0.05$). Seasonally there was a significant difference ($p<0.05$) among sampling months in all the physicochemical parameter measures.

Table1. Mean value of physicochemical parameters of Dangana Lake, Lapai (March-October 2019)

Parameters		Stations		Probabilities	
	Site A	Site B	Site C	Stations	Months
Water temperature (°C)	26.41±0.38	26.65±0.74	23.5±29.0	0.716	5.81E-06
	(23.20-29.50)	(23.50-29.00)	(24.60-28.90)		
DO (Mg/l)	4.02±0.10	3.98±0.15	4.13±0.20	0.538	0.001
	(3.60-4.40)	(3.40-4.50)	(3.40-4.70)		
BOD5 (Mg/l)	3.00±0.14	3.08±0.18	3.12±0.19	0.37	3.40E-07
	(2.3-3.5)	(2.3-3.8)	(2.2-3.8)		
pH	6.88±0.17	7.05±0.12	6.98±0.11	0.13	1.29E-06
	(6.1-7.4)	(6.3-7.5)	(6.5-7.4)		
Conductivity (µ/Sm)	86.43±8.57*	91.42±9.04	94.80±8.54	0.02	1.97E-08
	(60-120)	(65-125)	(65-121)		
Nitrate (Mg/l)	0.68±0.08	0.76±0.08*	0.67±0.09	0.002	8.25E-12
	(0.3-1.05)	(0.4-1.15)	(0.3-1.05)		
Phosphate (Mg/l)	0.90±0.10	1.04±0.12*	0.85±0.11	7.38E-05	3.51E-11
	(0.55-1.5)	(0.67-1.75)	(0.53-1.55)		

Note; values are Mean±S.E; range in parenthesis; values with asterisk (*) differs significantly

Table 2. Phytoplankton composition, distribution and percentage abundance in Dangana Lake, Lapai during the sampling periods

Division	Species	Site A	Site B	Site C	%
Dinophyta	*Linguilodium sp.*	21	8	36	
	Akashiwo sp	15	12	7	
	Amylax sp	13	33	18	
	Nuctiluca sp	30	28	10	
	Total	79	81	71	33.38
Chlorophyta	*Chlorella*sp	7	36	10	
	Volvox sp	10	6	10	
	Spirogyra sp	9	15	15	
	Total	26	57	35	17.05
Hoterokontophyta	*Pseudo-nitzchia* sp	18	7	9	
	Chaetoceros sp	5	4	5	
	Total	23	11	14	6.93
Bacilliariophyta	*Skeletonema* sp	28	10	20	
	Nitzchia sp	15	28	12	
	Diatoma sp	25	13	14	
	Fragillaria sp	26	8	7	
	Navicula sp	31	8	10	
	Total	125	67	63	36.84
Euglenophyta	*Euglena* sp	2	2	3	
	Total	2	2	3	1.01
Cyanophyta	*Oscillatoria* sp	5	7	0	
	Chrococcus sp	9	5	7	
	Total	14	12	7	4.76

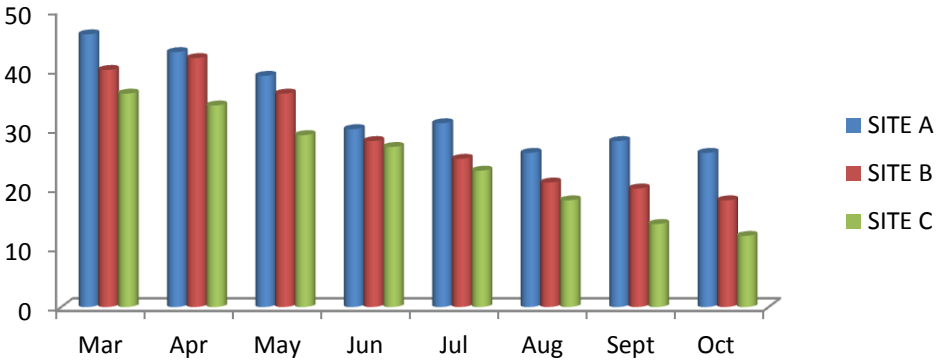

Fig. 2. Monthly distribution of phytoplankton in Dangana lake

Table 3. Phytoplankton diversity indices value of Dangana lake Lapai Niger State, Nigeria

	Site A	Site B	Site C
Taxa_S	17	17	16
Individuals	269	230	193
Dominance_D	0.0787	0.0938	0.08717
Shannon_H	2.653	2.566	2.608
Evenness_e^H/S	0.8355	0.7652	0.828
Margalef	2.86	2.942	2.85

3.2 Phytoplankton Assemblage and Distribution in Dangana Lake

A total of Seventeen (17) species of phytoplankton in six (6) divisions was identified in Dangana Lake, Lapai Niger state. Four (4) species of Dinophyta, three (3) species of Chlorophyta, two (2) species of Heterokontophyta, five (5) species of Bacillariophyta, one (1) species of Euglenophyta and two (2) species of Cyanophyta were identified as presented in Table 2. The percentage abundant revealed that Bacillariophyta (36.84%)>Dinophyta(33.38%)> Chlorophyta (17.05%)>Heterokontophyta (6.93%)>Cyanophyta (4.76%)> Euglenophyta (1.02%).

3.3 Spatio-temporal Distribution of Plankton

Spatial distribution of phytoplankton in all sampling sites shows high abundance in the month of March, April and May. There was a decrease in population in the months of June, July, August, September and October. Phytoplankton population was significantly higher during the dry season than in raining season as shown Fig. 2.

3.4 Diversity Indices of Recovered Planktons from Dangana Lake Lapai Niger State

The results of the diversity indices indicate that the lake varied within study station in term of diversity and species distribution. A total of 17 phytoplankton species were recorded in site A and site B of the lake with 269 and 230 individuals respectively while site C recorded 16 species with 193 individuals. Site A recorded dominance index of 0.078, site B recorded indices of 0.0938 followed by site C with 0.087. Shannon and Everest indices operate in a similar pattern by recording highest values in site A, then site C and the lowest values are recorded in site B. Site B recorded highest Margalef's index value of 2.94 and site A and C recorded value of 2.86 and 2.85 respectively (Table 3).

3.5 Phytoplankton and Environmental Parameters of Dangana Lake Lapai Nigers State

The Canonical Correspondence analysis (CCA) shows a strong positive correlation with the physicochemical parameters and the observed organism. CCA Axis1 account for 68.16% of the specie while Axis2 account for 31.84% of the total species as shown in table 4. From the CCA

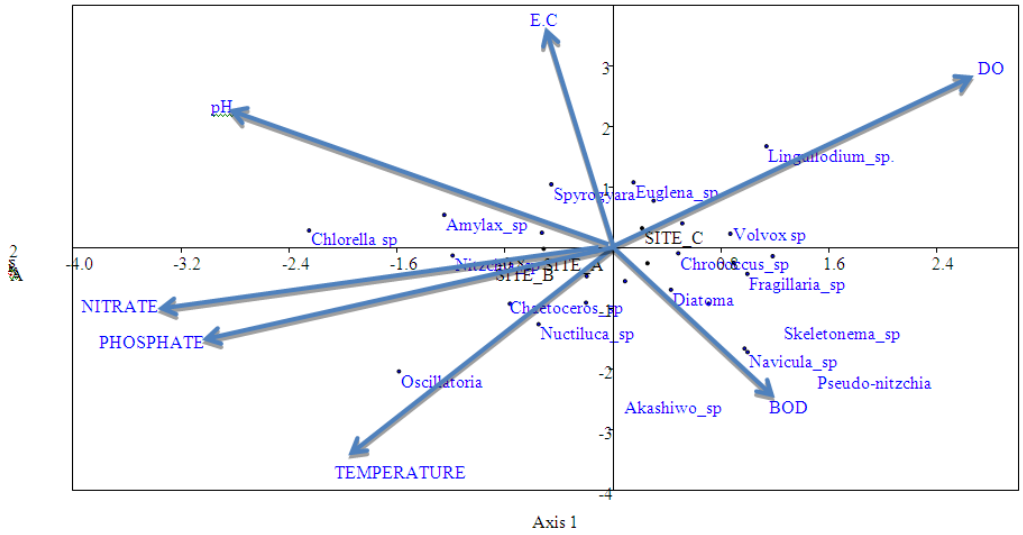

Fig. 3. CCA ordination plot for phytoplankton species among sampling sites of Dangana lake Lapai Niger state

Table 4. Weighted intraset correlation of engine value parameters with axis of CCA

	Axis1	Axis 2
Eigenvalue	0.1218	0.056896
%	68.16	31.84
Temperature	0.518952	-0.882061
DO	-0.67248	0.775994
pH	-0.25542	0.87453
BOD	0.234387	0.957775
E.C	-0.15642	0.977589
Nitrate	0.989068	-0.201652
Phosphate	0.954414	-0.350546

ordination plot organism in Axis 1 where positively influence by nitrate, phosphate, temperature and biochemical oxygen demand. Organism in Axis 2 correlated positively with pH, electrical conductivity and dissolved oxygen. Organism associated with CCA axis1 are *Oscillatoris* sp, *Nitchia* sp, *Chroccocus Flagillania* sp, *Skeletonema* sp, *Navicula* sp, *Pseudo-Nitchia* sp, *Chaetus* sp, *Akashiwo* sp, *Nuctiluca* sp Organisms associated with CCA Axis 2 are *Lingollidium* sp, *Ceriodaphnia* sp, *Amylax* sp, *Euglena* sp, *Volvox* sp, p and *Spyrogyara* sp as shown in Fig. 3.

4. DISCUSSION

4.1 Physicochemical Parameters

The conservation and management of water ecosystem is critical to the interest of the entire mankind, as long as biodiversity constitutes valuable natural resources in socio-economic, cultural, aesthetic, scientific and educational terms [25]. The physical and chemical characteristic of the lake shows general and similar trends that have been reported for other lakes in Nigeria [26]**.** The seasonal trend in the concentrations of Dissolved oxygen, Biochemical Oxygen demand, pH, Nitrate and Phosphate in the lake is in conformity with the usual pattern for most inland waters in Nigeria [12,27]. The result of the physicochemical parameters obtained in these studies shows no significant difference among sampling station ($p>0.05$) except Conductivity, Nitrate and Phosphate. All the physicochemical parameters show spatial and temporal variation between sampling months; this could be as a result of some natural factors and different anthropogenic activities taking place around the lake [10,28].

Water temperature of Dangana Lake Lapai Niger state was within the normal temperature range of 20 to 30°C required by aquatic organisms for metabolic activities [28]. The water temperature was moderate throughout the sampling period due to high rainfall and minimum amount of sunlight. The Dissolved oxygen (DO) concentration observed in this study ranged from 3.40 to 4.70mg/l. Higher DO value were recorded during raining season than in the dry season, this could be due to increase in volume of water in raining season and high temperature coupled with high sunlight intensity in the dry season [28,29]. Biochemical oxygen Demand (BOD) concentration ranged from 2.30 to 3.91mg/l. The higher BOD concentration recorded in raining season was as a result of influx of organic matters into the lake though surface run-off [15]. The water pH (Hydrogen ion concentration) range from 6.10 to 7.5 obtained from all the sampling sites was closed to neutral in both seasons. The pH value obtained from Dangana Lake slightly falls within the recommended pH of 6.5-8.5 for productivity in natural waters [12]. Electrical conductivity (E.C) value ranged from 60.00 to 121µS/cm obtained from the sampling sites of Dangana lake Lapai Niger state. The high electrical conductivity value observed in rainy season could be attributed to high amount of suspended and dissolved solid material and increases the concentration of dissolved cation such as calcium, magnesium and sulphate in the sampling sites [13].

Nitrates and Phosphate are among the limiting factors in aquatic environment [30]. This study revealed a high value of Nitrate and phosphate in the raining season which could be high anthropogenic activities around the lake and surface run-off from the surrounding [6,13].

4.2 Spatial and Temporal Variation in Phytoplankton Assemblage of Dangana Lake

Plankton abundance and distribution are affected by seasonal changes of both physical and chemical parameters as well as microplant life in aquatic environments [31]. Changes in plankton population in the lake could be distributed to various species having t different nourishment in temperature, pH, Do, BODs and nutrients [32]. High nutrient levels such as nitrate and phosphate enhance the growth of Baccillariophyta which forms the major diet of zooplankton [32]. In this study a significant abundance of some phytoplankton species were observed this could be attributed to increase in the intensity of solar radiation that can be captured by phytoplankton, hence increased photosynthesis and other metabolic activities which lead to a subsequent increase in population density of planktons [12,33]. Dinophyta, Chlorophyta, Heterokontophyta, Bacillariophyta, Euglenophyta and Cyanophyta were the phytoplankton groups encountered in the lake. Their presence has also been reported in other freshwater bodies of Nigeria [26,34,35]. The dominance of diatoms in this study could be due to the fact that they can withstand broadly changing hydrographical conditions [26]. Similarly, high intensity of the light in the tropics favors the development of Chlorophyta [26]. Increase in domestic, agricultural and industrial pollution in lakes accelerate the growth of Chlorophyceae and Cyanophyceae [36]. Wetzel [37] stated that the predominance of diatom population in a lake is an indication of eutrophic conditions. Several among the diatoms observed in Dangana lake are *Nitzchia sp*. and *Navicula* sp. which are good indicators of pollution as described by Palmer [38]. *Spirogyra* sp and *Oscillatoria* sp. are also pollution indicator species belonging to chlorophyceae [12]**.** The presence of *Euglena* sp. is a direct indication of pollution load because this specie is generally, considered to be dominant and tolerant genera of polluted ponds [38].

There is a great seasonal influence on abundance of the green algae in Dangana Lake as plankton population increases during the dry season and decreases during wet season. The low abundance of planktons observed during the wet season could best be attributed to further dilution of essential growth nutrients in the area [26]

5. CONCLUSION

Dangana Lake shows seasonal variation in physicochemical parameters and phytoplankton assemblage within the study period. There were different anthropogenic activities at the lakeshore and within the lake. The nutrient status of the lake shows a medium range as indicated by the measured environmental parameters.

DISCLAIMER

The products used for this research are common and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and

producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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