

DIVERSITY OF PLANKTON COMMUNITY AND WATER QUALITY IN LEKAN AARE LAKE, ABEOKUTA, NIGERIA

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Abstract

Phytoplankton composition, temporal distribution and diversity with physico-chemical water parameters were studied based on monthly sampling from three locations in the lake. The lake was delineated into three sampling areas. Each location sited in each sampling area. The study was carried out for the period of twelve months. Of the four groups identified in this study (Chlorophyta (52%), Bacillariophyta (26%), Cyanophyta (20%) and Xanthophyta (2%) consisting of 54 species. Xanthophyta was less diverse with one representative while Chlorophyta had the highest number of genera. Highest taxa (37) was recorded in June. Simpson diversity and evenness indices were generally high during the study period with highest values of 0.96 (June) and 0.95 (December) and least in August (0.85) and (0.70) respectively. High correlation coefficients 0.91 and 0.75 recorded in the relationship among TDS/EC and air/water temperature respectively. Canonical correspondence showed strong relationship between EC and TDS which were favourably disposed to abundance of *Aphanocapsa*, *Nostoc* and *Scenedesmus* with negative response of *Melosira*, *Polycystis*, *Amphora*, and *Microspora*. The monitoring of the lake system is essential for its sustainable management.

Keywords: biodiversity, aquatic, abundance, ecosystem, species, variation.

Introduction

Sustainable management of aquatic ecosystem requires monitoring of its biotic components and water qualities. Baker (1976) defined bio-monitoring as the use of living organisms to determine the presence, amounts, changes in and effects of biotic and physico-chemical factors in the environment. Physico-chemical and biological characteristics of aquatic ecosystem can be used to define its quality (Straskraba and Tundisi, 1999). Monitoring of physico-chemical characteristics of water are important because of their instability and as such provide information on its productivity (Offem and Ikpi, 2011). Lakes are major water resources, which are very diverse both in term of sizes and fisheries potentials. Lakes play important role in provision of water for domestic activities, irrigation, ground water recharge and prevention of flood. Also, they support human settlements, aquatic flora and fauna (Shirke *et al.*, 2014). According to Ndebele-Murisal *et al.*, (2010), African lakes contribute immensely to poverty reduction and food security; they are cheap sources of protein bordering rural communities. Besides, they provide potable water for human and livestock use, irrigation water for agriculture, means of transportation of goods, essential in generation of hydro-electric power and are sources of revenue from fishing and eco-tourism. The biotic components in lakes play functional role in fish

production. They provide habitats for diverse endemic fish fauna which have scientific and ecological significance. Phytoplankton, because of their role as primary producers in an aquatic ecosystem is the subject of great concern. They are central functional groups in all types of aquatic food web reflecting the trophic status of the water bodies (Kallf and Knoechel, 1978), plays role in the structure and functioning of freshwater ecosystems (Paszalenniec and Poniewozik, 2010). They are highly sensitive and their dynamics can be seriously affected by environmental perturbation. Quantitative and qualitative phytoplankton estimates provide good indices of water quality and its productive capacity (Offem *et al.*, 2011). According to Paerl *et al.*, (2003), phytoplankton can provide meaningful and quantifiable indicators of ecological perturbation in short time scales. Consequent to rapid responses and sensitivity of phytoplankton composition and abundance to changes in environmental conditions, Reynolds *et al.*, (2002), Brettum and Andersen (2005), Panda *et al.*, (2012) and Stanca *et al.*, (2013) considered them as natural bio-indicators of water quality. Species composition, relative abundance, spatial and temporal distribution of these aquatic biota are an expression of the environmental health of a particular water body (Limbu and Kyewaiyanga, 2015). The understanding of temporal and spatial

variation process of phytoplankton community could be useful in water quality improvement and management decision (Ahmed and Wanganeo, 2015). However, estimating the phytoplankton species diversity and abundance of aquatic system is very important in its natural resource management. Hence, this study was carried out to investigate the phytoplankton composition, abundance and water quality parameters of Lekan Aare Lake, Abeokuta, Nigeria.

Materials and Methods

The study Area

The study site is Lekan Aare Lake, an earth filled man-made lake, located within the premises of the headquarters of Ogun-Oshun River Basin and Rural Development Authority, Abeokuta. The lake was

constructed across a stream and impounded in 1982. The lake is used for fish production, irrigation of arable crops, source of water supply to the residents and production of commercial bottled water (Ikenweibe *et. al.*, 2012). It is under the management of Ogun-Oshun River Basin Development Authority (O-ORBDA) having its headquarters at Alabata Road, Abeokuta, Ogun State. The lake is situated at about 26 km North-west of the city of Abeokuta, which lies on latitude between 7° 15' and 7° 25' N and longitude 3° 5' and 3° 15' E (Figure 1). It is a gated spillway lake and covers an area of 40 km². Natural productivity and water quality of Lekan Aare Lake is principally driven by the small streams that drain into it which are seasonally influenced. The shore line of the lake is surrounded by derived savannah vegetation

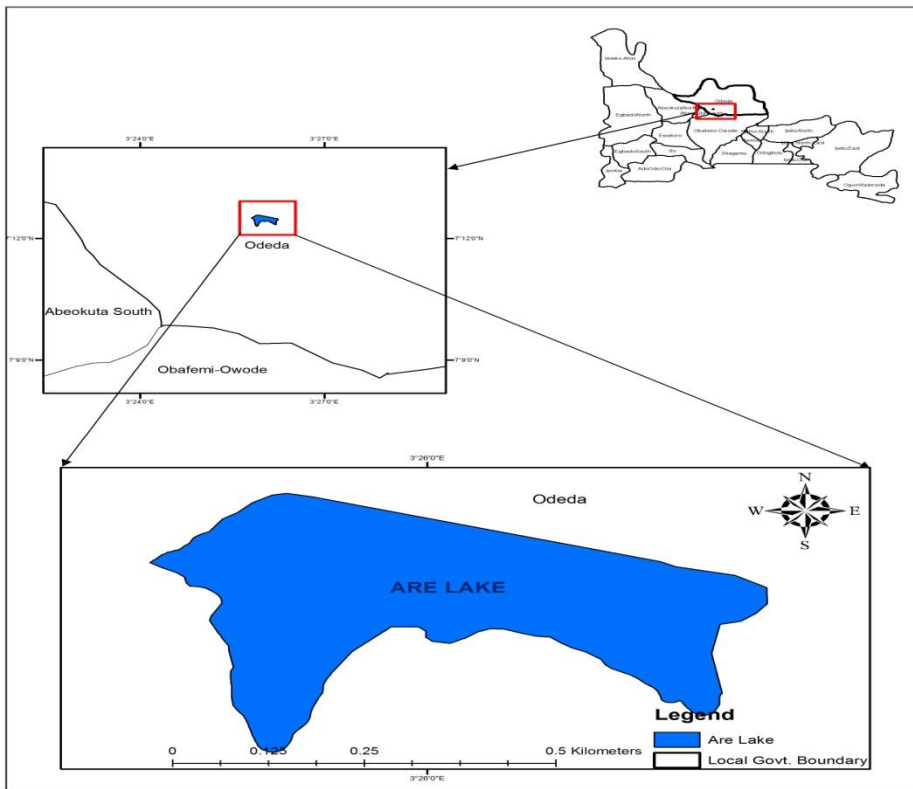


Figure 1: Map of Lekan Aare Lake, Abeokuta, Nigeria.

The lake was divided into three strata with one station in each strata; Station A (inlet), Station B (middle) and Station C (outlet area of the lake). Surface water samples, not below 0.5 m, were collected for water quality and phytoplankton analyses on monthly basis for the period of twelve months (July, 2013 to June, 2014) from each station. Water quality parameters determined in-situ were electrical conductivity (µS/cm), total dissolved solids (mg/l), pH, air temperature and water temperature (°C) using Hannah instrument

(Model HI 98129). Water transparency (m) was estimated by use of Secchi disc (Golterman, 1969). Dissolved oxygen, alkalinity, hardness, phosphate and nitrate were determined in the laboratory using standard laboratory techniques (APHA, 2005). Plankton net (68 µm mesh size) was used to collect water samples for plankton analysis which were preserved with 4% formalin. Plankton numerical assessment (abundance per ml) was carried out in the laboratory with the aid of binocular microscope according to (Verlencar and Desai, 2004).

Neehdam and Neehdam (1962) was used for the identification of the phytoplankton. Descriptive and inferential statistical analyses were performed using SPSS (version 16) software. Correlation analysis was carried out to detect the relationship among the water quality parameters. Diversity indices were estimated and canonical correspondence analysis was carried out by using Palaeontological Statistics (PAST) software (Hammer *et al.*, 2001).

Results

A total of four families of phytoplankton consisting of 54 genera which belong to Chlorophyceae (28 genera), Bacillariophyceae (14 genera), Cynaophyceae (11 genera) and Xanthophyceae (1 genus) were identified during the study period. The composition of the phytoplankton community was Chlorophyceae (52%) the most dominant family, Bacillariophyceae (26%), Cyanophyceae (20%) and Xanthophyceae (2%) as shown in Figure 2. Chlorophyceae (2184) and Bacillariophyceae (3864) were maximal in May while Cyanophyceae and Xanthophyceae were prominent in April and February with 1911 and 378 individuals respectively. Temporal variation in species composition of the phytoplankton genera ranged between 36 (June) and 11 (December). Spirogyra, Amphora, Nostoc had the highest proportion by composition among the Chlorophyceae, Bacillariophyceae and Cyanophyceae respectively. Tribonema was the

only Xanthophyceae observed in the study and was encountered in February, March and April. Generally, Spirogyra occurred most in the total distribution of the phytoplankton while Gonatozygon was least encountered and was reported in September. There was increasing gradient in abundance of species from December (1.01%, the lowest) to May (22.88%, highest). The three dominant species of Chlorophyceae were Spirogyra, Microspora, and Cyclotella, Bacillariophyceae (Amphora, Synedra and Asterinella) while Cyanophyceae were particularly Anabaena, Nostoc and Spirulina. In the dry season (November -March), Protococcus (Chlorophyceae), Amphora (Bacillariophyceae) and Nostoc (Cyanophyceae) were most favoured in the lake. Cladophora, Navicula and Spirulina were the Chlorophyceae, Bacillariophyceae and Cyanophyceae respectively that were prominent in the rainy season. In the dry and rainy seasons, 38.89% and 3.70% of the phytoplankton genera were absent in the collected samples respectively. Species taxa ranged from 11 (December) and 37 (June), while individuals (abundance) was highest in May and least in December as shown in Table 1. Month of June had the lowest species dominance and highest in August. Simpson diversity index was highest in June (0.96) and the least (0.85) was recorded in August but was generally high throughout the study period. Also, species evenness (0.95) and equitability (0.98) were highest in December

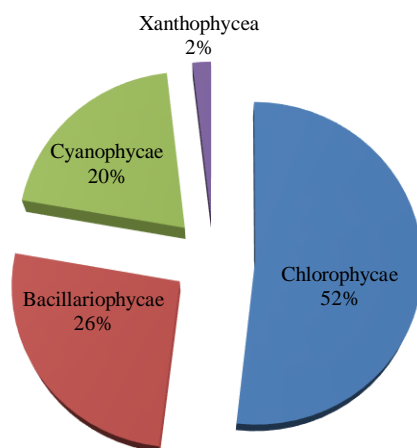


Figure 2: Percentage family composition of phytoplankton in Lekan Aare Lake, Abeokuta, Nigeria

Table 2 shows the result of the monthly mean variation of the physical and chemical water parameters. Air and water temperatures showed similar trend during the period of study. However, air temperature was generally lower than water temperature. Water temperature in the lake differed significantly ($p < 0.05$) among the months. It was significantly highest ($p < 0.05$) in February, 2015

($23.5 \pm 0.55^\circ\text{C}$) and lowest in August, 2014 with a mean value of $31.5 \pm 1.22^\circ\text{C}$. The temporal variation of dissolved oxygen was heterogeneous with a maximum value of 7.4 ± 0.69 mg/L in April, 2014 and lowest in October, November and December, 2013 with similar values. Dissolved oxygen was significantly higher ($p < 0.05$) in the rainy season (6.3 ± 0.21 mg/L) than wet season (5.3 mg/L). Station

B had the highest mean (5.45 ± 0.22 mg/l) among the stations while Station C had the lowest mean of 5.26 ± 0.20 mg/l. The pH was relatively steady except from July to November, 2013 and March to June, 2014. It was significantly higher in December 2013, January and February, 2014. The highest pH (8.4 ± 0.09) was recorded in February 2014 while the

lowest value of 7.1 ± 0.41 was obtained in May, 2014. It was significantly higher ($p < 0.05$) in dry season than rainy season. Total dissolved solids (TDS) varied from 42.0 ± 4.77 mg/L (August) to 110.3 ± 9.07 mg/L in February. No significant difference ($p > 0.05$) was observed in values of TDS in July to January and May to June

Table 1: Diversity indices of Phytoplankton in Lekan Aare Lake, Abeokuta, Nigeria.

Diversity indices	July, 2013	Aug	Sept	Oct	Nov	Dec	Jan, 2014	Feb	March	April	May	June
Taxa_S	17	14	19	13	13	11	20	13	20	23	26	37
Individuals	947	672	1043	473	484	326	3649	366	4221	508	756	422
Dominance_D	0.10	0.15	0.08	0.1	0.1	0.1	0.08	0.09	0.06	0.08	0.05	0.04
Shannon_H	2.53	2.28	2.75	2.4	2.4	2.3	2.75	2.45	2.85	2.81	3.14	3.32
Simpson_1-D	0.90	0.85	0.92	0.9	0.9	0.9	0.92	0.91	0.94	0.92	0.95	0.96
Evenness_e^H/S	0.74	0.70	0.83	0.8	0.8	0.9	0.78	0.89	0.86	0.72	0.89	0.75
Equitability_J	0.89	0.86	0.93	0.9	0.9	0.9	0.92	0.95	0.95	0.90	0.96	0.92

Seasonally, there was no significant difference between the seasons. Electrical conductivity steadily increased from July (85.0 ± 4.47 μ S/cm) and reached its peak in February (259.3 ± 10.75 μ S/cm) and decreased gradually to 85.9 ± 22.40 μ S/cm in June. Minimum mean value of 84.2 ± 5.78 μ S/cm was recorded in November while there was no significant difference between the seasons. Temporal values of Secchi disc transparency were relatively similar among the months of study except in December 2013. Minimum value of 0.9 ± 0.06 m was recorded in December with a mean value of 0.9 ± 0.06 m, while maximum value (1.7 ± 0.08 m) was observed in April and May which coincided with rainy season. There was no significant difference between the seasons. Water alkalinity significantly differs among the sampling months. Minimum and maximum values of water alkalinity were 2.3 ± 0.82 and 5.0 ± 0.89 CaCO₃mg/L in July, 2013 and February, 2014 respectively. Alkalinity during the rainy season was significantly lower than that of the dry season. The values of water hardness significantly varied among the months with maximum value of 41.5 ± 6.47 in April, 2014. Minimum value was obtained in November, 2013 with a value of 12.0 ± 1.79 CaCO₃mg/L. No significant difference was observed seasonally though it was relatively higher in the rainy season. Phosphate concentration decreased with time from July to November, 2013. However, it was significantly higher ($p < 0.05$) in January, February and March, 2014 compared with other months. No

significant difference was observed in the seasonal values. The concentration of nitrate was significantly highest with a value of 4.06 ± 0.59 mg/L in November, 2013 and lowest (1.01 ± 0.420 mg/L) in May, 2014. Its concentration was significantly lower in rainy season compared with the dry season. High positive correlations were observed in the relationship of TDS/EC, air/water temperature and transparency/hardness with the values of 0.91, 0.75 and 0.61 respectively as shown in Table 3.

Result of the canonical correspondence analysis is shown in Figure 3. It can be deduced that electrical conductivity and total dissolved solids are closely associated and were the major water parameters that influence phytoplankton abundance and distribution in Aare Lake. Water hardness is orthogonal to pH gradient. The species ordination diagram depicts ordination pattern with continuous gradients along the first ordination axis with given value of 0.61 (34.07%) while that of axis 2 is 0.37 (20.94%). It shows that increasing gradients of electrical conductivity and total dissolved solids were strongly positively correlated which influence the species abundance of *Aphanocapsa*, *Scenedesmus*, *Mougeotia*, *Nostoc* and *Asterionella*. While *Coelosphaerium*, *Rivularia*, *Synedra*, *Oscillatoria*, *Richterella* and *Tribonema* are positively influenced by increasing gradients of water alkalinity, pH and phosphate. Increasing gradient of dissolved oxygen played significant role in the abundance of *Cladophora*, *Anabaena* and *Spirulina*

Table 2: Monthly mean variation of physico-chemical water parameters in Lekan Aare Lake, Abeokuta, Nigeria.

	Air temperature (°C)	Water temperature (°C)	Dissolved Oxygen (mg/L)	pH	TDS (mg/L)	Electrical conductivity (µS/cm)	Transparency (m)	Alkalinity (CaCO ₃ /L)	Hardness (CaCO ₃ /L)	Phosphate (mg/L)	Nitrate (mg/L)
July, 2013	24.8±1.17 ^b	27.3±1.86 ^b	5.3±0.65 ^a	7.7±0.71 ^{cde}	42.5±2.26 ^a	85.0±4.47 ^a	1.0±0.08 ^{ab}	2.3±0.82 ^a	20.0±7.18 ^{bc}	0.15±0.02 ^a	2.79±1.39 ^b
Aug	23.5±0.55 ^a	24.8±0.41 ^a	5.8±0.81 ^a	7.6±0.15 ^{abc}	42.0±4.77 ^a	84.7±8.48 ^a	1.0±0.05 ^{ab}	3.5±0.55 ^{ab}	15.3±9.61 ^{ab}	0.12±0.03 ^a	1.99±1.34 ^a
Sept	27.7±0.52 ^c	29.2±0.75 ^{bc}	5.7±1.16 ^a	7.7±0.61 ^{bcd}	44.8±1.94 ^a	88.5±4.23 ^a	1.1±0.05 ^b	3.8±1.17 ^{bcd}	10.8±3.00 ^a	0.07±0.04 ^a	3.36±1.97 ^c
Oct	28.0±0.89 ^c	30.2±0.41 ^{cde}	5.1±0.55 ^a	7.8±0.12 ^{cde}	47.5±2.35 ^a	95.0±4.90 ^a	1.0±0.05 ^{ab}	4.2±0.98 ^{bcd}	13.8±5.08 ^{ab}	0.04±0.03 ^a	3.5±10.91 ^c
Nov	29.7±0.52 ^d	32.2±0.75 ^e	5.1±0.64 ^a	7.3±0.17 ^{abc}	42.3±2.94 ^a	84.2±5.78 ^a	1.0±0.05 ^{ab}	3.8±0.98 ^{bcd}	12.0±1.79 ^a	0.03±0.01 ^a	4.06±0.59 ^d
Dec	28.3±0.82 ^{cd}	30.8±0.75 ^{cde}	5.1±0.44 ^a	8.2±0.25 ^{ef}	50.8±3.60 ^a	102.8±8.04 ^{ab}	0.9±0.06 ^a	4.2±0.75 ^{bcd}	13.3±1.63 ^{ab}	0.05±0.02 ^a	3.88±0.70 ^c
Jan, 2014	29.0±1.41 ^{cd}	31.3±3.82 ^{de}	6.1±0.76 ^{ab}	8.0±0.69 ^{def}	53.2±9.24 ^a	142.5±5.87 ^{ab}	1.2±0.18 ^c	3.7±1.03 ^{abc}	23.8±2.04 ^d	1.06±0.23 ^c	1.51±0.33 ^a
Feb	31.5±1.22 ^f	35.8±3.82 ^f	5.2±0.71 ^a	8.4±0.09 ^f	110.3±9.07 ^c	259.3±10.75 ^c	1.7±0.15 ^{ef}	5.0±0.89 ^d	21.8±7.49 ^{cd}	0.78±0.54 ^b	1.50±0.33 ^a
Mar	28.7±1.51 ^{cd}	31.5±0.55 ^{de}	6.3±1.15 ^{ab}	7.9±0.52 ^{cde}	86.7±5.92 ^{bc}	176.3±12.6 ^b	1.6±0.16 ^e	4.3±1.37 ^{cd}	23.7±7.66 ^d	1.11±0.19 ^c	1.41±0.12 ^a
Apr	27.5±1.76 ^c	27.5±1.05 ^b	7.4±0.69 ^b	7.1±50.27 ^a	79.5±4.07 ^b	173.7±12.11 ^b	1.7±0.08 ^{ef}	2.8±0.75 ^{ab}	41.5±6.47 ^f	0.12±0.02 ^a	2.84±0.70 ^b
May	30.3±1.37 ^{ef}	30.3±1.51 ^{cde}	7.3±2.24 ^b	7.1±0.41 ^a	43.7±1.21 ^a	86.8±2.93 ^a	1.7±0.08 ^f	2.8±1.33 ^{ab}	23.0±5.48 ^d	0.16±0.13 ^a	1.01±0.42 ^a
Jun	27.6±1.07 ^c	28.8±0.82 ^{bc}	6.4±1.03 ^{ab}	7.4±0.49 ^{abc}	43.1±1.20 ^a	85.9±22.40 ^a	1.4±0.06 ^d	4.3±1.63 ^{cd}	30.7±2.16 ^e	0.15±0.07 ^a	1.91±0.55 ^a

* Values with the same superscript along the column are not significantly different at p>0.05 level.

TDS = Total dissolved solids.

Table 3: Correlation co-efficient of physico-chemical water parameters in Lekan Aare Lake, Abeokuta, Nigeria.

	Air temperature (°C)	Water temperature (°C)	Dissolved oxygen (mg/L)	pH	TDS (mg/L)	EC (µS/cm)	Transparency (m)	Alkalinity (CaCO ₃ /L)	Hardness (CaCO ₃ /L)	Phosphate (mg/L)	Nitrate (mg/L)
Air temperature (°C)	1										
Water temperature (°C)	0.75	1									
Dissolved oxygen (mg/L)	0.06	-0.07	1								
Ph	0.07	0.38	-0.20	1							
TDS (mg/L)	0.41	0.36	0.11	0.14	1						
EC (µS/cm)	0.42	0.39	0.08	0.12	0.91	1					
Transparency (m)	0.43	0.23	0.49	-0.14	0.44	0.37	1				
Alkalinity (CaCO ₃ /L)	0.20	0.35	-0.11	0.23	0.17	0.21	0.01	1			
Hardness (CaCO ₃ /L)	0.05	-0.11	0.41	-0.14	0.37	0.29	0.61	-0.22	1		
Phosphate (mg/L)	0.28	0.37	0.00	0.40	0.37	0.38	0.38	0.23	0.15	1	
Nitrate (mg/L)	-0.16	-0.10	-0.34	-0.07	-0.24	-0.24	-0.54	-0.05	-0.27	-0.46	1

* TDS = Total dissolved solids, EC = Electrical conductivity.

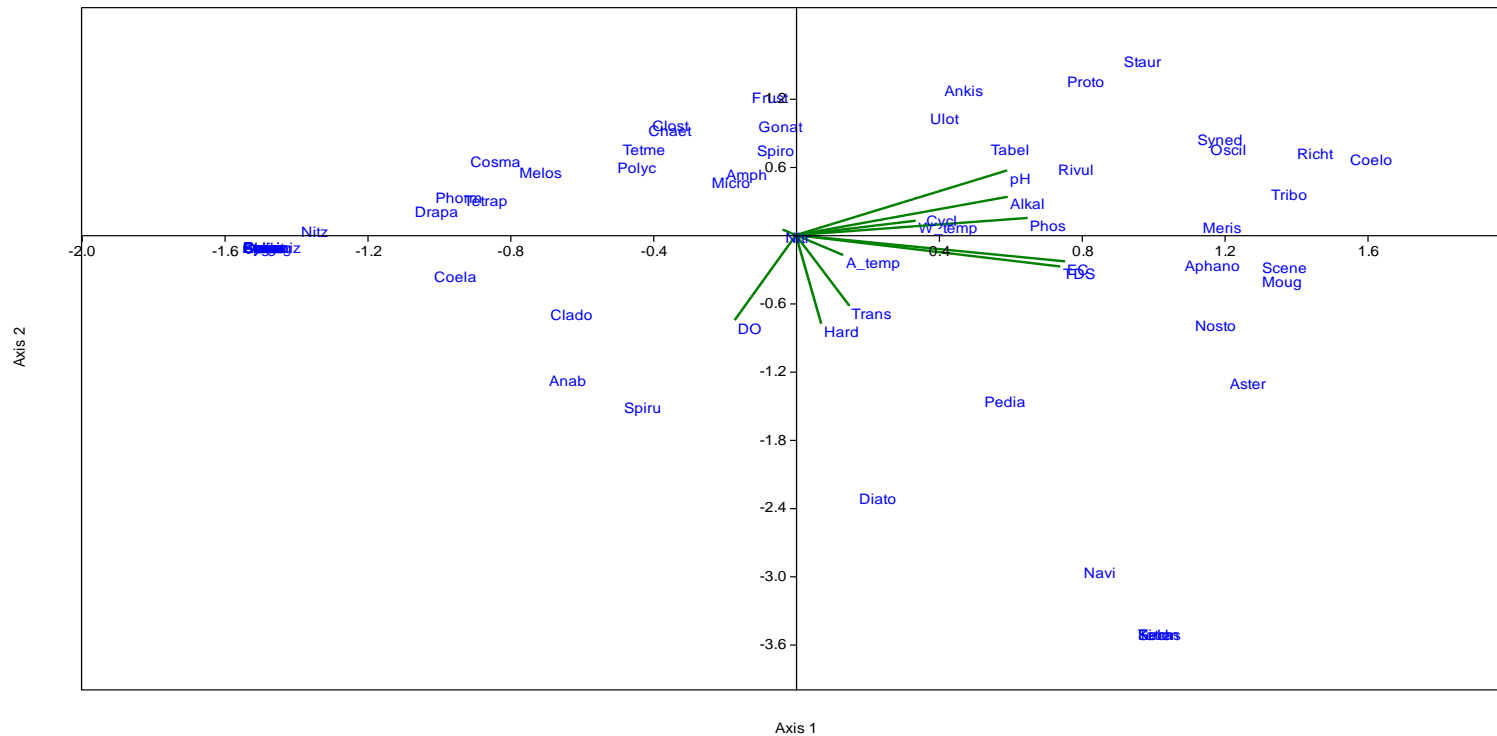


Figure 3: Biplot of the correspondence analysis of phytoplankton in Aare Lake, Abeokuta, Nigeria.

Amph (Amphora), Anab (Anabaena), Anki (Ankistrodesmus), Aphan (Aphanizomenon), Aphano (Aphanocapsa), Aste (Asterionella), Bulb (Bulbochaete), Chae (Chaetophora), Char (Characcium), Clad (Cladophora), Clos (Closterium), Cocc (Cocconeis), Coela (Coelastrum), Coelo (Coelosphaerium), Cosm (Cosmarium), Cruc (Crucigenia), Cycl (Cyclotella), Diat (Diatoma), Drap (Draparnaldia), Euno (Eunotia), Frag (Fragilaria), Frus (Frustulia), Gona (Gonatozygon), Kirc (Kirchneriella), Melo (Melosira), Meri (Merismopedia), Micr (Microspora), Moug (Mougeotia), Navi (Navicula), Nitz (Nitzschia), Nost (Nostoc), Oedo (Oedogonium), Osci (Oscillatoria), Pedia (Pediastrum), Phor (Phormidium), Poly (Polycystis), Prot (Protococcus), Rich (Richterella), Rivu (Rivularia), Scen (Scenedesmus), Sele (Selenastrum), Sora (Sorastrum), Spiro (Spirogyra), Spiru (Spirulina), Staur (Staurastrum), Suri (Surirella), Syne (Synedra), Tabe (Tabellaria), Tetm (Tetmemorous), Tetras (Tetraspora), Tribo (Tribonema), Ulot (Ulothrix), Zygn (Zygnema).

Discussion

Temporal variation in abundance and diversity of phytoplankton in the study might be due to the dynamics of physico-chemical water parameters, predation, competition for available resources and interaction between the living organisms in the system. Pasztaleniec and Poniewozik (2010) opined that phytoplankton plays a central role in the structure and functioning of freshwater ecosystems. According to Boyd (2000), species of phytoplankton that actually colonize a habitat depend on chance and suitability of the habitat for the growth of individual species. Kebede and Belay (1994) identified 100 species of phytoplankton in Awassa Lake, Ethiopia. Phytoplanktons play critical role in bioremediation of heavy metals and other toxicants (Pradhan *et al.*, 2008). It has been reported elsewhere that *Chlorella* was used to remove heavy metal contamination from water and soil. The observed decreasing gradient in phytoplankton abundance from rainy to dry months might be as a result of influx of nutrients load during the rainy season from farming areas adjacent to the lake. Rainfall is a major factor influencing phytoplankton production in inland waters and estuaries (Hong *et al.*, 2002; Robson and Hamilton, 2003). Tian *et al.*, (2013) noted that nutrient enrichment had a positive effect on the mean production rate of phytoplankton. High phytoplankton abundance in July suggested that most of the nutrients required for phytoplankton growth were available in the lake during this period. Composition of phytoplankton species in an aquatic ecosystem gives insight into changes in water quality than measurement of nutrient concentrations. To a large extent, phytoplanktons contribute to primary production and may have great influence on other components of the ecosystem (Pasztaleniec and Poniewozik, 2010). Qualitative and quantitative estimates of phytoplankton in aquatic ecosystem are highly influenced by the nutrient load. Pasztaleniec and Poniewozik (2010) reported that phytoplankton is one of the four biological quality elements required for the ecological status assessment of surface waters. Karr and Chu (1999) opined that biological monitoring schemes have advantages compared to chemical monitoring schemes. Such advantages include response of biotic organisms to intermittent pollution and integrating the effect of stressors over longer time scales (Lyche-Solheim *et al.*, 2013). Studies of phytoplankton diversity can be used in the pollution assessment of water bodies (Baba and Pandit, 2014).

Phytoplanktons are primary producers that support life and the knowledge of their spatio-temporal distribution provides insight to the dynamic of the aquatic ecological systems. In this study 54 phytoplankton species were identified which was relatively higher than 34 species

documented by Offem *et al.*, (2011) in Ikwori Lake, Nigeria. Abdul *et al.*, (2015) identified 42 in Ogun coastal estuary while Sharma *et al.*, (2015) reported 34 species in headwater stream of Garhwal Himalayas, 48 species in Lagos estuarine creek (Onyema, 2007), 32 species in Bonny estuary (Aujonu *et al.*, 2011), and 31 species in Lake Buhi, Philippines (Baloloy *et al.*, 2016). Meanwhile, 102, 89, 97, and 69 species were recorded in Lakes Masłuchowskie, Sumin, Głębokie and Rotoze respectively in Poland (Pasztaleniec and Poniewozik, 2010). This variation in species taxa might be as a result of differences in time of sampling and regional location of the study areas.

Chlorophyceae was most prominent in the lake followed by Bacillariophyceae, Cyanophyceae and Xanthophyceae in abundance. This result was similar to the observation of Shashikala and Anita (2014) in Vishrale, Krishnale and Dewale Lakes, India and Casterlin and Reynolds (1977) in a temperate lake. Desy *et al.*, (2005) reported Chlorophyceae as the most dominant phytoplankton group in Lake Tangayika. Chlorophyceae and Bacillariophyceae (Chaudhary and Pillai, 2009) were dominant groups in Sasthamcottah Lake, India and Kuinet dam, Kenya (Omondi *et al.*, 2014). Phytoplankton composition and abundance are natural biological indicators of variations in water quality because of their sensitivity and rapid response to fluctuations in environmental conditions (Panda *et al.*, 2012; Stanca *et al.*, 2013). Limbu and Kyewalyanga (2015) stated that species composition of phytoplankton; relative abundance, spatial and its temporal distribution are indices of the biological integrity of an aquatic ecosystem. Phytoplankton composition and abundance in African lakes often reflect their nutrient status (Ndebele-Murisa *et al.*, 2010). Ishida *et al.*, (2006) associated the growth of *Spirogyra* with increase in water temperature in Lake Biwa, Japan. Also, Liang *et al.*, (2016) and Garcia-Rodriguez *et al.*, (2015) reported that *Spirogyra* was responsible for production of methane in streams and removal of pharmaceuticals and endocrine-disrupting chemicals in treated wastewaters. The ultimate compositions of phytoplankton culminate from the balance between gains and losses within the pool of present species adapted to survive in that particular aquatic ecosystem (Reynolds, 1997). Among other factors, nutrient concentrations was reported as forces distinguishing among phytoplankton species thereby selecting those better adapted to a particular aquatic environmental condition (Anneville *et al.*, 2004). According to Forsberg (1982), understanding of energy turnover in aquatic ecosystems is influenced by species diversity, abundance, distribution and variation of the biotic

components of the systems. High variability in the distribution and structure of planktonic populations, which can be spatially and temporally heterogeneous, are induced by land and water circulation (Marques *et al.*, 2007).

Parameters such as temperature, pH, dissolved oxygen, nitrate and phosphate concentrations are important indicators of water quality for natural productivity (Odulate *et al.*, 2016). Water temperature is one of the important physical characteristics in aquatic environments that regulate life processes. Increase in the rate of photosynthesis in aquatic medium is directly influenced by rise in water temperature which provides adequate amount of nutrients. Water temperature plays significant role in the presence, abundance and distribution of biotic organisms in aquatic environments. According to Huang *et al.*, (2005), origin, availability and mobility of ions and their different forms in water bodies are regulated by pH. Photosynthetic activity relatively affects pH, causing water to become alkaline which could be as a result of increasing release of carbon dioxide (CO₂) into the environment. Water pH could affect aquatic organisms because most of their metabolic activities are pH dependent (Wang *et al.*, 2002). In natural waters, increase in alkalinity leads to increase in phytoplankton and fish production (Boyd, 2000). Vegetation cover on water surface reduces dissolved oxygen (Welcomme, 1985) which can be attributed to reduce solar energy obtained from the sun. Deekae *et al.*, (2010) reported that increase in water conductivity could be as a result of rise in concentration of ions by evaporation and increased organic matter mineralization. They further stated that nitrate value in aquatic ecosystems may possibly be high due to increase in the degradation of organic matters by microbial activities. The types of organism that inhabit a particular aquatic ecological systems are influenced by physical and chemical characteristics of the environment such as temperature, shelter, transparency, water flow and nutrient concentrations among others. The organisms that are able to adapt to the conditions of a particular habitat and utilize the available resources in the system will thrive.

The limiting nutrient concentrations depend and vary with phytoplankton community structure, location and season (Fisher *et al.*, 1992). Phosphate has been identified as major organic nutrients that can limit the phytoplankton population in tropical waters. Submerged aquatic vegetation in shallow lakes, plays prominent role because it indirectly influences water transparency and phytoplankton biomass in many ways (Havens and Gawlik, 2005). Water transparency is influenced by nutrients, total suspended solids and algae in the water column which plays a major role in controlling growth of submerged aquatic

vegetation. High water transparency aids visibility of higher trophic organisms in the ecosystem and make the organisms at lower food chain susceptible to the predators. Annual pattern of phytoplankton seasonality in African lakes are usually dominated by hydrological and hydrographic features (Talling, 1986). Seasonal changes in mean temperature, radiation and nutrient availabilities are the most important variables which determine phytoplankton composition and abundance (Reynolds, 1990; Marinho and Huszar, 2002). Ecologically, the relationship between ecosystem functioning and biodiversity is a central issue (Tian *et al.*, 2017).

The essence of canonical correspondence analysis (CCA), an ordination statistics, is to express the (dis) similarity between species based on the values of the variables associated with each of them so that similar species are shown near from each other and dissimilar species are positioned further apart from each other (Ramette, 2007). Ordination method, according to ter Braak and Verdonschot (1995), extracts, maximise and separate niche gradient of the measured environmental variables among species and that CCA has been widely used in aquatic sciences. CCA is frequently used to identify environmental gradients in ecological researches (Barker, 1994). ter Braak and Verdonschot (1995) opined that it provides general framework for statistical testing and estimation of effects of environmental other explanatory variables on biological communities. It shows how multitudes of species simultaneously respond to external environmental variables using data-sets from observational studies. In addition, it is a means of detecting relationships between species composition and environment (ter Braak and Prentice, 1988).

Conclusion

The understanding of basic components of aquatic ecological systems and the interaction among living organisms with their environment can lead to better management of human impacts on these systems. These properties can change as a result of natural and human related processes. At the base of food chain, phytoplanktons are responsible for energy transfer from the lower to higher trophic level in the aquatic ecosystems. They are also important in conversion of inorganic to organic substances which are readily made available for primary consumers. Human survival depends on many aquatic plants and their ecological functions. Hence, sustaining their biodiversity is essential to the health of our environment and to the quality of human life. This information would be helpful in the ecological monitoring of this ecosystem.

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