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Physicochemical and periphyton/phytoplankton study of Onah Lake, Asaba, Nigeria

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ABSTRACT: The physico-chemical parameters and periphyton composition of Onah Lake was monitored. The data obtained revealed that the concentration of all the nutrients were higher during the dry season than the rainy season. The observation connotes a discernible seasonal pattern in the concentration of the various nutrients in the lake. With the exception of transparency, total alkalinity and conductivity, that were significantly different ($P<0.05$), all other parameters were not significantly different ($p>0.05$) in the stations. Transparency was significantly lower in the upstream station as opposed to the down stream station that recorded a high value. The condition favoring the abundance of nutrients was discussed.

The principal component analyzer generated a sequence of variates known as components in a correlation matrics. Three components were selected which account for 100% of variance in the physico-chemical parameter, viz: ionic conductivity factor contributed 26.07%, nutrient factor contributed 40.61% while dissolved oxygen factor contributed 33.32%.

Three division, eight families and ten species of periphyton were encountered. The most abundant periphyton species recorded are *Closterium* spp (26.37%) *Cosmarium* spp (18.63%) and *Ulothrix* spp (16.56%). The least species encountered was *Anabaena* spp (2.88%). This was not implicated in any toxic bloom.

Keywords: Onah Lake; Nutrients; Physico-chemical parameters; Periphyton composition.

Introduction

Notable research on the limnology of lake systems (Nijasa, Tangayika, West Cameroon Craker, Kainji, Sonfon, Tchad and Niger lakes) date back from the early fifties (Araoyo,2002). These lakes are not only susceptible to man’s activities but are replict with optimal nutrient composition, adequate temperature regime and sufficient daylight periodicity, most adequate for algal growth throughout the year (Imoobe and Oboh, 2003). In Victoria Lake, a moderately high productivity was recorded by efficient mixing of nutrients mediated by wind action in its extensively shallow basin. George Lake in Uganda typifies a rather special kind of equatorial water body where phytoplankton growth was dominant throughout the year arising from favorable temperature regime. The frequent monitoring and evaluation of physico-chemical characteristics of lakes enable one to understand its tropic status with a view to establish the level of pollution, its impact on periphyton/plankton, the influence of the surrounding agricultural ground and fishing activities on the aquatics (Adeogun, *et al.*, 2004). Some periphyton are sensitive indicators of water quality assessment and produce the early warning signal of water pollution (Browder, *et al.*, 1998).

Periphyton composition have been governed by water quality parameters. The relationship water quality share with periphyton is reciprocal as the later strongly influence water quality through carbon-iv-oxide uptake, oxygen production , calcite precipitation and co-precipitation of phosphorus, the key nutrient responsible for eutrophication. Phosphorus limitation radically altered periphyton structure and composition (Quall and Richardson, 1995). Periphyton are an essential component of the aquatic food chain. They are the primary producers in freshwater bodies including lakes where different forms are present in various locations viz: epilithic (rock) epipsamic (mud), epiphytic (plant), epipelic (sediments) and epizoic (animals) forms (Kadiri,2002).They constitute a heterogeneous assemblage of algae whose distribution and seasonal succession are of interest to limnologist. This is why they do not only influence the food chain but are also of economic value and biological significant to man. Researches on them have contributed significantly to the impact of anthropogenic activities on them (Arayo, 2002). It is therefore proper that their spatio-temporal occurrence, composition and abundance be matched with opportunities provided in their environment. This accounts for the array of periphyton species displayed in each tropic spectrum.

The present study is an attempt to reduce the information gap and contribute to our current knowledge of the limnology and periphyton diversity of Onah, Lake, Asaba, Nigeria. The need for such study became important especially to provide opportunity for monitoring changes in the chemical content and algae composition of the lake water system. These will go a long way, as it would influence the socio-economic well being of the communities found in the immediate vicinity of the lake and beyond.

Materials and Methods

The Study Area:

Four adjuring streams located in Ugbolu town bound Onah Lake, which stretches beyond the Delta State University, Asaba Campus, in the North. On the South is Anwai River, on the West is a stretch of the campus, mile 5 and Ugbolu town while on the East is River Niger (Olele and Obi, 2003/2004).

The headwater streams of the lake are Iyiocha-Uno and Odo-Ogolo which join North of Ugbolu town. From this confluence the stream flows eastward a Oto-Oshushu stream before flowing southward as Uto stream into the lake. Three sampling stations located at about 3.4km intervals were chosen. The lake cover a total distant of 10.00km which translates to a surface area of 52.20 hectares. The lake which is a perennial one, is completely cut off from the streams and from the Niger and Anwai rivers during the dry season except during the rainy season when the lake, the entire rivers and streams overflows their banks inundating the adjoining floodplain. When the flood recedes as the dry season sets in, the lake forms three characteristic compartment popularly called Ododo, Ogbu and Obabala Onah designated as upstream, midstream and downstream portions and labeled as station A,B and C. The effect of the wind is minimal especially during the dry season but the intense solar radiation results in thermal stratification of the surface water.

Station 'A' is the widest and shallowest compartment. It is dominated by floating macrophytes. It's mean width is 450.0 meter with a mean depth of 12.13 meters . Station 'B' is the longest, narrowest and deepest, with a mean width of 88.5meters and mean depth of 16.3 meters. It is characterized by sparse human settlement around the floodplain. Active farming is carried out on the floodplain during the season where crops such as groundnut, yam and quick maturing variety of cassava are cultivated. The crops are harvested just before the flood sets in. The remains of the crops are left to decompose and then washed during the flood into the lake as allochthonous nutrients. Station 'C' represents the deeper and shallower compartment. A mean width of 100.5 meters and a mean depth of 12.84 meters characterize it. It is doted with pockets of depressions where fishes feed and breed.

Meteorological condition within the study area was obtained from the Federal Ministry of Aviation Meteorological station located in Asaba campus as follows: annual temperature range between 22.0-30.1^{o}C, annual rainfall range between 126.1-280.3mm and relative humidity range at 10.00am was between 15.0-87.0mm. The annual dry season months span through October to April while the rainy season began in May and ended in September, with a characteristic one week August break during which rainfall abates.

Modified tropical rainforest vegetarian surrounded the lake with aquatic macrophytes (*Nymphea lotus, Azolla pinnata, Pistia stratiotes, Salivina nymphellula* and *Panicum subalbidium*) growing within the lake.

Sampling and analysis

Water samples were collected at monthly intervals in an acid washed (10¯¹) polyethylene container, between 0900 and 1300hrs on each sampling day for 12 months lasting from January to December 2003. Temperature was determined *in-situ* with mercury in glass thermometer, measuring 0-50°c. The hydrogen-ion-concentration (pH) was determined by using a hand held sigma Hanna Checker pH meter. Conductivity was determined using WPA conductivity meter. Transparency was measured *in-situ* with an all white secchi-disc while dissolved oxygen was determined by Winkler's titrimetric method. Total alkalinity was analyzed using phenolphthalein and mixed indicators. Nitrate, phosphate and potassium were determined using the corning Flame Photometer (Model 400). Calcium and Magnesium were estimated by titrimetry using EDTA method (APHA, 1989).

Periphyton were scraped from boulders, rocks, mud, sand sediments, plants and substratum and preserved in 4% formalin for further analysis.

Physico-chemical parameters were analyzed to determine means, range and standard deviation. The New Duncan Multiple Range Test, was used to determine the location of significant different at $p<0.05$. The raw data was further subjected to a multivariate computer assisted statistical package equipped with the principal component Analyzer (PCA) that applies the soft ware stat view 513+. This analyzer generated a sequence of variates known as components in a correlation matrix (Omori and Ikeda, 1984). The components analyzed were the mathematical transformation of the original set of variables to a new set which being orthogonal (uncorrelated) summarizes the linear relationship exhibited in the data.

Results

Water temperature fluctuated between 20.0-30.1^{o}C (table 1) being higher during the dry season and lower in the rainy season. There was no significant difference ($p< 0.05$) in water temperature, observed in the stations (Table 2) although the upstream station 'A' was warmer than the downstream station 'C' at all times especially during the dry season. Solar radiation gave rise to thermal stratification of the surface water. The highest average temperature (27.41^{o}C) was recorded in station 'B' while the lowest average (26.85^{o}C) was recorded in station 'C' (Table 1). There was a slightly marked seasonality. The lake had a morph- edephic index (ME1) of 6.24 in the wet season and 10.75 in the dry season.

The hydrogen-ion-concentration (pH) ranged between 6.03-7.79 units. Slight acidic pH was recorded in all stations but with a tendency towards neutrality and alkalinity after the rains. Acidic pH (6.03- 6.20) was recorded in the month of May, June and July 2003, while November and March recorded neutrality to alkaline pH values (7.05- 7.79) in all the stations. There was a clear pattern of seasonal change in the pH value although; the changes were not significantly difference ($p>0.05$) amongst the stations (Table 2).

Temporal and spatial variation in the transparency was expressed in percentage of the water depth at the sampling stations. At station 'C' (downstream) visibility was highest but lowest in station 'A' (upstream). High water transparency was recorded for eight out of twelve months of the study period except in May, June, July and September 2003, when the lowest transparency was recorded during the month of heavy rain/flood. Statistically, there was a significant difference ($p<0.05$) (Table 2) in transparency records, thus demarcating the lake into an upper clear and lower dark turbid water.

The lake recorded dissolved oxygen concentration between 2.00 and 11.3mgl^{-l}.There was a distinct seasonal pattern but no spatial variation in the oxygen concentration of the lake. The highest value occurred in the month of March in the stations. The least values was recorded in the month of April 2003 when the water temperature record was the highest at the various stations. There was no significant difference ($p>0.05$) in the concentration of dissolved oxygen recorded at the stations (Table2).

The range of total alkalinity was during the study was (6.50-43.00mgl^{-1}) Table1. Low alkalinity was recorded during the rainy/flood months of May, June, and September at the stations. The reverse was the situation during the dry season. Statistically, there was a significant difference ($p<0.05$) in the level of this parameter (Table 2).

Table 1: Physico-chemical parameters of Onah lake, Asaba, Nigeria. (mean values +-SD. Range in parameters).

PARAMETERS	STATIONS A	B	C
Temperature °c	27.37± 0.23(22.5-29.4)	27.41± 0.25(24.2-30.0)	26.85± 0.17(25.7-30.1)
pH	6.54± 1.2 (6.20-7.79)	6.84 ±0.8 (6.03-7.64)	5.95 ±0.3 (6.11-7.655)
Transparency (cm)	32.33± 3.5 (15.0-60.7)	36.79± 2.6 (10.0-65.6)	38.3± 2.9 (8.0-72.0)
Dissolved oxygen (mgl^{-1})	5.0±0.73(2.75-8.40)	5.54±0.92(2.0-11.34)	4.6±1.30(2.41-9.45)
Total alkalinity (mgl^{-1})	24.0±1.51(6.50-38.91)	26.30±1.2(9.2-33.73)	28.59±1.30(0.73-3.80)
Conductivity (μScm^{-1})	51.2±6.08(25.50-77.50)	48.3±5.48(35.10-74.1)	45.3±4.48(17.7-60.1)
Magnesium (mgl^{-1})	1.79±4.5(0.57-3.82)	2.34±5.3(0.77-3.86)	2.07±3.0(0.73-3.80)
Calcium (mgl^{-1})	3.32±2.2(0.80-0.70)	3.68±0.96(0.05-9.00)	3.76±1.4(1.30-9.95)
Potassium (mgl^{-1})	0.26±0.19(0.15-0.33)	0.08±0.05(0.11-0.25)	0.21±0.08(0.11-0.32)
Nitrate (mgl^{-1})	0.61±0.08(0.61-0.92)	0.63±0.1(0.12-2.00)	0.61±0.08(0.52-0.71)
Phosphate (mgl^{-1})	0.80±0.04(0.12-2.87)	0.69±0.1(0.12-2.00)	1.00±0.03(0.10-4.13)

Source: Field Survey 2003.

Tables 2: Analysis of variance for physico-chemical parameters of Onah Lake.

PARAMETERS	STATIONS A	B	C	REMARK
Temperature ˚c	26.54	26.59	26.40	P>0.05
pH	6.82	6.91	6.98	P>0.05
Transparency (cm)	40.33a	44.65^{ab}	50.48ab	P<0.05
Dissolved oxygen (mgl^{-1})	7.08	5.44	5.13	P>0.05
Total alkalinity (mgl^{-1})	26.85^{ab}	28.34^{ab}	31.90b	P<0.05
Conductivity (μScm^{-1})	52.75^{ab}	51.28^{ab}	47.28^{a}	P<0.05
Magnesium (mgl^{-1})	2.01	2.04	2.07	P>0.05
Calcium (mgl^{-1})	4.32	4.68	4.75	P>0.05
Potassium (mgl^{-1})	2.21	1.54	2.00	P>0.05
Nitrate (mgl^{-1})	0.38	0.33	0.32	P>0.05
Phosphate (mgl^{-1})	0.84	0.73	1.13	P>0.05

Means with the same superscript are not significant different (p>0.05) while those with different superscripts are (p<0.05). Source: Field Survey 2003.

The range of the concentration of the cations (Mg^{2+} and Ca^{2+}) was also shown in Table1. The highest in Magnesium concentration was in station B while the lowest was in station C. The highest concentration in Calcium was in station C while the lowest was in station A. There was no significant difference ($p>0.05$) in the concentration in both cations (Table 2).

The dry season month experienced high conductivity, the reverse was the situation during the rainy season. There was a significant difference ($p<0.05$) in the record of conductivity in the stations. The highest conductivity was recorded in station 'A' while the lowest was in station 'C'.

The record of Potassium, Nitrate and Phosphate concentrations are also shown in Table 1. There was no significant difference ($P>0.05$) in their concentrations, in the station although the dry season concentration was higher than the rainy season concentrations, thus depicting seasonality.

Table 3 shows the Varimax-Rotated Component Matrix of physico-chemical parameters. Three components were selected which accounted for 100% of variance in the data. The first component accounted for 26.07%of variations with ionic conductivity (0.866) and water transparency (0.582) contributing the highest values in that order. Water transparency recorded a lower positive loading on this component. It can be referred to as the ionic conductivity factor. The second component was associated with nutrient composition, otherwise known as the nutrient factor. Total alkalinity (0.769) recorded the highest positive loading being followed by Calcium, Magnesium, Phosphate, Nitrate and Potassium in that order. This component accounted for 40.61% variation. The third component accounted for 33.32% variation. It was associated with dissolved oxygen (0.724) temperature (0.611) and pH (0.541) (Table 3). This can be referred to as the dissolved oxygen factor which incidentally recorded the highest loading on the component (Table 3).

Table 3: Principal component matrix of physico-chemical parameters in Onah Lake, Asaba, Nigeria.

	COMPONENTS		
PARAMETERS	1	2	3
Temperature	-0.286	-0.206	0.611
pH	0.122	0.064	0.541
Transparency	0.582	0.182	-0.245
Dissolved oxygen	-0.089	0.265	0.724
Total alkalinity	0.186	0.769	0.212
Conductivity	0.866	0.036	0.021
Calcium	-0.012	0.662	0.353
Magnesium	0.102	0.531	0.272
Potassium	0.112	0.331	0.037
Nitrate	0.187	0.490	0.191
Phosphate	0.063	0.525	0.125
Variance contribution	26.07%	40.61%	33.32%

Source: Field Survey 2003.

Table 4 shows that three divisions, eight families and ten species of periphyton were identified in Onah Lake during the study. The periphyton abundance and percentage composition was recorded in this table. The chlorophyta division recorded the highest composition/diversity and abundance (74.17%) while the cyanophyta recorded the least abundance (16.56%). *Closterium* species had the highest singular positive contribution (26.37%) to the periphyton assemblage of the lake while *Fragillaria* species (2.75%) contribution the least abundance in species composition. The most abundant species were the diatoms and dinoflagellates. There was a definite pattern of increase in periphyton abundance from month to month. The dry season months recorded a higher abundance than the wet season months. Station 'A' which had the highest influence from human activity as well as having the most encountered substratum, where the algae were scraped, recorded the highest diversity and abundance. Station 'B' was intermediate while station 'C' recorded the least composition.

Table 4: Periphyton assemblage of Onah Lake during the study period.

	Periphyton Assemblage	Total Abundance Per cm^{-3}	Percentage Abundance %
DIVISION	CHLOROPHYTA (Green algae)		
FAMILY	Scenedesmaceae *Scenedesnnis* spp	2000	9.17
FAMILY	Ulotrichaceae Ulothrix spp	625	2.88
FAMILY	Desmidiacae Clostrium spp *Cosmarium* spp	5,750	26.37
FAMILY	Zygnemataceae *Spirogyra* spp	4,062	18.63
DIVISION	BACILLARIOPHYTA (Yellow algae)	0750	3.44
FAMILY	Coscinodiscaceae *Coscinodiscus* sp	0780	3.58
FAMILY	Diatomaceae *Fragillaria* sp	0600	2.75
FAMILY	Naviculaceae Navicula sp *Pinnularia* sp	1,000	4.58
DIVISION	CYANOPHYTA (Blue green algae)	2,625	12.04
FAMILY	Nostocaceae *Anabaena* sp	3,610	16.56
	Total	21,802	100%

Source: Field Survey 2003.

Discussion

The marked value recorded for physico-chemical parameters may be due to ecological factors, periphyton density, concentration of organic mater and other related factors (Adeogun *et al*., 2004). In the tropics, water temperature variation is governed by climatic conditions. Rainfall and solar radiations are the major climatic factors that influence most physico-chemical hydrology of water bodies (Kadiri, 2000a and Odum, 1992). Solar radiation is dependent on duration and intensity of iridescence received daily by the water body. This intensity may be modified by variations in phytoplankton species composition and diversity, cloud cover, rives inflow, water flow, surface area, depth, wind velocity, solid matter suspension and tidal changes. Tidal changes was implicated for high concentrations of plankton (John, 1986) during the dry season when low tide, high temperature and intense sunlight lead to high periphyton productivity. All of these factors influence daily fluctuations in water temperature (Adeogun *et a*.,2004, Atoma, 2004) .

However, the absence of pronounced seasonal variation in surface water temperature is because water has a great specific heat capacity, hence, the daily radiations received hardly brings about significant fluctuation (Imoobe and Oboh, 2003).It takes time before 1^{oC} of heat radiation is gained or loss at the water surface due to the slow response of water bodies to heat radiation. According to (Egborge *et al.* , 1986) vertical temperature gradient (homoeothermic condition) was the condition in small lakes where temperature was uniform in the entire water body. On the contrary, longitudinal temperature gradient was common in bigger lakes.

Monthly variation in water temperature was more pronounced in the dry season especially in April compared to the situation in December due to intensified heat radiation and effect of harmattan respectively. Algae productivity in the month of April was the highest resulting from sufficient nutrient enrichment of water in conjunction with adequate solar radiation (Opute, 2000). The range in water temperature during the study ($22.0\text{-}30.1^{oC}$) compares well with values reported in Oguta Lake (27.0-28.9°c) and in Jebba Lake ($27.6\text{-}28.0\ ^{oC}$) (Ovie *et al.*,2000). High water temperature fluctuations revealed a direct opposite relationship with dissolved oxygen concentration as was observed in the present study. The low water temperature observed in January, February and December could have resulted from the cool dry North East trade wind effect (Ovie *et al*., 2000) and the time of the day sampling was conducted. Moderate temperature at this time resulted in the ability of water to absorb and retain more oxygen.

Generally, a low pH value was indicative of the presence of weakly ionizing acids, a high level of carbon –iv-oxide and an oligotrophic water body (Oseni, 1984). The limit of pH recorded in this study indicates that it was only slightly acidic with low alkaline conditions. There was a decrease in hydrogen-ion-concentration at the stations during the rainy/flood session. This is in consonance with the observation that pH of lake is low during the rain/flood season as a result of the influx of acidic ions from the surrounding forest, high carbon-iv-oxide, decomposition and mixing brought about by wind and tide. On the contrary, (Kolo, 1996) reported high pH values during the rains due to water volumes and greater water retention period. According to him, high pH enhance decay process. The record of pH in the present study (6.03-7.79) compares well with those of Lake Tchad (7.6-8.0), Tiga Lake (6.9-7.6), Shiroro Lake (6.7-7.0) and Volta Lake (6.8-8.06) (Kolo, 1996).

Water transparency varied directly with rainfall. Dry season was characterized by absence of flow velocity, flood, surface runoff, settling effect of suspended particles, non-tidal waves and non-organic/detrital transport which gave rise to high transparency, increased food abundance, high photosynthetic activity and vise-versa (Biwas, 1984, Baijot *et al*., 1997 and Atoma, 2004). This was the situation in the present study. The condition experienced during the rainy season, a period characterized by high turbidity, impeded light penetration, moderate phytoplankton generation and high decomposition, which resulted in decrease in oxygen concentration (Biwas, 1984).

Transparency is inversely proportional to the abundance of plankton, hence an increase in plankton abundance, reduced transparency (Atoma, 2004). Suspended materials, which cause low transparency, absorb the blue-green light spectrum while allowing the red part of the spectrum to penetrate to greater depth (Ovie, *et al*., 2000). The transparency recorded in the present study (8.0-72.0cm) is higher than those recorded in lakes Oguta (0.61-4.0cm); Kainji (0.80-2.44cm); Tchad (0.41-0.92cm) and Dadin Kowa (3.4cm). The lowest transparency recorded in Tchad was attributed to the underlying bedrock, human and livestock activity and dust carried by wind. Several pattern of transparency was more obvious in small lakes due to rain, evapo-transpiration, percolation and water supply for human population. Larger lakes experience these conditions to a lesser degree (Ovie *et al.*, 2000). Water transparency is an important physical parameter that affects algae community. It determines the depth of the photic zone and consequently affects the lower limit of light penetration. This lower limit is the limit of algae photosynthetic activity, which was a major influence on the primary productivity of the lake. Increased turbidity from floodwater decreased transparency and phytoplankton production (Adeniji *et al*., 1997).

The dissolved oxygen concentration of the lake revealed that, it was well aerated irrespective of season and station. This was expected because of the presence of periphyton macrophites, phytoplankton, surrounding derived forest zones, direct diffusion at the surface and various forms of surface water agitations (waves and turbulence) (Kolo,1996 and Baijot *et al*., 1997). Oxygen concentration was highest especially during the dry season as a result of the abundant oxygen contributed by plants during photosynthetic activity, which contributed in oxygenating the water column and at the same time reducing respiration by aquatic organisms and decomposition processes at the lake bottom. This observation was experienced during the present study. Oxygen concentration recorded in the present study ($2.00\text{-}11.34 mgl^{-1}$) compares well with records of Asa Lake ($3.4\text{-}7.3 mgl^{-1}$); Kainji Lake ($3.0\text{-}17.8 mgl^{-1}$); Shiroro Lake (2.0-

6.2mgl^{-1}) and Tiga Lake (0.3-7.8mgl^{-1}) (Adeniji *et al*., 1997). However, low primary productivity caused by low transparency and low nutrient load was implicated for low oxygen content of the water body (Kadiri and Omozusi, 2002).

Low total alkalinity was recorded during the rains, although (Kadiri, 2000) reported high values during this period. Low values recorded during the rains resulted from low photosynthetic activity. The range of alkalinity recorded for the present study was (6.50-43.00mgl^{-l}) and was higher than that reported in Oguta Lake (7.5-28.75mgl^{-1}) but lower than the value reported in Eleiyele Reservoir (55.0-80.0mgl^{-l}) (Atoma, 2004).

Conductivity has been viewed as an index of fertility and productivity. Water mixing caused gradual increase in conductivity during the dry season, which was attributed to carbon –iv- oxide release from accumulated organic matter decomposition. Conductivity and accumulation of minerals varied considerably depending on the season and on the water body (Baijot *et al*.,1997). High conductivity and alkalinity were indicative of high levels of ionic concentration. This was the situation in the present study. The relatively high conductivity recorded during the study may be attributed to the predominance of non-leached substratum and the large size of the catchments area (Kadiri, 2000) flood plains and connecting river/steams.

Low levels of dissolved solutes impair ionic exchange, which is attributed to the underlying solids in an area (Adeniji *et al*., 1997). The current status of nutrient composition in Onah Lake may have emanated from allochthonous decomposition of organisms, which contributed sufficient nutrients that gave rise to the present diversity of plankton. According to Bankole and Adikwu (1999) the amount of nutrient got during the rains through the allochthonous sources could be cyclic depending on the volume of water and human interference. Variation in conductivity is an indication of the extent to which the lake circulates nutrients, especially in a nutrient rich lake. The situation in the present study was such that increased conductivity during the dry season was enhanced by increased water evaporation and upwelling from wind, wave and tide. In view of these activities, the ionic concentration of lake systems could become highly variable with records of (15-24µScm^{-1}) in Opi Lake, Enugu State; 10-25µScm^{-1} in Lamingo Lake, 10.0-38.0µScm^{-1} in Liberty Reservoir and 2,400-8,200µScm^{-1} in Jakara Reservoir, Kano State (Biwas, 1984 and Adeniji *et al*., 1997). On a comparative basis, Onah Lake which recorded (17.7-77.5µScm^{-1}) is said to have high conductivity arising from the rich nutrient content of the lake.

A seasonal increase in the concentration of nutrients (calcium, potassium, nitrate, phosphate and magnesium) was associated with inflow from water drainage during the rains (Atoma, 2004). Kemdirim (2000) reported trace composition during this period asserting that the rains helped to dilute concentrations. Higher concentration of nutrients was recorded during the dry season in the present study arising from concentration of nutrients from various sources such as the incidence of indiscriminate cow droppings at such times they visit the lake to drink water along the shallow parts of the lake especially in stations `A´ and `C´. The use of fertilizers by farmers in the drainage basin (station B) including the use of detergent especially during the dry season, all lead to high concentration. Additional nutrients may have been derived from the decomposed organic matter remains of plants, animal and sewage, releasing more nutrients whose concentration becomes more pronounced as result of evaporation (Odukuma and Okpokwasili, 1993), although it was also argued that algae proliferation during this period depleted nutrient concentrations. The low concentration of phosphorous recorded during the study could be supported by the assertion that over 90% of the element was buried at the bottom sediment (Ovie *et al.,* 2000). Low concentration of phosphorous was therefore recorded 0.14mgl^{-1} in Victoria Lake and 0.03mgl^{-1} in Tiga Lake. Low concentration was also recorded for nitrates as follows: 0.12-2.24mgl^{-1} in Oguta Lake and 0.06-14.8mgl^{-1} in Shiroro Lake (Kolo, 1990). Dissolved phosphates have been the most widely available form of inorganic phosphate for phytoplankton growth and with nitrate were reported as limiting nutrients (Reynolds, 1998).

The algal species that eventually proliferate in the lake must not only be able to tolerate conditions of nutrient limitation but should be able to withstand and utilize other sources of nitrogen to their advantage. Low nitrate level was attributed to sedimentation and low pH, which was responsible for the reduction of nitrate to nitrite. The low levels of phosphate and nitrate recorded in the study may have contributed to the reduced abundance in the periphyton recorded in the present study. Both nutrients according to (Ayoade, 2000) are beneficial for algae productivity. High concentration in other nutrients (magnesium, calcium and potassium) was also observed during the dry season, which was attributed to evapo-transpiration while the rainy season's low concentration was due to dilution. Records of calcium in Kainji Lake (3.0-11.2mgl^{-1}) and Ikpoba Reservoir (5.5-14.8mgl^{-1}) were lower than that of the present study. The higher concentration of calcium than magnesium could be due to accumulation of soap and detergent used for washing. The record of low concentration of nutrients generally has significant implication for nutrient dynamics and phytoplankton composition (Kadiri, 2000a).

Periphyton species occurrence, composition and diversity was influenced by water chemistry/nutrient composition, temperature gradient, light intensity and predator level of the lake. The periphyton species diversity recorded during the study was remarkable arising from the nutrient rich water body and slight acidic nature of the lake.

Five important parameters were responsible for the optimal level of periphyton abundance namely temperature, dissolved oxygen, transparency, pH and total alkalinity. Chlorophyllous plants utilized the calcium because it was a vital macronutrient required for proper functioning in the aquatic food chain (Ovie *et al*., 2000). The relative importance of nutrients varies considerably among different taxa. The algae assemblage of Onah Lake indicated that chlorophyta recorded the highest division. The association of desmids whose order of abundance is as follows: Closterium > Cosmarium > Micraasteria was also reported in Opi Lake Enugu and in some Southern Nigeria rivers (Biwas, 1984; Kadiri and Omozusi, 2002). The proliferation of desmids was probably made possible by the not too high conductivity, low calcium level and slight acidic nature of the lake.

The general low mineral content during the rainy season was due to concentration through evaporation. The occurrence of these algae groups was an indication that the water body was relatively unpolluted (Kadiri and Omozusi, 2002). Generally, the reported high diversity of desmids in West Africa water bodies was due to the prevalence of high rainfall (Kadiri, 2002). Bacilliarophyta was reported as the second most abundant taxa while the cynaophyta, a non-toxic alga was the least abundant. Alkaline pH and high nutrient composition was reported to favor the abundance of cyanophytes. This accounted for their presence in this study, traceable to the nutrient level and slight acidity of the lake. According to Ayodele and Ajani (1999) green algae and diatoms dominate many tropical lake systems. The most diverse specie during the present study were *Pinnularia, Navicular, Fragillaria and Coscinodiscus* species which tallied with earlier works (Opute, 2002 and Kadiri, 2002). They reported that alternation in the abundance of species was a booster for year round food for fish.

Under conditions of nitrate and phosphate availability, the green algae (chlorophyta) are known to proliferate and form noxious bloom in freshwater environment (Ayoade, 2000). According to Oputa (2000), hydro biological changes emanate from adequate solar radiation and nutrient enrichment of the lake, which resulted in eutrophication. He reported that the formation of algae blooms depended on retention time, type and algae of the water body, calm weather condition and low turbulence. However, algae proliferation at the surface favored the photo- autrophic forms while at the bottom, the photo-heterotrophic forms predominated. The development of phytoplankton blooms in autotrophy lake was attributed to their ability to accommodate reduced nitrogen and phosphorus ratio, low edibility resulting from their large colony sizes coupled with large herbivorous regulation of other taxa. Reynolds (1998) reported that the oligotrophic indicators of blooms were desmids; chrysophytes and diatoms while the autotrophic indicators were cynobacteria and eugleniodes. To restrain any class of algae to one part of the tropic range was not possible because algae occurred across a wide range of the spectrum: from ultra-oligotrophic to hypereytrophic. Eutrophism was grouped on the bases of the differing arrays of adaptive attributes and how these interacted with the totality of processes, which together determine their pelagic environment. Importantly, blooming of algae species have detrimental effects on domestic and recreational uses of water and in many cases have acted as a direct motivation for restoration measures (Bryant, 1994).

Conclusions

- The lake experienced thermal stratification during the dry season.
- On the basis of transparency, the lake could be said to experience an upper clear zone and a darker lower zone, which emanated from the flood experienced annually.
- Asides from transparency, conductivity and total alkalinity, which were significantly different ($p<0.05$), all other parameters were not significantly different ($p>0.05$). Thus the lake could be said to be homogeneous.
- The lake was highly productive especially during the dry season with a morpho-adaphic index of 10.75, which signified a nutrient rich lake.

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