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EFFECTS OF PHYSICO-CHEMICAL FACTORS ON SEASONAL DYNAMICS OF THE PHYTOPLANKTON IN NGURU LAKE, NORTHEASTERN NIGERIA.

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Abstract

Studies were conducted in Nguru Lake between May 2006 and April 2008 to map temporal changes in phytoplankton composition and attempt to relate these changes to physico-chemical parameters in the ecosystem. Temperature, conductivity and alkalinity showed significant spatial variation. Nutrients showed significant seasonal variation. Twenty five phytoplankton genera were recorded. Green algae (Chlorophyta) were the most dominant contributing 46% of the total biomass followed by blue green algae-Cyanophyta(29%), Bacillariophyta(22%) and Dinophyta(2%). Seasonal changes were observed for the three major plant nutrients total phosphorus (PO_4-P) ranged from 5.2 -9.6mg/l. Total nitrogen (NO_3-N) ranged from 2.4-12.8mg/l and sulphates ranged from 1.0-10.1mg/l. wide variations in environmental variables were observed in the lake. Results obtained in this study showed that the lake was undergoing gradual eutrophication resulting in deterioration of water quality, decreased fish yield and subsequent reduced income to the local communities. The eutrophication was further aggravated by increasing human and livestock population.

Key Words: Biomass, Nguru Lake, Nutrients, Phytoplankton, Water quality.

1. INTRODUCTION

Water is an important basic resource for humanity. The availability and quality of this resource is however rapidly declining with increase in population.

The quality of water, especially of eutrophic waters is essentially determined by the quantity of algae. Drinking water supply, recreational activities and fisheries can be impaired by high phytoplankton biomass. Therefore, water quality management has to monitor the phytoplankton content in order to come up with preventive measures such as aeration to prevent fish kills during decay of the planktonic biomass (Imhoff and Alberrecht 1975).

Phytoplankton development in aquatic ecosystems is greatly enhanced by increased level of the major plant nutrients. This is because some of the nutrients are involved in the intercellular metabolic regulation and as building blocks in protein molecules (Crul 1993). The major nutrients that regulate algal growth are phosphorus, nitrogen and dissolved silica. Water temperature and turbidity are equally important for they have direct bearing on the development and regulation of phytoplankton.

Previous documented studies on Nguru Lake including the works of Abdullahi(1997), Lafiagi(1997) and WDI(2006) revealed that the phytoplankton of the lake was dominated by the green algae and to a less extent the blue green algae. In the recent past the lake has been besieged by a myriad of ecological disruptions including among others dumping of fertilizers as a result of agricultural activities thereby leading to frequent algal blooms, excessive siltation, proliferation of aquatic weeds, and draught.

The aim of the present study was to document the temporal changes of the phytoplankton and relate same to the physico-chemical variables.

2. MATERIALS AND METHODS

2.1 *Study area*

Nguru Lake is a part of the Hadejia Nguru wetlands (HNW), which are located in northeastern Nigeria. Nguru lake occupies an area of approximately 58.100ha and is located between latitude $12^{0}40$'N and $13^{0}60$'N and longitudes $10^{0}20$'E and $11^{0}00$'E. The lake developed from two main drainage systems. The Hadejia and Jama'are rivers. The lake is surrounded by a flood plain made up of a network of channels and pools producing a complete pattern of permanently and seasonally flooded land and dry land (Hollis *et al*,. 1993).

The inter-tropical convergence zone influences the climate of the Nguru area. This climate is characterized by distinct wet and dry seasons, which are controlled by the cyclical migration of the ICTZ. Rainfall in this area usually starts from May and end in September or October, in most cases with a long break of up to a month between the first rain and subsequent ones. There is also a wide variation of rainfall even within the wetlands area, from the south where the rains start earlier to the North-east were they occur later, the difference in amount of rainfall ranging from 500mm to about 700mm per annum. Latest records of rainfall show that it has been below average for almost twenty years (Adams, 1993).

Over half a million people depend upon the lake and the surrounding wetlands for their livelihoods, especially for water supply. Lafiyagi (1997) has identified about 65 species of fishes. Therefore, majority of the people living around the lake are either fishermen, or processors and marketers of fish. The land around the lake is irrigated in both dry and wet season for vegetables and rice. The lake is also used for livestock grazing, for recreation and research, since it has a large biodiversity of birds, insects, wildlife and flowering plants. In fact the lake and the surrounding wetlands is a particularly good representative of a natural or near-natural wetlands, which embodies all the diverse flora and fauna of both the Sahel and the Sudan in a single location; hence the area is important for ecotourism.

Nguru Lake is designated as a Ramsar site by the Ramsar convention; it is presently the only Ramsar site in Nigeria.

2.2 *Sampling for water and phytoplankton*

Samples for water and phytoplankton were taken on monthly basis from May 2006 to April 2008 from five stations (fig 3.1). The samples were collected between 07.00am and 11.00am.

Water samples were collected with a Van Dorn sampler. A portion of the water samples were analyzed for total alkalinity by titration with methyl orange and phenolphthalein indicators. Total phosphorus, nitrogen, sulphate and turbidity were determined spectrophotometrically as described by APHA (1998).

Transparency was determined in the field with a 20cm diameter black and white *Secchi* disc. Temperature, pH and conductivity were measured with pH meter model 3150.

For phytoplankton analysis, 250ml of the water was fixed in the field with Lugols solution. The sample was then sedimented for 48hours after which enumeration of the phytoplankton was done using Sedgwick-rafter counting chamber and identification was done using keys in Needham and Needham (1962). All the results obtained were subjected to analysis of variance and Pearson's product moment coefficient correlation.

3. RESULTS

The temperature ranged from 7^0c to 32^oC. In the rainy season (May-Sept) of the first year and in the second year temperature range was 15^0c to 32^0c, and 17^0c to 30^0c respectively. While in the dry season of the first and second year, the temperature range was from 9^0c to 21^0c and 70^0c to 22^0c respectively. The temperature at Nguru Lake showed highly significant seasonal variation ($p < 0.001$), there was also highly significant spatial variation ($p < 0.001$). pH showed a range of 7.6-9.5 with no significant seasonal or spatial variation. Transparency ranged from 11-147cm. The mean turbidity during the study period is 6.49 ±$0.02ml^{-1.}$ Conductivity and alkalinity showed significant seasonal and spatial variation during the study period, both showing maxima in the dry season. The nutrients, phosphorus, nitrogen and sulphate exhibited similar pattern, with all showing maxima during the rainy season mainly due to surface run-off from agricultural lands. All the nutrients showed significant seasonal variation. Only temperature, biological oxygen demand, chemical oxygen demand, calcium, iron and magnesium showed significant difference between the two years of the study. The concentration of sulphate ranged from $1.0mgl^{-1}$ to $10.1mgl^{-1}$. The sulphate concentration showed a clear seasonal pattern with higher concentrations during the rainy season and lower concentration in the dry season. The distribution pattern of the first year was similar to that of the second year. Mean concentration of sulphate during the study period was $6.6mgl^{-1}$. Sulphate concentration showed highly significant seasonal and spatial variation ($p<0.001$). The relationship between the seasons and stations was also significant ($p<0.05$). Sulphate concentration has significant correlation with the abundance and distribution of phytoplankton. There was no significant difference between the two years of the study.

Of all the physico-chemical parameters examined in this study only the nutrients (i.e total nitrogen, total phosphorus and sulphate) showed significant correlation with the phytoplankton. The phytoplankton showed highly significant seasonal and spatial variation ($p<0.001$). There is significant positive correlation between the abundance of phytoplankton and the concentration of sulphate, phosphorus and nitrogen. There is no significant difference in the abundance of phytoplankton between the two years of study.

The phytoplankton of Nguru Lake consists of four genera, with twenty-five species. The phytoplankton was dominated by the Chlorophyta, which makes up 46% of the total algae. The Cyanophyta constituted 29% and the Bacillariophyta contributes 22% of the population, while the Dinophyta makes up only 2% of the phytoplankton. The Chlorophyta was dominated by *Chlorella vulgaris, Zygnema sterile*, and *Ankistrodesmus falcatus*, which are most abundant and occured throughout the study period. The Cyanophyta had *Anabaena circinalis*, *Anabaena flos-aque* and *Gomphosphaeria sp.* occurring in all the sampling stations, all year round. None of the members of Bacillariophyta and Dinophyta was present throughout the year. All the phytoplankton showed significant seasonal and spatial variation.

4. DISCUSSION

The water regime in this lake was mainly influenced by rainfall and discharge from its tributaries. So it is expected that any variation, whether seasonal or spatial in physico-chemical properties of Nguru lake may be influenced by climatic factors or catchment characteristics The marked variations in temperature observed at Nguru Lake, may likely be due to climatic conditions in the area, and the shallow nature of the lake. Nguru Lake being located in a Sahelian region experiences extremes in environmental temperature, this coupled with the shallowness of the lake allows for mixing.

The slight seasonal variation in electrical conductivity at Nguru Lake was largely because of dilution by rains, which may most likely be due to release of ions dissolved from the previously exposed beds of the lake. This finding is consistent with the observation of Sarnelle (1992), who observed same in Lake Volta. Despite fluctuations, the water of Nguru Lake showed gradual increase in all nutrients (total phosphorus, Nitrogen and sulphates) except during the cool harmattan period. As expected, an increase in most nutrients could be attributable to the effect of natural causes like evaporation and inflow from domestic discharges. The decrease of nutrients during the harmattan period (November – February) corresponds with the period of algal bloom.

The concentration of nutrients in a water body is strongly influenced by the nature of the sediment. Wetzel (2001), states that the rate of phosphorus released into the water can double, when sediments are frequently disturbed. The values of nutrients obtained from Nguru Lake in the dry seasons were significantly higher than the respective values recorded in the rainy seasons. This could be attributed to dry season irrigation farming and concentrations of these nutrients due to evaporation. Spears *et al.,* (2007) studied seasonal partitioning of phosphorus across the sediment-water interface in Loch Leven, Scotland. They found that surface water total phosphorus concentrations were highest in late summer and lowest in early spring. In contrast, sediment total phosphorus concentrations were highest in mid-winter and lowest in late summer. In Nguru Lake, high levels of nutrients occur at the onset of the rainy season and decreased as it tends towards the dry season, in inverse proportion to plankton abundance. This agrees with fishar *et al*., (2006) who states that nutrients were probably taken up by rapid algal and macrophyte growth in the summer giving very low nitrate and phosphate levels for the rest of the year.

The Phytoplankton was characteristically dominated by two or three species at any given time. The phytoplankton of Nguru lake were dominated by the Chlorophyta followed by Cyanophyta and Bacillariophyta with Dinophyta being the least represented. This result is similar with the findings of Abdullahi (1997) and Abubakar (2007) who worked on Hadejia-Nguru wetlands and Nguru Lake respectively. The composition of Phytoplankton in Nguru Lake was an indication that the lake is undergoing eutrophication. This is collaborated by the findings of Van Vuuren *et al;* (2007) in Mohale dam in South Africa. However, recent trends in some sampling stations in the lake (i.e. sites 4 and 5) indicated that the Cyanophyta was becoming more dominant in these sites, which was a clear indication of deterioration of water quality. Observations by Odhiambo and Gichuki (1998) revealed that the Chlorophyta and the Cyanophyta dominated the algae of Lake Baringo and that the lake was in a state of gradual deterioration of water quality. This result also agrees with the findings of Ganai *et al*., (2010) who observed the increasing dominance of Cyanophyta in Wular Lake. These factors are applicable to Nguru Lake in the case of the present study.

5. CONCLUSION

The composition, abundance and distribution of phytoplankton acts as an ecosystem index, thereby indicating water quality and eutrophication level of the ecosystem (Mehdi *et al*., 2005). Now-a-days lakes and other deep water habitats is globally a subject of great ecological interest due to their socio-economic values and ecosystem services which has necessitated the need for reliable broad based information on their ecological status. The ecological functioning of these ecosystems has been greatly affected by the growing anthropogenic activities. From the results of the studies conducted, one can safely conclude that. Different levels of anthropogenic inputs have caused wide variations in physico-chemical parameters in the various parts of Nguru Lake. There was significant seasonal variation in the abundance of the phytoplankton. The variations observed in the flora of the lake were due to variability of nutrients.
The altered physico-chemical characteristics of the water together with growing occurrence of the pollution indicator *Anabaena* species, allows us to conclude that the Lake has evolved over the years as a eutrophic ecosystem and merits urgent attention for ecorestoration and sustainable management.

6. RECOMMEDATIONS

1. The government and other donor agencies should provide support for research and studies to collect analyze and synthesize information and harmonize existing policies, edicts and byelaws that conform to Integrated Water Resources Management (IWRM) principles, including establishing criteria for water –use.
2. The local farmers should be educated on the benefits of using organic fertilizer and the sustainable exploitation of both fish and non-fish fauna.
3. The application of agro-climatic and limnological researches carried out in our universities and research institutes to solve day-to-day problems like eutrophication should be encouraged.
4. There should be support for the preservation of wetlands, control of erosion, restoration of degraded areas and the creation of measures to control point and non-point pollutions.

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Table 1. Mean distribution of Phytoplankton in Nguru Lake and the diversity indices of the stations.

Chlorophyta	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**
Ankistrodesmus falcatus **Kom.**	****	****	**	**	*
Closterium aciculare **West**	***	****	**	-	-
Closterium parvulum **Nag.**	**	***	**	-	-
Closterium sp.	***	-	-	-	-
Spirogyra cormunis **Her.**	-	-	**	*	*
Pediastrum boryanum **Ralfs.**	**	*	-	-	-
Pediastrum simplex **Ralfs**	-	**	-	-	-
Staurastrum leptocladum **Kutz**	**	**	-	-	-
Zygnema sterile **Ehr**	**	***	***	*	*
Chlorella vulgaris **Breb**	**	**	*	*	*
Cyanophyta					
Anabaena circinalis **Nag.**	*	*	*	****	*
Anabaena flos-aque **Nag.**	*	*	**	****	**
Anacystis cyanae **Bom**	-	-	*	**	*
Gomphophaeria sp.	**	***	-	-	-
Microcystis aeroginosa **Kirchn.**	*	**	*	*	*
Spirulina massarti **Nag**	-	-	**	**	*
Oscillatoria limnosa **Gomont**	*	**	*	*	*
Bacillariophyta					
Asterionella Formosa **Grun**	-	-	-	*	*
Cyclotella bodanica **Kutz**	-	-	-	*	-
Diatom vulgare **Breb**	***	-	-	-	-
Navicula radiosa **Kutz**	*	*	*	-	-
Synedra ulna **Mer.**	**	**	*	-	-
Nitzchia palea **Kutz**	**	**	-	*	-
Dinophyta					
Ceratium hirundinella **Kom**	*	*	-	*	-
Mean No of individuals(N)	11963	12154	10402	13244	2434
Number of species(S)	18	16	14	13	11

Shannon-Weaver index(D)	5.32	3.89	4.67	2.92	2.11
Evenness index(E)	0.9821	0.8762	0.9211	0.6322	0.5412

Legend

**** Present in >50% of the samples

*** Present in > 30% of the samples

** Present in >20% of the samples

* Present in <10% of the samples