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Effects of environmental variables on phytoplankton distribution in Kusalla reservoir, Nigeria

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Abstract

The effects of physico-chemical factors on the composition, distribution and abundance of phytoplankton of Kusalla reservoir were studied. Water and phytoplankton samples were collected and analysed using standard methods for a period of one year. Data collected was subjected to analysis of variance, which shows that the phytoplankton has significant seasonal and spatial variation. Correlation analysis show that phytoplankton has significant positive correlation with temperature, conductivity, dissolved oxygen and the nutrients. The phytoplankton was dominated by the Chlorophyta followed by the Cyanophyta. Baccillariophyta and Dinophyta. The lake is adjudged to be tending towards deterioration of water quality. The abundance, composition and distribution of the phytoplankton in Kusalla reservoir is affected by the environmental variables. The physico-chemical parameters to a large extent determine the seasonal and spatial patterns of the phytoplankton. The numerical dominance of the Cyanophyta in the reservoir is an indication that autochtonous and allochtonous inputs into the reservoir are decreasing the water quality.

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Introduction

The persistent drought in some parts of northern Nigeria has necessitated the creation of water reservoirs for the purpose of domestic water supply, irrigation, livestock farming and fisheries production. Kusalla dam is one of the reservoirs in Kano State that serve as source of water supply to the surrounding communities. It is also used for irrigation, year round grazing and for fisheries production. It is also a source of income to the inhabitants via activities such as production of food or cash crops, through irrigation, fisheries etc and for tourist attraction.

Kano state has the largest number of manmade lakes in Nigeria with about 26 reservoirs across main seasonal rivers. This was sequel to the drought of the early 1970s and 1980s. Among the major dams in the state are Tiga dam, Challawa Gorge dam, Tomas dam, and Kusalla dam (Mbagwu, 1994). Over the years, climatic changes and increased human activities such as farming activity both rain fed and irrigation within the catchments basin of most of the reservoirs have resulted to gradual silting up, nutrient build up and aquatic macrophytes invasion. In addition to that, the water demand is on the increase, so also the rate of abstraction of water for water supply, seepage and evaporation (Balarabe, 1989).

The phytoplankton is responsible for about 90% of all primary production in a body of water (Boney, 1989). Phytoplankton is the main source of food for fishes in lakes, they use photosynthesis to fix carbohydrate and produce oxygen. They serve as primary producers in the aquatic ecosystem. Phytoplankton does not only produce oxygen, but also use ammonia produced by fish as nutrients (Swann, 2004).

According to Barone *et al.,* (1990) phytoplankton size, structure, and species diversity are related to tropic state of water bodies. Several recent comparative studies have demonstrated that eutrophication affect phytoplankton structure and seasonality in lakes of different types all over the world. In particular eutrophication alters the relative biomass of the major taxonomic groups (Reynolds, 1989). The composition, abunadance and distribution of phytoplankton in a water body acts as an ecosystem index, thereby indicating water quality and eutrophication level of the ecosystem (Mehdi *et al.*, 2005). Previous documented studies on the effects of environmental variables on the abundance, distribution and seasonality of plankton includes, the works of Abubakar and Balarabe (2008) and Abubakar et al., (2012) in Nguru Lake and that of Imam and Balarabe (2012) in the Bompai-Jakara catchment basin. There is very little information about the limnology of the lake. Therefore there is need for baseline data on the biodiversity of the lake. The aim of the present study is to determine the composition, abundance and distribution of phytoplankton in relation to environmental variables.

Materials and methods

Study Area

Kusalla reservoir is located at Kusalla village on latitude 10°02`N-11°00`N and longitude 11°42`E-12°42`E. It is in the Sudan savanna zone of Nigeria, with two distinct seasons (wet and dry). The rainy season period lasts from May to October, and dry season from November to April. Kusalla reservoir is approximately 90km southwest of Kano city. The dam was impounded in 1969 and commissioned in 1970. It has two major tributaries, river Kunkun and river Makugara. It covers about 200heactres with about 17.3 million cubic meters water capacity. About 1million people depend on the dam for their water supply, irrigation, livestock farming and fishing.

Sampling Stations

Six sampling stations were chosen for the study. Station 1 at the dammed site where human activities like washing, bathing, are taking place.

Station 2 at the tower point where there are less human activities. Station 3 at the deepest part of the reservoir and station 4 near the middle of the Dam. 5th station at the entrance point of river Makugara and 6th station at the entrance point of river Kunkun.

Water Sampling Method

Sampling was carried out monthly from each sampling station for a period of one year (June 2006 to May 2007). Water samples were collected between the hours of 8:00am and 1:00pm as described by Burns *et. al.,* (1999). In this method, water was sampled at surface level by dipping 1 litre plastic sampling bottle sliding over the most upper surface of the water with their mouth against the water current to permit undisturbed passage of the water in to the bottle . Water samples were then transported to the laboratory for the analysis of physico-chemical and biological parameters. The collected samples were analysed spectrophotometrically using the methods of APHA (1985).

Collection of Plankton

Sample of plankton were collected using plankton net of mesh size 70um (microns). The net was tied to a metal rod, and immersed into the water, towed for a fixed distance, and hauled out of the water. The water (containing plankton) that was collected in the plastic bottle at the end of the net was emptied into sample bottles and preserved with Lugol's solution, (Vollenweder, 1974, Wetzel and Likens, 1979). The volume of water that passed through the net was then estimated by using the following formula:

$V=\pi r^2 d$

Where V = volume of water filtered by the net, = radius of the mouth of the net and d = length of the haul (Downing and Rigler, 1982).

Plankton Enumeration

On coming to the laboratory, the phytoplankton samples were condensed by centrifuging 100ml of the sample to10mI. The concentrated sample was taken for enumeration with Sedgwick-Rafter counting chamber. Identification was done to species level, using keys in Prescott (1970) and Lind (1986). Data collected were subjected to analysis of variance (ANOVA), Pearson's product moment correlation coefficient and Duncan's multiple range tests.

Results and discussion

Environmental variables

Results of the physico-chemical parameters measured in the study were presented in tables 1 and 2. Water temperature ranged from 22°C in December to 28°C in July. This shows a similar pattern with the atmospheric temperature, which shows a clear seasonal pattern. Since the reservoir is shallow, it is expected to have a wind induced mixing. Kabir (1992) reported that thermal stratification is not possible in water bodies with less than 10m depth.

Table 1. Result of Physical Parameters of Kusalla Reservior.

Month	PH	Alkamity	Hardness	Turbidity	Cond.	Depth	Transparency
June	6.7a	122.5a	61.4a	15.2bc	54.8a	281.7a	42.5dc
July	6.6a	123.8a	2.5a	21.0b	55.0a	28.3a	45.0dc`
Aug	6.6a	69.2b	77.3b	85.8a	43.2b	451.8ab	28.3c
Sept	6.7a	68.3b	70.8b	95.7a	35.0ba	503.0bc	29.2c
Oct	6.5a	`72.5b	72.1b	92.2a	39.2ba`	508.7bc	40.7d
Nov	6.7a	66.6b	13.1b	87.0a	36.5ba	386.0b	49.8a
Dec.	6.4a	62.9bc	82.4b	14.3bc	57.3a	341.3b	60.3a
Jan	6.6a	52.0ba	81.0b	24.5b	59.3a	348.5b	52.7b
Feb	6.7a	60.7bc	78.2b	17.0bc	59.2a	158.7bd	59.2a
Mar	7.4b	59.2bc	82.1b	15.0bc	57.2a	165.8bd	63.3a
Apr	7.1b	50.8bc	87.3bc	12.8bc	53.8bc	310.7a	65.2a
May	6.4a	47.5ba	106.3ba	13.3bc	55.8bc	317.2a	64.2a

The pH range of 6.2 to 7,4 observed in Kusalla reservoir is lower than the range observed in other Nigerian manmade lakes. 7.6 to 9.5 in Nguru Lake (Abubakar, 2010), 7.2 to 7.9 in Kangimi reservoir (Kemdirim, 2000) and 6.8 to 7.6 in Shiroro Lake (Kolo and Oladimeji, 2004). The pH level observed here could support many fish species as reorted by Edema et al.,(2002). Oladipo and Williams (2003) Opine that a pH ranges of 6.5-9.0 is suitable for maximum growth and abundance of phytoplankton.

Electrical conductivity ranged from 25 to 65micro-ohm^{-1} with gradual decrease from June to October corresponding to the rainy season.

Dissolved oxygen (DO) results show a range of 7.4 to 8.65mg/l in Kusalla reservoir. The highest concentration of DO coincided with the lowest temperature in the water body. The DO of 7.8mg/l recorded in this study indicates good water quality as reported by Begum et al., (2012).

Table 2. Result of Chemical Parameters of Kusalla Reservior.

Month	Temp	D.O	BOD	CA	MG	CL	NO3- N	Po3-p	Fe
June	27.2a	7.5a	3.4c	15.9a	5.9a	8.9ba	6.0c	5.4b	0.3a
Jul	27.8a	7.5a	3.4c	17.6a	6.3b	10.1ba	9.3a	0.2b	0.3a
Aug	27.7a	7.4a	3.3c	12.7a	6.2b	6.5bc	8.5a	8.2a	0.4b
Sept	26.8a	7.5a	3.3c	10.6b	9.1bc	6.4bc	7.9b	8.8a	0.3a
Oct	26.5a	7.7a	3.4c	11.8a	5.9a	6.0bc	8.9a	10.6bc	0.3a
Nov	24.7a	8.2bc	3.7a	18.0a	8.9bc	15.6a	8.8a	8.3a	0.3a
Dec	22.5c	8.4ba	3.7a	26.2c	8.9bc	15.7a	7.1ba	8.0a	0.3a
Jan	23.2c	8.3ba	3.7a	18.5a	4.6c	13.9b	7.2a	8.1a	0.3a
Feb	24.3b	8.1b	3.8a	26.3c	9.7bc	16.7a	6.8c	8.6a	0.3a
Mar	24.7b	8.1b	3.8a	27.6c	8.bc	16.3a	6.2c	6.7b	0.3a
Apr	26.3a	7.1c	3.6b	30.2c	9.3bc	16.0a	6.2c	6.4b	0.3a
May	27.8a	7.3c	3.5b	41.5bc	9.5bc	14.8b	8.2b	8.4a	0.4b

Nutrients

Nitrate-nitrogen in Kusalla reservoir ranged from 5.6 to 10mg/l. the concentration was higher in the onset of the rainy season. This could be due to run-off from the farmlands into the reservoir, as a result of fertilizer application by farmers in the catchment area as observed by Kemdirim (2000).

Phosphate- phosphorus values ranged from 5.0mg/l to 10.6 mg/l, with the maximum value in October. This result is in agreement with the findings of Spears *et al.*,(2007) who studied seasonal partitioning of phosphorus across the water-sediment interface in Loch Leven, Scotland. In contrast the results of Abubakar *et al*,.(2012) in Nguru Lake shows that total phosphorus is highest at the beginning of the rainy season. According to Walker *et al.,* (2001) the input of nutrients, is the most significant factor affecting phytoplankton biomass and distribution in the Nyara estuary. They showed that when not receiving pulses of nutrients through freshwater inflow the estuary is a predominantly low nutrient, low phytoplankton biomass, stratified system, dominated by microbial food web.

Table 3. ANOVA for Phytoplankton of Kusalla Dam.

Sources of variation	DF	Bacillariophyta	Chlorophyta	Cyanophyta	Dinophyta
Station	5	1131.15**	517.32**	1595.97**	105.85**
Month	11	560.72**	335.55**	494.04**	74.71**
Station by Month	55	46.27NS	17.80NS	26.85NS	2.06NS
Residual	60	59.17	62.44	51.20	4.76
Total	71				

* Significant, ** Highly significant, NS Non Significant.

Phytoplankton

The phytoplankton of Kusalla reservoir is dominated by the Chlorophyta (36.25%) followed by the Cyanophyta (30.06%), Bacillariophyta (27.66%) and Dinophyta (7.03%). This composition is typical of waters in the semi-arid zone of Nigeria. The composition is similar to the findings of Abdullahi (1997), Abubakar (2007) and Abubakar *et al.*,(2012).

The Cyanophyta with only four species is the second most abundant group of the phytoplankton. The increasing dominance of the Cyanophyta in a water body is a clear manifestation of deterioration in water quality. This result agrees with the findings of Ganai *et al.*, (2010) who observed a positive correlation between Cyanophyta and water quality in Wular Lake. All the groups of phytoplankton show significant seasonal and spatial variation (table 3).

Pearson's correlation analysis showed that there is significant positive correlation between the phytoplankton and temperature, conductivity, dissolved oxygen, nitrate-nitrogen and phosphate-phosphorus. With negative correlation between phytoplankton and pH, water depth, chloride, calcium and magnesium.

Conclusion

The abundance, composition and distribution of the phytoplankton in Kusalla reservoir is affected by the environmental variables. The physico-chemical parameters to a large extent determine the seasonal and spatial patterns of the phytoplankton. The numerical dominance of the Cyanophyta in the reservoir is an indication that autochtonous and allochtonous inputs into the reservoir are decreasing the water quality.

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