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SPATIO-TEMPORAL VARIATION IN SOME ENVIRONMENTAL VARIABLES OF BOSSO DAM, NIGERIA

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ABSTRACT

Bosso dam was constructed primarily for the Niger River basin municipal supply of drinking water and for other domestic use. Physico-chemical properties of Bosso Dam, Bosso, Niger state Nigeria were investigated monthly between September, 2015 and February, 2016 to determine seasonal variation, as well as providing a baseline data for monitoring water quality changes prompted by human induced factors. Water samples were collected from three accessible stations of the dam for chemical analyses using standard methods. One – way ANOVA were used to evaluate relationships between environmental variables with PAST. Findings on the physico-chemical status of the water revealed that temperature ranged from 27.0^{o}C-30.5^{o}C, weak acidic to weak alkaline pH range of 6.7-7.3, Dissolved Oxygen Concentration (5.0-8.0mg/l) was marginally high while the BOD range of (2.0-5.0mg/l) was relatively high. The essential primary productivity nutrients, Nitrogen (0.12-0.19mg/l), Phosphate (0.02-0.09mg/l) and Sulphate (9.3-17.7mg/l) were relatively low in all the sampled stations. The lake is not eutrophic, so, various management strategies such as periodic monitoring of physico-chemical parameters should be carried out and hence the need for an effective anthropogenic inputs control programme in the dam. The study further revealed that the dam could be used for irrigation purposes for dry season farming, health wise; the water should undergo a little treatment before consumption even though the dam was constructed purposely for the supply of drinking water to the people of Bosso and the environs.

Key words: physico-chemical, seasonal variation, Bosso Dam

INTRODUCTION

Lake and reservoirs are valuable natural resources that also possesses tremendous economic value. They provide many beneficial uses such as flood control, recreation, aquatic life support, domestic water supply, irrigation and industrial water sources (Kansas Department of Health and Environment, 2011). In Niger State, there is Zungeru dam at Wushishi Local Government Area, Gurara waterfalls at Gurara Local Government Area, Chanchaga River and Bosso dam at Bosso Local Government Area, Kainji Lake at Borgu Local Government Area, just to mention but a few. Monitoring of a freshwater water bodies (i.e. sampling and analyzing water, sediments and biota) help to generate information on species richness in the ecosystem, as well as information on the health of the water body being studied (Ajuzie, 2012). Limnologist studies the physico-chemical and biological parameters of freshwaters (Idowu, *et al*., 2013). These parameters are used to analyze the quality of water (Goldman and Horne, 1983; Boyd and Tucker, 1998). They include Temperature (air and water), Transparency, Hydrogen ion concentration (pH), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Conductivity, Depth, Alkalinity, Total Dissolve Solid, Phosphate, Nitrate, Chlorophyll- *a* and others. Most reservoir and dam ecosystems in Nigeria are impacted by anthropogenic activities (Ibrahim*, et al*., 2009). The anthropogenic inputs from neighboring communities such as run-offs from agricultural farms containing manures and fertilizers are the major problem that the Bosso dam is experiencing (Ibrahim, *et al*., 2009). These inputs cause serious effect to the productivity, water quality and subsequently affect the biodiversity of the dam. The use of diverse methods for water quality monitoring is of importance to management of fisheries, pollution, water supply, sewage treatment reservoirs and freshwater impoundments. Bosso dam was constructed primarily for domestic consumption within Bosso town and its environs. There is dearth of information on some selected physico-chemical parameters. The present investigation is aimed at filling the information gap and contribute to the knowledge of limnology of the dam.

This study is necessary and timely especially as it will provide opportunity for monitoring changes in the physical and chemical status of the dam, which will help to initiate policy for the overall management of the ecosystem health and its productivity.

MATERIALS AND METHODS

Study Area

The study was conducted in Bosso dam, Bosso Local Government Area, Minna. The climate in Minna is tropical with annual temperature, relative humidity and rainfall of 30.2°C, 61% and 1334mm, respectively. The climate represents two distinct seasons, a rainy season (April and October) with the highest mean monthly rainfall in September and a dry season (November-March) completely devoid of rain. Bosso dam was

constructed in 1945 for the Niger River basin municipal supply of drinking water and for other domestic use and is located between latitude 9º39′ 56.45″N to 9º40′ 56.67″ N and longitude 6º 30′54.10″E to 6º32′21.45″E (Yakubu *et al*., 2010). It
is surrounded by trees and shrubs; the littoral zone is open void of any hydrophytes. It is underlain by granite (Amadi and Olasehinde, 2010). The dam plays host to crocodiles and is always serene void of any human activities. There are farm lands down the slope on a level ground around the dam. Crops cultivated are *Zea mays* and *Sorgum* sp. Inorganic fertilizer such as Nitrogen, Phosphorous and Potassium popularly referred to as N.P.K are used in the farms.

Sampling Stations

Three accessible stations (Station A, B & C) were selected for the purpose of this study (Fig. 1). The sites are surrounded with shrubs and the bank of each station had igneous rocks and a little further was silt, clay and sand. No human activity goes on there.

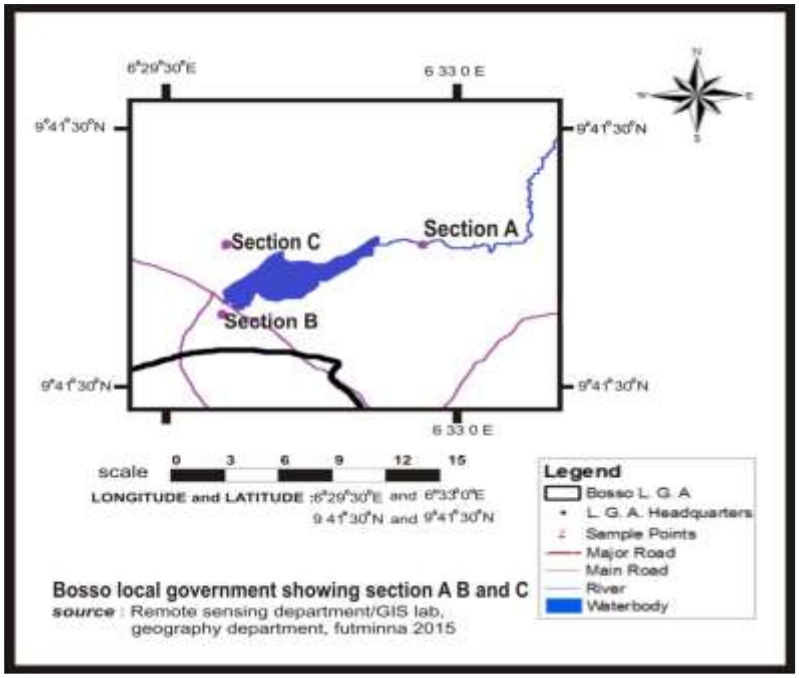

Fig. 1: Showing the sampling stations of Bosso Dam

Sampling Techniques

Monthly sampling of the three study stations was carried out from September to November 2015 for the wet season and December 2015 to February 2016 for the dry

season towards the end of every month, between 9am and 11.30am every sampling day.

Physico-chemical parameters

Air shade and water temperature were taken *in-situ* using a mercury-in-glass thermometer graduated in units of °C. Hydrogen Ion Concentration (pH), Electrical Conductivity and Total Dissolved Solid (TDS) were determined *in situ* using the HANNA CROCHEK meter model HI9813. The Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) were determined using the Winkler-Azide method (APHA, 2005). The turbidity of water was measured with turbidity probe (Nathanson, 2003). The nitrate and phosphate concentrations in the water samples were determined by spectrophotometric method (APHA, 2005) and sulphure was determined by turbidimetric method as reported by Golterman and Clymo (1969) and Chlorophyll *a* was determined using the method described by Holm-Harsen (1978)

Data Analysis

Range mean and standard error for each parameter and station were calculated. Physical and chemical features of station were compared using one-way ANOVA on log(x+1) transformed data except pH. Fix effect ANOVAs were performed using dates as replicate. Significant ANOVAs ($P<0.05$) were followed by post hoc {Tukey Honest (HSD)} tests to identify differences between station means.

RESULT

Environmental Conditions

A summary of some physico-chemical properties of the study stations of Bosso dam at Minna, Niger State from September 2015 to February 2016 is given in Table 1. The physico-chemical properties of the water investigated namely; Air temperature, Water temperature, pH, Conductivity, Dissolved Oxygen,, Total Hardness, Akalinity $CaCO_3$, Total Dissolved solid- (TDS), Turbidity, Nitrate, Phosphate, Sulphate and Chlorophyll-*a* showed no significant variation among the sampling stations ($P>0.05$) but Biochemical Oxygen demand was significant between the months. In general the Air shade temperature ranged from 29.0ºC to 34.5ºC; Water temperature from 27.0ºC to 30.5ºC; weak acidic to weak alkaline pH range of 6.7 to 7.3 was observed across the station. Dissolved Oxygen concentration range from (5.0 to 8.0mg/l), was high, while the BOD range from (2.0 to 5.0mg/l) was relatively high. The essential primary productivity nutrients, Nitrate (0.12 to 0.19 mg/l), Phosphate (0.02 to 0.09 mg/l) and Sulphate (9.3 to 17.7 mg/l) were relatively low in all the sampling stations. The Chlorophyll-*a* concentration range from (2.2 to 5.8µg/l) was relatively low.

TABLE 1

Summary of Environmental variables (mean±SE) of sampling stations of Bosso Lake from September 2015 to February 2016 (Note values are mean±S.E and range in parenthesis).

SN	PARAMETER				MONTHS		STATIONS	
		STATION A	STATION B	STATION C	F-ANOVA	P-VALUE	F-ANOVA	P- VALUE
1	Air shade Temperature	30.83±0.54 (29.0-32.32.0)	31.75±0.68 (30.0-34.5)	31.92±0.42 (30.0-33.0)	1.09	0.359	0.34	0.715
2	Water Temperature	28.60±0.62 (27.0-30.5)	28.38±0.27 (28.0-29.4)	27.7±0.20 (27.0-28.0)	1.32	0.303	0.81	0.465
3	pH	6.84 (6.7-7.0)	7.02 (6.9-7.2)	6.94 (6.7-7.3)	1.08	0.371	0.06	0.941
4	Conductivity (µS/cm)	76 .0±1.92 (72-82)	69.50±5.30 (60.5-89)	69.24±3.58 (62.2-82)	0.99	0.400	1.51	0.252
5	Dissolved Oxygen (DO mg/L)	5.96±0.20 (5.2-6.4)	6.56±0.44 (5.6-8.0)	5.40±0.35 (5.0-6.8)	2.84	0.098	1.54	0.246
6	Biochemical Oxygen Demand (BOD mg/L)	3.4±0.29 (2.8-4.2)	4.4±0.4* (3.0-4.0)	2.88±0.23 (2.0-3.4)	6.00	0.016*	2.92	0.085
7	Total Hardness (mg/L)	34.40±4.12 (20-44)	33.60±2.71 (24-40)	30.60±1.78 (25-36)	0.44	0.655	0.48	0.628
8	Alkalinity $CaCO_3$ (mg/L)	20.8±1.36 (16.0-24.0)	20.8±1.36 (16.0-24.0)	22.00±2.00* (16.0-28.0)	0.19	0.831	0.02*	0.983
9	Nitrate (mg/L)	0.136±0.0098 (O.12-0.16)	0.158±0.0156 (0.14-0.22)	0.18±0.0063 (0.16-0.19)	3.82	0.052	0.13	0.876
10	Phosphate (mg/L)	0.06±0.01 (0.04-0.08)	0.05±0.01 (0.02-0.08)	0.06±0.01 (0.04-0.09)	1.12	0.360	0.66	0.531
11	Sulphate (mg/L)	12.78±1.40* (9.4-17.7)	11.84±0.59 (10.3-13.7)	11.98±1.14 (9.3-16.1)	0.12	0.811	0.05*	0.954
12	Total Dissolved Solid (TDS) mg/L	22.12±3.33 (13.0-31.0)	23.62±4.06 (13.0-36.0)	20.98±2.05 (16.0-28.0)	0.16	0.855	0.19	0.830
14	Chlorophyll-*a* µg/L	3.38±0.33 (2.5-4.5)	3.94±0.56 (2.5-5.8)	2.84±0.22 (2.2-3.4)	1.93	0.187	2.27	0.136

**significant difference (P<0.05)*

DISCUSSION

Physico-chemical Characteristics

The marked variation and significant differences in physico-chemical parameters of the water indicate different environmental conditions. These variations may be related to patterns of water use, temperature and rainfall (Ayoade *et al*., 2006; Abolude, 2007; Atobatele and Ugwumba, 2008; Oso and Fagbenro, 2008; Usman, 2015).

The water temperature obtained in this study was typical of tropical inland fresh water and rivers (Arimoro *et al*., 2008). Temperatures were relatively higher throughout the period of the study from September 2015 to February 2016 across the study stations. The lowest water temperature was recorded at Station C (27.7^{o}C) while Station A and B had high temperature values of 28.60^{o}C and 28.38^{o}C. This result agreed with previous reports that the temperatures in tropics vary between 21^{o}C and 32^{o}C (Kramer and Botterweg, 1991; Atobatele and Ugwumba, 2008; Usman, 2015). The hydrogen ion concentration (pH) of water is important because many biological activities can occur only within a narrow range of pH. Thus, any variation beyond acceptable range could be fatal to aquatic organisms. The pH range observed during the study period was 6.7-7.3 throughout both seasons, and it was within the range for inland waters (pH 6.5 - 8.5), as reported by Mahar (2003). Thus, the pH range obtained in this study is within the acceptable level for 6.5 to 8.5 for culturing tropical fish species and, for the recommended levels for drinking water (WHO, 2006). Nigerian Standard for Drinking Water Quality (NSWQ 2007) recommended pH 6.5- 8.0 for drinking and 6.0-9.0 for aquatic life (Ibrahim *et al*., 2009). The pH range obtained in this study compares well with those of Lake Chad (7.6-8.0) and Shiroro Lake (6.7-7.0) as reported by Kolo (1996).

The level of conductivity in water gives a good indication of the amount of substances dissolved in it, such as phosphate, nitrate and nitrites. Different ions vary in their ability to conduct electricity (Zeb *et al*., 2011). Generally conductivity of the natural water is directly proportional to the concentration of ions (Usman, 2015). Conductivity levels below 50 µS/cm are regarded as low; those between 50-600 µS/cm are medium while those above 600 µS/cm are high (Anago *et al*., 2013) .Therefore the Conductivity values for the period of this study in all the study stations range from 69.24 µS/cm to 76 µS/cm and shows that the conductivity of the lake is medium. The monthly variation of Conductivity values of all the stations fluctuated between 60.5 µS/cm-89 µS/cm. The general trend in this study was that conductivity tended to decrease in the wet season and increased during the dry season. Increased conductivity during the dry season was enhanced by increased water evaporation and upwelling from wind, wave and tide (Olele and Ekelemu, 2008; Usman, 2015). This result is in conformity with the report of Oben,

(2000) who reported an increase in conductivity values during the dry season and attributed this to evaporation but it is in contrast with Mustapha, (2009) who reported lower value of Conductivity obtained in the dry season.

The dissolved oxygen values obtained during the period of study for Station A and Station C were relatively low (5.96 mg/l and 5.40 mg/l), while that of Station B was relatively high (6.58 mg/l). This result is not in conformity with the works of Arimoro and Oganah (2010). 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). Monthly variation of Dissolved Oxygen for all the Stations studied showed a gradual increase from low in September 2015 to high in February 2016. The high oxygen value for the dry season coincides with periods of lowest turbidity and temperature. The amount of dissolved oxygen in water has been reported not to be constant but fluctuates, depending on temperature, depth, wind and amount of biological activities such as degradation (Usman, 2015). The cool harmattan wind which increases wind induced turbulence, and decrease surface water temperature might have contributed to the increased oxygen concentration during the dry season, while the torrential rains, created increased turbidity and decreased oxygen concentration during the rainy season. Abolude (2007) and Usman (2015) made similar observation on A.B.U Zaria reservoir and Wawan Rafi Lake in Kazaure respectively.

Biochemical oxygen demand (BOD) indirectly depicts the amount of putressible organic matter degradable by microbial metabolism on the assumption that the water medium has no bacteriostatic effects. Abolude (2007); Idowu and Gadzama (2011) and Abolude *et al.* (2012) reported that BOD is a fair measure of cleanliness of any water on the bases that values of less than 2 mg/l are clean, 3 -5 mg/l, fairly clean and 10 mg/l definitely bad and polluted. The mean BOD values in Station A and Station B were relatively high (3.4 mg/l and 4.4 mg/l) when compared with Station C (2.88 mg/l). The monthly variation of BOD value of Station A and B fluctuated from 2 mg/l-5 mg/l which indicated that the water in these Stations were fairly clean. In Station C, the BOD fluctuated between 1.8 mg/l -3 mg/l which indicated that the water on this Station was clean. These fluctuations could be as a result of inflow of organic matter into the stations, it could also probably be as a result of the dead and decay of the aquatic organisms at these stations.

Nitrate is associated with algae growth and eutrophication, and concentration of inorganic Nitrogen greater than 0.3mg/L can cause algae to grow in abundance (Nathanson, 2000). The Nitrate values were relatively low in Station A and B (0.14 mg/l and 0.16 mg/l), while Station C (0.18 mg/l) was high when compared to stations A and B. The monthly variations in Nitrate levels were relatively low in all the sampling stations. This result is in contrast with the findings of Imoobe and Akoma, (2008) in Bahir Dar Gulf of Lake Tana, Ethiopia and Arimoro and Oganah, (2010) in a perturbed tropical stream in the Niger Delta, Nigeria who reported a higher value for nitrate concentration (0.92-4.18mg/L and 0.22-2.87 mg/L respectively). The observed sharp differences in the nitrate concentration between Bosso dam and the perturbed tropical stream in Niger Delta could be due to the release of organic effluent in to the stream

since high nitrate concentrations are generally indicative of industrial and organic effluents. The result however, is in agreement with the findings of Imoobe (2011) and Sarma *et al*. (2011) who recorded low value for nitrate (10-170 µg/l).

Phosphate is an essential nutrient for living organisms and exists in water bodies as both dissolved and particulate species. It is generally the limiting nutrient for algal growth and, therefore, controls the primary productivity of a water body. Artificial increases in concentrations due to human activities are the principal cause of eutrophication. Natural sources of phosphate are mainly the weathering of phosphorus-bearing rock sand the decomposition of organic matter. Domestic waste-waters (particularly those containing detergents), industrial effluents and fertilizer run-off contribute to elevated levels in surface waters. Phosphate associated with organic and mineral constituents of sediments in water bodies can also be mobilized by bacteria and released to the water column (Chapman and Kimstach, 1996; Wetzel, 2001; Ude *et al*., 2011; Mohammed and Saminu, 2012).The mean Phosphate level was relatively low (0.046-0.064 mg/L) in all the sampling Stations and was well correlated with the monthly variation. This result is in conformity with the report of Olele and Ekelemu (2008) who recorded phosphate values of 0.80-1mg/L; Imoobe and Akoma (2008); Arimoro and Oganah (2010); Imoobe (2011); Sarma *et al*. (2011); Joseph and Yamakanamardi, (2011) but in contrast with Adakole and Anunne (2003) who recorded phosphate values of 0.05-5.89 mg/l and Usman (2015) who also recorded very high phosphate value of 7.0-16.73 mg/l in Wawan –Rafin Lake.

Sulphates naturally occur in surface water which arises from the leaching of sulphur compounds either as sulphate minerals such as gypsum or sulphite as pyrite or from sedimentary rocks (Usman, 2015). The Sulphur concentration obtained in this study was moderate (11.84 mg/l-12.78 mg/l). Monthly concentration of Sulphur fluctuated between 8.6 mg/l-18 mg/l in Station A and C respectively while Station B recorded fluctuation of 10 mg/l-14 mg/l. This result is in agreement with Mustapha, (2009) and Usman, (2015) who had values of 9.4 mg/l±0.2 in Oyun reservoir and 5.94 mg/l-14.98 mg/l in Wawan-Rafi Lake respectively. The variation in concentration of sulphate at different locations could be due to the fact that the sulphate discharged to the lakes was used up as a source of oxygen by bacteria and was converted entirely to H_2S under anaerobic conditions (Kolo *et al*., 2010).

The Total Hardness value for all the Stations was low (30.60 mg/l-34.40 mg/l). The monthly variations fluctuated between 24 mg/l - 36 mg/l at Station B and C and in Station A the values fluctuated between 20 mg/l - 44 mg/l. The lowest value for Total hardness was recorded in October 2015 at Station A (20 mg/l) while the highest value of 44 mg/l was also recorded at the same Station in February 2016. The hardness scale of Hanna (2003) categorized water into very soft (0 – 70 mg/l), soft (70 – 150 mg/l), slightly hard (150 – 250 mg/l), moderately hard (250 – 320 mg/l), hard (320 – 420 mg/l) and very hard (420 mg/l and above). Therefore the water of the dam is a very soft water. This result is in agreement with the reports of Mustapha, (2009) of Oyun reservoir, who reported values of (32 - 60 mg/l).

The Total dissolved solids which usually consist of organic and inorganic substances dissolved and washed into the lake by runoffs (Bala and Bolorunduro, 2011) are essential in the life of aquatic bio-community. Total Dissolved Solids values obtained during the study periods were relatively constant. The monthly variation of the Total Dissolved solid fluctuated between 10.1mg/l-16mg/l in Station A and C. But Station B showed a fluctuation of 17 mg/l-40 mg/l. In all, the values were not above recommended values. Total Dissolved solids determination are important in water quality studies, though no serious health effect has been associated with dissolved solids ingestion in water but some regulatory agencies (Federal Ministry of Environment (2001); National Agency for Food, Drug Administration Control (2001) recommended a maximum Total dissolved solids value of 500 mg/l in drinking water supplies. The result is in agreement with Mustapha, (2009) and Usman, (2015) whose recorded values for Total Dissolved Solid were not beyond the recommended maximum value of 500 mg/l.

Alkalinity, also results from the dissolution of calcium carbonate ($CaCO_3$) from limestone bedrock which is eroded during the natural processes of weathering. The carbon dioxide (CO_2) released from the calcium carbonate into the stream, lakes and reservoirs water undergoes several equilibrium reactions (Kadhim, 2014). The values of Alkalinity in the study station were moderate. The monthly variation of the Alkalinity fluctuated all through the sampling stations throughout the period of September 2015 to February 2016 between 16 $CaCO_3$ mg/L to 28 $CaCO_3$ mg/L. This result is in conformity with the findings of Odo *et al*. (2014) in a tropical freshwater Lake.

CONCLUSION

This study revealed that the physico-chemical parameters of Bosso dam, Minna, Niger State, Nigeria were within the recommended levels for drinking water during the period of study amidst the seasonal variations. The study further revealed that the dam could be used for irrigation purposes for dry season farming, health wise; the water should undergo a little treatment before consumption even though the dam was constructed purposely for the supply of drinking water to the people of Bosso and the environs.

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