ASPECTS OF LIMNOLOGICAL STUDY OF WUSUM RESERVOIR IN MAKENI OF BOMBALI DISTRICT, NORTHERN REGION, SIERRA LEONE

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ABSTRACT

Seasonal changes in physico-chemical parameters of Wusum reservoir was investigated for twelve months in three selected stations. Water samples were taken from the surface of the reservoir and transported to the laboratory for analysis. Temperature was determined in-situ. Hydrogen ion concentration, conductivity, turbidity, nitrate-nitrogen and phosphate-phosphorus were determined in the laboratory. The results showed that temperature and conductivity were significantly higher (P<0.01) during the dry season whereas turbidity and phosphate-phosphorus were significantly higher (P<0.01) during the wet season. Correlation analysis showed that temperature was positively correlated with conductivity (P<0.05) and negatively correlated with turbidity (P<0.05), nitrate-nitrogen (P<0.05) and phosphate-phosphorus (P<0.01).

Keywords: Limnological studies, Wusum reservoir, Makeni, Sierra Leone

INTRODUCTION

Water is a natural resource necessary for social and economic development of any society. Though the commonest substance on earth, it is not found everywhere especially in the semi arid areas where it is scarcer. Water is life, and human beings need water for industrial, agricultural, domestic and recreational purposes including swimming, fishing and sailing thus water is indispensable to man and influences his choice of residence. On this note, Dedeke and Omotoso (2008) stated that usually the sighting of any village or dwelling of man or the growth of a community is hinged, on the availability of potable water for various domestic and developmental purposes. The development of many urban towns and cities warranted the construction of small lakes and reservoirs across small rivers and streams (Kolo and Tukura, 2007) for water supply. Thus Wusum reservoir was constructed to supply water to Makeni town to augment the existing surface and underground water sources which become drastically reduced or dried up during the dry season. The geochemical parameters of the basin, the limnology of the inflow rivers and the climatic conditions (Ofori-Danson and Antwi, 1994) influences the limnology of the reservoir. Human activities within and around the basin include farming, washing, bathing and quarrying. Run-off can wash inorganic fertilizers and agro-chemicals from farmlands down the basin causing eutrophication of the recipient reservoir. Also human activities introduce waste into the reservoir water thereby reducing its quality. Since water chemistry influences the distribution and abundance of aquatic life and since the reservoir is important economically, there is need to investigate the limnological parameters of Wusum reservoir as well as its dynamic changes with time and space. The specific aim of the present study is to assess the physico-chemical parameters of the reservoir as well as their spatial distribution and temporal dynamics.

MATERIALS AND METHODS

Study Area: The study was carried out in Makeni reservoir, Northern of region southern Sierra Leone. This reservoir is located in the Northern part of Makeni, towards Wusum hill. The dam was constructed in 1961 by Taylor

Wooded (a British), to supply water to Makeni metropolis. On dilapidating, a new system was constructed by ICC Construction Company in 1980. The gravity dam has a catchment area composed of granite. The reservoir is influenced by two seasonal patterns, dry season (October to March) and wet season (April to September). It receives runoff water from Wusum hill depression during the wet season. During the dry season, the reservoir receives water via surface pipes from Kunso River located 11.23 km from the dam site. The dam has a storage capacity of 6,750.7 m^3 (1,500,000 gallons).

Limnological Studies: The physico-chemical parameters of the reservoir were measured monthly between May, 2010 - April, 2011. Three sampling stations were selected for this study based on accessibility to the reservoir and human activities. Water samples were collected from each station using 1.5 litre capacity sampling bottle.

Temperature was measured in-situ using mercury-in-glass thermometer. The hydrogen ion concentration (pH) of the water samples was determined in the laboratory using the HACH 10 pH meter. Conductivity and turbidity were measured with HACH C0150 conductivity meter and turbidity meter respectively. Nitrate-nitrogen and phosphate-phosphorus were determined in the laboratory using the DR/2010 HACH Spectrophotometer.

Data analysis for significant differences between studied stations and sampled periods were performed using two-way analysis of variance and t-test at 5% level of probability. Pearson's correlation coefficient was performed to determine the relationship the various physico-chemical parameters.

RESULTS

Monthly Variations in the Physico-Chemical Parameters: Mean monthly variation of physico-chemical parameters of Wusum reservoir indicated that temperature fluctuated at the on set of the study, with relative increase towards the end of the investigation with an annual mean value of 27.60 ± 1.28^{0}C. The minimum temperature (25.9 ± 0.60 ^{0}C) was recorded in December while the maximum temperature (29.60 ± 10.90 ^{0}C) occurred in March (Table 1).

In Wusum reservoir during the period of study the highest monthly mean pH value (7.1 ± 10.06) occurred in November. The lowest mean pH value of 6.30 ± 0.25 and 6.30 ± 0.21 occurred in September and April, respectively. The annual mean value was 6.70 ± 0.36 implying that there was little variability in the hydrogen ion concentration values of Wusum reservoir. Conductivity varied from 7.4 ± 1.18 µS/cm in September to 62.2 ± 7.26 µS/cm in March. The annual mean conductivity of 39.76 ± 29.67 µS/cm obtained indicated wide dispersion in the values. The lowest and highest mean monthly turbidity values of 0.35 ± 0.25 NTU and 1.87 ± 0.15 NTU occurred in October and September, respectively. An annual turbidity mean value of 0.82 ± 0.51 NTU recorded indicated wide variability in the values. Nitrate content had its maximum mean monthly value of 1.93 ± 0.32 mg/l in September. A minimum mean monthly nitrate value of 0.22 ± 0.03 mg/l was recorded in the month of March. The annual mean nitrate value of 0.63 ± 0.56 mg/l indicated little variability in the nitrate content of Wusum reservoir. The phosphate varied in values with an annual mean of 0.33 ± 0.23 mg/l. The phosphate had its maximum monthly mean value of 0.83 ± 0.15 mg/l in September (Table 1).

Seasonal Changes in the Physico-Chemical Parameters: The most marked spatial changes revealed that the dry season mean values of water temperature, hydrogen ion concentration and conductivity were significant higher ($P < 0.05$) than those of the wet season months. Turbidity and phosphate on the other hand were significantly higher ($P < 0.05$) in the wet season than the dry season months. Nitrate had no significant ($P > 0.05$) seasonal fluctuation during the period of study.

Temporal Dynamics in the Physico-Chemical Attributes in Relation to Stations: There was much variability in the temperature values obtained at the study

Table 1: Mean monthly variation in the physico-chemical parameters of Wusum reservoir, Sierra Leone

Month	Parameters					
	Temp. ^{0}C	pH	Cond. (µS/cm)	Turb. (NTU)	NO – N (mg/l)	PO_4-P (mg/l)
May	29.1 ± 0.10	6.4 ± 0.46	69.4 ±1.63	0.50 ± 0.17	0.35 ± 0.05	0.29 ± 0.09
Jun.	26.5 ± 0.49	7.0 ± 0.15	24.7 ± 15.46	0.60 ± 0.20	0.25 ± 0.21	0.19 ± 0.18
Jul.	27.4 ± 0.26	6.6 ± 0.36	7.7 ± 1.40	0.87 ± 0.12	0.40 ± 0.40	0.11 ± 0.10
Aug.	26.5 ± 0.35	6.5 ± 0.25	7.9 ± 1.40	1.03 ± 0.06	0.87 ± 0.25	0.70 ± 0.18
Sep.	26.2 ± 0.25	6.3 ± 0.25	7.4 ± 1.18	1.87 ± 0.15	1.93 ± 0.32	0.83 ± 0.15
Oct.	27.6 ± 0.20	6.9 ± 0.15	25.2 ± 1.10	0.37 ± 0.25	0.42 ± 0.02	0.31 ± 0.17
Nov.	28.2 ± 0.10	7.1 ± 0.06	51.4 ± 1.63	1.50 ± 0.30	1.47 ± 0.12	0.29 ± 0.08
Dec.	25.9 ± 0.60	6.8 ± 0.15	52.4 ± 2.56	0.60 ± 0.53	0.70 ± 0.44	0.27 ± 0.03
Jan.	27.5 ± 0.50	6.5 ± 0.30	56.4 ± 5.25	1.00 ± 0.44	0.33 ± 0.06	0.21 ± 0.02
Feb.	29.4 ± 1.21	6.7 ± 0.30	59.2 ± 7.52	0.43 ± 0.32	0.28 ± 0.06	0.19 ± 0.03
Mar.	29.6 ± 0.90	6.6 ± 0.26	62.2 ± 7.26	0.57 ± 0.40	0.22 ± 0.03	0.28 ± 0.03
Apr.	27.2 ± 0.29	6.3 ± 0.21	53.2 ± 9.13	0.53 ± 0.32	0.30 ± 0.05	0.32 ± 0.09
Annual mean	27.6 ± 1.28	6.7 ± 0.36	39.8 ± 29.67	0.82±0.51	0.63 ± 0.56	0.33 ± 0.23

Key: *Temp. = Temperature, pH = Hydrogen ion concentration, Cond. = conductivity, Turb. = Turbidity, NO_3 –N = Nitrate-nitrogen, PO_4-P = Phosphate-phosphorus*

Table 2: **A summary of seasonal variations in physico-chemical parameters of Wusum reservoir**

Parameters	Dry season (0ctober - March)	Wet season (April - September)
Temperature (^{0}C)	28.1 ± 1.32	27.2 ± 1.08
pH	6.7 ± 0.41	6.1 ± 0.74
Conductivity (µS/cm)	51.14 ± 13.21	16.51 ± 11.68
Turbidity	0.74 ± 0.52	0.90 ± 0.51
Nitrate-nitrogen (mg/l)	0.57 ± 0.47	0.69 ± 0.64
Phosphate-phosphorus (mg/l)	0.26 ± 0.08	0.41 ± 0.30

**Significance at the 0.05 level (2-tailed)*

stations. Station 3 had the highest mean temperature of 28.0 ± 1.49 ^{0}C. Temperature was least at station 1 (27.3 ± 1.16^{0}C). The study revealed that the temperature values for the different stations were not significantly different. There was slight variability in the hydrogen ion concentration values obtained at the study stations. The highest value 6.72 ± 0.33 was recorded in station 2. There was no significant difference in the hydrogen ion concentration between study stations (Table 3).

Conductivity varied between 31.95 ± 22.0 µS/cm and 35.78 ± 24.50 µS/cm in station 1. Student's t-test showed that the difference between the stations were not significant (P>0.05). Turbidity varied between 0.79 ± 0.41 NTU at station 2 and 0.85 ± 0.49 NTU at station 1. Nitrate-nitrogen indicated slight variation between 0.25 mg/l and 0.35 mg/l at stations 2 and 1, respectively. The mean phosphate value ranged from 0.29 ± 0.18 mg/l in station 2 to 0.38 ± 0.29 mg/l in station 1 indicating little variability (Table 3).

Pearson's correlation coefficient performed to determine the relationship of various water quality parameters revealed that many parameters were significantly correlated. Conductivity correlated positively with water temperature (P<0.05) (Table 4).

Table 3: A summary of physico-chemical conditions of the study stations

Parameters	Stations		
	1	2	3
Temperature(^{0}C)	27.30 ± 1.16	27.7 ± 1.14	28.0 ± 1.49
pH	6.68 ± 0.36	6.72 ± 0.33	6.55 ± 0.39
Conductivity (µS/cm)	35.8 ± 24.50	33.9 ± 19.25	32.0 ± 22.0
Turbidity (NTU)	0.85 ± 0.49	0.79 ± 0.41	0.83 ± 0.65
Nitrate-nitrogen (mg/l)	0.62 ± 0.57	0.67 ± 0.66	0.58 ± 0.48
Phosphate-phosphorus (mg/l)	0.38 ± 0.29	0.29 ± 0.18	0.33 ± 0.19

Table 4: **Pearson's correlation coefficients (r) between physico-chemical parameters of the study reservoir**

Parameters	Temperature (^{0}C)	pH	Conductivity (µS/cm)	Turbidity (NTU)	Nitrate-nitrogen (mg/l)	Phosphate-phosphorus (mg/l)
Temperature (^{0}C)	0.00					
pH	-0.067					
Conductivity (µS/cm)	0.380*	0.252				
Turbidity (NTU)	-0.359*	-0.036	0.022			
Nitrate-nitrogen (mg/l)	-0.346*	0.072	-0.231	0.690*		
Phosphate-phosphorus (mg/l)	-0.474*	-0.364*	-0.434*	0.120	0.335*	0.00

** Significant correlation (r) at the 0.05 level (2-tailed)*

Water temperature correlated negatively with turbidity, nitrate-nitrogen and phosphate-phosphorus all of which correlated positively with one another (Table 4).

DISCUSSION

There are two distinct seasons in Wusum reservoir, wet and dry seasons. The wet season spans from April to September while the dry season spans from October to March. The onset of the rains signals a radical change in physico-chemical parameters of tropical rivers (Lowe-McConnel, 1978; Chapman and Kramer, 1991; Gbemisola, 2003). Also Vaas (1954), Chow (1958), Tucker (1958) and Ayoade *et al.* (2006) reported that the variations in chemical conditions of fresh water ponds have generally been found to be due to effects of rainfall. Thus the differences in the water quality parameters of the reservoir were due to rainfall. The reservoir annual mean temperature (27.6 ± 1.28 ^{0}C) is within desirable ranges (25 - 35 ^{0}C) for aquatic life including fish growth and reproduction (Boyd and Lichtkoppler, 1979).

Higher water temperature was recorded during the dry season. This possibly results from thicker cloud cover during wet season (Ayoade *et al.,* 2006), high specific heat capacity of waters (Abohweyere, 1990), the effect of high concentration of suspended particles in absorbing and scattering heat rays (Egborge, 1970) and lowering of solar heat radiation and the inundation of run-off (Ibemenuga and Inyang, 2007) into the reservoir during the wet months. The higher dry season temperature is attributed to increase in atmospheric temperature, decrease in relative humidity, low suspended particles, reduction in inundation run-off into the reservoir as well as human and anthropogenic activities within the catchment area.

Mean reservoir pH range of 6.3 ± 0.21 - 7.1 ± 0.06 recorded during the period of study falls within the recommended limits of 5 - 9.5 (Winger, 1981) suitable for aquatic life. Tarzwell

(1954) and Kemdirim (1993) gave a pH range of 6.5 - 8.5 as suitable for productive waters.

The high dry season pH of the present work is due to increased photosynthesis and evaporation of water. Photosynthetic assimilation of dissolved inorganic carbon can increase pH (King, 1970; Raven, 1970; Goldman, 1972; Farrell *et al.,* 1979; Khan and Chowdhury, 1994).

The conductivity of Wusum reservoir is low. The low conductance is attributed to low dissolved solids.

Granite, one of the rocks in the catchment area has been associated with low total dissolved solids and low content of bivalent cations (Winger, 1981; Kemdirim, 1993).

The higher wet season turbidity was attributed to input of silt and organic matter with run-off. Turbidity in the reservoir is low due to dilution, effect of rain water, low particulate organic matter and low plankton abundance.

The high nitrate-nitrogen content in the wet season could be due to agricultural activities within the catchment area. The element normally originate from agricultural input e.g. fertilizers and its increase in the wet season could be attributed to farming activities and the use of fertilizers in the gardens, which is leached or transported by run-off (Mkandawire, 2008).

The level of phosphate-phosphorus recorded was low. This could be due to low phytoplankton (Kemdirim, 1990) and low nutrient input from the water shed. Thus Wusum reservoir is oligotrophic.

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