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Evaluation of raw water quality of Bosso Lake in North-Central Nigeria

Ehigiator, O. A.* and Jimoh, O. I.

Department of Civil Engineering, Federal University of Technology P. M. B. 65, Minna, Niger State, Nigeria.

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This study focuses on the quality of water at Bosso Lake during the rainy season months of August to October. Water samples collected each month were examined for their physiochemical and bacteriological attributes. All the samples were obtained during the peak of the rainy season while traits such as nitrate concentration, pH values, total dissolved solids (TDS), total hardness, iron concentration, suspended solids, calcium hardness, total coliform count and Escherichia coli were analyzed. The results showed variations in concentration of the parameters with respect to rainfall intensity and frequency. Although, results indicate that most of the physiochemical parameters were within the acceptable range of the Nigerian Standard for Drinking Water Quality nevertheless the high concentration of pathogens in the raw water renders it non-potable.

Key words: Raw water, Bosso Lake, water quality, physico-chemical, coliform.

INTRODUCTION

In the developing world, diseases associated with poor water and sanitation has considerable public health significance (WHO, 2003). In 2004, it was estimated that 4% of the global burden of disease and 1.6 million deaths per year were attributed to unsafe water supply. This corresponds to 61 million disability-adjusted life-years lost (DALYs), taking into account burden of disease due to both morbidity and mortality. While there have been improvements since the 1980s, in 2004 an estimated 1.1 billion people were without access to safe water sources (WHO and UNICEF, 2006). Nearly 80% of the people using water from unimproved sources are concentrated in three regions: sub-Saharan Africa, Eastern Asia and Southern Asia. In sub-Saharan Africa progress was made from 49% coverage in 1990 to 56% in 2004.

Although, the Millennium Development Goals (MDG) drinking water target coverage of 88% was met in 2010 (UNMDG, 2010), over 884 million people of the developing world's population still depended on unsafe drinking water source (UNICEF, 2010). Whereas 76% of the global population had access to an improved drinking water source in 1990, 89% of the global population had access in 2012, an increase of 2.3 billion people. Fifty-six percent of the global population, almost four billion people, now enjoy the highest level of access: A piped drinking water connection on premises.

According to the 2014 update report of the World Health Organization and United Nations Children's Fund (WHO and UNICEF, 2014) Joint Monitoring Programme for Water Supply and Sanitation, well since 1990, over

*Corresponding author. E-mail: ayuduehigiator@yahoo.com.

2 billion people have gained access to improved sources of drinking water, and 116 countries have met the MDG target for water. Almost 2 billion people gained access to improved sanitation and 77 countries have met the MDG target. But much still remains to be done. More than 700 million people still lack ready access to improved sources of drinking water; nearly half of them are in sub-Saharan Africa. Eighty-two percent of the world's population without improved drinking water sources live in rural areas. The relative importance of water quality versus water quantity, sanitation and hygiene education interventions for protecting the population's health has been the subject of considerable debate (Esrey et al., 1985, 1991; Curtis et al., 2000).

In 2012, 64% of the population had access to an improved sanitation facility – up 15% from 1990. Two and a half billion people do not have access to improved sanitation, while one billion people still practise open defecation; nine out of ten are in rural areas. World Health Organization (WHO) Guidelines and most national drinking water standards, take the presence of *Escherichia coli* or thermo-tolerant coliforms as an indication of recent faecal pollution from human or warm-blooded animals (WHO, 1993). Thus, the WHO guideline value of zero *E. coli* or thermo-tolerant coliform bacteria in any 100 ml sample of drinking water was established because even low levels of faecal contamination may potentially contain pathogens. Given these clear and unambiguous guidelines, it is reasonable to conclude that drinking water exhibiting faecal contamination at any point in the distribution to consumption sequence should be cause for concern. In their physicochemical and *E. coli* assessment of selected packaged water products otherwise called "pure water" in Minna, Ndamitso et al. (2013) classified most of them as agents of disease transmission on the basis of WHO and EPA guidelines. Coliform levels obtained by them based on the most probable number (MPN) were between 75±2.00 and 23.33±0.33. Water-borne diseases are common within this watershed as a result of discharges from surface runoff and wash-off from farmlands adjacent to the dam which increases the nitrate and phosphorus concentrations as well as grazing activities near the lake.

MATERIALS AND METHODS

Context

The study area-Bosso is located on latitude 8° 3'north and longitude 4° 35' east of the equator and is situated in the transition zone between the forest and savanna regions of Nigeria (Figure 1). Its climate is characterized by a marked wet and dry seasons. The rainfall is mainly conventional with a normal total annual value of less than 1,100 mm. The temperature ranges between 32 and 20°C for the dry and wet seasons respectively and a mean temperature of about 27°C. The annual temperature ranges may, therefore be as high as 12°C or more. Relative humidity is usually high during the rainy season while the dry season is characteristically dry with low relative humidity. The vegetation of Bosso is derived savanna type and consists mainly of grasses. The heights of these grasses, however, vary from about 2 to 3 m near the forest to less than 1 m near the desert.

The grass land usually contains scattered trees. These are fairly tall, about 10 to 20 m or more near the forest and less than 10 m near the desert. The scattered nature of the trees gives rise to less transpiration. The trees are deciduous; they shed their leaves in the dry season to reduce transpiration. Soils of the area are lateritic in nature resulting from the combined effects of leaching during the rainy season and capillary attractions during the dry season. During rainy or wet season, mineral salts, mainly compounds of iron leaches down into the ground. At the same time, due to water table accretion, some minerals particularly iron and aluminum salts are brought nearer to the surface. In the dry season, evaporation of the soil-water leaves behind insoluble compounds of iron and aluminum slag-like concretions. The organic substances that pose the greatest threat to the quality of water are those that are relatively soluble, non-volatile and refractory.

Analysis and testing

The analysis was conducted in accordance with the standard method for examination of water and waste water (APHA, 1992). The physiochemical parameters were evaluated at the Civil Engineering Laboratory of Federal University of Technology, Minna while the bacteriological analysis was conducted at Niger State Water Board, Chanchaga. Sampling method was used for the physiochemical analysis which involved the use of reagents while material method was used for bacteriological analysis. All the apparatus used were well sterilized including the bench on which the experiments were conducted. Six (6) samples were collected at established reach within the basin on a weekly basis over a period of three months and were analyzed within 48 h of collection at normal temperatures.

In collecting the samples, the bottles were first sterilized in the laboratory and then rinsed twice with the water to be collected as sample before collection from below the water surface at both downstream and upstream sections of the lake. The bacteriological analysis of the water was carried out using the membrane filtration apparatus. 3.85 g of membrane lauryl sulphate broth was measured using balance weighing machine, which was then transferred into a 250 ml conical flask and dissolved with distilled water. The media was subsequently sterilized in an autoclave at a temperature of 121°C for 15 min. After the sterilization, it was allowed to cool and then 100 ml of the water sample was measured and filtered with membrane filtration apparatus. One piece of the media pad was removed and transferred to Petri dish which was soaked in membrane lauryl sulphate broth (sterilized). The filter paper was removed from the membrane filtration apparatus and placed on the soaked media pad, which was allowed to stay on the bench for 4 h. Then one of the plates (Petri dish) was transferred to the incubator, and incubated at 37°C for 14 h to determine the total coliform. The second plate was transferred to another incubator at 44°C for 14 h to assess the *E. coli*. After the incubation period was completed, the plate was removed and counting was done using the colony counter.

RESULTS AND DISCUSSION

The mean values of the physiochemical properties analyzed and the results of the bacteriological analysis were presented in Tables 1 and 2, respectively. According to Table 1, most of the parameters in the month of August have higher values than those in the

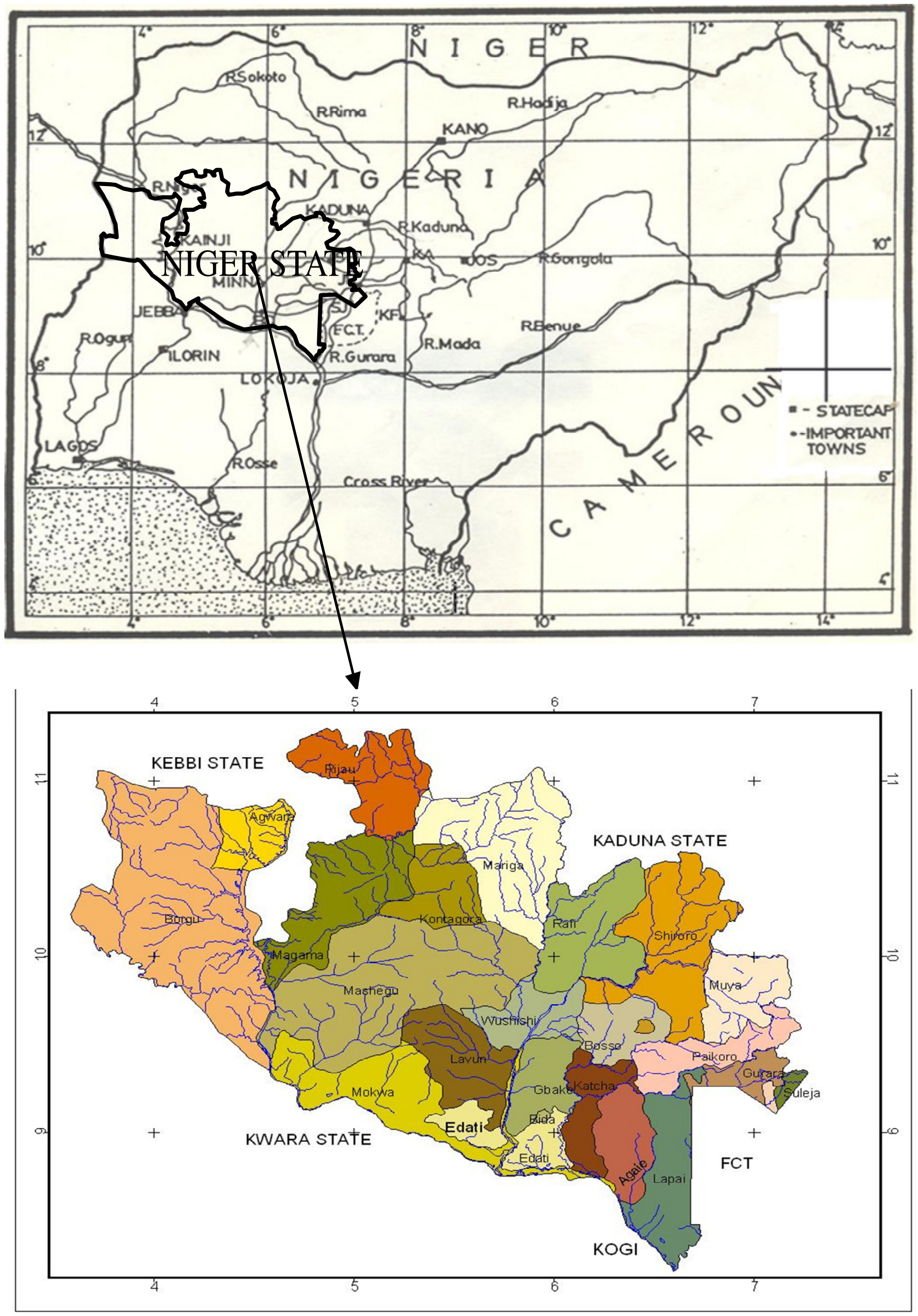

Figure 1. Location of the study area. Source: Federal Surveys (1976).

months of September and October. The electric conductivity (Ec) values of these samples which gave the measures of the ionized substances in the samples at a particular temperature (Akoto and Adiyiah, 2007) varied from 102.5 to 78 µs/cm and 115 to 90 µs/cm at the upstream and downstream sections of the dam, respectively. These were all below the 2500 µs/cm given for fresh waters by EPA (2011a) and WHO (2008), the recommended permissible limit of 1000 µs/cm (NSDWQ) for conductivity.

The results imply that these samples probably did not contain much ionized metals especially those that could pose serious health hazards. The total dissolved solid (TDS) contents ranged from 45 mg/l at the downstream end in October to 75 mg/l in August at the upstream with an average of 51±14.6 mg/l. The measured pH ranged from 6.8 to 7.5. There was high concentration of nitrate which resulted from the presence of heavy runoff from

Table 1. Physico-chemical properties of Bosso Lake water.

S/N	Parameters	Upstream			Downstream			NSDWQ
		Aug	Sept	Oct	Aug	Sept	Oct	
1	Electrical conductivity (µs/cm)	102.5	80	78	115	90	90	1000
2	Total dissolved solids (mg/l)	75	40	38.2	62.8	45	45	500
3	Temperature (ºC)	22	26.4	26.4	23.5	26.4	26.5	N/S
4	Turbidity (NTU)	7.2	5.0	5.0	9.0	6.0	4.53	5.0
5	Suspended solids (mg/l)	1.03	0	0.1	2.2	2.0	2.5	N/S
6	Colour (Hazen)	42	29	27	45	30	30	15
7	Iron content (mg/l)	1.2	0.08	0.08	0.9	0.03	0.03	0.30
8	Sulphate (mg/l)	2.05	2.0	2.3	1.2	1.0	2.5	100
9	Nitrate as Nitrogen (mg/l)	4.5	1.7	2.2	3.0	0.3	0.5	10
10	Nitrate (mg/l)	10	7.5	7.2	5.4	1.3	8.0	50
11	PH	7.2	6.8	6.8	7.5	6.9	7.0	6.5 – 8.5
12	Calcium hardness (mg/l)	67.5	57.5	57.7	80.2	67.5	68	N/S
13	Magnesium hardness (mg/l)	16.5	11.5	11.5	18	12.5	12.6	N/S
14	Total hardness (mg/l)	70	69	70	71	71	75	150
15	Total Alkalinity (mg/l)	96	96	96	97.2	96	97	N/S

Table 2. Bacteriological analysis.

S/N	Section	Month	*E. coli* (cfu/100 ml)	Total coliform (cfu/100 ml)	NSDWQ
i	Up-stream	August	12	48	0
		September	7	48	0
		October	8	48	0
ii	Down-stream	August	29	128	10
		September	23	120	10
		October	30	125	10

NSDWQ: Nigerian Standard for Drinking Water Quality.

Table 3. Mean monthly rainfall total in Bosso.

Month	Jan.	Feb	Mar	Apr	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Rainfall (mm)	0	0	0	1.2	3.6	93.3	137.4	208.5	249.1	69.7	0.5	0.1	763.4

Note: Jan. – January, Feb. – February, Mar. – March, Apr. – April, May, Aug. – August, Sept. – September, Oct. - October, Nov. – November and Dec. – December.

the adjacent farmlands. This is in concordance with the findings by Ndamitso et al. (2013) that the high level of nitrate found in the sachet water produced in this area might have been through contamination from refuse dump runoff or human and animal wastes.

Temperature influences the life of all biological organisms. A temperature range between 22 and 26.4°C at both upstream and downstream of the dam was recorded. The temperature variation is mainly related with the temperature of atmospheric and weather conditions (Adebowale et al., 2008).

Although no definite trend could be established, there were clear differences in the measured parameter values for the rainy season which covers the period from August to October. Rainfall event characterized by the amount, intensity, distribution, and duration of rainfall play an important role in water chemistry (Ifabiyi, 2006). The impact of contamination events on lakes and reservoirs is more severe and persistent than streams and rivers because there is no natural flushing process. A water body with a high velocity with respect to the frequent rainfall is said to have its water a bit purified from some contaminants like dissolved or suspended solids, unlike sluggishly flowing water body (Table 3).

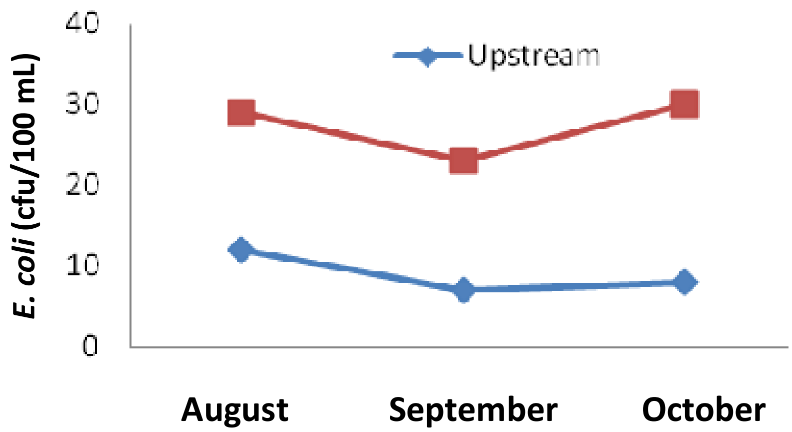

Figure 2. Microbial load.

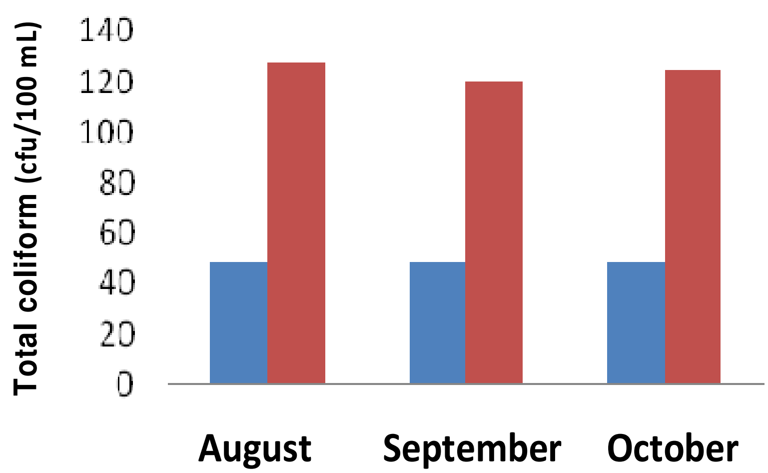

Figure 3. Total coliform.

It could be inferred from Figures 2 and 3 that both stretches have high faecal coliform and total coliform levels, which are attributable to sewage discharge, open defecation, cattle wallowing and disposal of animal carcasses. Coliform organisms serve as the major indicator of water pollution. The survey revealed that lot of effluent and sewage is being generated with virtually no treatment provided for the bulk of the effluent. Moreover, frequent use of fertilizers and pesticides, open defecation, lack of solid waste management practices also contribute to the surface water pollution.

CONCLUSIONS AND RECOMMENDATIONS

Consumption of raw water from Bosso Lake is absolutely deleterious due to the high concentration of coliform bacteria and *E. coli* found in both upstream and downstream sections of the dam. Grazing management along water courses has significant impact on water quality, where pollution by human and animal wash into the stream. Preventative measures such as modification of tilling methods and run-off control in agriculture, the use of lined catchment ponds for treatment of wastes, and double lined underground storage tanks could greatly reduce contamination of this drinking water source. Moreover, consumers need to be educated about the sources of tap water contamination and the options for treatment. Water management globally has undergone restructuring over the last decade. This is due in large part, the need to incorporate the principles of sustainable development (particularly those arising from the Rio Earth Summit in 1992) into water management practices (Michael, 1992) combined with attempts to adopt a market based approach towards water supply promoted by the World Bank, among others.

Consequently, many domestic water laws are in a state of flux, adapting to evolving scientific evidence and resource management theory as well as to growing environmental and social problems linked to water. Water pollution in the form of effluents, chemicals or drastic temperature change, is one of the major concerns facing water regulators. By requiring all dischargers in a water catchment to have licenses and to build facilities according to minimum technical specifications, water regulators can effectively lower the total amount of pollution in a catchment. By combining this regime with regular monitoring of water quality in different parts of a catchment area, regulators have a powerful tool to mitigate pollution. Although, global environmental issues are upstaging Africa-specific issues of water development, there is compelling need for better donor emphasis on water development. Improved access to quality water is a long-term goal that requires more than humanitarian funds.

Conflict of Interest

The author(s) have not declared any conflict of interests.

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