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Full Length Research Paper

Assessment of water quality in Ahor Lake - Ghana

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In the bid to boost the tourism industry, West Akyem Municipal Assembly identified Lake Ahor, a manmade lake as a potential tourism site in the municipality. However, the quality of the water is not known hence the assessment of the physical, chemical and bacteriological characteristics of the lake. A total of twelve samples of water from the lake were collected in June 2011 and were subjected to physical, chemical and bacteriological analysis. The measured water quality parameters included pH, colour, turbidity, alkalinity, TDS, total iron, nitrate, nitrite, trace elements like phosphates, zinc, copper, silicon, feacal coliform and *Escherichia coli* counts. The results showed that the averages for parameters like pH, colour, turbidity, alkalinity, TDS, total iron and nitrate were 6.6, 48.3 TCU, 4.8 NTU, 44.2, 1221.3 and 0.2 mg/l respectively. The tests for total coliform, faecal coliform, *E. coli* and total heterotrophic bacteria levels showed >8 CFU/100 ml for total coliform, between 1.00 and 8.00CFU/100ml for faecal coliform, 0.00 and 9.00 CFU/100 ml for *E. coli* and 42.00 and 155.0 CFU/100 ml for total heterotrophic bacteria. The water from the lake met the WHO guidelines in all parameters except the colour of the water which was light brownish which reduced the clarity at the deep areas of the lake. It is recommended that the appropriate authorities must demarcate safe swimming areas in the lake to prevent injury or drowning of those who will patronize the facility.

Key words: Recreation, water quality, bacteriological quality, lake.

INTRODUCTION

Water is essential for life and the wellbeing of all people. Natural water systems provide fisheries, flood plains, agriculture, natural services and products like aquifer replenishment, water quality improvement and bio-diversity (Naiman, 1992; Edmondson, 1991). It is no wonder that civilization both modern and ancient sprung along water bodies like the Nile, the Euphrates, the Ganges, and the Volta (Worster, 1992). The use of water bodies for recreational purposes is one of the most important aspects of eco-tourism around the world (Tyler, 1995; Jefferies and Mills, 1991; Lee and Brodie, 1982).

The main goal of the research was to assess the suitability of Ahor Lake for recreational activities such as swimming, diving and boating to ensure the safety of users of the facility. Specifically, the study assessed the bacteriological quality and some critical physicochemical parameters of the water of the Lake for recreational purpose.

Lake Ahor (Slum Dam) is an artificial lake found at Nyankomase- Otwenkwanta at the northern part of the West Akyem Municipal. This was created in 1963 by CAST, a European diamond mining company which was based in Akwatia, as a dam to argument their operational water demand during dry seasons. After the collapse of Ghana Consolidated Diamonds which took over operations from the CAST mining company, the Dam has been abandoned. Recently, the Municipal has taken interest in the water body to develop it for recreational purpose.

Climatically, Lake Ahor lies within the Wet Semi Equatorial Climatic Zone which experiences two raining seasons with March to July as the major and September to November as the minor with the heaviest rainfall in June. The average temperature ranges between 25.2°C

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minimum and 27.9°C maximum and relative humidity is highest during the rainy season of about 80 to 95%. (Ghana Meteorological Department, 2006).

METHODOLOGY

In all, twelve samples of 1500 ml of water each were collected from the lake at points shown in Figure 1.

The following equipment and glassware: Hach DR/2000, Spectrophotometer, Horiba Compact B-212 p^H Meter, analytical balance, incubator, autoclave, 250-ml conical flask, beaker, burette, pipette, dropper, wash bottle, measuring cylinder, magnetic stirrer, sterile sample bottles, culture tubes containing inverted Durham vials, beakers, markers, paper cello tape were used in the water quality analysis.

The analyses were carried out at the Water Quality Assurance Unit of Ghana Water Company/Aqua Vitens Rand Limited in Koforidua, Eastern Region of Ghana and Water Resources and Environmental Sanitation Laboratory, Civil Engineering Department, KNUST, Kumasi, using Standard Methods for the Examination of Water and Wastewater (20^{th} Edition).

Samples of water for analysis were prepared by adding the required type and amount of reagent depending on the test to be performed or quality parameter to be examined. Two sample cells were used for each analysis. One sample cell was filled with measured quantity of prepared sample and the other cell was filled with deionised water to serve as blank. The sample cells with its contents were placed in the Hach DR/2000 Spectrophotometer and analysed. The results obtained were displayed and the values recorded. The test was repeated for the samples depending on the quality parameter under investigation. The samples were analysed for colour, odour, turbidity, TDS, alkalinity, pH, temperature, trace metals (lead, mercury, cadmium, and iron), hardness, calcium, magnesium, chloride, phosphates, nitrates and nitrite, and bacteriological parameters (APAH, AWWA, WEF, 1998; Dukta, 1978; Mohammed, 2006; McCrady, 1985, 1988; Warburton et al., 1992).

RESULTS AND DISCUSSION

The results showed that all twelve samples have an average pH of 6.6 which is generally within the range of 6.4 to 6.9 which is with the recommended guidelines of WHO ranging from 6.5 to 6.9 (WHO, 2003). The pH is very important for recreational water quality because it has been proven that very low or high pH levels can cause skin and eye irritation (Mitchell and Stapp, 2005). The taste and odour from all twelve samples were inoffensive which is an acceptable recreational water quality standard. This implies that the taste and odour of the water is very good for recreational purposes and may not pose any health problem to users. The true colour measured from all twelve samples recorded values ranging from 44.00 to 61.00 TCU with an average value of 48.3 TCU. The WHO Guidelines for Safe Recreational Water and Environment (2003) stipulates that recreational water should be clear enough to allow the user to see physical hazards that may be present in the water (Stapp et al., 1997). With an average TCU of 48.3 mg/l the water is of a light brownish colour that may impede visibility and therefore there is the need for authorities to demarcate safe swimming areas in the lake to prevent injury or drowning. The light brownish colour of the water may be due to the decomposition of leaves and plant debris from the forest that surrounds the lake. The temperature of the twelve samples ranged between 24.8 and 25.8°C with an average value of 25.1°C. This means that the water is suitable for recreational activities since there is scientific evidence that prolonged emersion in water warmer than 34 to 35°C is hazardous to humans. The turbidity of the twelve samples ranged between 3.77 and 7.43 NTU with an average of 4.8 NTU all of which are below the stipulated values in the WHO Guidelines for Safe Recreational Water and Environment (2003) requirement of 50 NTU (Table 1a-f). This may be due to the fact that there are no human settlements in the vicinity of the lake and few agricultural activities are ongoing in the catchment. The TDS in the twelve samples ranges from 982 to 1370 mg/l with an average value of 1221.3 mg/l which falls within the TDS guidelines for recreational water as set by the WHO Guidelines for Safe Recreational Water and Environment (2006) requirement of 2000 mg/l.

The total hardness of all the samples ranged between 30.0 and 74.0 mg/l with an average of 41.0. This means that the waters of the lake are generally soft since the average is less than 60.0 mg/l. It indicates that the lake is suitable for recreational purposes. The alkalinity of the samples tested recorded values ranging from 37.0 to 55.0 mg/l, with an average of 44.2 mg/l, which is within the limit set by the WHO Guidelines for Safe Recreational Water and Environment (2006) requirement of 60.0 mg/l. The value for DO for all twelve sample were greater than 80% with an average value of 83.7% while that of BOD is between 38 and 74 mg/l with an average value of 42.6 mg/l. This is a good indicator for healthy aquatic life. The DO and by inference the BOD is an indication of the level of biodegradable contaminant or pollutants in the water. A high level of DO means a low BOD and indicates a low level of organic contaminants or pollutant in the water which enhances the aesthetic aspect of the facility (Stumm and Morgan, 1995). It must be noted that the BOD at the inlet was high (74 mg/l) while that of the outlet point was low (38.4 mg/l). The high DO and low BOD of the lake may be due to low organic load into the lake and the exposure of the lake to atmospheric oxygen, confirming the natural cleansing ability of the lake. The concentration of nitrates and nitrites in all the samples ranged between 0.00 to 0.30 mg/l and 0.00 to 0.4 mg/l respectively with average values of 0.2 and 0.1 mg/l respectively. These parameters are very important for recreational since they are sources of nutrient supply for algal bloom causing eutrophication which may adversely affect the aesthetic parameters of the lake giving greenish hue (Hounslow, 1995). The concentration of iron, phosphates, zinc, copper, silicon, calcium magnesium, manganese, potassium arsenic, cyanide and

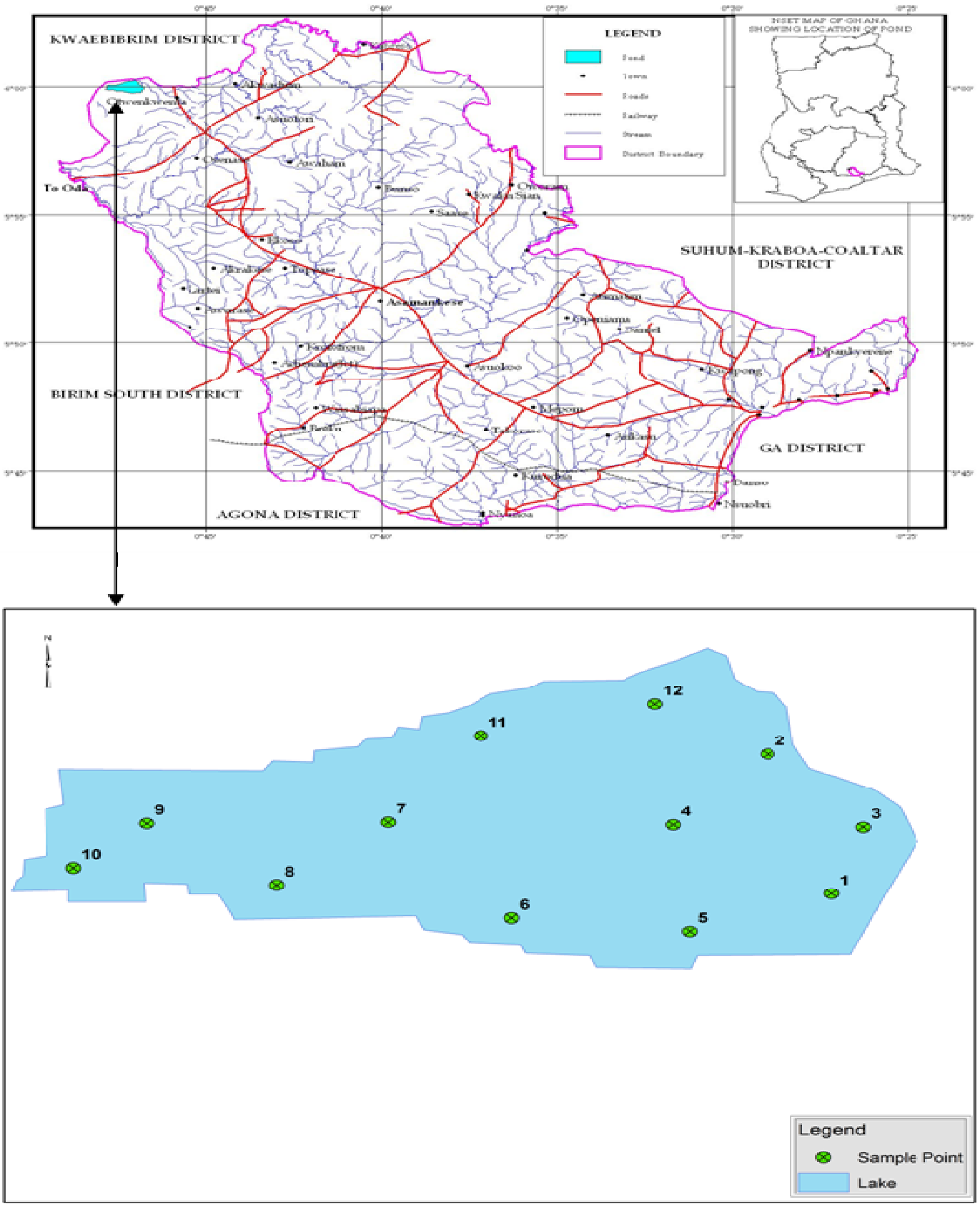

Figure 1. Map of Ahor Lake showing the sampling points.

Table 1a. Physico-chemical water quality analysis report.

Parameter	Unit	Sample test value			
		Sample 1	Sample 2	Sample 3	Sample 4
Taste and odour		Inoffensive	Inoffensive	Inoffensive	Inoffensive
Temperature	˚C	24.56	24.9	25.12	24.90
Colour	Pt.Co	61.00	49.00	42.00	44.00
Turbidity	NTU	7.43	4.49	3.77	4.66
pH		6.50	6.40	6.50	6.70
Conductivity	µS/cm	2330.00	24.50.00	2440.00	2430.00
Total dissolved solids	mg/l	1197.00	1266.00	1226.00	1222.00
Total Suspended Solids	mg/l	8.00	4.00	2.86	4.00
Total alkalinity ($CaCO_3$)	mg/l	51.00	40.00	41.00	40.00
Total hardness	mg/l	34.00	66.00	74.00	30.00
Chloride	mg/l	9.99	11.99	10.85	11.49
Fluoride	mg/l	0.00	0.12	0.00	0.01
Calcium Hardness	mg/l	15.00	11.00	10.00	8.00
Magnesium Hardness	mg/l	19.00	55.00	64.00	22.00
Calcium	mg/l	6.01	4.40	4.00	3.20
Magnesium	mg/l	4.56	15.95	18.56	6.38
Manganese	mg/l	0.05	0.05	0.046	0.09
Total iron	mg/l	0.03	0.02	0.01	0.02
Sulphate	mg/l	0.00	0.00	0.00	0.00
Ammonium Nitrogen (NH_4-N)	mg/l	0.08	0.32	0.11	0.20
Nitrate Nitrogen (NO_3-N)	mg/l	0.30	0.10	0.20	0.10
Nitrite Nitrogen (NO_2-N)	mg/l	0.00	0.00	0.00	0.00

Table 1b. Physico-chemical water quality analysis report.

Parameter (mg/l)	Sample test value			
	Sample 1	Sample 2	Sample 3	Sample 4
Aluminium	0.02	0.012	0.00	0.01
Cyanide	0.02	0.00	0.01	0.01
Phosphate	0.23	1.13	0.10	1.09
Potassium(K)	4.56	7.11	5.62	6.38
Arsenic	0.00	0.00	0.00	0.00
Zinc	0.09	0.02	0.22	0.03
Copper	0.03	0.03	0.01	0.00
Silica	6.40	3.40	2.90	4.30
Lead	0.00	0.00	0.00	0.00

lead were averagely 0.3, 0.5, 0.1, 0.0, 6.5, 5.5, 7.7, 0.1, 8.3, 0.0, 0.0 and 0.0 mg/l respectively. All these were within the acceptable standards for recreational water according to the WHO Guidelines for Safe Recreational Water and Environment (2006) requirements because these concentrations do not pose any health risk to users of the facility.

The results of bacteriological quality showed that all the twelve samples had a total coliform bacteria concentration of > 8.0 MPN Idex/100 ml which indicates the presence of bacteria in the water (Table 2). The presence of bacteria means there is a possibility of pathogenic bacteria in the water medium. The results also showed the presence of feacal coliform concentration between 1.00 and 8.00CFU/100 ml which was in line with the limits set by the WHO Guidelines for Safe Recreational Water and Environment (2006) requirements which stipulates 200 CFU/100 ml. Although a value of 8.00 CFU/100 ml is not acceptable for drinking water, it is however suitable for recreational purposes.

The results further showed the presence of *E. coli* with concentration between 0.00 and 9.00 CFU/100 ml which

Table 1c. Physico-chemical water quality analysis report.

Parameter	Unit	Sample test value			
		Sample 5	Sample 6	Sample 7	Sample 8
Taste and odour		Inoffensive	Inoffensive	Inoffensive	Inoffensive
Temperature	˚C	25.00	24.80	25.10	
Colour	Pt.Co	53.00	53.00	51.00	47.00
Salinity	%	1.20	1.20	1.20	1.20
Turbidity	NTU	4.02	5.07	4.16	4.33
pH		6.80	6.60	6.70	6.90
Conductivity	µS/cm	2370	2380.00	2390.00	2430.0
Total dissolved solids	mg/l	1207.00	1204.00	1209	1233
Total Suspended Solids	mg/l	3.00	4.52	4.00	4.24
Total alkalinity(CaCO3)	mg/l	38.00	37.00	51.00	40.00
Total hardness	mg/l	31.00	40.00	38.00	35.00
Chloride	mg/l	13.49	24.49	16.80	6.00
Fluoride	mg/l	0.00	0.12	0.03	0.21
Calcium Hardness	mg/l	9.00	16.00	21.00	10.00
Magnesium Hardness	mg/l	22.00	24.00	17.00	25.00
Calcium	mg/l	3.60	6.41	8.41	4.00
Magnesium	mg/l	6.38	6.96	4.93	7.25
Manganese	mg/l	0.06	0.06	0.06	0.05
Total iron	mg/l	0.03	0.01	0.53	0.51
Sulphate	mg/l	0.00	0.00	0.00	0.00
Ammonium Nitrogen(NH4-N)	mg/l	0.00	0.20	0.00	0.00
Nitrate Nitrogen(NO3-N)	mg/l	0.00	0.20	0.00	0.00
Nitrite Nitrogen(NO2-N)	mg/l	0.00	0.00	0.01	0.01

Table 1d. Physico-chemical water quality analysis report.

Parameter	Unit	Sample test value			
		Sample 5	Sample 6	Sample 7	Sample 8
Aluminium	mg/l	0.00	0.02	0.045	0.00
Cyanide	mg/l	0.00	0.01	0.00	0.00
Phosphate	mg/l	1.55	1.10	0.10	0.02
Potassium(K)	mg/l	4.56	7.86	11.21	8.56
Arsenic	mg/l	0.00	0.00	0.00	0.00
Zinc	mg/l	0.00	0.19	0.04	0.10
Copper	mg/l	0.00	0.03	0.00	0.01
Silica	mg/l	5.50	14.00	4.40	9.60
Lead	mg/l	0.00	0.00	0.00	0.00

was within the limit set by the WHO Guidelines for Safe Recreational Water and Environment (2003) requirements which stipulates 100 CFU/100 ml. Although a value of 9.00 CFU/100 ml is not acceptable for drinking water, it is however very suitable for recreational purposes because at such concentrations it will pose no health threat to users of the facility. The examination of all the water samples revealed that they were contaminated with total heterotrophic bacteria in values ranging from 42.00 to 155.00 CFU/ 100 ml. This is however acceptable compared to CROSQ Guidelines value of 200 CPU/100 ml (CROSQ, 2007). This means that the lake is suitable for recreation purposes because of the low tendency of the water to transmit diseases.

Conclusion

The research conducted on Ahor Lake indicates that the water is very suitable for recreational activities because

Table 1e. Physico-chemical water quality analysis report.

Parameter	Unit	Sample test value			
		Sample 9	Sample 10	Sample 11	Sample 12
Taste and odour		Inoffensive	Inoffensive	Inoffensive	Inoffensive
Temperature	˚C	25.2	25.30	25.00	25.80
Colour	Pt.Co	46.00	44.00	45.00	44.00
Turbidity	NTU	4.87	4.41	5.15	4.99
Ph		6.50	6.50	6.50	6.70
Conductivity	µS/cm	2500	2540	2700	1959.0
Salinity	%	1.30	1.30	1.40	1.00
Total dissolved solids	mg/l	1271.00	1268.00	1370.00	982.00
Total Suspended Solids	mg/l	1.00	2.56	3.45	4.00
Total alkalinity($CaCO_3$)	mg/l	39.00	52.00	55.00	46.00
Total hardness	mg/l	40.00	33.00	36.00	35.00
Chloride	mg/l	7.44	2.40.	30.56	23.11
Fluoride	mg/l	0.00	0.00	0.00	0.04
Calcium Hardness	mg/l	9.00	16.00	18.00	23.00
Magnesium Hardness	mg/l	31.00	17.00	12.00	12.00
Calcium	mg/l	3.60	6.41	7.21	9.21
Magnesium	mg/l	8.99	4.93	3.48	3.48
Manganese	mg/l	0.08	0.10	0.08	0.07
Total iron	mg/l	0.35	0.50	0.60	0.57
Sulphate	mg/l	0.00	0.00	0.00	0.00
Ammonium Nitrogen(NH_4-N)	mg/l	0.22	0.28	0.27	0.22
Nitrate Nitrogen(NO_3-N)	mg/l	0.20	0.10	0.30	0.20
Nitrite Nitrogen(NO_2-N)	mg/l	0.3	0.03	0.04	0.25

Table 1f. Physico-chemical water quality analysis report.

Parameter	Unit	Sample test value			
		Sample 9	Sample 10	Sample 11	Sample 12
Aluminium	mg/l	0.011	0.04	0.00	0.01
Cyanide	mg/l	0.00	0.00	0.00	0.00
Phosphate	mg/l	0.07	0.22	0.19	0.20
Potassium(K)	mg/l	9.65	11.24	15.30	7.56
Arsenic	mg/l	0.00	0.00	0.00	0.00
Zinc	mg/l	0.14	0.19	0.09	0.10
Copper	mg/l	0.10	0.00	0.00	0.00
Silica	mg/l	6.40	8.40	6.30	6.90
Lead	mg/l	0.00	0.00	0.00	0.00

Table 2. Bacteriological analysis report.

Parameter	Unit	Sample test value							
		1	2	3	4	5	6	7	8
Total Coliform Bacteria	MPN Index/100 ml	>8.00	>8.00	>8.00	>8.00	>8.00	>8.00	>8.00	>8.00
Faecal Coliform	CFU/ml	2.00	0.00	2.00	6.00	5.00	1.00	7.00	2.00
E.coli (thermotolerant coliforms)	CFU/ml	2.00	4.00	3.00	7.00	3.00	7.00	1.00	9.00
Total heterotrophic bacteria	CFU/ml	71.00	42.00	115.00	98.00	105.00	78.00	65.00	47.00

the parameters analyzed met international guidelines for recreational water. All the physico- chemical and bacteriological parameters determined in this research were within acceptable limits and pose no health hazard to users of the facility apart from the general light brownish colour of the water that affects the clarity if the facility will be used for swimming in deep waters. It is therefore recommended that the appropriate authorities should demarcate safe swimming areas in the lake to prevent injury or drowning of those who will patronize the facility. Continuous monitoring of physico-chemical and bacteriological qualities must be conducted on the lake periodically, sediments analysis and presence of other aquatic organisms. Similar tests should be done in the dry season to ascertain whether there will be seasonal variations in the results.

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