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RESEARCH PAPER

Assessment of the Limnological characteristics of Lake Bosomtwe in the Ashanti Region of Ghana

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Abstract

The quality of the water from Lake Bosomtwe was assessed to aid in the conservation decision on the lake. Twenty-six parameters of physico-chemical, bacteriological, and organic effects and major and trace ions were evaluated using the principal component analysis. The levels of these parameters were also compared with surface water benchmarks of Ghana EPA, WHO, EU, US EPA and CCEM. As prescribed by the benchmarks of these regulatory bodies, the mean levels of temperature, pH, dissolved oxygen, total suspended solids, total dissolved solids, nitrates, phosphate, biochemical oxygen demand, chemical oxygen demand, total hardness, conductivity, alkalinity, turbidity and fluorine did not signal any lake pollution, but sulphate, total and faecal coliforms, chlorophyll-a, cadmium and mercury showed pollution tendencies. Temperature, pH, dissolved oxygen, total suspended solids, total dissolved solids, nitrates, phosphate, sulphate and total coliform bacteria were found to be the main parameters that drive 71.2% of the limnological characteristics of the lake water and deserve careful consideration in designing conservation strategies for the lake.

Keywords: Lake Bosomtwe, physico-chemical, bacteriological, pollution, principal component analysis

INTRODUCTION

Water is a resource of critical importance to all life forms and indeed all life on earth depends on it. It is next to air in the maintenance and sustenance of life and therefore, forms an integral part of social life. It is a primary resource required for the balance of the general global environment. The distribution of global water indicates that about only 2.5% of the total is fresh. Of this, only 0.8% is accessible or available with the remaining being locked up in the polar ice caps. Surface water is more accessible to humans and more exposed to natural factors than groundwater, making surface water more vulnerable to contamination. The UNDP (2006) cautioned that the idea that water is abundant is a misconception since the amount available for human utilization is below 1%. Population growth is a major contributor to water scarcity (Kummu et al., 2016). Liyanage and Yamada (2017) pointed out that with the passage of time the situation is being worsened globally by the ever-increasing population, with its attendant increasing demand, stress and deficit (Bu et al. 2016) coupled with pollution on global water. In recent times, aquatic systems have been subjected to impact by anthropogenic interventions

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(Bhat et al. 2017), leading to rapid loss of their sustainability vigour (Bashir et al., 2020). A typical instance is the loss of resilience of lake ecosystems and the associated socio-economic downtrends. Among the factors that seriously degrade water bodies is climate change (Statham, 2012), which in turn has some anthropogenic underpinnings (Johnson et al., 2021; Stern and Kaufmann, 2014). Nutrients loading directly into water and indirectly through water courses have been on the rise significantly (Arnell et al. 2015). The effect is felt directly or indirectly by all global inhabitants, placing a huge burden of pollution prevention on global society (Mateo-Sagasta et al. 2017). Therefore, when the issue of poor water quality is being addressed, several variables need to be considered.

In Ghana, like other developing countries, water is either inadequate in supply or not of sufficient quality. The situation serves as a cause of illness, which in turn retards economic development and undermines the wellbeing of the entire society. All facets of life; social, economic and health of ecosystems are affected by scarcity of water. The effect is that the desired environmental, economic, social, recreational attributes of the communities that are affected by the phenomenon are likely to be driven to a halt. The Bosomtwe Basin is an enclave that houses Lake Bosomtwe which is a closed natural hydrological basin without an outlet. The lake is an important source of water for the livelihood of the fringe communities (Mensah and Amuquandoh, 2010). It is depended on by several communities for agriculture, which is the main activity through which pesticide residues are introduced into the lake (Ntow, 2005).

The escalating rate at which the lake is being degraded is a disturbing phenomenon. Recent acceleration of fishing in the lake and farming along the fringes pose a continuous threat to sustainability of the lake (Adu-Boahen et al., 2015; Adjei et. al., 2017). Currently, it is perceived that the rate of influx of contaminants from both point and diffuse sources outweighs the capacity of the lake to assimilate contaminants in order to avert pollution. This paper aims to study the conditions relating to the limnological characteristics of the lake in order to generate information that will help map out strategies for the restoration of the ecological processes that support its conservation and protection for sustainable benefits for the communities that depend on the lake.

MATERIALS AND METHODS

The study was carried out in Lake Bosomtwe, which is located in the Bosomtwe Basin in the central part of the Ashanti Region of Ghana, the Guinea Coast Region, southern Sahel, West Africa. The lake, located at latitude 6°30’16”N and longitude 1°24’31”W, is a natural lake with distinguished frequent and long periods of dryness. It is averagely circular in shape and has a diameter of about 10.5 km. The lake is believed to have existed for 1.3 million years. It is noted to be the only lake in the West African region formed by a meteoritic phenomenon (Shanahan et al., 2008). The lake was declared Biosphere Reserve in 2016 by United Nations Educational, Scientific and Cultural Organization (UNESCO). The limnological characteristics of the lake are affected by climatic conditions (Arnell et al., 2015).

Water quality parameters show the cumulative effects of human and natural disturbances on water body. The quality of the water of the Lake Bosomtwe was monitored for fishing and domestic purposes. Using standard sampling methods, water was sampled from three points, in each of eight sampling stations designated S_1 to S_8 and close to communities in the catchment of the lake (Figure 1). These communities were chosen based on the uses to which the lake water was put and the extent of usage.

At each sampling point, water samples were collected at a depth of approximately 0.20 meters and at a distance of 3 meters from the shore. Depending on the type of parameter under consideration, it was either determined *in-situ* or collected and transported to the laboratory for

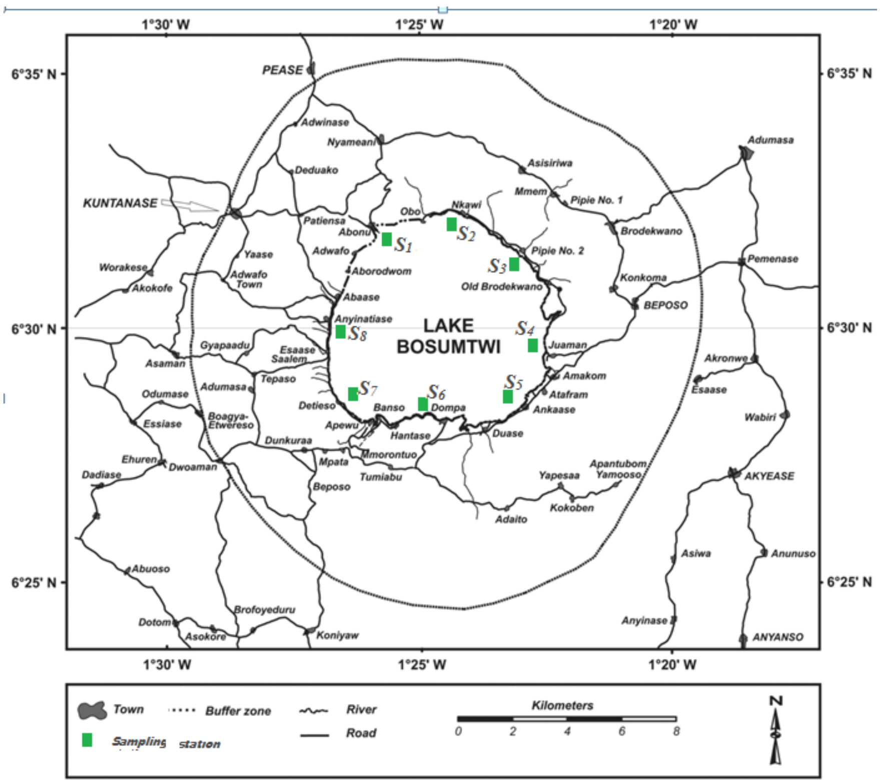

Fig. 1. A map of the catchment area of Lake Bosomtwe, with the sampling stations

analysis. Levels of three (3) readings each of temperature, dissolved oxygen (DO), pH, conductivity and turbidity were taken *in-situ* using the Hannah (HI 9828) Multi-Parameter Probe. To ensure consistency, water samples for laboratory analyses were taken in triplicates, at the same respective points, into well-labeled sterilized bottles and transported on ice under refrigeration condition. Consistency in terms of the day and time of sampling was also observed. Unless otherwise stated, determination of the levels of parameters followed the standard methods prescribed by (APHA, 2012). Laboratory analyses of samples involved determination of physical parameters (total alkalinity, total hardness, total dissolved solids (TDS), total suspended solids (TSS); nutrients (nitrate, phosphate and sulphate), chlorophyll-*a*; oxygen demand (BOD and COD); metals (As, Cd, Cr, Cu, Fe, Hg, Mn, Pb and Zn), ions (Ca, Mg, Cl, F^-, SO_4^{2-}) and bacteriological quality (total coliform and faecal coliform). With the exception of sample for TSS, TDS, bacteriological and chlorophyll-a analyses, all samples were filtered through Whatman GF/C filter paper 47mm. The lake has varied intended uses, e. g. drinking, domestic purpose and aquatic life. Therefore, the measured parameters were viewed against national and international benchmarks, namely Ghana EPA, WHO, FAO, USEPA and CCEM to determine their acceptability.

The principal components analysis was applied to twenty-five (25) parameters that describe the limnological properties of the lake water. The use of this technique was to help transform and organize the variables to produce a scale of relevance for the water quality situation.

RESULTS AND DISCUSSION

The physico-chemical, bacteriological and heavy metal quality parameters of the water of Lake Bosomtwe are presented (Tables 1 and 2) with their standard deviations (where applicable). The levels of most of the measured parameters were either higher or lower than the benchmarks for the designated use against which they were viewed.

Table 1. Levels of limnological parameters of water in Lake Bosomtwe for drinking

Parameter	Mean	Benchmarks for drinking water			
		Ghana EPA	WHO	EU	Canada
pH	6.1- 8.8	6.5-9.0	< 8.0	6.5 – 8.5	6.5 – 8.5
Total Hardness (mg/L $CaCO_3$)	138.1±6.9	–	–	–	80 - 100
TDS (mg/L)	62.7±1.7	1000	100	-	500
Cl^- (mg/L)	<0.08	–	5	–	-
Fe (mg/L)	<0.05	-	1.5	1.5	1.5
As (mg/L)	0.01±0.001	0.01	0.01	0.05	0.06
Cd (mg/L)	0.01±0.004	0.003	–	–	–
Cr (mg/L)	0.2±0.001	–	0.05	0.05	-
Cu (mg/L)	0.13±0.06	2.0	2	-	1.3
F^- (mg/L)	0.6±0.01	–	1.5	1.5	1.5
Hg (μg/L)	0.002±0.001	0.001	6	1	0.05
Ni (mg/L)	0.01±0.002	0.02	–	–	–
Pb (mg/L)	0.01±0.001	0.01	–	–	–
Faecal coliform (cfc/100ml)	<61.21	0.00	–	–	–
Total coliform (cfc/100ml)	165.15±8.3	0.00	–	–	–

In this study, a mean temperature of 29.43±2.7°C was recorded. Although this was lower than the limit (37°C) set by the Ghana EPA, it was higher than the mean annual of 24°C of the Bosomtwe District (Ghana Statistical Service, 2013). It was also higher than the average of 27°C water at the surface of Palminhas Lake, a tropical lake, and 25°C at the bottom (Venturoti et al., 2015). Given the potential of narrow temperature change to affect the survival of certain freshwater organisms, the high temperature of the water of Lake Bosomtwe may possibly lead to elimination of some species that cannot tolerate extreme changes in their natural temperature range (Jain et al., 2013). The elevated temperatures of the lake may facilitate transpiration and reduce the volume of water, thus increasing the concentrations of pollutants and their effects, which then offers competitive advantage to the better-adapted species (Paerl and Climate, 2008). Thermal pollution, which usually occurs in surface water bodies due to removal of vegetation cover as well as indiscriminate discharge of waste into the water, as occurred in this study, may contribute to the elevated concentrations of pollutants observed.

pH exerts its influence on the solubility of all metals and other chemical and biological processes in aquatic systems (Akan et al., 2012). After formation, water of many lakes exhibits high pH values or is alkaline in nature. However, the pH values decrease with time through accumulation of organic matter, the decomposition of which releases carbon dioxide which dissolves in water to form a weak acid (carbonic acid). The Ghana EPA and EU prescribed a standard range of 6.5-9.0. In this study, the pH of water recorded was in the range of 6.1-8.8. Although the results of this study suggest that the lake water is of safe pH for human consumption and aquatic habitation, it may show slight acidity. At a lower pH limit of 6.1, humans who depend on the water for consumption could experience adverse health issues such as eyes, skin and mucous membrane irritations. Although the low pH level may be tolerated by the lake organisms, it may be outside the optimum value for better physiological and reproductive performance of the organisms and therefore affect the ecological balance of the lake (Belhaj et al., 2014).

The mean concentration of DO, 4.3±0.6 mg/L (Tables 2), which ranged from 3.216 mg/L to 6.768 mg/L, fell below the permissible limits by the Ghana EPA permissible and the WHO

Table 2. Levels of limnological parameters of water in Lake Bosomtwe for aquatic life

Parameter	Mean	Benchmarks for Aquatic life			
		Ghana EPA	WHO[1]	EU	Canada
Temperature (°C)	29.43±2.7	≤ 37	-	-	-
pH	*6.1- 8.8	6.5-9.0	6.0 – 9.0	6.0 – 9.0	-
Dissolved Oxygen (mg/L)	4.3±0.6	5.0	5.0 – 9.0	5.0 – 9.5	4.0– 6.0
Conductivity (µs/cm)	1319.7±12.2	1500	2500	-	-
Turbidity (NTU)	7.91±0.5	5.0	5.0	-	-
Total Alkalinity (mg/L)	165.1±13.4	500.0	-	-	-
TSS (mg/L)	46.1±2.9	50.0	25	10	
TDS (mg/L)	62.7±1.7	-	-	-	-
NO_3^- (mg/L)	0.9±0.1	50	-	-	40
NH_3 (mg/L)	0.03±0.01	-	0.04 – 1.0	1.4 – 2.2	0.5
PO_4^{2-} (mg/L)	0.7±0.04	1.0	-	-	-
Chlorophyll-*a* (µg/L)	7.6±0.8	0.0	-	-	-
Zn (mg/L)	<0.05	-	-	-	0.75
SO_4^{2-} (mg/L)	510.0±19.5	250.0	-	-	100
BOD (mg/L)	1.4±0.7	50.0	3.0 – 6.0	-	3
COD(mg/L)	86.0±2.0	250.0	-	-	-
As (mg/L)	0.01±0.001	-	-	0.005– 0.1	-
Cd (mg/L)	0.01±0.004	0.003	-	-	-
Cu (mg/L)	0.13±0.06	2.0	-	-	-
F^-(mg/L)	0.6±0.01	-	-	-	0.75
Hg (µg/L)	0.002	0.001	-	-	-
Ni (mg/L)	0.01±0.002	0.01	-	-	-
Pb (mg/L)	0.01±0.001	-	-	-	-
Faecal coliform (cfc/100ml)	<61.21	-	-	-	-
Total coliform (cfc/100ml)	165.15±7.5	-	-	-	-

guideline value. Several scientific studies have reported that DO concentration of 5 mg/L is the threshold below which the lives of a diverse population of fish could not be supported and that, fishes die at DO concentrations below 3.0 mg/L (Bhateria and Jain, 2016; Jeppesen et al., 2018). Periodic gulping for surface air at the surface of the lake water in the morning, which is a sign of oxygen stress as reported by (Oluah and Mgbenka, 2020)**,** observed on some occasions was not surprising. The relatively higher mean temperature than the mean annual of the lake may contribute to the low DO concentration of the lake water, through expulsion ((Bhatnagar and Pooja, 2013).

The recorded TSS values ranged from 42.76 mg/L to 59.17 mg/L, with a mean of 46.1±2.9 mg/L, which was lower than the Ghana EPA standard value of 50.0 mg/L. The occurrence of outliers points to the possibility of the levels exceeding the acceptable limits if the current anti-conservation practices are maintained. The high level of recorded TSS suggests that effectiveness of treatment including, coagulation, filtration, and disinfection for consumption could be challenging due to interference by suspended solids (Salaudeen et al., 2019). The suspended sediments in the lake water may harbour pathogens, e. g. bacteria and protozoa and also interfere with recreational use and aesthetic experience of the lake. The suspended solids may absorb heat from solar radiation and accelerate heat transfer to the surrounding water molecules by conduction. This may create a hypoxic condition in the lake, a precursor to loss of biodiversity (Chigor et al., 2013). Transmission of sunlight in the lake water could also be impeded by the suspended solids and cause reduction in photosynthesis by submerged plants which would exacerbate the problem of oxygen deficiency in the lake water.

The lake water exhibited a lower mean level of TDS (62.7±1.7 mg/L) than the benchmarks by Ghana EPA and the WHO. This suggests low effects of ions and agrees with Boyd (2015). The problems, e. g. taste, odour, appearance, and transient diarrhea that characterize water of high TDS concentrations are therefore not expected. Although different species inhabit water with different salinity levels in the lake, the level could generally pose problems of osmotic regulation and toxicity to inhabiting organisms.

Lake pollution has usually been attributed to excessive inputs of substances, including nitrates, phosphates and sulphates that are essential plant nutrients**.** Although nitrogen is required in lakes for plant growth, its concentration is required within limits, as extremely low or high concentrations do not promote the health of the lake and its biodiversity. A mean nitrate concentration of 0.9±0.1 mg/L and a range of 0.51 - 1.88 mg/L were recorded for the lake water. The mean was much lower than the Ghana EPA value (50 mg/L). At such low levels, plant and animal growth could be hampered (Ansar and Khad, 2005). Phosphate stimulates growth of aquatic flora for production of food for other aquatic organisms (Isiuku and Enyoh, 2020). It is not associated with hazard to humans, unless it occurs in very high concentrations, where it causes digestive problems. At higher concentrations, it becomes detrimental to aquatic health through eutrophication and extraction of DO following decomposition of dead flora. The mean concentration of phosphate (0.7±0.04mg/L) recorded from a set of data ranging from 0.27 to 1.497 mg/L was lower, compared to the Ghana EPA standard value (1mg/L). This is an indication that the lake water is not phosphate-polluted. This notwithstanding, the tendency for levels to go beyond the set benchmark and cause eutrophication cannot be ruled out if conservation rules are not adhered to.

The water of Lake Bosomtwe exhibited relatively higher sulphate concentration (510±19.5mg/L) than the WHO guideline value (250 mg/L). Therefore, it has the potential to deplete the lake of oxygen (Gilly et al., 2013). Furthermore, the high levels of sulphate could cause temporary laxative effect and impart an unpleasant taste and also cause elevated acidity to the lake water (Enyoh et al., 2018) which serves as a drinking source for some communities around the lake.

Total coliform bacteria and faecal coliform bacteria (e. g. *Escherichia coli*) used to assess the microbiological quality of Lake Bosomtwe, provide as indication of the health status of the lake, giving an indication of human or animal faecal pollution (Clottey et al., 2016). Results of the current study show mean total coliform load of 165.15±7.5(CFU) per 100 ml. However, the World Health organization recommends zero CFU/100 ml for drinking water. Therefore, this indicates that the lake water is generally unfit for domestic purposes without any further treatment (Ashbolt et al., 2001).

Chlorophyll-a was measured to provide information on the presence of phytoplankton, which die in response to unfavourable environmental conditions and further cause depletion of DO and fish kills. High concentrations of *Chl-a*, ranging between 5.973 μg/L and 13.670 μg/L and a mean of 7.6±0.8μg/L were recorded for the lake. It gave a reflection of excessive input nutrient in the lake. Beyond the threshold of 100 mg/L *Chl-a* fish could be negatively affected *(*Liu et al. 2006). Moreover, the DWAF (1998) recounted that Chl-*a* level range from <1 μg/L in clear waters to > 50 μg/L in worrisome situations while a slightly green coloration is imparted to water bodies at *Chl-a* level < 7 μg/L. Algal breakdown may produce anoxic and hypoxic conditions (Giordani et al., 2009). The results suggest a possible significant influence of *ChL-a* on DO levels in the lake water.

In the aquatic systems, dissolved salts and minerals may affect the hardness, conductivity and alkalinity of the lake water, depending on the kind of ions present. The most influential of these ions in the phenomenon are calcium and magnesium ions. The mean levels of total hardness, conductivity and alkalinity recorded were 138.09±6.9 mg/L, 1319.73±12.2 mg/L and 165.1±13 mg/L respectively. All these values were within the WHO guideline value and therefore suggest that the lake water had acceptable levels for total hardness, conductivity and alkalinity and posed no threat to plants and animals that inhabit the lake. For example, it will exhibit high buffering capacity (Bhatnagar and Pooja, 2013) and also will not offset the osmotic balance due to differential ionic concentrations between their internal and external environments (Nabybaccus, et al., 2018).

A measure of lake turbidity provides information on the ability of the lake water to scatter light rays upon incidence (Wetzel, 2001), which in turn depends on the extent to which the lake water is loaded with organic matter. Again, it gives indication of the level of clarity of the water body. The values recorded in this study, which were in the range of 5.043 NTU to 10.432 NTU with a mean of 7.9±0.5NTU was higher than that (5.000 NTU) prescribed as the maximum for acceptance by the Ghana EPA and the WHO. Sharma and Bhattacharya (2017) indicated nausea, cramps, diarrhoea and headache as symptoms associated with intake of turbid water. Substances that account for turbidity may provide adsorption sites for chemicals that cause undesirable taste and odour and may partially protect organisms against disinfectant. It could be speculated that the high turbidity of Lake Bosomtwe is responsible for the reduced clarity of the lake water. Ecologically, the turbidity agents interfere with light penetration and reduce primary production, which affects the growth of organisms in the lake.

In aquatic systems that have high BOD or COD, there is rapid depletion of DO. The implication is that there is not enough oxygen for use by aquatic life forms. Thus, high BOD is equivalent to low DO all of which culminate in stressing, suffocation and death of aquatic organisms. High BOD leads to fish kills in water bodies (Pleto et al., 2018). The mean values of BOD (1.4±0.7 mg/L) and COD (86.0±2.0 mg/L) recorded in the present study fell below the Ghana EPA benchmarks of 50 mg/L and 250mg/L respectively. Again, the recorded BOD was lower than that (25 mg/L) reported by Solanki et al. (2007) for the Bellal Lake. Sharifinia et al. (2019) also observed a mean COD of 37.4 ±84. The results of the present study suggest that the water of Lake Bosomtwe is not polluted with respect to BOD and COD.

Fluoride has both beneficial and detrimental effects on humans and aquatic health. The range at which these occur is narrow. At concentrations below 1 mg/L, fluoride provides human health benefits, e. g. prevention of dental caries. A higher concentration of fluoride causes dental and skeletal fluorosis (Demelash et al., 2019). The mean fluoride concentration in the lake (0.6±0.01) was lower than the WHO guideline value (1.5mg/L). In aquatic systems, fluorides are transported and transformed through the water cycle under the influence of factors such as pH and hardness (Environment Canada, 1994) and may reach the high trophic levels through some biochemical pathways. Anthropogenic discharges and the geological environment of the lake may explain the presence of fluoride in the water of Lake Bosomtwe.

While the concentrations of some of the metals assessed in this study were higher than their respective WHO guideline values, others were not. Those that did not show detrimental effects in water were Arsenic, copper, iron, lead, nickel and zinc. The levels recorded for these metals were 0.01±0.001mg/L, 0.13±0.06mg/L, <0.05mg/L, 0.01±0.001mg/L, 0.01±0.002mg/L and <0.05 mg/L respectively. Those that showed higher values were cadmium (0.01±0.004 Mg/L) and mercury (0.002±0.001 mg/L) with mean values, which were greater than their respective benchmark values of 0.003 mg/L and 0.001 mg/L. The toxicity of some of these metals is a concern (Giri and Singh, 2015). Evidently, these metals may enter and accumulate in the food chain involving fish of the lake and via bio- magnifications in humans who consume the fish (Noor and Zutshi, 2016). For example, mercury has a devastating effect on humans and other living organisms that may consume mercury-polluted water (Li et al., 2013). According to the WHO (2010), higher concentrations of mercury, particularly the inorganic form, are associated with nausea, vomiting, pain, ulceration, and diarrhea and other disorders in life forms that depend on affected aquatic systems. Management of the lake water quality through identification and treatment of runoff that is laden with cadmium, mercury, coliforms and chlorophyll-a before entering the lake is key in stemming influx of these pollutants.

By principal component analysis, the contributions of factors that may not be directly related were established (Table 3). This allowed the parameters that exerted significant effect on the quality of the lake water to be identified. Eight (8) of the measured parameters; temperature, pH, dissolved oxygen, total suspended solids, nitrate, phosphate, sulphate and total coliform bacteria with eigenvalues of not less than one (Table 3) were found to exert the most significant influence on the variations that existed in the lake water quality.

These eight parameters formed the principal components with respective contributions of 18.76%, 14.01%, 10.89%, 8.22%, 6.16%, 4.96%, 4.30%, and 3.90% and explain 71.20% of the total variation. The results give indication that analyses of the quality of the water could be grounded on Temperature, pH, Dissolved Oxygen, total suspended solids, nitrate, phosphate, sulphate and total coliform bacteria (Yang et al., 2020) and therefore resources and remediation efforts will efficiently be utilized if these parameters are targeted.

Table 3. Distribution of eigenvalues of measured water quality parameters of lake Bosomtwe

Serial No	Parameter	EIGENVALUE		
		Total	% of Variance	Cumulative (%)
1.	Temperature (°C)	4.877612	18.76	18.76
2.	pH	3.642513	14.01	32.77
3.	Dissolved Oxygen (mg/L)	2.830187	10.89	43.66
4.	TSS (mg/L)	2.138406	8.22	51.88
5.	NO_3^{2-} (mg/L)	1.604442	6.16	58.04
6.	PO_4^{2-} (mg/L)	1.290405	4.96	63.00
7.	SO_4^{2-} (mg/L)	1.128385	4.30	67.30
8.	Total coliform (cfc/100ml)	1.004605	3.90	71.20
9.	Chlorophyll-a (µg/L)	0.892745	3.43	74.63
10.	Total Hardness (mg/L $CaCO_3$)	0.830502	3.17	77.80
11.	Conductivity (µs/cm)	0.760294	2.72	80.52
12.	Total Alkalinity (mg/L)	0.697515	2.65	83.17
13.	COD (mg/L)	0.655914	2.42	85.49
14.	TDS (mg/L)	0.602114	2.32	87.81
15.	Turbidity (NTU)	0.550374	2.10	89.91
16.	BOD (mg/L)	0.426376	1.44	92.52
17.	F^- (mg/L)	0.360874	3.14	95.66
18.	Zn (mg/L)	0.350856	1.17	91.08
19.	Cu (mg/L)	0.300472	1.16	96.82
20.	Ni (mg/L)	0.25119	0.77	97.59
21.	Pb (mg/L)	0.200148	0.55	98.14
22.	Cd (mg/L)	0.171119	0.65	98.79
23.	Hg (µg/L)	0.146308	0.54	99.33
24.	As (mg/L)	0.093095	0.36	99.69
25.	Fe (mg/L)	0.048508	0.19	99.88
26.	Faecal coliform (cfc/100ml)	0.031200	0.12	100

CONCLUSIONS

Among the measured quality parameters of Lake Bosomtwe water, detrimental effect could not be linked to temperature, pH, dissolved oxygen, total suspended solids, nitrate, phosphate, sulphate and total coliform bacteria which formed the principal components and explained 71.2 % of the variation in the limnological characteristics of the lake. The lake water was also not threatened by biochemical oxygen demand, chemical oxygen demand, total hardness, conductivity, alkalinity, turbidity and fluorine. However, long-term exposure to cadmium, mercury, and chlorophyll-a, which occurred at elevated levels, poses risk of health disorder to the lake organisms and humans who depend on the lake water for drinking. At the present elevated nutrient loading, which is a precursor of eutrophication, the tendency for the ecological balance to be offset cannot be ruled out. These situations have been water quality challenges globally and therefore support the call for prompt attention and action by the Water Resources Commission of Ghana.

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CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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