Water quality of fresh water bodies in the lower Volta Basin: A case study of lakes Kasu and Nyafie

H. Bobobee[11], D. Carboo[12], R. Akuamoah, & W. J. Ntow[13]

Abstract

The study was carried out on water from lakes Kasu and Nyafie, two of the fresh water bodies situated near Asutsuare, an agricultural town in the lower Volta basin of Ghana to determine the level of water quality parameters. To be able to this, water samples were taken from designated points in both lakes. Sampling was done over a period of seven months (January to July) and the determination of the water quality parameters was carried out using GEMS Water Operational Guide as well as APHA's Standard Methods for Examination of Water and Wastewater. The parameters measured were; temperature, pH, dissolve oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), conductivity, turbidity, suspended solids, dissolved solids and total solids. Others were nutrients and ions such as; nitrates, nitrites, phosphates, chlorides, sodium and potassium. The rest came under hardness of water, such as calcium, magnesium and total hardness. Though most of the values of the parameters fall within the acceptable limits of WHO values for potable water, turbidity values i.e. 68.0 NTU (Kasu) and 25.2 NTU (Nyafie) as well as BOD values of 73.8 mg/L for Kasu and 49.7 mg/L for Nyafie, were far beyond the WHO guideline limits (5 NTU – turbidity and < 3 mg/L – BOD) for drinking water, thereby reducing the potability, recreational and aesthetic values of the water in these lakes. Also, despite the fact that the mean DO values for the lakes (5.4 mg/L for Nyafie and 7.0 mg/L for Kasu) fall short of the WHO minimum value of 8.0 mg/L, the lakes cannot be said to be polluted to signal the unset of eutrophication.

Keywords water quality parameters, runoff water, fresh water bodies

Introduction

The desired benefit of increased food production using modern methods from the ever-dwindling viable agricultural lands is the prime aim of all farmers and governments, the world over (WHO, 1997, UNESCO, 1975). However, the attainment of this food sufficiency goal seems to carry with it a higher price which if not identified and checked in time, will eventually outweigh the desired benefits. This is because the agricultural wastes and the increasing wrong practices in the application and use of fertilizers and pesticides (Sequillae et. al, 1996), especially in a developing country like Ghana, threaten the very existence and survival of man and his environment.

The incorrect application of the right types of fertilizers in the correct amounts results in them being washed by runoff water, or leached into both surface and ground water,

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which if not checked especially in surface waters, leads to the massive growth of aquatic flora which eventually leads to the eutrophication of the water body (Borkess and Edelson, 1973, Baird, 1995). The movement of chemicals in the aquatic system is very fast, and generally difficult to detect initially, thus making lakes to become increasingly polluted and species die out without any obvious signs at least in the early stages Alloway and Ayres, 1993). Agricultural wastes such as fertilizers, pesticides and animal wastes, are a major source of water pollution as they are often carried off into water bodies such as lakes, rivers and the oceans by surface runoffs (Wong and Tanner, 1997).

Analysis of the water from water bodies can therefore provide a basis for the determination of the pollution or otherwise status of water bodies by the relevant governmental and non-governmental agencies in declaring the right status of a water body and the remedial actions to take in ameliorating the situations that may arise.

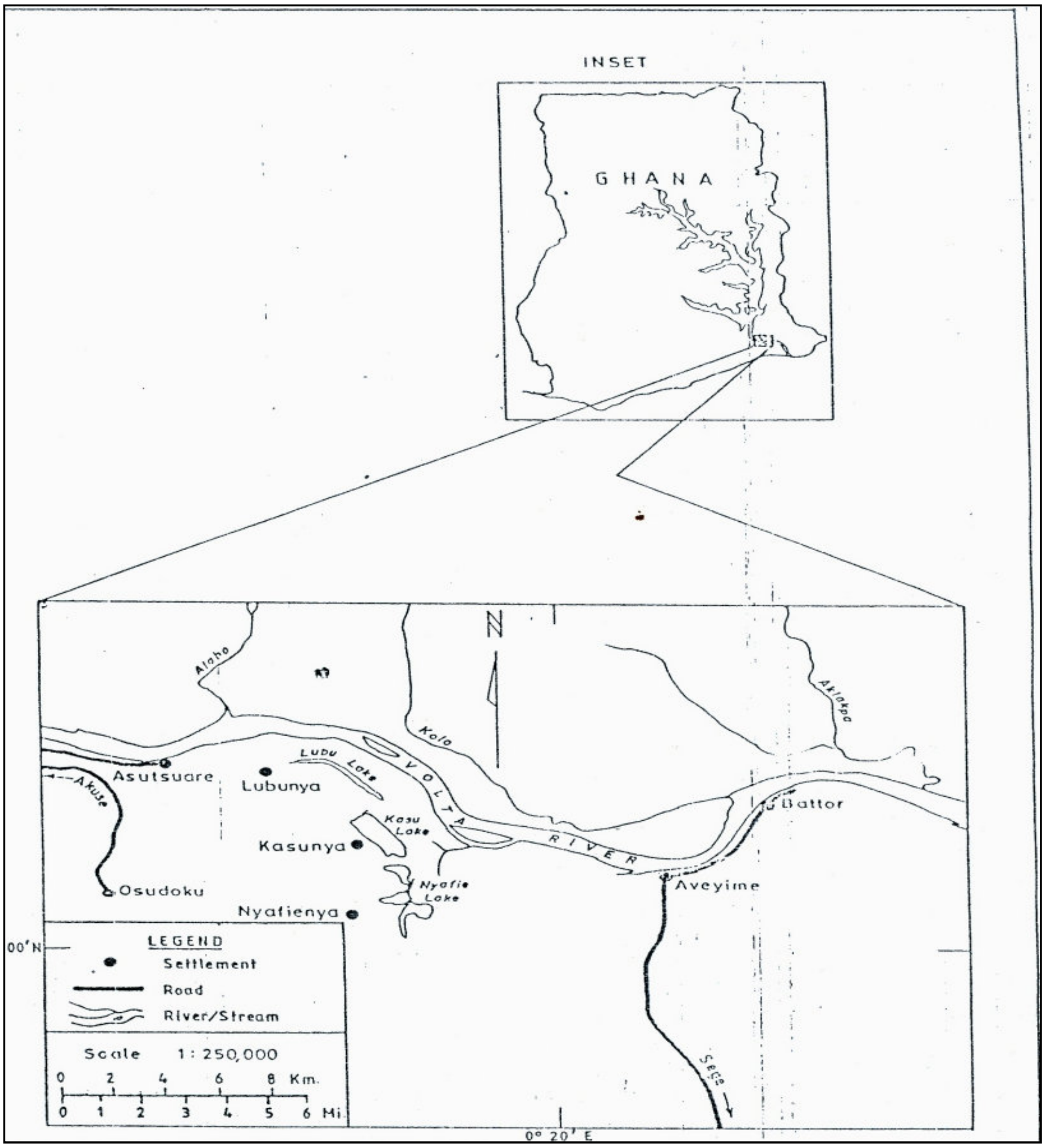

Fig. 1 Map of Study Area with the map of Ghana

Materials and Method

The study area

Lakes Kasu and Nyafie are large fresh water bodies at Kasunya near Asutsuare in the Tettimang traditional area in the Lower Volta basin of the Dangme-West district, within the Greater-Accra region of Ghana. Lake Kasu which is about 1 km wide and 3 km long, as well as others, all of which lie about 3 km off on the eastern flank of the Volta river, facing north, serve as the sole source of drinking water for the communities staying along their banks in addition to being reservoirs for fishes and recreational uses. The study area is as shown in Fig. 1.

Hydrology

The catchments areas of the lakes are the hubs of large scale agricultural activities with farms of the Irrigation Development Authority (IDA) situated on lake Kasu while those on lake Nyafie were owned by Korean Semaul Farms Limited (KSF). The IDA in developing the land for its rice production directed all the drains from the rice fields into Lake Kasu, through a large single large drain, locally termed 'super-drain'. Due to the intensive mechanized nature of the farms, large quantities of agricultural chemicals were used to increase yields (Gordon and Amatekpor, 1997, Gordon and Ankrah, 1998). The periodic flooring of the fields with water from the Volta and its consequent release into Lake Kasu carries with it un-utilized chemicals as well as silt into the lake through the 'super-drain'. In the case of the KSF, the water for the irrigation of the fields was from Lake Nyafie, but though the released water goes back into the same lake, there was no well defined channel as in the case of Lake Kasu.

Sampling points and sample collection

Lake water, unlike the water in a river, is not uniform in the sense that resident time and turnover rate of substances including the water, is very high and very low, respectively (Brown, 1987). Thus no single sample can be taken to be representative of the lake, and as such, several sampling point were chosen in each lake. As the purpose of the study was to determine the levels of water quality parameters of the lakes, sampling points were selected such that, the overall sample collected in each lake would be representative of that lake. In all, five sampling points (K1 to K5) on Lake Kasu and six points (N1 to N6) on Lake Nyafie, were chosen as shown in fig. 2

Sampling was done four times over a seven month period in the year, i.e. in January and February for the dry season and in June and July for the rainy season. At each sampling point, three samples were collected at a time, one each for DO, BOD and the third for the other parameters.

In all 33 samples were collected on monthly basis, while in a canoe. During the sampling process, the 250 mL reagent glass bottles, prepared purposely for the samples, were uncapped and dipped just below the water surface and filled with water. This water was then poured out on the other side of the canoe and was repeated two more times. After the third rinsing, each water filled bottle without any air bubbles was capped below the water surface, for use as sample for the determination of all parameters with the exception of DO. Samples for DO determination were fixed before capping, by adding 2 mL of manganous sulphate solution below the surface followed by 2 mL of alkaline-azide-iodide solution at the surface of the sample, shaken for some time and allowed to stand. All samples were then packed into ice filled ice-chest and transported to the Chemistry laboratory of the Water Research Institute (WRI) of the Center for Scientific and Industrial Research (CSIR), Accra, for preparation and analysis for all parameters with the exception of temperature and pH.

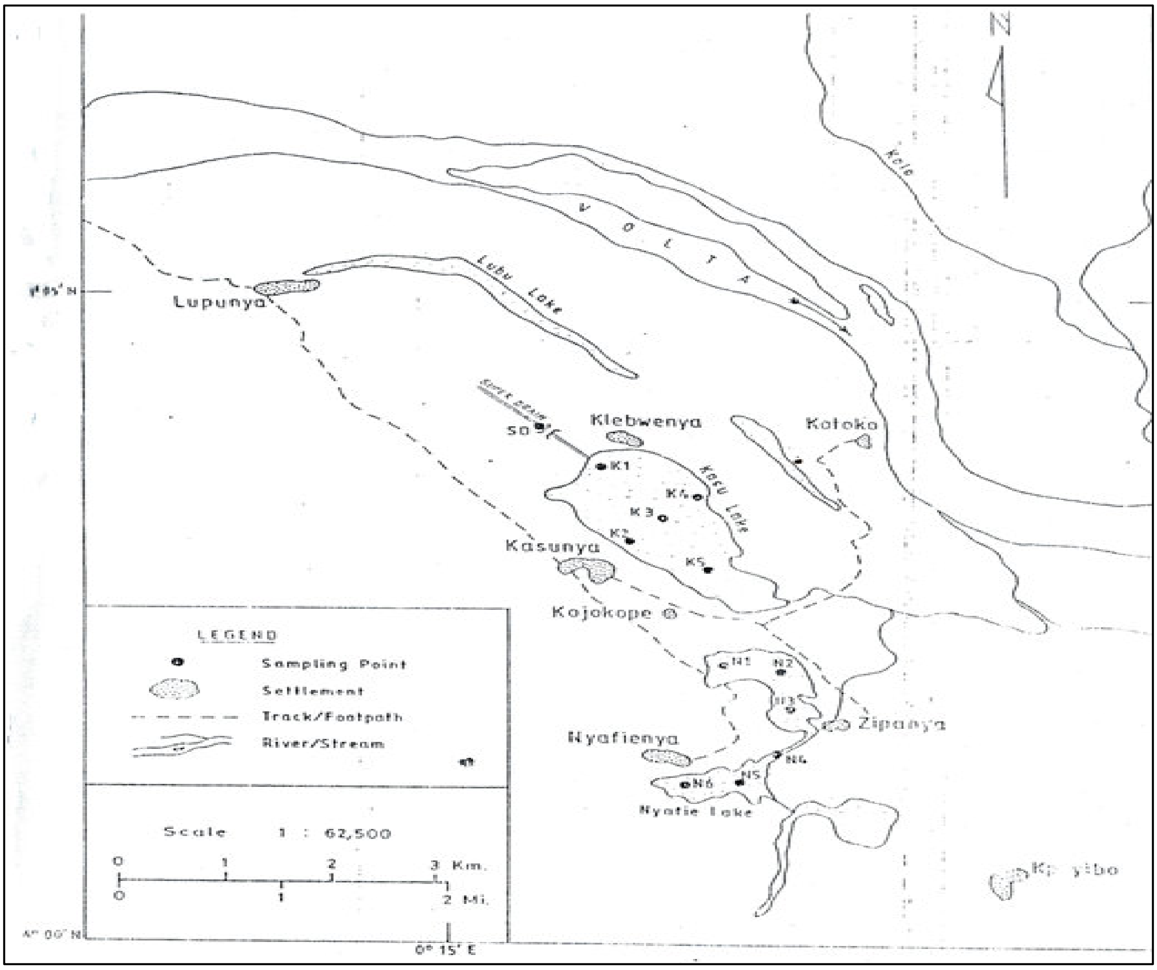

Fig. 2 Map of study area showing sampling points

Sample preparation and analysis

Most of the methodologies used in the preparation and analysis of the samples were based on the established protocol at the chemistry laboratory of the WRI of CSIR, Accra and on GEMS Water Operational Guide GEMS *et. al*, 1997) as well as APHA's Standard Methods for Examination of Water and Wastewater (APHA, 1998), with relevant modifications when necessary. All determinations for parameters were carried out in triplicates after which a mean was calculated for each parameter.

pH and temperature

Temperature and pH were determined directly in the field using portable battery operated digital electronic sensometers (Philip Harris). For pH measurements, the equipment after being calibrated was dipped into the lake water and held still for a constant reading was obtained. This procedure was followed at each sampling point for triplicate readings after which mean values were calculated. For temperature measurements, the equipment was also dipped just below the surface of the water and held still for a constant reading to be attained.

Turbidity and conductivity

Turbidity measurements were carried out using a DRT 100 HF instrument. After the calibration of the instrument, a sample from a point is shaken and a quantity poured into the special glass bottle and put into the instrument and the turbidity value read in Nephelometric Turbidity Unit (NTU). This procedure was followed for each sample for triplicate readings after which mean values were calculated.

For conductivity measurements, a Jenway 4020 was used after calibration. The conductivity probe is then dipped into 50 mL of water from a sample after shaking and the reading taken in mS/cm.

Dissolved solids (DS), Suspended solids (SS) and Total solids (TS)

Gravimetric methods were used for the determinations of these parameters. Glass-fiber filter discs (Whatman GF/C grade) with pore size of 0.45 um and evaporating dishes for filtration and drying respectively. 100 mL of a sample after vigorous shaking was rapidly transferred into the filtration funnel with the disc by means of a 100 mL graduated cylinder and suction applied.

The filtrate was carefully transferred into the pre-weighed evaporation dish and evaporated on water bath. The evaporated sample was then dried at 105 ± 2oC for an hour in an oven. It was allowed to cool in a dessicator and weighed. The drying and weighing were continued until a constant weight was obtained for DS values.

For the SS determination, the glass-fiber filter paper was also dried in the oven at 104oC for an hour in the oven, cooled in the dessicator and weighted to a constant weight. TS values were obtained by the addition of the DS and SS values previously determined.

Dissolved Oxygen (DO), Biological oxygen demand (BOD) and Chemical oxygen demand (COD)

The sample for the DO determination, though fixed on the field was analysed the same day in the laboratory using the Winkler's Azide Modification Method.

Samples for BOD analysis were incubated at 20^0C for 5 days in the laboratory before being fixed and analysed in the same way as the DO. The COD determination was done using the dichromate method, where the COD was measured as O_2 equivalent, proportional to the dichromate consumed during the refluxing, by the organic matter present when the Cr^{6+} ions were reduced to Cr^{3+} ions.

Nutrients (NO3--N, NO2--N and PO43- -P)

All the ions listed above were analysed using an LKD Biochron Ultrospec II UV/Visible spectrophotometer, with different preparation procedures. The samples for the determination of nitrate-N and nitrite-N were prepared in almost the same way, except for the fact that in the case of nitrate-N, a reducing agent (amalgamated Cd/Cu) was added and the solution heated at 600C for 10 minutes. The concentrations of the ions were then determined by measuring their absorbance at 540 nm.

The molybdenum blue method was used for the determination of phosphate-P and the concentration determined by measuring the absorbance at a wavelength of 690 nm.

Chloride (Cl-), Sodium (Na+) and Potassium (K+) ions

The Vallard (argentometric) method was used to determine the concentration of chloride ions, using K2CrO4 as indicator. The concentrations of sodium and potassium ions on the other hand were determined using a Gallenkamp Flame Emission spectrophotometer with liquid petroleum as the fuel gas.

Calcium (Ca2+), Magnesium (Mg2+) ions and Hardness.

Calcium ion concentration, calcium hardness and total hardness were determined by complexometric titration, using EDTA as indicator. The magnesium ion concentration and magnesium hardness were calculated from the respective calcium values.

Results and discussion

The mean values as well as the seasonal values of the various parameters for the lakes have been presented and discussed. Parameters determined included:

- *Physical parameters*; pH, temperature, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), turbidity, conductivity, suspended solids (SS), dissolved solids (DS) and total solids (TS).
- *Chemical parameters (nutrients and ions)*; nitrates (NO_3^-), Nitrites (NO_2^-), phosphates (PO_4^{3-}), chloride (Cl^-), Calcium (Ca^{2-}), Magnesium (Mg^{2+}), potassium (K^+) and sodium (Na^+)
- *Hardness of water*: calcium, magnesium and total hardness.

For a fresh water source to be potable, it should satisfy the requirements of the World Health Organisation (WHO). For monitoring and surveillance purposes, the WHO has come out with some maximum levels of these parameters for fresh water, beyond which the potability of the water becomes questionable. These maximum values as contained in the WHO Guideline Values (WHO, 1993) for Potable Water, part of which shown in table 1, is what is adopted by the Ghana Water Company.

From tables 2, 3, 4 and 5, it is evident that the values determined for most of the physical and chemical parameters of water from the lakes, used for drinking, fall within the WHO limits with the exception of turbidity and BOD. The higher turbidity values of 68.04 NTU for Kasu and 25.22 NTU for Nyafie are far above the 5 NTU WHO guideline value. The BOD values of 73.80 mg/L for Kasu and 49.7 mg/L for Nyafie are also well beyond the WHO value of < 3 mg/L.

Based on the BOD values, the waters of the lakes can be said to be organically polluted, since they tend to be higher than the COD values.

Table 1 WHO guideline values for some parameters of potable water

Parameter	Value	Parameter	Value
Total hardness as CaCO3	500 mg/L	Na+	200 mg/L
Chloride	250 mg/L	K+	30 mg/L
Nitrate	10 mg/L	Ca2+	200 mg/L
Phosphate	<0.3 mg/L	Mg2+	150 mg/L
Turbidity	5NTU	pH	6.5 – 8.5
Conductivity	700 mS/cm	DO	8 mg/L
Dissolved solids	1000 mg/L	BOD	<3 mg/L
		COD	250 mg/L

General water quality and seasonal variations within the lakes

The results in Tables 2, 3 and 4 show the general water quality and seasonal variations within the lakes. The pH is an important parameter in water quality measurement, as if influences many biological and chemical processes within a water body and all the processes associated with water treatment and supply. The pH of water determines which substances would dissolve in or precipitate out of it. The life of the organisms in the water, such as fishes as well as those that depend on it, such as man, birds and animals, is affected by the pH of the water.

From Tables 3 and 4, it is evident that the pH in the rainy season is higher than that for the dry season for both lakes. This increase in pH can be attributed to the large volume of runoff water that came into the lakes to dilute the relatively acidic conditions for the dry season.

Table 2 ***Mean Values of Some Physical Parameters of the Lakes***

	Parameters				
Lake	**pH**	**Temp. (0C)**	**DO (mg/L)**	**BOD (mg/L)**	**COD (mg/L)**
Kasu	7.2 ± 0.2	31.4 ± 1.4	7.0 ±1.1	73.8 ± 63.3	66.8 ± 55.0
Nyafie	6.9 ± 0.1	31.6 ± 1.2	5.4 ± 2.5	49.7 ± 37.7	19.0 ± 12.6

Table 3 **Seasonal Mean Values of Some Physical Parameters of Lake Kasu**

	Parameters									
Season	**pH**	**Temp (^{0}C)**	**DO (mg/L)**	**BOD (mg/L)**	**COD (mg/L)**	**Conductivity (mS/cm)**	**Turbidity (NTU)**	**SS (mg/L)**	**DS (mg/L)**	**TS (mg/L)**
Dry	7.05	32.35	7.59	15.89	17.27	187.49	40.90	138.75	415.50	554.25
	±0.0	±0.5	±1.6	±0.6	±0.5	±27.5	±6.9	±31.3	±38.6	
Rainy	7.25	29.77	6.45	132.24	116.37	130.85	95.17	98.84	215.67	314.51
	±0.2	±0.8	±0.3	±34.4	±33.8	±25.2	±11.5	±1.2	±80.3	

Table 4 **Seasonal Mean Values of Some Physical Parameters of Lake Nyafie**

	Parameters									
Season	**pH**	**Temp (^{0}C)**	**DO (mg/L)**	**BOD (mg/L)**	**COD (mg/L)**	**Conductivity (mS/cm)**	**Turbidity (NTU)**	**SS (mg/L)**	**DS (mg/L)**	**TS (mg/L)**
Dry	6.80	33.37	8.63	5.80	3.61	187.93	10.67	48.67	253.33	302.02
	±0.05	±0.35	±0.56	±3.4	±0.52	±30.5	±2.6	±23.5	±25.9	
Rainy	6.99	30.67	3.25	72.09	26.71	83.04	32.50	124.34	114.67	239.01
	±0.02	±0.2	±0.7	±24.6	±6.9	±37.1	±14.5	±19.7	±14.3	

Dissolved Oxygen (DO)

The DO concentration in a water body is important for the evaluation of surface water quality and waste water treatment. The mean DO values for the lakes (table 2) which ranged from a low of 5.4 mg/ L for Nyafie to a high of 7.0 mg/L for Kasu though below the WHO value of 8.0 mg/L, are not so low as to declare the waters in the lakes to be totally unwholesome for human and animal or fish usage. It is however worth taking note that, the seasonal variation of the DO values for the lakes as shown in tables 3 and 4 should be of concern. The high DO values for the dry season as compared to that for the rainy season can be explained on the bases of the increased levels of biodegradable materials carried into the lakes by the runoff waters, which required the DO for oxidation.

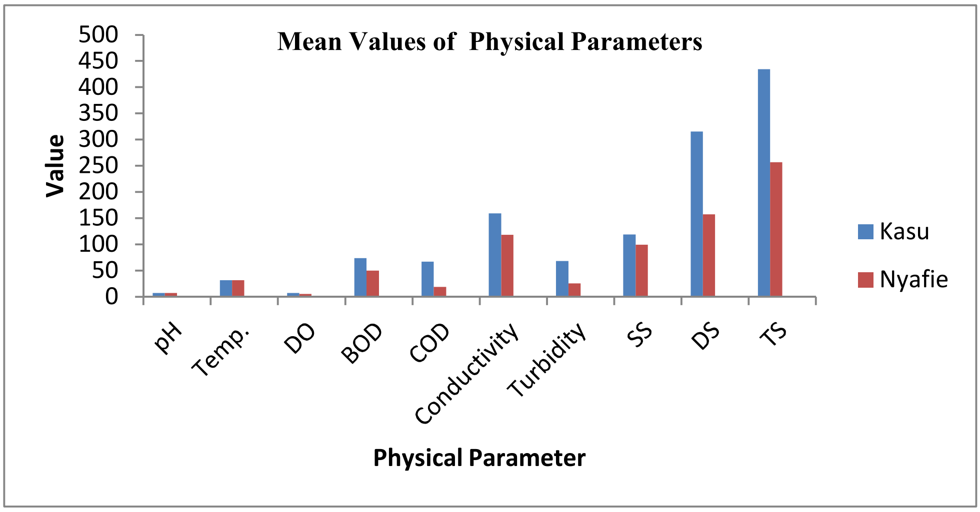

Fig. 3 ***Mean values of some physical parameters in the lakes***

Biological Oxygen Demand (BOD)

The BOD is an approximate measure of the amount of biologically degradable organic matter present in a water sample. Generally, as the BOD levels increase, DO levels drop. This trend was clearly shown in the lakes (Tables 2, 3 and 4). Considering the levels of human activities in the areas of the lakes, it can be said that, though the BOD values are high, they are not as high as expected. The increased values for the BOD in the lakes for the rainy season as compared to those of the dry season (Tables 3 and 4), is as a result of the large influx of biological Materials brought into them by surface runoffs. Thus tables 3 and 4 clearly show the inverse relationship between DO and BOD, making the very low values of DO and the very high BOD values for the rainy season, to point to the lakes as polluted, if the BOD and DO values are the sole variables.

Table 5 Mean Values of Some Physical Parameters of the Lakes

	Parameters				
Lake	Conductivity (mS/cm	Turbidity (NTU)	SS (mg/L)	DS (mg/L)	TS (mg/L)
Kasu	159.22 ± 38.6	68.04 ± 28.7	118.79 ± 29.8	315.36 ± 117.9	434.15 ±141.0
Nyafie	118.00 ± 58.0	25.22 ± 15.7	99.1 ± 96.4	157.35 ± 68.7	256.66 ± 91.3

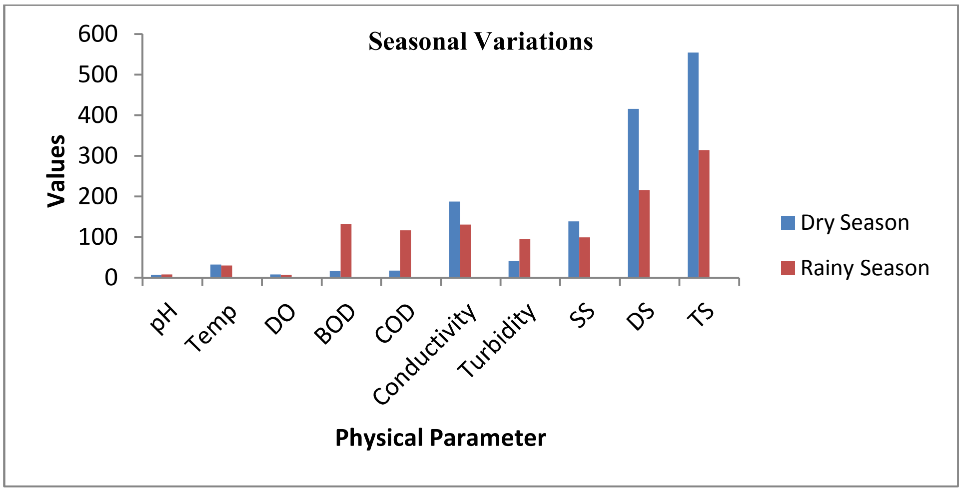

Fig. 4 ***Seasonal Variations of some physical parameters in Lake Kasu***

Conductivity

Conductivity or specific conductance is a measure of the ability of water to conduct an electric current. It is sensitive to variations in dissolved solids, mostly mineral salts. The degree to which these dissolved salts dissociate into ions, the magnitude of the electrical charge on each ion, the mobility of the ions and temperature of the solution, all have an influence on the conductivity. On the whole, the mean conductivity values for the lakes (Table 5) are within the WHO limits, but the general decrease in conductivity as observed from the dry season to the rainy season for both lakes (tables 3 and 4) are consistent with decrease in the concentration of ions such as K+, Na+, Cl- and Ca2+. This trend can be attributed to the large volume of runoffs in the rainy season, resulting in the dilution of the ion concentrations of the lake waters.

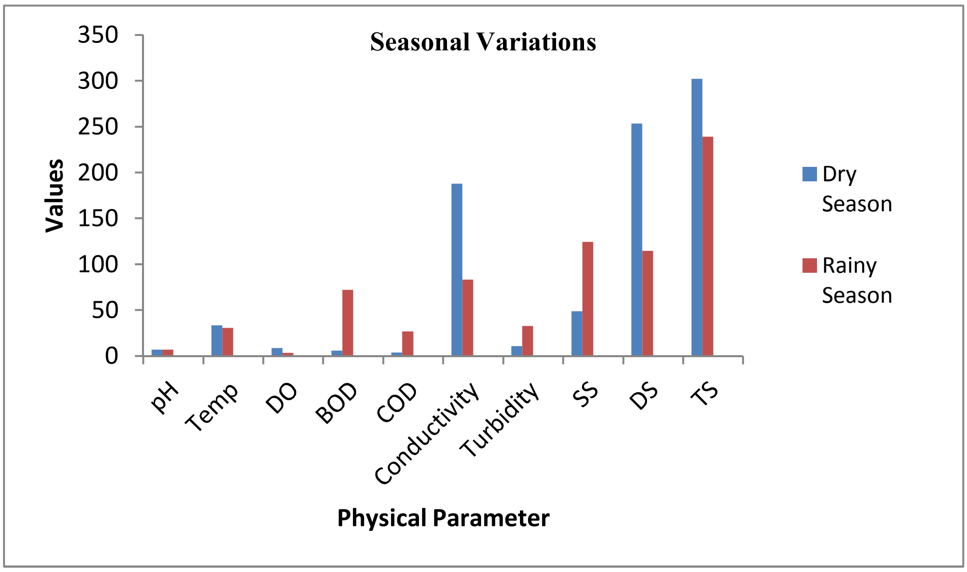

Fig.5 Seasonal Variations of physical parameters in Lake Nyafie

Turbidity

The mean values for turbidity of the lakes (table 2) are very high as compared to the WHO value of 5 NTU. The increase in the turbidity values from dry to the rainy season (tables 3 and 4) is as expected as a result of the runoff waters into the lakes from their catchment areas bringing with them a lot of soil and other particulate matter. The high turbidity values for the lakes render the lakes to lave very low aesthetic values.

Suspended Solids (SS), Dissolved Solids (DS) and Total Solids (TS)

These are the solid residues contained in the water samples from the lakes. As evident from table 2, their values for the lakes are within the WHO accepted limits. From tables 3 and 4, it is clear that these parameters did not show any particular pattern across the seasons. While some such as SS and TS increased from the dry to the rainy season, DS on the other hand, decreased from the dry to the rainy season for both lakes. These trends shown by the parameters are in line with conditions in the catchments areas of the lakes. Naturally, it is expected that, the runoff waters would carry a lot of soil and organic matter with it as it moves towards these water sources, thus increasing SS and TS. The decrease in the value of the DS on the other hand could be due to either the dilution of contents of the water sources by the runoffs or the inability of most of the nutrients, both organic and inorganic, to dissolve sufficiently at the time of sampling, or both.

Table 6 ***Mean Values of Nutrients and Ions in the Lakes***

	Parameters (mg/L)							
Lake	**NO_3^-**	**NO_2^-**	**PO_4^{3-}**	**Cl^-**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**	**K^+**
Kasu	0.178±0.02	0.058±0.02	0.087±0.04	11.11±3.9	8.62±5.0	3.71±0.4	17.40±4.1	6.61±1.0
Nyafie	0.137±0.02	0.033±0.01	0.192±0.02	7.50±4.3	5.37±2.8	3.65±0.7	12.46±6.6	4.79±2.1

Table 7 **Mean values of hardness of water of the Lakes**

	Parameters (mg/L)		
Lake	**Ca Hardness**	**Mg Hardness**	**Total Hardness**
Kasu	20.19 ± 6.0	15.23 ± 1.7	35.42 ±12.1
Nyafie	13.41 ± 6.9	15.01 ± 2.8	28.43 ± 8.8

Table 8 **Seasonal mean values for nutrients and ions in Lake Kasu**

	Parameters (mg/L)								Hardness		
Season	**NO_3^-**	**NO_2^-**	**PO_4^{3-}**	**Cl^-**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**	**K^+**	**Ca^{2+}**	**Mg^{2+}**	**Total**
Dry Season	0.07 ±0.01	nd	nd	14.66 ±0.7	5.63 ±0.4	3.54 ±0.5	21.24 ±0.7	7.30 ±0.2	11.35 ±1.9	14.53 ±2.1	25.88
Rainy Season	0.286 ±0.02	0.058 ±0.02	0.087 ±0.04	7.57 ±2.1	11.61 ±5.7	3.87 ±0.2	13.57 ±1.9	5.93 ±1.0	29.02 ±13.7	15.95 ±0.9	44.97

Note: nd means 'not detected'.

Table 9 **Seasonal mean values for nutrients and ions in Lake Nyafie**

	Parameters (mg/L)								Hardness		
Season	**NO_3^-**	**NO_2^-**	**PO_4^{3-}**	**Cl^-**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**	**K^+**	**Ca^{2+}**	**Mg^{2+}**	**Total**
Dry Season	0.02 ±0.01	nd	nd	9.63 ±0.5	4.52 ±0.9	2.74 ±0.5	20.60 ±1.2	7.46 ±0.6	11.29 ±2.8	11.27 ±3.5	22.56
Rainy Season	0.254 ±0.03	0.033 ±0.01	0.192 ±0.06	6.44 ±2.4	5.79 ±3.3	4.20 ±0.4	8.88 ±4.0	3.45 ±1.1	14.48 ±8.3	16.89 ±1.3	31.37

Nutrients (Nitrates, Nitrites and Phosphates)

The nitrate ion (NO3-) is the common form of combined nitrogen found in natural waters. Nitrate, which is an essential nutrient for aquatic plants, experiences seasonal fluctuations as a result of aquatic plant growth and decay. When influenced by man's activities, surface waters normally contain nitrate concentrations up to 5 mg/L but most often, less than 1 mg/L. Levels in excess of 5 mg/L usually indicate pollution by human and or animal waste, or fertilizer in runoffs. From table 6, the mean values for nitrate and nitrite ions are far below the WHO maximum value of 10 mg/L and as such the lakes can be said to be good for potability purposes. The very large variation in the seasonal values for nitrogen nutrients (tables 8 and 9) points to the fact that the source of the ions in the lakes is mainly from runoffs as shown by the high values for the rainy seasons compared to the lows for the dry season.

Phosphate (PO43-) is an essential nutrient for living organisms and exists in water bodies as both dissolved and particulate species. High concentrations of phosphate is an indicator of pollution and largely responsible for eutrophic conditions. The mean values of phosphate in the lakes (table 6) are generally low with large variations between the dry and rainy seasons (tables 8 and 9). The fact that there was no detection of the nutrient in the dry season in the lakes means that its presence in the rainy season is as a result of the inflows from runoffs from the farms around.

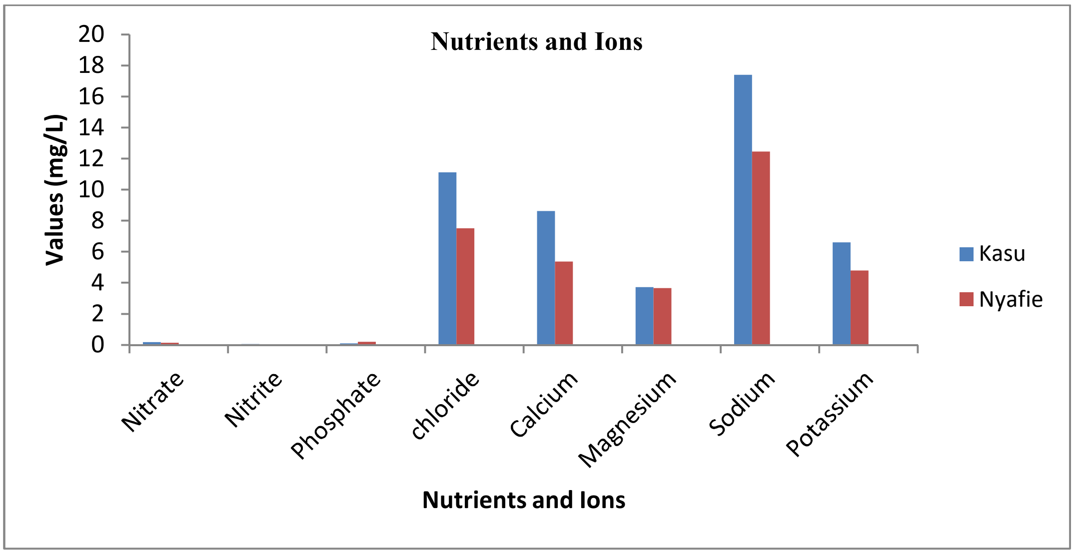

Fig. 6 ***Mean Values for Ions and Nutrients in the Lakes***

Ions (sodium, potassium, chloride, calcium and magnesium) and Hardness

All natural waters contain some amount of sodium as its salts are highly water-soluble. The mean values for sodium (Na+) content of the lake waters (table 6) is far below the maximum WHO value of 200 mg/L. The low values for the rainy season as compared to those of the dry season (table 8 and 9), may be is the possibility that some amount of sodium may be contained in the runoffs as well.

Most chlorine occurs as chloride (Cl-) ions in solution. The presence of chlorine in natural waters can be attributed to dissolution of salt deposits, sewage discharges, irrigation drainage and contamination from refuse leachates, among others. As chlorine is associated with sewage, it is it is often incorporated into assessments as an indication of possible fecal contamination or as a measure of the extent of dispersion of sewage discharge in water bodies, if possibility of seawater intrusion or bedrock contributions can be ruled out. The low mean values of chloride (table 6) in the lakes as compared to the WHO value of 250 mg/L, can lead one to say that, if chloride ion concentration can be used as a measure of fecal contamination, then the water bodies can be said to be free from fecal pollution. The season changes in the values of chloride ions concentration (tables 8 and 9) can also be attributed to dilution effect of the floodwaters.

Calcium and magnesium are present in all waters as the Ca2+ and Mg2+ ions respectively, and are readily dissolved from rocks rich in their minerals and from organometallic compounds in organic matter as they form essential elemental components in flora and fauna. The mean calcium and magnesium levels in the lakes (table 6) are far below the WHO levels and as such of no threat to the usage of the lake waters.

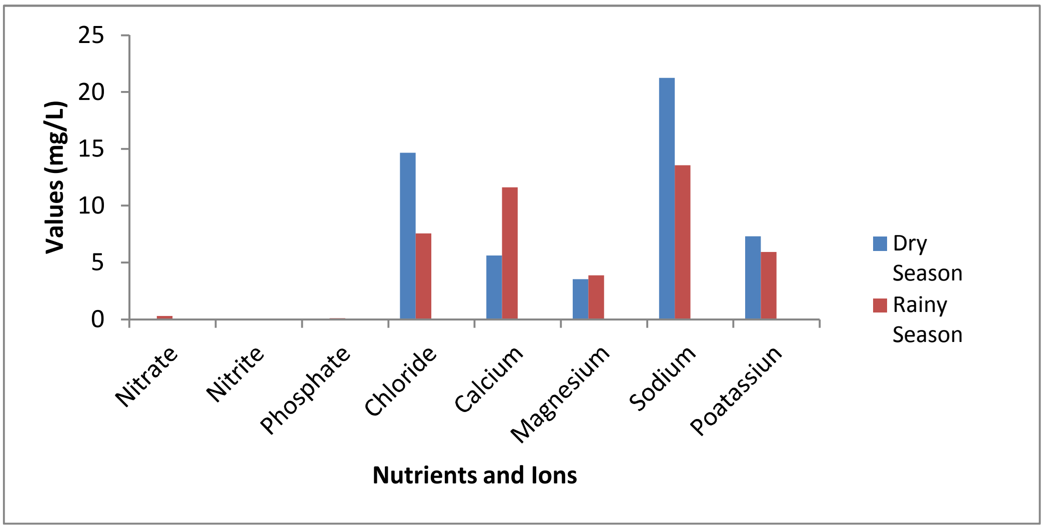

Fig. 7 Seasonal variations of nutrients and ions in Lake Kasu

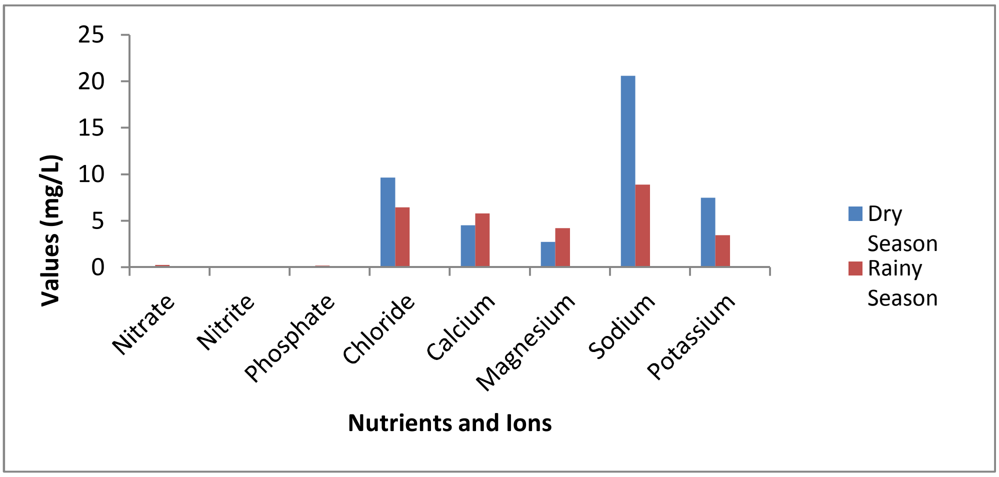

Fig. 8 Seasonal Variations of Nutrients and Ions in Lake Nyafie

Hardness of water is the traditional measure of the capacity of the water to react with soap, with hard water requiring a considerable amount of soap to produce lather. The extent of hardness in natural waters depends mainly on the levels of dissolved calcium and magnesium salts. The mean levels of total hardness as the sum of calcium and magnesium hardness in the lakes (table 7) is far below the WHO limits and the seasonal variations (tables 8 and 9) with the decrease from the dry season to the rainy season, follows the expected trend of dilution caused by the floodwaters.

Conclusion

A world without water is difficult to imagine, but images from the moon and Mars show clearly what conditions might be like without it. Water is vital for drinking, sanitation, agriculture, industry and other countless purposes. Life on earth begun in water, now fresh water brings life to thirsty cities and parched crops, and provides habitat for a multitude of living things. However, water can also mean death and destruction. Polluted water brings diseases and death to those who drink it and kills the birds, fish and other forms of life that need it to survive.

The significance of changes in the structure and quality of aquatic systems is not often closely related to the specific effects of separate stresses on individual components, but rather to the total or joint impact of man-induced changes. Interactions between pollutants and their impacts after use, appear to be the rule rather than the exception, and the total effects of a large number of 'minor' pollutants or their impacts, each in small concentrations or intensity, may be as great as the effect of one 'major' pollutant or impact acting alone.

From the results obtained in the study, it can be concluded that with the exception of turbidity and BOD values which were far above the WHO maximum values for potable water, the waters of the lakes can be considered to some extent wholesome except for it aesthetic value which is lost on someone seeing it for the first time. As a result of high values for these two parameters as well as the low value for DO, there is need for periodic surveillance and monitoring of the lake waters.

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