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Research Article
Limnological Qualities and Heavy Metal Status of Water from Southern Basin of Kainji Lake, Nigeria

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Abstract

Background and Objective: Limnological information of Kainji Lake is key in the development and management of the lake. Kainji Lake receives organic and inorganic wastes through animal husbandry operations, illegal mining activities, washing, bathing, direct waste disposal and other human activities. The objective of this research is to evaluate the limnological qualities of water from southern basin of the lake. **Materials and Methods:** Determination of faecal coliform (an indicator of biological pollutants) was carried out. Bacterial identification was also determined using primary isolation media and microbat identification kits, 12A and 12B (MB1132A/Australia). The concentration of lead (Pb), copper (Cu), cadmium (Cd), chromium (Cr), arsenic (As) and physicochemical parameters such as dissolved oxygen (DO), Biological Oxygen Demand (BOD), temperature, transparency, pH, conductivity, Total Alkalinity (TA), Total Dissolved Solids (TDS), nitrate and phosphate were determined. **Results:** Mean faecal coliform count in all the sampling stations were observed to be below the maximum permissible limit of 1.0×10^3 MPN/100 mL according to WHO. Faecal coliform counts during the wet season were higher than that during the dry season. Bacterial pathogens were identified. Physicochemical parameters were observed to be within an acceptable range for aquatic lives. Copper and arsenic were observed to be within the acceptable limit. Concentrations of cadmium in all sampling stations were above the maximum permissible limit. **Conclusion:** Faecal coliform count and physicochemical parameters are within favorable range for aquatic lives; however there was the presence of pathogens. Cadmium (Cd) in all sampling stations was above the maximum permissible limit.

Key words: Kainji lake, limnological, faecal coliform, bacteria, heavy metals, physicochemical

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Water is a transparent, odorless, tasteless liquid. It is a chemical compound consisting of two hydrogen atoms and one oxygen atom. The name water typically refers to the liquid state of the compound. The solid phase is known as ice and the gaseous state is called steam. Water is a basic need for life. It is required for the biochemical reactions that take place in human cells. A person may survive for a month without food, but only about a week without water[1]. Limnological studies should evaluate optimum water quality and factors affecting water quality to suggest the most sustainable way of utilizing the water system[2]. Kainji Lake receives organic and inorganic wastes through animal husbandry operations, illegal mining, washing, bathing, direct waste disposal and other human activities. These may introduce toxic heavy metals and microbial pathogens into the lake. According to WHO, the mortality of water-associated diseases exceeds 5 million people per year[3].

Heavy metals are produced from a variety of natural and anthropogenic sources; they are indeed intrinsic natural constituents of our environment[4]. They can be grouped as: potentially toxic (e.g. cadmium, arsenic, antimony, lead and mercury) and they can be essential (copper, zinc, selenium)[5]. For normal metabolism of fish, the essential heavy metals are taken up from water, food or sediment[6]. These essential heavy metals can also cause toxic effect when the metal intake is excessively elevated[7]. Some microorganisms are normal flora, while others are pathogenic to aquatic lives e.g. fish[8,9]. Pathogens of these aquatic lives may be transferred to humans through the consumption of the contaminated animals[9]. The aquatic environment is at the receiving end of these pollutants either through the natural course (run off) or direct dumping of the waste into the aquatic system by man.

World Health Organization (WHO) estimated that up to 80% of ill-health in developing countries are water related[8]. United Nations Environmental Protection estimates that 25,000 deaths in a day in developing countries are due to the consumption of polluted water[10]. Water from Kainji Lake is used for aquaculture, irrigation, drinking purposes by surrounding villagers and also as a source of fish from the wild. In order to get good quality water for aquaculture, irrigation and domestic consumption, water is usually treated in some way to remove harmful microorganisms and chemicals. Harmful microorganisms and chemicals poses a health risk to consumers and also add additional expenses to the cost of fish and crop production. Bacteria are critically dangerous pathogens for both cultured and wild fish and are responsible for mass losses in fish production[11]. With various anthropogenic activities in and around Kainji Lake, this study is aimed at evaluating the physical, chemical, biological qualities and heavy metal status of this water body and recommend ways to keep the water sources clean.

MATERIALS AND METHODS

Study area: This study was carried out at the microbiology and chemistry laboratory of the National Institute for Freshwater Fisheries Research, New Bussa from January, 2017 to December, 2017.

Kainji Lake is located along River Niger in Northwestern Nigeria. It was impounded in 1968 along the Guinea savannah vegetation zone. This waterbody is located between longitude 9°50" and 10°55" East and Latitude 4°20" and 4°45" North. Kainji Lake is the largest manmade lake in Nigeria. It has a length of 134 km, the maximum width of 21.1 km, a maximum depth of 60 m and a surface area of 1270 km^2. The lake with its large size after impoundment attracted many fishermen both within and outside the country who settles along the bank with their families and depend on the lake fishery for their livelihood. Other activities like navigation, irrigation and washings are also carried out in addition to the generation of hydroelectric power. Figure 1 shows the map of Kainji Lake and sampling stations.

Description of sampling stations: Samples were collected from 5 different stations at the southern basin of Kainji Lake. Sample stations were chosen at about 7-10 km apart from each other. The selection of the sample stations was based on different human activities being carried out around the station such as cattle husbandry operations, mining activities, domestic washings, irrigation and power generation.

Station 1 (Warra) is characterized with many agricultural farms, domestic washings and high animal husbandry operations with low mining activities. It lies adjacent to Warra market and it is also the route in which boats come in and out of Warra town. Station 2 (Garafini) is at the lower course of Warra and is characterized by high mining activities and agricultural farms. This station has low animal husbandry operations. Station 3 (Yunawa) has heavy animal husbandry operations and many domestic activities (Washing, bathing, fishing, blacksmiths). It has high mining activities going on around the lake. Station 4 (Anfani) is at the lower course of Yunawa, it also has minimal mining activities and animal husbandry operation going on around the station. Station 5 (Kaya) has minimal animal husbandry operation and less

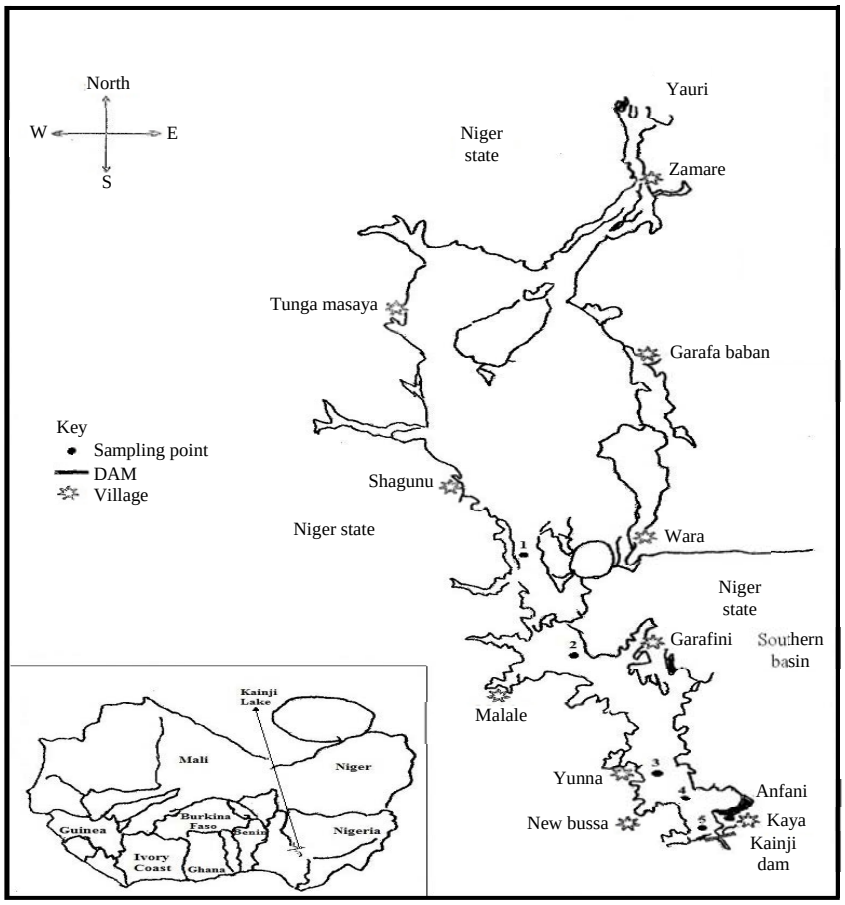

Fig. 1: Kainji Lake showing sampling station
Source: Abiodun[12]

domestic activities such as washings and bathing, without any mining activities. In some of these stations, the water is used raw for drinking purposes by the villagers.

Collection of water samples for bacteriological and physicochemical analyses: Water samples were collected monthly for twelve months from January 2017 to December, 2017. Samples were collected from five (5) different sample stations in the lake. During the sampling exercise, a global positioning system (GPS) device-Model 12 XL:S/N 84567093 was used to take coordinates at each sampling station. With the help of a boat, water samples were collected at 150 m away from the bank and at a depth of 30 cm below the surface using van-dorn water sampler. The water was collected directly into 250 mL sterilized bottles and corked airtight as previously described by Mudasiru *et al.*[13]. The bottle containing each water sample was labeled and stored in a portable ice chest box at a temperature of not more than 5°C so as to stop or reduce microbial activity before it was analyzed in the laboratory.

Water samples for the determination of physicochemical parameters were collected into a clean 250 mL capacity bottle. It was collected from each sampling station for determination of Dissolved Oxygen (DO), temperature, pH, Biological Oxygen Demand (BOD), conductivity, nitrate, total alkalinity and phosphate. Water sample for BOD was covered immediately with thick black colored leather, while the other set for Dissolved Oxygen (DO) was fixed immediately with 2 mL each of Winkler I ($MgCl_2$) and Winkler II (KOH+KI) reagents before it was taken to the laboratory for analysis according to the procedure of Mudasiru *et al.*[13].

Collection of water samples for determination of heavy metals: Water samples were collected from all the 5 sample stations of the lake. Two liters of polyethylene sampling bottles were used to collect water samples (4 times) at each sampling station. The pre-cleaned sampling bottle was immersed about 20 cm below the water surface to collect the water sample. These water samples collected at each sampling site were mixed in a plastic bucket and a representative

Table 1: Coordinates of sample stations in Kainji Lake

Sampling station	Coordinates	Coordinates	Lake
KL 1 (Warra)	N10° 13.845'	E 004° 36.951′	Kainji
KL 2 (Garafini)	N10° 02.624′′	E 004° 36.713'	Kainji
KL 3 (Yunawa)	N 09° 56.035'	E 004° 36.163'	Kainji
KL 4 (Anfani)	N 09° 54.556'	E 004° 37.709'	Kainji
KL 5 (Kaya)	N 09° 52.309'	E 004° 37.123'	Kainji

KL: Kainji Lake

sample of one liter was transferred into a polyethylene bottle. Samples were acidified with 2 cm^3 of 10% HNO_3, this was placed in an icebox in order to stabilize the metal ions and prevent volatility of constituents[14]. This was transported to the laboratory for further analysis according to the procedure of ÖztÜrk *et al.*[15]. Table 1 shows various coordinates of the sampling station.

Determination of faecal coliforms using Most Probable Number (MPN) technique: Faecal coliform count was determined using the most probable number technique[16]. In the presumptive test three series of five tubes each containing 10, 1 and 0.1 mL portions of the sample were inoculated with sterilized macConkey broth. Pure sterilized macConkey broth was inoculated with sterilized distilled water to serve as a control. Inoculated tubes were then incubated at 37°C for 24 hrs. Using a sterilized wire loop, transfer was made from all tubes showing acid and gas production (an indication of the presence of total coliform) to tryptose bile broth (EC Broth) and incubated at 44.5°C for 24 hrs. Gas production in a fermentation tube within 24 hrs is considered as a positive reaction for faecal coliform.

The estimated number of faecal coliform present in 100 mL was read from a tabulated probability table using corresponding results of various combinations of positive and negative reactions from each of the three batches[16].

In the confirmatory test, two loopful of broth from the positive tubes above were transferred to brilliant green lactose bile broth (BGLB) and incubated at 44.5°C. Gas formation after 24 hr is an indication of a positively confirmed test[1].

In the completed test, with the help of a sterilized loop, positive growth from BGLB was streaked on eosin methylene blue (EMB) agar and incubated at 44.5°C for 24 hr according to the procedure of Nduka[1]. After 24 hr, colonies showing metallic sheen coloration and gram-negative rods on staining are indications of a positive completed test.

Bacterial identification: Bacterial identification was carried out using primary isolation media according to standard procedures[8,17-20]. Isolates obtained from primary isolation media were further screened biochemically using Microbact Identification Kits, 12A and 12B (MB1132A/ Australia).

Analysis of physicochemical parameters of water: The following physicochemical parameters were determined.

The temperature was determined in situ using mercury in a glass thermometer according to Emmanuel and Ayeni[21]. Dissolved oxygen (DO) was determined following Modified Winkler's method according to the procedure of APHA[14]. Determination of BOD follows the same procedure as that of dissolved oxygen except that the sample bottles were covered with a thick black polythene bag and the samples after collection were allowed to stand for 5 days before titration. Transparency was measured using the Secchi disc and expressed in Centimeter.

Total alkalinity was determined according to the method of Abdolmajid and Sadeghi[22] and expressed in mg L^{-1}. The conductivity test was carried out using a conductivity meter expressed in microsiemens/centimeter. pH was measured using Jenway pH meter.

Chemical analysis of nitrate-nitrogen (NO_3-N) and phosphate was determined using the colorimetric method.

Sample preparation for determination of heavy metals: Water samples were digested according to APHA[23]. One hundred milliliters of water sample was transferred into a 125 mL conical flask. Five milliliters of concentrated HNO_3 was added. The solution was allowed to boil slowly and evaporate on a hot plate to allow precipitation. Heating and addition of concentrated HNO_3 continued until a light-colored clear solution was obtained. The sample was not allowed to dry during the digestion. The wall of the flask was rinsed with distilled water and the solution filtered. The filtrate was transferred into a 100 mL volumetric flask, diluted to the mark and mixed thoroughly. This was stored in a plastic vial prior to heavy metal determination. The portion of this solution was used for heavy metals determination using Atomic Absorption Spectrophotometer (PG instrument model, AA500 Spectrophotometer).

Determination of heavy metals: After digestion, the filtrate of each sample was thoroughly mixed and analyzed using atomic absorption spectrophotometer (PG instrument model, AA500 Spectrophotometer). A standard solution of each of the heavy metal determined was prepared from their salts. Reagent blank was similarly prepared. The atomic absorption spectrophotometer was set at optimum conditions for maximum absorbance signal at the wavelength of each element and this was used to determine the concentration of

each element in the samples, standards and the blanks. The concentration for each of the elements was obtained based on Beer Lambert's law[24], which states that absorbance is directly proportional to the concentration of metal at a particular wavelength. The standard calibration curve was drawn using signals (absorbance) of the standard solutions of each element. Concentrations of elements in the samples were determined by extrapolation of the absorbance on the calibration curve.

Statistical analysis: Student t-test was used to show a significant difference ($p<0.05$) between faecal coliform count of the wet and dry season. Mean values of physicochemical parameters were calculated and analyzed statistically using Analysis of Variance (ANOVA) to determine a significant difference between sampling stations. Variations in heavy metal concentrations between sampling stations were carried out using Duncan Multiple Range Test.

RESULTS

Mean Faecal coliform count of water from Kainji Lake sample stations using Most Probable Number (MPN) technique: Table 2 shows mean faecal coliform count of water from Kainji Lake sampling stations. It was observed that faecal coliform count in Kainji Lake station 1(Wara) had the highest mean coliform count (305.17 MPN/100 mL), while station 4 (Yunawa) had the lowest count (171.83 MPN/100 mL). Sampling station 1 and sampling station 3 however had a maximum count of 540.00 MPN/100 mL each.

Seasonal faecal coliform count of water from Kainji Lake using Most Probable Number (MPN) technique: Faecal coliform count during the wet season was higher than that of the dry season (Table 3). The minimum faecal coliform count in Kainji Lake during the dry season was 6.0 MPN/100 mL, while the count in wet season was 63.0 MPN/100 mL. The maximum count during the wet season was 540.00 MPN/100 mL and during the dry season was 430.00MPN/100 mL.

Bacterial species isolated in water samples from Kainji Lake: Biochemical analysis of bacterial isolates from Kainji Lake water revealed the presence of the following bacterial species as shown in Table 4.

Physicochemical qualities of Kainji Lake water: Table 5, shows the minimum, maximum and mean of the physicochemical parameters of Kainji Lake water. The mean temperature value of Kainji Lake water was 29.80±1.96°C. Transparency was 0.56±0.34 m and pH level of the lake was 7.3. This implies that the lake will support more growth of bacteria than fungi by virtue of its pH level. Total alkalinity, biochemical oxygen demand, nitrate and phosphate content in Kainji Lake were 10.03±2.95, 2.10±1.44, 12.70±4.12 and 0.30±0.18 mg L^{-1}, respectively. All parameters examined were found to be within the acceptable range for aquatic lives.

Table 2: Mean Faecal coliform count (cfu/100 mL) of water from Kainji Lake sampling stations

Sampling station	Min	Max	Mean±SD	Max permissible limit (MPN/100 mL)
KL 1	8.00	540.00	305.17±184.02	1000[a]
KL 2	6.00	350.00	206.33±139.11	1000[a]
KL 3	14.00	540.00	303.58±190.31	1000[a]
KL 4	20.00	430.00	171.83±136.85	1000[a]
KL 5	10.00	430.00	191.83±127.86	1000[a]

KL: Kainji Lake, [a]: WHO[25]

Table 3: Mean seasonal faecal coliform count of water from Kainji Lake

Parameter	Wet	Dry
Minimum	63.00	6.00
Maximum	540.00	430.00
Mean±SD	325.90±152.13	145.65±118.43

Table 4: Bacterial species isolated in water samples from Kainji Lake

Sampling stations	Name of organisms
KL 1	*Aeromonas caviae, Aeromonas Veronii bio sobria, Aeromonas hydrophila, Pseudomonas fluorescens-35, Burkholderia pseudomallei, Vibrio alginolyticus, Mannheimia (pasturella) haemolytica, Escherichia coli, Moraxella* species, *Actinobacillus* species
KL 2	*Escherichia hermannii, Aeromonas hydrophila, Pseudomonas fluorescens-25, Burkholderia pseudomallei, Vibrio alginolyticus, Escherichia coli, Vibrio hollisae*
KL 3	*Pseudomonas fluorescens-35, Aeromonas hydrophila, Pseudomonas fluorescens-25, Escherichia hermannii, Escherichia coli, Actinobacillus* species
KL 4	*Vibrio alginolyticus, Escherichia* inactive, *Aeromonas caviae, Pseudomonas fluorescens-25*
KL 5	*Escherichia coli Actinobacillus* species, *Aeromonas hydrophila, Pseudomonas fluorescens-35*

KL: Kainji Lake

Table 5: Physicochemical qualities of Kainji Lake water

Parameter	Kainji lake (Min. - Max.)	Mean±SD	Standard
Temperature (°C)	25.00 - 32.50	29.80±1.96	25-32[a]
Transparency (m)	0.10 - 1.40	0.56±0.34	0.3-0.6[a]
pH	6.60 - 8.00	7.30±0.27	6.5-9.0[a]
Conductivity (µS cm^{-1})	32.00 - 78.00	49.10±11.57	<500[a]
Dissolved Oxygen (mg L^{-1})	4.00 - 10.00	7.26±1.12	5.0-9.0[a]
Total Alkalinity (mg L^{-1})	4.40 - 14.00	10.03±2.95	5.0-500[a]
Biochemical oxygen demand (mg L^{-1})	0.50 - 6.00	2.10±1.44	<15.0[a]
Total Dissolved Solids (mg L^{-1})	0.002 - 0.05	0.02±0.01	<1200[a]
Nitrate (mg L^{-1})	6.80 - 18.77	12.70±4.12	≤50.0[b]
Phosphate (mg L^{-1})	0.098 - 1.16	0.30±0.18	<0.5[C]

[a]: Krishnani *et al.*[26], [b]: ANZECC[27], [C]: WHO[28]

Table 6: Mean physicochemical qualities of sample stations in Kainji Lake water

Sampling station	Temperature (°C)	Transp. (m)	pH	Cond. (µS cm^{-1})	DO	TA	BOD	TDS	Nitrate	Phosphate
					(mg L^{-1})					
Kl.1	29.50±2.05^{a}	0.46±0.30^{a}	7.31±0.25^{a}	51.25±12.30^{a}	7.00±0.83^{a}	10.13±2.93^{a}	1.78±1.40^{a}	0.03±0.01^{a}	12.11±4.19^{a}	0.30±0.16^{a}
Kl.2	29.67±2.05^{a}	0.58±0.28^{a}	7.35±0.24^{a}	46.00±10.63^{a}	6.91±1.47^{a}	9.34±2.69^{a}	2.05±1.33^{a}	0.02±0.01^{a}	12.25±4.45^{a}	0.30±0.15^{a}
Kl.3	29.90±2.18^{a}	0.60±0.35^{a}	7.32±0.21^{a}	49.83±13.58^{a}	7.82±1.17^{a}	9.78±2.90^{a}	2.39±1.72^{a}	0.02±0.01^{a}	12.91±4.32^{a}	0.37±0.28^{a}
Kl.4	29.96±1.93^{a}	0.57±0.34^{a}	7.26±0.29^{a}	48.75±10.60^{a}	6.99±1.13^{a}	10.20±3.14^{a}	2.09±1.41^{a}	0.02±0.01^{a}	13.03±4.39^{a}	0.27±0.13^{a}
Kl.5	30.04±1.96^{a}	0.63±0.42^{a}	7.25±0.38^{a}	48.67±12.00^{a}	7.58±0.86^{a}	10.43±3.45^{a}	2.08±1.55^{a}	0.02±0.01^{a}	13.00±4.10^{a}	0.24±0.11^{a}

Values on the same column with different superscript are significantly different (p<0.05), Kl: Kainji lake, DO: Dissolved oxygen, TA: Total alkalinity, BOD: Biological oxygen demand, TDS: Total dissolved solids

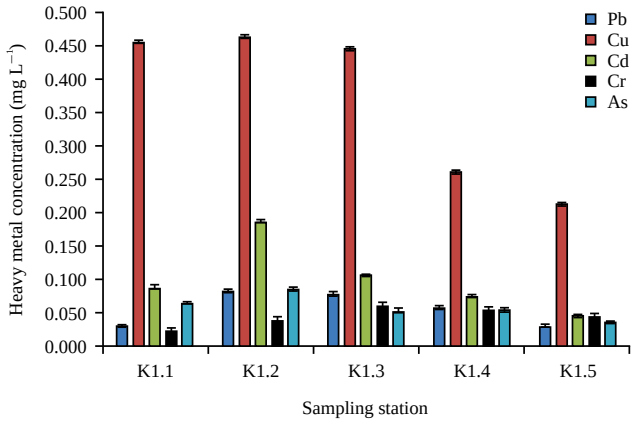

Fig. 2: Heavy metal concentration in water from Kainji sampling stations

Mean physicochemical qualities of sample stations in Kainji Lake water: Table 6 shows mean physicochemical qualities of water in different sample stations. It was observed that station 1 (Warra) had the highest conductivity level (51.25 µS cm^{-1}) and total dissolved solids content (0.03 mg L^{-1}). Station 3 (Yunawa) had the highest biological oxygen demand (2.39 mg L^{-1}) and high phosphate level (0.37 mg L^{-1}), station 4 (Anfani) had the highest temperature value and nitrate level (respectively). Analysis of Variance shows that there was no significance difference (p<0.05) in the physicochemical parameters at different sample stations.

Heavy metal concentration in water from Kainji sampling stations: The concentration of heavy metals from different sampling stations of kainji lake shows that sampling station 2 (Kl.2) had a higher concentration of Pb (0.082 mg L^{-1}), Cu (0.464 mg L^{-1}), Cd (0.187 mg L^{-1}) and As (0.085 mg L^{-1}) than other sampling stations (Fig. 2). Sample station 3 (Kl.3) had higher concentration of Cr (0.061 mg L^{-1}) than other stations. A higher concentration of heavy metals in station 2 may be due to high mining activities around station 2 (Garafini) than other stations. Duncan multiple range test shows a significant difference (p<0.05) in metal concentrations between the sampling stations.

DISCUSSION

Sampling station 1 (Warra) and station 3 (Yunawa) had a maximum faecal coliform count of 540.00 cfu/100 mL each, being higher than that of other sampling stations. This might be due to high animal husbandry operations and many domestic activities (Washing, bathing and fishing) in and around these sampling stations. Sampling station 1 lies adjacent to warra main market and serves as a route where boats go into and out of warra town. These results in stations 1 and 3 agree with Lejeune *et al.*[18], who stated that the presence of bacteria in a natural aquatic ecosystem is dependent upon the rate of contamination and the equilibrium that is established between bacteria proliferation in the environment and the rate of their elimination.

Higher faecal coliform count during the wet season above that of the dry season is an indication that pollution of the lake was majorly caused by runoff from adjacent farms into the lake. This agrees with the study of Ampofo and Clerk[29], who showed that lack of animal waste management would directly affect water quality as a result of surface runoff. The presence of faecal coliform in the lake is an indication of contamination since faecal coliforms are not normal flora of surface water. It therefore means that this contamination could have arisen from human and livestock activities. T-test result shows that there was a significant difference (p<0.05) between wet and dry season. Normal flora and pathogens that were isolated from the water may have originated from both human and animal sources, including runoff from animal and municipal waste. This agrees with a study carried out by Christy *et al.*[30] who showed that livestock manure are contaminated with pathogenic bacteria such as *Escherichia. coli* 0157:H7, *Salmonella* species, *Listeria monocytogenes*, *Yersinia*, *Bacillus* species, *Pseudomonas* species.

The levels of physicochemical parameters determined were consistent with the findings of Olatunde and Oladele[31] and were also found to be within the acceptable range for aquatic lives according to Krishnani *et al.*[26] and WHO[28]. Values of temperature, electrical conductivity and total dissolved

solids in this study were however lower when compared with findings from the study of Nikita *et al.*[32].

The concentrations of lead in sample stations 2, 3 and 4 were above the maximum permissible limit of 0.05 mg L^{-1} according to the World Health Organization (WHO)[33]. This may be due to high mining activities around these stations compared to station 1 and station 5. Mining areas are chief sources of heavy metal pollution. Lead has a harmful effect on kidney and nervous system (saturnism) and also causes anemia in humans[32].

Concentrations of cadmium (Cd) in all the sampling stations were above the maximum permissible limit of 0.01 mg L^{-1} according to the World Health Organization (WHO)[33]. This may be partly due to mining activities around the lake, effluents from power generation plant and also agricultural phosphate fertilizers being applied to farmlands along the bank and receded areas of the lake. This result agrees with Agency for Toxic Substance and Disease Registry[34] which stated that natural as well as anthropogenic sources of cadmium which includes industrial effluents, fertilizers and sewage sludge to farmland could increase the environmental level of cadmium. Cadmium has no importance in human metabolism. It causes renal malfunction in both humans and animals. It also causes "Ita-Ita" a disease characterized by renal deficiency associated to osteoporose[32]. The concentration of chromium at sampling station 3 (0.061 mg L^{-1}) which is above the maximum permissible limit of 0.05 mg L^{-1} may be as a result of effluent from domestic waste and scraps from the activities of blacksmiths while that of sampling station 4 (0.055 mg L^{-1}) may be an upper course (station 3) effect. The concentration of copper and chromium in this study were lower when compared with the findings of Olatunde and Oladele[31] on heavy metals in inland freshwater of lower River Niger, Nigeria. However, the concentration of lead and cadmium in some sample stations from this study were higher than that from lower River Niger. This variation may be due to high illegal mining activities around Kainji Lake and the activities of Ajaokuta steel production mill at lower River Niger. It is, therefore, necessary that illegal mining activities should be checked and open grazing of livestock should be prohibited.

CONCLUSION

The study confirms that, Mean faecal coliform count was found to be below maximum permissible limit, hence water is conducive for aquatic lives. There were the presence of pathogens in water samples thus the need for proper waste management. Physicochemical qualities of the water body were found to be within an acceptable range that is favorable for aquatic lives. Concentrations of cadmium and lead were found to be above maximum permissible limit due to illegal mining activities and the application of inorganic fertilizers around the lake.

SIGNIFICANCE STATEMENT

This study revealed the presence of pathogens in the water and also a high concentration of cadmium and lead above the maximum permissible limit in some sampling stations. The study will help policymakers to make informed decisions on waste management/disposal and also decisions on illegal mining activities around the lake.

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