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Investigation on the quality of water from Jabi Lake in Abuja, Nigeria

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Abstract
Surface water may constitute public health issues if the water is contaminated. Consequent upon this assertion, the physicochemical parameters and trace metal concentration of Jabi Lake surface water were analysed and compared with WHO standards. Sixteen water samples were taken for analysis from Jabi Lake within Abuja in Nigeria. Official Methods of Analysis of the Association of Official Analytical Chemists (AOAC) were adopted in the analysis of the physicochemical parameters while heavy metals ions determination was performed using Atomic Absorption Spectrophotometer. The results obtained revealed marked differences in the levels of some physicochemical properties and trace metal ion concentration in the surface water samples when compared with WHO standards. Though most physicochemical parameters were within acceptable and safe limits, but with nitrate having higher concentrations. The concentrations of manganese, iron, cobalt, lead and chromium were well above the WHO maximum permissible limits for surface water. The pollution index of manganese, iron, cobalt, lead and chromium were above unity (1.0), indicating very high level of pollution. The results of the physicochemical and trace metal analysis when compared with WHO suggest that the water samples from Jabi Lake was not suitable for drinking while the concentrations of the metal ions were found decreasing in this order; Pb >Fe>Cr>Mn>Co>Zn.
Keywords: Jabi Lake, surface water, trace metal, concentration, physicochemical properties.

Introduction

Water is a natural resources that is significantly important for life and is used for home purposes, agricultural production and industrial activities [1]. Water therefore should be accessible, affordable and available in pure form [2- 4]. Safety and portability of water in its pure form for drinking purpose is a function of its acquiescence with the physical, chemical and microbiological criteria set by World Health Organization and other local regulatory bodies [5, 6]. Water is a compound consisting of two hydrogen atoms bonded to an electronegative oxygen atom. Water is a universal solvent that is characterized by its outstanding ability to dissolve mineral elements and other substances in contact with it. In nature, pure water is scarce to find largely because of anthropogenic contamination of our environment [7]. The extent of water pollution in any specific area depends greatly on the degree of contamination of its immediate environment [8]. Rainwater even collects impurities from the atmosphere as it drops down. Gaseous substances such as SO2, CO2, and NO2 dissolved in trickling rain water to form acid rain. Heavy metal pollution is a major environmental problem especially of growing cities in developing countries predominantly due to unrestrained contamination levels as a result of contributing factors such as industrial growth and increase in vehicular emission of fossil fuel [9]. Other sources of contamination of surface water are impurities from surface run-off, sewage discharges, seepage from waste sites, decaying plant life, pesticides, fertilizers, petroleum oil spillage and industrial effluents which found their way into water bodies as the bank of rivers and streams over flowed [10]. Pearse in his report said that surface water may be contaminated by particles discharged during mining, smelting and industrial manufacturing [11]. Other source of water pollution is the direct discharge of synthetic micro pollutants into surface waters [12]. Poor sanitary condition at the closest vicinity of a borehole, landfills, and petroleum oil spillage, septic tanks, channeling of runoff into wells, excessive usage of pesticides and fertilizers are the sources of pollution of underground water [10, 12]. Generally metals occur in minerals, glasses, and melts in the geosphere but in hydrosphere metals are present as dissolved ions and complexes, colloids, and suspended solids.

Trace metals occur naturally in the earth's crust at different concentrations, but are not biodegradable and lack natural elimination processes in the environment. The presence of free metal ions in drinking water is very useful in determining the levels of pollutant and nutrient element it contain [13]. Heavy metals enter the human body through food, drinking water and inhalation from air. Iron, cobalt, copper, manganese, molybdenum, and zinc are essential element which may be required by humans in very small amount. Heavy metals are jointly categorized as ecological pollutants because they are poisonous and hazardous to health at minute concentration. Consequently upon this reason, it then becomes necessary to periodically investigate environmental samples for the presence of heavy metals for environmental and public health safety as well as for pollution studies [14]. Over 70% of resident in the locality of Jabi Lake are dependent on groundwater and surface water for their immediate use. Jabi Lake is known to have supported farming, fishing, domestic and recreational activities of the local communities around it. Any deterioration in the quality of water in this lake will have very crucial negative impact in the livelihoods of local communities. This study is therefore aimed at assessing the water quality of Jabi Lake by determining the level physicochemical and trace metal elements and comparing values with WHO permissible limits.

Materials and methods

Sample Collection and Preparation

The sampling was carried out in January 2020. Three replicate samples were collected from each sampling point with the same coordinate. The replicate samples were then pooled together to form composite mixtures. Sampling was done on sixteen (16) different points each 200 meters apart from the other. The composite samples were collected with 1 liter polyethylene containers and the samples were processed immediately after returning to a laboratory. Analyses were performed based on standard methods as suitable to each water quality parameter, as stipulated in the APHA [15] and AOAC [16].

Study Area

Jabi Lake is situated in Federal Capital Territory (FCT) Abuja, Nigeria. Geographical coordinates of Jabi Lake are 9° 3' 45" North, 7° 25' 27" East respectively. Jabi Lake is a place of increasing tourist attraction, fishing activity, domestic and recreational activities. Jabi Lake is being serenaded by nature's ambience which provides an inexpensive way to have fun, picnics with families. Jabi Lake is in a very safe location surrounded with shopping malls and Jabi Lake Park. The location map is shown in Figure 1 below.

Figure 1: Map of Jabi Lake showing study area. (Excerpt from Google Map)

Table 1: Coordinates of sampling stations from Jabi Lake

S/N	Points	Latitude (N)	Longitude (E)	Elevation
1	S1	9.07328^0	7.41811^0	270
2	S2	9.07323^0	7.41442^0	269.3
3	S3	9.07303^0	7.41799^0	180
4	S4	9.07291^0	7.41642^0	181
5	S5	9.07285^0	7.41838^0	269.9
6	S6	9.07275^0	7.41816^0	269.0
7	S7	9.07280^0	7.41865^0	99.7
8	S8	9.07292^0	7.41877^0	99.5
9	S9	9.07293^0	7.42023^0	85.0
10	S10	9.07252^0	7.42010^0	85.0
11	S11	9.07338^0	7.42029^0	40.1
12	S12	9.07358^0	7.42049^0	39.6
13	S13	9.07418^0	7.42015^0	90.0
14	S14	9.07416^0	7.42013^0	90.2
15	S15	9.07445^0	7.41963^0	242.1
16	S16	9.07447^0	7.41966^0	242.4

A total of 16 samples were represented as S1 to S16 with their coordinate and elevations respectively.

Determination of Physicochemical Properties

The pH of water samples were determined using pH meter (Thermo Scientific, USA).

The electrical conductivity and total dissolved solid (TDS) of water samples were measured using electrical conductivity/TDS/Temperature meter (HM Digital COM-100) [17]. Turbidity meter (HI88703 HANNA) instrument was used to estimate the values of turbidity of the water samples after calibration with standards, 10, 15, 50, 100, 500, 1000 Nephelometry Turbidity Unit (NTU) and the results were recorded in NTU. The dissolve oxygen was carried out using DO meter (JENWAY 9500 DO, England pontrish).

The biochemical oxygen demands were carried out in the laboratory by adopting the bottle incubation method. Concentration of chloride was measured argentometrically by titration of 50 ml of sample against silver nitrate indicator. Nitrate, sulphate and phosphate concentrations were performed using Spectrophotometric methods (HACH DR 2000 spectrophotometer). Salinity of the water sample was measured using a salinity meter (thermo scientific Orion versaster pro advanced electrochemistry meter, USA).

Determination of Trace Metals (Zn, Mn, Pb, Co, Cr, Fe)

Atomic absorption spectrophotometer (HACH DR2) was used in the analysis of metal element concentration according to American Public Health Association [15]. Calibration curves were prepared for each metal using serially diluted concentrations of the respective metal stock solution. The concentrations of the trace metal ions were determined through graphical extrapolation from the calibration curves.

Pollution index (Pi)

Pollution index is a geochemical index which has been widely used to estimate the level of pollution of surface water samples. In explicit terms, it describes the comparative contribution of each parameter to the overall pollution of the environmental water sample [14].

$$(Pi) = \frac{Concentration\ of\ individual\ parameter}{Concentration\ of\ standard}$$

Pollution index has a threshold value of 1.0. Values lower than 1.0 stipulates that pollution has not occurred whereas values greater than 1.0 establish substantial level of water pollution.

Results and Discussion

The results of the physicochemical parameters of the environmental water sample are presented in Table 2. The results revealed that pH ranged from 6.62 ± 0.50 to 7.52 ± 0.20 while conductivity ranged from 159.10 ± 1.01 to 187.1 ± 1.07 µs/cm. This shows that the water is slightly acidic with closeness to neutrality. The pH of pure water is approximately 7.00. Generally, water with a pH lower than 7 is considered acidic, whereas pH greater than 7 is considered basic. The pH values were within the range of value (6.5-8.5) recommended by world health organization (WHO) and standard organization of Nigeria (SON) respectively [5, 17]. The range of pH were similar to values reported on Imo river [14] but higher than the range of 4.84 to 7.2 reported on Imo river [19]. The levels of the conductivity of water obtained in this study were below the allowable limits (1000 µs/cm) recommended by (WHO, 2011). The measure of water's ability to pass electrical flow is known as conductivity. This capability is directly correlated to the concentration of dissolved solids and ions in the water [20]. These conductive ions arise from dissolved salts and inorganic materials such as alkalis, chlorides, sulfides and carbonate compounds [21]. The conductivity of Lake Water may be largely controlled by numerous factors such as watershed geology, the watershed's size relative to Lake dimension, wastewater from point sources, runoff from non point sources, atmospheric inputs, evaporation rates, and some types of bacterial metabolism. The fewer ions present, the lower conductivity of water. Introduction of other organic compounds in the Lake might decrease conductivity as these elements cannot dissociate into ions. Saltiness or dissolved inorganic salt content of a body of water is known as salinity. Reduced rainfall and increase in evaporation loses of water as a result of increase temperature, would definitely bring about increase in the salinity as solutes in water become more concentrated [20,21]. A small increase in the water salinity can cause a significant loss of biodiversity whereas low salinity favours aquatic live, and indeed support fishing activity [14]. Salinity values recorded was low, which varied from 0.07 ± 0.00 to 0.12 ± 0.01 psu. Low levels of salinity may be attributed to increasing rainfall and decreasing evaporation loses. It is expected therefore that as rainfall increases, the volume of water in the Lake increases which consequently decreases the salt content of the water due to over dilution. Total Dissolved Solids (TDS) ranged from 85.10 ± 1.04 to 95.50 ± 0.11 mg/L whereas turbidity had minimum and maximum values of 1.36 ± 0.15 to 5.90 ± 0.60 NTU respectively. The WHO permissible limit for TDS and turbidity are 500 mg/L and 5.0 NTU respectively [5]. Consequently, the water is not polluted with respect to TDS. However, four sampling stations (S1, S2, S7 and S8) had turbidity above the recommended value 5.0 NTU. Dissolved oxygen (DO) ranged from 20.98 ± 0.01 to 28.00 ± 0.60 % and biochemical oxygen demand (BOD) had minimum and maximum levels of 1.00 ± 0.00 to 2.00 ± 0.03 mg/L. The World Health Organisation permissible limit for dissolved oxygen is 5.0% but there is none for BOD. Low BOD values may be an indication of limited levels of organic matter requiring oxygen from the water for decomposition [19, 20]. The less the quantity of organic matter requiring oxygen for decomposition, the more available dissolved oxygen in water. The levels of dissolved oxygen (DO) in a stream, lake or river speaks volume of water quality. Chloride and sulphate ion concentrations ranged from 20.37 ± 0.35 to 59.55 ± 1.50 mg/L, and 0.32 ± 0.01 to 11.00 ± 0.21 mg/L. Chloride ion and sulphate ion concentrations were within the WHO recommended permissible limit of 250- 500 mg/L and 500 mg/L respectively [5]. Hence the water is not polluted with respect to chloride ions and sulphate ions respectively. Nitrates and nitrogen recorded minimum and maximum levels of 32.70 ± 0.31 to 224.10 ± 2.01 mg/L and 6.40 ± 0.01 to 60.00 ± 0.98 mg/L respectively. These nitrate concentrations in most of the water samples were well above the allowable limit of 50 mg/L [5]. Therefore, the water samples are polluted with respect to nitrate. The source of high nitrate in Jabi Lake water may be attributed to runoff water which contain fertilizers and manure from agricultural land, industrial effluents, sewage and wastewater [7]. It could also be as a result of nitrification process that takes place in soil and water in Jabi Lake [22, 23]. Ammonium ion may have been progressively oxidized by microorganisms first to nitrite and then to nitrate.

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Table 2: Physicochemical Properties of water Sample from Jabi Lake

Parameter	pH	Conductivity (µs/cm)	Salinity (psu)	TDS (mg/L)	Turbidity (NTU)	DO (%)	BOD (mg/L)	Cl^-(mg/L)	SO_4^{2-} mg/L	NO_3^- mg/L	N mg/L	PO_4^{3-} mg/L
S1	7.52±0.11	187.1± 1.07	0.10±0.01	95.50±0.11	10.90±0.60	22.00±0.51	1.00±0.00	59.55±1.50	10.20±0.12	115.1±6.70	26.00±0.51	10.83±0.01
S2	7.23±0.50	185.01± 0.82	0.09±0.00	92.30±0.80	9.91±0.10	20.98± 0.01	1.00±0.01	57.25±1.01	11.00±0.21	110.10±3.20	25.00±0.20	9.88±0.23
S3	7.52±0.20	176.60± 0.50	0.09±0.01	86.60±3.45	4.89±0.50	23.00±0.20	2.00±0.01	39.70±0.30	5.00±0.01	264.40±1.35	59.20±0.65	10.93±0.55
S4	7.42± 0.10	178.00± 0.11	0.08±0.01	85.10±1.04	3.96±0.20	22.50±0.50	2.00±0.03	40.20±0.70	4.50±0.10	224.10±2.01	60.00±0.98	10.93±0.01
S5	7.46±0.32	179.50±2.01	0.09±0.01	87.93±2.22	2.61±0.01	23.50±0.11	1.00±0.02	39.87±0.11	1.55±0.01	132.81±1.45	30.00±0.41	10.90±0.32
S6	7.49± 0.33	180 .10±0.22	0.09±0.01	88.11±0.22	2.54±0.02	21.80±0.03	1.00±0.01	38.34±0.43	1.40±0.03	121.82±0.98	30.00±0.66	10.90±0.12
S7	7.43±0.10	183.0±1.40	0.07±0.00	89.53±1.01	7.09±0.61	25.10±0.60	2.00±0.02	34.03±0.23	5.10±0.20	134.10±0.89	29.20±0.65	11.20±0.22
S8	7.41± 0.08	180.01±3.11	0.08±0.01	90.31±1.19	6.80±0.05	26.30±0.10	2.00±0.01	35.02±0.03	5.20±0.05	140.10±2.08	28.90±0.01	10.80±0.01
S9	7.32±0.64	178.40±1.55	0.08± 0.01	87.43±1.05	1.36±0.15	27.00± 0.45	1.00±0.01	28.30±1.10	5.30±0.01	130.02±4.05	36.20±0.34	11.12±0.05
S10	7.33±0.04	176.01±0.45	0.08±0.00	88.34±0.85	1.45±0.26	28.00±0.60	1.00±0.01	28.91±0.50	5.10±0.01	131.21±1.52	35.20±0.11	12.10±0.15
S11	7.14±0.01	182.10± 0.63	0.09±0.01	89.07±2.11	1.86±0.07	22.00±0.10	1.00±0.01	28.36±0.22	6.70±0.10	134.80±1.89	30.40±0.31	11.04±0.10
S12	6.98±0.55	181 .09±1.90	0.08±0.01	88.01±1.50	1.81±0.55	22.50±0.38	1.00±0.01	29.16±0.12	6.10±0.05	130.20±0.99	30.40±0.02	10.04±0.24
S13	6.95±0.21	178.60± 0.98	0.08±0.00	87.47±1.07	3.11±0.18	21.00±0.06	2.00±0.02	28.40±0.11	0.32±0.01	133.20±5.02	32.00±0.98	11.11±0.02
S14	6.76± 0.28	177.03±0.38	0.07±0.01	86.70±2.01	2.94±0.11	21.80±0.28	2.00±0.10	24.01±0.01	0.36±0.01	131.40±0.64	33.10±0.31	09.91±0.06
S15	6.62±0.50	177.50±2.50	0.12± 0.01	86.87±0.51	3.62±0.06	23.00±0.90	1.00±0.01	22.69±0.65	4.31±0.20	32.70±0.31	7.40±0.01	11.19±0.01
S16	6.72±0.10	159.10± 1.01	0.08± 0.01	85.79±0.92	3.42±0.01	22.80±0.11	1.00±0.01	20.37±0.35	4.83±0.18	53.10±0.62	6.40±0.01	11.62±0.10
WHO standards	6.5-8.5	1000		500	5.0	5.0		250	250-500	50		100

** Mean of three ± Standard Deviation

The concentration of phosphate ion ranged from 9.88 ± 0.23 to 12.10 ± 0.15 mg/L. The availability of phosphate ions in water could enhance the amount of nutrients and thus increase the whole population of microscopic organisms and microscopic plant in any water body. The trace metal concentrations in the water sample are presented in Table 3. Zinc concentration ranged from 0.054 ± 0.01 to 0.694 ± 0.41 mg/L while manganese had concentrations which ranged from 0.186 ± 0.02 to 0.340 ± 0.05 mg/L. The concentrations of Zn were within recommended permissible limit of 5.0 mg/L whereas manganese concentration exceeded the WHO recommended limit of 0.05 mg/L, indicating that the water samples were polluted with respect to manganese. The biological role of zinc in both human and plant cannot be over highlighted, nevertheless zinc is an essential trace element for human and micro-organisms [24]. Zinc has been established to be present in all enzyme classes and play the role of structural ions in transcription factors. Zinc is very vital in prostate gland function, reproductive organ and consequently semen is rich in zinc [24].

Table 3: Trace metal concentration in Water Sample

Parameter	Zn (mg/L)	Mn (mg/L)	Fe (mg/L)	Co (mg/L)	Pb (mg/L)	Cr (mg/L)
S1	0.299±0.50	0.278±0.05	1.218±0.10	0.104±0.06	5.310±0.30	0.125±0.04
S2	0. 293±0.01	0.296± 0.08	1.205±0.06	0.120±0.01	5.320±0.10	0.142±0.03
S3	0.106±0.03	0.198± 0.01	1.123±0.02	0.005±0.00	5.999±0.70	0.204±0.08
S4	0.112±0.01	0.186±0.02	1.140±0.07	0.004±0.00	7.786±0.22	0.221±0.05
S5	0.694±0.41	0.241± 0.10	1.274±0.10	0.001±0.00	6.807±0.11	0.204±0.23
S6	0.620±0.01	0.248± 0.07	1.292±0.03	0.003±0.00	6.721±0.09	0.211±0.01
S7	0.084±0.01	0.232±0.04	1.654±0.22	0.379±0.01	4.872±0.08	0.307±0.07
S8	0.080±0.02	0.205± 0.02	1.616±0.02	0.201±0.02	4.565±0.05	0.312±0.02
S9	0.089±0.01	0.257± 0.02	1.739±0.01	0.225±0.03	4.491±1.00	0.412±0.12
S10	0.078±0,02	0.276±0.03	1.781±0.88	0.231±0.08	4.473±0.61	0.401±0.09
S11	0.057±0.01	0.324±0.01	1.864±0.11	0.193±0.05	3.803±0.53	0.160±0.01
S12	0.066±0.01	0.340± 0.05	1.870±0.09	0.201±0.10	3.612±0.11	0.171±0.06
S13	0.067±0.02	0.285±0.03	1.894±0.32	0.463± 0.12	2.936±0.21	0.597±0.16
S14	0.054±0.01	0.292±0.10	1.816±0.15	0.472±0.15	2.892±0.20	0.532±0.13
S15	0.077±0.02	0.208± 0.01	1.819±0.33	0.208±0.07	2.507±0.04	0.561±0.16
S16	0.065±0.01	0.214±0.02	1.825±0.06	0.210±0.04	2.611±0.28	0.534±0.11
Control	0.021±0.01	0.056±0.01	0.514±0.02	0.001±0.00	0.307±0.01	0.011±0.01
WHO Permissible standards	5.0	0.05	0.30		0.01	0.004

**** Mean of three ± Standard Deviation**

It act together with organ ligands and facilitates the metabolism of RNA- DNA signal transduction and gene expression in human [25]. Deficiency of zinc can be linked with diabetics, malignancy, malabsorption, acrodermatitis, enteropathica, chronic liver disease, chronic renal disease and sickle cell disease. Disproportionate absorption of zinc can suppress copper and iron absorption and often harmful.

Iron recorded minimum and maximum concentrations of 1.123 ± 0.02 to 1.894 ± 0.32 mg/L respectively, which were well above the maximum permissible limit of 0.30 mg/L. The concentration range of iron above recommended values shows that the water samples were polluted with respect to iron. The concentration of cobalt ranged from 0.001 ± 0.00 to 0.472 ± 0.15 mg/L but lead concentrations ranged from 2.507 ± 0.04 mg/L to 7.786 ± 0.22 mg/L. The ranged of concentrations of Pb surpassed the WHO maximum recommended concentration limit of 0.01 mg/L [5], indicating pollution of water by lead. Lead occurs naturally in the environment, however, lead salts enter the environment mainly through combustion of fossil fuels, automobile exhausts and generator sets. Greater proportion of lead particles drop on the ground and contaminate soils and surface waters. Lead is a non-essential element which finds its route into human body through uptake of food, water and air [26, 27]. At higher concentrations, lead can cause the disruption of synthesis of haemoglobin, increase blood pressure, impaired kidney function, miscarriages and subtle abortions, disruption of nervous systems, brain damage, low sperm count and infertility, reduced learning abilities in children and behavioural disruptions of children [26-28].

Chromium recorded concentrations which varied-from 0.125 ± 0.04 to 0.597 ± 0.16 mg/L. These range of chromium concentrations appeared to be far above maximum recommended limit of 0.004 mg/L in surface water. The Jabi lake is therefore, polluted with respect to Chromium. Chromium occurring naturally in rocks, animals, plants, soil, volcanic dust and gases. Considerably higher concentrations of chromium are a consequence of human activities, especially pollution from mining, industrial activities, sewage discharges and solid waste incineration [29]. The pollution index of the trace metal elements were computed in order to ascertain the degree of pollution. This was done by taking the ratio of the concentration of individual parameter evaluated to that of recommended standard, or reference sample in situation where recommended standard does not exists as in cobalt. The values of the pollution index are represented in Table 4.

Table 4: Pollution index of Trace metal elements in Water Sample

arameter	Zn (mg/L)	Mn (mg/L)	Fe (mg/L)	Co (mg/L)	Pb (mg/L)	Cr (mg/L)
S1	0.060	5.560	4.062	104.000	531.002	31.250
S2	0.057	5.920	4.017	120.000	532.009	35.512
S3	0.021	3.960	3.743	5.000	599.906	51.090
S4	0.022	3.720	3.832	4.000	778.608	55.251
S5	0.139	4.820	4.247	1.000	680.702	51.000
S6	0.124	4.960	4.307	3.010	672.101	52.753
S7	0.017	4.640	5.513	379.000	487.203	76.752
S8	0.016	4.120	5.387	201.143	456.507	78.121
S9	0.018	5.140	5.797	225.330	449.105	103.001
S10	0.014	5.521	5.937	231.004	447.303	100.254
S11	0.012	6.482	6.213	193.100	380.301	40.233
S12	0.013	6.841	6.233	201.001	361.206	42.751
S13	0.013	5.732	6.313	463.200	293.604	149.250
S14	0.011	5.841	6.053	472.030	289.201	133.433
S15	0.015	4.161	6.063	208.010	250.703	140.252
S16	0.013	4.282	6.083	210.100	261.102	133.501

Although the pollution index of zinc ranged from 0.011 to 0.060 but was less than unity (1.0), signifying that no pollution has occurred. The pollution index of Mn, Fe, Co, Pb, and Cr ranged from 3.72 to 6.84, 3.74 to 6.31, 1.00 to 472.03, 250.70 to 778.60 and 31.25 to 149.25 respectively. Besides, the pollution index of manganese, iron, cobalt, lead and chromium were far above unity (1.0), indicating very high level of pollution. This implies that the water from Lake Jabi is not suitable for drinking, considering the very high levels of these trace elements in water samples.

Conclusion

The physicochemical parameters were within the maximum permissible limits apart from nitrate that had higher values. Besides, the concentrations of manganese, iron, cobalt, lead and chromium were well above the maximum permissible limits for portable drinking water, indicating that Jabi Lake water was not suitable for consumption in its present state, though may support irrigation, aquatic lives and other domestic activities. The outcomes of this research will help our relevant agencies on the need to enact policies that will be effective in protecting our water bodies and also to design an affordable treatment measures which shall ultimately be useful in enhancing the quality of the water.

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