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Composition and Dynamics of Some Nutrient and Physic-Chemical Parameter in Lower Course of Gwagwalada River in Federal Capital Territory, Abuja, Nigeria

R. O. Ojutiku[1*], R. J. Kolo[1] and C. A. Mbanaso[1]

[1]Department of Water Resources, Aquaculture and Fisheries Technology, School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author CAM designed the study, performed the statistical analysis. Authors RJK and ROO wrote the first draft of the manuscript, managed the analyses of the study. Author ROO managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims: Jabi dam, Lower Usuma dam and Gwagwalada river in the Federal Capital Territory were studied for a period of twelve months (January 2007–December 2007) to determine their nutrient composition and dynamics.
Methodology: Samples were collected from these water bodies on monthly basis. The concentration of some nutrient parameters such as Phosphate-phosphorus (PO_4-P), Nitrate-Nitrogen (NO_4-N), Total Dissolved Solids (TDS), Calcium (Ca), Potassium (K) and Sodium (Na) were assessed. The results obtained were statistically analysed to show any relationship amongst them.
Results: The mean values for NO_4-N, Ca and K were not significantly different ($P>0.05$) between the three water bodies. While the mean value for PO_4-P were significantly different ($P<0.05$), with Jabi dam having the highest mean value of 11.61mg/l, followed by Gwagwalada river, 9.96mg/l and Lower Usuma dam had least mean value of 2.46mg/l. Jabi dam, Lower Usuma dam and Gwagwalada river had mean TDS of 95.0mg/l, 88.5mg/l and 104.5mg/l respectively, Gwagwalada river being significantly different ($P<0.05$) from Jabi and Lower Usuma dams. Similarly, Jabi dam, Lower Usuma dam and

**Corresponding author: Email: rasheedojutiku@yahoo.com;*

Gwagwalada river had mean Sodium values of 2.42mg/l, 2.85mg/l and 3.73mg/l respectively, Gwagwalada river being also significantly different ($P<0.05$) from Jabi and Lower Usuma dams. PO_4-P and NO_4-N showed no significant ($P>0.05$) monthly variations in the three water bodies. However, TDS, Ca, K, and Na showed significant ($P<0.05$) difference in monthly variations in the three water bodies. TDS, Ca, K, and Na had all their wet season mean values higher than their dry season mean values in all the three water bodies studied, while PO_4-P and NO_4-N had their wet season mean values lower than the dry season mean values in the three water bodies.
Conclusion: The study revealed that the nutrient parameters measured were slightly lower than the World Health Organization (WHO) recommended values for aquatic life.

Keywords: Jabi dam; lower usuma dam; gwagwalada river; nutrients levels and variations.

1. INTRODUCTION

The trends of the study of water resources in the time past has been tailored towards the engineering aspects (e.g. generation of electricity and irrigation purposes), and also its specific need i.e. providing potable drinking water for man. However, only little work has been done in the ecological aspect of these water bodies. This neglect has generated threats to the organisms in such water body and a potential public health hazard to the user of such water resources and its ecosystem. Water is fundamental to life. It is capable of dissolving many substances including nutrients more than any other known solvent; hence it is called the universal solvent.

Increase in the rate of industrialization and consequently urbanization always exacerbates its effect on the environment [1-3]. It is a known fact that inadequate sanitary facilities in most rural and urban settlements have turned many surface waters into open sewers, thus most urban rivers and streams are dumping grounds for human wastes as found in Rivers Kaduna, Niger, Ogunpa, Ogun and Chanchaga [4].

Nutrients such as phosphorus and nitrogen are essential for the growth of algae and other plants. Aquatic life is dependent upon these photo synthesizers, which usually occur in shallow surface water [5]. Excessive concentration of nutrients however can over-stimulate aquatic plants and algae growth thus affecting water quality and primary productivity potentials [6,7]. Over availability of nutrients in a stagnant environment can lead to consequent effect of eutrophication and its attendant consequences [8,9].

Nutrient balances which consider the inputs and outputs from the system have been used to estimate the magnitude and extent of nutrient mining. Inputs are fertilizers, organic residues, manures, nitrogen fixation and sediments while outputs are through uptake, export, erosion, leaching and volatilization [5].

Abuja as a growing city and also being the Federal Capital Territory of Nigeria with its growing population and increased demand of water as a resource and its other potentials, calls for study and research work that will help guide and give a benchmark data on the primary productivity potentials of some of the water bodies in Abuja, thus the objective of this research is to assess the nutrient composition and dynamics of Jabi dam, Lower Usuma dam and Gwagwalada river all within the Federal Capital Territory of Nigeria.

The water nutrient and physico-chemical parameters assessed in this study include Nitrate-Nitrogen, Phosphate-Phosphorus, Total dissolved solids, Calcium, Potassium and Sodium.

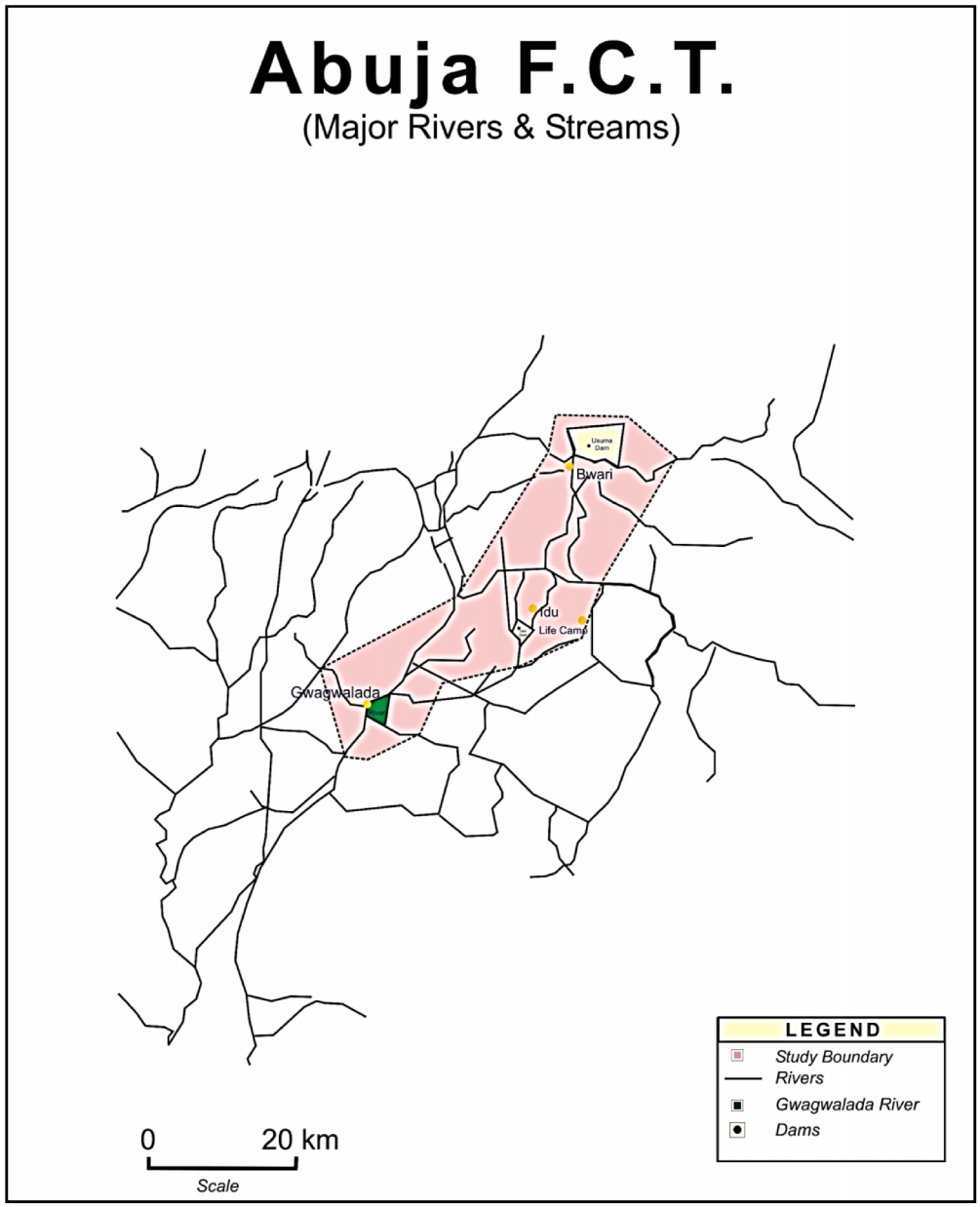

Fig. 1. Map of the study area showing sampling Stations

2. MATERIALS AND METHODS

2.1 The Study Area

The Nigerian Federal Capital Territory (FCT) was established by decree No. 6 of 1976 under the Federal Capital Development Authority (FCDA). Abuja itself has been said to be the fastest growing city in Africa. Growth in this sense encompasses both the tangible and intangible developmental activities, including huge construction activities, as well as other economic activities.

The detailed plan of the research involved monthly sampling for water nutrient parameters at Jabi dam, Lower Usuma dam and Gwagwalada River, The sampling period spanned between January 2007 and December 2007. The sampling stations are shown in (Fig 1).

Station 1 is the Jabi dam reservoir which used to supply treated water to Jabi village and it's environ but now use as a recreational center. Fishing activities and inhabitants around the area use the water boundaries to wash clothes and some other utensils.
Station 2 is the Lower Usuma dam reservoir which is 24 kilometers to the Central area of Abuja and supply treated water to the whole of FCT.
Station 3 is the Gwagwalada River at the mini water treatment plant constructed at Gwagwalada River. The sampling site is near the Gwagwalada township bridge. Vehicles passing over this bridge most at times disposed off remnants into the river and communities living around this place dispose remnants from the house and wash their cloths in this river.

2.2 Determination of Nutrient Elements

Calcium (Ca) was determined by Atomic Absorption Spectrometer (AAS) using a computer controlled SOLAAR 969 Atomic Absorption Spectrometer using nitrous oxide-acetylene flame. The potassium and sodium levels were determined by flame photometer. Phosphate-Phosphorus was determined using the Ascorbic acid method, Nitrate-Nitrogen was determined using the phenoldisulphuric acid and Total dissolved solids all as described in standard methods [10].

3. RESULTS

The results of the concentration of nutrients and cations measured at Jabi dam, Lower Usuma dam and Gwagwalada river and their monthly variations are shown in (Tables 1-3) and (Figs. 1– 6) respectively.

The monthly variations of phosphate-phosphorus for the three water bodies showed sharp contrasts and fluctuations (Fig. 2) and differed significantly ($P<0.05$) and Jabi dam had the highest mean value of 16.38mg/l followed by Gwagwalada river 9.96mg/l and Lower Usuma dam 2.46mg/l (Table 1). In the seasonal variations, the dry season mean values were higher than the wet season mean values (Table 3).

The monthly variations of nitrate-nitrogen concentration in the different water bodies showed wide fluctuations (Fig. 3) but there was no significant difference ($P>0.05$) in nitrate concentrations in the three water bodies, however, Lower Usuma dam had the highest mean value of 4.30mg/l, while Jabi dam had the least mean value of 3.25mg/l (Table 1). The

seasonal variations showed no sharp distinction and no significant difference (P>0.05) between the wet and dry seasons (Table 3).

Gwagwalada river had the highest total dissolved solids mean value of 104.5mg/l followed by Jabi dam, which had a value of 95.0mg/l, while Lower Usuma dam recorded the least mean value of 88.5mg/l (Table 1). There were significant differences (P<0.05) (Table 2) in the monthly variations of total dissolved solids (Fig. 4).

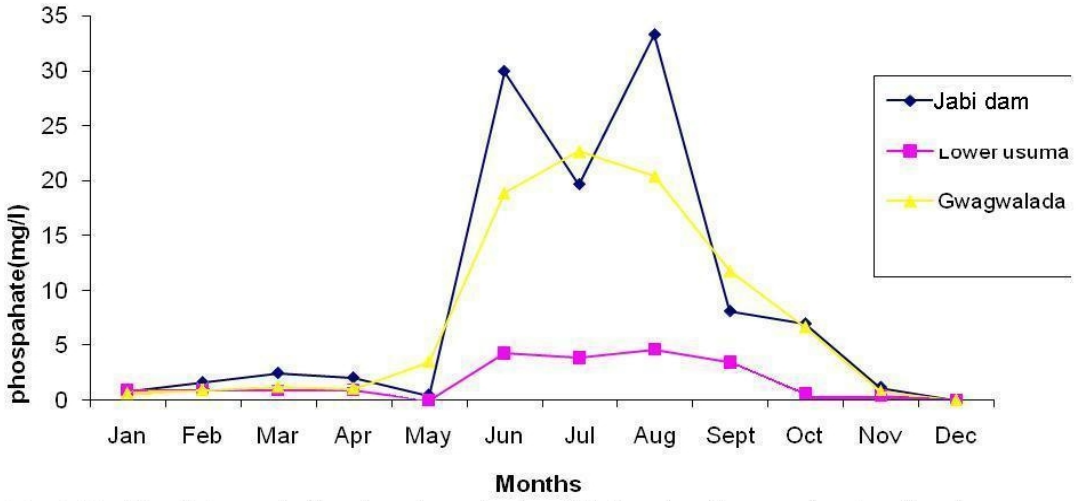

Fig. 2. Monthly variations in phosphate of 3 contrasting water bodies in Abuja

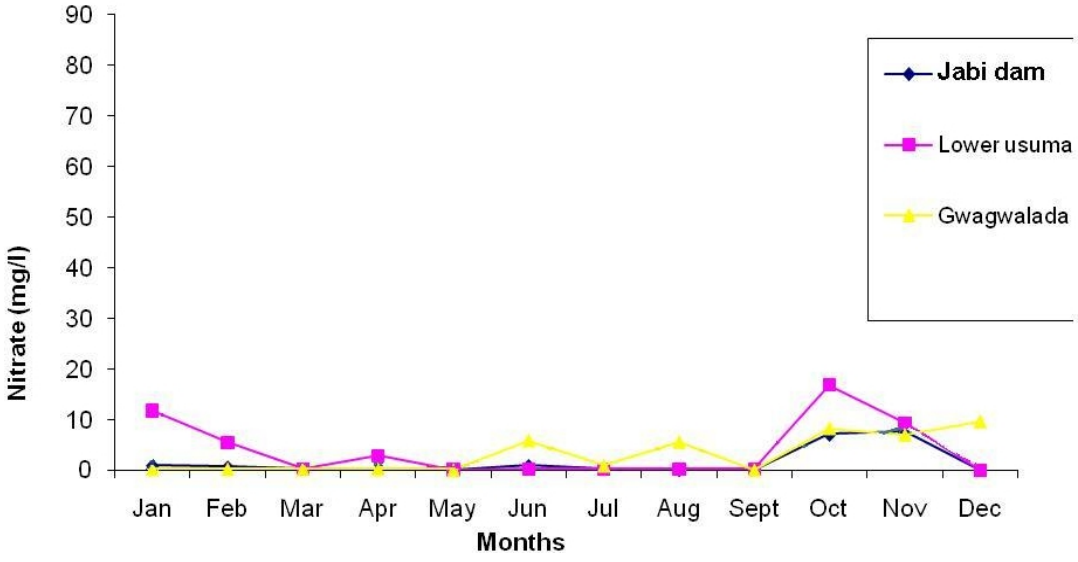

Fig. 3. Monthly variations in nitrate of 3 contrasting water bodies in Abuja

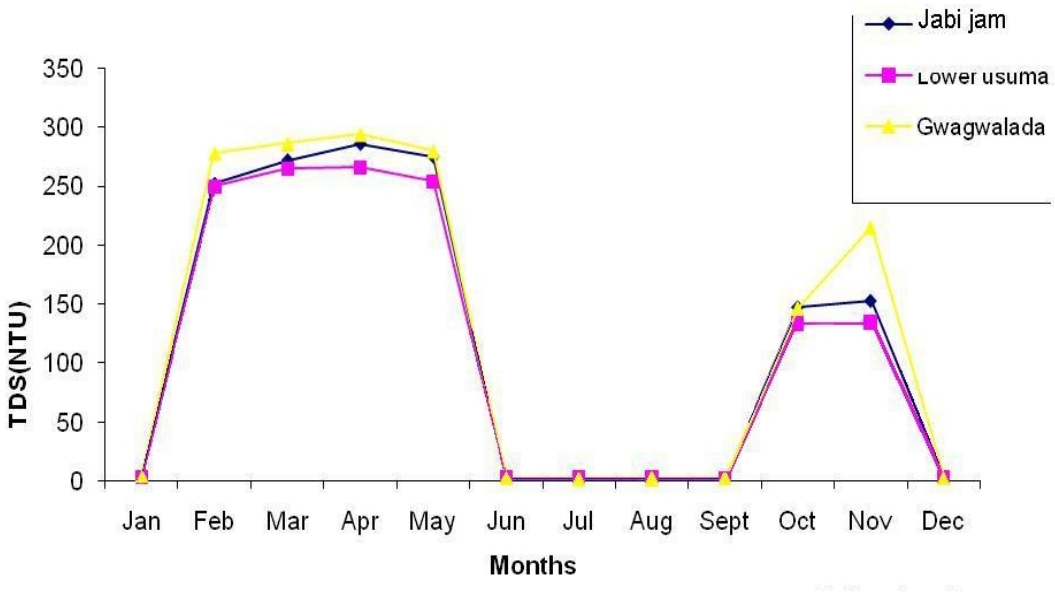

Fig. 4. Monthly variations in total dissolved solid of 3 contrasting water bodies in Abuja

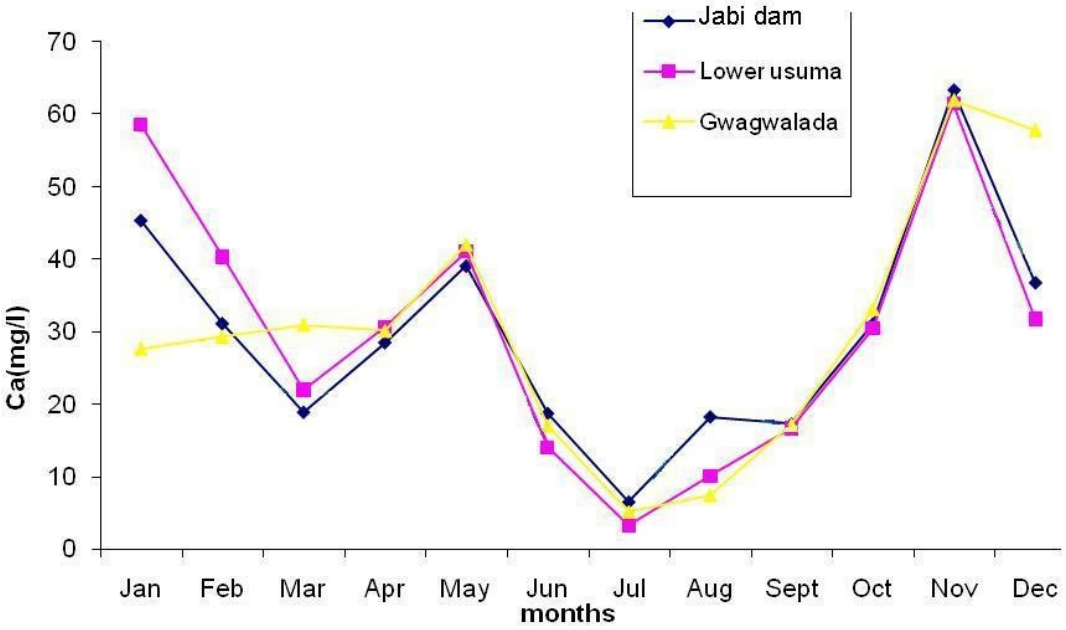

Fig. 5. Monthly variations in calcium of 3 contrasting water bodies in Abuja

Table 1. Mean concentrations of some nutrient elements and cations measured at Jabi dam, Lower Usuma dam and Gwagwalada river in FCT, Abuja

Parameters	Jabi dam	Usuma dam	Gwagwalada river	SE
Phosphate(mg/l)	11.61^{c} ±19.73	2.46^{ab}±3.21	9.96^{b}±13.31	2.27
Nitrate(mg/l)	3.25^{a}± 6.59	4.30^{a} ±6.72	3.99^{a}±4.23	0.44
TDS(mg/l)	95.0^{a}±135.1	88.5^{a}±125.5	104.5^{ab}±152.2	3.31
Calcium(mg/L)	28.39^{a}±26.15	27.48^{a}±27.25	27.86^{a}±27.60	4.53
Potassium(mg/L)	3.64^{a}±1.78	4.19^{a} ±3.10	4.64^{a}±2.46	0.37
Sodium(mg/L)	2.42^{a}±0.84	2.85^{a} ±1.12	3.725^{ab}±1.52	0.20

Mean values on the same row carrying the same superscript are not significantly different at P>0.05

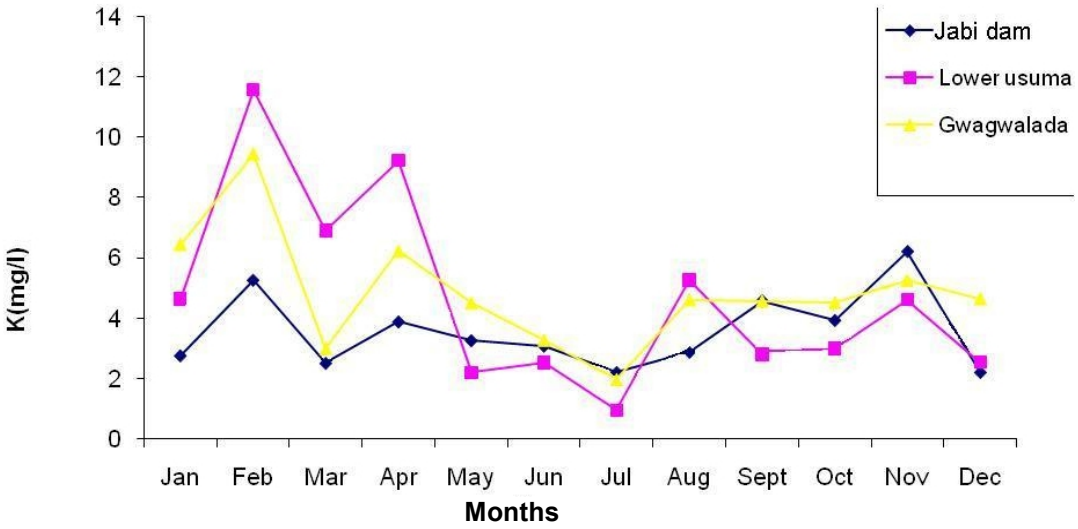

Fig. 6. Monthly variations in potassium of 3 contrasting water bodies in Abuja

Jabi dam had highest calcium mean value of 28.39mg/l, while Gwagwalada river and Lower Usuma dam had 27.86mg/l and 27.48mg/l respectively (Table 1). There were monthly variations (Fig. 5), which were significant at (P<0.05) (Table 2).

The monthly mean concentration of potassium in the three water bodies shows fluctuations. The lowest concentration of potassium was obtained in lower Usuma dam in June and July (Fig. 6). There were no significant variations (P>0.05) in the potassium concentrations in the three water bodies, though Gwagwalada river had the highest potassium mean value of 4.64mg/l while Jabi dam had the least mean value of 3.64mg/l (Table 1).

The monthly variations of sodium concentration showed that the three water bodies had the lowest values in July (Fig. 7). Gwagwalada River showed the highest mean value (3.73mg/l) which was significantly different (P<0.05) from Jabi and Lower usuma dams which had 2.42mg/l and 2.85mg/l respectively (Table 1).

In all the three water bodies studied, TDS, Ca, K, and Na had their wet season mean values higher than the dry season mean values (Table 3). Most of the parameters measured fell below WHO recommended standard for aquatic life (Table 4).

Table 2. Monthly concentrations (mg/l) in the nutrient elements and cations in Jabi dam, Lower Usuma dam and Gwagwalada river in FCT, Abuja

Parameter	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
PO_4-P(mg/l)	0.73^{a}±0.15	1.10^{a}±0.35	1.53^{a}±0.66	1.33^{a}±0.49	1.98^{a}±2.15	12.76^{a}±19.31	12.29^{a}±14.40	14.99^{a}±23.86	6.63^{a}±7.49	3.55^{a}±4.16	1.92^{a}±3.39	1.92^{a}±3.35
NO_4-N(mg/l)	3.52^{a}±5.43	1.74^{a}±2.44	0.21^{a}±0.07	0.97^{a}±1.19	0.33^{a}±0.31	3.14^{a}±3.95	2.07^{a}±3.34	3.41^{a}±3.43	3.02^{a}±4.83	7.94^{a}±7.7	8.08^{a}±7.46	5.27^{a}±6.0
TDS(mg/l)	3.15^{a}±0.72	256.00^{bc}±15.06	270.00^{c}±12.30	275.00^{c}±18.29	261.50^{bc}±19.84	1.78^{a}±1.07	1.86^{a}±0.97	1.81^{a}±1.05	1.85^{a}±1.01	141.05^{b}±148.06	159.56^{bc}±174.66	2.85^{a}±0.65
Ca	42.69^{a}±12.83	31.44^{ab}±6.37	23.18^{ab}±5.34	28.06^{ab}±3.47	39.61^{ab}±2.49	16.08^{ab}±15.69	4.55^{b}±2.64	14.26^{bc}±9.27	16.77^{b}±6.92	30.26^{b}±5.03	59.9^{c}±59.28	41.31^{bc}±11.41
K	4.30^{a}±1.63	7.85^{b}±3.17	3.80^{a}±2.07	5.93^{ab}±2.41	3.41^{ab}±0.95	3.23^{ab}±1.52	1.76^{a}±0.52	4.09^{ab}±2.94	3.71^{ab}±2.42	3.59^{ab}±2.09	5.11^{ab}±1.08	3.00^{ab}±1.11
Na	5.01^{a}±1.34	3.65^{ab}±0.8	3.07^{ab}±0.97	3.35^{ab}±0.84	4.21^{ab}±1.02	2.41^{b}±0.95	1.68^{b}±0.50	2.89^{b}±1.61	3.10^{b}±1.62	2.76^{b}±1.40	2.88^{ab}±0.81	4.16^{ab}±1.31

Data on the same row carrying the same superscript are not significantly different at P>0.05

Table 3. Seasonal mean values of nutrient elements and cations measured at Jabi dam, Lower Usuma dam and Gwagwalada river in FCT, Abuja

Parameter	Seasons	Jabi dam	Usuma dam	Gwagwaladariver
PO_4-P(mg/l)	Wet	1.33	0.68	0.76
	Dry	16.38	2.79	13.95
NO_4-N(mg/l)	Wet	1.63	4.85	2.86
	Dry	1.33	8.43	3.37
TDS(mg/l)	Wet	161.52	153.43	180.12
	Dry	71.52	65.95	72.11
Ca(mg/l)	Wet	37.26	40.74	39.62
	Dry	22.06	19.19	20.30
K(mg/l)	Wet	3.79	6.58	5.83
	Dry	3.31	2.79	3.9
Na(mg/l)	Wet	2.65	3.37	4.35
	Dry	2.30	2.64	3.52

Table 4. Comparison of WHO recommended nutrient content and cations for aquatic life and research findings

Parameter	WHO recommended value (mg/l)	Research findings
Phosphate-phosphorus (mg/l)	-	2.11–11.61
Nitrate-nitrogen (mg/l)	-	0.97–8.08
Total dissolved solids (TDS)	-	86.3–104.3
Calcium	1000	29.7–34.00
Potassium	10	3.5–5.8
Sodium	10	1.00–0.01

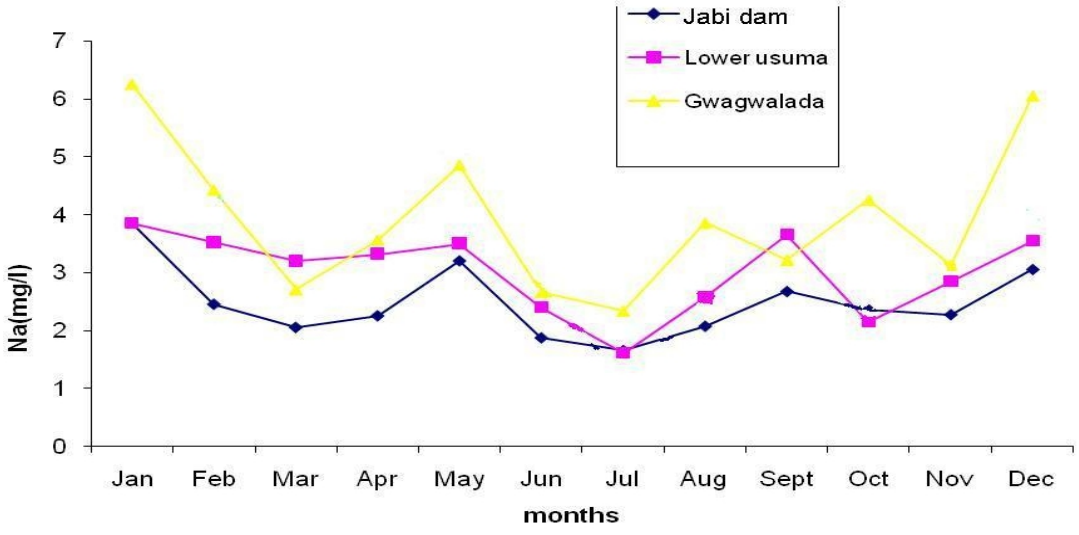

Fig. 7. Monthly variations in sodium of 3 contrasting water bodies in Abuja

4. DISCUSSION

The higher dry season mean values of phosphate in all the water bodies studied is similar to the observed phenomenon by [11] in some rivers in Cross-river State of Eastern Nigeria, where he observed higher dry season mean of phosphate [4]. Also observed same in Chanchaga River. The higher dry season mean values observed in all the stations could be attributed to concentration effect as a result of reduced water volume; while the low wet season mean values recorded in all the stations could be due to run-off from the farmlands during the wet season into the dams which has dilution effect and also could be due to co-precipitation of dissolved phosphate with carbonates ($CaCO_3$) a phenomena which sometimes occurs in lakes [12]. The higher mean phosphate value in Jabi dam and Gwagwalada river than Lower Usuma dam might be due to the latter shallow and lentic nature coupled with dry season irrigation farming activities [13]. Also observed farming activities to contribute to phosphate value in Kubani dam. The phosphate levels recorded ranged from 2.11mg/l–11.61.00mg/l. This is within the tolerable limit of 50mg/l recommended by [14].

The run-off discharges of fertilizer application to farm lands which washes into the water bodies may be responsible for the high concentration of nitrate in soil and water. The higher dry season mean value observed in the water bodies could be due to concentration effect during the dry season as a result of reduced water volume. There were no significant difference ($P>0.05$) between the nitrate values in the three water bodies studied. The higher nitrate mean value in Lower Usuma dam suggests autocthonous origin as a result of mineralization and also might be due to large catchment area. The range value of 0.2mg/l to 13mg/l observed during the study period is relatively low compared 24.46mg/l to 56.60mg/l recorded by [15] in Dan-Zaria dam. This might be because of the shallow nature of Dan-Zaria dam coupled with farming activities around the dam and constant visitation of the dam by cattle for the purpose of drinking which in the process defecates and urinates into the water.

Higher total dissolved solids observed in Gwagwalada river could be due to erosion of sand particles as a result of swift water movement which characterizes lotic water bodies and human activities. The relatively high level at Jabi dam might be due to construction activities that encourages movement of dissolved solids in to the dam during raining season as a result of run offs. Similarly, the higher wet season mean values in all the water bodies obviously could be as a result of run off prevalent at that season which bring into the water bodies allochtonous materials. Contrary to [13], the lower wet season mean value observed in man-made lake was attributed probably to dilution effect.

The range of 29.7-34.0mg/l of Calcium mean value recorded in all the stations fall far below the recommended value of 1000mg/l for drinking water for the livestock [14]. However the above range is higher than the range of 2.2 to 18.3mg/l recorded by [4] in River Chanchaga and Minna portable water. The higher wet season mean value observed in all the water bodies could be as a result of rains and flood water influx.

The potassium range of 3.5-5.8mg/l compares well with the range recorded in River Chanchaga and Minna portable water by [4]. The relatively higher value of potassium recorded in Gwagwalada river though not significantly different ($P>0.05$) from other water bodies could be due to its lotic nature. Gwagwalada River could be as a result of peasant and dry season farming with their application of potassium based fertilizers.

The none significant difference (P>0.05) of sodium in Jabi dam and Lower Usuma dam could be because of their lacustrine nature while the higher mean value recorded in Gwagwalada river might be due to washing activities around the river with sodium based detergent.

5. CONCLUSION

[It was found that the parameters measured fell below the recommended standard for drinking and culturing of fish and the water bodies are therefore recommended for intensive fish production to improve the fish production capacity of the country.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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