IJABR Vol. 12(2): 76 - 87 (2021)

Original article

SEASONAL VARIATION OF SOME PHYSICO-CHEMICAL CHARACTERISTICS OF SHIRORO LAKE, NIGER STATE, NIGERIA.

[1]Yusufu, F.O., [1]Kolo, R. J., [1]Ojutiku, R.O and [1]Ibrahim, S.U

[1]Department of Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology, Minna, Niger State, Nigeria.

Submitted: August, 2021; Accepted: October, 2021; Published: December, 2021

ABSTRACT

The main purpose of this study was to assess seasonal variation of some physicochemical parameters of Shiroro lake water. Physicochemical parameters influence the abundance of species composition, diversity, stability, production and physiological condition of indigenous population, hence its usefulness in accessing water quality. Water samples were taken monthly for twenty-four (24) months from five (5) stations in the lake, stations selected based on the entry points of effluent. There were variations in the mean values of physico-chemical parameters observed,(air temperature, water temperature, biological oxygen demand, alkalinity, electrical conductivity ,pH and carbon (iv) oxide) were not significantly different (P>0.05) between the stations while significant difference (P<0.05) were noticed between stations for dissolved oxygen, hardness , transparency ,phosphate and nitrate .Seasonal variations in mean values of all the physico-chemical parameters were significantly different except that of water temperature. Dry season mean values of air temperature, water temperature, dissolved oxygen, biological oxygen demand, electrical conductivity, hardness, transparency and phosphate were higher than rainy season mean values while nitrate, pH, alkalinity and carbon (iv) oxide had their mean values higher in the rainy season. There were no significant difference (P>0.05) between some physico-chemical parameters mean values recorded in year 1 and year 2 of the study for phosphate, air temperature, transparency and nitrate, while significant difference (P<0.05) was observed between year 1 and year 2 for electrical conductivity, alkalinity, hardness ,chloride, dissolved oxygen, biological oxygen demand ,water temperature and carbon(iv)oxide. All the physico-chemical parameters studied were within World Health Organization (WHO) range set standard for optimal fish production and survival except for electrical conductivity and carbon (iv) oxide that were slightly below the set limits. The water is productive and not heavily polluted yet. The implication is that water from Shiroro Lake can support the survival, growth and development of various fish species. However, it is recommended that the Lake resource should be monitored and effective management strategies put in place by responsible authorities to ensure sustainable development.

Key words: Physicochemical parameters, seasonal, variation, Shiroro Lake. Early dry season (EDS),

*corresponding author's address: fridale2003@yahoo.com, +2348052797077

INTRODUCTION

The total surface area of water body in Nigeria is estimated to be about 14,991,900 hectares (149,919 km2) and this constitutes about 15.9 % of the total area of Nigeria[1].These include both natural and manmade lakes/reservoirs, flood plains and cattle ponds, rivers and streams [2]. Water plays an important role in human existence. Water is the most naturally occurring mineral compound known to man. It is essential for life on earth and occupies a very important place in science, philosophy and even in religion [3].Water is an essential component of all living organisms .In addition to its being needed for all aspects of human life, it is needed in agricultural production, thus its importance and essential nature to these organisms is threatened if its quality is not maintained optimally. The importance of water as a resource is not limited to its availability and quantity, but also to its quality. It is quality that determines and supports its biological usefulness. Aquatic environments are being polluted due to increasing natural and anthropogenic activities [4].

In Nigeria as well as other parts of the world, due to rapid urbanization, industrialization and high population pressure, we now experience increased domestic and waste disposal into nearby water courses as well as pollution from agricultural activities, hence aquatic environments are being polluted with heavy metals [5]. The communal activities of man as a social being have created a new order of by-products which have increased in volume at a faster rate than population. However, excessive contamination is that which interferes with the water quality, health and the population of an ecosystem. Water pollution is the contamination of water bodies such as lakes, oceans, aquifers and groundwater [6]. Environmental contamination is an inevitable consequence of the activities of man and a natural phenomenon as well. The importance of baseline data of any natural or man-made lake like Shiroro that is economically viable especially now when all attention (both Government and individuals) is focused on economic diversification cannot be over emphasized, this brings about the need for a study that will help generate data, compare and review with previous similar work (assessing changes caused by nature and man over time) for effective management of the Lake resource.

Shiroro Lake was primarily dammed for hydro-electric power generation, but with secondary objectives in Fisheries and Agriculture. Recently, anthropogenic activities near the lake for economic development have intensified continually and rapidly. This study therefore examined the seasonal variation in some physicochemical characteristics of water from Shiroro Lake, Niger State, Nigeria.

MATERIALS AND METHODS

Study Area

Shiroro Lake is a man-made hydro-electric power generation dam constructed on River Kaduna in Shiroro Gorge in Niger State. It is located on latitude 9°57′N Longitude 6°13′E.

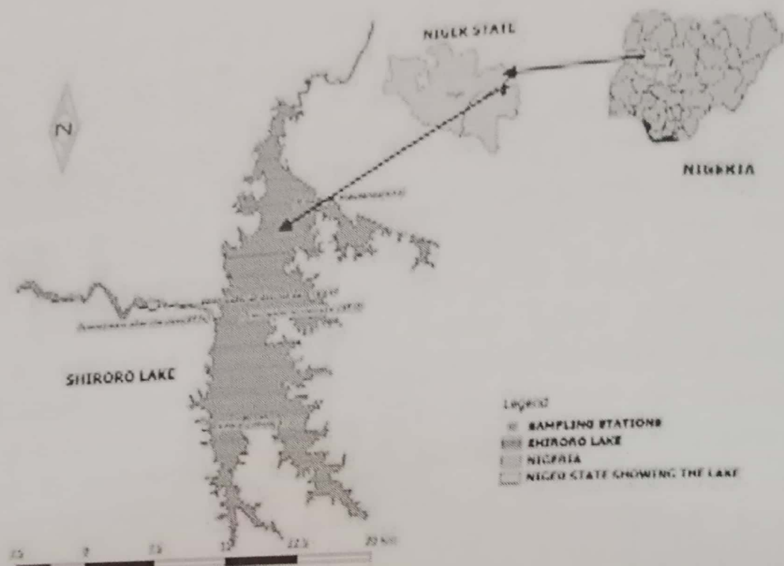

FIGURE 1: Map of the study area showing the sampling Stations of Shiroro Lake, Niger State

Sampling stations and water sampling

Water samples were collected from five (I, II, III, IV and V) stations. The choice of sampling stations was based on the entry points of the tributaries into the Lake. Station I is on River Kaduna entry point (tributary), station II, on open water at the dam site, station III on point near the Zumba market (Kwata Zumba) where market activities take place, station IV on downstream (immediately after the dam) and station V, open water of the downstream, Water samples were taken monthly for 24 months, three (3) water samples were taken from each sampling station (October 2018 to September 2020). Niger State Ministry of Livestock and Fisheries surveillance boat was engaged in accessing sampling stations. The surface water and air temperatures were determined by mercury-in-bulb thermometer. Dissolved oxygen was determined both in the field and the laboratory. In the field by the use of jen-way dissolved oxygen meter. The pH was determined in the field using a portable pH meter. The alkalinity, phosphate and nitrate samples were determined following standard methods as described by APHA [7]. The water samples were transported to the Water Resources, Aquaculture and Fisheries Technology Laboratory of the Federal University of Technology, Minna, Niger State.

Data Analysis: One-way statistical analysis of variance (ANOVA) was used to determine the significant difference ($P<0.05$) of physicochemical parameters between the sampling stations and T test was used to compare two seasons at ($P \leq 0.05$) probability using SPSS.

RESULTS

Data on some physicochemical properties of Shiroro Lake water are presented in Table 1-.Some marked variations in the physicochemical parameters were observed between samples, stations, months and seasons.

Water temperature range recorded during the sampling period was between 24.9^{0}C -33.1^{0}C. There was significant difference in water temperatures within the months ($P<0.05$) (Table 1). The lowest water temperature was recorded in January followed by February. The highest water temperature was recorded in November. Figure 2 shows seasonal variation in water temperature, the highest water temperature was recorded between late dry season and early rainy season, while late rainy (wet) and early dry seasons recorded the lowest water temperature. There was no significant difference ($P>0.05$) in water temperature among the seasons (Table 3) The lowest dissolved oxygen concentration recorded was in stations V, 7.61 mg/l and the highest concentration was recorded in station III, 8.65 mg/l. It showed significant difference ($P<0.05$) both in the stations and monthly variations (Table 2, Table 3). Figure 3 shows seasonal variation in dissolved Oxygen. The monthly mean concentration of pH recorded the highest value in the month of June with mean value of 7.66, while the lowest mean value of 7.15 was recorded in October, late rainy (wet) season. There was no significant difference ($P>0.05$) within station (Table 2) and within seasons ($P>0.05$) (Table 3) .The total alkalinity value ranged from 10.8 mg/l to 20.1 mg/l. A minimum mean value of 14.83 mg/l was recorded in station V while a maximum mean value of 15.13 mg/l was recorded in statin II. Result indicated that total alkalinity showed no significant difference ($P>0.05$) between stations (Table 2) but differ significantly ($P<0.05$) between both months as well as between the seasons (Table 1) (Table 3). The month of January (early dry season) recorded the highest mean value of 0.29 mg/l while April (early rainy (wet) season) recorded the lowest mean concentration value , 0.12 mg/l .Phosphate dry season mean concentration was higher than wet season (Figure 6) .There was significant difference ($P<0.05$) observed within the months and sub-seasons (Table 1),(Table 3). Nitrate variation ranged between 0.32 mg/l and 0.53 mg/l. The lowest mean value of 0.32 mg/l was recorded in December while the highest value of 0.53 mg/l was recorded in the month of October (Table 1). There was significant difference ($P<0.05$) between the months and stations (Table 1) (Table 2). Sub-seasonal variations were observed (Table 3) (Figure 4).Mean value on NO_3 was higher in dry seasons compared to the wet season but without significant difference ($P>0.05$).

Table 1: Monthly mean variation of physico-chemical parameters in water sample

Month	Air T°	H_2O T°	Do	pH	TA	PO_4	NO_3
January	25.50^{a}	24.90^{a}	7.81^{ab}	7.30^{a}	15.30^{c}	0.29^{e}	0.40^{bc}
February	28.80^{cd}	25.90^{ab}	7.60^{ab}	7.21^{ab}	14.80^{bc}	0.21^{cd}	0.49^{de}
March	29.90^{def}	27.40^{cd}	8.40^{bc}	7.28^{b}	13.80^{b}	0.22^{d}	0.52^{e}
April	33.60^{h}	29.60^{e}	7.62^{ab}	7.46^{c}	11.40^{a}	0.12^{a}	0.45^{cd}
May	32.10^{g}	29.40^{e}	7.61^{ab}	7.48^{c}	11.40^{a}	0.13^{a}	0.39^{bc}
June	29.70^{de}	28.70^{de}	7.10^{a}	7.66^{d}	20.10^{e}	0.13^{a}	0.34^{ab}
July	27.80^{c}	27.70^{cd}	8.30^{bc}	7.27^{ab}	17.30^{d}	0.13^{a}	0.44^{cd}
August	25.80^{ab}	26.60^{bc}	8.30^{bc}	7.63^{d}	18.30^{d}	0.17^{b}	0.39^{bc}
September	26.70^{b}	27.10^{bc}	7.88^{ab}	7.45^{c}	15.20^{c}	0.19^{bc}	0.44^{cd}
October	30.70^{ef}	29.60^{e}	8.42^{bc}	7.15^{a}	10.80^{a}	0.13^{a}	0.53^{e}
November	30.90^{f}	33.10^{f}	9.60^{d}	7.46^{c}	14.70^{bc}	0.30^{e}	0.40^{bc}
December	27.90^{c}	27.30^{c}	9.02^{cd}	7.51^{c}	15.30^{c}	0.31^{e}	0.32^{a}
±S.E	0.21^{a}	0.20	0.09	0.02	0.23	0.01	0.01
Permissible Limits (WHO, 2008)	25-30	25-30	3.5-6.0	6.5-8.5	20-300		40-50

Mean in the same Column carrying same superscript are not significantly different ($P>0.05$). TA= Total Alkanity, pH= Hydrogen Ion, PO_4= Phosphate, Do= Dissolved oxygen, Air To= Air temperature, H_2O T° =water temperature, NO_3 = Nitrate,

Table 2: Mean variation of physico-chemical parameters in water samples at different stations

Station	H_2O T° °C	Do (mg/l)	pH	TA (mg/l)	PO_4(mg/l)	NO_3 (mg/l)
I	28.71^{b}	8.45^{bc}	7.43^{a}	14.25^{a}	0.19^{a}	0.42^{ab}
II	28.83^{b}	7.97^{ab}	7.40^{a}	15.13^{a}	0.19^{a}	0.38^{a}
III	28.79^{b}	8.65^{c}	7.36^{a}	15.08^{a}	0.21^{a}	0.43^{ab}
IV	27.96^{b}	8.02^{ab}	7.40^{a}	15.04^{a}	0.18^{a}	0.45^{b}
V	26.25^{a}	7.61^{a}	7.42^{a}	14.83^{a}	0.20^{a}	0.45^{b}
±S.E	0.20	0.09	0.02	0.23	0.01	0.01
Permissible Limits (WHO,2008)	25-30	3.5-6.0	6.5-8.5	20-300	-	-

Mean in the same Column carrying same superscript are not significantly different ($P>0.05$). TA= Total Alkanity, pH= Hydrogen ion, PO_4= Phosphate, Do= Dissolved oxygen, Air To= Air temperature, H_2O T° =water temperature, NO_3 = Nitrate,

Table 3: Mean Seasonal variation of physico-chemical parameters in water samples at different stations

Season	Air T°	H_2O T°	Do	pH	TA	po_4	No_3
ERS	29.87^{b}	28.60^{a}	7.67^{a}	7.47^{a}	16.27^{c}	0.13^{a}	0.39^{a}
LRS	27.73^{a}	27.77a	8.20^{b}	7.41^{a}	14.77^{b}	0.16^{b}	0.45b
EDS	28.10^{a}	28.43^{a}	8.81^{c}	7.42^{a}	15.10^{ab}	0.30^{c}	0.37^{a}
LDS	30.77^{b}	27.63^{a}	7.87^{ab}	7.32^{a}	13.33^{a}	0.19^{c}	0.48^{b}
±S.E	0.21	0.20	0.09	0.02	0.23	0.08	0.01
Permissible Limits (WHO,2008)	25-30	25-30	3.5-6.0	6.5-8.5	20-300	-	

Mean in the same Column carrying same superscript are not significantly different ($P>0.05$). TA= Total Alkanity, pH= Hydrogen Ion, PO_4= Phosphate, Do= Dissolved oxygen, Air To= Air temperature, H_2O To =water temperature, NO3 = Nitrate, ERS = early rainy season, LRS = Late rainy season, EDS= early dry season, LDS = Late dry season

Table 4: Yearly mean variation of physico-chemical parameters in water sample

Month	Air T°	H_2O T°	Do	BOD	pH	TA	po_4	No_3
1st Year	29.37^{a}	29.00^{a}	7.92^{a}	4.03^{a}	7.38^{a}	13.58^{a}	0.16^{a}	0.42^{a}
2nd year	28.87^{a}	27.22^{b}	8.36^{b}	3.59^{b}	7.43^{a}	16.15^{b}	0.23^{a}	0.43^{a}
±S.E	0.36	0.33	0.16	0.11	0.03	0.51	0.01	0.01

Mean in the same Column carrying same superscript are not significantly different ($P>0.05$)
Cond=Electrical conductivity TA= Total Alkanity, TH= Total hardness, Cl= Chloride, pH= Hydrogen Ion, PO_4= Phosphate, Do= Dissolved oxygen, BOD= Biological Oxygen Demand, Air T°= Air temperature, H_2O T° =water temperature, NO_3 = Nitrate, CO_2= Carbon (iv) oxide

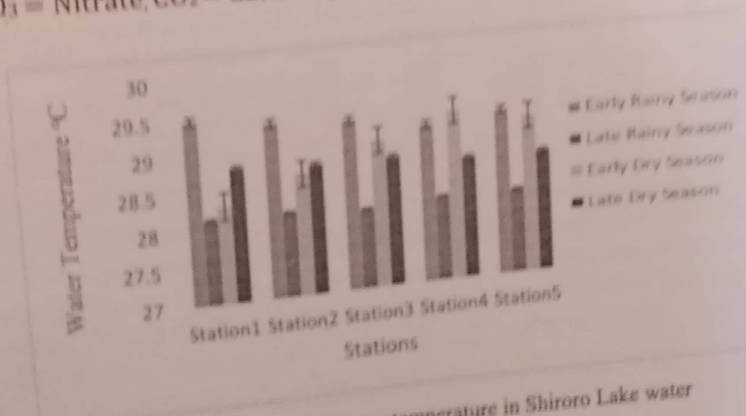

Figure 2: Seasonal variation of water temperature in Shiroro Lake water

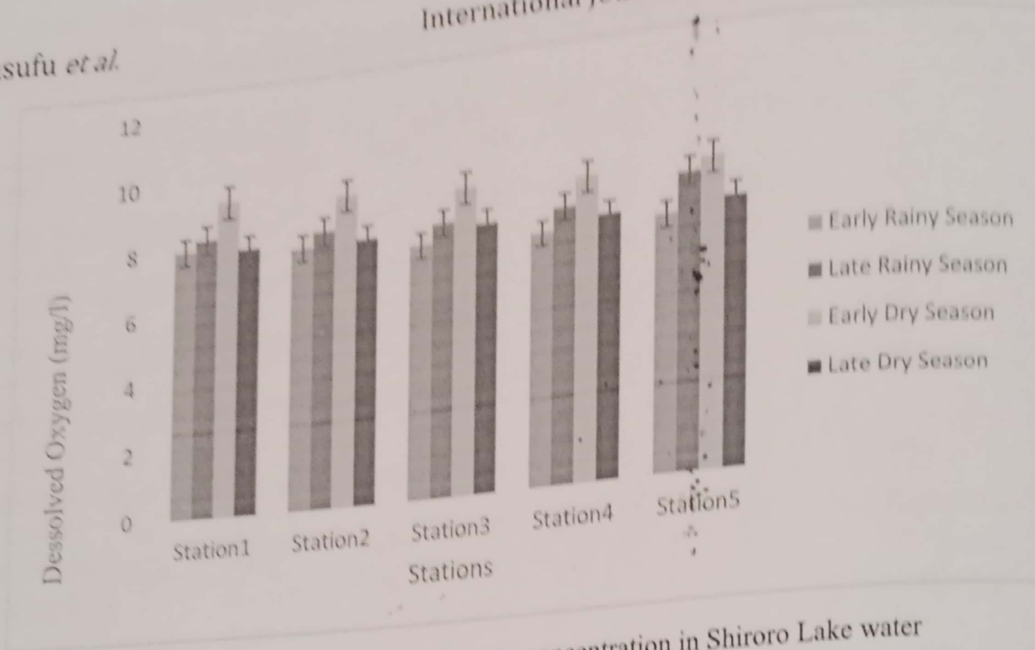

Figure 3: Seasonal variation of Dissolved Oxygen concentration in Shiroro Lake water

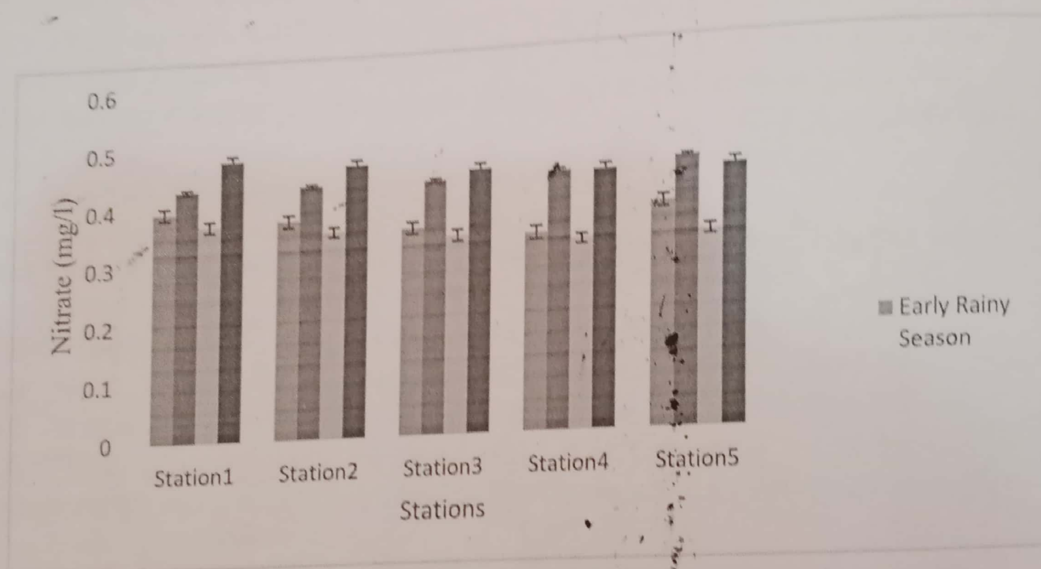

Figure 4: Seasonal variation of Nitrate concentration in Shiroro Lake water

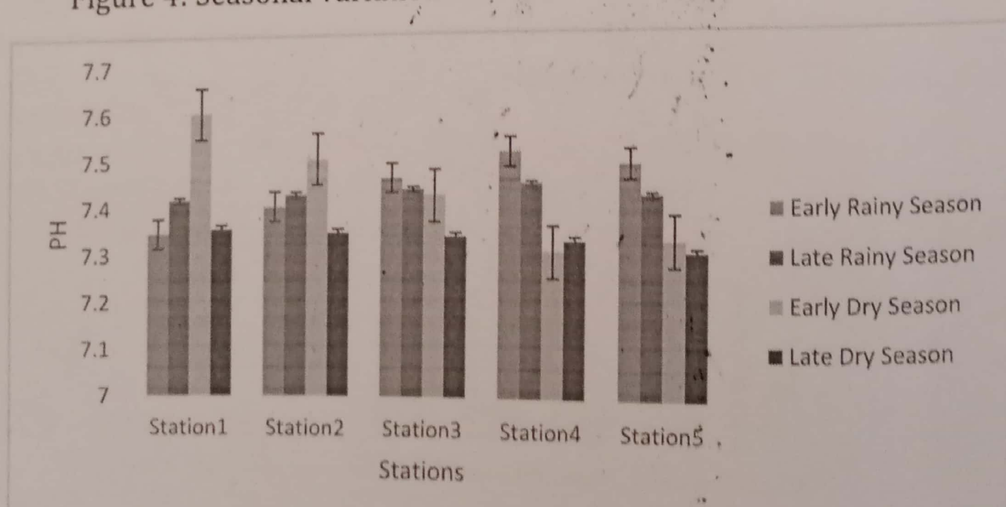

Figure 5: Seasonal variation of pH in Shiroro Lake water

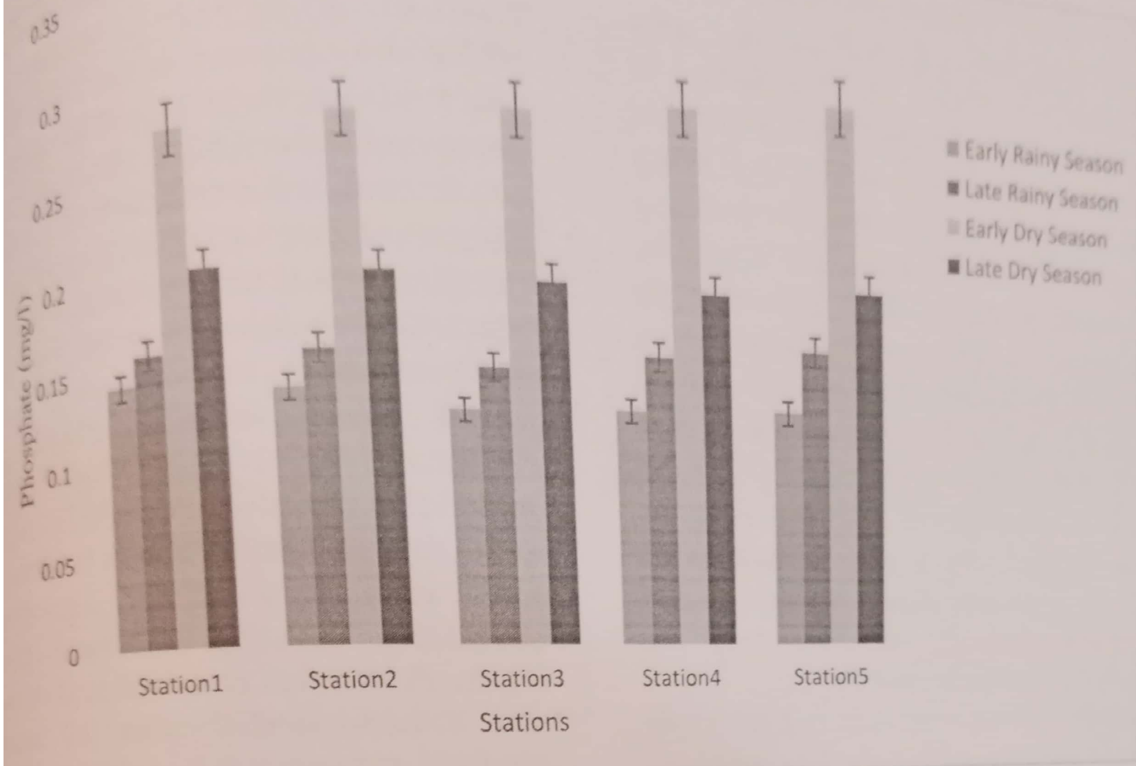

Figure 6: Seasonal variation of phosphate concentration in Shiroro Lake water

DISCUSSION

The water temperature range recorded during the sampling period compares with other tropical water bodies. The highest water temperature was recorded in November which is in late dry season and early rainy season, while late rainy (wet) and early dry seasons recorded the lowest water temperature. Water temperature had similar trend in both sub-seasonal and stations variation and this is consistent with similar work done on this lake and other tropical water bodies [8, 9, 10]. Water temperature range falls within the recommended value for aquaculture as reported by [11] who observed that warm water fish grow optimally at temperature range of 25 °C and 32 °C.

Dissolved oxygen range fell within the WHO recommended range for optimal fish production [12]; [13]. The lowest mean concentration was recorded in June. The decrease in dissolved oxygen observed in June during early rainy season could be due to phytoplankton bloom and decomposition taking place at this time of the year. The highest mean concentration, which was recorded in November, early dry season, probably was as a result of the prevailing low temperature due to harmattan wind resulting in much agitation of water at that period .This agrees with the work of [3] which showed that dissolved oxygen content of any water depends on water temperature, the quantity of organic matter, submerged vegetation, partial pressure of oxygen in the gaseous phase and concentration of dissolved salts. The decrease in dissolved oxygen observed in June during early rainy season could be probably due to phytoplankton bloom and decomposition taking place at this time of the year.

The index of hydrogen ions (pH) in water affects most chemical and biological processes, thus it is a crucial variable in water quality management [14]. The pH levels observed in this study were comparable with the results of [15];[16],[17] and [18]. The low October (rainy season) could be as a result of heavy load of organic degradation that occurs at this time due to inflow brought in by rain, this tends to reduce the oxygen through utilization in organic degradation which give rise to fall in pH .The high in June could be as a result of dilution effect from rain fall and run-off as reported by [8] in the same lake. Though sub-seasonal variations were noticed, there was no significant difference, an indicative that water quality received through effluents has no significant effect on the lake.

Alkalinity values ranged during the study period which is within the recommended range of acceptable values 20-300 mg/l [19] for inland water fish culture .The relatively low values for total alkalinity may be as a result of no or little limestone deposit in the lake surrounding soil. A higher early rainy season mean value in all the stations was observed though not significantly different indicated an elevated concentration of ions in the water body.

The finding is consistent with that of [16] who reported seasonal values of different water bodies in Jabi Lake, Usuma dam and Gwagwalada River. Result showed that, wet season values were higher than that of dry season.

The higher early dry season phosphate mean value recorded in stations III, IV and V could be due to concentration effect because of reduced water volume , this conforms to [5] who reported relatively higher dry season mean values in Geriyo lake, Adamawa State, Nigeria Higher mean value recorded in station III and V might be due to surface run-off from the farmland close to these stations since phosphate fertilizer application is practiced and could also be as a result of detergent usage for cloths and fishing boats . The result falls within the optimum range (0.12 mg/l) which disagrees with [20] in the study of Bosso reservoir, Niger State, Nigeria. Lower mean value recorded during both early rainy season and late rainy season in all stations could be as a result of dilution effects of the rains, high water level and flood water.

Nitrate mean value is within the recommended limit [21].The lower nitrate mean value recorded at station II which is at the dam site may be due to far distance from surface run-off of agricultural activities and also high water dept. Higher nitrate mean value recorded at station IV and V both located close to nearby farmland and community settlement with the accompanying agricultural discharge and run-off since the use nitrogen based fertilizer is a common practice in the area. The result recorded is consistent with [22] and [11] in similar studies in Jakara Lake, Kano State and Geriyo lake Adamawa State respectively. The result trend however disagrees with [23] who recorded a higher range value of 4.71-29.83 mg/l in river Chanchaga which He suggested has no greater primary production potentials. The higher wet season mean values recorded in all stations could be due to run-off from the farmlands into the lake water during the rainy season. This conforms to [3] in river Benue, [23] in Chanchaga river, [11], [5] in lake Geriyo and [24] in river Kaduna and College of Agriculture and Animal Science dam Kaduna State.

CONCLUSION

The findings of this study revealed that most of the physico-chemical parameters determined in Shiroro lake from October 2018 to September, 2020 fell within the permissible limits set by WHO 2008 with the exception of conductivity and CO_2 that fell below set limits. The water is productive and not heavily polluted yet. The implication is that water from Shiroro Lake can support the survival, growth and development of various fish species.

From the result obtained, seasonal variation was observed in all the physico-chemical parameter of Shiroro Lake apart from water temperature that was not significantly different.

REFERENCES

1. Oladimeji, Y. U., Abdusalam, Z. & Damisa, M. A. (2013). Socio-Economic Characteristics and Returns to Rural Artisanal Households in Asa and Pategi LGAs of Kwara State, Nigeria. International Journal of Science and Nature.4 (3):445-455.

2. Atobatele, O. E & Ugwumba, O. A. (2008). Seasonal variation in the physico chemistry of a small tropical reservoir (Abia reservoir) Iwo, Osun Nigeria. *African Journal of Biotechnology*, 7(12), 1962-1971.

3. Okayi, R.G (2001). Assessment of the water quality parameters of River Benue, effluents, and their effects on the abundance and distribution of plankton and fish species, Ph.D thesis, University of Ibadan. (2011).

4. Ojutiku, R.O., Olayode, H.F & Kolo, R.J. (2017). Bioaccumulation of some Heavy Metals in three Commercially important Fish Species Tissues relative to their concentration in Agaie-Lapai Dam, Minna, Niger State, Nigeria. *Journal of Agriculture and Agricultural Technology* 8(1): 63-68.World Health Organization.

5. Yusufu, F. O. (2015). Effect of Domestic effluent on water quality, abundance and distribution of zooplankton in Lake Geriyo, Yola, Nigeria. M.Tech. Thesis, Dept. of Fisheries, Modibo Adama University of Tech. Yola, Nigeria.

6. Hogan, M.C (2010). Water quality encyclopedia of earth, topic ed. Mark McGinley; ed in C. Cleveland National council on science and environment. Washington D.C.102p.

7. American Public Health Association (2005). Standard methods for the examination of water and wastewater. 15th edition Washington D.C PP 119.

8. Kolo, R.J & Oladimeji, A.A. (2004).Water quality and some nutrient levels in Shiroro Lake, Niger State. *Nigeria Journal of aquatic sciences*, 19 (2):99-106.

9. Eneji, I.S, Sha'Ato, R, & Annune, P.A(2012).An assessment of heavy metals loading in River Benue in the Makurdi metropolitan Area in Central Nigeria. *Environmental monitoring and assessment.* 184 (1)201-207.

10. Ojutiku, R.O, Kolo, R.J., Oyero, J.O., Bello, R.O, & Chukwuemeka, V.I. (2014).Fish biodiversity and water.

11. Kefas, M, Abubakar, K. A, and Ali, J. (2015).The assessment of water

quality via physicochemical parameters and macroinvertebrates in lake Geriyo, Yola, Adamawa State, Nigeria. *International journal of Science and Technology*, 3(2):284-290.

12. Araoye, P.A (2009).The seasonal variation of pH and dissolved oxygen concentration in Asa lake, Ilorin, Nigeria. International Journal of Physical Sciences, 4(5):271-274.

13. Abowei, J. F (2010). Salinity, dissolved oxygen and surface water temperature conditions in Nkoro river, Niger Delta, Nigeria, Advanced Journal of Food Science and Technology, 2(1):36-40.

14. Boyd, C.E., Tucker, C.S and Viriyatum, I. (2011). Interpretation of pH, acidity and alkalinity in aquaculture and fisheries. *North American Journal of Agriculture*, 73(4):403-408.

15. Haruna, A.B and Adikwu, I.A. (1995).Surface water ammonia conditions and their use in predicting fish welfare in Jakara Lake, Kano, Nigeria. Tambari Kano Journal of Education.2 (2)7-10.

16. Mbanaso, C.A., Kolo, R.J., Lamai, S.L., Oladimeji, A. A. & Ojutiku, R.O. (2014). Physico-chemical characteristics of Jabi Dam, Lower Usuma Dam and Gwagwalada river in Federal capital Territory, Abuja Nigeria. Journal of Agriculture and Agricultural Technology pg.42.

17. Yusufu, F.O., Haruna, A.B and Sogbesan, O. S. (2019). Spatio-temporal variation in physicochemical parameters in lake Geriyo, Yola, Nigeria .Proceedings of 2nd annual conference of Freshwater Biological Association (FBAN),Oct 23-26.33-46pp.

18. Ajijola, K. O and A.A.A Ugwumba (2019). Physico-chemical properties of upper Benue river, Jimeta, Adamawa State, Nigeria. Proceedings of the 34th annual conference of FISON pg.83.

19. WHO (2008).Guidelines for Drinking-Water quality Edition 3rd; World Health Organization, Geneva. pp 80-83.

20. Ibrahim, B.U., Ogueji, E.O and Adedayo, P. (2019).Study of some aspects of the physico-chemical parameters of Bosso reservoir, Niger State, Nigeria. Proceedings of 34th FISON annual conference.pg 277.

21. World Health Organization (WHO) (2010).Guidelines for drinking water quality (ii): Health criteria and supporting information, WHO, Geneva, Switzerland. pp 90-102 Google Scholar.

22. Haruna, A. B & Abdullahi, B.A. (1999). Observations on the seasonal variations in water quality and some Ecological implications of Jakara Lake, Kano-Nigeria. America journal of material and Natural Science.1, 107-112.

23. Ojutiku, R.O (2008). Limnological assessment of River Chanchaga and portable water in Minna environs,

Nigeria, PhD Thesis, Federal University of Technology, Minna.

24. Ojutiku,R.O,Habibu,S.,Kolo, R.J & Oyero, J.O(2016).Assessment of physico-chemical parameters of River Kaduna and College of Agriculture and Animal Science Dam,(CAAS) Kaduna, Nigeria. Ethiopian. Journal of Environmental Studies & Management.9 (6):691-699.