International Journal of Ecotoxicology and Ecobiology
2019; 4(2): 58-72
http://www.sciencepublishinggroup.com/j/ijee
doi: 10.11648/j.ijee.20190402.13
ISSN: 2575-1727 (Print); ISSN: 2575-1735 (Online)

Assessment of Physico-Chemical Parameters and Their Pollution Implications on the Major Dams in Ekiti State

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To cite this article:

Olagbemide Peter Taiwo, Owolabi Olufemi. Assessment of Physico-Chemical Parameters and Their Pollution Implications on the Major Dams in Ekiti State. *International Journal of Ecotoxicology and Ecobiology*. Vol. 4, No. 2, 2019, pp. 58-72. doi: 10.11648/j.ijee.20190402.13

Received: June 10, 2019; **Accepted**: July 8, 2019; **Published**: July 17, 2019

Abstract: The study was aimed at assessing the Physico-chemical parameters namely, temperature, electrical conductivity (EC), pH, turbidity, total alkalinity (TA), total hardness (TH), total dissolved solids (TDS), dissolved oxygen (DO_2); total solids (TS), total suspended solids (TSS) colour, potassium, Zinc, Copper, total Iron, BOD, COD etc. in three dams in Ekiti State, South-West Nigeria. The seasonal variations in the physicochemical parameters of water of the dams were studied from November, 2017 to October, 2018. Water samples were collected from the dams on monthly basis and analyzed for 26 water physico-chemical parameters by using standard methods. The standards for the drinking water recommended by the Indian Council of Medical Research (ICMR), World Health Organization (WHO), Nigerian Industrial Standard (NIS), National Environmental Standards and Regulations Enforcement Agency (NESREA) and Bureau of Indian standards (BIS) were used in this study. The comparison of the physico-chemical parameters values with the standard values of WHO guidelines and other international standards revealed the high level of BOD, COD, turbidity, DO_2, pH, colour, K, Fe, Mn, Cu, Zn, Pb and Cd in the water content. There were significant differences ($p > 0.05$) between the seasons (dry and wet) values of some of the physicochemical parameters in Egbe dam, Ureje dam and Ero dam. pH, DO_2, TSS, EC, TDS and TS had higher values in the rainy season while Temperature, BOD, COD, NO_3, Alkalinity, NO_2 and PO_4 had higher values during the dry season in the dams with few exemptions. The accumulation of these parameters in high values may render the dams' water unsuitable for drinking. In this study, it was observed that most of the physico-chemical parameters except metals were higher in Ureje dam than Egbe dam and Ero dam. This might be due to population increase, indiscriminate dumping of refuse around the dam, urbanization, domestic effluents and other attendant problems of the State capital where the dam is located and thus indicate that Ureje dam was more contaminated than Egbe and Ero dams in terms of anthropogenic contamination. Conclusively, the water from Egbe, Ureje and Ero dams may support fish production but is not fit for domestic and drinking purpose without adequate treatment.

Keywords: Physico-chemical Parameters, Dams. Seasonal, Ekiti State

1. Introduction

Water is an essential component of the environment and it sustains life on the earth. In addition to the need of water for drinking, water resources play a vital role in various sectors of economy such as agriculture, livestock production, forestry, industrial activities, hydropower generation, fisheries and other creative activities. Provision of clean and potable water is the major challenges in the 21st century with the increasing urbanization, industrial pollution, globalization, the use of fertilizers in agriculture and other anthropogenic activities since public health and life of the people are greatly influenced and endanger by the contaminated water. Researches revealed that approximately 3.1% of deaths (1.7 million) and 3.7% of disability- adjusted-life-years (DALYs) (54.2 million) worldwide are attributable to unsafe water, poor sanitation and hygiene [1]. Physico-chemical parameters provide the basis for judging the suitability of water for its designated uses and to improve existing conditions [2] and also serve as a basis for the biological productivity of any aquatic environment [3]. The utility of water body for various purposes is governed by physicochemical and biological parameters of the water [4] and thus, the quality of water can be regarded as a network of variables such as pH, oxygen concentration, temperature, etc. and any changes in these physical and chemical variables can affect aquatic biota in a variety of ways [5]. The impact of human activities in and around water body is felt on the unique physical and chemical properties of water on which the sustenance of aquatic life is built as well as the functions of the water body. Aquatic organisms need a healthy environment to live and adequate nutrients for their growth, therefore their productivity depends on the physicochemical characteristics of the water body [6, 7] and the maximum productivity can be obtained only when the physical and chemical parameters are present at optimum level. Rating of physico-chemical parameters is important to determining the environmental condition of waters and the general content of metals, organic substances in water provides valuable information not only for the general level of pollution in the water, but also helps in determining the pollutant source. Studies have shown the use of physico-chemical properties of water to assess the water quality of a dam [8, 9].

Ekiti state is located south-west Nigeria and the dams are located in various local Government Areas in the state: Ureje dam (Ado Ekiti), Egbe dam (Gbonyin) and Ero dam (Moba). Water from these dams is supplied to the public for domestic uses and fishes from the dams are consumed generally by the populace of the state. Apart from the study of Adefemi *et al*. on the physico-chemical parameters of the dams [10], there was no up to date information on the physico-chemical status of water of the dams despite the increased population size and the growth of anthropogenic activities and increase in the use of fertilizers in agriculture throughout the state. This study is therefore focused on the assessment of physico-chemical parameters of the dams to show the present state of the dams and the fitness of the dams for public consumption and aquatic life.

2. Material and Methods

2.1. Study Area

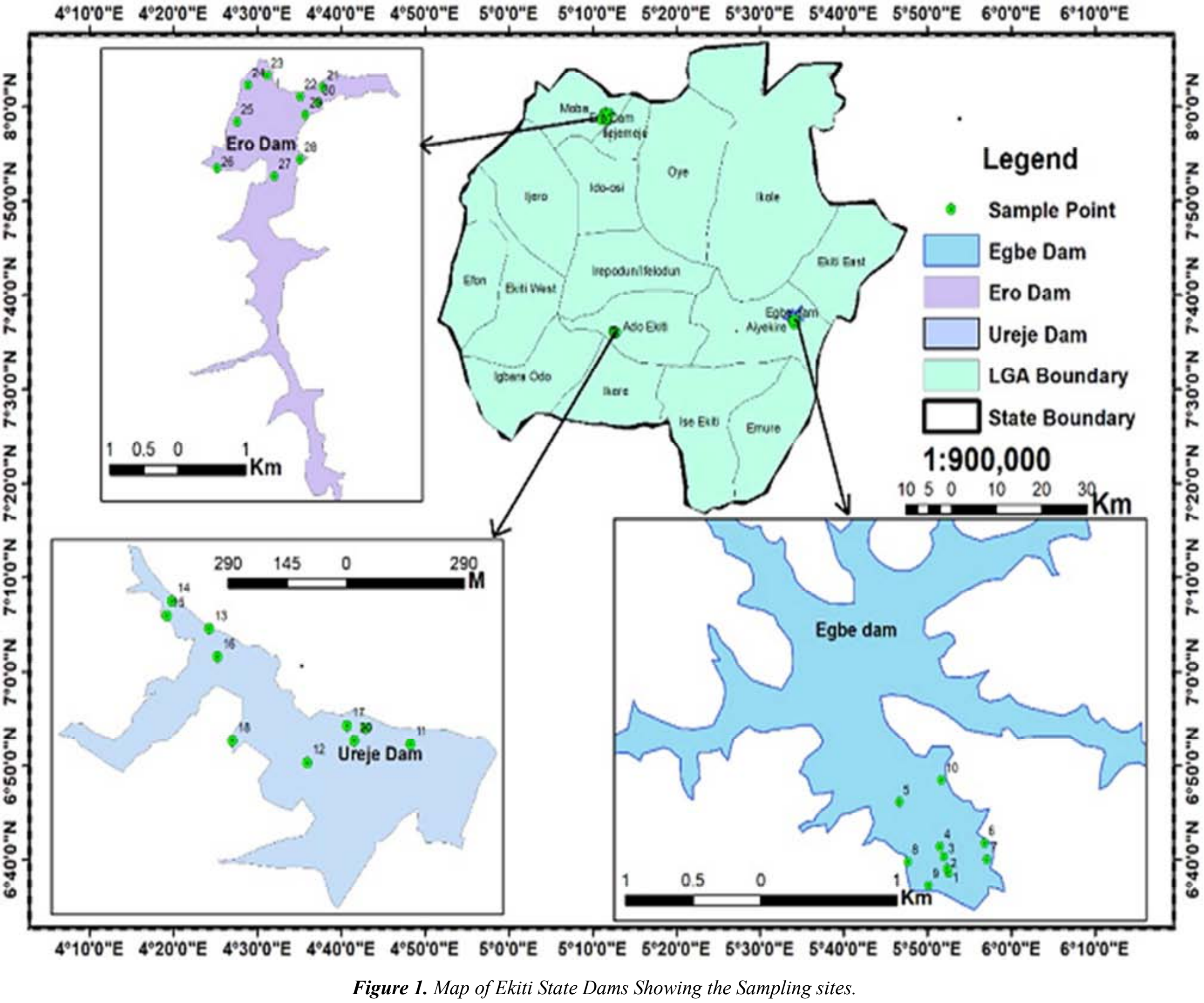

Figure 1. Map of Ekiti State Dams Showing the Sampling sites.

Ekiti state is geographically located between longitude 4° 45' to 5° 45' East of Greenwich Meridian and on latitude 7° 15' to 8° 5' North of the equator. It shares boundaries with Kwara State in the north, Kogi State in the north-east Osun State in the south and south-east. Ekiti state dams lie within the South western Basement Complex of Nigeria [11]. Human activities including defecation, washing, recreation (boating, swimming/bathing and fishing), agricultural activities and waste disposal are prevalent especially where human settlements exist around the dams. This study involves the three major dams in the state. They are: Ureje Dam, located at Longitude 5° 14[1]E and Latitude 7° 38.2[1]N; Egbe Dam, situated at Longitude 5° 36.9[1] E and Latitude 7° 37.1[1] N and Ero Dam, situated at Ikun-Ekiti, Moba Local Government Area of Ekiti State, Nigeria between latitudes 7° 15' and 8° 5'N and longitude 4° 45' and 5° 31' E.

2.2. Sample Collection

Samples of surface water were collected monthly from Ureje, Ero and Egbe dams from November, 2017 to October, 2018. Ten sampling sites were chosen in each dam to make pooled water sample monthly according to [12, 13, 14]. The sites were selected to represent the open water bodies and different variations within each dam so as to obtain a realistic overall representation. The GPS of sampling sites were taken using Garmin hand-held GPS. The geographical location of each selected sampling site within the reservoir is shown in Table 1.

Table 1. *The Sampling Sites and GPS Co-Ordinates.*

EGBE DAM			UREJE DAM			ERO DAM		
S/N	Lat.	Long.	S/N	Lat.	Long.	S/N	Lat.	Long.
1	7°38'0.15"N	5°34'6.15"E	11	7°36'0.30"N	5°12'52.98"E	21	7°59'14.68"N	5°12'11.57"E
2	7°37'49.93"N	5°33'44.19"E	12	7°35'58.97"N	5°12'44.77"E	22	7°59'1.24"N	5°11'49.96"E
3	7°37'39.96"N	5°33'42.62"E	13	7°36'8.46"N	5°12'36.96"E	23	7°59'19.58"N	5°11'38.59"E
4	7°37'12.77"N	5°34'12.02"E	14	7°36'10.41"N	5°12'33.99"E	24	7°59'15.42"N	5°11'29.52"E
5	7°37'16.20"N	5°34'3.00"E	15	7°36'9.36"N	5°12'33.60"E	25	7°59'0.51"N	5°11'35.96"E
6	7°37'35.25"N	5°34'23.55"E	16	7°36'6.48"N	5°12'37.62"E	26	7°58'46.31"N	5°11'22.93"E
7	7°37'4.02"N	5°34'23.93"E	17	7°36'1.61"N	5°12'47.92"E	27	7°58'14.84"N	5°11'32.92"E
8	7°37'28.09"N	5°33'53.02"E	18	7°36'0.54"N	5°12'38.81"E	28	7°58'32.51"N	5°11'44.57"E
9	7°37'1.91"N	5°34'12.11"E	19	7°36'1.45"N	5°12'49.42"E	29	7°58'50.92"N	5°11'42.88"E
10	7°37'49.16"N	5°33'55.76"E	20	7°36'0.55"N	5°12'48.51"E	30	7°57'45.39"N	5°11'39.13"E

Water samples from all ten sampling sites were collected during morning hours between 8.00 to 10.00 a.m. at a depth of about 0.3m below water surface into 2 Litre polyethylene plastic containers. Prior to sampling, the containers were cleaned with 10% nitric acid and rinsed with distilled water. The containers were rinsed three times with the dam water at the time of sampling. Samples were then collected by direct immersion of the sampling containers into the dam. All sample containers were properly labeled to indicate date of sampling and the sampling location. Immediately after sample collection, 2 ml of concentrated nitric acid was added to the water samples for metal analysis to reduce adsorption of metals onto the walls of the plastic containers and to prevent microbial growth in the water sample. Winkler's bottles were used to collect water samples for COD and BOD. Samples were transported to the laboratory at temperature of about 4 degree Celcius (4°C) (ice/cold packs) to retard reactions and stored at 4°C awaiting analysis. *In situ* water quality variable were recorded using Jenway portable 970 DO_2 Meter and Jenway 430 pH/Conductivity Meter. The *in situ* water quality parameters taken were temperature (°C), pH and electrical conductivity (µS/cm) and dissolved oxygen (mg/L).

2.3. Water Sample Analysis

The samples were analyzed in the laboratory as per standard methods [15] for different physico-chemical parameters namely, conductivity, turbidity, total solids, pH, DO_2, BOD, COD, alkalinity, turbidity, total dissolved solids, hardness, colour, phosphates, nitrates and nitrite. Metals (Cu, Pb, Mg, K, Mn, Fe, Na, Ca, Zn and Cd) in the water samples were determined by atomic absorption spectrophotometric method using Atomic absorption spectrophotometer (Bulk Scientific Model 211 VGP).

2.4. Data Analysis

Statistical analysis was performed using SPSS software version 23. The means of the physico-chemical variables, evaluation of significant differences between different samples were determined using descriptive statistics and analysis of variance (ANOVA) respectively. Results of the test were considered significant if the calculated P values were ≤ 0.05 or ≤ 0.01. T -test was used to show the variations of physico-chemical parameters between the two seasons.

3. Results and Discussion

The physico-chemical parameter is an index of biotic interaction of any water body and it affects biochemistry, heamatological and hepatological parameters of the fish which could be attributed to individual adaptation patterns, survival life history pattern and reproduction success [16]. Physico-chemical properties of water quality assessment give a proper indication of the status, productivity and sustainability of a water body [8]. The use of physicochemical parameters to assess water quality gives a good assessment of the status, productivity and sustainability of such water body and information on the quality of the water, the sources of the variations and their impacts on the functions and biodiversity of the reservoir can be inferred from the changes in the parameters [17]. Table 2 shows the physico-chemical parameters during the dry and wet seasons for Egbe, Ureje and Ero Dams. There were significant differences (p > 0.05) between the seasons (dry and wet) values of some of the physicochemical parameters in Egbe dam, Ureje dam and Ero dam. Figures 2, 3 and 4 show the monthly variations in the physico-chemical parameters in the dams.

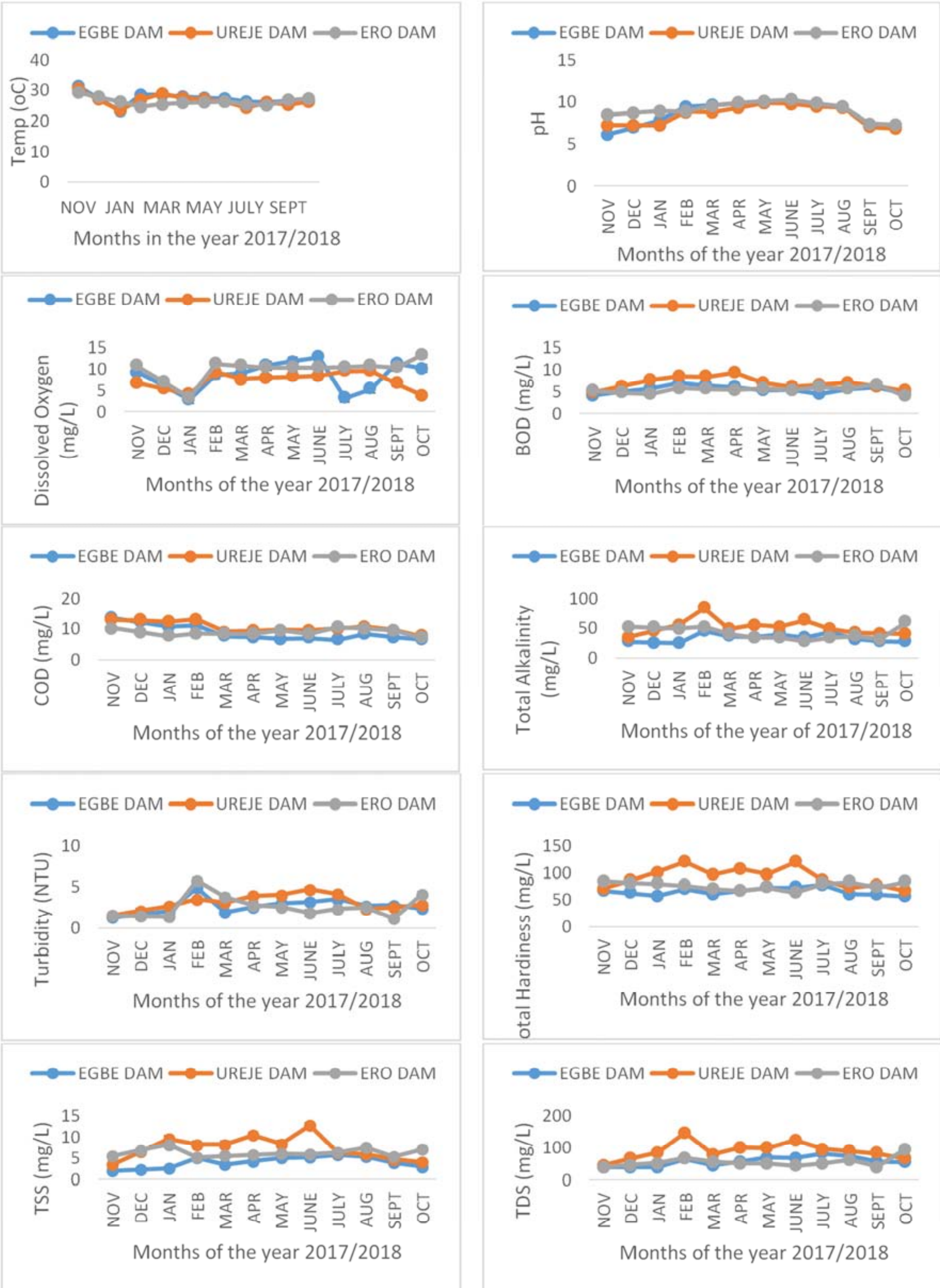

Figure 2. *Graphs depicting monthly variations in the values of physico-chemical parameters during the study period.*

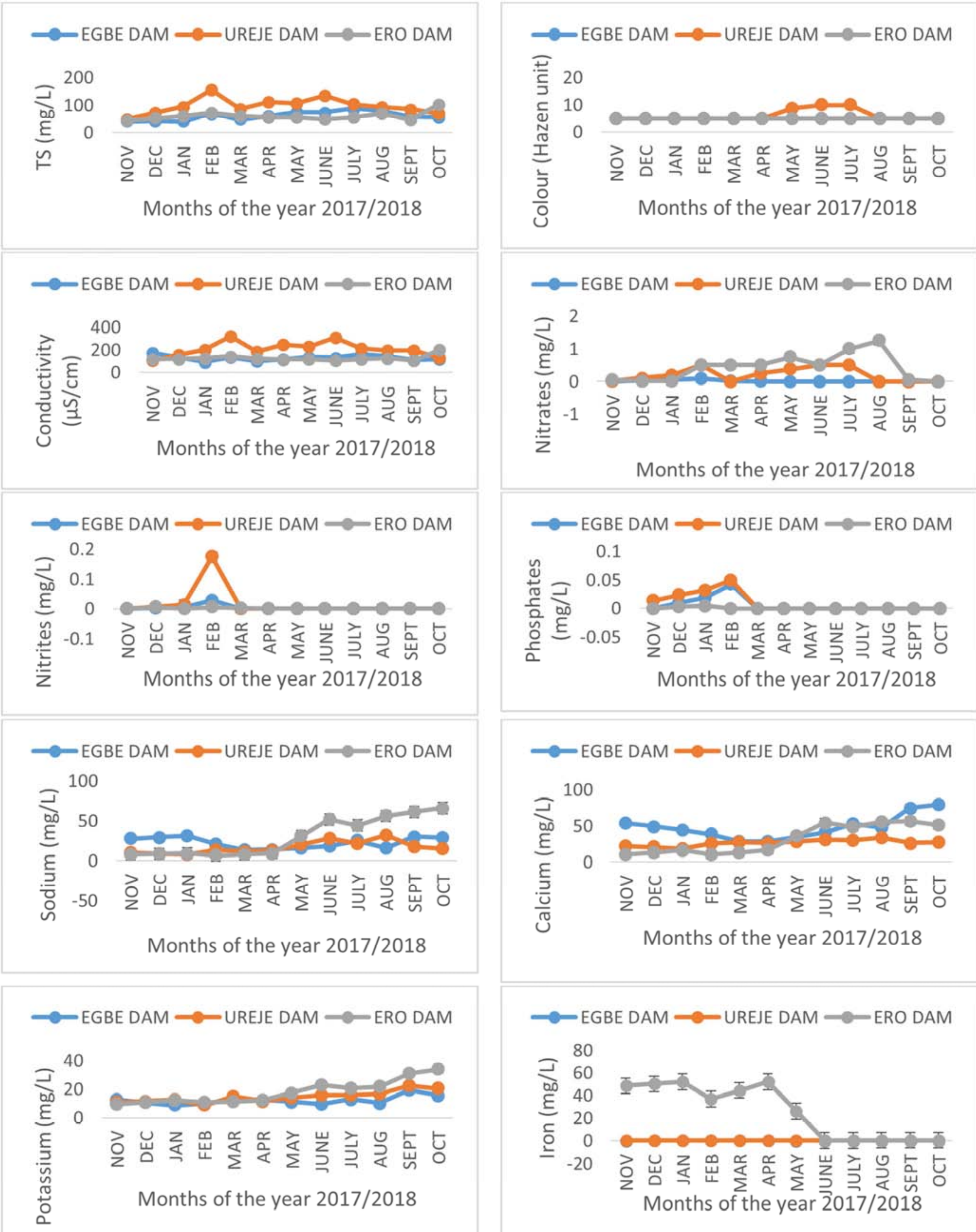

Figure 3. *Graphs depicting monthly variations in the values of physico-chemical parameters during the study period.*

Figure 4. *Graphs depicting monthly variations in the values of physico-chemical parameters during the study period.*

Table 2. *Average with standard errors values of physico-chemical parameters of water samples from the dams.*

Parameters	YEAR 2017-2018						Standard value	Agencies
	EGBE DAM		UREJE DAM		ERO DAM			
	DRY SEASON	WET SEASON	DRY SEASON	WET SEASON	DRY SEASON	WET SEASON		
Temp (°C)	27.93±3.35a	26.61±0.50a	27.44±3.01a	25.66±0.87a	26.75±2.35a	26.14±0.97a	< 40	WHO
pH	8.30±1.55a	8.83±1.30a	8.11±0.96a	8.72±1.39a	9.05±0.54a	9.07±1.33a	8.5	ICMB/BIS
DO_2 (mg/l)	7.77±2.85a	9.06±3.90a	6.86±1.85a	7.65±2.14a	8.85±3.13a	10.07±1.22a	5	ICMB/BIS
TUR (NTU)	2.37±1.31a	2.91±0.39a	2.78±0.89a	3.43±1.01a	2.76±1.75a	2.39±1.00a	5	WHO
COL (Hazen)	5.00±0.00a	5.00±0.00a	5.42±1.02a	7.29±2.55a	5.00±0.00a	5.00±0.00a	5	BIS
EC (µS/cm)	126.08±29.08a	134.22±18.91a	202.56±74.04a	212.65±57.09a	124.93±10.67a	129.67±36.08a	300	ICMB
TS (mg/l)	50.43±11.98a	72.09±11.80b	94.97±36.37a	99.53±22.20a	58.34±9.56a	63.77±20.74a	-	-
TDS (mg/l)	47.40±10.63a	67.43±10.08b	87.26±34.78a	92.62±19.15a	52.17±9.66a	57.42±20.12a	500	ICMB/BIS
TSS (mg/l)	3.26±1.20a	4.67±1.04a	7.72±2.46a	6.98±3.12a	6.15±1.31a	6.35±0.82a	25	NESREA
TH (mg/l)	63.88±4.69a	66.31±8.90a	97.05±17.08a	86.32±19.26a	76.07±6.92a	75.34±7.54a	300	ICMB/BIS
Totalk (mg/l)	33.82±8.02a	33.40±6.47a	53.60±16.70a	47.41±8.83a	46.10±7.63a	36.61±11.49a	120	ICMB
BOD (mg/l)	5.68±1.01a	5.21±0.59a	7.46±1.67a	6.32±0.70a	5.21±0.53a	5.54±0.84a	5	ICMB/BIS
COD (mg/l)	10.36±2.53a	6.99±0.73b	11.80±1.88a	9.53±1.11b	8.62±0.94a	9.13±1.32a	10	WHO
NO_3 (mg/l)	0.041±0.04a	NDa	0.143±0.22a	0.20±0.27a	0.187±0.27a	0.56±0.56a	45	1CMB/BIS
NO_2 (mg/l)	0.006±0.01a	NDa	0.033±0.07a	NDa	0.002 ±0.002a	NDa	0.2	NIS
PO_4 (mg/l)	0.015±0.02a	NDa	0.024±0.02a	NDa	0.002±0.003a	NDa	0.1	USEPA
Na (ppm)	22.62±7.39a	22.94±5.99a	10.74±2.09a	22.39±6.09b	40.22±1.29a	53.90±3.66b	200	NIS
Ca (ppm)	40.30±10.35a	54.92±17.56a	23.18±3.34a	29.47±2.63b	53.12±3.61a	52.54±1.50a	75	WHO
K (ppm)	11.11±1.61a	13.16±3.44b	11.60±2.00a	17.50±3.12b	31.57±1.09a	26.11±2.22a	10	WHO
Fe (ppm)	0.18±0.02a	0.10±0.03b	0.31±0.04a	0.20±0.04b	0.06±0.005a	0.081±0.03b	0.1	WHO
Mn (ppm)	0.21±0.05a	0.17±0.04b	0.19±0.08a	0.12±0.04a	0.096±0.005a	0.24±0.02b	0.1	BIS

Parameters	YEAR 2017-2018						Standard value	Agencies
	EGBE DAM		UREJE DAM		ERO DAM			
	DRY SEASON	WET SEASON	DRY SEASON	WET SEASON	DRY SEASON	WET SEASON		
Zn (ppm)	0.24±0.07a	0.27±0.10a	0.12±0.005a	0.30±0.09b	0.101±0.002a	0.39±0.034b	3.0	NIS
Mg (ppm)	4.82±0.44a	4.87±0.69a	4.21±0.34a	4.96±0.53b	2.25±0.05a	5.57±0.31b	30	BIS
Cu (ppm)	0.17±0.04a	0.16±0.05a	0.12±0.03a	0.16±0.03b	0.030±0.004a	0.069±0.012b	0.05	BIS
Pb (ppm)	0.005±0.003a	0.0013±0.0010b	0.001±0.0004a	0.001±0.0005a	0.0031±0.0006a	0.0048±0.0014a	0.05	WHO
Cd (ppm)	0.001±0.0005a	NDb	NDa	NDa	0.0003±0.0002a	0.0000±0.0000a	0.003	WHO

Physico-chemical parameter values of dry season and wet season with similar superscription are not significant[1]

The temperature values recorded during the dry season ranged from 23.30 to 31.30 (mean 27.93 ± 3.35)°C, 23.50 to 30.50 (mean 27.44 ± 3.01)°C and 24.65 to 29.30 (mean 26.75 ± 2.35)°C for Egbe dam, Ureje dam and Ero dam respectively while temperature during the rainy season ranged from 26.00 to 27.30 (mean 26.61 ± 0.50)°C, 24.30 to 26.40 (mean 25.66 ± 0.87)°C and 25.00 to 27.40 (mean 26.14 ± 0.97)°C for Egbe dam, Ureje dam and Ero dam respectively. The mean temperature values during the dry season were higher than the mean temperature values during the rainy season in the three dams. This similar to the result obtained by Asaolu when he studied the physico-chemical parameters of the coastal water in Ondo state [18] and by Adefemi *et al*. on their study on the physico-chemical parameters of major dams in Ekiti state [10]. Higher water temperatures during the dry season can be attributed probably to high atmospheric temperature, low relative humidity and reduction in the amount of suspended particles [19]. Temperature impacts both the chemical and biological characteristics of surface water. It affects the dissolved oxygen level in the water, photosynthesis of aquatic plants, metabolic rates of aquatic organisms, and the sensitivity of these organisms to pollution, parasites and disease. Temperature affects conductivity; increase in temperature increases conductivity by decreasing the viscosity of water and thus increase the mobility of ions in water. Turbidity and colour are indirectly related to temperature, because temperature affects coagulation. The efficiency of coagulation is strongly temperature dependent and the optimum pH for coagulation decreases as temperature increases. Studies showed that air, solar radiation, humidity, rainfall as well as water discharge, groundwater percentage are among the main factors that influence water temperature changes [20, 21]. The distribution of water temperature in lakes had been showed to be equally strongly (or sometimes even more strongly) determined by the effect of wind than air temperature [22]. Transparency also to some extent determines the temperature of lake as lakes that have low transparency retain heat nearer the surface [23]. In this study, decrease in temperature during rainy season in the dams was likely due to turbidity, effect of wind, solar radiation and different characteristics of flow paths. The temperature range of the three dams during both dry and wet seasons is within the range of 10°C – 50°C for river and dam water meant for domestic purposes, and for fish culture in tropical waters [24].

The results of pH varied from 6.12 to 9.77 (mean 8.30 ± 1.55); 7.24 to 9.29 (mean 8.11 ± 0.96) and 8.50 to 9.90 (mean 9.07 ± 0.54) for Egbe dam, Ureje dam and Ero dam respectively during the dry season. The pH varied from 7.15 to 9.92 (mean 8.83 ± 1.30); 6.85 to 9.85 (mean 8.72 ± 1.39) and 7.31 to 10.23 (mean 9.05 ± 1.33) for Egbe dam, Ureje dam and Ero dam respectively for the rainy season. The pH ranges of the three dams during dry and rainy seasons were higher than the ones reported by Adefemi *et al* on these dams and contrast to their reports, the pH of the water samples during rainy season are less acidic than dry season samples [10]. The lower value of the pH of the dams during the dry season may be due to high carbon dioxide concentration occurring from organic decomposition. Increased water volume, greater water retention and good buffering capacity of total alkalinity may have been the reason for slightly higher pH during the wet season. The pH ranges of Ureje dam indicated that the water samples were almost neutral to sub-alkaline in nature during both seasons. The pH for Egbe dam during both seasons ranged from mild acidity to alkaline while that of Ero dam was purely alkaline during the dry season and ranged from mild acidity to alkaline during rainy season. The relative low pH recorded in September and October in all the dams when the tempo of rainfall was very high was as a result of surface run-off which can lead to low pH values. pH ranges have different effects on aquatic organisms. Extreme pH can kill adult fish and invertebrate life directly and can also damage developing juvenile fish. pH also modifies the bio-accumulation of metals in fish tissue [25] and high pH may increase the toxicity level of some heavy metals [26]. The pH values for the dams varied from month to month and the pH changes may be due to the variation in photosynthetic activities of the aquatic plants which increases as a result of consumption of carbon dioxide in the process. In this study, it was observed that the mean pH values increased with increase in dissolved oxygen in all the dams during the rainy season. The pH ranges in the dams are good for fish production according to [27].

The dissolved oxygen (DO_2) ranged from 2.87 to 10.85 (mean 7.77 ± 2.85) mgL^{-1}, 4.16 to 9.23 (mean 6.86 ± 1.85) mgL^{-1}, and 3.27 to 11.20 (mean 8.85 ± 3.13) mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively during the dry season while the rainy season DO_2 values ranged from 3.19 to 12.74 (mean 9.06 ± 3.90) mgL^{-1}, 3.87 to 9.56 (mean 7.65± 2.14) mgL^{-1} and 10.25 to 13.35 (mean 10.07 ± 1.22) mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively. The values of DO_2 were beyond the standard value in all the dams in all the months except in January, July in Egbe dam and

October in Ureje dam. The measurement of DO_2 can be used to indicate the degree of pollution by organic matter, the destruction of organic substances and the level of self-purification of the water [28]. Concentrations below 5 mg L^{-1} may adversely affect the functioning and survival of biological communities and below 2 mg L^{-1} may lead to the death of most fish [28]. The optimum concentration of DO_2 in pond waters is 6 to 9 mg/L [29]. This indicates the capability of the dams to support aquatic life since dissolved oxygen is one of the major indicators of water quality. The amount of dissolved oxygen in a lake is related to photosynthesis and respiration rates as well as mechanical actions such as wind. Apart from usefulness in respiration, dissolved oxygen combines with other important elements such as carbon, sulphur, nitrogen and phosphorous to form carbonates, sulphates, nitrates and phosphates, respectively, which constitute the required compounds for the survival of aquatic organisms. In the absence of adequate oxygen levels, the above elements, among others, could form compounds which are toxic to the aquatic biota. The lowest values of DO_2 recorded in the dams in months of January during the dry season when the lowest temperature values were also recorded in the dams could be due to cloudy weather in January. On cloudy days, the production of oxygen through photosynthesis is slowed or halted. In addition, still and windless days do not allow circulation of the water and limits surface diffusion of atmospheric oxygen. The relatively low oxygen values recorded in Egbe and Ureje dams in comparison to Ero dam during the rains were likely to be a reflection of the greater inputs of run-offs from the surroundings especially domestic effluents from the residential areas around Ureje dam; the decomposition of which brought down the values of oxygen in the dams. The effects of the influx of run-offs in Ureje dam brought about colour change of the water observed in May, June and July. Rubio- Arias *et al* observed similar results and reported that low concentration of DO_2 value was due to the use of oxygen by bacteria to biodegrade organic matter and other elements from runoffs [30]. In overall, the mean DO_2 values during rainy season were higher than during the dry season in the three dams. The depletion of DO_2 during the dry season may be attributed to the increase in surface water temperature that increases the mineralization of non-living matter which also demands more oxygen resulting in lowering DO_2 levels.

The values of BOD recorded ranged from 4.15 to 6.95 (mean 5.68 ± 1.01) mgL^{-1}, 4.80 to 9.30 (mean 7.46 ± 1.67) mgL^{-1} and 4.45 to 5.85 (mean 5.21 ± 0.53) mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively during the dry season while the rainy season BOD values ranged from 4.50 to 6.00 (mean 5.21 ± 0.59) mgL^{-1}, 5.10 to 7.10 (mean 6.32 ± 0.70) mgL^{-1} and 4.05 to 6.60 (mean 5.54 ± 0.84) mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively. BOD is an indicator of organic pollution with higher values indicating higher levels of organic pollution [31]. BOD values above 5 mg/l are undesirable. The mean values of BOD in the three dams during both seasons were beyond the critical limit which indicated poor water quality conditions. Unpolluted waters are likely to have a BOD value of < 3 mg/L, while values above 5.0 mg/L recorded in the dams indicate a possibility of organic pollution effect on water in the dams. The mean value of BOD was slightly higher during the rainy season than the dry season only in Ero dam but in Egbe dam and Ureje dam, the recorded BOD values were slightly higher in dry season. The overall high BOD values in the dams means that a lot of oxygen is being used up, typically by bacteria breaking down organic material [32]. This is associated with loss of water clarity that has its own negative effects. The permissible limit for BOD for drinking water is 0.2 mg/L, for recreation 3mg/L, for fish 6 mg/L and 10 mg/L for irrigation [33]. The BOD values obtained in this study indicated that the dams' water is suitable for fish culture and irrigation activities and not suitable for drinking purpose.

The recorded values of COD ranged from 7.20 to 13.49 (mean 10.36 ± 2.53) mgL^{-1}, 9.10 to 13.10 (mean 11.80 ± 1.88) and 7.50 to 10.30 (mean 8.62 ± 0.94) mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively during the dry season while values of COD during the rainy season ranged from 6.30 to 8.30 (mean 6.99 ±0.73) mgL^{-1}, 7.45 to 10.70 (mean 9.53 ± 1.11) mgL^{-1} and 7.00 to 10.55 (mean 9.13 ± 1.32) mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively. Higher COD levels mean a greater amount of oxidizable organic material in the sample, which will reduce DO_2 levels. If the COD is much greater than the BOD in raw wastewater, then the waste is not readily biodegradable, and it may be toxic to the microorganism. If the COD is similar to the BOD, then the waste is readily biodegradable [34]. The mean values of COD during the dry season were higher than the standard limit for drinking water in the dams except Ero Dam which indicated the polluted nature of Egbe and Ureje dams in comparison to Ero dam. The high COD level at Egbe dam and Ureje dam during the dry season may be due to high rate of organic decomposition resulting from human activities which produce sewage and agricultural run-offs into the dams which have negative impact on the water quality. However, the mean values of COD during rainy season were slightly lower than standard limit for drinking water. This was likely due to increase in dissolved oxygen during rainy season. Higher concentrations of COD were recorded in Egbe dam and Ureje dam during dry season and this may be due to less dilution of pollutant as noted by other study [35]. In all the dams during both seasons, the values of COD were higher than the values of BOD; which means that some of the pollutants in the dams are not readily biodegradable.

Total alkalinity recorded from the dams in this study ranged from 24.20 to 44.85 (mean 33.82 ± 8.02) mgL^{-1}, 34.10 to 83.60 (mean 53.60 ± 16.70) mgL^{-1} and 33.65 to 52.15 (mean 46.10 ± 7.63) mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively during the dry season while during the rainy season, Alkalinity values ranged from 26.45 to 43.00 (mean 33.40 ± 6.47) mgL^{-1}, 40.10 to 62.60 (mean 47.41 ± 8.83) mgL^{-1} and 27.50 to 59.45 (mean 36.61 ± 11.49) mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively. The values of total alkalinity recorded in the dams every month were lower than recommended limits for drinking water but higher than the lower limit (20 mg/L $CaCO_3$) in production ponds [36]. Levels below 10 mg/L indicate that the aquatic ecosystem is poorly buffered, and is very susceptible to changes in pH from natural and human-caused sources [37]. In this study, the buffering capacity of the dams was good because the level of total alkalinity in the dams was above 10 mg/L. In all the dams, the mean values of total alkalinity recorded in wet season were lower than those recorded during the dry season. Similar result was reported on southern Nigerian reservoir and Ureje dam [38, 19]. This could be due to several factors. Water bodies of the tropics usually show a wide range of fluctuations in total alkalinity, the values depending on the location, season, plankton population and nature of bottom deposits [19].

Turbidity during the dry season ranged from 1.25 to 4.90 (mean 2.37 ± 1.31) NTU, 1.50 to 3.90 (mean 2.78 ± 0.89) NTU and 1.35 to 5.75 (mean 2.76 ± 1.75) NTU for Egbe dam, Ureje dam and Ero dam respectively while in the wet season, the values ranged from 2.35 to 3.50 (mean 2.91 ± 0.39) NTU, 2.30 to 4.75 (mean 3.43 ± 1.01) NTU and 1.10 to 4.10 (mean 2.39 ± 1.00) NTU for Egbe dam, Ureje dam and Ero dam respectively. It is an important indicator of the amount of suspended sediment in water and it is a measure of the cloudiness of the water, which can have many negative effects on aquatic life. The turbidity values observed in the dams in each of the month during both seasons were below the standard limit (5 NTU) for drinking water except in February, 2018 in Ero Dam. This could be due to the effect of opening of spill way of the dam during that period. Turbidity can raise water temperature above normal because suspended particles near the surface can facilitate the absorption of heat from sunlight. This was not the case in all the dams in this study as mean temperature was lower during the wet season than the dry season in Egbe dam and Ureje dam when the average turbidity value in the two dams was higher than the wet season. The higher turbidity in the Egbe and Ureje dams during the wet season may be due to higher mean values of TDS in all the dams during the rains. Similar observation was reported on Owena multipurpose dam in Ondo state [39].

The recorded values of hardiness during the dry season varied from 57.10 to 69.85 (mean 63.88 ± 4.69) mgL^{-1}, 70.80 to 119.75 (mean 97.05 ± 17.08) mgL^{-1}, and 66.44 to 84.50 (mean 76.07 ± 6.92) for Egbe dam, Ureje dam and Ero dam respectively while the water hardiness values during the wet season ranged from 55.50 to 77.70 (mean 66.31 ± 8.90) mgL^{-1}, 66.50 to 119.15 (mean 86.32 ± 19.26) mgL^{-1} and 63.25 to 82.80 (mean 75.34 ± 7.54) mg^{-1} for Egbe dam Ureje dam and Ero respectively. The values of hardness recorded in the dams each month during both seasons were well within permissible limits. The variations of total hardness every month were due to the fluctuations in the quantity of water and waste disposals in the dams. According to water hardiness classification, during both seasons Egbe dam contains soft water while Ureje and Ero dams contain moderately hard water [40]. The obtained values of hardness in the dams in this study are supportable of fish production as reports showed that more than 15 mg $CaCO_3$/L hardness is suitable for fish growth, while less than this value causes slow growth of fish and require liming for high fish production [41]. Metals are more toxic in soft water than in hard water [42, 43], it means that metal pollution is likely to produce more serious effects on aquatic life in Egbe dam than in Ureje and Ero dams. In addition, the relative proportions of Ca^{2+} and Mg^{2+} in the water (Ca:Mg ratios) are important in fish culture, and imbalances between Ca^{2+} and Mg^{2+} adversely affect embryonic development, larval growth, and survival [44, 45]. The mean Ca: Mg ratios were 0.19, 0.09 and 0.04 for Ureje dam, Egbe dam and Ero dam respectively during the dry season while it was 0.17, 0.08 and 0.11 for Ureje dam, Egbe dam and Ero dam respectively during the rainy season. Ca: Mg ratios less than 1:20 or greater than 8:1 had adverse influences on hatching, feeding, development, larval growth, and survival [46]. This may contribute to low quantity of *Oreochromis niloticus* collected throughout the year especially at Egbe dam and Ero dam. Waters with more than 60 ppm hardiness which is equivalent to 60 mg$CaCO_3$/L hardness are classified as 'nutrient rich' waters [47] and water with hardness below 60 mg$CaCO_3$/L are soft, between 61 and 120 mg$CaCO_3$/L are moderately hard and between 121 to 180 mg$CaCO_3$/L are hard and more than 181 mg$CaCO_3$/L are very hard [48]. Hence, the water in the three dams could be said to moderately hard and referred to as nutrient rich water and thus be able to sustain aquatic life.

The TSS in this study ranged from 1.95 to 4.95 (mean 3.26 ± 1.20) mgL^{-1}, 3.50 to 10.40 (mean 7.72 ± 2.46) mgL^{-1} and 5.20 to 8.15 (mean 6.15 ± 1.31) mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively during the dry season while in the wet season, the values ranged from 2.95 to 5.69 (mean 4.67 ± 1.04) mgL^{-1}, 4.05 to 12.60 (mean 6.98 ± 3.12) mgL^{-1} and 5.30 to 7.50 (mean 6.35 ± 0.82) mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively. The mean TSS increased from the dry season to the wet season in Egbe dam and Ero dam. Reduction in TSS during the dry season could be due to water filtration. The mean TSS values in Egbe dam, Ureje dam and Ero dam were below the permissible limits of 25 mgL^{-1} [49].

Conductivity serves as a good and rapid measure of the total dissolved solids in water [50]. The values of Electrical conductivity (EC) during the dry season ranged from 92.85 to 174.50 (mean 126.08 ± 29.08) µS/cm, 105.40 to 318.65 (mean 202.56 ± 74.04) µS/cm and 115.33 to 144.95 (mean 124.93 ± 10.67) µS/cm for Egbe dam, Ureje dam and Ero dam respectively while during the rainy season, the values ranged from 109.75 to 161.15 (mean 134.22 ± 18.91) µS/cm, 131.00 to 306.90 (mean 212.65 ± 57.09) µS/cm and 105.45 to 202.50 (mean 129.67 ± 36.08) µS/cm for Egbe dam, Ureje dam and Ero dam respectively. The importance of Electrical Conductivity (EC) is due to its measure of cations which greatly affects the taste and thus has significant impact on the user acceptance of the water as potable [51]. In this study, the mean highest values of conductivity were recorded in Ureje dam in both seasons. The observed values of conductivity were lower than recommended limits in all the dams during both seasons and low conductivity might be responsible for the soft and moderately hard nature of the water of the dams. The highest value of conductivity recorded in Ureje dam during both seasons was likely to be influenced by the highest value of TDS recorded in the same dam during the study since the higher the concentration of total dissolved ions and salts in solution, the greater the conductivity [52]. In Egbe dam, Ureje dam and Ero dam the mean monthly electrical conductivity was higher in the wet season than in the dry season, possibly because the water bodies were recharged during the rainy season and salts and nutrients were leached to the water table. This result is in agreement with the findings of Rubio-Arias *et al* on aquatic man-made lake in Mexico and reported that higher EC levels do not mean that the water will present a health issue but it can be indicative of the amount of dissolved chemicals in the water [30]. High conductivity value was reported to be indicative of an increase in the amount of polluting particles [53]. The higher level of electrical conductivity of the dams during the wet season is a good measure of dissolved solids and can be used in determining the suitability of water for irrigation purposes [54].

The values of TDS during the dry season ranged from 39.05 to 64.35 (mean 47.40 ± 10.63) mgL^{-1}, 45.50 to 147.00 (mean 87.26 ± 34.78) mgL^{-1} and 39.50 to 68.00 (mean 52.17 ± 9.66) mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively while the TDS values for the rainy season ranged from 53.95 to 82.40 (mean 67.43 ± 10.80) mgL^{-1}, 66.20 to 123.15 (mean 92.62 ± 19.15) and 40.85 to 95.40 (mean 57.42 ± 20.12) mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively. The mean TDS values during the rainy season were higher than the mean TDS values during the dry season in all the dams. The increase in mean TDS during the rainy season may be due to increase run-offs and higher oxygen content observed during the rainy season which facilitated dissolution, ion exchange capacity. Similar to TSS, high concentrations of TDS may also reduce water clarity, contribute to a decrease in photosynthesis, and combine with toxic compounds and heavy metals. An increase in TDS beyond acceptable levels can have a significant impact on municipal, industrial, and agricultural use of water as TDS imparts an unusual taste to water and lessen its usefulness as potable water [55, 56]. However, the values of TDS recorded in the three dams during both seasons were lower than the recommended limit.

The colour values were 5 hazen units through the months of sampling and during both seasons except May, June and July, 2018 at Ureje dam when the colour values were different. Hence, higher mean colour values were noticed in May during the commencement of the rain and in June and July during the wet season in Ureje dam. The highest mean colour value (5 Hazen unit) recorded during the dry season was about 1½ times lower than the highest mean colour value (7.29 ± 2.55 Hazen unit) recorded in Ureje during the wet season. High colour values measured during the wet season compared to the dry season's values in Ureje can be attributed to runoff into the water body with high entrained suspended particles and coloured substances predominantly of organic origin.

Total solids (TS) ranged from 40.95 to 69.30 (mean 50.43 ± 11.98) mgL^{-1}, 48.90 to 155.20 (mean 94.97 ± 36.37) mgL^{-1} and 45.00 to 73.40 (mean 58.34 ± 9.56) mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively during the dry season while the TS values for the rainy season ranged from 56.87 to 88.09 (mean 72.09 ± 11.80) mgL^{-1}, 70.21 to 135.80 (mean 99.53 ± 22.20) and 46.15 to 102.50 (mean 63.77 ± 20.74) mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively. The mean TS values during the rainy season were higher than the mean TS values during the dry season in all the dams. The higher TS values recorded in the dams during the rainy season indicated the input of runoffs that brought large amount of dissolved solids and suspended solids into the dams.

The concentration of nitrate (NO_3) was recorded to be in the range of 0.01 – 0.10 (mean 0.041 ± 0.04) and 0.00 mgL^{-1} respectively for dry and wet seasons in Egbe dam; range of 0.00 – 0.50 (mean 0.143 ± 0.22) and 0.00 – 0.50 (mean 0.20 ± 0.27) mgL^{-1} respectively for dry and wet seasons in Ureje dam and a range of 0.01 – 0.50 (mean 0.187 ± 0.27) and 0.00 – 1.25 (mean 0.56 ± 0.56) mgL^{-1} respectively for dry and wet seasons. This study has shown that the overall level of nitrate was very low. The values of nitrate in the study dams during dry and rainy seasons were well below the permissible standard limits. Maximum acceptable permissible concentration of nitrate for humans, as well as animals including wildlife either for drinking or for recreation and aesthetics is 10 mg/l to 100 mg/l [57]. Higher mean value of nitrate during the rainy season than dry season was recorded in Ero dam and lower values in Egbe dam and Ureje dam. Nitrate in the studied dams may result from soil erosion, livestock wading, bathing, and washing clothes in dams' banks. Unlike temperature and dissolved oxygen, the presence of normal levels of nitrates usually does not have a direct effect on aquatic insects or fish. However, excess levels of nitrates in water can create conditions that make it difficult for aquatic insects or fish to survive. Many fish will not show any symptoms of nitrate poisoning until the level reaches 100 ppm or even higher, but studies have shown that long-term exposure to sub-critical concentrations of nitrate stresses fish, making them more susceptible to disease, interfering with the growth of young, and decreasing the likelihood of reproduction [58]. High concentrations of nitrate in drinking water can be detrimental to both humans and other animals as elevated nitrate concentrations in drinking water can cause methaemoglobinemia in infants and stomach cancer in adults [59]. In this study, nitrate was not detected in most of the samples in the three dams during the rainy season and this in agreement with Hooda *et al*, who reported that the greatest leaching of nitrate occurs after heavy rainfall [60].

The recorded values of nitrite (NO_2) in the dams varied from 0.00 to 0.03 (mean 0.006 ± 0.01) mgL^{-1}, 0.00- 0.18 (mean 0.033 ± 0.07) and 0.00 – 0.01 (mean 0.002 ± 0.002)

mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively during the dry season while nitrite was not detected in any of the three dams during the rainy season. The values of nitrite in all the three dams during the dry season were below the minimum standard limit for drinking water.

The recorded values of phosphate (PO_4) varied from 0.00 to 0.04 (mean 0.015 ± 0.02) mgL^{-1}, 0.00- 0.05 (mean 0.024 ± 0.02) and 0.00 – 0.01 (mean 0.002 ± 0.003) mgL^{-1} for Egbe dam, Ureje dam and Ero dam respectively during the dry season while the phosphate was not detected in any of the three dams during the rainy season. The values of phosphate in all the three dams during the dry season were below the minimum limit while phosphate was not detected in any of the three dams in any of the months during the rainy season. The highest mean value of phosphate recorded at Ureje dam during the dry season may be due to point source discharges from domestic effluents around the dam. Enrichment of water with organic phosphates and nitrates may result in an excessive growth of plants and other organisms which leads to eutrophication and increased biological oxygen demand. As with nitrate, the low level of phosphate recorded overall in the three dams indicates that the dams were not yet expose to eutrophication.

The three dams contained detectable amounts of Na, Ca, K, Fe, Mn, Zn, Mg, Cu, Pb, and Cd in water. In Egbe dam, Na value was highest in January (31.10 ppm) and the lowest value was recorded in March (13.55 ppm) with average value of 22.62±7.39 ppm during the dry season while the highest Na value was recorded in September (30.5 ppm) and the lowest value (16.10 ppm) was obtained in August with an average value of 22.94±5.99 ppm during the rainy season. Na values recorded the lowest value in January (7.55 ppm) and highest value in April (12.475 ppm) and the average value was 10.74±2.09 in Ureje dam during dry season while during the rainy season, Na value was highest in August (32.05 ppm) and lowest in October (15.15 ppm) with an average value of 22.39±6.09 ppm. The highest value of Na in Ero dam was recorded in January (44.45 ppm) and the lowest value was obtained in November (36.65 ppm) with an average value of 40.22±1.29 ppm during the dry season while during the rainy season, the highest value of Na was recorded in October (66.05 ppm) and the lowest value was obtained in May (44.10 ppm) with average value of 53.90±3.60 ppm.

The highest value of Ca during the dry season was recorded in Egbe dam in November (54.00 ppm) and the lowest value was obtained in March (27.90 ppm) with the average of 40.30 ± 10.35 ppm while during the rainy season the highest value of Ca was recorded in October (79.20 ppm) and the lowest in May (34.13 ppm) with average value of 54.92±17.56 ppm. In Ureje dam, the highest value of Ca was obtained in March (26.95 ppm) and the lowest value in January (18.25 ppm) with average value of 23.18 ± 3.34 ppm during dry season while during the rainy season, Ca had the highest value in August (33.80 ppm) and the lowest value in September (26.45 ppm) with the average value of 29.47±2.63 ppm. Ca recorded the highest value during dry season in Ero dam in February (65.20 ppm) and the lowest value in January (43.40 ppm) with the average value of 53.12±3.61 ppm while during rainy season, the highest value of Ca was obtained in September (56.65 ppm) and the lowest value in May (48.44 ppm) with the average of 52.54±1.50 ppm.

The value of K in Egbe dam during the dry season was highest in November (12.55 ppm) and lowest in January (8.60 ppm) with the average value of 11.11±1.61 ppm and during the rainy season, the highest value was recorded in September (19.55 ppm) and the lowest value in June (9.80 ppm) with the average value of 13.16±3.44 ppm. The highest value of K during the dry season was recorded in Ureje dam in March (14.85 ppm) and the lowest value was obtained in February (8.55 ppm) with the average of 11.60 ± 2.00 ppm while during the rainy season the highest value of K was recorded in September (22.60 ppm) and the lowest in May (13.75 ppm) with average value of 17.50±3.12 ppm. In Ero dam, the highest value of K was obtained in February (35.7 ppm) and the lowest value in November (28.20 ppm) with average value of 31.57±1.09 ppm during dry season while during the rainy season, K had the highest value in October (33.80 ppm) and the lowest value in July (20.55 ppm) with the average value of 26.11±2.22 ppm.

The highest value of Fe during the dry season was recorded in Egbe dam in January (0.194 ppm) and the lowest value was obtained in November (0.140 ppm) with the average of 0.18 ± 0.02 ppm while during the rainy season the highest value of Fe was recorded in May (0.141 ppm) and the lowest in September (0.069 ppm) with average value of 0.10 ± 0.03 ppm. In Ureje dam, the highest value of Fe was obtained in March (0.359 ppm) and the lowest value in January (0.241 ppm) with average value of 0.31 ± 0.04 ppm during dry season while during the rainy season, Fe had the highest value in May (0.266 ppm) and the lowest value in July (0.153 ppm) with the average value of 0.20 ± 0.04 ppm. Fe recorded the highest value during dry season in Ero dam in April (0.074 ppm) and the lowest value in February (0.0437 ppm) with the average value of 0.060±0.005 ppm while during rainy season, the highest value of Fe was obtained in October (0.094 ppm) and the lowest value in May (0.0526 ppm) with the average of 0.081± 0.03 ppm.

The value of Mn in Egbe dam during the dry season was highest in November (0.275 ppm) and lowest in February (0.116 ppm) with the average value of 0.21±0.05 ppm and during the rainy season, the highest value was recorded in May (0.221 ppm) and the lowest value in September (0.120 ppm) with the average value of 0.17±0.04ppm. The highest value of Mn during the dry season was recorded in Ureje dam in March (0.269 ppm) and the lowest value was obtained in November (0.064 ppm) with the average of 0.19±0.08 ppm while during the rainy season the highest value of Mn was recorded in May (0.186 ppm) and the lowest in October (0.085 ppm) with average value 0.12±0.04 ppm. In Ero dam, the highest value of Mn was obtained in February (0.114 ppm) and the lowest value in January (0.0835 ppm) with average value of 0.096±0.005 ppm during dry season while during the rainy season, Mn had the highest value in September (0.308 ppm) and the lowest value in May (0.168 ppm) with the average value of 0.24±0.02 ppm.

The highest value of Zn during the dry season was recorded in Egbe dam in November (0.314 ppm) and the lowest value was obtained in February (0.170 ppm) with the average of 0.24±0.07 ppm while during the rainy season the highest value of Zn was recorded in July (0.41 ppm) and the lowest in October (0.152 ppm) with average value of 0.27±0.10 ppm. In Ureje dam, the highest value of Zn was obtained in March (0.130 ppm) and the lowest value in February (0.117 ppm) with average value of 0.12±0.005 ppm during dry season while during the rainy season, Zn had the highest value in August (0.419 ppm) and the lowest value in September (0.211 ppm) with the average value of 0.30±0.09 ppm. Zinc recorded the highest value during dry season in Ero dam in November (0.107 ppm) and the lowest value in April (0.094 ppm) with the average value of 0.101±0.002 ppm while during rainy season, the highest value of Zn was obtained in August (0.509 ppm) and the lowest value in May (0.2875 ppm) with the average of 0.39±0.034 ppm.

In Egbe dam, Mg value was highest in January (5.313 ppm) and the lowest value was recorded in November (4.118 ppm) with average value of 4.82±0.44 ppm during the dry season while the highest Mg value was recorded in July (5.721 ppm) and the lowest value (3.858 ppm) was obtained in September with an average value of 4.87±0.69 ppm during the rainy season. Mg values recorded the lowest value in November (3.666 ppm) and highest value in March (4.676 ppm) and the average value was 4.21±0.34 in Ureje dam during dry season while during the rainy season, Mg value was highest in August (5.717 ppm) and lowest in October (4.102 ppm) with an average value of 4.96±0.53 ppm. The highest value of Mg in Ero dam was recorded in November (2.472 ppm) and the lowest value was obtained in April (2.135 ppm) with an average value of 2.25±0.05 ppm during the dry season while during the rainy season, the highest value of Mg was recorded in June (6.201 ppm) and the lowest value was obtained in May (4.135 ppm) with average value of 5.57±0.31 ppm.

Cu showed the highest value in April (0.207 ppm) and the lowest value in January (0.111 ppm) with the average value of 0.17±0.04 ppm in Egbe dam during the dry season while during the rainy season, Cu had the highest value in October (0.248 ppm) and the lowest value in August (0.099 ppm) with the average value of 0.16±0.05 ppm. Ureje dam recorded the highest value of Cu in March (0.155 ppm) and the lowest value in November (0.09) with the average value of 0.12±0.03 ppm during the dry season while during the rainy season, Cu had the highest value in October (0.193 ppm) and the lowest value in June (0.111 ppm) with average value of 0.16±0.03 ppm. In Ero dam, the highest value of Cu was recorded in April (0.0425 ppm) and the lowest in February (0.0135 ppm) with the average of 0.030±0.004 ppm during the dry season while during the rainy season, the highest value of Cu was obtained in June (0.114 ppm) and lowest in May (0.04 ppm) with the average value of 0.069±0.02 ppm.

The value of Pb in Egbe dam during the dry season was highest in January (0.011 ppm) and lowest in April (0.003 ppm) with the average value of 0.005±0.003 ppm and during the rainy season, the highest value was recorded in May and July (0.0025 ppm) and the lowest value in September (ND) with the average value of 0.0013±0.0010 ppm. The highest value of Pb during the dry season was recorded in Ureje dam in November, December, February, March and April (0.001 ppm) and the lowest value was obtained in January (ND) with the average of 0.001±0.0004 ppm while during the rainy season the highest value of Pb was recorded in May, June, July, August (0.001 ppm) and the lowest in September and October (ND) with average value of 0.001±0.0005 ppm. In Ero dam, the highest value of Pb was obtained in February (0.0055 ppm) and the lowest value in April (0.00125 ppm) with average value of 0.0031±0.006 ppm during dry season while during the rainy season, Pb had the highest value in July (0.01 ppm) and the lowest value in May (0.002 ppm) with the average value of 0.0048 ± 0.0014 ppm.

In Egbe dam during the dry season, Cd had the value of 0.001 ppm from November to February and was not detected in March and April. It has average value of 0.001±0.0005 ppm during dry season while it was not detected in water samples during the rainy season. In Ureje dam, Cd was not detected in water samples both during dry and rainy season. In Ero dam, the highest value of Cd was obtained in February (0.001 ppm) and was not detected in November to January and had average value of 0.00032±0.0002 during the dry season while Cd was not detected in the water samples during the rainy season.

In natural aquatic ecosystem, metals occur in low concentrations. Metals, though are essential to life, all metals are toxic at higher concentrations, because they cause oxidative stress by formation of free radicals and they can replace essential metals in pigments or enzymes disrupting their function. In the present study, it was obvious that the mean metal concentrations (ppm) in the water of the three Ekiti State dams based on monthly sampling for the metals (Na, Ca, K, Fe, Mn, Zn, Mg, Cu, Pb and Cd) were below recommended and permissible limits for drinking water by WHO and other international Agencies in all the dams except for Cu, Mn, Fe and K in Ureje and Egbe dams and K, Cu, Mn, Fe, Pb and Cd in Ero dam during the dry season. The mean seasonal values of metals during the rains were below safe limits except for Cu, Mn, K and Fe in Ureje dam; Cu, Mn, K, Fe and Zn in Egbe dam and Ero dam. The concentration of these metals in water above the recommended limit by WHO and other Agencies indicated that the water of the dams may not be suitable for drinking nor the fish safe for human consumption. There were seasonal variations in the metals concentrations in the three dams. Wet season recorded higher levels of heavy metals than dry season with an exception of Mn, Fe, Cu, Pb and Cd in Egbe dam and Ero dam and Cu, Fe and Mn in Ero dam (Table 2). Surface run-offs following rainfall therefore seem to be one of the main methods of washing the metals into the dams.

Ca is most abundant ions in fresh water and is important in shell construction, bone building and plant precipitation of lime. The highest amount of calcium recorded in water samples of the dams during the rainy season may be due the addition of sewage waste along with rain water. The lowest amount of Ca in water sample recorded during dry season may be due to calcium absorbed by the large number of organisms for shell construction, bone building and plant precipitation of lime [61]. Mg is often associated with Ca in all kinds of waters, but its concentration remains generally lower than the calcium as observed in this study [62]. Magnesium is essential for chlorophyll growth and acts as a limiting factor for the growth of phytoplankton [61]. The highest amount of sodium recorded during rainy season in the dams may be due to the addition of waste water from the use of detergents and soaps for clothes washing and for bathing brought into the dams by runoffs from around the dams. This is in agreement with the observation of Chin that an elevated concentrations of Na in surface waters may arise from sewage and industrial effluents which directly joins lake water [63]. Though Mn concentration in the dams was higher standard limit but according to the EPA, health effects of Mn are not of a concern until concentrations are approximately 10 times higher. In concentrations higher than 0.05 mg/l Mn may become noticeable by impairing color, odor, or taste to the water. Water with a high concentration of Fe and Mn as in this study may cause the staining of plumbing fixtures or laundry. Mn solids may form deposits within pipes and break off as black particles that give water an unpleasant appearance and taste. Similarly, iron can collect and block pipes or fixtures and produce rust flakes in water. Both substances can increase the growth of unwanted bacteria that form a slimy coating in water pipes. Water with a Zn concentration of more than 5 mg/L may start to be become chalky in appearance with a detectable deterioration in taste. In addition, high concentration of Zn can be toxic to the organism. Contamination of drinking water with high level of Cu may lead to chronic anemia [64]. Cd can accumulate in the kidneys and is implicated in a range of kidney diseases [65]. Lead mimics calcium, thereby inhibiting neurotransmission [66].

Conclusively, from the results of this study it may be said that the water from Egbe, Ureje and Ero dams may support fish production but is not fit for domestic and drinking purpose without adequate treatment and measures are to be put in place to prevent accumulation of contaminants in the dams.

References

[1] World Health Organization (WHO) (2005). Water, Sanitation and Hygiene Programming Guidance Water Supply and Sanitation Collaborative Council and World Health Organization, 2005 Printed in Geneva 1219 Chatelaine, Geneva, Switzerland.

[2] M. Ali, A. Salam, N. Ahmed, B. Khan and M. Y. Khokhar (2004). Monthly Variation in physico- chemical characteristics and metal contents of Indus River at Ghazi Ghat, Muzaffargarh, Pakistan. *Pakistan Journal of Zoology*, 36 (4): 295-300.

[3] A. M. A. Imevbore (1970). Some Preliminary observations on the ratios and fecundity of the fish in River Niger. In: S. A Visser (ed) *Kainji Lake Studies*. Vol. I, Ecology, S. A Visser (ed), 87-88.

[4] Y. Singh, P. W. Ramteke, M. Shashwat and K. S. Pradeep (2013). Physico-chemical analysis of Yamuna River Water. *International Journal of Research in Environmental Science and Technology*, 3 (2): 58-60.

[5] O. M. Kolawole, K. T. Ajayi, A. B. Olayemi and A. I. Okoh (2011). Assessment of water quality in Asa River (Nigeria) and its indigenous Clarias gariepinus fish. *International Journal of environmental research and public health*, 8 (11): 4332-4352.

[6] P. O. Agbaire and C. G. Obi (2009). Seasonal variation of some physico-chemical properties of River Ethiope water in Abraka, Nigeria. *Journal of Applied Sciences and Environmental Management* 13: 55-57.

[7] P. U. Verma, D. Chandawat, U. Gupta and H. A. Solanki (2012). Water quality analysis of an organically polluted lake by investigating different physical and chemical parameters. *International Journal of Research in Chemistry and Environment* 2: 105-112.

[8] N. Djukic, S. Maletin, V. Pujin, A. Ivanc and B. Milajonovic (1994). Ecological assessment of water quality of Tisze by physico-chemicaland biological parameters. *Tisca Szeged*, 28 (1), 37-40.

[9] X. Kepuska, L. Daija and I. Kristo (2014). Determination of Physico-Chemical parameters of water in Biological minimum in the Lake"Radoniq" *European Scientific Journal,* special/ edition vol. 3, 63-70.

[10] S. O. Adefemi, S. S. Asaolu and O. Olaofe (2007). Assessment of physico-chemical status of water samples from major dams in Ekiti State, Nigeria. *Pakistan Journal of Nutrition*, 6 (6): 657- 659.

[11] H. A. Jones and R. D. Hockey (1964). The Geology of part of S. W. *Nigeria Geological Surv. Bulletin* 31, 87p.

[12] D. R. Prakash, A. S. Jadhav, S. G. Chonde and S. G. Patil (2011). Study of physicochemical and biological characteristics of lakes from Shivaji University Campus, Kolhapur, Maharashtra. *Advances in Applied Science Research*, 2 (6): 505-519.

[13] S. A. Khaled, M. Said, Shuhaimi-Othman and A. K. Ahmad (2012). The Evaluation of Water Quality and Metal Concentrations of Titiwangsa Lake, Selangor, Peninsular Malaysia. *Pakistan Journal of Biological Sciences,* 15: 459-468.

[14] G. C. Tichkule and S. S. Bakare (2017). Physico-Chemical Analysis of Two Freshwater Lakes near Lakhani Dist. Bhandara (M.S.). *Asian Journal of Multidisciplinary Studies*, 5 (9), 31-35.

[15] AOAC (2005). *Official method of analysis Association of analytical Chemist*. Wash. Dc, 15th ed. 11-14.

[16] I. K. Dorcas and R. J. Solomon (2014). Calculation of liver function test in *Clarias gariepinus* collected from three commercial fish ponds. *Nature and Science*, 12 (10): 107-123.

[17] M. K. Mustapha (2008). Assessment of the water quality of Oyun Reservoir, Offa, Nigeria, using selected physico-chemical parameters. *Turkish Journal of Fisheries and Aquatic Sciences* 8: 309-319.

[18] S. S. Asaolu (1999). Variation in the in the physico-chemical parameters of the coastal water of Ondo state. *African Journal of science*, pp: 81-86.

[19] E. O. Idowu, A. A. A. Ugwumba, J. B. Edward and J. A. Oso (2013). Study of the Seasonal Variation in the Physico-Chemical Parameters of a Tropical Reservoir. *Greener Journal of Physical Sciences*, Vol. 3 (4), pp. 142-148.

[20] L. Lambs (2004). Interactions between groundwater and surface water at river banks and the confluence of rivers. *J. Hydrol*., 288: 312-326.

[21] M. A. O'Driscoll and D. R. DeWalle (2006). Stream-air temperature relations to classify stream- ground water interactions in a karst setting, Central Pennsylvania, USA. *J. Hydrol*., 329: 140-153.

[22] M. R. Magee and C. H. Wu (2017). Response of water temperatures and stratification to changing climate in three lakes with different morphometry. *Hydrol. Earth Syst. Sci*. 21, 6253- 6274.

[23] J. S. Read and K. C. Rose (2013). Physical responses of small temperate lakes to variation in dissolved organic carbon concentrations. *Limnol. Oceanogr*. 58, 921–931.

[24] M. Huett (1977). *Text Book of Fish Culture, Breeding and cultivation of fish*. 2nd edition, News Book Publ. University Press, Cambridge, Pp 438.

[25] D. G. McDonald, J. P. Reader, J. P. and Dalziel, T. R. K. (1989). The combined effects of pH and trace metals on fish ionoregulation. In: *Acid toxicity and aquatic animals*. R. Morris, E. W. Taylor, D. J. A. Brown and J. A. Brown (Eds.). Cambridge University Press, Cambridge. pp. 221-242.

[26] D. Chapman and V. Kimtsach (1992). Water Quality Assessment. In: *Selection of Water Quality Variables*. Chapman D., editor. UNESCO, WHO, United Nations Environment Programme, E & FN Spon; Londres, UK. pp. 59–126.

[27] C. E. Boyd and V. K. Pillai (1984). *Water quality management in aquaculture*. CMFRI, Spl. Pub. 22: 1-96.

[28] D. Chapman (1992). Water Quality Assessment. 2nd Edn., World Health Organization, New York, USA.

[29] C. E. Boyd (1982). *Water quality management for pond fish culture*. Elsevier Science Publishing Company, New York.

[30] H. Rubio-Arias, M. Contreras-Caraveo, R. M. Quintana, R. A. Saucedo-Teran and A. Pinales- Munguia, A. (2012). An overall water quality Index (WQI) for a man-made aquatic Reservoir in Mexico. *Int J Environ Res Public Health*; 9 (5): 1687–1698.

[31] S. G. Patel, D. D. Singh and D. K. Harshey (1983). Pamitae (Jabalpur) sewage polluted water body, as evidenced by chemical and biological indicators of pollution. *J. Environ Biol*. 4: 437–449.

[32] C. N. Sawyer, R. L. McCarty and G. F. Parkin (2003). *Chemistry for Environmental Engineering and Science* (5th edition). New York: McGraw-Hill. ISBN 0- 07-248066-1.

[33] GoB (Government of Bangladesh), (1997). Environment Conservation Rules, E.C.R- Shedule 3, Standards for Water.

[34] M. Scholz (2016). Water Quality Standards. In: *Wetlands for Water Pollution Control*; 2^{nd} Edition. Elservier; pp. 1-7. https://doi.org/10.1016/B978-0-444-63607-2.00001-0.

[35] R. Sharma and A. Capoor (2010). Seasonal Variations in Physical, Chemical and Biological Parameters of Lake Water of Patna Bird Sanctuary in Relation to Fish Productivity. *World Applied Sciences Journal* 8 (1): 129-132.

[36] W. A. Wurts (2002). Alkalinity and hardness in production ponds. *World Aquaculture*, 33 (1): 16-17.

[37] BASIN. (2007). General information on alkalinity by Shiela Murphy. Retrieved from http://bcn.boulder.co.us/basin/data/NEW/info/Alk.html

[38] E. O. Idowu and A. A. A. Ugwumba (2005). Physical, Chemical and Benthic faunal characteristics of a Southern Nigerian Reservoir. *The Zoologist, 3:* 15-25.

[39] G. I. Oyakhilome, A. F. Aiyesanmi and F. C. Akharaiyi (2012). Water quality assessment of the Owena multipurpose dam, Ondo State, Southwestewrn Nigeria. *Journ. Envir. Protect*., 3 (1), 14-25.

[40] APHA (2003). *American public Helth Association*. Standard methods for examination of water and wastewater, 20th, Ed. Washington DC, USA.

[41] F. Iqbal, M. Ali, A. Salam, B. A. Khan, S. Ahmad, M. Qamar and U. Kashif (2004). Seasonal variations of physico-chemical characteristics of River Soan water at Dhoak Pathan. *Int. J. Agri. Biol.,* Vol. 6, No. 1, 89-92.

[42] M. Ebrahimpour, H. Alipour and S. Rakhshah, S. (2010). Influence of water hardness on acute toxicity of copper and zinc on fish. *Toxicol Ind Health*. 26 (6): 361-365.

[43] V. Kiyani, M. Hosynzadeh and M. Ebrahimpour (2013). Investigation acute toxicity some of heavy metals at different water hardness. *International journal of Advanced Biological and Biomedical Research*, Volume 1, Issue 2, 2013: 134-142.

[44] G. J. Wang, J. Xie and D. B. Pan (2002). Effects of Ca^{2+}, Mg^{2+} concentration and Ca^{2+}/Mg^{2+} on hatching rates for the eggs of *Anguilla japonica* reared in artificial seawater. *Marine Sciences* 26: 69–71.

[45] L. V. F. Silva, J. I. Golombieski and B. Baldisserotto (2005). Growth and survival of silver catfish larvae, *Rhamdia quelen* (Heptapteridae), at different calcium and magnesium concentrations. *Neotrop Ichthyol* 3: 299–304.

[46] S. Luo, B. Wu, X. Xiong and J. Wang (2016). Effects of Total Hardness and Calcium to Magnesium Ratio of Water during Early Stages of Rare Minnows (*Gobiocypris rarus*). *Comparative Medicine*, *66* (3), 181–187.

[47] D. H. N. Spence (1964). The macrophytic vegetation of freshwater Loch, In: *The vegetation of Scotland*. Ed. A. H. Burnell, Oliver and Boyd, Edinburg and London 306- 425.

[48] C. N. Durfor and E. Becker (1964). Public water supplies of 100 largest cities in United States. *U. S. Geological survey water Quality paper*, 1812: 1-364.

[49] NESREA (2009). National Environmental Standards and Regulation Enforcement Agency Regulations. Volume 96, Number 65. The Federal Government Printer, Abuja, Nigeria.

[50] A. Srivastava, R. Kr, V. Gupta, G. Agarwal, S. Srivastava and I. Singh (2011). Water Quality Assessment of Ramganga River at Moradabad by Physico-Chemical Parameters Analysis. *VSRD Technical & Non-Technical Journal*, 2 (3): 119-127.

[51] WHO (2004). World Health Organization, "*Guidelines for Drinking- Water Quality*," 3rd Edition, World Health Organization WHO), Geneva, 2004.

[52] S. E. Shinde, T. S. Pathan, P. R. Raut, P. R. More and D. L. Sonawane (2010). Seasonal variation in physicochemical characteristics of Harsool- Savangi Dam, District, Aurangabad, India. The Ecoscan- the international quarterly journal of Environmental sciences, 4 (1): p 37-44.

[53] B. O. Oben (2000). Limnological assessment of the impact of agricultural and domestic effluent on three man-made lakes in Ibadan, Nigeria. *Ph.D. Thesis*, University of Ibadan, p. 334.

[54] V. V. Sugunan (1995). Reservoir fisheries of India. FAO Fish Tech. Pap. No. 345. Rome, 423 pp.

[55] J. H. Sherrard, D. R. Moore and T. A. Dillaha (1987). Total Dissolved Solids: Determination, Sources, Effects, and Removal. *The Journal of Environmental Education,* 18: 2, 19-24, DOI: 10.1080/00958964.1987.9943484.

[56] K. M. Mohammed Sheriff and A. Zahir Hussain (2012). Monitoring the quality of groundwater on the bank of Cooum River at Chennai City, Tamil Nadu, India. *Advances in Applied Science Research*, 2012, 3 (6): 3587-3592.

[57] J. O. Riordan (1993). Ambient water quality objectives for Yakoun and its Tributaries, Water quality branch, Water management division, Ministry of Environment, Lands and Parks, Overview Report, Govt. of British Columbia, Canada. Assessed at https://www.researchgate.net/publication/287488931 in May 31st 2019.

[58] S. Jackson (2011). Keeping up with nitrate. *Tropical Fish Magazine*; February issue.

[59] F. M. Anayah and M. N. Almasri (2009). Trends and occurrences of nitrate in the groundwater of the West Bank, Palestine. Applied Geography; 29: 588–601.

[60] P. S. Hooda, A. C. Edwards, H. A. Anderson and A. Miller (2000). A review of water quality concerns in livestock farming areas. *The Science of the Total Environment*; 250: 143–167.

[61] H. A. Solanki (2012). Status of soils and water reservoirs near industrial areas of Baroda: pollution and soil - water chemistry. Lap Lambert Academic Publishing, Germany, ISBN 376.

[62] U. M. Qureshimatva, R. R. Maurya, S. B. Gamit, R. D. Patel, H. A. Solanki (2015). Determination of Physico-Chemical Parameters and Water Quality Index (Wqi) of Chandlodia Lake, Ahmedabad, Gujarat, India. *J Environ Anal Toxicol* 5: 288. doi: 10.4172/2161- 0525.1000288.

[63] D. A. Chin (2006). Water-Resources Engineering, second edn. Pearson Prentice Hall Eaton, F. M. 1950. Significance of carbonate in irrigation waters. *Soil Sci*., 67 (3), 128-133.

[64] M. A. Iqbal, M. N. Chaudary, M. Shujah Zaib, M. Imran, K. Ali, Asma Iqbal; et al. (2011). Accumulation of Heavy Metals (Ni, Cu, Cd, Cr, Pb) in Agricultural Soils and Spring Seasonal Plants, Irrigated by Industrial Waste Water", Journal of Environmental Technology and Management, 2, 3.

[65] WHO (1997). *Health and Environment in Sustainable Development*. WHO: Geneva.

[66] H. Bradl (2005). *Heavy Metals in the Environment*: Origin, Interaction and Remediation. Elsevier/Academic Press, London.