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Water Quality Characteristics of Oyan Lake, Ogun State, Nigeria

O.A. Olopade and O.T. Okulalu

Department of Renewable Resources, College of Agricultural Sciences,
Olabisi Onabanjo University, Ogun State, Nigeria

Abstract: A limnological study to determine the water quality of Oyan Lake, Ogun State, Nigeria was carried out between April 2007 and March 2008 at the dam site. Standard methods were used to monitor the physico-chemical parameters. The physico-chemical parameters investigated are water temperature, pH, alkalinity, conductivity (physical), hardness, dissolved oxygen, biological oxygen demand (BOD) (chemical), total dissolved solid, total suspended solid, total solid (solute content), chloride concentration, calcium, magnesium, sodium, potassium (ionic concentration), lead and zinc (heavy metals). Following results obtained, Ranges and means of each physico-chemical parameters measured were water temperature 23.23 to 28.87°C (mean 26.28°C); pH 5.80 to 8.01 (7.04); alkalinity, 4.17 to 20.0mg/l (mean 8.92mg/l); hardness, 29.33 to 86.67mg/l (mean 51.92mg/l); conductivity 50.0 to 100.0µs/cm (66.39µs/cm); dissolved oxygen concentration 5.43 to 8.03mg/l (6.96mg/l); biological oxygen demand 4.04 to 6.87mg/l (5.08mg/l); total dissolved solid 0.37 to 1.47mg/l (0.65mg/l); total suspended solid 0.13 to 0.73mg/l (0.27mg/l); total solid 0.53 to 1.73mg/l (0.93mg/l); calcium 25.33 to54.67mg/l (31.06mg/l); magnesium 4.00 to 38.67mg/l (24.03mg/l); sodium 3.00 to 6.00mg/l (4.44mg/l); potassium 1.00 to2.33mg/l (1.64mg/l); lead 0.01 to 1.33mg/l (0.30mg/l); zinc 0.02 to 0.61mg/l (0.20mg/l). Further result shows that there were marked seasonal variations in the physico-chemical characteristics of the lake and these were observed to be influenced by the volume of water available per time. The result obtained indicates that at point of significance ($P<0.05$) temperature had a negative but strong relationship with BOD; conductivity also had negative relationship with BOD, sodium and potassium; magnesium had negative but weak relationship with total solid (TS); TDS and sodium also had negative relationship with potassium. The physico-chemical recorded throughout the period of study was in conformity with recommended values for tropical waters expect for alkalinity and hardness, which fell below the recommended values. Oyan Lake is therefore confirmed as containing water of acceptable quality and quantity to be suitable for municipal, acquacultural, agricultural and industrial purposes.

Key words: Water Quality · Limnology · Physico-Chemical Characteristics · Oyan Lake

INTRODUCTION

Nigeria has numerous water bodies most of which provides the populace with needed animal protein [1] These inland water resources include rivers, streams, flood plains, wetlands and lakes (natural and man made). There are over 323 man made lakes [2] occupying a total not less than 303,600 hectares of land [3]. Such vast water resources have added considerably to already existing rich water potential for the development of the country's fishery resources. These man- made lakes will continue to grow in number with mounting demand of water for irrigation, power generation, domestic and industrial needs.

Studies have shown that the conversion of a lotic ecosystem into a lacustrine one causes changes in the water quality (Egborge, [4, 5, 6, 7]. This variation in water quality has been explained in terms of dominance of precipitation chemistry or bedrock chemistry or evaporation- crystallization process within the lake and its entire basin i.e. the hydrological regime of the lake which affects water depth and inundation of areas and nutrient from tributary streams affect water quality [8]. As a result of the effect of the change in water quality on the existence and productivity of aquatic flora and fauna, especially in newly formed lentic environment. The Oyan dam is the largest man- made Lake in Ogun State. It was created about 15 years ago by the damming of Oyan and

Corresponding Author: O.A. Olopade, Department of Renewable Resources, College of Agricultural Sciences, Olabisi Onabanjo University, Ogun State, Nigeria

Ofiki Rivers. The increase in pressure on the dam resulting from diverse human activities and the renewed government interest aimed at optimizing the use of the facility by including the hydro electric power generated from it in the national grid as well as using the water (quantity) for irrigation of farmlands around the area, thereby boasting the nation's food security campaign. As a result of all these, knowledge of the physico- chemical regimes of this water body is of immense value, as it will ensure availability of information, which will help in determining its productivity and usefulness to the entire state and the nation as a whole.

The Objectives of the Study Were:

- To assess the present water quality of the Oyan dam.
- To examine the concentration of trace metal in the Oyan dam
- To draw inferences on the consistence or variation of data collected during the period of this study in comparism with previous assertions on the water quality of the Oyan Lake.

MATERIALS AND METHODS

Study Area: Oyan Lake, owned and operated by the Ogun-Oshun River Basin Development Authority (O-ORBDA) lies between latitude 7°15'N and longitude 3°16'E (Figure 2) at an elevation of 43.3 meters above sea level on the confluence of Oyan and Ofiki Rivers, both tributaries of Ogun River, some 20 kilometers Northwest of Abeokuta, close to Badagry-Sokoto highway [9, 10]. It has a catchment area of approximately 9,000 km^2 within the southern climatic belt of Nigeria. The lake covers an area of 4000 hectares. It was constructed to supply 525 million litres and 175 million litres of raw water per day to the water corporations at Lagos and Abeokuta, respectively. It was also designed to provide water for the irrigation of about 3000ha lower Ogun irrigation project under construction.

The dam consists of an earth fill embankment with gated concrete service pillage and auxiliary spillways. The earth fill consists of a central impervious core of clay lateritic material surrounded by a shell of compacted granule. The total length of the embankment is 10.44m while its maximum height is 30m.

Rainfall is the source of moisture in Oyan Lake area; it is brought about by the southwestern wind from the Atlantic Ocean [11]. Rain commences effectively in March/ April reaching its peak in June/ July and another peak in September/October with an August break between thereby giving a bi-modal pattern of histogram. The belt is therefore characterized by a rainy season of about 8 m onths and a dry season of about 4 months (November-February) with a mean relative humidity of 75-100% [12] a mean precipitation of 1000-1250mm [13] and a mean temperature of about 30°C [14].

The economic activities in the catchment include cultivation of crops such as maize, cassava, vegetables and yam as well as the raising of livestock and fishing. The communities around the river use the water extensively for drinking and other domestic purposes without prior treatment.

Sampling and Fieldwork: Three sampling stations were chosen based on accessibility. Each station was sampled monthly from April 2007 to March 2008. The sampling covered both wet and dry seasons of the year for Nigeria. Surface water samples for physico- chemical analysis were collected mid-stream at depth 20-30cm directly into clean 1 litre plastic bottles

Temperature and pH were measured insitu using a temperature probe and portable pH meter (model Kent, EIL 7045/46) respectively. For the dissolved oxygen (DO) determinations, separate samples were collected into 300ml plain glass bottles and the DO fixed using the DO meter (model 970 DO_2 meter, JENWAY). Samples for the Biological Oxygen Demand (BOD) were collected into dark glass bottles for incubation and subsequent DO determination after 120 hours (5 days). Samples for alkalinity, hardness, calcium and chloride concentrations were collected into sterilized plain glass bottles. All samples were stored in an icebox at 4°C and transported to the laboratory for analysis.

Laboratory Analysis: The physico-chemical parameters were determined according to the procedures outlined in the Standard Method for the Examination of Water and Waste Water [14]. Conductivity was measured with the HACH conductivity meter (model WPA CMD 400). Calcium and Magnesium were measured by EDTA titration, Chloride by Argentometric titration and Alkalinity by strong acid titration method. Total dissolved solid and suspended solids were measured gravimetrically after drying in an oven to a constant weight at 105°C. BOD was determined by iodometric titration. Samples for heavy metals were analysed using Alpha 4 Atomic Absorption spectrophotometer (AAS)

Statistical Analysis of Data: Simple statistical manoeuvre such as means, analysis of variance (ANOVA) and correlation were adopted from [15] and estimated using the Software Statistic 5.0 on the computer.

RESULTS AND DISCUSSIONS

Physico-chemical Parameters: The results presented in Table1 shows that the range of surface water temperature of Oyan Lake indicated a generally low temperature (23.0°C-29.1.°C) throughout the period of study.

The lowest water temperature (23.0°C-26.2°C) of the rainy season of April to August may be due to the succession of heavy downpour which reached its peak in June with the lowest temperature of 23.0°C. The rains caused a reduction in atmospheric temperature hence low surface water temperature.

The highest water temperature (28.0°C-29.1°C) recorded in the months of October to December and subsequent relatively lower temperature averaging 24.03°C and 24.83°C for January and February were due to the cool dry North East trade wind effect (harmattan) that was severe during the period of study. Temperature observation is thus similar to that recorded for other tropical lakes [5, 17].

An increase in temperature results in a corresponding increase in the concentrations of TDS since such temperature increase aided evaporation of surface water thereby reducing the volume of water in the lake [18]. This means that more solute is dissolved into the water during higher temperature causing a faster rate of decomposition of rocks and the release of more solute into the lake. The observation of a high TDS value in the dry season months of March and April (Table 3) is in accordance with the observation of Adeniji [19]. Who observed that a rise in temperature results in a corresponding increase in concentration of TDS. However, the exceptionally high TDS observed in the month of June (1.47mg/l) was as a result of flooding and consequently, a great influx of materials along with run-off into the water. The month of May marked or signified the on-set of the rains though sparingly and a gradual increase in the volume of water. This was most likely responsible for the low TDS value recorded that month and the lowest TDS value (0.37mg/l) recorded in October was as a result of the highest volume of water in the lake at the beginning of the dry season. The volume of water was the highest as a result of accumulation of rainwater through the previous rainy months. These values were not high compared with WHO guideline value of 1000mg/l.

Table 1: Means of surface water temperature, pH, alkalinity and hardness of Oyan Lake

Month	Temperature (°C)	pH	Alkalinity	Hardness (mg/l)
Wet Season:				
April	25.97	8.01	16.67	29.33
May	26.00	5.80	13.33	45.33
June	23.23	6.77	20.00	86.67
July	26.10	7.50	6.67	40.67
August	26.13	7.57	7.50	45.33
September	27.90	6.88	4.17	56.67
October	28.07	5.80	5.00	47.00
Dry season:				
November	28.50	6.77	5.00	44.67
December	28.87	7.02	5.00	62.67
January	24.03	7.58	11.67	63.33
February	24.83	6.80	6.67	57.33
March	25.73	8.01	5.33	44.00

Source: Field survey, 2007/08

Table 2: Monthly mean of conductivity, DO and BOD of Oyan Lake

Month	Conductivity (μs/cm)	DO	BOD
Wet Season:			
April	63.33	6.70	4.88
May	100.00	6.73	4.96
June	76.67	6.40	4.36
July	50.00	8.00	5.91
August	83.33	7.98	5.33
September	60.00	8.03	4.67
October	60.00	7.14	5.22
Dry season:			
November	60.00	6.23	4.04
December	73.33	6.25	5.13
January	60.00	6.71	4.49
February	56.67	6.70	5.13
March	73.33	5.43	6.85

Source: Field survey, 2007/08

From the results presented in Table 2, DO conformed to [20, 21] with an observation of high DO values during high water volume periods (July-September) of the rainy season. Rainfall caused movement and agitation on the water surface resulting in aeration i.e. oxygenation of surface water. The reduction in DO value during the dry season could be attributed to the reduction in the wind action during this period as well as the need for a continuous decomposition as a result of inundation of the lands and the surrounding forest areas. In general, the mean DO values of 6.86mg/l recorded for the lake falls within the recommended level for fish [22].

Table 3: The concentration of solute

Month	TDS (mg/l)	TSS (mg/l)	TS (mg/l)
April	0.93	0.20	1.13
May	0.53	0.73	1.27
June	1.47	0.27	1.73
July	0.37	0.17	0.53
August	0.48	0.25	0.73
September	0.63	0.37	1.00
October	0.37	0.23	0.60
November	0.47	0.22	0.68
December	0.52	0.13	0.65
January	0.67	0.24	0.90
February	0.53	0.25	0.78
March	0.93	0.23	1.17

Source: Field survey, 2008

Table 4: Mean of Ionic Dominance Pattern of the Oyan Lake

Month	Ca (mg/l)	Cl (mg/l)	Mg (mg/l)	Na (ppm)	K (ppm)
Wet Season:					
April	25.33	11.00	4.00	3.67	1.00
May	30.00	15.00	15.33	4.00	1.67
June	54.67	12.67	32.00	5.33	2.33
July	24.00	9.67	16.67	5.67	1.67
August	26.67	8.00	18.67	5.67	1.00
September	36.67	10.00	20.00	4.00	1.00
October	28.67	21.00	19.33	4.33	2.33
Dry season:					
November	25.33	39.00	25.33	3.00	2.33
December	28.00	45.33	34.67	6.00	1.67
January	27.33	41.33	38.67	4.00	2.00
February	26.00	44.33	36.33	4.00	1.67
March	30.00	47.00	23.33	3.67	1.00

Source: Field survey, 2007/08

The pH was within the range of 6.5-8.5 stipulated for drinking and domestic purposes [23]. The pH range recorded in the year of study was within the tolerable range for aquatic life [24]. However, the lowest pH recorded in May and October (Table 1) may be due to the accumulated effect of acid rain at the beginning of the rainy season and in October as a result of the in-flow it received. With the exception of these two months, the pH recorded over this period was within the recommended range of 6.5-9.0 [22]. [25] gave an optimum pH range for most fresh water species of fish to be 6.0-9.0. [26] reported that low pH values such as that recorded in May and October were associated with low depth.

From the Table 2, alkalinity range (4.17mg/l-20mg/l) recorded during this study was far below the recommended value of 50mg/l as Ca to 300mg/l as $CaCO_3$ for freshwater fish culture [27]. This could be because there is no much limestone (Carbonate of Ca and Mg) deposit in the surrounding soils and along the course of the tributaries that enters the reservoir. Waters with an alkalinity less than 10mg/l rarely produce large crops i.e. indicative of poor production [28], it likely has low buffering capacity and will respond poorly to fertilization if diverted for aquacultural purpose.

Table 5: Concentration of Trace metals in Oyan Lake

Month	Lead (ppm)	Zinc (ppm)
Wet season		
April	0.14	0.21
May	1.33	0.61
June	0.45	0.36
July	0.03	0.02
August	0.03	0.03
September	0.03	0.04
October	0.01	0.11
Dry season		
November	0.02	0.03
December	0.03	0.03
January	0.03	0.11
February	1.33	0.61
March	0.14	0.21

Source: Field survey, 2007/08

Thurston, R.V. *et al*. [29] classified 0-75mg/l as soft water and 75-150mg/l to be moderately hard water (alkaline). Therefore the result obtained from this study showed the Oyan Lake as soft. Hard water are however said to be more productive biologically than the soft water.

Wetzel, R.G. [30] described the ionic status of an aquatic system has an index of its fertility, usually determining the level of productivity of such a water body. Such ionic concentration, usually derived from decomposition of submerged vegetation and soils, is also dependent on inflowing streams. The highest conductivity value of 100μs/cm recorded in May and the lowest (50μs/cm) in July (Table 2) indicated that conductivity value was increased with water depth [21, 31]. An increase in conductivity also indicated an increase in available nutrients or food in the lake [32]. The range of conductivity values recorded during the study period was similar to that reported for Jebba Lake [33] which was typical of the Nigerian inland water. The highest concentration of acid, base and salt in the water the highest electrical conductance [34]. However, the parameter does not give cause for concern and it makes the water suitable for direct domestic use.

Table 6: Pearson Correlation of Parameters

	PH	TEMP	CONNs	ALK	HARD	CHLR	CAL	MAGN	DOXY	BOXY	TDS	TSS	TSPPM	SPPM	POTPPM	LEPPM	ZPPM
PH	1.0000																
TEMP	-0.2666	1.0000															
CONNs	-0.3829	-0.1170	1.0000														
ALK	0.0593	-0.6979	0.4140	1.0000													
HARD	-0.2316	-0.3942	0.1664	0.2905	1.0000												
CHLR	0.1107	0.0803	-0.0354	-0.3762	0.1592	1.0000											
CAL	-0.0664	-0.4243	0.3808	0.4327	0.6810	-0.1234	1.0000										
MAGN	-0.0354	-0.2534	-0.0551	-0.1515	0.7390	0.7252	0.2502	1.0000									
DOXY	-0.0739	0.1186	-0.4103	-0.1663	-0.1596	-0.7194	-0.2915	-0.3961	1.0000								
BOXY	0.3688	-0.0138*	-0.0074*	-0.3512	-0.3808	0.1374	-0.0240	-0.1203	-0.1023	1.0000							
TDS	0.2711	-0.6147	0.3077	0.7309	0.5030	-0.0935	0.8356	0.1225	-0.4312	-0.1046	1.0000						
TSS	-0.5570	-0.1102	0.7466	0.2496	-0.0372	-0.2957	0.1258	-0.2504	0.0690	-0.1360	-0.0310	1.0000					
TSPPM	-0.0031	-0.6076	0.6137	0.7756	0.4402	-0.2173	0.8152	-0.0008*	-0.3608	-0.1558	0.8943	0.4195	1.0000				
SPPM	0.0587	-0.0411	-0.0133*	0.0368	0.3451	-0.2848	0.1079	0.1231	0.3741	0.1897	-0.0200	-0.2585	-0.1338	1.0000			
POTPPM	-0.5815	-0.0492	-0.0012*	0.1414	0.4634	0.2057	0.1167	0.4164	-0.2261	-0.5016	-0.0074*	-0.0563	-0.0319	-0.0129*	1.0000		
LEPPM	-0.4501	-0.3798	0.5027	0.2790	0.1237	0.0746	0.0480	0.1137	-0.1654	-0.0540	0.0446	0.6491	0.3311	-0.1764	0.0718	1.0000	
ZPPM	-0.3856	-0.5096	0.5416	0.4331	0.1705	0.0787	0.2027	0.1070	-0.2996	-0.0287	0.2530	0.6087	0.5023	-0.2411	0.0886	0.9640	1.0000

P<0.05 P (0.05) = 1.62

* Shows 5% level of significance

Ionic Dominance Pattern: Table 4 shows that Oyan lake exhibited an overall ionic dominance pattern of Ca>Cl>Mg>Na>K. like most tropical fresh water, there was a dominance of Ca and HCO_3 in the cationic and anionic components respectively [35] Lakes have been classified as poor, medium and rich depending on their calcium content in mg/l being less than 10, between 10-25,and more than 25 respectively [28]. The concentration of chloride varied from 8.00 to 47.00 mg/l and these values were the highest in the dry season as marked by the steady rise in chloride value from October to March. Low chloride level of between 8.00- 47.00 mg/l compared to the WHO limit of 250 mg/l was recorded for the water samples. The magnesium and sodium ions ranged from 4.00- 38.67 mg/l and 3.00- 6.00 mg/l, respectively.

Trace Metals: From the result showing the concentration of trace metals for Oyan Lake recorded during the period of study (Table 5) showed that these metals are within the recommendation for municipal water use and fish production. The concentration of lead in the lake is generally lower than the WHO guideline value for drinking water. The [23] recommended limit for the level of lead in drinking water is 1.0μg per litre. Zn occurs as a natural mineral in many drinking waters. It is an essential dietary nutrient and beneficial element in human metabolism [36]. Levels of Zn in the lake water ranged between 0.02ppm-0.61ppm and these values were far below the background level of 0.50mg/l. therefore, there is no detrimental effect when the water is used for domestic purposes and fish production at the level obtained in this study.

The results shown in Table 6 indicated that at point of significance (P< 0.05) temperature had a negative but strong relationship with BOD; conductivity also had negative relationship with BOD, sodium and potassium; magnesium had negative but weak relationship with total solid (TS), TDS; and sodium also had negative relationship with potassium. The table shows that 80 out of 153 correlation coefficients (52.3%) have positive correlation. Water temperature positively correlates with chloride (R = 0.0803), DO(R = 0.1186). pH positively correlate alkalinity (R = 0.0593), chloride (R = 0.1107), BOD (R = 0.3688), TDS (R = 0.2711) sodium (R = 0.0587).

This result further shows a positive correlation of hardness with conductivity and alkalinity and a negative correlation with temperature and pH.

RESULTS

CONCLUSIONS AND RECOMMENDATIONS

Conclusions: This study on Oyan Lake has revealed some seasonal variation in water quality parameters. These variations have brought about by the rains and the dry season, which determines the volume of the water available in the Lake [37]. Heavy metals concentration in the water was detected to be below the permissible level in Nigeria [38].

The result obtained thus showed that most of the physico-chemical parameters were in conformity with the recommended values for tropical waters except for alkalinity and hardness, which falls below the recommended values. Since hard water is said to be more productive, Oyan Lake is not likely to be highly productive.

Oyan Lake is thus confirmed to be suitable for numerous uses including municipal (domestic) use, aquaculture and agricultural purpose and industrial purposes.

Recommendations: In view of the availability of water, both in quantity and quality, it was noted in this study that this available scarce resource is underutilized. The following recommendations are therefore made to ensure a more effective utilization of this resource.

A policy, which permits the allocation of the surrounding lands for different agricultural practices, which it can successfully, support, should be formulated, judged by the capacity of the dam to supply such volume of water needed.

The dam could as well serve effectively in the supply of domestic water for not just Abeokuta Township but its environs as well. Since the water available falls within the recommendation for municipal purposes, it could be channeled to other neighboring towns including Ayetoro through existing pipelines of the state water corporations. This will ensure the availability of safe water to the citizens of the state since it will require a little effort such as boiling from its users.

Though capture fisheries might have its limitations on the lake due to the felled logs which yet lies beneath the water thereby restricting possibility of gear use to passive thereby limiting catch, the available resource (water) could be channeled for aquacultural purposes. There would also be ready source of cultivars or fingerlings from the various culturable fish species supported by this system.

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