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The Physico-Chemical Water Quality of the Obafemi Awolowo University Teaching and Research Farm Lake, Ile-Ife, Southwest, Nigeria

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Abstract

The physico-chemical water quality of the Obafemi Awolowo University Teaching and Research Farm Lake, Ile-Ife, Nigeria, was studied over an annual cycle (September 2006 to August 2007) almost 40 years after its impoundment in 1967. This was with a view to obtaining the then current state of physico-chemical water quality parameters with their variations in time and space as well as using some of the data obtained to evaluate the aging process of the lake for the 40 years of its existence. There was no significant ($p > 0.05$) horizontal variation (i.e. upstream - dowstream) in the physico-chemical characteristics of the lake whereas, Apparent-colour, True colour, Turbidity, Total Suspended Solids (TSS), Total Solids (TS) and Total Acidity increased significantly ($p < 0.05$) from the lake surface towards the bottom of the lake. In the other hand, water pH, Dissolved Oxygen (DO); Dissolved Oxygen Saturation (DO% Sat.) and Biochemical Oxygen Demand (BOD5) decreased significantly ($p < 0.05$) from the lake surface towards the bottom of the lake.

Dissolved Oxygen (DO), Dissolved Oxygen Saturation (DO% Sat.) and Nitrate ion (NO3-) were significantly higher ($p < 0.05$) in the dry season than in the rainy season while, True colour, pH, Conductivity, Total Hardness, Calcium ion (Ca2+), Magnesium ion (Mg2+), Potassium ion (K+) and Sulphate ion (SO42-) were significantly higher ($p < 0.05$) in the rainy season than in the dry season. The lake water could be regarded shallow, colored, turbid, less transparent, slightly acidic, soft and well-buffered fresh-waterbodies with evidence of aging (i.e. transforming the lake from an oligotrophic status to a eutrophic waterbody). The results indicated that the lake is suitable for most of its applications with little or no adjustments.

Keywords: Inundation; Oligotrophic; Eutrophic; Aging; Man-made; SpillwayUrbanization

Introduction

Water is probably the most important natural resource in the world, since without its life cannot exist and industries cannot operate. Unlike many other resources and/or raw materials, there is no substitute for water in many of its uses. Water plays a vital role in the development of communities since a reliable supply of water is an essential prerequisite for the establishment of a permanent community [1]. Water intended for human consumption should be “safe” and “wholesome” i.e. free from pathogenic agent and harmful chemicals, pleasant to taste and usable for domestic purpose [2]. The immense importance of water in our daily life makes it imperative that thorough examinations be conducted on it for most of its uses. The examinations mostly conducted are under the broad headings viz: physical, chemical and biological analysis. Physical analysis involves measurements of temperature, colour, odour and taste, solids and turbidity. Chemical analyses involve the measurements of cations, anions, nutrient compounds, toxic and non-toxic compounds and, of course tests for oxygen demands by inorganic and organic substances [3].

Boyd (1981) defined water quality as any characteristics of water, whether physical, chemical and biological, that can also affect the survival, reproduction, growth and management of fish. However more stringent control of water contaminants and higher quality standards apply to water intended for human consumption than for other uses. Compounds such as phosphate and nitrate are two important nutrients in the lake loading through point and non-point pollution sources such as washing, bathing, agricultural activities in fringe area, joining of domestic raw sewage, leading to the cultivation of water caltrop (*Trapa spp.*) and huge growth of aquatic macrophytes. These nutrients have been found to support the fast growth of aquatic plants (such as: water hyacinth (*Eichhornia crassipes*), Esthwaite waterweed (*Hydrilla spp.*), hornwort (*Ceratophyllum spp.* etc.) as a result the abundance of these plants lead to gradual shrinking of the lake area along with other complications like low light penetration, reduces oxygen concentration, clogging of water channels, lowers entertainment value of lake and sometimes the depletion of the oxygen level can lead to fish mortality also [2].

The Obafemi Awolowo University Teaching and Research Farm Lake was impounded between March and July 1967 majorly for agricultural purposes like irrigation and fish farming by regular stocking of the lake with different fish species. Adeniyi [4] indicated that fish in the lake survive on the natural food materials supplied through the two inlets (tributaries) and that the lake is often colored darkish brown due to the abundance of plankton life. Besides, in 1969 the following compounds were recommended by the Fisheries Division, Ministry of Agriculture and Natural Resources, Ibadan as manure for the lake

a. About 4 standard head-pans of poultry droppings per acre per month. This was spread uniformly over the lake for some periods in 1969 and 1970.

b. Four pound of Triple superphosphate per acre per month for a period of six months. This was also done for a while and later cancelled due to experiment being conducted by the Zoology Department of the then University of Ife.

The lake was also drained several times in 1970 due to cropping activities and this has continued till present. However, Aderounmu & Adeniyi [5] observed that in 1970, the average minimum depth of 1.37 m was recorded for the lake in the month of April 1970, before drainage began; and the average maximum depth of 5.70 m was recorded in September and October 1970. This present study was conducted between September, 2006 and August, 2007 almost 40 years after its impoundment in 1967 with a view to obtaining the then current state of physico-chemical water quality parameters with their variations in time and space as well as using some of the data obtained to evaluate the aging process of the lake for the 40 years of its existence.

Materials and Methods

Area of Study

Ile-Ife is an ancient town in Southwestern Nigeria in which Obafemi Awolowo University formerly known as University of Ife is situated. The Faculty of Agriculture of the University had set apart the Teaching and Research Farm for the purpose of teaching students on the practical aspects of their courses as well as research at various capacities for education, growth and development. The studied lake is then situated in the Farm within the University. Ile-Ife and its immediate satellite villages lie at approximately Latitudes 07^{0} $26^{/}$ - 07^{0} $33^{/}$ N of the Equator and Longitudes 004^{0} $30^{/}$- 004^{0} $35^{/}$ E of the Prime Meridian at mean altitude of roughly 300 ± 50 m above the mean sea level. Ife is about 40 km south of Osogbo, the Osun State Capital, about 120 km north of the Atlantic Coast, and about 600 km southwest of Abuja the Federal Capital of Nigeria [6].

The lake is man-made being formed by the inundation of the area above the dam constructed a little below the confluence of two streams Elerin which flows between two villages, Kajola and Obagbile villages and its tributary, Omifunfun stream, and both flow from a relatively higher plains through a secondary forest. The lake is situated north to north-east of the University Campus with a wavy-line trapezium basin shape, occupies an approximate area of 11 acres at maximum fill [4]. The dam wall lies at the valley below the Poultry unit of the farm just immediately after The Faculty of Pharmacy drug research garden. The dammed end is being provided with both auxillary and mechanical spillways for the drainage and regulation of excess water. Fluctuation of water levels is always gradual as the shoreline slopes gently except at the dam area where the slope is steep.

The climate of the Ile-Ife area is of the Moist Monsoon Equatorial type [7,8]. Two major seasons prevail in the area, which are: the dry season and the rainy season. The dry season extends from November to March while the rainy season covers the remaining part of the year [9]. The average rainfall is about 1433 ± 256mm (1955 - 1998) with a rainfall surplus of less than 1000 mm. The annual regime is characterized by two peaks (occurring mostly in July and September) separated by a relatively dry spell in August commonly referred to as 'August break' [10]. Ambient air temperatures are moderately high throughout the year with maximum temperatures (32.2 - 34.4^{0}C) usually occurring in July-September [6].

The area lies within the rainforest zone of Nigeria. It is mainly a lowland rainforest, with some areas of derived grassland [11]. The forest subtype is the dry deciduous forest [12]. The vegetation is that of the Guinean Congolean forest [13]. The lake area itself has a narrow shoreline even during dry season and the marginal vegetation consist of grass and water course community. Dominant among the marginal plant species are: *Aneilema beniniense* which tend to encroach on the water; and *Axonopus compresus* which was intentionally planted and maintained by regular cutting. The marginal vegetation gradually leads to a thin stretch of regrowth community which is bordered by the vegetable garden and plant nursery along the path leading from the Poultry unit and either cocoa plantation or secondary forests [4]. Ile-Ife area is underlain by the Pre-Cambrian Basement Complex rocks of which the major types are gneiss, pegmatite, pegmatite schist and undifferentiated schist [14]. The soils of the area are Lixosols and Ultisols.

Sampling Stations and Sample Collection

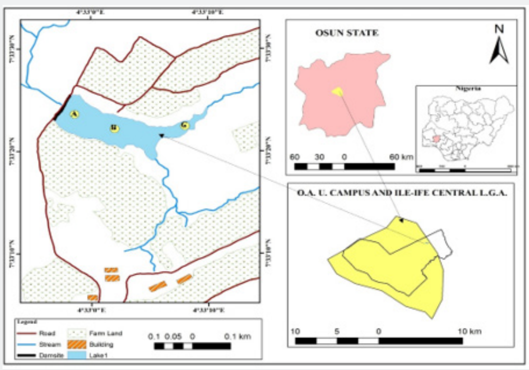

Figure 1: Map of Obafemi Awolowo University (O.A.U.) and Ile-Ife Central L.G.A. showing Teaching and Research farm Lake 1, O.A.U

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Three sampling stations (Station A, B and C; representing the upper reach, mid basin and dam site respectively) were sited along the horizontal axis of the lake from where samples were collected from surface and at one-meter depth intervals towards the bottom of the lake as indicated (Figure 1). The grid-coordinates of the stations were determined using portable global positioning system (GPS) set and are presented in table 1. The field survey for this study was conducted monthly for a period of one year (September 2006 to August 2007). An improvised water sampler made of a bottle with heavy stone tied at the bottom to sink the bottle to the desired depth of the lake water and a removable cork as well as a calibrated rope on it was used for sampling subsurface water at the indicated depths of the lake water. (Table 1)

Table 1: Description and grid-coordinates of the Sampling Stations.

S/N	Sampling Station	Sampling Depth	Site Description	Latitude (N)	Longitude (E)	Altitude (m)
1	AS	Surface	Near the dam	07^0 33.385/	004^0 32.980/	274
	A1	1 m				
	A2	2 m				
	AB	Bottom				
2	BS	Surface	Mid lake	07^0 33.373/	004^0 33.032/	275
	B1	1 m				
	BB	Bottom				
3	CS	Surface	Near inflow	07^0 33.382/	004^0 33.129/	281
	CB	Bottom				

m = meters, N = North, E = East

Water temperature was measured in-situ using mercury-in-glass bulb thermometer with calibration range (-10 ^{0}C – 110 ^{0}C), depth and transparency were also measuring in the field (using a Secchi disc). Samples for analysis of the physico-chemical parameters were collected in a clean 2 litres plastic bottles (except samples for Dissolved Oxygen (DO) and Boichemical Oxygen Demand (BOD)). Glass reagent bottles were used to collect samples for DO determination and the samples were fixed on the field immediately after collection with Winkler's reagent (Manganous sulphate and Alkaline Iodide) while dark reagent bottles were used for BOD determination then kept in a dark cupboard for 5 days for subsequent analysis. Sample pH was measured using a Lovibond (1000 - model) pH comparator, while electrical conductivity was measured with (Jenway 4071 model) conductivity meter at 25 ^{0}C. The conductivity meter was standardized using a set of potassium chloride (KCl) standard solutions [15].

Laboratory Analyses of Samples

The analytical determinations of the physico-chemical parameters of the lake water quality were carried out within the holding time of each parameter, following applicable standard methods [3,16,17]. The (DO) dissolved oxygen content and Boichemical Oxygen Demand (BOD) were determined by Iodiometric titration. The total solids (TS) as well as total dissolved solids (TDS) of the samples were determined gravimetrically after the samples were oven dried to constant weight at 105 ± 2 ^{0}C. Total suspended solids (TSS), was calculated as the difference between TS and TDS.

Color was determined calorimetrically using a colorimeter (Jenway 6051 model) standardized with a set of potassium chloroplatinate-cobalt solutions as Pt-Co standards, while turbidity was determined using a turbidimeter with values expressed in nephelometric turbidity units (NTU) [3]. Total acidity, total alkalinity and chloride ions (Cl^-) contents were determined by titrimetric methods while sulphate (SO_4^{2-}), nitrate (NO_3^-) and phosphate (PO_4^{3-}) ions were determined by spectrophotometric methods. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions were determined by complexio-metric titration method using Na_2 EDTA while Sodium (Na^+) and Potassium (K^+) ions were determined by the atomic emission spectrophotometric method using a flame analyzer. All the recommended quality control (QC) and quality assurance (QA) measures were taken for each determination.

The data obtained were subjected to appropriate statistical analyses including descriptive statistics, analysis of variance (ANOVA), cluster analysis and Principal Component Analysis (PCA) using relevant statistical software *viz:* Paleontological Statistics (PAST), Microsoft Excel, Statistical Product and Service Solutions (SPSS).

Results

Spatial variations of physico-chemical characteristic of the lake

There was no significant ($p > 0.05$) horizontal variation (i.e upstream - dowstream) in the physico-chemical characteristics of the lake as obvious in (Table 2). Vertical variations of the physico-chemical parameters revealed that the values of Apparent-colour, True colour, Turbidity, Total Suspended Solids (TSS), Total Solids (TS) and Total Acidity increased significantly ($p < 0.05$) from (the lake surface = 420.3 ± 59.4 Pt-Co; 122.3 ± 11.8 Pt-Co; 31.1 ± 5.9 NTU; 135.0 ± 22.7 mgL^{-1}; 194.3 ± 23.1 mgL^{-1}; 10.87 ± 0.75 mgCaCO$_3$L^{-1}) towards (the bottom = 749.6 ± 85.2 Pt-Co; 210.2 ± 25.2 Pt-Co; 62.9 ± 7.7 NTU; 205.4 ± 22.6 mgL^{-1}; 261.2 ± 22.6

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mgL^{-1}; 16.69 ± 1.17 $mgCaCO_3L^{-1}$). . In the other hand, water pH, Dissolved Oxygen (DO); Dissolved Oxygen Saturation (DO% Sat.), Biochemical Oxygen Demand (BOD_5) in the respective order decreased significantly ($p < 0.05$) from the lake surface (6.64 ± 0.05; 5.61±0.24 mgL^{-1}; 73.74 ± 3.13 mgL^{-1}; 5.71 ± 0.55 mgL^{-1}) towards the bottom (6.27 ± 0.04 mgL^{-1}; 2.35 ± 0.23 mgL^{-1}; 29.69 ± 2.91 mgL^{-1}; 2.98 ± 0.61 mgL^{-1}) of the lake respectively (Table 3).

Table 2: Horizontal variation of the physico-chemical characteristics of the lake water

S/N	Parameter	Unit	Station			Anova	
			Upper reach(n =37) Mean ± S.E	Mid basin (n = 26) Mean ± S.E	Dam site(n = 13) Mean ± S.E	F	P
1	Water-Temperature	^0C	28.0 ± 0.3	28.4 ± 0.4	29.2 ± 0.5	1.763	0.179
2	Apparent-Colour	Pt-Co	619.9 ± 72.0	494.6 ± 59.5	341.7 ± 31.9	3.088	0.052
3	True-Colour	Pt-Co	168.3 ± 19.6	158.6 ± 17.3	161.9 ± 18.6	0.071	0.931
4	Turbidity	NTU	47.7 ± 6.9	37.3 ± 5.6	27.1 ± 3.9	1.913	0.155
5	Total Suspended Solids (TSS)	mgL^{-1}	164.0 ± 20.9	152 ± 22.1	111.0 ± 11.2	1.079	0.345
6	Total Solids (TS)	mgL^{-1}	220.0 ± 21.0	208 ± 22.5	170.0 ± 13.2	0.896	0.413
7	pH	0-14	6.44 ± 0.04	6.48 ± 0.06	6.50 ± 0.05	0.379	0.686
8	Conductivity	μScm^{-1}	84.00 ± 3.50	83.00 ± 3.90	75.00 ± 2.40	1.185	0.312
9	Total Dissolved Solids (TDS)	mgL^{-1}	56.00 ± 1.00	55.00 ± 2.70	50.00 ± 2.00	0.868	0.424
10	Total-Alkalinity	$mgCaCO_3L^{-1}$	22.10 ± 0.80	21.90 ± 0.60	22.20 ± 0.90	0.029	0.971
11	Total-Hardness	$mgCaCO_3L^{-1}$	11.54 ± 0.77	12.01 ± 0.98	10.38 ± 0.74	0.559	0.574
12	Total-Acidity	$mgCaCO_3L^{-1}$	14.00 ± 1.00	13.00 ± 1.00	12.00 ± 1.50	0.84	0.436
13	Calcium ion (Ca^{2+})	mgL^{-1}	3.92 ± 0.26	4.13 ± 0.31	3.59 ± 0.26	0.571	0.567
15	Magnesium ion (Mg^{2+})	mgL^{-1}	0.43 ± 0.06	0.39 ± 0.08	0.34 ± 0.08	0.286	0.752
16	Sodium ion (Na^{+})	mgL^{-1}	6.42 ± 0.16	6.16 ± 0.17	5.93 ± 0.18	1.624	0.204
17	Potassium ion (K^{+})	mgL^{-1}	2.56 ± 0.17	2.49 ± 0.21	2.11 ± 0.12	1.022	0.365
18	Bicarbonate ion (HCO_3^{-1})	mgL^{-1}	26.50 ± 1.00	26.20 ± 0.80	26.60 ± 1.10	0.029	0.971
19	Chloride ion (Cl^{-1})	mgL^{-1}	4.29 ± 0.18	4.39 ± 0.23	4.18 ± 0.30	0.15	0.861
20	Sulphate ion (SO_4^{2-})	mgL^{-1}	4.63 ± 0.18	4.81 ± 0.32	4.66 ± 0.52	0.121	0.887
21	Dissolved Oxygen (DO)	mgL^{-1}	3.60 ± 0.30	4.20 ± 0.40	4.60 ± 0.50	1.803	0.172
22	Dissolved Oxygen Saturation	%	45.60 ± 4.00	54.10 ± 4.90	60.20 ± 6.60	2.022	0.14
23	Biochemical Oxygen Demand (BOD_5)	mgL^{-1}	4.30 ± 0.60	4.10 ± 0.60	3.20 ± 0.30	0.667	0.517
24	Organic-Matter (OM)	mgL^{-1}	8.16 ± 0.58	7.45 ± 0.61	7.11 ± 1.06	0.588	0.558
25	Nitrate ion (NO_3^{-})	mgL^{-1}	1.29 ± 0.14	1.13 ± 0.12	0.92 ± 0.09	1.505	0.229
26	Phosphate (PO_4^{3-})	mgL^{-1}	0.22 ± 0.01	0.23 ± 0.02	0.20 ± 0.02	0.809	0.449

S.E. = Standard Error of Mean

Table 3: Vertical variation of the physico-chemical characteristics of the lake water

S/N	Parameter	Unit	Water Level			Anova	
			Surface (n = 30) Mean ± S.E	Mid-depth(n = 20) Mean ± S.E	Bottom(n = 26) Mean ± S.E	F	P
1	Water-Temperature	^0C	29.7 ± 0.3	27.5 ± 0.3	27.5 ± 0.3	18.64	$2.88x10^{-7}$***
2	Apparent-Colour	Pt-Co	420.3 ± 59.4	406.9 ± 34.4	749.6 ± 85.2	8.494	0.0005***
3	True-Colour	Pt-Co	122.3 ± 11.8	166.0 ± 17.8	210.2 ± 25.2	6.011	0.004**
4	Turbidity	NTU	31.1 ± 5.9	25.9 ± 2.8	62.9 ± 7.7	10.23	0.0001***
5	Total Suspended Solids (TSS)	mgL^{-1}	135.0 ± 22.7	103.5 ± 9.7	205.4 ± 22.6	5.81	0.005**

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6	Total Solids (TS)	mgL^{-1}	194.3 ± 23.1	156.5 ± 10.6	261.2 ± 22.6	5.759	0.005**
7	pH	0-14	6.64 ± 0.05	6.44 ± 0.04	6.27 ± 0.04	18.26	$3.71x10^{-7}$***
8	Conductivity	μScm^{-1}	83.90 ± 3.73	79.30 ± 3.60	82.27 ± 4.02	0.338	0.715
9	Total Dissolved Solids (TDS)	mgL^{-1}	55.33 ± 2.17	52.50 ± 2.39	55.00 ± 2.88	0.336	0.716
10	Total-Alkalinity	$mgCaCO_3L^{-1}$	21.50 ± 0.88	23.00 ± 0.51	21.90 ± 0.87	0.84	0.436
11	Total-Hardness	$mgCaCO_3L^{-1}$	11.29 ± 0.90	11.49 ± 0.77	11.76 ± 0.96	0.074	0.928
12	Total-Acidity	$mgCaCO_3L^{-1}$	10.87 ± 0.75	12.20 ± 1.17	16.69 ± 1.17	9.612	0.0002***
13	Calcium ion (Ca^{2+})	mgL^{-1}	3.85 ± 0.28	3.95 ± 0.27	4.02 ± 0.32	0.088	0.916
15	Magnesium ion (Mg^{2+})	mgL^{-1}	0.40 ± 0.06	0.39 ± 0.07	0.40 ± 0.08	0.008	0.992
16	Sodium ion (Na^+)	mgL^{-1}	6.44 ± 0.19	6.06 ± 0.17	6.16 ± 0.16	1.269	0.287
17	Potassium ion (K^+)	mgL^{-1}	2.50 ± 0.19	2.42 ± 0.21	2.45 ± 0.20	0.036	0.964
18	Bicarbonate ion (HCO_3^{-1})	mgL^{-1}	25.80 ± 1.10	27.60 ± 0.60	26.20 ± 1.00	0.84	0.436
19	Chloride ion (Cl^{-1})	mgL^{-1}	4.20 ± 0.23	4.22 ± 0.20	4.49 ± 0.22	0.552	0.578
20	Sulphate ion (SO_4^{2-})	mgL^{-1}	4.49 ± 0.30	4.98 ± 0.31	4.71 ± 0.22	0.713	0.493
21	Dissolved Oxygen (DO)	mgL^{-1}	5.61±0.24	3.52 ± 0.25	2.35 ± 0.23	50.65	$1.6x10^{-14}$***
22	Dissolved Oxygen Saturation	%	73.74 ± 3.13	44.55 ± 3.10	29.69 ± 2.91	58.19	$7.7x10^{-16}$***
23	Biochemical Oxygen Demand (BOD_5)	mgL^{-1}	5.71 ± 0.55	2.81 ± 0.23	2.98 ± 0.61	9.869	0.0002***
24	Organic-Matter (OM)	mgL^{-1}	7.38 ± 0.64	6.90 ± 0.74	8.77 ± 0.65	2.029	0.139
25	Nitrate ion (NO_3^-)	mgL^{-1}	1.16 ± 0.14	0.91 ± 0.05	1.39 ± 0.16	2.813	0.067
26	Phosphate (PO_4^{3-})	mgL^{-1}	0.23 ± 0.01	0.20 ± 0.02	0.23 ± 0.02	0.433	0.651

S.E. = Standard Error of Mean; ** = highly significant; *** = very highly significant

Seasonal Variations of Physico-Chemical Characteristic of the Lake

Table 4: Seasonal variation of the physico-chemical characteristics of the lake water

S/N	Parameter	Unit	Season		Anova	
			Dry season (n =18) Mean ± S.E.	Rainy season (n = 58) Mean ± S.E.	F	P
1	Water-Temperature	^0C	27.9 ± 0.5	28.5 ± 0.3	1.345	0.25
2	Apparent-Colour	Pt-Co	586.8 ± 126.3	511.6 ± 39.7	2.295	0.134
3	True-Colour	Pt-Co	105.1 ± 10.2	182.1 ± 14.0	8.899	0.004**
4	Turbidity	NTU	48.0 ± 12.8	38.3 ± 3.5	1.059	0.307
5	Total Suspended Solids (TSS)	mgL^{-1}	181.0 ± 42.8	142.0 ± 110.5	1.674	0.12
6	Total Solids (TS)	mgL^{-1}	231.0 ± 42.8	200.0 ± 10.9	0.993	0.322
7	pH	0-14	6.68 ± 0.08	6.75 ± 0.03	13.5	0.0004***
8	Conductivity	μScm^{-1}	73.00 ± 1.60	85.00 ± 2.70	6.171	0.015*
9	Total Dissolved Solids (TDS)	mgL^{-1}	50.00 ± 1.30	56.00 ± 1.80	3.089	0.083
10	Total-Alkalinity	$mgCaCO_3L^{-1}$	22.10 ± 1.70	22.00 ± 0.40	0.017	0.898
11	Total-Hardness	$mgCaCO_3L^{-1}$	6.65 ± 0.49	13.01 ± 0.52	41.98	$9.05x10^{-9}$***
12	Total-Acidity	$mgCaCO_3L^{-1}$	12.00 ± 1.00	14.00 ± 0.80	0.889	0.349
13	Calcium ion (Ca^{2+})	mgL^{-1}	2.36 ± 0.19	4.43 ± 0.17	40.65	$1.4x10^{-8}$***
15	Magnesium ion (Mg^{2+})	mgL^{-1}	0.16 ± 0.02	0.47 ± 0.05	13.78	0.0004***
16	Sodium ion (Na^+)	mgL^{-1}	6.29 ± 0.26	6.22 ± 0.11	0.114	0.737
17	Potassium ion (K^+)	mgL^{-1}	1.67 ± 0.04	2.70 ± 0.13	18.82	$4.48x10^{-5}$***
18	Bicarbonate ion (HCO_3^{-1})	mgL^{-1}	26.50 ± 2.00	26.40 ± 0.40	0.017	0.898

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19	Chloride ion (Cl^{-1})	mgL^{-1}	4.16 ± 0.26	4.35 ± 0.15	0.393	0.533
20	Sulphate ion (SO_4^{2-})	mgL^{-1}	3.98 ± 0.25	4.92 ± 0.19	6.573	0.012*
21	Dissolved Oxygen (DO)	mgL^{-1}	5.10 ± 0.40	3.60 ± 0.20	10.22	0.002**
22	Dissolved Oxygen Saturation	%	65.50 ± 5.00	46.50 ± 3.20	8.941	0.004**
23	Biochemical Oxygen Demand (BOD_5)	mgL^{-1}	3.90 ± 0.90	4.00 ± 0.40	0.018	0.895
24	Organic-Matter (OM)	mgL^{-1}	7.30 ± 1.00	7.87 ± 0.42	0.365	0.548
25	Nitrate ion (NO_3^-)	mgL^{-1}	1.47 ± 0.29	1.08 ± 0.05	4.391	0.040*
26	Phosphate (PO_4^{3-})	mgL^{-1}	0.22 ± 0.02	0.22 ± 0.01	0.001	0.976

S.E. = Standard Error of Mean; * = significant; ** = highly significant; *** = very highly significant

Dissolved Oxygen (DO); Dissolved Oxygen Saturation (DO% Sat.) and Nitrate ion (NO_3^-) were significantly higher ($p < 0.05$) in the dry season (5.10 ± 0.40 mgL^{-1}; 65.50 ± 5.00 mgL^{-1}; 1.47 ± 0.29 mgL^{-1}) than in the rainy season (3.60 ± 0.20 mgL^{-1}; 46.50 ± 3.20 mgL^{-1}; 1.08 ± 0.05 mgL^{-1}) respectively. Likewise, True colour, pH, Conductivity, Total Hardness, Calcium ion (Ca^{2+}), Magnesium ion (Mg^{2+}), Potassium ion (K^+) and Sulphate ion (SO_4^{2-}) were significantly higher ($p < 0.05$) in the rainy season: (182.1 ± 14.0 Pt-Co; 6.75 ± 0.03; 85.00 ± 2.70 μScm^{-1}; 13.01 ± 0.52 $mgCaCO_3L^{-1}$; 4.43 ± 0.17 mgL^{-1}; 0.47 ± 0.05 mgL^{-1}; 2.70 ± 0.13 mgL^{-1}; 4.92 ± 0.19 mgL^{-1}) than in the dry season: (105.1 ± 10.2 Pt-Co; 6.68 ± 0.08; 73.00 ± 1.60 μScm^{-1}; 6.65 ± 0.49 $mgCaCO_3L^{-1}$; 2.36 ± 0.19 mgL^{-1}; 0.16 ± 0.02 mgL^{-1}; 1.67 ± 0.04 mgL^{-1}; 3.98 ± 0.25 mgL^{-1}) respectively (Table 4).

Relationships among the sampling stations and the physico-chemical characteristics of the lake

Table 5: Correlation coefficient matrix showing relationships among the sampling stations based on the physico-chemical parameters of water quality

Station	AS	A1	A2	AB	BS	B1	BB	CS	CB
AS	X								
A1	0.981	X							
A2	0.981	0.988	X						
AB	0.983	0.967	0.992	X					
BS	0.998	0.986	0.978	0.974	X				
B1	0.981	0.999	0.988	0.967	0.987	X			
BB	0.991	0.985	0.994	0.993	0.987	0.985	X		
BB	0.969	0.99	0.961	0.933	0.981	0.991	0.962	X	
CB	0.981	0.995	0.986	0.969	0.985	0.996	0.99	0.985	X

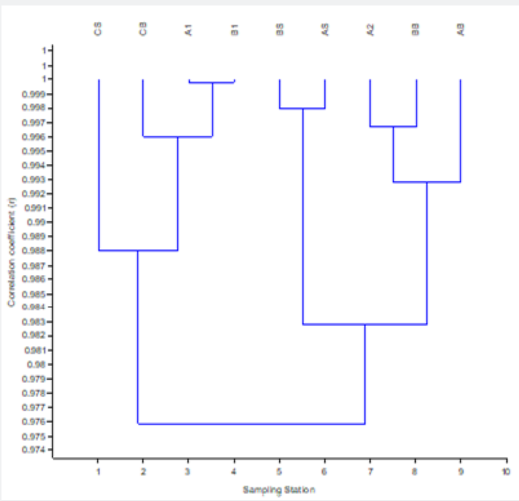

Figure 2: Cluster analysis of the relationships among the Sampling Stations

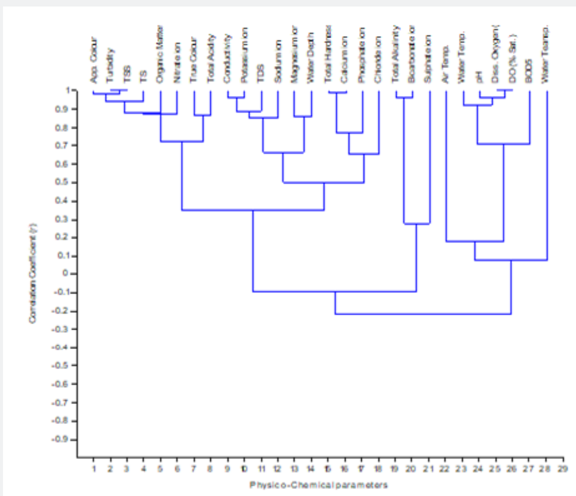

Figure 3: Cluster analysis of the relationships among the physico-chemical characteristics of the lake water

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A relationship among the Sampling Stations based on the physico-chemical characteristics of the lake water is presented in Table 5 (Figure 2). Stations A1 and B1 were the most related forming the first cluster followed by Stations BS and AS; A2 and BB respectively. Altogether two major clusters were formed (CS, CB, A1, B1) and (BS, AS, A2, BB, AB). All the Sampling Stations showed significant ($p < 0.05$) positive relationships based on the physico-chemical contents of the water samples (Figure 3).

Figure 3 is a cluster analysis of the relationships among the physico-chemical characteristics of the lake. Altogether five major clusters were formed; the clusters (Apparent Colour, Turbidity, TSS, TS, Organic Matter, Nitrate ion, True Colour, Total Acidity) and (Conductivity, Potassium ion, TDS, Sodium ion, Magnesium ion, Water Depth) as well as (Total Hardness, Calcium ion, Phosphate ion, Chloride ion) were significantly ($p < 0.05$) positively correlated. The cluster (Total Alkalinity, Bicarbonate ion, Sulphate ion) showed positive non-significant ($p > 0.05$) relationship with the first three clusters while (Water Temperature, pH, DO, DO % Saturation, BOD_5, Water Transparency) showed inverse but non-significant ($p > 0.05$) relationships with the other four clusters.

Comparison of the values of the physico-chemical characteristics of the lake water with some Standard Water Quality Guides

Table 6: Comparison of the values of the physico-chemical characteristics of the lake water with some Standard Water Quality Guides (NIS, 2007 and Meade, 1989).

S/N	Parameter	Unit	Range	Current Study Mean ± S.E	Drinking Water Quality (NIS, 2007) (MPL)	Water Quality for Fish/ Aquatic life (Meade, 1989)
1	Water-Temperature	^0C	24.0 – 33.5	28.3 ± 0.2	Ambient	-
2	Apparent-Colour	Pt-Co	181.1 - 1826.3	529.4 ± 42.2	15 TCU	-
3	True-Colour	Pt-Co	37.6 - 643.5	165.2 ± 11.6	15 TCU	-
4	Turbidity	NTU	7.6 - 183.3	40.6 ± 4.0	5	-
5	Total Suspended Solids (TSS)	mgL^{-1}	40 – 550	151 ± 12.8	ND	< 80
6	Total Solids (TS)	mgL^{-1}	90 - 590	207 ± 13.1	ND	-
7	* pH	0-14	6.00 - 6.85	6.38 ± 0.09	6.5-8.5	6.5-8.0
8	Conductivity	μScm^{-1}	58 - 130	82 ± 2.2	1000	-
9	Total Dissolved Solids (TDS)	mgL^{-1}	40 - 90	54 ± 1.5	500	< 400
10	* Total-Alkalinity	$mgCaCO_3L^{-1}$	8.0 – 28.0	22.0 ± 0.5	ND	10-400
11	* Total-Hardness	$mgCaCO_3L^{-1}$	0.93 - 23.31	11.51 ± 0.52	150	10-400
12	Total-Acidity	$mgCaCO_3L^{-1}$	4.0 - 30.0	13 ± 0.7	ND	-
13	Calcium ion (Ca^{2+})	mgL^{-1}	0.19 - 7.57	3.94 ± 0.17	ND	4-160
15	Magnesium ion (Mg^{2+})	mgL^{-1}	0.11 - 1.52	0.40 ± 0.04	0.2	< 15
16	Sodium ion (Na^+)	mgL^{-1}	5.09 - 9.34	6.24 ± 0.09	200	75
17	Potassium ion (K^+)	mgL^{-1}	1.42 - 5.17	2.46 ± 0.11	ND	< 5
18	Bicarbonate ion (HCO_3^{-1})	mgL^{-1}	9.6 - 33.6	26.4 ± 0.6	ND	-
19	Chloride ion (Cl^{-1})	mgL^{-1}	1.14 - 6.94	4.31 ± 0.13	250	-
20	Sulphate ion (SO_4^{2-})	mgL^{-1}	1.91 - 9.92	5.14 ± 0.41	100	< 50
21	*Dissolved Oxygen (DO)	mgL^{-1}	0.0 – 8.0	4.0 ± 0.2	ND	5
22	Dissolved Oxygen Saturation	%	0.0 - 105.5	51.0 ± 2.8	ND	-
23	Biochemical Oxygen Demand (BOD_5)	mgL^{-1}	0.4 – 16.0	4.0 ± 0.3	ND	-
24	Organic-Matter (OM)	mgL^{-1}	2.03 - 17.23	7.75 ± 0.40	5	-
25	Nitrate ion (NO_3^{-})	mgL^{-1}	0.55 - 4.70	1.17 ± 0.08	50	0-3
26	Phosphate (PO_4^{3-})	mgL^{-1}	0.10 - 0.56	0.22 ± 0.01	ND	-

ND= No Data; MPL = Maximum Permitted Levels; S.E. = Standard Error

* = denotes most common water quality characteristics which will influence fish health and growth (Meade, 1989)

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Except for the Apparent Colour, True Colour, Turbidity that were not within the permissible levels of the NIS, Meade [18,19] values for drinking water and fish/aquatic life respectively, the other phisico-chemical parameters of the lake water were very much within the prescribed limits (Table 6).

Comparison between the results the present study with previous works on the lake

Table 7: Comparison between the results the present study with previous works on the lake

S/N	Parameter	Unit	Previous Studies		Current Study		References
			Range	Mean ± S.E.	Range	Mean ± S.E.	
1	Depth	m	1.37 – 5.70	3.54 ± 2.17	0.16 - 4.07	2.25 ± 0.18	Aderounmu & Adeniyi [5]
2	Transparency	m	0.5 - 0.9	0.65 ± 0.04	0.16 - 1.12	0.69 ± 0.05	Imevbore et al. [26]
3	Water-Temperature	^0C	26.5 – 30.0	28.8 ± 0.5	24.0 - 33.5	28.3 ± 0.2	Imevbore et al. [26]
4	Apparent-Colour	Pt-Co	-	-	181.1 - 1826.3	529.4 ± 42.2	-
5	True-Colour	Pt-Co	-	-	37.6 - 643.5	165.2 ± 11.6	-
6	Turbidity	NTU	-	-	7.6 - 183.3	40.6 ± 4.0	-
7	Total Suspended Solids (TSS)	mgL^{-1}	-	-	40 - 550	151 ± 12.8	-
8	Total Solids (TS)	mgL^{-1}	-	-	90 - 590	207 ± 13.1	-
9	* pH	0-14	6.40 – 7.70	7.02 ± 0.24	6.00 - 6.85	6.38 ± 0.09	Imevbore et al. [26]
10	Conductivity	μScm^{-1}	93.1 – 112.4	103.9 ± 2.8	58 - 130	82 ± 2.2	Imevbore et al. [26]
11	Total Dissolved Solids (TDS)	mgL^{-1}	-	-	40 - 90	54 ± 1.5	-
12	* Total-Alkalinity	$mgCaCO_3L^{-1}$	0.166 – 0.272	0.217 ± 0.009	28-Aug	22.0 ± 0.5	Imevbore et al. [26]
13	* Total-Hardness	$mgCaCO_3L^{-1}$	-	-	0.93 0 - 23.31	11.51 ± 0.52	-
15	Total-Acidity	$mgCaCO_3L^{-1}$	-	-	30-Apr	13 ± 0.7	-
16	Calcium ion (Ca^{2+})	mgL^{-1}	5.90 – 6.90	6.58 ± 0.15	0.19 - 7.57	3.94 ± 0.17	Imevbore et al. [26]
17	Magnesium ion (Mg^{2+})	mgL^{-1}	3.20 – 4.10	3.58 ± 0.17	0.11 - 1.52	0.40 ± 0.04	Imevbore et al. [26]
18	Sodium ion (Na^+)	mgL^{-1}	2.40 – 3.80	2.97 ± 0.24	5.09 - 9.34	6.24 ± 0.09	Imevbore et al. [26]
19	Potassium ion (K^+)	mgL^{-1}	3.20 - 4.70	3.83 ± 0.27	1.42 - 5.17	2.46 ± 0.11	Imevbore et al. [26]
20	Bicarbonate ion (HCO_3^{-1})	mgL^{-1}	-	-	9.6 - 33.6	26.4 ± 0.6	-
21	Chloride ion (Cl^{-1})	mgL^{-1}	4.30 – 6.70	5.47 ± 0.38	1.14 - 6.94	4.31 ± 0.13	Imevbore et al. [26]
22	Sulphate ion (SO_4^{2-})	mgL^{-1}	-	-	1.91 - 9.92	5.14 ± 0.41	-
23	*Dissolved Oxygen (DO)	mgL^{-1}	-	-	0.0 - 8.0	4.0 ± 0.2	-
24	Dissolved Oxygen Saturation	%	-	-	0.0 - 105.5	51.0 ± 2.8	-
25	Biochemical Oxygen Demand (BOD_5)	mgL^{-1}	-	-	0.4 - 16.0	4.0 ± 0.3	-
26	Organic-Matter (OM)	mgL^{-1}	1.03 – 4.24	-	2.03 - 17.23	7.75 ± 0.40	*Alamina [42]
27	Nitrate ion (NO_3^{-})	mgL^{-1}	-	-	0.55 -4.70	1.17 ± 0.08	-
28	Phosphate (PO_4^{3-})	mgL^{-1}	0.012 – 0.140	0.075 ± 0.025	0.10 - 0.56	0.22 ± 0.01	Imevbore et al. [26]

S.E: Standard Error of Mean; * = Alamina, 1969 cited by Hall (1969).

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Comparing the current values of some of the physico-chemical characteristics of the lake water to the previous works on the lake; it is obvious that the nutrients parameters (Organic matter and Phosphate) have increased over time. Meanwhile, Depth, pH, Conductivity, Cations and Anions (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+} and HCO_3^-) have all reduced in their values from the period of 1969 till present 2006 – 2007 (Table 7).

Discussion

The significant increase ($P < 0.05$) in the mean values of apparent colour, true colour, turbidity, TSS and TS from the surface of the lake to the bottom of the lake could be due to resuspension of deposits materials from the bottom of the lake during sampling. For instance, resuspension of (organic particles: decomposed plant and animal matter as well as living organisms e.g. plankton) and/or (inorganic particles: silt, clay and some chemical compounds) along the vertical column of the lake. The significant ($p < 0.05$) decrease in the hydrogen ion concentration (pH) values of water samples from surface water level to the bottom of the lake and the corresponding significant ($p < 0.05$) increase in the acidity values from surface water level to the bottom of the lake have also been reported in some lakes/reservoirs by some authors. For instance, in Eleiyele Reservoir, Opa Reservoir, Erinle Lake and its major inflows, Guma dam in Sierra Leone and Russell Pond, Woodstock, New Hampshire USA [9,20-23].

Such downward decrease in pH seems to be a common limnological phenomenon in lakes and probably because the top levels of water column usually comprise the photosynthetic zone (trophogenic layer) while the bottom column is tropholytic and characterised by relatively high organic matter decomposition and the release of carbon dioxide. A decrease in pH often imply decrease in photosynthetic activities and this is usually coupled with increased concentration of carbon dioxide and other bye products of organic matter decomposition at the lake bottom [24]. The increase in acidic condition with depth could also, be attributed to build-up of carbon dioxide from respiring organisms in the water column as respiration often exceeds production of oxygen by primary producers at these depths. The carbon dioxide produced by respiring organisms combines with water molecules to produce carbonic acid leading to increase in acidic condition.

Significant ($p < 0.05$) gradual decrease in dissolved oxygen (DO) and DO (% Sat.) concentrations, along the water column from surface towards the bottom of the lake could be linked with higher photosynthetic activities at the surface and/or the higher decomposition processes at the bottom of the lake [25]. There was total oxygen depletion (anoxic condition) at the bottom of the lake in April 2007. Akinbuwa [24] and Mtada [22] respectively recorded similar anoxic conditions from Opa Reservoir and Guma dam at different times of the year of their studies. Also, worthy of note is the level of oxygen saturation in the lake which was mostly below 100 %. This trend of under saturation of oxygen was also recorded for Eleiyele Reservoir, River Oshun, The Blue Nile, and River Sokoto [26-29]. Egborge [27] and Holden and Green [29] explained that the conditions of under saturation were associated with high iron concentration as oxygen is involved in the oxidation of ferrous iron to ferric iron.

High amounts of iron are associated with anaerobic conditions [30]. This was probably the situation in the studied lake in view of its high iron contents (from 0.00-20.20 mgl^{-1}) with overall mean of 3.99 mgl^{-1}. Ekpenyong [31] explained that some insoluble forms of iron such as ferric hydroxide could be present in the lake that could not be detected and may reduce the iron content but also contributed to reduction in oxygen saturation. Supersaturation was found to be a constant feature of the Volta River with considerably low iron content. Akinbuwa [21] also, recorded similar condition of supersaturation with no anoxic condition at the bottom of Erinle Lake, and explained was due to low iron content of the lake. The vertical variation in similar manner of the Biochemical oxygen Demand (BOD_5) could be because life processes and organic activities were more pronounced at the surface mainly within the euphotic zone. Akinbuwa [21] observed similar trend in vertical variation of (BOD_5) in Erinle Lake.

Significantly, higher ($p < 0.05$) values of oxygen concentrations (DO and DO%Sat.) during the dry season than in the rainy season is in line with the observation on six impoundments on River Oshun by Ayodele & Adeniyi [32] but contrast the results of Yusoff *et al.* [33] on Kenyir Reservoir, Malaysia. Higher record of oxygen concentration during the dry season than in the rainy season as recorded in this present study could probably be due to higher photosynthetic activities during the dry season when there is normally more solar energy available to the lake than during the rainy season. Likewise, higher values of nitrate (NO_3^-) in the dry season could be because of reduction in the water volume during the dry season and the dilution effect of precipitation and flooding during the rainy season.

Significantly, higher ($p < 0.05$) true colour values in the rainy season could be because of vegetation decay and higher influx into the basin during the rainy season. The lower pH values (i.e. more acidic) during the rainy season than in the dry season recorded in this study was like the observations on six impoundments on River Oshun, Southern Nigeria [32]. This could be attributed to the influx of acidic flood water, resuspension of bottom sediment during the rains in contrast to evaporation of water, concentration of calcium salts as well as increased photosynthetic consumption of carbon dioxide during the dry season as suggested by Imevbore [20], Talling and Rhoska [28], Holden and Green [29], Akinbuwa [24], and Umaru [34].

Higher conductivity values measured from the lake water during the rainy season could be attributed to run-off from the surrounding agricultural land. Run-off from agricultural land is suspected to be chief contribution to solids and dissolved ions in lakes and rivers, which in turns usually bring about corresponding increase in the conductivity values. This can also be corroborated by the similar significant higher concentrations of some major cations (Ca^{2+}, Mg^{2+} and K^{+}) and anion (SO_4^{2-}) during the rainy

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season than in the dry season. Conductivity is a measure of the ability of water to conduct electric current. Current is conducted in aqueous solution by the movement of ions (cations and anions) in water which depends on their total concentration, valence and on the water temperature. It is also noteworthy that the conductivity values of the lake fell within the low-end range of known values for African lake waters being less than 600μScm^{-1} [27].

The lake thus belongs to Class 1 of the African waters about conductivity values. Class 1 waters are generally poor in chemical nutrients. Similarly, the corresponding significant higher values of total hardness during the rainy season is expected as calcium and magnesium have been noted to be the most common sources of water hardness [35]. The positive significant ($p < 0.05$) relationships among the sampling stations as obvious in the cluster analysis of the relationships among the sampling stations is an indication of the fact that the sampling stations were similar in their physico-chemical properties. This is a common phenomenon in most small shallow lakes.

The water from the lake could be regarded as being relatively clean as the physical parameters (apparent colour, true colour and turbidity) were the only parameters having their overall mean values higher than the prescribed standards limits for both drinking water and water for fish and aquatic life. Sources of colour in waterbodies could be from phytoplankton blooms, decayed vegetal materials as well as presence or introduction of fluvic and humic acid from microbial degradation of dead organisms (Nova Scotia Environment, 2008). Turbidity could result from allochthonous and autochthonous weathered suspended materials in the water. It is a measure of the cloudiness and murkiness of water due to suspended particles. The shallower the waterbody, the much easier for re-suspension of suspended materials in the water that could cause an increase in the turbidity of the water [36]. However, the lake water will require minimal treatment for its suitability for drinking because high colour and turbidity values may indicate potential risks for consumption.

There should also be adequate cares and control measures for its suitability for agriculture mostly fish culture as high colour and turbidity values could all adversely affect the organisms living within the waterbody by interfering with their food chain as well as releasing pollutants in the aquatic ecosystem. Increments in the nutrient compounds (Organic matter and Phosphate) and the corresponding decrease in Depth, pH, Conductivity, Cations and Anions (Ca^{2+}, Mg^{2+}, Na^+, K^+ and HCO_3^-) over time, i.e. from the period of 1969 till present 2006 – 2007is an indication of the fact that the lake is aging. Similar changes in these recorded parameters and phenomena have been used as an indication of eutrophication in lakes and other water bodies by various authors [37-43].

Conclusion

The Obafemi Awolowo University Teaching and Research Farm Lake could be regarded as slightly acidic, soft and well-buffered fresh-waterbodies. The lake is shallow, coloured, turbid and less transparent. There is evidence of gradual deposits of allochthonous materials from the catchment basin transforming the lake from the original oligotrophic status to a eutrophic waterbody.

References

1. Tebbutt T H Y (1983) Principle of Water Quality Control. In: 3rd (Edn), Pergamon Press Ltd, Oxford, UK, p. 235.
2. Parashar C, Dixit S, Shrivastava R (2006) Seasonal Variations in Physico-chemical Characteristics in Upper Lake of Bhopal. Asian J Exp Sci 20(2): 297-302.
3. Ademoroti CMA (1996b) Standard Methods for Water and Effluents analysis. In: Foludex Press Ltd, Ibadan, Nigeria, p. 182.
4. Adeniyi F (1971) A Preliminary Ecological Study of the Parasite Fauna of Fishes from the Farm Pond, University of Ife, Nigeria. Unpublished B. Sc. Thesis, Department of Zoology, OAU, Ile-Ife, Nigeria, p. 56.
5. Aderounmu E A and Adeniyi F (1972) Cestodes in Fish from a Pond at Ile-Ife, Nigeria. The African Journal of Tropical Hydrobiology and Fisheries 2: 151-156.
6. Adeniyi I F and Olabanji I O (2005) The physico-chemical and bacteriological quality of rainwater collected over different roofing materials in Ile-Ife, Southwestern Nigeria. Chemistry and Ecology. 21(3): 149-166.
7. Papadakis J (1961) Crop Ecology in West Africa. FAO 2(1).
8. Ojo O (1977) The Climates of West Africa. Heinemann Educational Books Ltd.
9. Akinbuwa O and Adeniyi I F (1996) Seasonal variation, distribution and inter-relationships of rotifers in Opa Reservoir, Nigeria. Afr J Ecol 34(4): 351-363.
10. Muoghalu J I and Johnson S O (2000) Interception, pH and soil content of rainfall in a Nigerian lowland rainforest. J Ecol 38: 38-46.
11. Keay R W J (1959) An outline of Nigerian vegetation. In: 3rd (edn), Government Printer, Nigeria.
12. Onochie C F A (1979) The Nigerian rainforest ecosystem. In: Okali A U U (eds.): The Nigerian Rainforest Ecosystem; Proceedings of the man and biosphere on the Nigerian Rainforest Ecosystem. University of Ibadan, Nigeria National MAB Committee, Ibadan, Nigeria. p. 1-13.
13. Olabanji I O and Adeniyi I F (2005) Trace metals in bulk freefall and roof intercepted rainwater at Ile-Ife, Southwest Nigeria. Chemistry and Ecology 21(3): 167-179.
14. Ako B D, Adeniyi I F and Adepoju I F (1990) Statistical tests and chemical quality of shallow groundwater from a metamorphic terrain, Ile-Ife/Modakeke, South Western Nigeria. Journal of Africa Earth Sciences 10(4): 603-613.
15. Golterman R I, Clymo R S and Ohnstad M A M (1978) Methods for physical and chemical analysis of freshwater. IBP Handbook No. 8. Blackwell Scientific Publication, Oxford, UK, P. 214.
16. APHA, AWWA and WEF (1995) Standard methods for the examination of water and wastewater. In: 19th (edn) Washington, USA
17. USEPA (1983) Methods for chemical analysis of water and wastes. EMSL, United State Environmental Protection Agency, Cincinnati, US
18. Nigerian Industrial Standards (NIS) (2007) Nigerian Standard for Drinking Water Quality, p. 30.
19. Meade J W (1989) Aquaculture Management. In: Chapman & Hall, p. 175.
20. Imevbore A M A (1967) Hydrology and plankton of Eleiyele reservoir Ibadan, Nigeria. Hydrobiologia 30(10): 154-176.

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21. Akinbuwa O (1999) The rotifera fuana and physico-chemical conditions of Erinle Lake and its major inflows at Ede, Osun State, Nigeria. In: Zoology Department Obafemi Awolowo University, Ile-Ife, Nigeria. p. 333.

22. Mtada O S M (1988): Observations on the limnology of a tropical reservoir in West Africa (The Guma Dam, Sierra Leone). Part II: Factors influencing its limnochemistry. Tropical Ecology 29(2): 50-60.

23. Bailey M and Davignon T (1999) A limnological assessment of Russell Pond, Woodstock, New Hampshire. UNH center for Freshwater Biology Research 1(2): 13-22.

24. Akinbuwa O (1988) The study of the physic-chemical factors and rotifera fauna of Opa Reservoir, Ile-Ife, Nigeria. Zoology Department, University of Ife, Ile-Ife, Nigeria. p. 261.

25. Arumugam P T and Furtado J I (1980) Physico-chemistry, destratification and nutrient budget of a lowland eutrophicated Malaysian reservoir and its limnological implications. Hydrobiologia 70: 11-24.

26. Imevbore A M A, Meszes G and Boszormenyi Z (1972) The primary productivity of a fish-pond at Ile-Ife, Nigeria. In: Kajak Z and Hillbricht-Ilkowska A (eds.). Productivity Problems of Freshwaters. Proceedings of the IBP-UNESCO symposium, pp. 715-723.

27. Egborge A B M (1971) The chemical hydrology of the River Oshun, Western State, Nigeria. Fresh Water Biol 1(3): 257-271.

28. Talling J F and J Rzoska (1967) The development of plankton in relation to hydrological regime in the Blue Nile. J Ecol 55: 637-662.

29. Holden M J and Green J (1960) The hydrology and plankton of River Sokoto. J Animal Ecol 29: 65-84.

30. Krenkel P A and Novotny V (1980) Water Quality Management. In: Academic Press, New York, US, p. 671.

31. Ekpenyong H (1982) The physico-chemical quality of water in relation to primary production of fish ponds in Ile-Ife, Oyo State, Nigeria. Unpublished M. Sc. Thesis, University of Ife, Nigeria, p. 23.

32. Ayodele H A and Adeniyi I F (2006) The zooplankton fauna of six impoundments on river Osun, South West, Nigeria. The Zoologist 1(4): 49-67.

33. Yusoff F M, Matias H M and Khan N (2002) Changes of water quality, chlorophyll and zooplankton along the river-lacustrine continuum in a tropical reservoir. Verh Internat Verein Limnol 28: 295-298.

34. Umaru D D (1990) The study of physic-chemical parameters in ABU Pond and Federal Government Demonstration Fish Farm at Mando Road, Kaduna. Unpublished B. Sc. Dissertation, Nigerian Defence Academy, Kaduna, Nigeria.

35. Wurts W A and Durborow R M (1992) Interactions of pH, carbon dioxide, alkalinity and hardness in fishponds. Southern Regional Aquaculture Center 464.

36. (MWSMH) Manitoba Water Stewardship and Manitoba Health (2011) Turbidity in Manitoba Water Supplies. Manitoba Water Stewardship's Office of Drinking Water.

37. Popp A, Hoagland K D and Hergenrader G L (1996) Zooplankton community response to reservoir aging. Hydrobiologia. 339(1-3): 13-21.

38. Vollenweider R A (1980) Eutrophication control. Nature and Resources XVI (3): 9-14.

39. Matsumura-Tundisi T, Galizia-Tundisi J and Rocha O (2002) Zooplankton diversity in eutrophic systems and its relation to the occurrence of cyanophycean blooms. Verh Internat Verein Limnol 28: 671-674.

40. Winner R W (1972) An Evaluation of Certain Indices of Eutrophy and Maturity in Lakes. Hydrobiologia 40(2): 223-245.

41. Cole G A (1975) Textbook of Limnology. In: The C V Mosby Company, US, p. 283.

42. Hall JB (1969) Plant Ecology and taxonomy. Ife University herbarium bulletin 1: 36-37.

43. Nova Scotia Environment (2008): The drop on water colour. The Nova Scotia Environment p. 8.

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