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Research article

ASSESSMENT OF THE PHYSICO-CHEMICAL PARAMETERS OF SURFACE WATERS IN OBUBRA TOWN, CROSS RIVER STATE, NIGERIA

[1]Obia, C. I., [2]Ogwuche, J. A. and [3]Alao, J. S.

[1 and 3]Dept of Social and Environmental Forestry, University of Agriculture, Makurdi, Nigeria
[2]Department of Geography, Benue State University, Makurdi, Nigeria.

E-mail: ogwuche.jonathan@yahoo.com

ABSTRACT

Assessment of physico-chemical properties of surface waters in Obubra Town, Cross River State, Nigeria was carried out from July, 2014 to February, 2015. Water samples were collected bimonthly from four perennial surface water bodies; one river and three streams. The physicochemical properties of water determined included; Temperature, Turbidity, Colour, Electrical Conductivity, pH, Total Dissolved Solids, Total Hardness, Dissolved Oxygen, Total Alkalinity, and Flouride. Analysis of variance (ANOVA) showed marked significant variations in all the physicochemical properties in the sites and seasons of samples collection at $P \leq 0.05$. Temperature, Turbidity, Colour, pH, Total Alkalinity and Flouride showed marked variations across the study period at $P \leq 0.05$, while Dissolved Oxygen, Electrical Conductivity, Total Hardness, Total Dissolved Solids showed no variations at $P > 0.05$ across the study period. There were also no variations ($P > 0.05$) in physicochemical properties of water samples in the time of samples collection. Except for Turbidity, all surface waters investigated in this study contained physicochemical properties within the safe limits recommended by the World Health Organization (WHO) and the Nigerian Standard for Drinking Water Quality (NSDWQ), and therefore not responsible for the incidence and prevalence of illnesses in the area. However, for the sustenance of water quality in the area, the current land use can be maintained and water treated during the rainy season to take care of the turbidity.

Key words: Surface Waters, Physicochemical Parameters, season of sample collection, site of sample collection.

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Introduction

One of the primary issues of the 21st century is the need for usable water in sufficient quantities to meet the needs of human and ecosystems (Eden and Lawford, 2003). Inadequate water supply and poor water quality give rise to health and other societal issues, limit agricultural productivity and economic prosperity, and pose national security risk in some countries (Lawford *et al.*, 2003; Nwidu *et al.*, 2008).

The importance of water to humans and the ecosystem cannot be over emphasized, and there are numerous scientific and economic facts that, water shortage or its pollution can cause severe decrease in productivity and deaths of living species (Garba *et al*., 2008; 2010). Water plays an important role in the world economy. Approximately 70% of the fresh water used by humans go to agriculture (Baroni, *et al.*, 2007). Domestically, water is used for drinking, cooking, laundry, dish washing, house-cleaning, personal washing, car washing, watering of lawns and for other activities, making them unavoidable for the evolution, of society and civilization (Orubu, 2006). It is also important in the area of agriculture and industrial production including the processing of raw materials for export (Howard 2003).

Studies by Shiklomanov (2002), Alayande (2005) and Emaobina (2006) reveal that water supply in Nigeria, like other developing countries, is facing serious challenges many of which are economic, and socio-political in nature. Water is essential for the life of our planet and its availability in the required proportion and quality for human consumption has assumed a crisis dimension across the globe (Green, 2002).

The physical and chemical properties of water greatly influence its uses, the distribution and richness of the biota (Unanam and Akpan, 2006). Because of the importance of surface waters, there is increased interest in their quality requirements of physico-chemical properties like temperature, turbidity, dissolved oxygen, electrical conductivity, colour, total dissolved solids, total alkalinity, total hardness, nitrate, sulphate, pH and fluoride.

Several researches have been carried out on surface water the world over (Cessna and Elliot 2004; Rajiv *et al.*, 2012). In Nigeria, most of the researches on surface water are limited only to physico-chemical parameters and heavy metals (Ibrahim *et al.*, 2007; Jaji, 2007; Arabi *et al.*, 2009; Fidelis *et al.*, 2012).

Statement of the Problem

In spite of the efforts of Obubra Local Government Area of Cross River State, Nigeria, to ensure a healthy populace by providing health services, the incidence and prevalence of illnesses are on the increase. The source of the illnesses seems to be tied to common sources of water supply in the area. The sources of fresh water include the rivers, streams, springs, boreholes and hand dug wells of which the Cross River, Upper Source, Iwuwohk and Ogoh streams are some of the surface water sources most depended on, especially during the dry season. There is therefore the need to assess the relevant physico-chemical properties of the surface waters in Obubra town, in relation to the water quality requirements for domestic use, with a view to ascertaining their suitability.

MATERIALS AND METHODS

The Study Area

Obubra is one of the eighteen (18) Local Government Areas of Cross River State, Nigeria, with administrative headquarters at Obubra town. It is located in the Central Senatorial District of the State and is made up of eleven (11) Council wards. Obubra Local Government Area has a land mass of 1,115km^2 and lies between latitudes 8°12′ and 8°32′North and longitudes 5°52′and 6°15′ East of the Equator. Height above sea level is 109 metres. It is bounded in the North by Ikom Local Government Area, Yakurr Local Government Area in the South, Yala Local Government Area in the West and Akamkpa Local Government Area in the East (Figure 1).

From the 2006 census, the Local Government has a total population of 172, 543 (NPC, 2006). The soil is mainly ultisols. Obubra Local Government lies within the rich fringes of the tropical rainforest zone of South Eastern Nigeria with abundant agricultural, forest and mineral resources. It is basically an agrarian society.

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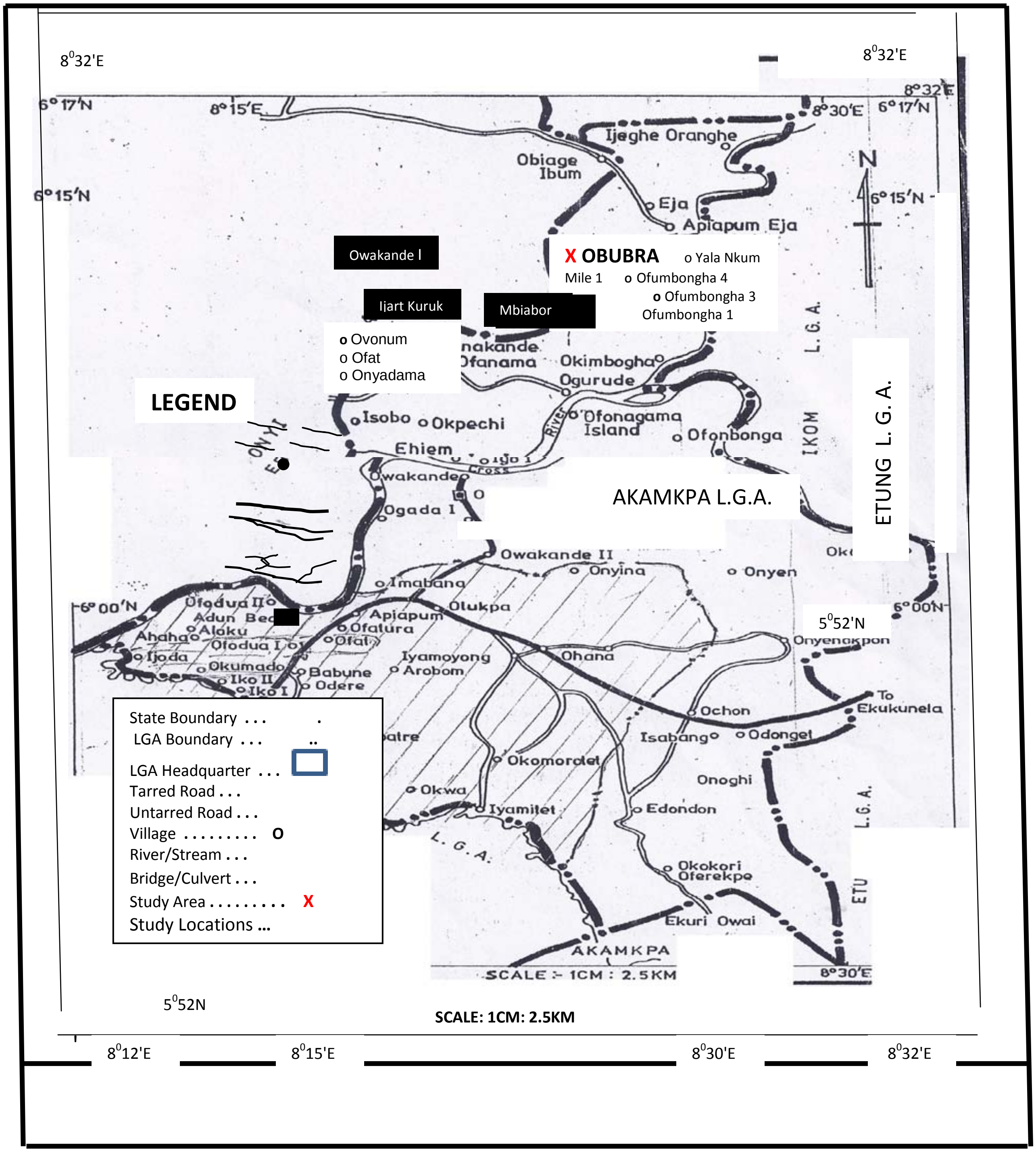

Figure 1: Map of Obubra Local Government Area Study Location and Sampled Sites

Data Collection

Water samples were collected from four stations; one river and three streams. Samples were collected bi-monthly for eight months; July 2014 to February 2015, to capture four months each of rainy season (July to October) and dry season (November to February) respectively in the study area. Grab water samples were collected using one litre high density plastic bottles with screw caps. The containers were sterilized and labeled accordingly; S1 to S4 according to the 4 sampling stations. Canoe was used to collect water samples at the depth of 30cm below the surface, at the middle of the river, away from the point of use to avoid possible disturbance and pollution from users. Stream samples were collected at the point of use, where the inhabitants have specific points of collection in the streams. Sample bottles were filled completely to eliminate any airspace; this was to prevent water-air interface which may allow some chemicals to evaporate prior to analysis. All water samples for analysis were packed with iced blocks and transported to the laboratory of the Cross River State Water Board Limited (CRSWBL) for analysis, on the same day of collection to meet up with the holding time of some of the parameters.

Data Analysis

Water temperature was measured in-situ with mercury in glass thermometer. The probe of the meter was rinsed and inserted into the water and the reading taken in °C. pH was analyzed with a HACH Sension$^+$ Bench top pH Meter using the methods of CRSWBL (2011)**.** The probe of the meter was inserted into the water after being rinsed with distilled water and the readings were taken. Turbidity was determined with a Bench top turbidity Meter model HACH 2100N using APHA (1998) method 214A. Electrical conductivity was determined using a Thermo Electronic. Total Dissolved Solids values were derived by dividing the values obtained in electrical conductivity by 0.6. Hardness was estimated using the titrimetric method (AOAC, 2002; Wurts, 2009) with HACH 230 total hardness set. Water colour was determined with a Lovibond using colorimetric method. Dissolved Oxygen was determined with a thermo electronic, using the Azide Modified Winkler Membrane Electrode method. Total Alkalinity was determined using standard method described by APHA 1998 method 2320 B. Nitrate was determined with a UV visible HACH DR 5000 Spectrophotometer using the Automated Calcium Reduction Method 4500-NO_3. Sulphate and Flouride were determined with a UV visible HACH DR 5000 Spectrophotometer using Acid-based titration and colorimetric methods respectively.

A two-way analysis of variance was used to analyze the variations in the physic-chemical properties of water from the sampling points. Duncan multiple Range Test (DMRT) was used to separate mean values where there was significant difference in results. $P \leq 0.05$ was selected for statistical significance and the results were reported as mean ± S.E and actual p-values.

RESULTS

Results of the Analysis of variance (ANOVA) showed marked variations in the following physico-chemical parameters of water samples analyzed; temperature, turbidity, colour, pH, total hardness and fluoride ($p \leq 0.05$), while parameters like dissolved oxygen, electrical conductivity, total hardness and total dissolved solids showed no variation across the study period ($p > 0.05$) as shown in table 1.

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Table 1: Mean Values of Physico-Chemical Properties of Water Samples across the study period in Obubra Town from July 2014 – February 2015

Month	Temp. (^{o}C)	Turb (NTU)	Colour (Pt.Co)	pH	DO (Mg/L)	EC (Mg/L)	TH (μS/cm)	TDS	TA ($CaCo_3$)	Fl (Mg/L)
					Mean ± S.E.					
July	33.60^{d}	23.46^{ab}	11.24^{c}	7.33^{b}	6.78^{a}	29.55	22.59^{ab}	17.73	5.39^{b}	0.31^{a}
Aug	34.65^{d}	24.49^{ab}	11.55^{c}	7.65^{b}	6.15^{a}	26.68	21.14^{ab}	16.74	5.13^{b}	0.31^{a}
Sept.	33.55^{d}	39.37^{b}	15.05^{d}	7.58^{b}	9.99^{ab}	26.03	19.76^{ab}	15.62	4.78^{a}	0.39^{a}
Oct.	33.87^{d}	39.17^{b}	8.17^{bc}	7.56^{b}	9.42^{ab}	26.33	18.49^{a}	15.79	6.19^{c}	0.65^{b}
Nov.	28.88^{c}	12.19^{a}	5.76^{ab}	6.42^{a}	9.25^{ab}	34.22	30.67^{ab}	20.65	7.84^{e}	0.76^{b}
Dec.	25.86^{b}	10.95^{a}	5.33^{ab}	6.64^{a}	10.17^{ab}	31.93	34.25^{ab}	19.16	7.32^{d}	0.75^{b}
Jan.	22.68^{a}	9.65^{a}	4.32^{a}	6.68^{a}	12.12^{ab}	28.94	26.25^{ab}	17.37	6.13^{c}	0.68^{b}
Feb.	26.14^{b}	8.72^{a}	3.85^{a}	6.67^{a}	13.44^{b}	27.58	37.24^{b}	17.44	6.10^{c}	0.66^{b}
S.E.	0.78	5.36	1.14	0.22	1.97	7.92	5.46	4.76	0.14	1.83
F	34.83	5.65	12.62	6.06	1.57	0.14	1.66	0.13	56.12	31.65
P.Value	0.00**	0.00**	0.00**	0.00**	$0.17^{N.S}$	$0.99^{N.S}$	$0.14^{N.S}$	$0.99^{N.S}$	0.00**	0.00**

****= Significant at $p \leq 0.05$ Results given as Mean ± Standard Error (S.E.). N.S. Not Significant. Mean values in the same column with same alphabet in superscript are not statistically different from each other. Temp = Temperature, Turb = Turbidity, DO = Dissolved Oxygen, EC = electrical Conductivity,**

From the Analysis of Variance in table 1, across the study period has the highest temperature recorded in the month of August (34.65°C ± 0.78), while December recorded the lowest temperature of 25.86°C ± 0.78. The highest mean turbidity value (39.37 ± 5.36) was recorded in September, the lowest value was observed in the month of February (8.72 ± 5.36). The highest colour mean value was recorded in September (15.05 ± 1.14), while the lowest mean was recorded in February; 3.85 ± 1.14 (table). pH was observed to be highest in August (7.65 ± 0.22) and lowest in November; 6.42 ± 0.22. DO was highest in February (13.44 ± 1.97), while August had the lowest value, 6.15 ± 1.97); Electrical conductivity was highest in November; 32.22 ± 7.92, while September recorded the lowest mean value of 26.03 ± 7.92; The highest value of hardness was observed in February; 37.24 ± 5.46, while the lowest value was observed in October; 18.49 ± 5.46; TDS was highest in November; 20.65 ± 4.76, while September recorded the lowest mean value; 15.62 ± 4.76; Total alkalinity was highest in November; 7.84 ± 0.14, while the lowest value was recorded in August; 5.13 ± 0.14 and Fluoride was highest in the month of November (0.76 ± 1.83), while the lowest (0.31**±1.83**) was recorded in July and August.

Marked variations were also observed in the seasons of samples collection ($p \leq 0.05$). All the physico -chemical properties showed no variation in the time of sample collection; first and second weeks at $p > 0.05$ (table 2).

Table 2: Mean values of Physico-chemical Parameters for the Time of Sample collection First and Second Weeks in Obubra Town

Time	Temp. (°C)	Turb (NTU)	Colour (Pt.Co)	pH	DO (Mg/l)	EC (Mg/l)	TH (µS/cm)	TDS (CaCo₃)	TA (Mg/L)	Fl
					Mean ± S.E.					
First week	29.94	20.97	8.18	7.09	9.83	29.21	26.25	17.62	6.14	0.57
Second week	29.87	21.03	8.09	6.99	9.64	28.60	26.35	17.50	6.08	0.55
S.E.	0.39	2.68	0.57	0.11	0.98	3.96	2.73	2.38	0.07	0.12
F	0.02	0.00	0.01	0.38	0.02	0.01	0.00	0.01	0.38	0.00
P. Value	0.90	0.99	0.91	0.54	0.89	0.09	0.98	0.97	0.54	0.79

Results given as Mean ± Standard Error (S.E.)
**** Significant at p ≤ 0.05**

Table 3 shows temperature (33.92°C ± 0.38 and 25.89°C ± 0.38) turbidity (31.62 ± 1.21), colour (11.45 ± 0.39 and 4.81 ± 0.39), pH (7.53 ± 0.05 and 6.56 ± 0.05) respectively were higher in the wet than in the dry season (table 3). While dissolved oxygen, electrical conductivity, total hardness, total dissolved solids, total alkalinity and flouride were higher in the dry season than the wet season with mean values of 11.38 ± 0.43 and 8.09 ± 0.43, 30.67 ± 0.53 and 27.14 ± 0.53, 32.09± 1.2 and 20.49 ± 1.2, 18.66 ± 0.28 and 16.47 ± 0.28, 6.85 ± 0.14 and 5.37 ± 0.14, 5.01 ± 0.05 and 0.71 ± 0.02 and 0.41 ± 0.02, respectively.

Table 3: Mean values of Physico-chemical Parameters for the Seasons of sample collection in Obubra Town

Season	Temp. (°C)	Turb (NTU)	Colour (Pt.Co)	pH	DO (Mg/l)	EC (Mg/l)	TH (µS/cm)	TDS (CaCo₃)	TA (Mg/L)	Fl
					Mean±S.E					
Wet	33.92	31.62	11.45	7.53	8.09	27.14	20.49	16.47	5.37	0.41
Dry	25.89	10.38	4.81	6.56	11.38	30.67	32.09	18.66	6.85	0.71
S.E	0.38	1.21	0.39	0.05	0.43	0.53	1.2	0.28	0.14	0.02
F	229.45	154.68	143.75	180.62	28.87	21.89	46.67	31.59	54.42	81.27
P. Value	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**

**** Significant at p ≤ 0.05**
Results given as Mean ± Standard Error (S.E.)

Table 4 shows that sampled site 1 recorded the highest mean temperature, turbidity, colour, and fluoride; temperature 32.33°C ± 0.53 while site 2 recorded the lowest temperature of 27.88°C ± 0.53, turbidity, 37.88 ± 1.71 while site 2 recorded the lowest 6.93 ± 1.71, colour, 10.95 ± 0.55 while the lowest value was recorded in site 2; 5.34 ± 0.55 and fluoride, 0.68 ± 0.03, while sites 2 and 4 had lowest mean values of 0.51 ± 0.03 each (table 4). Sampled site 3 recorded the highest pH value of 7.79 ± 0.07, while site 4 recorded the lowest; 6.59 ± 0.07, highest DO mean value of 17.67 ± 0.61, while the lowest value (6.51 ± 0.61) was observed in site 4 and highest total alkalinity value of 6.39, while sampling site 4 recorded the lowest value of 5.84 ± 0.20 (table 4). Sampled site 2 recorded the highest values of electrical conductivity, 56.93 ± 0.75 while site 1 recorded the lowest value; 10.97± 0.75, total hardness mean values of 45.99 ± 1.69 while site 4 recorded the lowest value, 16.06 ± 1.69, the highest total dissolved solids mean value of 21.76 ± 0.39, while site 1 recorded the lowest value of 6.58 ± 0.39.

International Journal of Environmental Science, Botany and Zoology
Vol. 1, No. 1, November 2015, pp. 1-11
Available online at http://ijesbz.com/

Table 4: Mean values of Physico-chemical Parameters for the Four Sites of Samples Collection in Obubra Town

Site	Temp. (°C)	Turb (NTU)	Colour (Pt.Co)	pH	DO (Mg/L)	EC (Mg/L)	TH (µS/cm)	TDS (CaCo₃)	TA	Fl (Mg/L)
Site 1	32.33[c]	37.88d	10.95[b]	7.09[a]	7.74[a]	10.97[a]	16.71[a]	6.58[a]	6.22	0.68[b]
Site 2	30.24[b]	6.93[a]	5.34[a]	6.69[a]	7.01[a]	56.93[c]	45.99[c]	34.56[c]	5.97	0.51[a]
Site 3	29.16[ab]	25.79[c]	10.70[b]	7.79[c]	17.67[b]	36.41[b]	26.45[b]	21.76[b]	6.39	0.55[a]
Site 4	27.88[a]	13.39[b]	5.55[a]	6.59[a]	6.51[a]	11.32[a]	16.06[a]	7.36[a]	5.84	0.51[a]
WHO	28.00	< 5.0	NA	6.5-8.5	NA	0-40	500	1000	500	1.5
NSDWQ	Ambient	< 5.0	15	6.6-8.5	NA	1000	500	500	200	1.5
S.E	0.53	1.71	0.55	0.07	0.61	0.75	1.69	0.39	0.20	0.03
F	12.59	64.42	31.55	56.26	75.16	866.63	67.56	1.17	1.54	6.09
P. Value	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00*

Mean values in the same column with same alphabet in superscript are not statistically different from each other.

**** Significant at $p \leq 0.05$**; **Result given as Mean ± Standard Error (S.E.)**

WHO = World Health Organization; NSDWQ = Nigerian Standard for Drinking Water Quality

Discussion

Water temperature across the study period ranged from 22.68 – 34.65°C and 32.33 – 27.88°C. These range of temperatures fall below 40°C – a range that is supportive of good surface water quality (NIS, 2007). This agrees with similar studies by Akoteyon *et al*., 2011; Osibanjo *et al*., 2011 and Adeogun *et al*., 2012, in some selected rivers in south-western Nigeria. The fall in temperature during the dry season could be as a result of seasonal changes in air temperatures associated with the cool dry North – East trade winds (harmattan) which was very severe during the study period. A rise in temperature from 22.68 in January to 26.14°C in February is not unconnected with the normal increase in temperature characterized in Obubra after harmattan season.

Turbidity units of 8.72 – 39.37 were observed across the study period. The high turbidity in the month of September is attributed to the rainfall that reached its peak in Obubra and was characterized by floods and overbank flows. High turbidity values in Nigerian rivers during the rainy season have also been reported by Ajibode (2004), Adefemi *et al*., (2007) and Nakawa *et al*. (2007). Turbidity values reported for most rivers in Nigeria were far greater than 5.0 NTU limit given by the WHO (2008). Turbidity was lower in the dry season than in the wet season due mainly to the absence of flood water, surface run-offs and settling effects of suspended materials that follow the cessation of rainfall. River water was observed to be more turbid than other streams. High turbidity has a corresponding low primary productivity as it reduces light penetration, which is dangerous for aquatic flora and fauna. All the water bodies in consideration in this study have turbidity values greater than the recommended limit of < 5 by World Health Organization (WHO) and Nigerian Standards for Drinking Water Quality (NSDWQ).

Colour values in this study ranged from 3.85pt.co in February to 15.05pt.co in September. The wet season value of 11.45pt.co is an indication of the presence of materials in the water bodies. The high value in sampling site 1 is a characteristic of a water body that is large and carries so much debris and dissolved metals in it. Water Colour is generally considered on the basis of aesthetics rather than as a health hazard. All the water bodies in this study had colour units within the WHO and NSDWQ of 15 pt.co/sc. and are therefore safe for drinking and other recreational uses.

The hydrogen ion concentration obtained in this study was near neutral. The values obtained ranged from 6.5 – 7.65 across the study period; 6.56 – 7.53 across the seasons of sample collection and 6.59 – 7.79 among the sampling sites. This is within the range of 6.5 – 8.0 recommended for fresh water (NSDWQ and WHO).

Dissolved Oxygen (DO) ranged from 6.15 – 13.44 across the study period. The high DO level observed in February is an indication of the transparency and penetration of sunlight into the water bodies. Also the high DO level during the dry season coincides with the period of low water turbidity and temperature. The amount of DO in water has been reported not constant but fluctuates, depending on temperature, depth, wind and amount of biological activities such as degradation (Ibe, 1993). In this study, the cool harmattan wind which increases wave action and decreases surface water temperature contributed to the increased oxygen concentration during the dry season, while the torrential rains created turbidity and decreased oxygen concentration during the wet season. Oniye *et al*. (2002), made a similar observation for Zaria dam.

Electrical Conductivity values across the period of this study ranged from 26.03 – 34.22. The high dry season value (30.67) obtained could be attributed to the concentration effect of ions due to reduced water volume. The high value in sampling site 2 (56.73) is due to the presence of dissolved ions in the water because of leaf and root litter in the water. All the four water bodies considered in this study fall within the limits of 1000mg/l recommended by WHO and are therefore safe for drinking and other uses.

The values of Total Hardness in this study ranged from 18.49 – 37.24mg/l across the study period; 16.06 – 45.99mg/l among the sites of sample collection. The high value observed during the dry season was as a result of low water levels and the concentration of ions, while and the low value in the wet season was due to water dilution and precipitation. This agrees with the result of Kolo and Oladimeji (2004) for Shiroro Lake and Ufodike *et al*., (2002) for Dokowa mine lake. All four water bodies in this study fall within the recommended limits of 500mg/l by WHO and are therefore safe for drinking and other uses.

Total dissolved solids across the study period ranged from 15.62 – 20.65mg/l and 7.36 – 34.56mg/l for the sites of sample collection. TDS values in all the sampling sites fall within the WHO limit of 1000mg/l and 500mg/l by the NSDWQ (2007) and are safe for drinking and other purposes. The low TDS in the entire sampling sites could be attributed to the effect of self-purification processes in the waters, as flowing waters could reduce the microbial population. Higher TDS means that there are Cations and Anions in the water; with more ions in the water, the water becomes saline and increases the electrical conductivity. However, waters in the study area are not saline and this can be attributed to the effective recharge from both precipitation and surface/river drainages, although all naturally occurring waters have some amount of salt in them (Ayotamuno and Kogbara, 2001).

Alkalinity values in this study ranged from 4.78 – 7.84mg/l across the study period and5.84 – 6.39mg/l among the sites of sample collection. The high value in the dry season is attributed to the low water levels with its attendant concentration of salts, and the lower value in the wet season could be attributed to dilution by precipitation. Ufodike *et al*., (2001) recorded similar result for Dokowa Mine Lake. Sampling site 3 has the lowest alkalinity value and this could be due to the presence of bicarbonates formed from reactions in the soils through which the water percolates (USEPA, 2001). All the water bodies in this study fell within the recommended limits of 200Mg/L by WHO and NSDWQ and are therefore safe for drinking and other uses.

In this study, Fluoride concentration ranged from 0.31 – 0.76 across the period of study and 0.51 – 0.68 among the sampling sites. Fluoride levels in all the water bodies under consideration fall within the recommended limits of 1.5Mg/L of WHO and NSDWQ.

Conclusion and Recommendation

From the results obtained on the surface waters investigated in this study across the watersheds in Obubra, it is shown that surface waters contained physico-chemical parameters in safe limits as stipulated by the World Health Organization (WHO) and the Nigerian Standards for Drinking Water Quality (NSDWQ), and are therefore safe for drinking and other uses as they are not responsible for the illnesses in the area. However, for the sustenance of water quality in the area, the current land use can be maintained and water treated during the rainy season to take care of the turbidity.

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