ISSN No:-2456 –2165

Seasonal Variation in Water Quality Parameters of A West African Concrete Structured Stream

Ibemenuga Keziah Nwamaka
Department of Biological Sciences,
Chukwuemeka Odumegwu Ojukwu University
P.M.B. 02, Uli
Anambra State, Nigeria
jesusvesselofhonour@yahoo.com

Abstract:-The changes in water quality parameters were monitored from May 2008 – April 2009 in Ogbei Stream, Anambra State, Nigeria. Water samples were taken from study stations twice every month. The samples were transported to laboratory for analysis. Physico-chemical parameters were determined using standard methods. Temperature, water velocity, depth, transparency, conductivity and pH were determined in the field while dissolved oxygen, alkalinity, hardness, nitrate-nitrogen, phosphate-phosphorus and total dissolved solids were determined in the laboratory. The result revealed that air temperature, water temperature, water velocity, depth, transparency, conductivity, pH, dissolved oxygen, alkalinity, hardness, nitrate-nitrogen, phosphate-phosphorus and total dissolved solidsranged from 27.0-31.8°C (29.98±0.08°C), 25.9-29.8°C (28.14±0.08°C), 0.13-0.55 ms^{-1} (0.28±0.01 ms^{-1}), 0.19-0.56m (0.35±0.06 m), 14.00-40.60 cm (28.03±0.93 cm), 0.01-0.17 µmhos/cm (0.05±0.00 µmhos/cm), 4.30-7.50 (5.47±0.05), 3.03-6.95 mg/l (4.99±0.04 mg/l), 0.01-20.10 mg/l $CaCO_3$ (4.60±0.38 mg/l $CaCO_3$), 0.00-23.10 mg/l $CaCO_3$ (4.88±0.37 mg/l $CaCO_3$), 0.00-0.01mg/l (0.04±0.0l mg/l), 0.30-8.40 mg/l (3.67±0.13 mg/l) and 0.01-12.40 mg/l (1.44±0.22 mg/l) respectively in various months. The dry season mean values for temperature, transparency, alkalinity, phosphate-phosphorus and total dissolved solids were significantly ($p<0.05$) higher than those for the rainy season. However for water velocity, depth, pH and dissolved oxygen, the rainy season mean values were significantly higher than the dry season mean values. The concrete structure, effect of deforestation and fertilizer application were among the factors that might be responsible for the fluctuations of the physic-chemical parameters determined in the stream.

Keywords: Water Quality, Parameters, Concrete Structured Stream

I. INTRODUCTION

Ogbei Stream is a lotic perennial rain forest stream. The stream takes its source form Umuezeagwu highlands in Isioji village in Nkpologwu town and stretches through Akpo (in the south) before joining Otalu River to empty into Anambra River (Ibemenuga, 2005). Recently river modification and instream structures have been on the increase due to accelerated development. Thus a concrete structure of height 2.44 m, length 5.55 m and width 3.60 m was erected eastwards at the source of Ogbei Stream in 2005 by the Nkpologwu Progressive Union under the rulership of Igwe Nathaniel Ogbonnaya Obi, the Obi I of Nkpologwu to harness water for domestic, industrial and agricultural purposes. Since concrete structure affectphysico-chemical conditions of water, the present study is undertaken to determine the physico-chemical parameters of the stream and their seasonal variations.

II. MATERIALS AND METHODS

A. The study Area

Ogbei Stream is a perennial freshwater system. It is situated in Isioji village, Nkpologwu town of Aguata Local Government of Anambra State, Nigeria. The study area is within the tropical rainforest zone. The stream lies between latitudes 5º 58′ N and 6º 01′ N and longitudes 7º 06′ E and 7º 08′ E (Fig. 1).

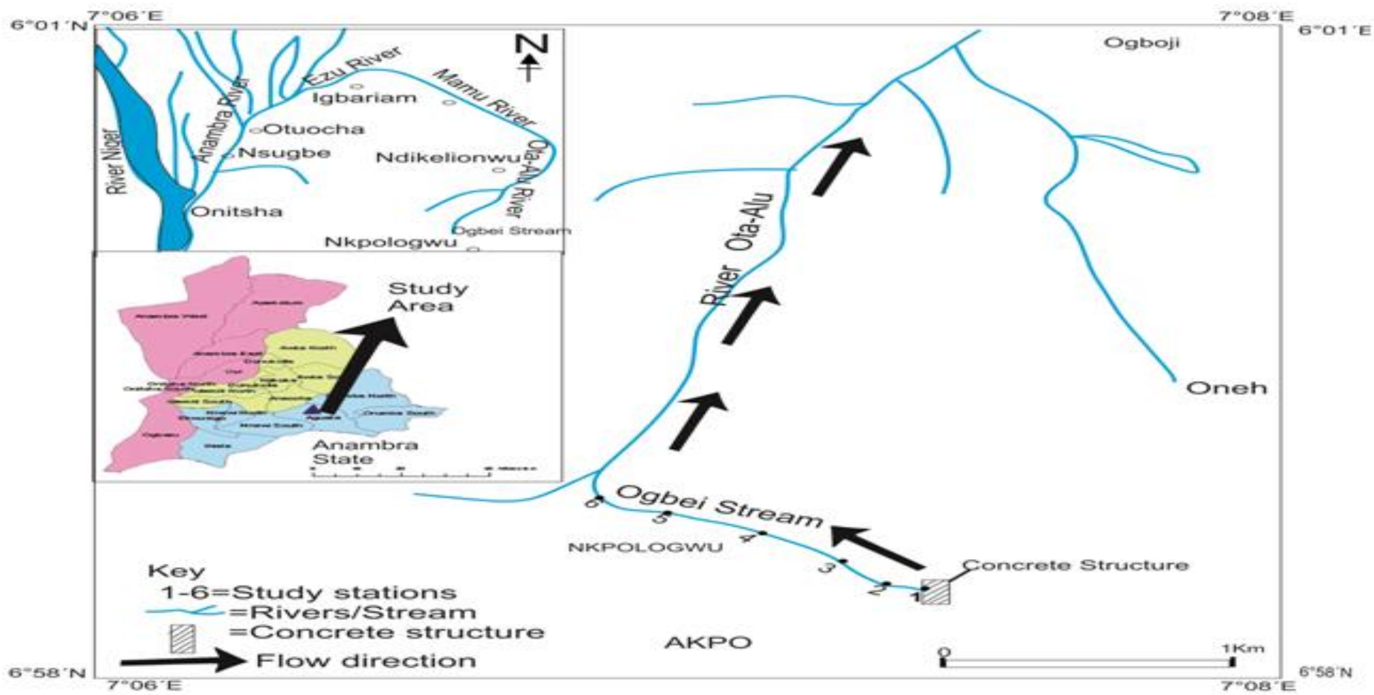

Fig. 1: Map of the Study Area

The typical tropical climate of the area is governed by the northeastern and southwestern winds which generally influence the climate of Nigeria (Arimoro*et al.,* 2007). There are two main seasons, the rainy season (April to September) and the dry season (October to March) which according to Ezenwaji (1998) approximately correspond to the dry and flood phase of the hydrologic regime. Essentially the stream flows easterly along its course. It stretches to the west through Akpo, before discharging into OtaluRiver which flows through Ndikelionwu before joining MamuRiver (in Ugwuoba), EzuRiver (in Igbariam) and AnambraRiver (in Otuocha and Nsugbe) which then confluences with the River Niger at Onitsha in AnambraState (Fig. 1). A concrete structure was erected in the stream to harness water for domestic, industrial and agricultural purposes. It is located eastwards at source of Ogbei Stream.

Notable riparian flora along the banks of the stream include Oxytenantheraabyssinica "Bamboo" (Bambusaeae), Anchormanesdifformis "Arum"(Araceae),Musangacecropioides "Corkwood"(Moraceae), Calopogoniummucunoides Papilionaceae), Pandanuscandelabrum (Pandanaceae), Costus afar and Marantocholaleucantha (Marantaceae).

B. Sample Collection and Analysis

Routine sampling was conducted in each sampling station from May 2008 – April 2009. Temperature was determined in the field using mercury-in-glass thermometer. Water velocity was measured in meters per second using a weighted cork and an L-tube for purposes of comparison. The depth of water was measured by a graduated pole caliberated in meters. Transparency was measured using secchi disc. Conductivityof water samples was determined in the field using a battery operated conductivity meter. Water pH was measured using a portable HANNA pH meter (Model H196107). Dissolved oxygen was estimated by the Azide modified techniques of Winkler's method (APHA, 1998). Total alkalinity was determined in the laboratory using methyl orange and phenolphthalein titrimetric methods (APHA, 1998). Total hardness was determined using titrimetric method according to APHA (1998). Nitrate-nitrogen Brucinesulphanillic acid colourimeter method was used to determine nitrate in the water samples (APHA, 1998). Phosphate-phosphorus was determined using Stannous chloride method (APHA, 1976).

C. Statistical Analysis

Data were analyzed using SPSS version 20.0. All data on the physical and chemical parameters were assessed for normality and homogeneity of variance. Non-normal data were transformed using appropriate transformation before analysis of variance (ANOVA). When the effects are significant in the ANOVA, Duncan's New Multiple Range Test (DNMRT) was used to separate monthly and station means ($P < 0.05$). Paired t-test was used to compare data on rainy season and dry season.

III. RESULTS

A. Variations in Physico-Chemical Parameters of Ogbei Stream in rRelation to Months

The results of physico-chemical characteristics of Ogbei Stream are presented in Table 1 (a and b).

The overall mean air temperature of 29.89±0.08°C (range 27.0-31.0°C) was recorded in the study area. The highest mean air temperature (31.01±0.14°C) recorded in March was similar to February value (30.85±0.14°C) but significantly different (p<0.05) from the values of all other months. The lowest mean value (28.33±0.19°C) was recorded in September.

Mean monthly water temperature varied between 26.94±0.22 °C in September and 29.33±0.12 °C in March (Table 1a) with annual mean value and range of 28.14±0.08 °C. These values were significantly different (p<0.05) from each other. March and September values were not significantly different (p>0.05).

Water velocity observed in this study varied in relation to months with annual mean value of 0.28±0.01 ms^{-1}. The mean monthly velocity increased from 0.29±0.02 ms^{-1} (range 0.17-0.38 ms^{-1}) in May to 0.39±0.02 ms^{-1} (range 0.28-0.55 ms^{-1}) in September. Conversely, in the dry season months (October to March) the mean water velocity decreased from 0.30±0.01 ms^{-1} (range 0.21-0.36 ms^{-1}) in October to 0.20±0.02 ms^{-1} (range 0.13-0.28 ms^{-1}) in March. The highest mean value recorded in September which was not significantly different (p>0.05) from July mean value was significantly different (p<0.05) from the values of all other months. The lowest value (0.20±0.02 ms^{-1}) recorded in March.

In the present study, depth ranged from 0.19-0.56 m with the overall mean of 0.35±0.06 m. Depth varied slightly between months (Table 1a). The highest mean depth (0.44±0.02 m, range 0.33-0.56 m) was recorded in the rainy season month of September, followed by July (0.40±0.02, range 0.28-0.48 m). These values were not significantly different (p>0.05). However, September mean value was significantly different (p<0.05) from the values of all other months. The lowest mean depth (0.28±0.02 m, range 0.19-0.36 m) was recorded in March.

Transparency was highest in February (35.25±2.15 cm, range 30.40-30.60 cm) followed by January (33.40±1.53 cm, range 31.10-37.70 cm). These values which were not significantly different (p>0.05) from the March, April, August, October and December mean values were significantly different (p<0.05) from the mean values of all other months. The lowest mean value of 21.88±4.58 cm recorded in September was significantly different (p<0.05) from January, February and March mean values (Table 1a).

Conductivity value ranged from 0.01 – 0.17 µmhos/cm with annual mean values of 0.05± 0.00 µmhos/cm. The highest mean value (0.12±0.01 µmhos/cm) recorded in April was followed by 0.07±0.00 µmhos/cm recorded in November. These were significantly different from each other and from the values of all other months. The least value 0.03±0.00 µmhos/cm occurred from December to February (Table 1a).

Parameter	MONTHS					
	RAINY SEASON					DRY SEASON
	May	Jun.	Jly.	Aug.	Sept.	Oct.
Air temperature (°C)	29.84±0.12^{de} (29.1-30.5)*	29.46±0.18^{e} (28.5-30.0)	28.87±0.27^{f} (27.0-30.0)	29.42±0.17^{e} (28.5-30.5)	28.33±0.19^{g} (27.3-29.5)	30.09±0.16^{cd} (29.3-0.08)
Water temperature(°C)	28.01±0.20^{cd} (27.2-29.5)	27.69±0.16^{de} (26.9-28.5)	27.39±0.25^{ef} (26.3-28.8)	27.62±0.16^{de} (26.9-28.7)	26.94±0.22^{f} (25.9-28.3)	28.38±0.21^{bc} (27.3-29.6)
Current/water velocity (ms^{-1})	0.29±0.02^{cde} (0.17-0.38)	0.32±0.02^{bc} (0.24-0.43)	0.35±0.02^{ab} (0.25-0.45)	0.31±0.01^{cd} (0.23-0.38)	0.39±0.02^{a} (0.28-0.55)	0.30±0.01^{cd} (0.21-0.36)
Depth (m)	0.34±0.02^{bcde} (0.21-0.43)	0.37±0.02^{bc} (0.26-0.45)	0.40±0.02^{ab} (0.28-0.48)	0.36±0.02^{bcd} (0.28-0.45)	0.44±0.02^{a} (0.33-0.56)	0.37±0.02^{bc} (0.26-0.45)
Transparency (cm)	24.23±3.08^{bc} (16.00-30.10)	23.15±3.20^{c} (16.00-30.50)	22.83±4.34^{c} (15.50-35.40)	26.63±2.54^{abc} (23.00-34.00)	21.88±4.58^{c} (14.00-35.00)	27.80±2.43^{abc} (21.00-32.20)

Conductivity (µmhos/cm)	0.05±0.01^{d} (0.01-0.10)	0.04±0.01^{d} (0.01-0.10)	0.04±0.01^{d} (0.01-0.06)	0.04±0.01^{d} (0.02-0.90)	0.04±0.01^{d} (0.01-0.09)	0.09±0.00^{b} (0.08-0.11)
pH	5.89±0.16^{a} (5.30-6.60)	5.93±0.11^{a} (5.50-6.70)	5.98±0.12^{a} (5.30-6.60)	6.07±0.15^{a} (5.40-6.70)	5.48±0.06^{b} (5.10-5.80)	6.07±0.15^{a} (5.40-7.50)
Dissolved oxygen (mg/l)	5.08±0.01^{bc} (5.00-5.13)	5.10±0.01^{bc} (5.04-5.21)	5.19±0.09^{b} (5.00-6.21)	5.61±0.20^{a} (5.00-6.95)	5.23±0.07^{b} (5.00-5.85)	5.15±0.02^{b} (5.05-5.30)
Alkalinity (mg/lCaCO$_3$)	0.07±0.01^{e} (0.03-0.11)	5.72±1.70^{cd} (0.10-12.00)	7.64±0.81^{cd} (4.20-13.60)	1.58±0.16^{e} (0.60-2.50)	0.53±0.03^{e} (0.40-0.80)	0.40±0.05^{e} (0.40-0.80)
Hardness (mg/lCaCO$_3$)	12.12±0.90^{a} (5.70-16.50)	7.41±2.34^{b} (0.20-23.10)	4.63±2.00^{bc} (0.00-19.30)	5.63±0.63^{bc} (3.20-11.11)	1.23±0.02^{d} (1.10-1.40)	1.48±0.11^{d} (0.90-2.20)
Nitrate-nitrogen (mg/l)	0.03±0.01^{b} (0.00-0.06)	0.04±0.01^{b} (0.00-0.06)	0.04±0.00^{b} (0.02-0.07)	0.03±0.01^{b} (0.00-0.09)	0.04±0.01^{b} (0.00-0.07)	0.04±0.00^{b} (0.02-0.06)
Phosphate-phosphorus (mg/l)	3.42±0.13^{bc} (2.70-4.30)	2.88±0.96^{cde} (2.10-3.60)	2.31±0.08^{de} (1.80-2.60)	1.98±0.50^{e} (0.30-4.20)	3.53±0.53^{bc} (1.50-6.30)	3.58±0.34^{bc} (1.60-4.90)
Total dissolved solids (mg/l)	1.05±0.28^{c} (0.30-2.50)	0.59±0.11^{cd} (0.60-1.40)	0.18±0.03^{cd} (0.10-0.40)	0.41±0.06^{cd} (0.20-0.90)	0.40±0.08^{cd} (0.10-0.90)	0.82±0.48^{cd} (0.20-6.10)

Table 1: Summary of Results of Physico-Chemical Parameters At Ogbei Stream (May 2008 - April 2009)

Parameter	MONTHS						Annual mean
	RAINY SEASON					DRY SEASON	
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	
Air temperature (^{o}C)	30.43±0.12^{bc} (29.7-31.0)	29.87±0.22d^{e} (28.7-31.5)	30.13±0.22^{cd} (28.6-31.5)	30.85±0.14^{ab} (30.3-31.8)	31.01±0.14^{a} (30.5-31.8)	30.35±0.13^{bcd} (29.5-31.0)	29.89±0.08 (27.0-31.8)
Water temperature (^{o}C)	28.70±0.16^{b} (28.0-29.7)	27.78±0.18^{de} (26.9-28.9)	28.47±0.19^{bc} (27.6-29.7)	28.88±0.16^{ab} (28.1-29.7)	29.33±0.12^{a} (28.5-29.8)	28.47±10.21^{bc} (27.5-29.7)	28.14±0.08 (25.9-29.8)
Current/water velocity (ms^{-1})	0.26±0.04^{def} (0.20-0.32)	0.25±0.01^{efg} (0.18-0.32)	0.23±0.01^{fgh} (0.16-0.30)	0.21±0.01^{gh} (0.15-0.29)	0.20±0.02^{h} (0.13-0.28)	0.23±0.01^{fgh} (0.17-0.30)	0.28±0.01 (0.13-0.55)
Depth (m)	0.35±0.02^{bcd} (0.26-0.43)	0.33±0.02^{bcde} (0.24-0.42)	0.32±0.02^{cde} (0.23-0.40)	0.30±0.02^{de} (0.22-0.39)	0.28±0.02^{e} (0.19-0.36)	0.31±0.02^{de} (0.20-0.38)	0.35±0.06 (0.19-0.56)
Transparency (cm)	29.20±0.58^{abc} (27.80-30.30)	29.68±2.9^{abc} (24.20-37.90)	33.40±1.53^{a} (31.10-37.70)	35.25±2.15^{a} (30.40-40.60)	32.85±1.27^{ab} (30.00-35.00)	29.53±1.28^{abc} (26.00-32.10)	28.03±0.93 (14.00-40.60)
Conductivity (µmhos/cm)	0.07±0.00^{c} (0.04-0.09)	0.03±0.00^{d} (0.02-0.00)	0.03±0.00^{d} (0.02-0.06)	0.03±0.00^{d} (0.03-0.04)	0.04±0.00^{d} (0.03-0.0)	0.12±0.01^{a} (0.10-0.17)	0.05±0.00 (0.01-0.17)
pH	4.77±0.08^{c} (4.30-5.20)	4.87±0.64^{c} (4.50-5.20)	5.38±0.17^{b} (4.70-6.30)	4.84±0.05^{c} (4.60-5.10)	5.46±0.06^{b} (5.00-5.70)	4.92±0.06^{c} (4.60-5.20)	5.47±0.05 (4.30-7.50)
Dissolved oxygen (mg/l)	5.04±0.00^{b} (5.03-5.06)	4.79±0.13^{c} (4.02-5.06)	4.80±0.13^{c} (4.06-5.06)	3.98±0.15^{d} (3.03-5.03)	4.94±0.11^{bc} (4.05-5.18)	4.92±0.11^{bc} (4.10-5.13)	4.99±0.04 (3.03-6.95)
Alkalinity (mg/lCaCO	5.30±0.27^{d}(5.	14.10±0.68^{a}(12.	8.34±0.18^{b}(6.	7.13±0.33^{bc}(5.	4.33±0.24^{d}(2.	0.06±0.02^{e}(0.	4.60±0.38(0.

$_3$)	00-6.90)	20-20.10)	80-9.20)	40-8.50)	70-5.40)	01-0.16)	01-20.10)
Hardness (mg/lCaCO$_3$)	7.30±0.39^{b} (5.20-9.10)	3.50±0.71^{cd} (1.00-6.20)	3.68±0.15^{cd} (3.10-4.30)	4.87±0.15^{bc} (4.00-5.60)	5.33±0.47^{bc} (3.20-8.40)	1.44±0.04^{d} (1.20-1.60)	4.88±0.37 (0.00-23.10)
Nitrate-nitrogen (mg/l)	0.01±0.00^{b} (0.00-0.05)	0.04±0.01^{b} (0.02-0.10)	0.12±0.08^{a} (0.01-1.01)	0.03±0.00^{b} (0.02-0.05)	0.01±0.00^{b} (0.00-0.04)	0.01±0.00^{b} (0.00-1.01)	0.04±0.01 (0.00-1.01)
Phosphate-phosphorus (mg/l)	5.53±0.28^{a} (4.80-8.40)	3.55±0.62^{bc} (0.40-5.70)	5.07±0.08^{a} (4.60-5.60)	5.19±0.09^{a} (4.90-5.90)	4.08±0.18^{b} (4.00-4.20)	2.97±0.17^{cd} (1.50-3.50)	3.67±0.13 (0.30-8.40)
Total dissolved solids (mg/l)	9.20±0.68^{a} (6.10-12.40)	0.62±0.03^{cd} (0.40-0.80)	0.81±0.04^{cd} (0.60-1.00)	0.39±0.03^{d} (0.30-0.60)	0.09±0.01^{d} (0.01-0.13)	2.67±0.22^{b} (1.40-4.40)	1.44±0.22 (0.01-12.40)

Table 2: Summary of Results of Physico-Chemical Parameters, Ogbei Stream (May 2008 - April 2009) (Contd.)

Mean (±S.E.) value with the same superscript on the same row are not significantly different from each other at $p > 0.05$.
* The figures in parenthesis show range in monthly samples of the species.

The pH of the stream fluctuated from 4.30-7.50 with annual mean value of 5.47±0.05. The highest mean pH value (6.07±0.15) was recorded in August (rainy season) Table 1a). This value was not significantly different ($p>0.05$) from May, June, July and October mean values. However, it was significantly different ($p<0.05$) from the pH values recorded for all other months. The lowest mean value of 4.77±0.08 (range 4.30-5.20) was recorded in November (dry season).

Dissolved oxygen fluctuated from 3.03-6.95 mg/l with annual mean value of 4.99±0.04 mg/l (Table 1a). The highest mean value (5.61±0.20 mg/l range 5.00-6.95 mg/l) was recorded in August and the lowest mean value (3.98±0.15 mg/l, range 3.03-5.03 mg/l) was recorded in February. These values were significantly different ($p<0.05$) from each other and from the mean values of all other months. The lowest mean value 3.89±0.15 mg/l, range 3.03±5.03 mg/l) was recorded in February. This value differed significantly from the values of all other months.

The alkalinity of Ogbei Stream varied with season with annual mean value of 4.60±0.38 mg/l$CaCO_3$, range 0.01-20.10mg/l$CaCO_3$. Alkalinity of the stream decreased in the rainy season (May - September and April) but increased in the dry season(October – March). Mean alkalinity fluctuated between months with the highest mean values (14.10±0.68 mg/l $CaCO_3$, range 12.20-20.10 mg/l$CaCO_3$) recorded in December. This values was significantly different ($p<0.05$) from the mean values recorded for all other months. The lowest mean value (0.06±0.02 mg/$CaCO_3$) was recorded in April (Table 1a).

Water hardness varied across the months of study (Table 1b). The hardness values ranged between 0.00 – 23.10 mg/l $CaCO_3$ with overall mean value of 4.88±0.37 mg/l $CaCO_3$. Generally, water hardness increased in the rainy season than dry season. The highest mean hardness value (12.12±0.90 mg/l $CaCO_3$) recorded in May, was significantly different ($p<0.05$) from the mean values recorded for all other months. The lowest mean value of 1.23±0.02 mg/l $CaCO_3$ was recorded in September.

Table 1 shows the result of the mean nitrate-nitrogen values in relation to months with annual mean value and range of 0.04±0.01 mg/l and 0.00-1.01 mg/l respectively. Generally higher monthly mean values of nitrate-nitrogen were recorded in the dry season months. The highest mean value of 0.12±0.08 mg/l with a range of 0.01-1.01 mg/l recorded in January (dry season) was significantly different ($p<0.05$) from the values of all other months. The least mean value of 0.01±0.00 mg/l was recorded in November.

The annual mean value (3.67±0.13 mg/l) recorded in the study fluctuated from 0.30-8.40 mg/l. Higher mean phosphate-phosphorus values were recorded in the dry season months (October-March) while lower mean values were recorded in the rainy season months of May – September 2008 and April 2009. (Table 1b) The highest mean phosphate-phosphorus value was recorded in November (5.53±0.28) followed by 5.19±0.09 mg/l and 5.07±0.08 mg/l recorded in February and January (dry season months) respectively. These values were not significantly different ($p>0.05$) from each other. However, they were significantly different from the values recorded for all other months. The lowest mean value of 1.98±0.50 mg/l

ISSN No:-2456 –2165

recorded in August did not differ significantly ($p>0.05$) from June and July values.

Table 1b shows that higher mean monthly values of total dissolved solids were recorded in dry season when compared to the lower mean monthly values recorded in the rainy season. The highest mean value 9.20±0.68 mg/l recorded in November was significantly different ($p<0.05$) from the mean values of all other months. March had the lowest mean value (0.09±0.01 mg/l) which was significantly different ($p<0.05$) from the values of other months.

A. Seasonal Variations of Physico-Chemical Parameters

Results from the study showed that the dry season values for temperature, pH, alkalinity, nitrate-nitrogen, phosphate-phosphorus and total dissolved solids were significantly higher ($p<0.05$) than those of the rainy season (Table 2).

T-test computations showed significant difference ($p<0.05$) between the dry season and rainy season transparency values. Water velocity, depth, hydrogen ion concentration and dissolved oxygen values in rainy season increased over those of the dry season ($p<0.05$). However, conductivity, hardness and nitrate-nitrogen values for both seasons were not significantly different ($p>0.05$).

Physico-chemical Parameter	**Season**	
	Rainy season (Mean ± S.E.)	**Dry season (Mean ± S.E.)**
Air temperature (ºC)	29.378 ± 0.105^a	30.397 ± 0.083^b
Water temperature (ºC)	27.687 ± 0.098^a	28.589 ± 0.088^b
Current/ water velocity (ms^{-1})	0.314 ± 0.009^a	0.242 ± 0.006^b
Depth (m)	0.369 ± 0.009^a	0.326 ± 0.008^b
Transparency (cm)	24.704 ± 1.329^a	31.404 ± 0.893^b
Conductivity (µmhos/cm)	0.053 ± 0.005^a	0.051 ± 0.003^a
pH	5.710 ± 0.066^a	5.230 ± 0.069^b
Dissolved oxygen (mg/l)	5.186 ± 0.049^a	4.784 ± 0.062^b
Alkalinity (mg/l $CaCO_3$	2.602 ± 0.466^a	6.60 ± 0.514^b
Hardness (mg/l $CaCO_3$	5.408 ± 0.686^a	4.359 ± 0.264^a
Nitrate-nitrogen (mg/l)	0.031 ± 0.003^a	0.040 ± 0.014^a
Phosphate - phosphorous (mg/l)	2.846 ± 0.141^a	4.499 ± 0.155^b
Total dissolved solids (mg/l)	0.888 ± 0.118^a	1.988 ± 0.407^b

Mean values with the same superscript on the same row are not significantly different from each other at $p > 0.05$

Table 3: Seasonal Variations of Physico-Chemical Parameters at Ogbei Stream (May 2008 - April 2009)

IV. DISCUSSION

The results of physical and chemical parameters obtained from the study showed some variations between samples, months, and rainy season and dry season of the year of study.The highest mean ambient temperature recorded in March corresponds to the period of heat which undoubtedly affect ambient temperature probably by increasing the solar heat radiation caused by deforestation during the dry season. A deforested or degraded water shed is exposed to wind, temperature change, pressure, flood, soil moisture content, and interplay of other physical and chemical influences (Okonkwo and Eboatu, 1999). The lower ambient mean temperature recorded in the rainy season may be due to rainfall and relative humidity which Ayoadeet al. (2006) reported to be higher during rainy season thus lowering the atmospheric temperature. The sharp decrease in ambient temperature observed in December may be associated with harmattan. Cool harmattan wind increases wave action, and decreases surface water temperature (Ibrahim et al., 2009).The lower mean ambient temperature recorded in the rainy season (29.378±0.105°C) could be attributed to the thicker cloud cover in the rainy season which had a reducing effect on the solar radiation and in addition, the high concentration of suspended particles (Ayoadeet al., 2006). Suspended particles reduce solar heat radiation to bottom dwellers and so help in eliminating or reducing predatory organisms (Boyd, 1979; Aguigwo, 1997). This agrees with the findings of Anetekhai (1986).

The highest mean water temperature observed in March and the lowest mean water temperature recorded in September could be due to increase and decrease in solar radiation during the months. The temperature of 25.9°C-29.8°C recorded over the study period fell within the tropical temperature range (25°C-35°C) of natural tropical water (Alabaster and Lloyd, 1980). The absence of marked variability in water temperature in this study is in consonance with reports of Armitage (1984) and King (1998) for tropical streams. The mean water temperature value (28.14±0.08°C) was higher compared to some other streams such as NnamdiAzikiwe University Stream (27.25±0.55°C) (Aguigwo, 1998) and Dilimi River (Anaduand Akpan, 1996). The higher mean water temperature observed in the dry season could be due to temperature increase associated with dry season, and clearing of vegetation which has increasing effect on the solar radiation.

The decrease in water current observed from October to March may be attributed to reduced rainfall. The increased water current recorded in the rainy months of May to September through April was due to rainfall associated with these periods. The low velocity is attributed to the fact that the water in the stream was reduced to a trickle in the dry season. In lotic freshwaters rainfall plays an important part, causing fast currents during the rainy season when the river is flooded compared with the trickle of slow moving water during the dry season.

Depth varied from 0.28±0.02 m in March to 0.44±0.02 m in September with a range of 0.19 m-0.36 m and 0.33 m – 0.56 m respectively. This was lower than 0.37 m – 7.59 m recorded by Edokpayi and Osimen (2001) in Ibiekuma River. The increase in depth obtained in September and the rainy months may be associated with rise in water level due to rainfall during the rainy season. Depth increase during the rainy season was as a result of precipitation and runoff during the rainy months (Ibemenuga and Inyang, 2007).

Water transparency of Ogbei Stream showed distinct seasonal variation. Higher values were recorded in the dry season which tend to reduce during the rains, which can be attributed to increased input of particualte organic debris through surface runoff while high transparency during the dry season may be due to sedimentation of suspended solids and decrease in the input of surface run-off (Ehigiator and Obi, 2016). Omoigberale (2005) in his assessment of water quality of River Osse made similar observations.

The highest electrical conductivity recorded in the rainy season month of April may be attributed to runoff from catchment area. Higher conductivity was observed during the high level period in some water bodies (Rai and Hill, 1981; Kolo and Oladimeji, 2004; Kolo and Tukura, 2007).Low conductivity value recorded in the dry season (December – February), may be caused by reduction or complete absence of runoffs from the watereshed. Thus the usual pattern in which conductivity rises during the dry season and falls during the wet season (Ogbeibu and Victor, 1995; Edokpayi and Osimen, 2002) was not observed in the study.The dry season mean value (0.051±0.003 μmhos/cm) was fairly uniform with rainy season mean value (0.053±0.005 μmhos/cm). This may be due to evapotranspiration. In the dry season water shrinks into stagnant pools (Ogbogu and Hassan, 1996).

Judging from the conductivities of the stream in Eastern Nigeria, the Iyi-Ogighe Stream 22.50 μmhos/cm (Umeham and Elekwa, 2005), and Eme Stream 33.0 μmhos/cm (Umeham and Elekwa, 2005), Ogbei Stream has very low conductivity. The conductivity in Ogbei Stream places it in class 1 of Talling and Talling’s (1965) classification of African waters (the most dilute waters of conductivity <600 μmhos/cm): this class of water is said to be poor in nutrients (Emere and Nasiru, 2007). The conductivity of the Ogbei Stream fell within the recommended (<450 μs/cm) limits of World Health Organization for drinking source (WHO, 2004).

The pH range of 4.30-7.50 recorded in Ogbei Stream was acidic. Variations in the values generally followed the fluctuations in water level with the highest pH values occurring in August (rainy season) during the period of high water level. Due to the presence of naturally occurring humic acids, streams may have very low pH (sometimes less than 5) (Commonwealth of Australia, 2002). A pH range of 6.0 to 9.0 appears to provide protection for the life of fresh water fish and bottom dwelling invertebrates (Usuman, 2016).

The highest mean dissolved oxygen recorded in August could be attributed to wind occurrence. The lowest dissolved oxygen recorded in February was due to decrease in rainfall. Seasonal variations in dissolved oxygen content in Ogbei Stream with higher values in the rainy season could be attributed to low water temperature and increased aeration because of heavy rainfall with attendant increase in spate. Olaniyan (1978) indicated that owning to the rapid movement of water, more surface is exposed to air than in quiet water and this leads to an increase in oxygen content.The quality of dissolved oxygen in any water would be influenced by temperature (Cooper and Kochi, 1984) and dissolved oxygen decreases with increase in temperature (Aguigwo, 1998). The low dissolved oxygen reported in this study is obvious reflection of alterations in the stream continuum due to the erected concrete structure.

Variations in the total alkalinity were erratic during the dry months (October - March) and relatively stable during the rainy months (May - September and April). The alkalinity range (0.01 - 20.10 mg/l) obtained in this study falls far below the recommended value of 50 mg/l $CaCO_3$ to 300 mg/l CaCO3 for freshwater fish culture (Stirling, 1985). Freshwater quality standard of 500 mg/l for bicarbonate has been recommended by WHO (1973). Results of the study for carbonate (alkalinity) were generally below this value. The low alkalinity in this study is a reflection of the low lime content of the underlying rock type and surrounding soils along the

stream course. The low alkalinity may be due to high photosynthetic rate in the water as a result of high transparency(Umeham, 2000).
The seasonality regime of the studied stream comparedfavourably with the pattern in most tropical rivers (Adebisi, 1981; Hall et al., 1977; Edokpayi and Osimen, 2002; Ali et al., 2007).

The hardness values recorded in Ogbei Stream for all months was higher during the rainy season (May - September and April) compared to the dry season (October - March). The water hardness values obtained in the peak of the rainy season (May– September and April) ranging from 0.00 - 23.10mg/l $CaCO_3$ fall within the classification of soft water. This and the maximum value recorded in May could be attributed to the effect of rain water, which neutralized the chemical concentration of the water within the stream. The low dry season hardness value contrasts that of Kolo and Tukura (2007). The low value recorded could be attributed to watering of vegetable gardens during the dry season.

Generally nitrate-nitrogen in Ogbei Stream is low throughout the study period. This may be due to their utilization by plants. Hynes (1970; 1980) has indicated that ions are rapidly taken up by plants. The mean monthly value obtained in January may be due to excess fertilizer application by farmers farming around the stream. Nitrate-nitrogen could get into water through various sources such as cattle dungs, fertilizer runoff (Nwoko, 1991), drainage from agricultural areas (Reid and Wood, 1976) and domestic effluents such as sewage (Ogbogu and Hassan, 1996). The low nitrate-nitrogen observed in other months may be attributed to heterotrophic uptake by microbes, sediment absorption and clearing of plants growing along the banks. The range (0.00 - 1.01mg/l) level obtained in this study is lower than the values obtained inSalantariver (Kawo, 2005), but compared approximately with 0.14 - 0.73mg/l obtained inNnamdiAzikweStream (Aguigwo, 1997) and 0.19 - 0.55 mg/l in EthiopeRiver (Omo-Irabor and Olobaniyi, 2007).

The phosphate-phosphorus value obtained in the study was lower compared with 20 – 51 mg/l in Dilimi River (Anadu and Akpan, 1996). The lower value of phosphate-phosphorus was probably due to its rapid utilization by aquatic organisms (Kumar, 2003).

Total dissolved solid displayed erratic temporal and spatial variations. The highest value recorded in November could be associated with change in water flow downstream due to the concrete structure erected in the stream and bank clearing which encourage evaporation.Concentration of solids by evaporation (Edokpayi and Osimen, 2002) results to high level of total dissolved solids. The seasonality regime of the study stream contrast with that of Offemet al. (2011) in which total dissolved solids was higher in the rainy season but lower in the dry season. The concentration and composition of total dissolved solids in inland waters is determined by the geology of the drainage, atmospheric precipitation and the water balance (evaporation-precipitation) (Weber-Scannell and Duffey, 2007). Seasonally, all the physico-chemical parameters with the exception of conductivity, hardness and nitrate nitrogen showed significant difference ($p<0.05$) in the study.

V. CONCLUSION

There was significant difference ($p<0.05$) in dry and rainy season of temperature, water velocity, depth, transparency, pH, dissolved oxygen, alkalinity, phosphate-phosphorus and total dissolved solids. Conductivity, hardness and nitrate-nitrogen values for both seasons were not significantly different at $p>0.05$. The concrete structure, effect of deforestation and fertilizer application might be among the factors responsible for the fluctuations of some of the water quality parameters determined in Ogbei Stream.

REFERENCES

[1]. Adebisi, A. A. (1981).The physico-chemical properties and hydrology of a tropical seasonal river - upper Ogun River. Hydrobiologia, **79**: 157 - 165.
[2]. Aguigwo, J. N. (1997). Studies on plankton productivity in relation to water quality parameters and nutrient levels. Journal of Aquatic Sciences, **12**: 15 - 22.
[3]. Aguigwo, J. N. (1998). Studies on the physico-chemical parameters and plankton productivity of a productive stream. Journal of Aquatic Sciences, **13**: 9 - 13.
[4]. Alabaster, J. S. and Lloyd, R. (1980). Water Quality Criteria for Freshwater Fish. FAO and Butterworths, London.
[5]. Ali, M. M., Mageed, A. A. and Heikal, M. (2007). Importance of aquatic macrophytes for invertebrate diversity in large subtropical reservior. Limnologia, **37**: 155 -169.
[6]. American Public Health Association (APHA) (1976). Standard Methods for the Examination of Water and Waste Water. 14th Edition. American Public Health Association, APHA Washington DC.
[7]. American Public Health Association (APHA) (1998). Standard Methods for the Examination of Water and Waste Water. 20th Edition, Washington, DC, U.S.A.
[8]. Anadu, D. I. and Akpan, A. W. (1996). A survey of the functional feeding groups in the Dilimi River in Jos, Plateau State, Nigeria. Nigerian Journal of Applied Fisheries and Hydrobiology, **1**: 25 - 31.
[9]. Anetekhai, M. A. (1986). Aspects of the Bioecology of the African River Prawn Macrobrachiumvollenhovenii(Herklots) in Asejire Lake, Oyo State, Nigeria.Ph.D Thesis, University of Ibadan.
[10]. Arimoro, F. O., Ikomi, R. B. and Efemuna, E. (2007). Macro-invertebrate community patterns and diversity in relation to water quality status of River Ase, NigerDelta, Nigeria. Journal of Fisheries and Aquatic Sciences, **2**(5): 337 - 344.

[11]. Armitage, P. D. (1979). Stream regulation in Great Britain. In: Ward, J. V. and Stanford, J. A. (Editors). The Ecology of Regulated Streams. Plenum Press, New York.

[12]. Armitage, P. D. (1984). Environmental changes induced by stream regulation and their effect on lotic Macro-invertebrate communities. In: Lillehammer, A. and Saltveit, S. J. (Editors). Regulated Rivers. Oslo University Press, Oslo, Norway.

[13]. Ayoade, A. A., Fagade, S. O. and Adebisi, A. A. (2006). Dynamics of limnological features of two man-made lakes in relation to fish production. African Journal of Biotechnology, **5**(10): 1013 - 1021.

[14]. Boyd, C. E. (1979). Water Quality in WarmWater Fish Pond. Craftmaster Printers INC. OpelikaAlabama.

[15]. Commonwealth of Australia (2002). WaterwatchAustralia Technical Manual: Module 4 Physical and Chemical Parameters 52pp. http://www.waterwatch.org.au//publications /module 4/pubs/module 4. pdf. Accessed November 26, 2009.

[16]. Cooper, J. J and Kochi, D. L. (1984). Limnology of destrio-terminal lake, Walker Lake, NevadaU.S.A.Hydrobiologia,**118:** 267 - 274.

[17]. Edokpayi, C. A. and Osimen, E. C. (2001). Hydrobiological studies of IbiekumaRiver at Ekpoma, Southern Nigeria, after impoundment: the faunal characteristics. African Journal of Science and Technology,**2**(1): 72-81.

[18]. Edokpayi, C. A. and Osimen, E. C. (2002). The impact of impoundment on the physical and chemical hydrology of Ibiekumastream in Southern Nigeria. Tropical Ecology,**43**(2): 287 - 296.

[19]. Ehigiator, F.A.R. and Obi, A. (2016). Interelationships among physical parameters in Ovia River, Niger Delta, Nigeria. Nigerian Journal of Fisheries, **13**(1 & 2): 1000 – 1007.

[20]. Emere, M. G. and Nasiru, C. E. (2007). Macro-invertebrates as Indicators of the water quality of an urbanized stream, Kaduna Nigeria. Nature and Science, **6**(4): 1 - 7.

[21]. Ezenwaiji, H. M. G. (1998). Observations on the biology of ClariasagboyiensisSyndenham, 1980 (Osteichthyes: Clariidae) in the Anambra Flood River System, Nigeria. Fisheries Research, **36:** 47 - 60.

[22]. Hall, A., Calente I. M. and Davies, B. R. (1977). The Zambezi river in Mozambique and lower dam. Freshwater Biology, **7:** 187 - 206.

[23]. Hynes, H. B. N. (1970). The Ecology of Running Waters.University of Toronto Press, Toronto.

[24]. Ibemenuga, K. N. (2005). The Ecology of Macro-invertenrate Fauna of Ogbei Stream in Nkpologwu, Aguata Local Government Area, Anambra State, Nigeria. M.Sc. Project Report, University of Nigeria, Nsukka.

[25]. Ibemenuga, K. N. and Inyang, N. M. (2007). Physico - chemical characteristics of a tropical stream in Nigeria. Journal of Biological Research and Biotechnology, **2:** 275 - 281.

[26]. Ibrahim, B.U., Auta, J. and Balogun, J.K. (2009). An assessment of the physico-chemical parameters of Kontagora Reservoir, Niger State, Nigeria. Bayero Journal of Pure and Applied Sciences, **2**(1): 64–69.

[27]. Kawo, A.H. (2005). Algal dynamics and limological parameters of Salanta River, Kano, Nigeria. Biological and Environmental Sciences Journal for the Tropics, Best, **2**(1): 101–104.

[28]. King, R. P. (1998). Physico-chemical indices of the fisheries potential of a Nigerian rainforest pond. Journal of Aquatic Sciences, **13:** 49 – 54.

[29]. Kolo, R. J. and Tukura, M. D. (2007). Aspects of limnological studies of Tagwai Dam, Minna, Niger State, Nigeria. Journal of Aquatic sciences, **22**(2): 27 - 32.

[30]. Kolo, R.J. and Oladimeji, A.A. (2004). Water quality and some nutrient levels in Shiroro Lake, Niger State, Nigeria. Journal of Aquatic Sciences, **19**(2): 99–106.

[31]. Kumar, K. A. (2003). AquaticEcosystems. A. P. H. Publishing Corporation, New Delhi.

[32]. Maitland, P. S. (1978). Biology of Freshwaters. Second Edition. Chapman and Hall, New York.

[33]. Nwoko, C.U. (1991). Fisheries resources and the politics of inland water resources development in Nigeria, with particular reference to the arid zone. In: Arid Hydrobiology and Water Resources. University of Maiduguri Press, Nigeria. Pp. 493–500.

[34]. Offem, B. O., Bassey, I. and Ikpi, G. U. (2011). Downstream changes on a tropical fish community structure by effluent from wood processing factory. Journal of Environmental Protection, 2: 982 - 995.

[35]. Ogbeibu, A. E. and Victor, R. (1995). Hydrobiological studies in the Okomu forest Reserve (sanctuary) in Southern Nigeria 2: physical and chemical hydrology. Tropical Freshwater Biology, 4: 83 - 100.

[36]. Ogbogu, S. S. and Hassan, A. T. (1996). Effects of sewage on the physico-chemical variables and Ephemeroptera (Mayfly) larvae of a stream-reservoir system. Journal of Aquatic sciences, 11: 43 - 55.

[37]. Okonkwo, E.M. and Eboatu, A.N. (1999). Environmental Pollution and Degradation. Onis Excel Publishing, Zaria. 156pp.

[38]. Olaniyan, C. I. O (1978). An Introduction to West African Animal Ecology. Heinemann Education Books Ltd, London.

[39]. Omoigberale, M.O. (2005). Assessment of water quality of River Osse using Physical, chemical and Biological indices. Ph.D Thesis, University of Benin, Benin-City. 179pp.

[40]. Omo-Irabor, O.O. and Olobaniyi, S.B. (2007). Investigation of Hydrological Quality of Ethiope River Watershed, Southern Nigeria. Journal of Applied Science and Environmental Sciences, 11(2): 13–19.

[41]. Rai, H. and Hill, G. (1981). Physical and Chemical studies of LagoTupe; a Central Amazonian black water ‘RiaLake’. International Revue der GesamtenHydrobiologie, 66: 37 - 82.

[42]. Reid, G.K. and Wood, R.D. (1976). Ecology of Inland Waters and Estuaries. D. Van Nostrand Company, New York. 485pp.

[43]. Stirling, H. P. (1985). Chemical and Biological Methods of Water Analysis for Aquaculturist, 25 - 30.

[44]. Ugwu, L. L. C. and Mgbenka, B. O. (2006). Fisheries and Wildlife (A Systematic Approach). Jones Communication Publishers, Enugu.

[45]. Umeham, S. N. (2000). Some aspects of the physico-chemical and the drinking water quality of Aba River, Abia State. Journal of Health and Visual Sciences, 2(2): 91 - 95.

[46]. Umeham, S. N. and Elekwa, I. (2005). The hydrobiological status of Ngwui, Ikwu and EmeStreams in Umuahia North L. G. A., Abia State, Nigeria. Journal of Environment,1: 31 – 36.

[47]. Usuman, L.U. (2016). Effects of Anthropogenic Activities on the Seasonal Variation of Some Physico-Chemical Parameters in Ajiwa Reservoir, Katsina State, Nigeria. Annals of Experimental Biology, 4(4): 11−16.

[48]. Weber-Scannell, P. K. and Duffey, L. K. (2007). The effects of elevated total dissolved solids on freshwater aquatic biota largely from acute toxicity biossays.

[49]. World Health Organization (WHO) (1973). Health hazards from waste water treatment practices. Environmental Letters, 4: 225 - 234.

[50]. World Health Organization (WHO) (2004). Guidelines for Drinking Water Quality.
Third Edition. Volume Recommendations.