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Assessment of water quality parameters of Ombi Stream in Lafia, Nigeria.

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Abstract
The water quality parameters of Ombi Stream were evaluated for a period of four weeks to investigate the level of the pollutant load at three selected sites. Physico-chemical analysis of Dissolved oxygen (mg/L), free Dissolved carbon dioxide (mg/L), Hydrogen ion concentration (pH), Water temperature (˚C) and Depth (m) revealed a significant difference ($p<0.05$) among the selected sites and found to be within recommended tolerable limits for the survival of most aquatic organisms. Total alkalinity (mg/L) and Turbidity (m) revealed no significant difference ($p>0.05$) among the selected sites and were not within the desirable range especially for good fish production. From our results, we can conclude that, pollutants at site III had significantly depleted the water's vital dissolved oxygen, site I is the best aquatic ecosystem and site II is better compared to site III whose dissolved oxygen is at lethal levels that might hardly support aquatic life.

Keywords: Water quality parameter, Pollution, Ombi Stream, Stream status.

1. Introduction

Due to rapid population growth, development, urbanization and industrialization, the activities of humans on our natural water bodies have increased and virtually every human activity on these natural waters have lead to alterations in the quality and ecology of receiving water bodies as they are most targeted effluents discharged points.

Lloyd (1992) [1] stated that Rivers and Lakes are very important part of Nigeria heritage which are widely utilized by mankind over the centuries to the extent that very few, if any are now in a 'natural condition'. Knowledge of the physico-chemical regime of a water body is of great value in the determination of its productivity, usefulness and other characteristics (Adebisi, 1980) [2].The surface water resource such as rivers, ponds and dams located around cities are heavily polluted as a result of the discharge of effluents from municipal and industrial waste. Water is regarded as been polluted when it is unfit for it intended use (Turk, 1980) [3]. Any alteration in the physical, chemical and biological properties of any water due to discharge of any liquid, gaseous or solid substances that is likely to create detrimental or injurious effect to aquatic life and consequently public health, could be termed water pollution (Pandey and Shukla, 2005) [4] or can be referred to as any impairment to the quality of water that prevent it beneficial use. Thus, affecting the biota of an aquatic ecosystem. Human activities of domestic, non-domestic, agricultural and industrial origin are known to be sources of point and non-point pollution to rivers, streams, lakes, etc.

The activities of car, motorcycle, clothes washings, bathing, agro-products processing, pesticides and herbicides dissolved in rainwater run-off from adjacent farms etc. are the major sources of effluents to streams. Presently the Ombi stream is experiencing pollution as a result of increased domestic activities going on within it axis in the stream resulting in the accumulation of hydrocarbons from the petroleum products, detergents and oil spills. This has increased the pollution load, thereby altering the hydro-dynamics of the stream.

A typical stream system can be regarded as a functional continuum where energy inputs are partially processed in each reach and these, together with unused materials are transported downstream for further utilization (Vannote, Minshall, Cummins, Sedell, Cushing, 1980) [5]. This phenomenon applies to Ombi Stream, where some of the unused or partially processed organic matters are transported downstream.

The objective of the present study is to determine the water quality parameters in relation to stream status as a result of pollutant loads of the three selected sites of Ombi Stream.

2. Materials and Methods

2.1 Description of Study Area

The Ombi Stream is located north of Lafia LGA between Delta Prospectors (Baryte) Company and College of Agriculture, and lies between latitude 8˚32′N and 8˚34′N of the equator and longitude 8˚30′E and 8˚34′E(Fig.1). The stream has it source behind Akurba, community approximately 1km. The water comes out of the ground (aquifers) and flows through the city's outskirts. The river is surrounded by trees, and grasses. It is more shaded in some areas compared to others. The stream is generally shallow, slow moving in nature and of riparian vegetation. The stream is engaged by neighboring settlers with activities of washing clothes, bathing, processing of agricultural raw materials, car washings, motorcycle washings, etc. These activities are carried out directly in the stream thereby polluting the water as point source pollution. The spray of herbicides, pesticides and fertilizers which later wash downstream as storm water runoff into the stream is referred to as non-point source pollution. The different sources of effluents to this stream have altered the quality of the stream's water. Hence, the reason for the study of its water quality and the choice of these study three sampling sites.

2.1.1 Study Site I

It is the main source of the Ombi Stream which is also the control site for the study. It is of little water volume located behind Akurba community approximately 1km away and of sparse vegetation and is shaded.

2.1.2 Study Site II

Is about 2 km away from site I and approximately 1km away site III and slightly deeper, of much water volume compared to site I and of riparian vegetation, and is better shaded. Located adjacent to College of Agriculture Farm, Lafia.

2.1.3 Study Site III

It is about 1km away from site II and approximately 3 km from site I the major source. It is slightly deeper and would have received effluents along before prominent effluent points where activities of motor vehicle and motorcycle washings, bathing, clothes washing, etc. are done. The vegetation here is sparse and the site less shaded. Located adjacent to Delta Prospectors (Baryte) Company.

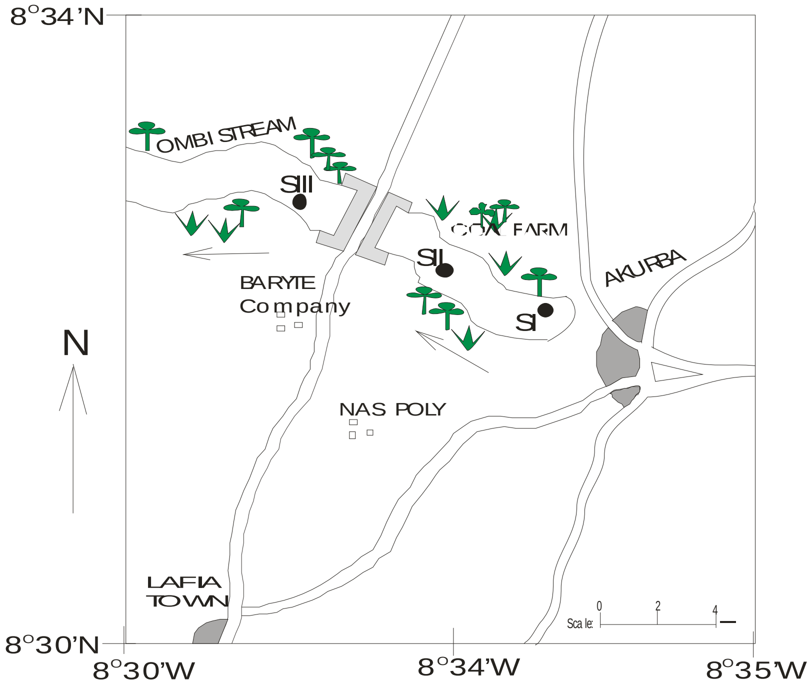
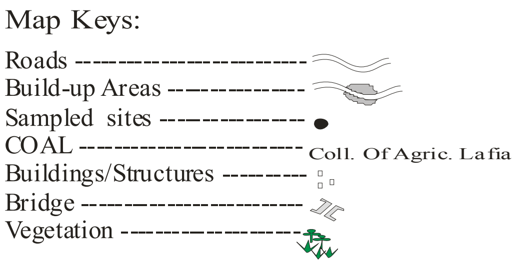


Fig.1 Map of study area indicating Ombi Stream & sampled sites: SI, SII & SIII (•)



2.2 Collection of Water Samples

The duration of study was one month: July, 2009 in the rainy season. Three sampling sites were chosen for this study and different sampling aspirator bottles were used in collecting the water samples at various locations and depths in the three sites. The water samples were analysed for physico-chemical parameters. Chemical analyses of samples were done immediately after collection in the laboratory except for physical parameters that were determined in the field. Parameters to be determined titrimetrically were duplicated for accuracy and precision of results and the averages of the readings were taken as the correct estimated values.

2.3 Physico-chemical Analysis of Water Samples

2.3.1 Depth (m)

The depth of the water was measured with a standard meter rule.

2.3.2 Turbidity (m)

The turbidity of the water was determined using a Secchi disc. The Secchi disc of 15 cm in diameter painted black and white was lowered and raised respectively in the water using a graduated string measured in centimeters. The average depth at which the disc disappeared and reappeared as it was being lowered and raised respectively was taken to be the Secchi disc transparency of the stream's water.

2.3.3 Temperature (˚C)

The temperature was determined in the field using a portable automatic temperature compensation digital thermometer. The air temperatures were taken by holding the thermometer 5 cm above the water surface for about 2-5 minutes. The water temperatures were taken by lowering the thermometer electrode sensor into water at immersion level. 2-3 minutes before the readings were taken.

2.3.4 Dissolved Oxygen (mg/L)

Using winkler's method which is a modification of Alsterberg (Azide) method. 250 ml of water samples from an aspirator was transferred into a 250 ml stoppered bottle and allowed to overflow for 20 seconds and restoppered. There after 2 ml Manganese sulphate ($MnSO_4$) was added followed immediately by addition of 2 ml conc. Sulphuric acid (H_2SO_4) was carefully added allowing the acid to run down the neck of the bottle. The bottle was restoppered and mixed until solution was completely greenish-yellow in color appearance. Then 200 ml of the solution was collected into a conical flask and titrated against 0.025N Sodium thiosulphate until pale yellow color was obtained. 1 ml starch solution (1%) was added and a dark blue solution resulted. Titration continued until the blue color first disappeared. The burette readings were taken at the meniscus and recorded in mg/L as against the equation given by Boyd (1979) for dissolved oxygen concentration is sampled water.

$$\text{Conc. of DO (mg/L)} = \frac{V(D) * N(D) * 8 * 1000}{\text{Volume of sample}}$$

Where: V (D) = Volume of Sodium thiosulphate used in titration
N (D) = Normality of Sodium thiosulphate 0.025N
(D) = Sodium thiosulphate.

2.3.5 Free Carbon dioxide (mg/L)

The free carbon dioxide was determined using the method described by Lind (1979) [6]. 100 ml water sample was measured into a conical flask, 10 drops of phenolphthalein indicator were added and a clear mixture was observed. N/44 Sodium hydroxide (NaOH) was titrated against the mixture, until a weak pink color end point resulted which lasted for at least 30 seconds. The burette readings taken of N/44 NaOH were multiplied by 10 and the concentration of free dissolved carbon dioxide expressed in mg/L.

2.3.6 Alkalinity (mg/L)

Total alkalinity was determined using standard methods described by Boyd (1979) [7] and APHA (1992) [8]. 100 ml of water was measured into a conical flask and 4 drops of phenolphthalein indicator was added and recorded as 0.0 mg/L phenolphthalein alkalinity as no color change was observed. To another 100 ml sample 2-4 drops methyl orange indicator was added. The resulting yellowish solution was titrated against 0.02N H_2SO_4 until a pink end point was observed. The titer value obtained was multiplied by 10 to give methyl orange alkalinity. Total alkalinity was computed as the sum of phenolphthalein and methyl orange alkalinities expressed in mg/L.

$$\text{Total alkalinity} = (a) + (b) \text{ in mg/L as } CaCO_3.$$

2.3.7 pH (Hydrogen Ion Concentration)

The pH was determined in the field using a portable high accuracy pen type pH meter (ATC 009(III) model) with automatic temperature display. The sensing electrode of the digital display pocket pH meter was dipped into water to immersion level and was allowed for about 4 minutes to stabilize readings before records were made.

2.4 Statistical Analysis

2.5 The data collected in the study were statistically analysed. The appropriate methods of analysis were used in order to give clear and lucid interpretation and presentation of the information gathered.

ANOVA (Analysis of Variance)

One way ANOVA method was used. The null hypothesis of one way analysis of variance is that the values are independent of the treatment and that the means of treatments vary solely due to sampling error.

Duncan's Multiple Range Test

This was used to investigate differences between treatments. It gives information on the nature of variation between the samples. It is more sensitive and allows all treatment means to be compared.

3. Results

3.1 Air and Water Temperature

The mean air temperature ranged from 27.77 ˚C to 33.17 ˚C at site I, 28.07 ˚C to 29.20 ˚C at site II and 28.47 ˚C to 30.57 ˚C at site III (Table 1).The result showed that a significant difference ($p<0.05$) of the parameter was observed among the selected sites. Mean surface water temperature ranged from 29.87 ˚C to 32.57˚C at site I, 26.40 ˚C to 27.93 ˚C at site II and 26.13 ˚C to 28.17 ˚C at site III (Table 1). The result showed that there was a significant difference ($p<0.05$) of the parameter among the selected sites.

Table 1: Variation in the Air & Water Temperatures of Sites I, II & III in ˚C

Weeks	Site I Means (±S.E)		Site II Means (±S.E)		Site III Means (±S.E)	
	Air	Water	Air	Water	Air	Water
1	27.77±0.03	29.87±0.03	28.07±0.07	26.83±0.33	28.47±0.03	26.13±0.33
2	31.60±0.30	31.37±0.03	29.13±0.33	27.83±0.33	28.87±0.03	26.33±0.07
3	28.47±0.03	30.60±2.51	28.10±0.20	26.40±0.40	29.83±0.17	28.17±0.03
4	33.17±1.07	32.57±0.23	29.20±0.10	27.93±0.33	30.57±0.03	27.13±0.07

3.2 Water Depth
The mean values for water depth ranged from 0.348m to 0.367m at site I, 0.206m to 0.227m at site II and 0.315m to 0.368m at site III (Table 2). The result showed a significant difference ($p<0.05$) of the parameter among the selected sites.

Table 2: Changes in the Depth of Sites I, II & III in Meters (m)

Weeks	Site I Means (±S.E)	Site II Means (±S.E)	Site III Means (±S.E)
1	0.367±0.01	0.227±0.05	0.368±0.03
2	0.348±0.01	0.206±0.05	0.334±0.02
3	0.360±0.02	0.224±0.05	0.341±0.04
4	0.353±0.01	0.207±0.05	0.315±0.04

3.3 Turbidity
Mean values for water transparency ranged from 0.00 m to 0.20 m at site I and at sites II and III was 0.00 m at minimum and maximum range (Table 3). There was no significant difference ($p>0.05$) of the parameter between site II and III but there was between sites I and II and I and III ($p<0.05$).

Table 3: Variation in Secchi disc transparency of Sites I, II & III in Meters (m)

Weeks	Site I Means (±S.E)	Site II Means (±S.E)	Site III Means (±S.E)
1	0.17±0.00	0.00±0.00	0.00±0.00
2	0.00±0.00	0.00±0.00	0.00±0.00
3	0.20±1.96	0.00±0.00	0.00±0.00
4	0.00±0.00	0.00±0.00	0.00±0.00

3.4 Total Alkalinity
The mean values for total alkalinity ranged from 8.33 to 14.00 mg/L at site I, 9.33 to 11.00 mg/L at site II and 10.00 to 12.33 mg/L at site III (Table 4) There was no significant difference ($p>0.05$) of the parameter among the three selected sites.

Table 4: Variation in Alkalinity of Sites I, II & III in mg/L

Weeks	Site I Means (±S.E)	Site II Means (±S.E)	Site III Means (±S.E)
1	8.33±0.33	9.33±0.33	10.00±0.00
2	14.00±0.00	10.33±0.33	10.33±0.33
3	9.33±0.33	10.00±0.00	11.33±0.33
4	12.67±0.33	11.00±0.58	12.33±0.33

3.5 pH (Hydrogen Ion Concentration)
The mean values for Hydrogen ion concentration (pH) of the water ranged from 5.10 to 5.47 at site I, 6.05 to 6.16 at site II and 6.02 to 6.60 at site III (Table 5). There was a significant difference ($p<0.05$) of the parameter among the selected sites.

Table 5: pH (Hydrogen Ion Concentration) Variation of Sites I, II & III

Weeks	Site I Means (±S.E)	Site II Means (±S.E)	Site III Means (±S.E)
1	5.27±0.03	6.05±0.03	6.59±0.00
2	5.47±0.03	6.09±0.03	6.60±0.05
3	5.40±6.28	6.16±0.07	6.57±0.03
4	5.10±0.00	6.13±0.04	6.02±0.00

3.6 DO (Dissolved Oxygen)
Dissolved oxygen mean values ranged from 3.03 to 4.05 mg/L at site I, 3.83 to 4.50 mg/L at site II and 1.57 to 2.07 mg/L at site III (Table 6). The result showed a significant difference ($p<0.05$) of the parameter among the selected sites.

Table 6: Dissolved Oxygen (DO) Variation of Sites I, II & III in mg/L

Weeks	Site I Means (±S.E)	Site II Means (±S.E)	Site III Means (±S.E)
1	4.05±0.06	4.50±0.00	2.07±0.07
2	3.57±0.03	4.00±0.03	1.63±0.03
3	4.03±0.03	4.55±0.03	1.83±0.03
4	3.03±0.03	3.83±0.03	1.57±0.03

3.7 CO_2 (Carbon dioxide)
The free dissolved carbon dioxide mean values ranged from 16.67 to 26.05 mg/L at site I, 12.44 to 19.44 mg/L at site II and 5.11 to 23.20 mg/L at site III (Table 7). The result showed a significant difference ($p<0.05$) of the parameter among the selected sites.

Table 7: Carbon dioxide (CO_2) Variation of Sites I, II & III in mg/L

Weeks	Site I Means (±S.E)	Site II Means (±S.E)	Site III Means (±S.E)
1	16.67±0.33	18.38±0.33	4.95±0.33
2	26.05±0.33	19.44±0.33	5.11±0.33
3	18.55±0.33	12.44±0.00	5.36±0.33
4	24.30±0.33	13.06±0.58	23.20±0.33

4. Discussion
In this study, the mean air temperatures were similar to those obtained by Umeham (1989) [9] of mean value 27.25 ˚C when he studied some aspects of the physico-chemical parameters of Lake Chad. The mean temperature of surface water was slightly different from each other probably as a result of sampling sites, large surface area, vegetation, pollutant load, weather and season. The result were similar to those obtained by Gras and Leveque-Duwat (1967) [10] from their studies on the physico-chemical parameters of the coastal water of Lake Chad and recorded a surface water temperature of between 20 ˚C to 30.4 ˚C. It is also similar to those obtained by Asaolu (1999) [11] who worked on physico-chemical parameters of the coastal waters in Ondo State. The average mean water temperature of the Ombi Stream (Appendix 1) was slightly higher than the WHO recommended value of 25 ˚C for drinking water, but within the recommended range of 21 ˚C to 30 ˚C (Murphy, 2008) [12] for the survival of warm water aquatic organisms. It was also within the range of 25 ˚C to 32 ˚C and 25 ˚C to 35 ˚C recommended for best performance in warm water fishes (Boyd and Lichtkoppler, 1979; Gupta and Gupta, 2006) [7, 13]. It was also observed from the results that at higher air temperatures, water temperatures were lower and at lower air temperatures, water temperatures were higher. This was supported by the work done by Crisp and Howson (1982)

[14] that water temperature is influenced by air temperature and that a standard air temperature could be used to predict water temperature.

The results for turbidity was of no significance ($p>0.05$) among the selected sites. Implying low suspended materials or plankton density. They were within WHO recommended value of 5.0 NTU for drinking water quality but not within the suitable ranges of 30-60 cm and 25-70 cm recommended for fish culture (Boyd and Lichtkoppler, 1979; Gupta and Gupta, 2006; Pandey and Shukla, 2005) [7, 13, 4].

In the present study, it was observed that the increase in alkalinity leads to increase in carbon dioxide. The range is below the desirable range of 20-200 mg/L $CaCO_3$ that would be suitable for fish culture (Wurts and Durborow, 1992) [15] and is below recommended standards for drinking water (WHO, 1993) [16]. This could be as a result of low presence of bicarbonates (HCO_3^-) in the water compared to a similar trend of 40.96 mg/L and 48.9 mg/L observed by Akpan and Ufodike (1995) [17] which indicated the preponderance of bicarbonates (HCO_3^-) in the estuarine water of Qua Iboe River.

The low pH observed at site I could be as a result of the presence of high levels of carbon dioxide. However, the pH range was within tolerable limits, but not the desired range of 6.5-9.0 necessary for the survival of aquatic life (Boyd and Lichtkoppler, 1979) [7]. In addition, 7.0-8.5 was recommended by WHO (1984) [18]. Though a 6.5-8.5 range is recommended for good fish production (Gupta and Gupta, 2006; FAO, 1997) [13, 19]. 5.5-10.0 was recommended for tropical fish culture, Bennet (1973) [20]. But, below the range of 6.5-9.5 recommended for drinking water.

Threshold value for DO is 5.0 mg/L for drinking water and should be more than 5.0 mg/L for agricultural purposes (Cruise and Miller, 1994) [21]. Dissolved oxygen results in the study were within the survival range of 1.0-4.9 mg/L for most aquatic organisms and 4.0-8.0mg/L recommended for fish production (Boyd and Lichtkoppler, 1979; Gupta and Gupta, 2006) [7, 13]. However, it was lower than the minimum allowable limit (5 mg/L) for aquatic life (WHO, 1984) [18]. The much depleted dissolved oxygen levels observed at site III was due to the presence of pollutants(petroleum products, oil spill, detergents, etc.) resulting from the activities of car and motorcycle washing, bathing, clothes washing, etc. which depletes dissolved oxygen levels. Site II had best levels because stream water had undergone purification as it flows to each reach and site I observed to have better dissolved oxygen levels compared to III because it is the major source of the stream and thus, rarely polluted.

The free dissolved carbon dioxide is within the range tolerated by some aquatic species. According to Boyd and Lichtkoppler (1979) [7] fishes can tolerate up to 60 mg/L in waters with appreciable dissolved oxygen levels and that water with total alkalinity of less than 15 or 20 mg/L usually contain relatively little available carbon dioxide. However, the carbon dioxide concentrations observed to be higher at site I compared to the others could be as a result of it source from aquifers and bacterial processes in the soils and various underground particulate mineral formations through which water moves.

5. Conclusion

The results from the study indicated that Ombi Stream is most polluted at site III along its course as the Physico-chemical parameters were more below recommended standards compared to sites I and II. The changes observed in the chemical properties of the three selected sites of Ombi Stream dissolved oxygen, free dissolved carbon dioxide and pH are within tolerable or survival limits for most aquatic species, as they are within recommended ranges. The physical properties notably water temperature is within acceptable limits suitable for the survival of most aquatic organisms. However, from the present study, it could be deduced that the three sites are natural aquatic ecosystems, but the site I is more suitable for the growth and development of organisms as well as other beneficial uses like aquaculture as it has parameters within recommended ranges. Whereas, site I could be used as well with little modifications to suite aquacultural purposes. Site III is poor (polluted) only pollution tolerant species can survive in the unconducive water conditions. However, water at site III could better be used for irrigation purposes with no or little modifications.

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