Fisheries and Aquaculture Journal
ISSN: 2150-3508

Adeosun et al., Fish Aquac J 2014, 5:1
DOI: 10.4172/2150-3508.1000088

Research Article Open Access

Physical and Chemical Parameters of Lower Ogun River Akomoje, Ogun State, Nigeria

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Abstract

The aims of carrying out this experiment were to determine the water quality and to investigate if the various human and ecological activities around the river have any effect on the physico-chemical parameters of the river's resources with a view to effectively utilizing these resources. Water samples were collected from two stations on the surface water of Lower Ogun River Akomoje biweekly for a period of 5 months (Jan-May, 2011). Results showed that temperature ranged between 24.0-30.7oC, transparency (0.53-1.00 m), depth (1.0-3.88 m), alkalinity (4.5-14.5 mg/l), nitrates (0.235-5.445 mg/l), electrical conductivity (140-190 µS/cm), dissolved oxygen (4.12-5.32 mg/l), phosphates (0.02 mg/l-0.75 mg/l) and total dissolved solids (70-95). The parameters at the deep end (station A) accounted for the bulk of the highest values; there was however no significant differences between the stations at P<0.05 with the exception of transparency, depth, total dissolved solids and electrical conductivity. The phosphate value was relatively low which accounted for the low productivity and high transparency. The results obtained from the physico-chemical parameters agreed with the limits set by both national and international bodies for drinking and fish growth. It was however observed that during the period of data collection, catches was low and this could be attributed to low level of primary productivity due to the quality of physico-chemical parameters of the water. It was recommended that the agencies involved in the management of the river should put the right policies in place that will effectively enhance proper exploitation of the water resources. More research should also be carried out on the physico-chemical parameters since this work only studied the water for five months.

Keywords: Physical parameters; Chemical parameters; Water quality; Ogun river

Introduction

Fresh water ecosystem is exploited in every possible way and one of the ways of its exploitations is through fish production, which is directly dependent on the productivity of the water ecosystem. Water is known to contain a large numbers of chemical elements [1]. Physical parameters such as temperature, turbidity, depth and current are known to operate in aquatic ecosystem [2]. The interaction of both physical and chemical properties of water plays a significant role in the composition, distribution and abundance of aquatic organisms. The productivity of the freshwater community that determines the fish growth regulated by the dynamics of its physical, chemical and biotic environment [3]. Fish growth depends on water quality in order to boost its production and physico-chemical parameters affect the biotic components of an aquatic environment in various ways [4].

A knowledge of the hydrological conditions and plankton of any body of water is not only useful in assessing its productivity, but will also permit a better understanding of the population and life cycle of the fish community in the presence of environmental stress such as low dissolved oxygen, high temperature and high ammonia [5] the ability of organisms to maintain its internal environment (i.e. metabolism and reproduction) is reduced [6]. Monitoring of water quality, which centres on determination of optimal, sub-lethal and lethal values of physico-chemical parameters standardized for fish growth and productivity should be embraced [7].

The balance of physical, chemical and biological properties of any given water body is thus an essential ingredient for successful production of fish and other aquatic resources. The presence or absence of certain chemical elements in a water body might be a limiting factor in the productivity of such water body. Such physico-chemical parameters include Dissolved Oxygen (DO_2), temperature, Dissolved Carbon Dioxide (DCO_2), pH, conductivity, Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD). Several of these physico-chemical parameters have been studied on indigenous habitats [7,8]. However, unlike natural water, pond habitats can be easily manipulated by controlling the water characteristics for an optimum environment yielding high level of fish production.

Also, the abundance of a particular element might suggest the types of organism that may be found as well as indications of ecologically unstable or unfavourable ecosystem which can have negative or positive impact on the population. Studies have shown that water rich in silica will contain a high population of diatoms, while high species diversity of snail could be explained by high concentration of calcium [9]. Adequate combination of nitrate and phosphate will increase a relative and sustainable algal population which will enable adequate plankton-fish relationship thus increase the fish yield of the water body.

However, a high concentration of nitrogen and phosphate is an indication of eutrophication that may lead to algal bloom and consequently deoxygenation which can results in the death of fish

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Received January 13, 2014; **Accepted** January 28, 2014; **Published** February 09, 2013

Citation: Adeosun FI, Akin-Obasola BJ, Oyekanmi FB, Kayode JO (2014) Physical and Chemical Parameters of Lower Ogun River Akomoje, Ogun State, Nigeria. Fish Aquac J 5: 088. doi: 10.4172/2150-3508.1000088

also submitted that physical properties such as light penetration, temperature and water movements have been shown to play important roles in planktonic distribution and lentic water stratification [2,10].

This study determines some physico-chemical parameters of water in lower Ogun river Akomoje. The study will examine certain physical and chemical properties of the river which are Total Dissolved Solids (TDS), Electrical Conductivity (EC), temperature, pH, water transparency/turbidity, water depth, nitrates (NO_3), phosphates (PO_4^{2-}), alkalinity and dissolved oxygen.

Materials and Methods

Study area

The study was carried out in lower Ogun River, Akomoje in Abeokuta, Ogun state. The river is located in Abeokuta North Local Government of Ogun state and lies between longitude 3°21'S and latitude 7°21'E North of Abeokuta with a size of 1000 hectares. Ogun River is a perennial river in Nigeria, which has a coordinate of 3°28'E and 8°41'N from its source in Oyo State to 3°25'E and 6°35'N in Lagos state where it enters Lagos Lagoon. The dry season is between November to March while the wet season is between April to October. The annual rainfall ranges from 900 mm in the North of the River to 200 mm towards the South. Total annual potential evapotranspiration is 1600 mm and 190 mm. Ogun river catchment area is located in South West Nigeria, bordered geographically by latitude 6°26'N and 9°10'N and longitude 2°28'E and 4°4'E. The land is about 230 km^2. The relief is generally low, with the gradient in the North-south direction. The water source is from the Igaran hills at an elevation of about 540 m above the sea level and flows directly southward over a distance of 480 km before it discharge into the Lagos Lagoon. The major tributaries of the river are Ofiki River and Opeki River.

Water analysis

The study was carried out between January and May 2011 by collecting water samples every two weeks. A total of four samples were taken using a 1 litre bottle with two samples per station and average value recorded. The sample bottles were rinsed thoroughly with river water. Water samples were taken on board from canoe to the sampling stations. The samples were taken from 10cm depth from the surface by holding the bottles upward and taken to the laboratory of the Department of Environmental Management and Toxicology, College of Environmental Resource Management, University of Agriculture Abeokuta, for further analysis of dissolved oxygen, nitrates, phosphates and alkalinity. The temperature, pH, electrical conductivity were measured in-situ using Combo metre by Hanna, model HI 98130. The metre was used by submerging the probe into the water and switching it on the values of the water temperature, electrical conductivity and pH were measured while the metre's probe was submerged. The value of the electrical conductivity read on the metre was in millisiemens/cm, hence the value was multiplied by 1000 to convert it to µsiemens/cm. The total dissolved solids values was derived by multiplying the value read for the electrical conductivity by 0.5. The depth was measured with the aid of calibrated bamboo stick of height 6 m while the transparency was measured using a secchi disc. The bamboo was lowered into the water depth and the depth at which the lowered end reached the river's base was recorded. The transparency was measured by using a secchi disc of 20 cm in diameter, painted in alternative black and white colours was lowered into each pond until it just disappeared and pulled up until it reappeared again. The two readings were recorded and an average value was calculated.

Measurement of Dissolved Oxygen (DO): This was achieved by Winkler's method using Manganese II sulphide ($MnSO_4$) solution, alkali-iodide-azide, concentrated sulphuric acid ($H2SO_4$), Sodium thiosulphate ($Na_2S_2O_3.5H_2O$) solution, starch solution were used as reagents.

250 ml of the sample was poured into a dark bottle, 2 ml of $MnSO_4$ and alkali-iodide-azide was added to the sample, to preserve the dissolved oxygen within the sample. The sample was allowed to settle for about 2 minutes and it was observed to have coagulated. In order to dissolve the coagulant, 2 ml concentrated H_2SO_4 was added to the sample and shaken. The sample was observed to give a clear solution.

203 ml of the sample was taken into a conical flask and titrated with 0.0125M of the $Na_2S_2O_3$. $5H_2O$ to give a pale straw colouration, 2 ml of the starch solution was also added and the titration continued, the colour became green and added thiosulphate in drops till a colourless solution was observed.

Measurement of Nitrate: A nitrate (NO_3-) stock was prepared by dissolving 0.7222 g of potassium nitrate (KNO_3) into 1000 ml of distilled water giving 100 ppm of NO_3-N.

After preparing the nitrogen stock, standard preparations were made by adding 40 ml of distilled water to 550 ml centrifuge tubes. 0, 0.5, 1.0, 1.5 and 2.0 ml were then subtracted from the 5 tubes respectively, and the same amounts of 100 ppm of the NO_3-N initially prepared. The individual tube will contain 0, 1.25, 2.50, 3.75 and 5.00 ppm of the NO_3-N.

1 ml of the sample to be tested was taken into a cuvet and 4 ml of distilled water is added. The same is also done for the standard samples. Both the sample and the standards are read in a spectrophotometer at wavelength 210 nm after which a standard curve is plotted and the reading gotten from the standard curve's plot is multiplied by 4 [11].

Measurement of Alkalinity: The reagent used was concentrated hydrochloric acid (Hcl) while the indicators used were phenolphthalein and methyl orange. 100 ml of the sample was poured into a conical flask. 3 drops of phenolphthalein indicator was added. No colour change was recorded, a few drops of methyl orange indicator was added and titrated using 0.1 M of conc. HCl. The sample was titrated till a pink end point was observed. The alkalinity was calculated as thus:

Alkalinity (mg $CaCO_3$/l)=Volume N/10 acid (ml)×50 OR Volume N/50 acid (ml)×10

Measurement of phosphate: The phosphate was measured using the Vanado-molybdo-phosphate acid colorimetric method. The reagent used was vanadate-molybdate reagent [12].

25 ml of the sample was poured into a 50 ml volumetric flask. 10 ml of the vanadate-molybdate reagent was then added to the sample giving a mixture of 35 ml. 15 ml of distilled water was added to give 50 ml. The dilution factor (the volume initially diluted to give 50 ml i.e 25 ml). A blank sample was prepared using 25 ml of distilled water to substitute for the sample in another volumetric flask. Both the standard and blank samples were then read in a spectrophotometer after 10 minutes at wavelength 470 nm and the curve plotted. The phosphate values were gotten from the calculation below:

$$\text{Phosphate}\left(\text{mg}/\text{l PO}_4^{3-} - \text{P}\right) = \frac{\text{Reading from curve} \times 1{,}000 \times \text{D}}{\text{ml sample}}$$

Where D=dilution factor.

Statistical analyses

Statistical analyses were performed with SPSS 16.0 (1997). The probability level (α) for rejection of the null hypothesis was 0.05. The difference between the two sampling stations was compared by using paired sample *t*-test (Figure 1 and Plate 1).

Results

The results of the physical parameters of the two stations are presented in Tables 2 and 3, respectively. Temperature ranged between 24.0°C-30.7°C, the maximum value was obtained at station A and B in the month of March. The least temperature was obtained at station B in January. Transparency ranged between 0.53 m^{-1} m, the maximum value was obtained at station A in the month of January. The least value was also observed at station A in May. Depth ranged between 1.02 m-3.88 m, the greatest value obtained was in station A in the month of January. The least temperature was observed at station B in March (Tables 1-4).

Discussion

The results obtained from the paired sample *t*-test for all the parameters with the exception of transparency, depth, total dissolved

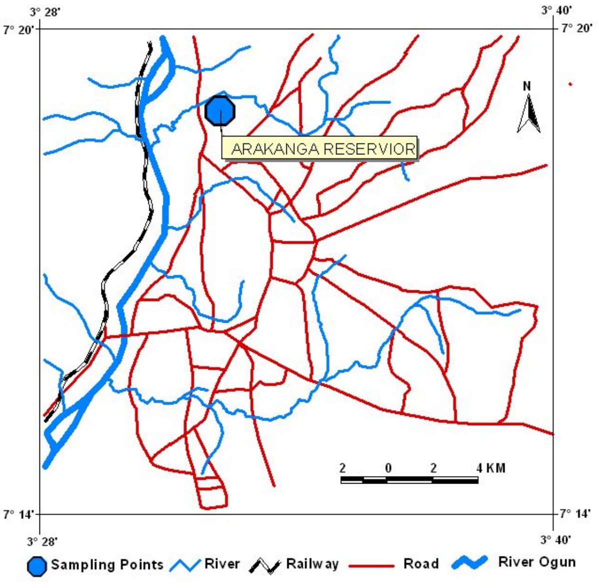

Figure 1: Map showing Arakangba Reservoir, source- Ogun State Fisheries statistics sub committee (2008).

Plate 1: Station A located at the deep end of the river.

Week	Temperature (°c)	Transparency (M)	Depth (M)
1	24.1 ± 2.20	1.00 ± 0.16	3.88 ± 0.27
2	27.5 ± 1.91	0.97 ± 0.15	3.28 ± 0.24
3	28.2 ± 1.92	0.93 ± 0.15	3.49 ± 0.23
4	29.8 ± 2.07	0.88 ± 0.14	3.77 ± 0.25
5	30.0 ± 2.09	0.70 ± 0.14	3.08 ± 0.27
6	30.7 ± 2.20	0.77 ± 0.14	3.48 ± 0.23
7	29.9 ± 2.07	0.59 ± 0.15	3.55 ± 0.23
8	26.9 ± 1.91	0.69 ± 0.14	3.71 ± 0.24
9	28.8 ± 1.96	0.56 ± 0.15	3.80 ± 0.25
10	28.0 ± 1.92	0.53 ± 0.15	3.67 ± 0.24

Table 1: Mean values ± standard error of the physical parameters of station A.

Week	Temperature (°c)	Transparency (M)	Depth (M)
1	24.0 ± 2.23	0.86 ± 0.11	2.13 ± 0.39
2	27.4 ± 1.93	0.72 ± 0.09	1.91 ± 0.36
3	28.1 ± 1.95	0.76 ± 0.09	1.84 ± 0.36
4	30.4 ± 2.19	0.79 ± 0.1	2.24 ± 0.41
5	30.5 ± 2.20	0.67 ± 0.09	1.02 ± 0.41
6	30.7 ± 2.23	0.75 ± 0.09	1.58 ± 0.35
7	29.7 ± 2.09	0.54 ± 0.11	1.70 ± 0.35
8	27.1 ± 1.94	0.60 ± 0.10	1.74 ± 0.35
9	28.8 ± 1.99	0.55 ± 0.11	1.68 ± 0.35
10	29.3 ± 1.95	0.56 ± 0.11	1.55 ± 0.35

Table 2: Mean values ± standard error of the physical parameters of station B.

solids and electrical conductivity indicated no significant difference ($p<0.05$). The result obtained for all the parameters at the two stations indicated a direct proportionate relationship in the values. This interaction was however minimal in phosphates and pH.

The surface water temperature of the river is close to air temperature. The temperature variation recorded during the study was optimum for normal growth and survival of aquatic organisms [13]. Since the mean surface water temperature was also in accordance with various works like [4,11]. The least temperature of 24°C could be as a result of the periods of collection (early in the morning).

Mean transparency values of water is 0.53-1.00 m recorded were similar to values documented by [4,14,15]. This shows that the pond waters contain adequate nutrients hence it's being fairly turbid with consideration to the season of carrying out the experiment [16]. There was however a significant difference in the transparency values within the two stations ($p=0.014$). This could be due to the variation in depth which also recorded significant difference between the stations ($p=0.000$).

The higher dry season secchi-disc transparency mean value compared to that of the rainy season could be due to absence of floodwater, surface run-offs and settling effect of suspended materials that followed the cessation of rainfall. Kamdirim [17] reported similar observations. Low secchi-disc transparency recorded during rainy season, agrees with the findings of Wade [18] who observed that onset of rain decreased the secchi-disc visibility in two mine lakes around Jos, Nigeria. Lower transparency recorded during rainy season when there was turbulence and high turbidity, has a corresponding low primary productivity, because turbidity reduces the amount of light penetration, which in turn reduces photosynthesis and hence primary productivity [19,20].

Depth of water followed a seasonal pattern with an impact of ambient temperature and quantum of rains. Lower depth was recorded in dry season and higher depth during rainy season. Dagaonkar and

Week	Total Dissolved Solids	Electrical Conductivity (µs/Cm)	Ph	Nitrate (Mg/L)	Phosphate (Mg/L)	Alkalinity (Mg/L)	Dissolved Oxygen (Mg/L)
1	95 ± 6.67	190 ± 13.33	9.73 ± 0.76	0.285 ± 1.72	0.120 ± 0.23	5.5 ± 2.68	4.22 ± 0.38
2	90 ± 6.01	180 ± 12.02	8.80 ± 0.66	2.026 ± 1.52	0.081 ± 0.23	13.0 ± 2.83	4.97 ± 0.36
3	95 ± 6.69	190 ± 13.33	8.59 ± 0.66	2.030 ± 1.52	0.081 ± 0.23	6.5 ± 2.57	5.32 ± 0.40
4	80 ± 6.01	160 ± 12.02	7.45 ± 0.76	2.029 ± 1.52	0.153 ± 0.22	6.5 ± 2.57	4.92 ± 0.35
5	90 ± 6.01	180 ± 12.02	8.46 ± 0.66	3.215 ± 1.49	0.120 ± 0.23	7.0 ± 2.52	4.12 ± 0.40
6	85 ± 5.77	170 ± 11.55	8.45 ± 0.66	4.3501.57	0.413 ± 0.21	4.5 ± 2.83	4.42 ± 0.36
7	75 ± 6.67	150 ± 13.33	8.32 ± 0.66	4.671 ± 1.61	0.090 ± 0.23	6.0 ± 2.62	4.97 ± 0.36
8	80 ± 6.01	160 ± 12.02	8.76 ± 0.66	5.445 ± 1.72	0.020 ± 0.24	8.5 ± 2.46	5.12 ± 0.37
9	85 ± 5.77	170 ± 11.55	9.23 ± 0.69	5.218 ± 1.68	0.750 ± 0.24	8.5 ± 2.46	4.72 ± 0.35
10	80 ± 6.01	160 ± 12.02	9.61 ± 0.74	4.703 ± 1.61	0.248 ± 0.22	9.0 ± 2.46	4.82 ± 0.35

Table 3: Mean values ± standard error of the chemical parameters of station A.

Week	Total Dissolved Solids	Electrical Conductivity (µs/Cm)	Ph	Nitrate (Mg/L)	Phosphate (Mg/L)	Alkalinity (Mg/L)	Dissolved Oxygen (Mg/L)
1	T85 ± 6.01	170 ± 12.02	9.47 ± 0.57	0.235 ± 1.60	0.130 ± 0.09	4.5 ± 3.33	4.22 ± 0.35
2	90 ± 6.67	180 ± 13.33	7.85 ± 0.54	2.026 ± 1.40	0.081 ± 0.09	14.5 ± 3.33	4.92 ± 0.32
3	90 ± 6.67	180 ± 13.33	7.72 ± 0.56	2.032 ± 1.40	0.081 ± 0.09	8.5 ± 2.91	5.02 ± 0.33
4	75 ± 6.01	150 ± 12.02	8.71 ± 0.49	3.034 ± 1.39	0.175 ± 0.85	5.5 ± 3.18	4.42 ± 0.32
5	85 ± 6.01	170 ± 12.02	7.72 ± 0.56	3.575 ± 1.42	0.180 ± 0.85	10.0 ± 2.89	4.13 ± 0.36
6	85 ± 6.01	170 ± 12.02	8.21 ± 0.50	4.125 ± 1.47	0.323 ± 0.10	5.0 ± 3.25	4.32 ± 0.33
7	75 ± 6.01	150 ± 12.02	8.21 ± 0.50	4.381 ± 1.50	0.080 ± 0.09	5.5 ± 3.18	5.21 ± 0.35
8	75 ± 6.01	150 ± 12.02	8.74 ± 0.49	4.990 ± 1.59	0.030 ± 0.10	7.5 ± 2.96	5.17 ± 0.35
9	75 ± 6.01	150 ± 12.02	8.48 ± 0.49	5.024 ± 1.60	0.083 ± 0.09	7.0 ± 3.00	4.62 ± 0.31
10	70 ± 6.67	140 ± 13.33	9.13 ± 0.52	4.139 ± 1.47	0.285 ± 0.09	7.5 ± 2.96	4.89 ± 0.32

Table 4: Mean values ± standard error of the chemical parameters of station B.

Saksena [21] had reported the maximum depth of Kailasagar in rainy season and minimum in summer season, low water depth was noticed due to evaporation of water. In Harsi and Ramsagar reservoir, Garg et al. [22,23] reported maximum water level in monsoon period while minimum water level in summer season. This observation has also been true for almost all water bodies in India.

Aquatic organisms are affected by pH because most of their metabolic activities are pH dependent [24]. Optimal pH range for sustainable aquatic life is pH 6.5 - 8.2 [25]. The variation in the pH within the stations was 7.45-9.73. The results showed that is above neutral, pH levels at the two stations were within the range of 6.5-9.0 documented by Sondergaard et al. [2] and Boyd [5] as values most suitable for fish production for maximum productivity level. There was no significant difference p=0.155) between seasons [26].

The fluctuations in the values of conductivity could be due to variations in the rate of decomposition of organic matter, low level of water caused by evaporation, influx of seepage and nutrients from the drainage basin and also the presence of higher concentration of inorganic salts. The conductivity of Lower Ogun river Akomoje ranged between 140 µScm^{-1} and 190 µScm^{-1}. It was higher in dry season and lower in wet season during the period of study. Olsen [27] had classified water bodies on the basis of values of conductivity as oligotrophic, mesotrophic and eutrophic. The present findings in relation to electrical conductivity are in conformity with the work [28,29]. The criterion of is applied to Lower Ogun river Akomoje then the reservoir can be placed under the categories of meso-eutrophic water body [27].

Total dissolved solids were affected by the geographical location of the water body, drainage, rainfall, deposit organic material at the bottom level, incoming water and nature of biota. The excess amount of total dissolved solids in water disturbed the ecological balance due to osmotic regulation and suffocation caused in aquatic fauna. In various water bodies in Nigeria, the total dissolved solids are variable. In this study, total dissolved solids in Lower Ogun river Akomoje have been observed up to75 mg l^{-1} to 95mg l^{-1}. Lower values of total dissolved solids values were recorded in wet season and higher in dry season throughout the period of study. High values of total dissolved solids during dry season may be attributed to increased evaporation due to high temperature and, decrease in water volume and also due to less or no turbulence and to the sedimentation process. The suspended solids include silt, soil, colloid particles, plankton and other substances. In the presence of high total dissolved solids, water will heat up more rapidly and hold more heat, this in turn, adversely affects aquatic life that has been adapted to a lower temperature regime. Low concentrations of total solids can result in limited growth of aquatic organisms due to nutrient deficiencies. High total solids affect the light penetration and also influence the water quality indirectly and cause imbalance as reported in a culture pond (Gwalior) and in Triveni lake in Maharastra [30,31].

The mean total alkalinity of 4.5-14.5 mg/l recorded agreed with the range values documented by Boyd and Lichtkopple and Moore et al. [7,32] for natural waters.

The maximum nitrate concentration was observed in location A (5.445 mg/l) which fell between the range of most freshwater body in Nigeria. 0.54 mg/l in Shiroro lake [33], 4.0 mg/l in Jebbalake [34] and 5.1 mg/l in Oyunlake [10]. According to studies, increase in nitrogen or phosphorus which tends to limit productivity will lead to eutrophication [35]. Eutrophication could also lead to unpleasant taste and odour of the water when the algae die and decompose thus deteriorating the quality of the water. Unlike nitrogen, the phosphate concentration is higher (0.75 mg/l maximum) compared to its concentration in most freshwater bodies [7]. The high concentration could be traced to the water released by the Ogun State water corporation or leaching of phosphate fertilizer into the water. Similar range were reported at

Shiroro Lake and attributed this to leaching of phosphate fertilizer into the lake [33].

Mean dissolved oxygen with range of 4.12-5.32 mg/I had the maximum value falling within the ranges documented for good water quality on fish production [35,13]. This is because oxidation converts otherwise poisonous compounds to useful material. It also encourages good feeding, food utilization and high density of fish eggs, larvae and adults within the area [36].

Conclusion

The surface water quality parameters measured within Lower Ogun River Akomoje could be clasified as class 1 (excellent) according to classification. The river was quite productive and with the information gathered towards the end of the data collection (at the start of the rainy season) it was shown that the river will be able to support diverse number of organisms from planktons, benthos to fishes and macrophytes going by the abundance of chemical ions needed for interconversion of energy and production of organic materials present in the river. The physico-chemical data obtained in this river could be used as a baseline and reference point when assessing changes caused by nature and man within the river. It could also be observed from catch statistics that there was a reduction in the fish catch during the peiod of no rain [6,37]. The water quality will however support aquaculture.

Authors' Contributions

F.I. supervised the research and drafted the manuscript, B.J. carried out the statistical analysis and also helped in drafting the manuscript, F.B. participated in study design, T. took the photographs, J.O. carried out the field work.

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