ASSESSMENT OF PHYSICO-CHEMICAL PARAMETERS OF RIVER FETE, BENUE STATE, NIGERIA

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Abstract

The physico-chemical properties of River Fete, Benue State, Nigeria were investigated from January to December, 2016 to determine its water quality. Water samples were collected from five sites chosen to reflect human impacts, lentic and lotic characteristics of the river ecosystem for the analysis of the parameters. Temperature, pH, conductivity and total dissolved solids were measured in situ using Hanna PH/EC/TDS tester and mercury-in-glass thermometer while Transparency was measured using secchi disc. The chemical factors were analyzed according to the standard procedure for examination of water and waste water. Two- way ANOVA at $p<0.05$ were used to analyze the result using GLM procedures of the statistical analysis system (SAS). The result showed water temperature ranging from 26.12^oC to 27.23 ^oC, total hardness (156.41mg/L to 224.52mg/L). The mean values of; pH ranged from 6.62 to 7.46, dissolved oxygen 5.11mg/L to 6.96mg/L, biological oxygen demand 1.81mg/L to 2.28mg/L, Chloride 116.84mg/L to 253mg/L, the nutrients levels ranged from 0.97-1.89 mg/L for nitrate, 1.94-4.95) mg/L for phosphate and (17. 32-28.50) mg/L for sulphate. Significant variations were observed in the parameters by season and stations with nutrients being highly abundant in wet season. It can be concluded that the water is suitable for fish culture.

Key words: physico-chemical parameters, River Fete

Introduction

Water is essential for all socio-economic development and for maintaining healthy ecosystems; However freshwater sources have experienced increased stress due to the ever-rising demands and degenerate uses, as well as by growing pollution worldwide (UN, 2006). The water quality of a river is influenced by the catchment characteristics with various imposed pollution loads. The pollution loads imposed on a river system consists of three components, direct/point wastewater discharge, diffuse/non – point contribution in seepage and runoff water from the catchment and back ground contribution from natural sources (Hema and Muthalagi, 2009). These three aspects must be considered in catchment water quality management plan.

Urbanization in Benue State has resulted in rural-urban migration (since 1980) resulting in development of informal settlements with inadequate or no waste disposal facilities, (The World Bank, 2002). The high rate of untreated effluent discharges into River Benue (which forms tributary with River Fete) at Makurdi is alarming coupled with some rural dwellers that use the river as their toilet while some people use the same river as their main source of drinking water calls for attention.

River Fete consists of rich Fadama or flood plain areas and is endowed with some macrophytes. The Fadama area provides good fertile land for subsistence vegetable production and livestock grazing. Local fishing activities are also carried out. Fish growth depends on water quality in order to boost its production. Water physico–chemical parameters are known to affect the biotic component of an aquatic environment in various ways (Bartram and Balance, 1996). The important characteristics of River Fete to its riparian owners can never be over emphasized and also the damage done to its quality by man and animals call for more attention so as to protect and preserve the river and its valuable fisheries resources. The research was therefore set out to determine the water quality of River Fete in order to establish its base line data for effective and sustainable fisheries management in the River and also for aquaculture uses.

Study Area

The study area, Makurdi is bounded by longitudes 8^0 30''E and latitudes 7^0 48.5N. The climate of Makurdi is tropical climate with distinct rainy and dry seasons. The annual rainfall ranges from 700mm per a 1158 1100mm per annum while the mea temperature ranges from 22.18^{0}Cto 33.25^{0}C. The area has guinea savannah vegetation, characterized by woodland which has given way to grassland due to frequent bush burning, fig. 1

River Fete cuts across Gwer East and Makurdi Local Government Area of Benue State. The River has its starting point at Igbor hills in Gwer East Local Government Area to Mbaku community where it emties into River Benue. It passes through a major Federal high way linking Benue State and Kogi state at Adaka community in Makurdi, Makurdi Local Government.

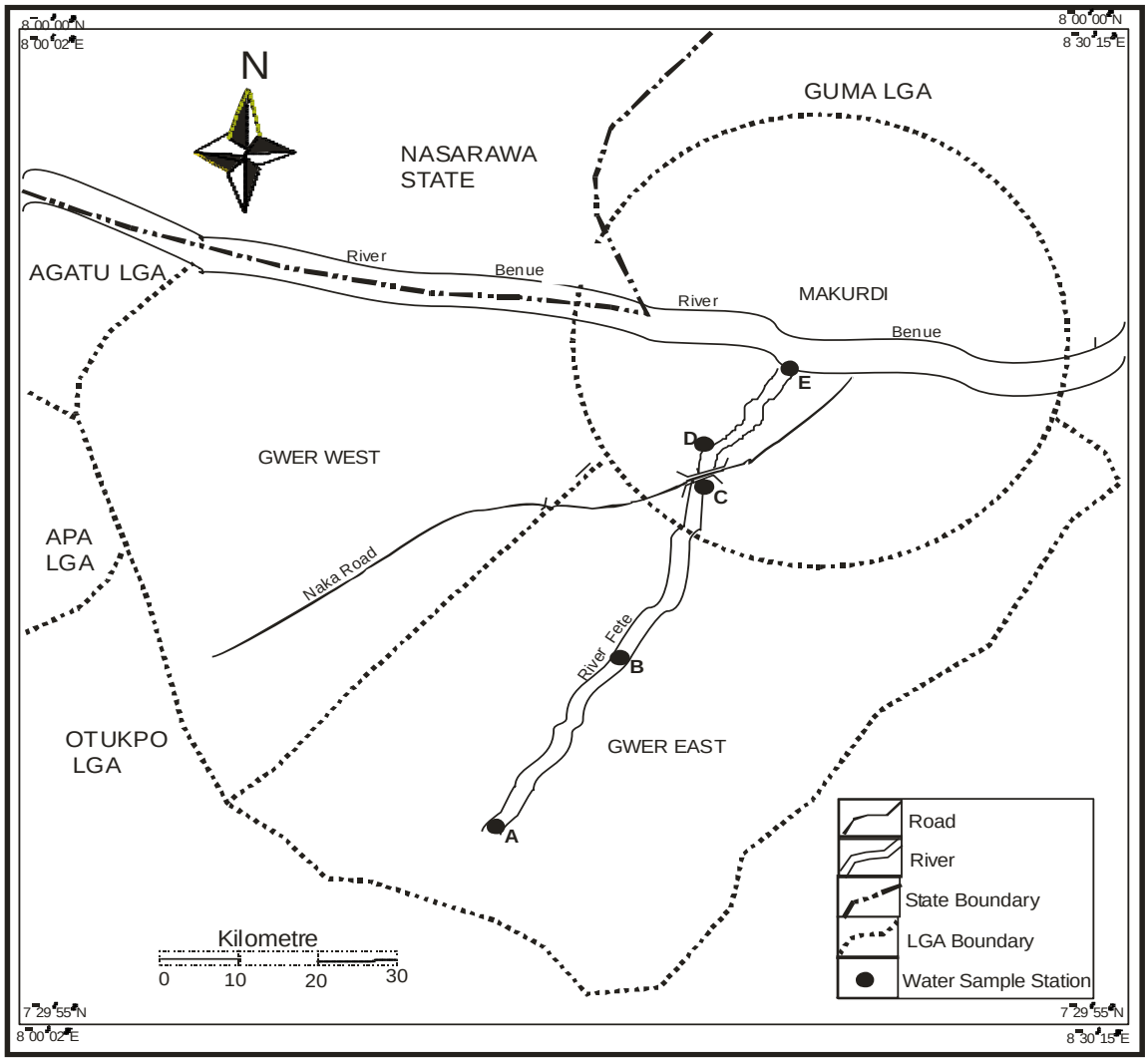

Figure 1: Map of the Study Area Showing Water Sample Stations.
Source: Ministry of Lands and Survey, Makurdi

Materials and Methods

Sampling Procedures

The study was carried out for a period of twelve (12) months. Five sampling stations (A, B, C, D and E) were located on the River. The sites were selected at strategic but easily accessible places based on the presumption that there is a measurable problem at that location along the river. On the five sites chosen, the

water quality, and plankton diversity were assessed on monthly bases.

Water Analysis

The water samples collected from the field were subjected to analysis. Dissolved Oxygen, Biological Oxygen Demand, hardness, alkalinity was analyzed using the method of APHA, 1995. The temperature was with the aid of mercury in bulb thermoı 1159 was measured with pH meter model labtech digital 152R, TDS was measured with the aid of conductivity meter CO150 conductivity meter. CO_2 was measured using the method of Saxena 990.

Statistical Analysis

Data obtained during the experiment were subjected to one-way analysis of variance (ANOVA). The differences in means were separated with LSD at 95% confidence level using Genstat software version. Analysis of co-variance was used to estimate the correlation and level of dependence among the physico-chemical parameters.

Results

Figure 2 shows that there was little variation in water temperature across the stations. This is evident in the cluster nature of the trend graph.

During the monitoring periods in both seasons, pH increased steadily from January and peaked in October. The trend was however different in November and December as observed in fig. 3. The dissolved oxygen trend across the five sampling stations during the dry and rainy season was similar to that of pH. The trend witnessed a steady increase which peaked at November and descended through December (fig. 4).

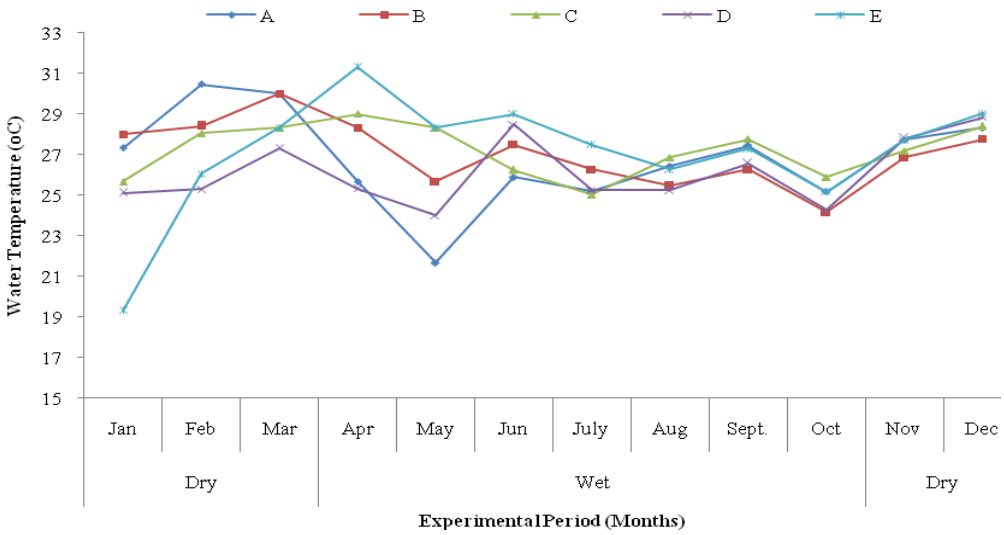

Fig. 2: Monthly variation in Water Temperature of River Fete

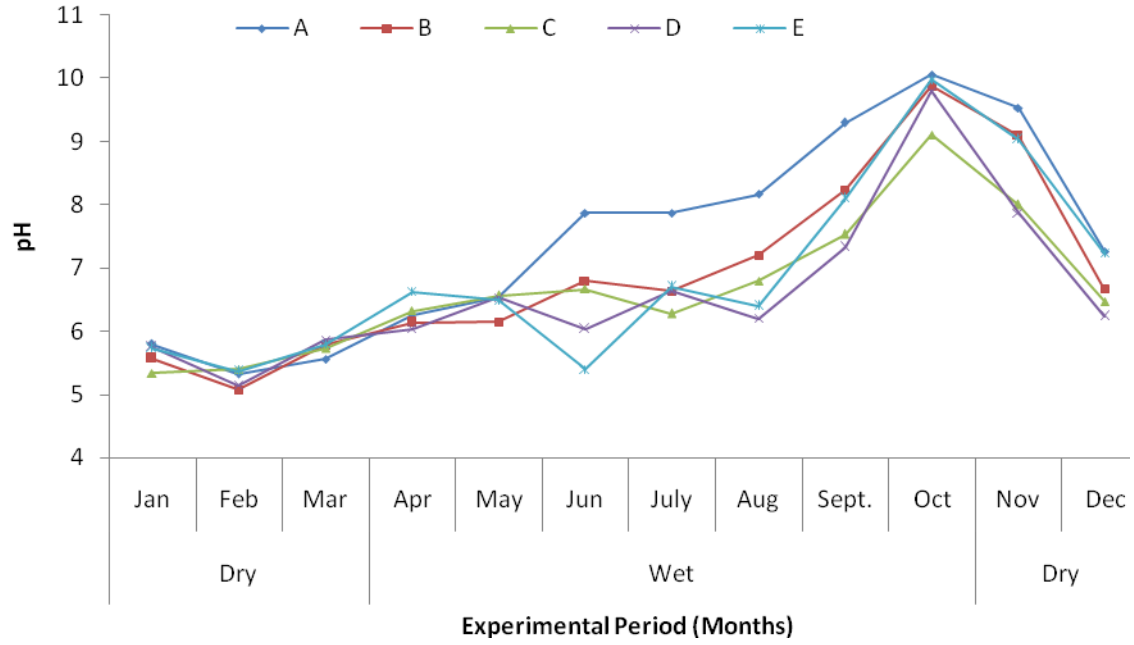

Fig. 3: Monthly variation in pH of River Fete

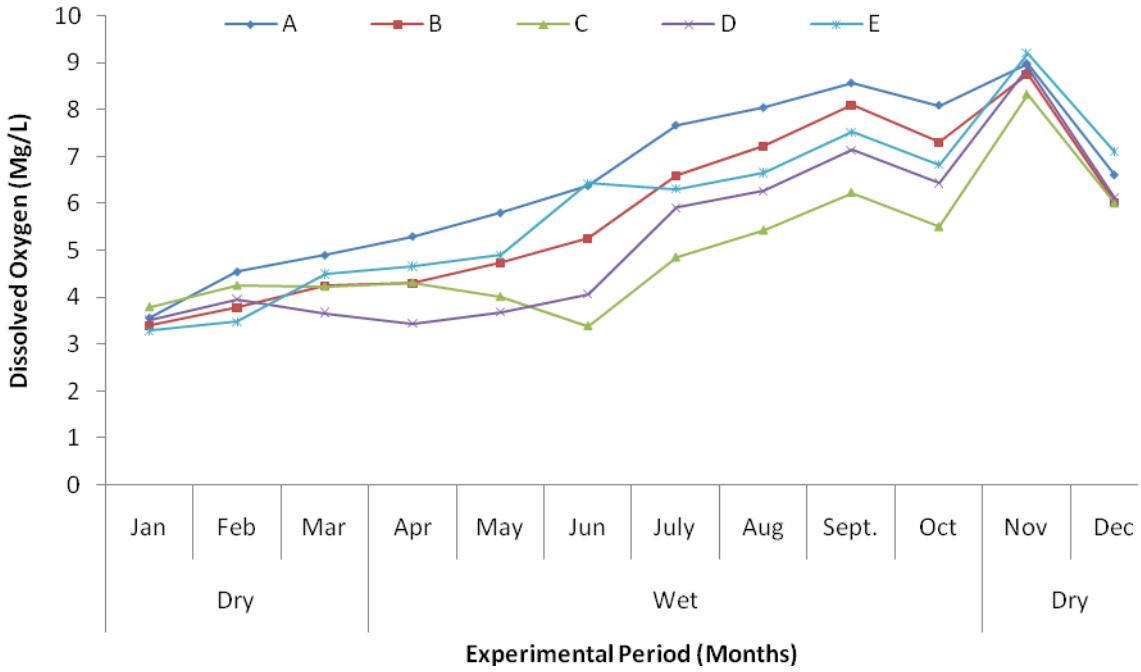

Fig. 4: Monthly variation in Dissolved Oxygen of River Fete

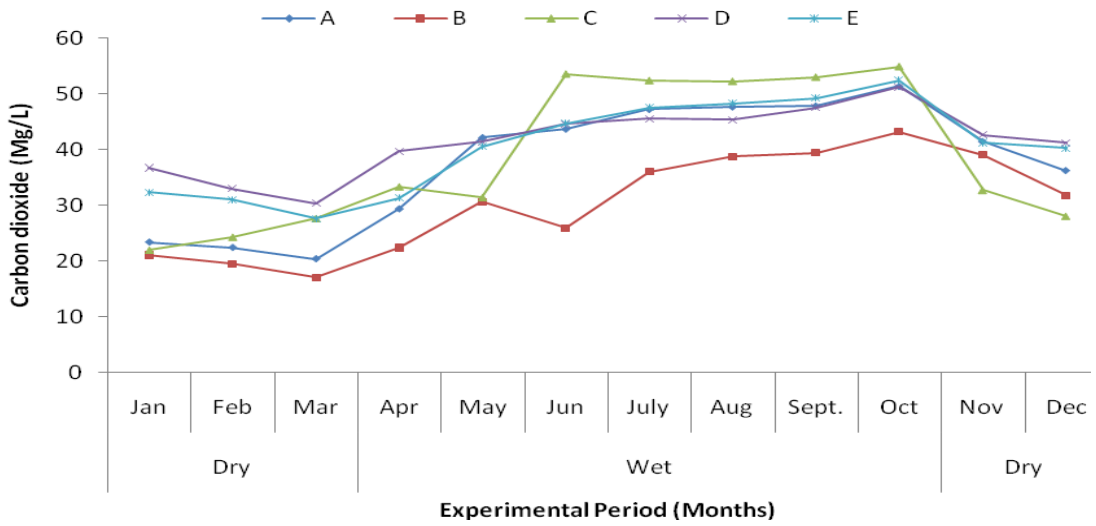

Fig. 5: Monthly variation in Carbon-dioxide of River Fete

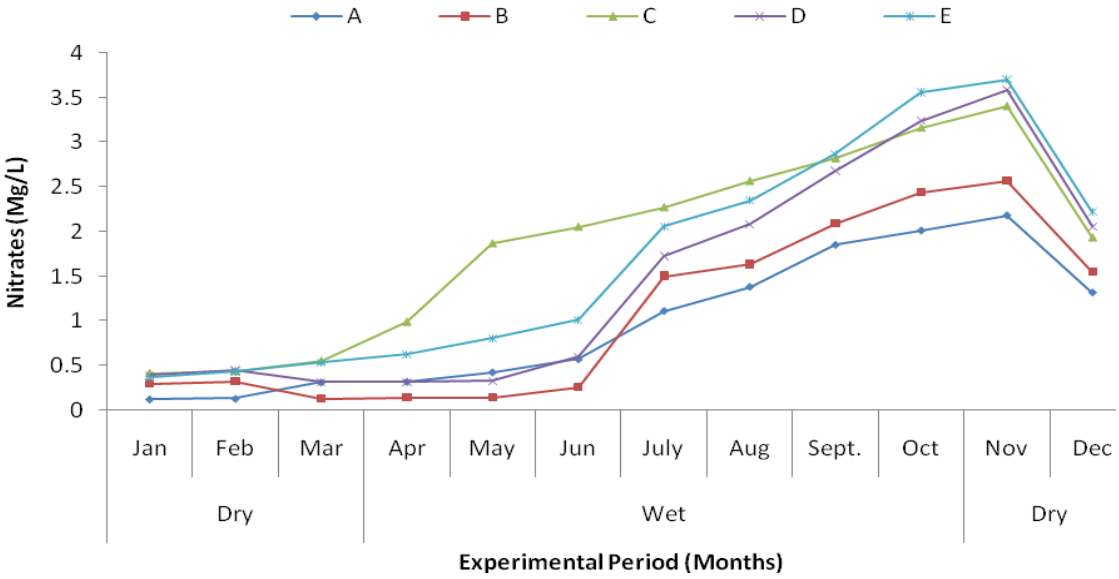

Fig. 6: Monthly variation in Nitrates of River Fete

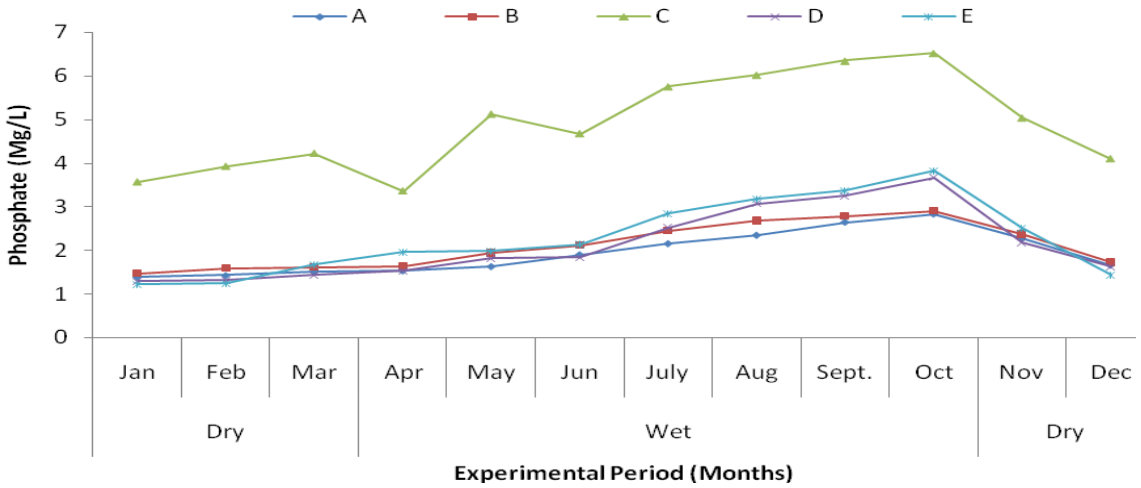

Fig. 7: Monthly variation in Phosphates of River Fete

The behavior in the trends in changes of sulphate across the sampling stations was not completely different from many other water quality parameters observed so far. The dry season generally recorded low level of phosphate as compared to rainy season. There was a steady increase in the level of phosphate across the rainy season months which peaked in October and decline from November through December and then January. The total alkalinity of station C was higher compared to other stations. Stations A, B, D and E recorded total alkalinity within the range of 20mg/L to 30mg/L with rainy season recording the highest values

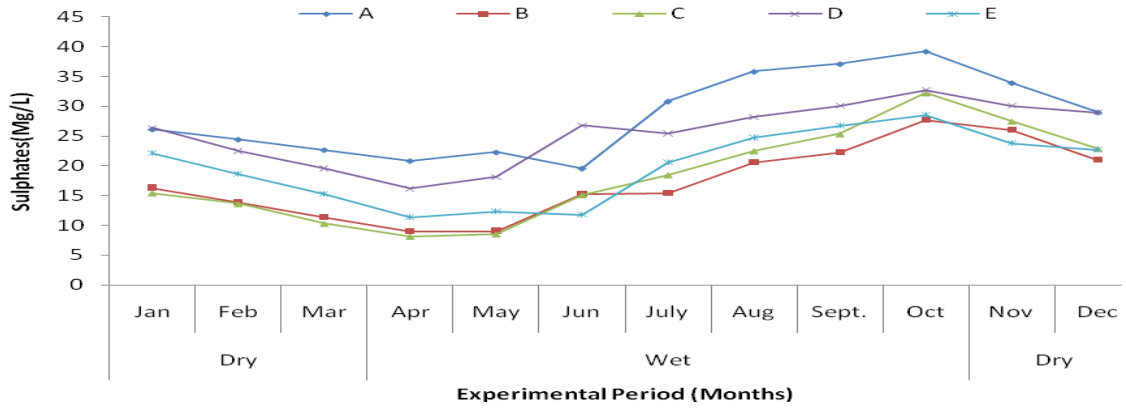

Fig. 8: Monthly variation in Sulphates of River Fete

Table1. Mean Variation of Water Quality Parameters by Stations in River Fete

Water Quality Parameter	Experimental Sites					P-Value
	A	B	C	D	E	
Physical Properties						
Air Temperature (°C)	26.24±0.49	27.06±0.46	26.51±0.51	26.05±0.43	26.79±0.35	0.52^{ns}
Water Temperature (°C)	$26.77±0.39^{ab}$	$27.06±0.26^{ab}$	$27.23±0.21^{a}$	$26.12±0.27^{b}$	$27.11±0.48^{a}$	0.05
Transparency (cm)	$21.76±1.39^{a}$	$15.48±0.92^{bc}$	$14.03±1.12^{c}$	$17.58±1.12^{b}$	$15.90±0.97^{bc}$	<0.01
Depth (cm)	$128.63±6.65^{ab}$	$121.70±27.70^{a}$	$115.65±4.35^{b}$	$113.40±10.90^{b}$	$135.50±14.10^{ab}$	0.03
Total Dissolved Solids (Mg/L)	$81.11±3.38^{c}$	$68.65±2.53^{d}$	$182.81±3.53^{a}$	$148.30±5.26^{b}$	$155.86±5.78^{b}$	<0.01
Electrical Conductivity (µS/cm)	$58.86±2.34^{b}$	$46.06±1.98^{c}$	$246.42±3.04^{a}$	$43.47±1.69^{c}$	$36.69±2.82^{c}$	<0.01
Hardness (Mg/L)	$175.24±6.21^{bc}$	$156.41±8.90^{d}$	$224.52±7.08^{a}$	$164.49±5.25^{cd}$	$190.91±4.03^{b}$	<0.01
Chemical Properties						
pH	$7.46±0.26^{a}$	$6.93±0.23^{ab}$	$6.68±0.18^{b}$	$6.62±0.20^{b}$	$6.90±0.23^{ab}$	0.05
Dissolved Oxygen (Mg/L)	$6.96±0.42^{a}$	$5.89±0.30^{bc}$	$5.11±0.24^{c}$	$5.52±0.35^{bc}$	$6.04±0.30^{ab}$	<0.01
Biochemical Oxygen Demand (Mg/L)	$1.81±0.09^{b}$	$1.97±0.29^{ab}$	$2.28±0.16^{a}$	$1.88±0.08^{ab}$	$1.91±0.08^{ab}$	0.03
Chloride (Mg/L)	$180.51±2.22^{b}$	$158.91±4.42^{c}$	$253.98±8.44^{a}$	$134.68±2.84^{d}$	$116.84±2.95^{e}$	<0.01
Total Alkalinity (Mg/L)	$22.98±0.57^{d}$	$24.35±0.67^{e}$	$64.28±3.56^{a}$	$28.60±1.25^{c}$	$33.81±1.04^{b}$	<0.01
Carbon dioxide (Mg/L)	$37.76±1.82^{a}$	$30.32±1.63^{b}$	$38.79±2.35^{a}$	$41.58±1.04^{a}$	$40.54±1.36^{a}$	<0.01
Nutrients						
Nitrate (Mg/L)	$0.97±0.12^{c}$	$1.08±0.15^{bc}$	$1.87±0.17^{a}$	$1.48±0.20^{ab}$	$1.71±0.20^{a}$	<0.01
Phosphate (Mg/l)	$1.94±0.09^{b}$	$2.09±0.08^{b}$	$4.95±0.17^{a}$	$2.12±0.13^{b}$	$2.28±0.14^{b}$	<0.01
Sulphate (Mg/L)	$28.50±1.16^{a}$	$17.32±1.01^{c}$	$18.33±1.27^{c}$	$25.43±0.85^{b}$	$19.88±0.97^{c}$	<0.01

Means on the row with different superscript are statistically significant ($p<0.05$); ns = not significant

Table 2 Seasonal Variation of Water Quality Parameters in River Fete

Water Quality Parameter	Season		df	T-Value	P-Value
	Dry	Wet			
Physical Properties					
Air Temperature (°C)	28.40±0.27	25.16±0.20	147	9.48	<0.01**
Water Temperature (°C)	27.47±0.25	26.41±0.18	144	3.43	<0.01**
Transparency (cm)	19.70±0.95	14.94±0.53	120	4.38	<0.01**
Depth (cm)	132.30±14.20	130.00±5.69	98	0.15	0.88
Total Dissolved Solids (Mg/L)	115.18±5.67	136.24±5.01	164	-2.78	<0.01**
Electrical Conductivity (µS/cm)	77.43±8.96	93.82±8.20	167	-1.35	0.17
Hardness (Mg/L)	167.25±5.45	193.01±4.01	146	-3.81	<0.01**
Chemical Properties					
Ph	6.42±0.15	7.28±0.13	162	-4.33	<0.01**
Dissolved Oxygen (Mg/L)	5.40±0.23	6.27±0.20	163	-2.85	<0.01**
Biochemical Oxygen Demand (Mg/L)	2.27±0.09	1.75±0.10	174	3.70	<0.01**
Chloride (Mg/L)	156.94±5.98	177.78±5.53	168	-2.56	0.01*
Total Alkalinity (Mg/L)	28.32±1.24	39.55±2.11	160	-4.58	<0.01**
Carbon dioxide (Mg/L)	30.48±0.91	43.15±0.92	174	-9.72	<0.01**
Nutrients					
Nitrate (Mg/L)	1.17±0.13	1.60±0.09	146	-2.61	0.01*
Phosphate (Mg/l)	2.14±0.12	3.07±0.14	177	-4.96	<0.01**
Sulphate (Mg/L)	21.77±0.69	21.98±0.85	177	-0.19	0.84

* indicates statistical significance at 0.05%; ** indicates statistical significance at 0.01%

Discussion

Physico-Chemical Parameters

Lower temperatures are reported to likely reduce metabolism and growth (Abowei, 2010). The study recorded a mean surface water temperature that agrees with the results of an earlier study in River Benue in both dry and rainy season that reported surface water temperature mean value of 28.20 ± 0.06^0C (Eneji *et al*., 2012). Okayi *et al*. (2011) reported a surface water temperature that ranged from 20.00 to 23.10^0C in River Benue which is in disagreement with the result of this study, this may be due to the fact that larger water bodies tend to respond much slower to temperature changes than smaller rivers.

The result of mean conductivity of water samples obtained in this study was below the maximum limit of 1000.00 µs/cm specified by WHO and Nigerian standard (WHO 2004, NSDW 2007). The mean conductivity result obtained in this study was close to that of Eneji *et al.*, (2012) who reported mean conductivity value of 86.85 ± 2.43 us/cm. The low mean conductivity result of this study may be due to lack of saline intrusion in River Fete.

The mean PH value recorded falls within the recommended range of 6.5 – 8.5 set by the National Standard for fish culture (NSDW, 2007) and fish survival. Previous studies in river Benue reported pH in the range

5.9-6.8 (Okayi e*t al*., 2011). Similarly, Eneji *et al*, (2012) reported the mean pH value of 7.01 ±0.03 in River Benue at Makurdi. Higher pH values are an indicator of pollutant intrusion. The mean value of pH of this work shows that there is no intrusion of pollutants impacting on the study. The result of this study disagrees with Abowei (2010) who reported a pH range of 7.3 – 7.6 in Nkoro River, Niger Delta, Nigeria.

The total dissolved solids (TDS) in water consist of inorganic salts and dissolved materials. High value of TDS may lead to change in taste of water and deteriorate plumbing and appliances. During The difference in TDS between dry and wet season was highly significant ($p<0.01$). This result was within the WHO recommended value of 1000.00gm/L and 500.00gm/L of the National standard (WHO 2009, NSDWQ, 2005). The low level of TDS during the study may be due to the low surface run off into the River. Dunsin et al; (2012) reported lower values of TDS of 18.50 ± 6.75mg/L in a drainage channel in south western Nigeria. The TDS values obtained during the course of this work is suitable for fish culture and growth in River Fete (WHO 2004).

The presence of Nitrate in a lotic system mostly depends on the activities of nitrifying bacteria, stream currents and the characteristics of the catchment area, domestic and agricultural sources. In this study, the difference in dry and wet seasons was significant ($P<0.05$). This result is far below the recommended standard of 50.00mg/L nitrate (WHO, 2004, NSDW, 2005). Similar trends of nitrate were reported in surface waters Ogidiaka *et al*., 2012). The mean nitrate value in this study may be due to the activities of nitrifying bacteria's in the river and run off from fertilized farms.

Sulphur is present in natural waters as sulphate. During the present investigation, mean sulphate ion concentration was below the 250mg/L recommended value set by WHO and 100mg/L by NSDWQ (WHO 2004, NSDW 2005). Sulphate is found in fertilizers and can lead to water pollution due to increased sulphate concentration in water body that is washed from the farm (Shinde *et al.,* 2011). Sulphate in surface water is also leached from runoff containing relativity large quantities of organic sulphur compounds, (Shinde *et al.,* 2011). The sulphate ion concentration in the present study may be due to run off of fertilizers from the farms on the catchments of the River Fete into the water as was observed during the course of the study. Sulphate is a source of nutrient that facilitates the growth of plankton and support the fish population in River Fete which is suitable for aquaculture production.

In most natural waters, phosphorus usually ranges from 0.005 – 0.020mg/L (Shinde *et al.,* 2011). Algae requires only small amount of phosphorus. However, excess amount of phosphorus can result to eutrophication leading to excessive algal growth (Shinde *et al.,* 2011). In the present study mean phosphates concentration recorded was not in agreement with the result of an earlier study in River Benue that reported mean phosphate concentration of 5.34 ± 0.32mg/L (Eneji *et al.,* 2012). Furthermore, Okaye *et al.,* (2011) reported phosphate in River Benue in range of 0.07 – 0.17mg/L. In this present investigation, plausible reasons for the concentration of phosphate determined may be probably attributed to surface water runoff and anthropogenic activities.

During the course of this study, DO value recorded during the dry and wet seasons was in disagreement with the result of an earlier study in River Benue that reported much lower mean value of DO (1.80 ±0.06mg/L) during the course of the study (Eneji *et al*., 2012). However, Maitera *et al.,* (2011) reported DO value in the range of 5.27 ± 0.24 to 6.41mg/L in River Benue at Adamawa station which agrees with the result of this study. Similarly, Wazir and Ogugbuaja (2010) reported DO that varied from 5.87 ± 0.43 to 7.38 ± 0.43 in River Yobe, Nigeria. The difference in DO between dry and wet season was highly significant ($P<0.01$). The high DO concentration in wet season may be due to aeration of surface water by wave action and photosynthetic reaction by green aquatic plants. Water with DO value less that 5mg/L may not be suitable for aquaculture production.

The total alkalinity of River Fete is a reflection of its carbonate and bicarbonate profiles with likelihood of silicate and phosphates contributing to it. This is so because phenolphthalein alkalinity was absent in the river. Campbell and Wildberger 2001) reported that phenolphthalein alkalinity is usually low or absent in water dominated by bicarbonate ions. Higher values obtained during the dry season could be due to higher concentration of carbon dioxide and the release of bicarbonates ions by sediments and rocks (Wetzel, 2001). The lower value recorded during the rainy season could be attributed to low concentration of CO_2, dilution of water or the sediments taking up the carbonates ions. The total alkalinity value could have had an impact on the productivity of the

river and might have aided fish production. According to Carlander (1955), positive correlation exists between alkalinity and fish production, while it is believed that total alkalinity above 40mg/L is indicative of high productivity (Suguman, 1995). Alkalinity was a buffer for pH changes caused by photosynthesis thus helping to stabilize the pH in the river. The higher concentration of total alkalinity in Station 'C' could be due to the presence of carbonate and bicarbonates ions from anthropogenic activities.

The mean range of water hardness of River Fete indicated moderately soft water according to the hardness scale of Hanna (2003). The ions were probably derived from drainage of its underlying rock basins (Hutchinson 1957). The total hardness of this river was due to the presence of calcium and magnesium ions. This agrees with Boyd (1979) observation of total hardness of lakes and reservoirs. The range of values of total hardness of the river must have supported the growth of fishes in the river (Rottman and Shireman, 1990). According to Boyd and Lichtkoppler (1979), desirable range of total hardness for fish production falls within 20mg/L to 300mg/L. The higher value of total hardness in the rainy season could be due to high concentration of calcium and magnesium ions. The lower concentration seen in the dry season may be as a result of uptake of these ions by planktons and shelled animals.

Conclusion

The limnological assessment of River Fete showed that the surface water quality could be classified under Cclass 1 of the Prat *et al* (1971) index of water quality classification. Using environmental quality standards (EQS) (WWI, 2007), the ecological status could be said to be high while the chemical status could be described as pass. The determinants used in arriving at this classification such as dissolved oxygen, nitrate, phosphate, BOD, conductivity, total dissolved solids and pH were found in the range acceptable for drinking water (WHO 1997) and fish production, irrigation and recreation (Hach, 2003).

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