Caspian Journal of Applied Sciences Research, 1(5), pp. 27-35, 2012
Available online at http://www.cjasr.com
ISSN: 2251-9114, ©2012 CJASR

Seasonal Physico-Chemistry of Lower River Benue, Nigeria

Edward Terhemen Akange*, Pius Adebayo Araoye

Department of Biological Sciences, Benue State University, P.M.B. 102119, Makurdi, Benue State, Nigeria
*Corresponding author: E.T. Akange, Phone Number: +2347037157305, E-mail: akangeter@yahoo.com

River Benue has been greatly impacted by seasonal variations and human activities on the *fadama* areas bordering the river. This research assessed the impact of seasonality and riparian activities on some crucial water quality variables of River Benue. Water samples were collected at 3 points on the river course in Makurdi fortnightly for a period of 12 months (April 2010 – May 2011). The means of water quality variables in the rainy season: temperature (26.24 $\pm$ 0.170 ^{o}C); pH (6.66 $\pm$ 0.083); turbidity (4.579 $\pm$ 0.220 NTU); dissolved oxygen (5.93 $\pm$ 0.128 Mgl^{-1}); total dissolved solids (41.34 $\pm$ 1.970 Mgl^{-1}); nitrate (1.320 $\pm$ 0.084 Mgl^{-1}) and phosphate (1.140 $\pm$ 0.065 Mgl^{-1}) varied significantly (P<0.05), with those of the dry season: temperature (26.70 $\pm$ 0.366 ^{o}C), pH (7.03 $\pm$ 0.053); turbidity (1.483 $\pm$ 0.369 NTU); dissolved oxygen (5.30 $\pm$ 0.122 Mgl^{-1}): total dissolved solids (32.3 $\pm$ 1.660 Mgl^{-1}). Apart from pH, all the variables also varied significantly across stations with B being significantly higher. All the parameters correlated significantly with each other except temperature and pH (rs = 0.071); temperature and turbidity (rs = 0.130); temperature and phosphate (rs = 0.010); TDS and phosphate (rs = -0.061) and nitrate and phosphate (rs = 0.103).

Key words: fadama areas, Seasonal variations, riparian zones, River Benue, water quality variables.

1. INTRODUCTION

One of the major environmental issues of our time is the growing concern about the quality of water suitable for use both by human and animals particularly fish (Calamari and Naeve, 1994). The inconsistency in seasonal variations occasioned by global warming has posed adverse challenges on the hydrologic regimen of tropical river systems. River Benue has been seriously impacted by these variations qualitatively and quantitatively. Additionally, the river has also suffered from human and other biogeographical alterations on the riparian zones hosted by the large expanse of *fadama* bordering the river banks.

The growing need to restore and preserve the physical, chemical and biological integrity of river and other water bodies vis-à-vis the consequences of human and other geographically altering variables underscore the relevance of water quality assessment. The large expanse of *fadama* bordering the lower River Benue encourages a number of riparian activities ranging from farming to excavation of sand and clay for making burnt bricks. These perturbations adversely affect the river physico-chemistry and its flora and fauna compositions. Riparian zones are recognized as areas of biological, physical and chemical interaction between terrestrial and aquatic ecosystem (Gregory *et al.*, 1991) and its influence on aquatic environment is dependent on the size of stream, landscape and hydrologic regime (Naiman and Decamps, 1997). Fish communities are therefore adversely affected by riparian destruction and recover only when riparian integrity is re-established (Penczak, 1997).

Several works have been done on the Lower River Benue at Makurdi. Solomon et al., (2009) investigated on dry season zooplanktons; Ogbe et al., (2008) worked on the feeding and growth parameters of *Hydrocynus forskalii* and *Alestes nurse* while Fagade, (1983) researched on the food and feeding habits of the fishes of lower River Benue. There has not been extensive limnological research considering seasonal variability and riparian effects on the water quality status of lower river Benue. This work would therefore provide information on the seasonal variation of the physico-chemistry of River Benue and its influencing indices.

2. MATERIALS AND METHODS

2.1. Study Area

The Benue River originates in the Adamawa Mountains of the central Cameroun and flows westward for 1,400km until it meets the Niger River about, 450km above the delta, near the city of Lokoja, Nigeria (Ashley, 2010).The upper reaches of River Benue forms narrow valleys and contain falls and rapids. Most of the lower portions however are free from rapids and have extensive floodplains (1,800km^2) and braided stream channels of different sizes which meander across the floodplain. The floodplain also contains seasonally inundated depressions known as *fadamas*. These provide importance fishery resources, which are exploited after the flood has receded (Sarch, 2001).

The average annual rainfall is between 1000 and 1500mm. These seasonal differentials markedly affect the rivers physico-chemistry, fauna composition and abundance.

In the rainy season, the river overflows the banks and inundates the grassy riparian zones. Additionally, there is a wash down of a high load of allochthonous inputs from domestic and farm areas. In the dry season however, the water level recedes considerably leaving a silted river bed with clear shallow water.

Three stations were selected along the river course in Makurdi, Benue State (7^{o}46'N, 8^{o}29 B' E) as follows:

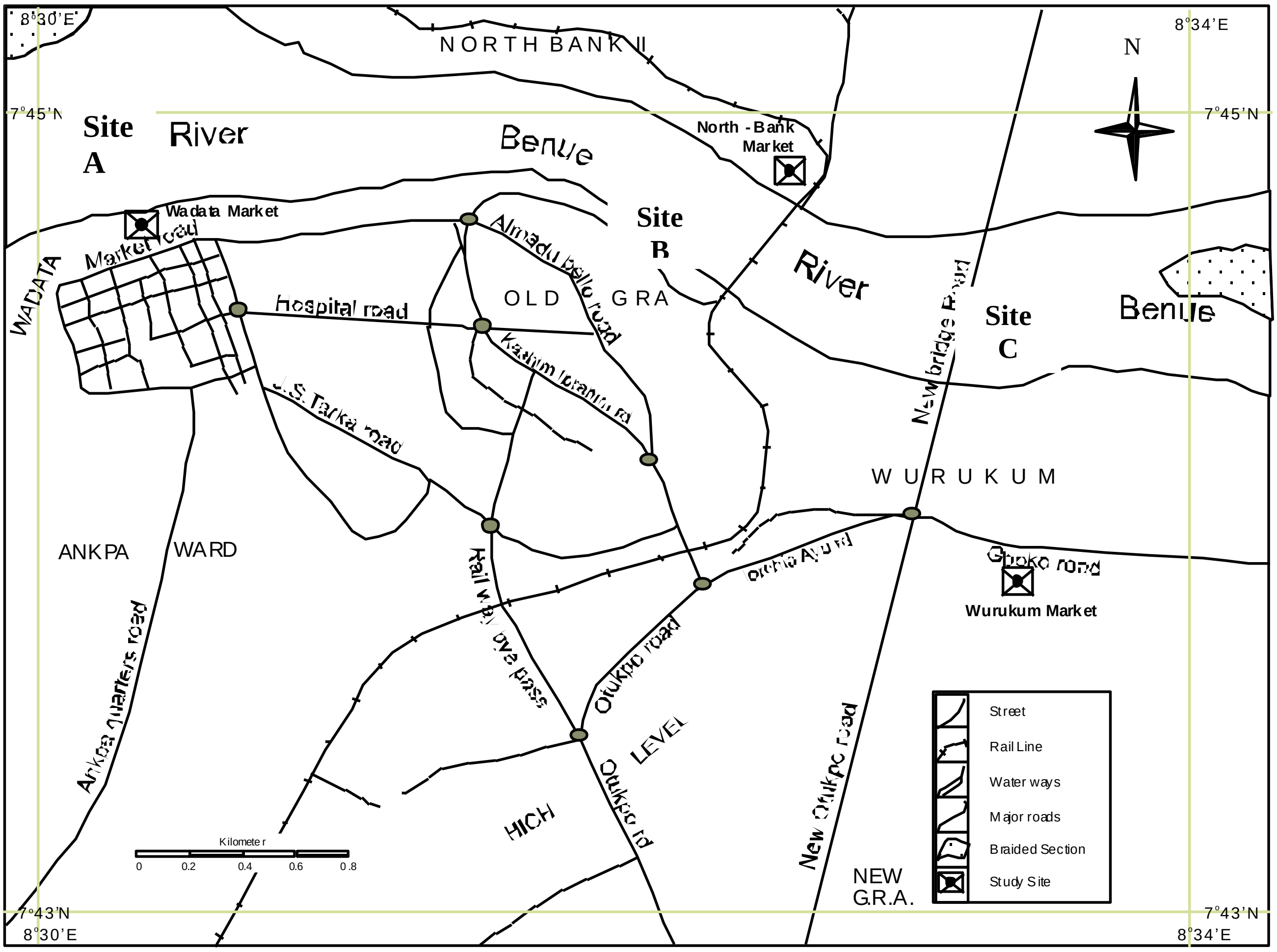

Fig. 1: Map of lower River Benue showing the Sampling sites

<u>Site A</u>**:** this site is located behind Benue Brewery Limited approximately 5 kilometers away from the New Bridge (Station B).

<u>Site B</u>**:** this site is impacted by the wash-in of inland water through the Idye and Katungu basins. There were elaborate human activities like washing and vegetable farming at this station.

<u>Site C</u>**:** this site is located behind the Wadata Market approximately 4 kilometers away from station B. This station collects a high load of market wastes in addition to the wash down of domestic sewages from the Wadata settlement.

2.2. Sample Collection and Analysis

Water samples were collected fortnightly (2 weeks) for a period of 12 months (June 2010 – May 2011) at the 3 stations. Sampling was usually done in the mornings (6-10 am). Water samples were collected in a 2-litre clean jerry-can and immediately taken to the laboratory for analysis. Water samples were collected at points 2 m from the fringes of the water.

Temperature was determined insitu using Mercury-in-Glass Thermometer (0-100^{o}C). pH was determined using pH-meter (Lovibond 2000).

Two drops of Bromothymol Blue was added to the water samples in a bottle receptacle and shaken thoroughly. The resultant colours were variants of blue colours. These colours were compared with the quadrants of colours that match the various pH levels meter. Turbidity was measured using a spectrophotometer (HACH-DR/2000-Programme Number: 750; wavelength: 450nm). Dissolved Oxygen was measured with a spectrophotometer (HACH-DR/2000-Programme Number: 445; wavelength: 535nm). TDS-meter (HACH, model 50150) was used to measure the total dissolved solids. Nitrate was measured using HACH-DR/2000 (Programme Number: 355; wavelength: 500nm) Phosphate was measured with spectrophotometer (HACH-DR/2000- Programme Number: 490; wavelength: 809nm).

2.3. Data Analysis

Water quality data were analysed using two Statistical softwares. Means were determined using Minitab 14 while Genstat Discovery Edition from Lawes Agricultural Trust, Rothamsted was used for the Analysis of Variance (2-Way ANOVA). The ANOVA determined the significant difference among means of water quality parameters across stations and between seasons while separation of means was carried out using Fischer Least Significant Difference (F-LSD).

3. RESULTS AND DISCUSSION

3.1. River Seasonality

The lower River Benue at Makurdi showed marked seasonal fluctuations in water volume. In the rainy season (June–Sept 2010), the *fadama* areas bordering the banks were inundated sub-merging the vegetation.

In the dry season (Oct 2010-April 2011) however, the water level receded gradually to an extreme extent of leaving the river broken into channels with the sandy bed exposed. There were also elaborate human activities in the dry season such as washing and vegetable farming especially at the new bridge (site B).

3.2. Physico-Chemistry of River Benue

Temperature showed a significant difference in the means across the sites (LSD=0.553, $P<0.05$). Sites B (B=26.98± 0.534) was significantly different from the other two sites (Table1). The means between seasons also varied significantly (LSD 0.458, $P< 0.05$). Temperature was highest in months of March and least in January across sites Figure 2).

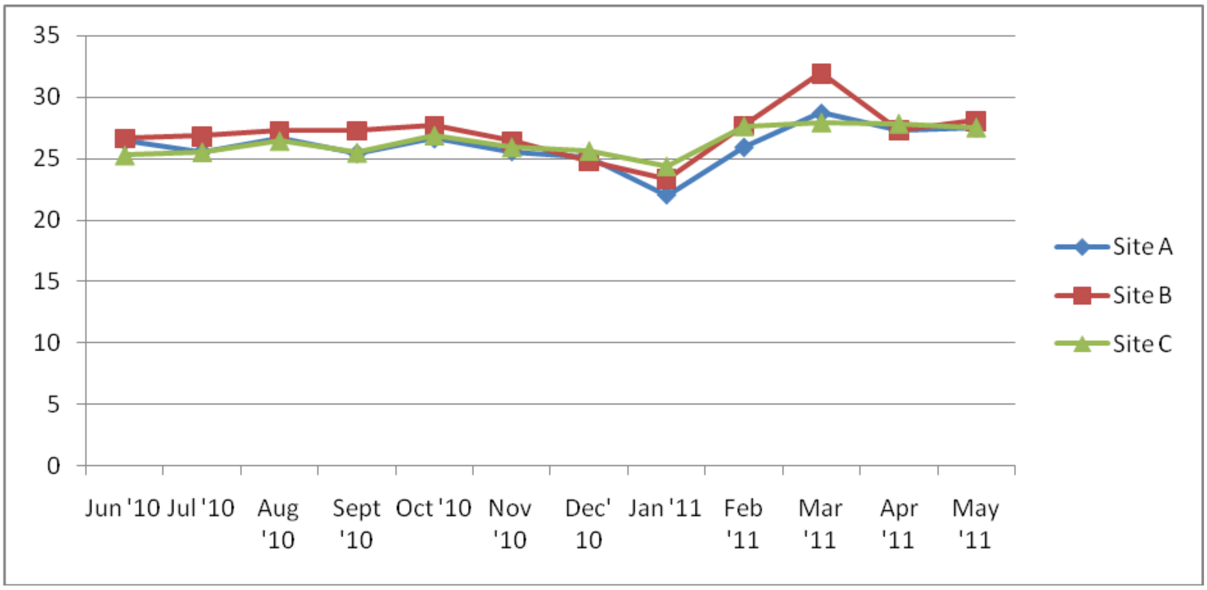

Fig. 2: Monthly Variation of Temperature across the Sampling sites in Lower River Benue

Table 1: Mean Variation of Water Quality Variables in Lower River Benue

Station	*Temperature*	*pH*	*Turbidity*	*Dissolved Oxygen*	*Total Dissolved Solids*	*Nitrate* (NO_3^-)	*Phosphate* (PO_4^{2-})
A	26.18 ± 0.317^a	6.94 ± 0.091^a	2.675 ± 0.369^a	5.605 ± 0.141^a	37.16 ± 2.730^a	1.081 ± 0.133^a	1.162 ± 0.067^a
B	26.98 ± 0.534^b	6.87 ± 0.091^a	3.014 ± 0.382^b	5.5824 ± 0.207^a	33.88 ± 1.60^b	1.370 ± 0.726^b	1.404 ± 0.069^b
C	26.39 ± 0.264^a	6.84 ± 0.085^a	2.630 ± 0.369^a	5.508 ± 0.149^b	32.38 ± 1.660^b	0.994 ± 0.104^a	1.160 ± 0.068^a
LSD	0.553	0.1159	0.281	0.4440	2.366	0.1823	0.1889
Season							
Rainy	26.24 ± 0.170^a	6.66 ± 0.083^a	4.579 ± 0.222^a	5.93 ± 0.128^a	41.34 ± 1.970^a	1.320 ± 0.084^a	1.140 ± 0.065^a
Dry	26.70 ± 0.366^b	7.03 ± 0.053^b	1.483 ± 0.369^b	5.30 ± 0.122^b	29.57 ± 0.963^b	1.028 ± 0.133^b	1.310 ± 0.051^b
LSD	0.458	0.096	0.232	0.368	1.959	0.151	0.156

Means of the same column with different superscript are significantly different (p<0.05)

There was no significant difference comparing the means of pH across sites (LSD= 0.1159) (Table 1). There was however a significant difference comparing the means between season (LSD= 0.0960, P<0.05). The pH during the study period was relatively stable (Figure 3).

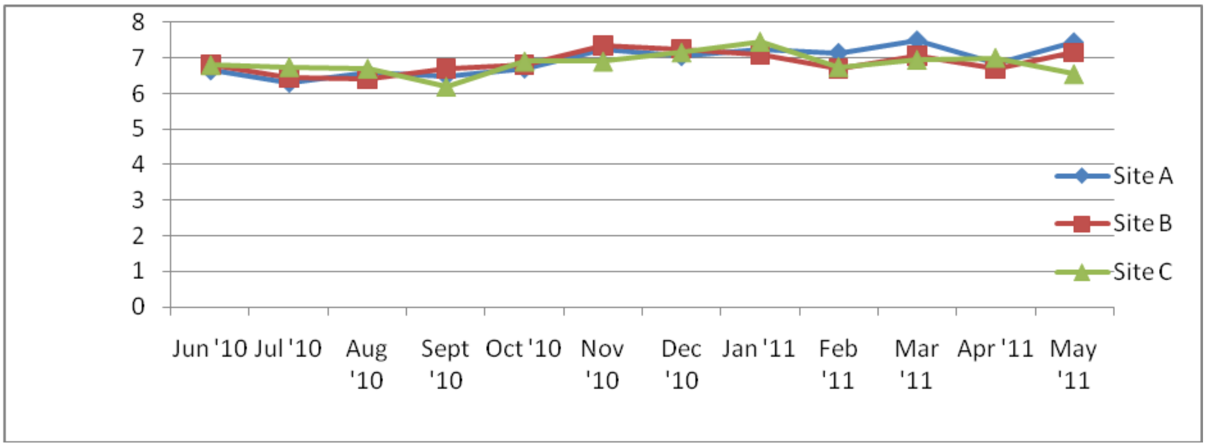

Fig. 3: Monthly Variation of pH across the Sampling sites in Lower River Benue

Sites B recorded the highest turbidity (3.014 ± 0.382 NTU) which was significantly different from sites A and C (LSD= 0.281, P<0.05). The seasonal variation was also significantly different (LSD= 0.232, P<0.05). The mean turbidity value recorded in the rainy season (4.579±0.2220 NTU) was more than twice the value recorded in the dry season (1.483±0.1140 NTU). The month of July recorded the highest turbidity level across all the sites while January and February had the least turbidity value. (Figure 4).

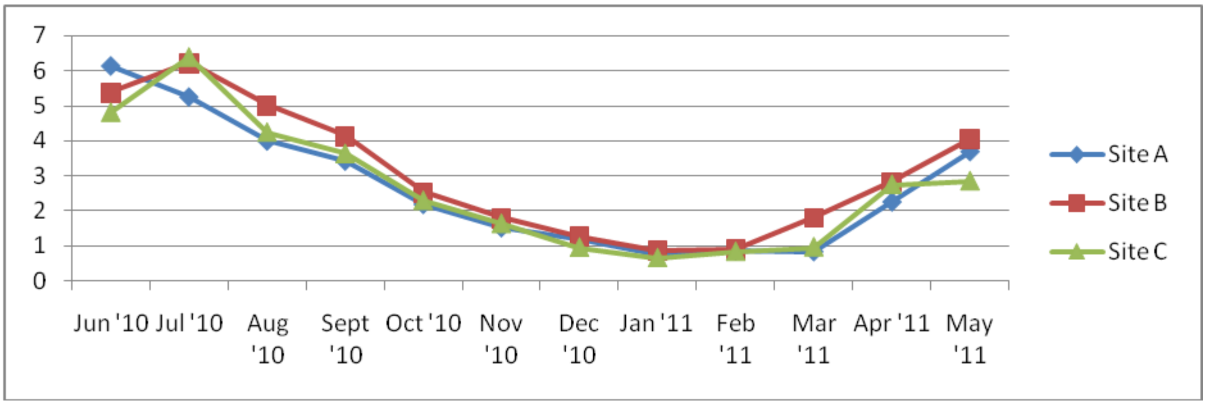

Fig. 4: Monthly Variation of Turbidity across the Sampling sites in Lower River Benue

Dissolved Oxygen had a higher mean value (5.93±0.1280 mgt) was recorded in the rainy season which was significantly different from that of the dry season (5.30±0.1220 Mgl^{-1}) (LSD= 0.3677, P<0.05) (Table 1). No significant difference was recorded on comparing the means across sites. Although the concentration of dissolved oxygen was relatively stable during the year, the month of March and part of April recorded a lower concentration of dissolved oxygen at all sampling sites (Figure 5).

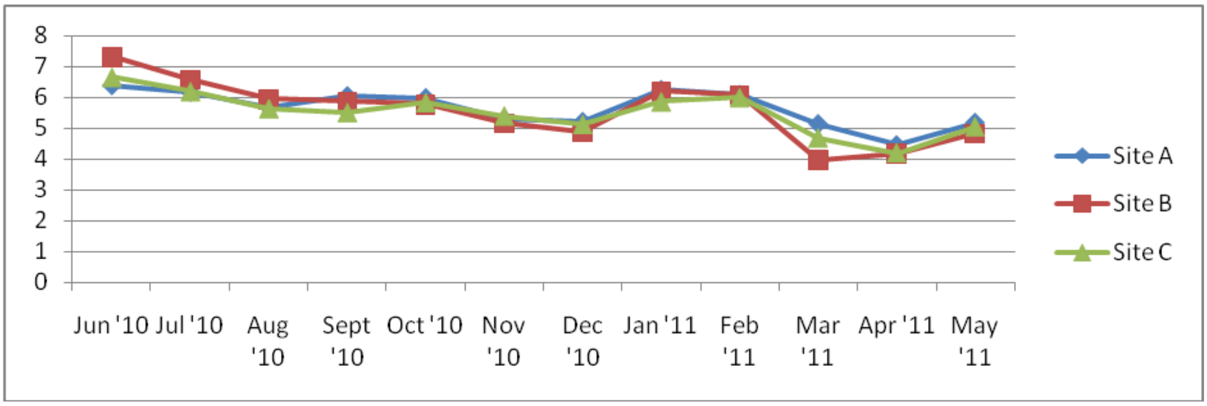

Fig. 5: Monthly Variation of Dissolved Oxygen across the Sampling sites in Lower River Benue

The mean value of Total Dissolved Solids (TDS) was highest at site A (37.16±2.730 Mgl^{-1}) which varied significantly with the other two sites. There was a significant different of means between the rainy (41.34±1.9700 Mgl^{-1}) and dry season (29.57±0.9630 Mgl^{-1}) (LSD=1.959, P<0.05) (Table 1). The months of August and September recorded the highest value of total dissolved solids across all sites (Figure 6).

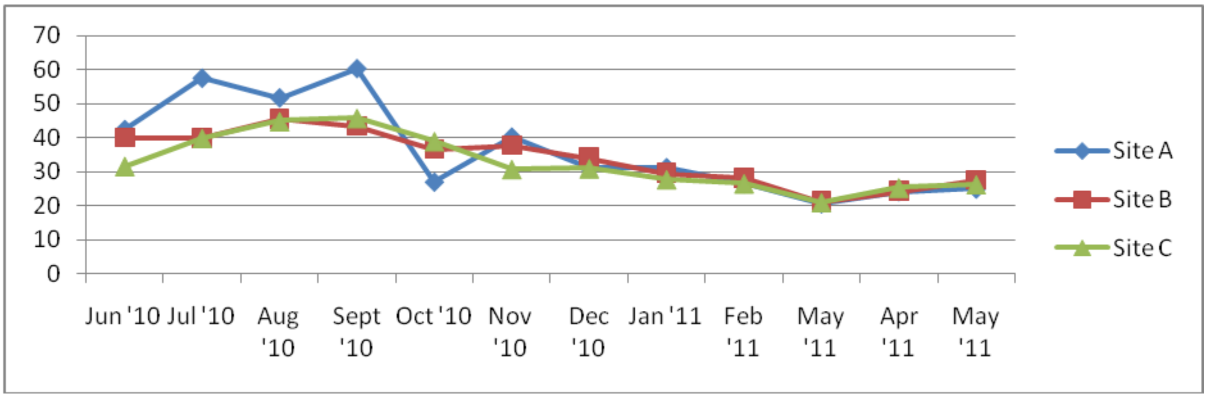

Fig. 6: Monthly Variation of Total Dissolved Solids across the Sampling sites in Lower River Benue

The monthly variation of nitrate is shown in Figure 7. The mean monthly variation fluctuated between 0.371 Mgl^{-1} and 3.08 Mgl^{-1} during the study period. Sites B (91.370 ± P<0.05) than the other two sites. The variation between seasons was also significantly higher concentration of nitrate (two LSD = 0.1823 P<0.05) than the other sites. The variation between seasons was also significant (LSD=0.15098, P<0.050). (Table 1).

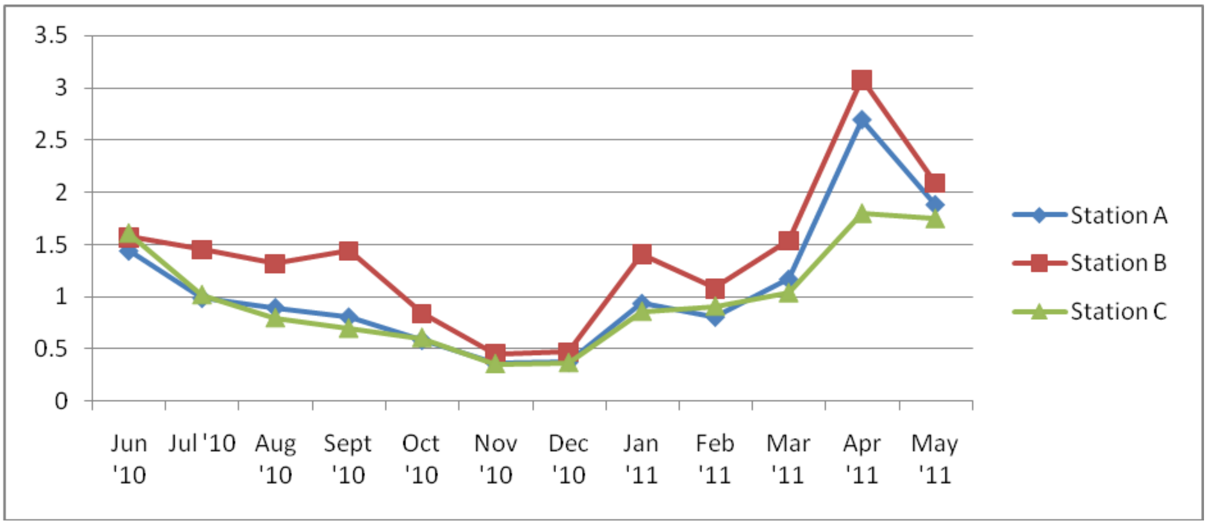

Fig. 7: Monthly Variation of Nitrate across the Sampling Stations in Lower River Benue

Site B recorded the highest concentration of phosphate (1.404±0.069 Mgl^{-1}) which was significantly different (LSD = 0.1889, P<0.05) from the other two sites. The variation between seasons also showed a significant difference (LSD=0.1564, P<0.05) (Table 1).

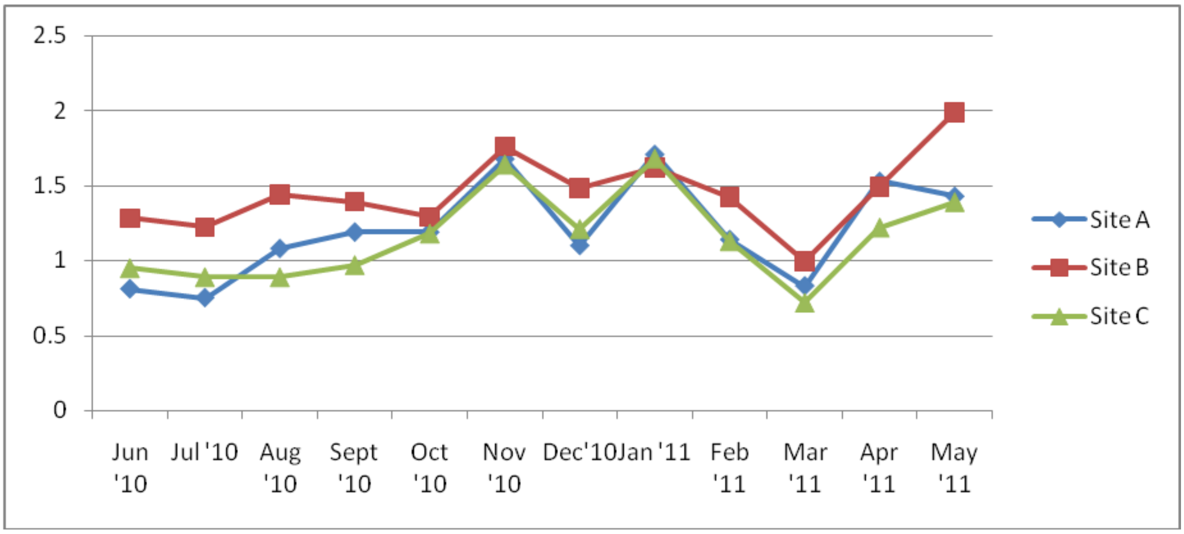

Fig. 8: Monthly Variation of Phosphate across the Sampling Stations in Lower River Benue

3.3. Correlation Matrix of Water Quality Variables

The correlation Matrix (Table 3) shows a significant difference (p<0.05) in temperature and dissolved oxygen (rs= -0.481) temperature and total dissolved solids (rs=-0.436); temperature and nitrate (rs=0.533); pH and turbidity (rs=-0.469); pH and dissolved oxygen (rs= -0.252) pH and total dissolved solids (rs=-0.464); pH and phosphates (rs= 0.285). Other pairs of water quality variables that varied significantly were turbidity and dissolved oxygen (rs= -0.295); turbidity and total dissolved solids (rs=0.572); turbidity and nitrate (rs=0.380) turbidity and phosphate (0.271); dissolved oxygen and total dissolved solids (rs=

0.528) and total dissolved solids and nitrate (rs=0.363).

The relationship between temperature and pH (rs= 0.071); temperature and turbidity (rs= 0.130); temperature and phosphate (rs= 0.230) dissolved oxygen and nitrate (rs=-0.66); dissolved oxygen and phosphate (rs=0.01); total dissolved solids and phosphate (rs =-0.061) and nitrate and phosphate (rs= 0.103) were not significant (p>0.05).

Table 2: Correlation Matrix of Water Quality Variables in Lower River Benue

	Temperature	***pH***	***Turbidity***	***Dissolved Oxygen***	***Total Dissolved Solids***	***Nitrate*** (NO_3^-)	***Phosphate*** (PO_4^{2-})
Temperature	-	-0.071	0.130	-0.481^*	-0.436^*	0.533^*	0.230
pH		-	-0.469^*	-0.252^*	-0.464^*	-0.094	0.285
Turbidity			-	0.295^*	0.572^*	0.380^*	0.271^*
Dissolved Oxygen				-	0.538^*	-0.660	0.010
Total Dissolved Solids					-	0.363^*	-0.061
Nitrate (NO_3^-)						-	-0.103
Phosphate (PO_4^{2-})							-

*** Correlation is significant at 0.05% level**

The general variations of water quality variables between site and across sites reflect the high variability of River Benue which is a tropical system. The driving force for these fluctuations is attributed to the rainy and dry seasons (Mustapha, 2010).

The mean water temperature in the dry season was higher than that of the rainy season probably due to the prevalent ambient temperatures occasioned by high solar radiations and reduced water volume. This observation is similar to that of Chindah and Braide (2004) for the Elechi Creek and Deekae et al., (2010) for the Luubra Creek who reported significantly higher water temperatures in the dry season than in the rainy season. Temperature was highest at site B due to the severely silted river bed in the dry season. Water is a poor conductor and therefore retained some heat from the solar radiation. Site A and C had comparatively deeper waters especially in the rainy season. Temperature correlated negatively with pH. This could have been due to the high load of organic materials (acidic, low pH) whose decomposition is not favoured by low temperatures. Boyd (1982) reported that high temperature promote organic matter decomposition in water. These high temperatures also trigger the dissociation of compounds into their ions. This explains why temperature correlated positively with nitrates ($No_3^{-)}$) and phosphates (PO_4^{2-}) which are ions of nitrogen and phosphorus respectively. The temperature range was within the culturable limits (25 – 32^{o}C) for tropical fish as proposed by Boyd and Lichtkoppler (1979).

The pH value for the rainy season was lower (acidic) due to the acidification of a high load of undicomposed allochthonous organic matter from the *fadama* areas. This disagrees with the work of

Offem et al., (2011) who reported a lower (acidic) pH in the dry season. The wash-down of inorganic fertilizers which are acidic from the river may also contribute to lowering the pH. The increased pH in the dry season was likely to be caused by reduced organic matter load and increased human activities like washing using soaps and detergents of alkaline origin. pH correlated negatively with turbidity and total dissolved solids probably because the ionic composition that constitutes turbidity and total dissolved solids are usually acidic (low pH) in nature. pH for both seasons were within the desirable range for warm water fishes production of 8.5 – 9.0 (Boyle and Lichkoppler, 1979).

The rainy season recorded a higher concentration of dissolved oxygen. This is not unconnected to the turbulence caused by wind and currents as the water flow. This is in agreement with Abowei (2010) on Nkoro River. The significantly low temperatures of the Harmattan (January/February) also resulted to a higher concentration of dissolved oxygen. At low temperature, more oxygen diffuses into water because of reduced partial pressure (Kutty, 1987).The month of March and part of April recorded the least concentration during the study period. The river broke into braided channels and the heat received by solar radiation increased the water temperature which in turn adversely affected oxygen solubility in the water. This explains why temperature correlated negatively with dissolved oxygen.

The highest value of turbidity recorded at site B was likely cause by the wash down of water from the Idye basin which collect water from the township areas of High Level and Wurukum and the Katungu basins in the North Bank area. Seasonally too, turbidity was analysed to be significantly higher in concentration in the rainy season. Offem (2011) reported higher turbidity in Ikwori Lake and linked it to the flooding that occurred due to heavy rainfall causing a runoff from nutrient rich agricultural lands that introduced some particles into the lake. Turbidity correlated negatively with dissolved oxygen. This is because turbidity impedes sunlight penetration into the water depths for the usage of phytoplankton to release oxygen. Boyd and Frobisch (1990) also reported that the temperature in turbid waters continuing mater were usually greater than those of clear water.

The total dissolved solids were recorded to be higher in site A. The brewery effluent discharged into the river around this station and the run-off from the comparatively larger span of *fadama* areas could have constituted the higher concentration of total dissolved solids. Saxena (1990) reported that an elevation of water density and its consequent influence on the osmo-regulation of freshwater organism was caused by organic and inorganic salts of bicarbonates, calcium, magnesium, sodium etc.

The cultivation of vegetable and other crops and the consequent application of nitrogenous fertilizer possibly constituted to the significantly higher concentration of nitrate at site B. Generally in the rainy season the river received nutrients from the catchment areas which were predominantly ionized forms of ammonia and other compounds of nitrogen whose major sources were excrements and mineralization of organic nutrients. Deekae et al., (2010) reported human and animal wastes, weathering of igneous and volcanic rocks and the oxidation of vegetable and animal debris as the major sources of nitrate in water bodies. Nitrates ionize in waters of higher temperatures. Temperature effect the dissociation of nutrient compounds into their ionized forms (Boyd, 1982). This explains why nitrate correlated positively with temperature.

Similarly, phosphate had its highest concentration at site B and in the rainy season. Most of the fertilizers used on vegetable farms are NPK compound fertilizers. Their application and consequent wash down into the river during the rainy season could have constituted to the high concentration of phosphate at site B and generally during the rainy season.

4. CONCLUSIONS

The marked seasonal variations of all the tested limnological variables confirm a gross seasonality impact of the lower river Benue. This variation is rain-induced as the volume of river water and influx from the river catchments and township inflows are regulated by rainfall. The distortion of the river morphometry due to clay excavation for the making of burnt bricks has widened the river bed and introduced silt lowering river depth. The inorganic fertilizers applied on the *fadama* farms in the any season washes into the river at rainy season influencing the level of nutrients held by the river.

The excavation of clay at the river banks for the making of burnt bricks should be prohibited. The Federal Government should extend the dredging of project of the Niger River to River Benue. This would improve the geomorphology of the river with attendant improvement on the river physico-chemistry. The *fadama* farmers should substitute inorganic fertilizer usage for organic fertilizers. Apart from improving the soil structure, organic fertilizers would in themselves serve as food for fish and other aquatic lives.

REFERENCES

Abowei JFN (2010). Salinity, Dissolved Oxygen, pH and surface water temperature conditions in Nkoro River, Niger Delta. J. Food Sci. Technol., 2(1): 16-21.

Ashley B (2010). Freshwater Ecoregions of the world. The Natural Conservancy. WWF/TNC, 2008.

Boyd CE, Lichtkoppler F (1979). Water Quality Management in Pond fish culture. Research and Development Series No. 22. Project: AID/DSAN – G0039. International Centre for Aquaculture-Agricultural Experiment Station, Auburn University, Auburn, Alabama, 30pp.

Boyd CE (1982). Water Management of Pond fish culture. Elsevier scientific publications, Amsterdam Development on Aquaculture and fisheries science.

Boyd CE, Frobisch LT (1990). Water Quality in Ponds for Aquaculture. Alabama Agricultural Experiment Station, Auburn University, Auburn, Alabama.

Calamari D, Naeve H (1994). Towards Management of the aquatic environment. Caribbean Inland Fisheries Association (CIFA). Tech pap., 25:7-22.

Chindah AC, Braide SA (2004). The Physico-Chemical Quality and Phytoplankton Community of Tropical Waters: A Case of 4 biotopes in the Lower Bonny River, Niger – Delta, Nigeria. Caderno de prequisa Serie Biol., 16(12): 7-35.

Deekae SN, Abowei JFN, Alfred-Ockiya JF (2010). Seasonal variation of some physical and chemical parameters of Luubra Greek, Ogoni Land, Niger Delta. Research Journal of Environmental and Earth Sciences, 2(4): 208-215, 2010.

Fagade SO (1983). The food and feeding Habits of the fishes of Lower River Benue, Nigeria. Bull II F.A.N. T., 45:28-36.

Kutty, M.N. (1987). Site selection for Aquaculture: Chemical features of water. Working Paper, African Regional Aquaculture Centre, Port Harcourt. ARAC/87/WP/2(9).p53.

Mustapha MK (2010). Seasonal influence of Limnological variables on plankton dynamics of a small, Shallow, Tropical African Reservoir. Asian J. Exp. Biol. Sci., 1(1) 2010.

Naiman RJ, Decamps H (1997). The Ecology of interfaces: Riparian zones. Annual Review Ecology and Systematic. 28, 621-658.

Offem BO, Ayotunde EO, Ikpi GK, Ochang SN, Ada FB (2011). Influences of seasons on water quality, Abundance of fish and Plankton species of Ikwori Lake, South-Eastern, Nigeria. Fish. Aquat. J. Vol. 2011: FAJ-13.

Ogbe FG, Ataguba GA, Okosuwe EH (2008). Feeding Habits and growth parameters of Hydrocynus forskalii and Alestes nurse in River Benue, Makurdi, Nigeria. J. App. Biosciences, 2: 576-583.

Penczak T (1997). Effects of Removal and Regeneration of Bank side vegetation on fish population on the resistance to flooding and the resilience of stream fish Assemblages. Transactions of the American Fisheries Society, 121: 427-436.

Sarch M, Madakan SP, Ladu BL (2001). Investigating systems of fisheries access along the River Benue in Nigeria. PLA notes CD-ROM, 1988-2001

Saxena, M.M. (1990). Environmental Analysis: Water, Soil and Air. Agro-Botanical Publishers, India.

Solomon SG, Ataguba GA, Baiyewunmi AS (2009). Study of dry season zooplankton of lower River Benue at Makurdi, Nigeria. J. Ani Pl. C., 1 (3): 42-50.