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# Studies on Evaluation of the Status of Nutrient Loading as Indication of Eutrophication in Lower River Benue at Makurdi, Nigeria

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**Abstract:** The influence of daily human activities on the water quality of lower River Benue at Makurdi was studied for a period of 24 months at five selected sampling stations. The sampling stations were selected based on the human activities on the River. Water samples were collected at each of the sampling stations and analyzed for nitrate, sulphate and phosphate load level using standard methods for the examination of waters and waste waters. The results of the nutrient load level across the sampling sites were varied as follows: nitrate 2.20±3.10-3.80±5.20mg/L, sulphate 10.40±9.18-17.20±15.20mg/L and phosphate 0.90±1.10-1.50±2.10mg/L. The nutrient load level were within the WHO recommended limit. The result of the study revealed a low level of nutrient load in the lower River Benue and indicate that its waters were not contaminated with respect to nutrients that will facilitate the excessive growth of algal blooms and that will result to eutrophication which is a menace to aquatic environment. The study conclude that during the study period the lower River Benue was not contaminated with respect to the monitored nutrient parameters.

**Key words:** Nutrient load, Nitrate, Sulphate, Phosphate, Lower River Benue

## 1. Introduction

All living system required nitrogen and phosphorus as the important nutrients (Mueller and Helsel, 1996). The natural sources of nutrients include soils and decaying organic plant materials such as fallen leaves, grass etc. However, most of the nutrients are introduced by the activities of humans into the surface waters. Rivers are linked with agricultural and urban and industrial activities (Mueller and Helsel, 1996). Nagargoje and Bhosle (2002) reported that human beings through the use of inorganic fertilizers are the main source of nitrates in surface waters in the rural areas while detergents is the source of phosphorus in the waters in the

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urban areas. Badu *et al.*, (2013) reported that the nutrients load of nitrate, phosphorus and Sulphur in Owabi, reservoir, in Ashanti Region of Ghana. All the same when pollution sets the nutrients will degrade the water of the reservoir. This study is aimed at assessing the nutrient level of lower River Benue with respect to checking its effect on excessive algal blooms.

## 2. Materials and Methods

### 2.1 Study Area

The source of River Benue is from the Cameroonian mountains. The River flows downstream towards the west direction into Nigeria. River Benue within the Nigerian boulders measures approximately 310,000 Ha and it is the second largest River in Nigeria. The River Benue is about 1.488Km in length and there is alluvia fertile flood plains on its banks of the River (Welcomme, 1986). River Benue flows downstream through Makurdi city and meets with River Niger at Lokoja the capital city of Kogi state, Nigeria. Makurdi is the capital city of Benue state and the city is located on Latitude $7^0$41' N and Longitude $8^0$ 28' E. The length of the River Benue within Makurdi settlement is approximately 671 meters (Udo, 1981). The rainfall periods in Makurdi produces a river regime of peak flows from August to early October and low flow from December to April. The rainy season which last for seven months (April to October) has a mean annual rainfall ranging from 1200-2000mm. The Makurdi settlement is characterized by high temperature values that ranged from 28-33$^0$C throughout the year, most observable is from March to April. During the nights of December and January harmantan winds are usually prevalent coming with cooling wind but mostly dusty (Nyagba, 1995). Nevertheless the seasonal dust plumes that characterize this time of the year may result to surface water pollution (Nyagba, 1995). Five sampling stations were chosen along the river course at Makurdi , with respect to human activities on the bank of the river that may deteriorate the water quality as shown in Fig 1 as follows: Station I (N07$^0$ 43.663 E008$^0$ 35.427): it is located behind Coca cola plc plant along Gboko road and it is approximate 1.5 kilometers away from Site II.

Station II (N07$^0$ 43.615 E008$^0$ 35.300): it is located directly behind Benue Brewery Plc plant at Kilometer 5 along Gboko road. This site is impacted by the brewery effluents generated from the factory into the river.

Station III (N07$^0$ 43.649 E008$^0$ 35.302): this site is located behind Mikap Nigeria Ltd, a rice processing factory along Gboko road. It is approximately 1 kilometer away from Site II and 2.5 kilometers away from site I. This site receive effluents from the rice mill into the river.

Station IV (N07$^0$ 44.076 E008$^0$ 32.840): this site is located behind Wurukum abattoir close the new bridge across the river. Abattoir waste is washed directly into this site. Farming and sand dredging also take place at this site on routine bases.

Station V (N07$^0$ 44.789 E008$^0$ 30.624): This site is located behind Wadata market along the river water course at Makurdi. Wastes from the heap refuse dumpsite behind the market are leached directly into the river with other domestic activities like washing. More so abattoir wastes are washed directly into the river at this site.

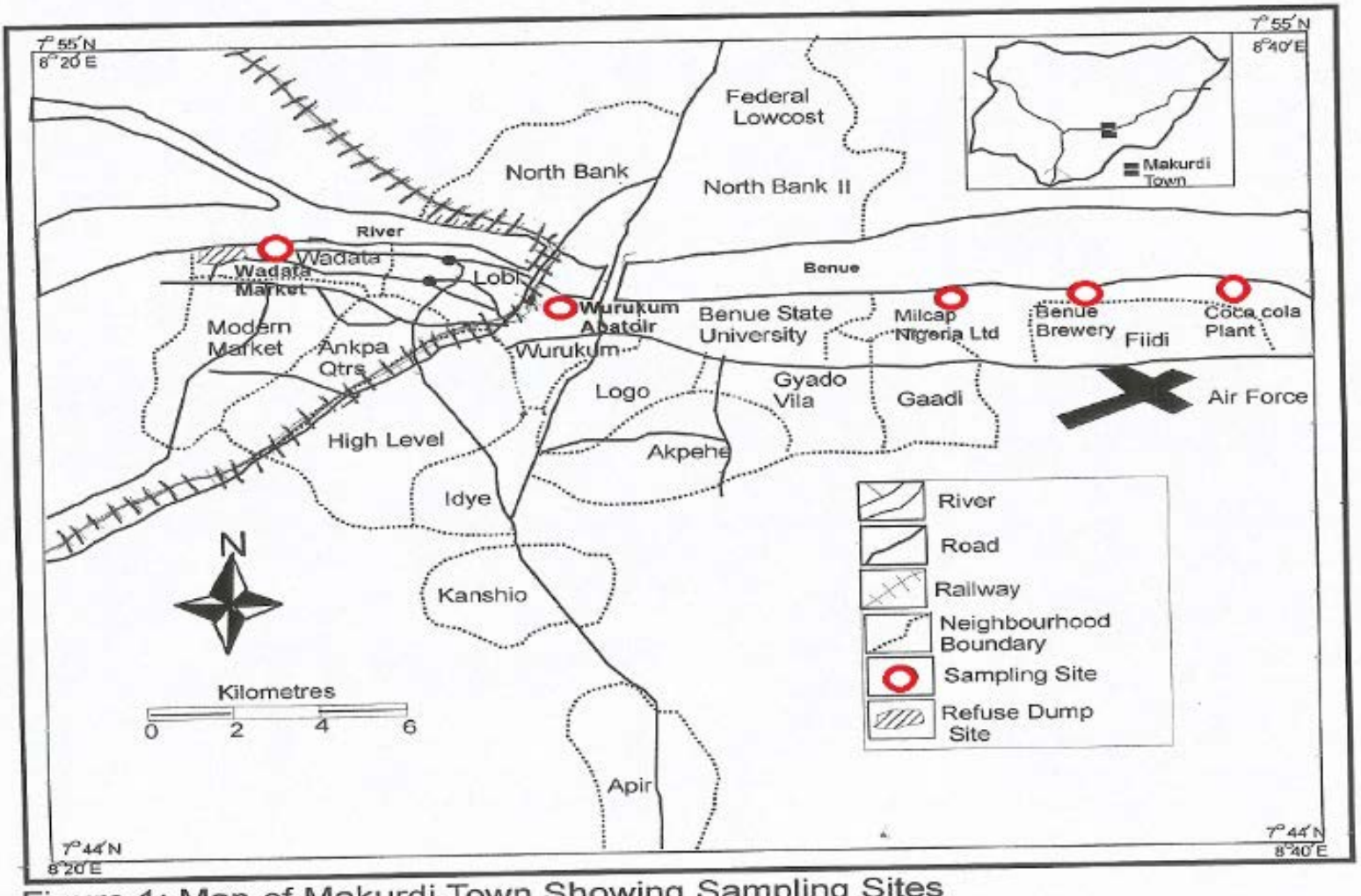


Figure 1: Map of Makurdi Town Showing Sampling Sites
Source: Ministry of Lands and Survey Makurdi

## 2.2 Water Sample Collection

Water samples for nutrient load analysis were collected at five different points from each of the five sampling locations. Monthly routine sampling was conducted between 8:00am and 12:00 noon on each sampling day. Prior to the sampling day, the containers for the collection of the water samples were washed dried and corked, fully labeled and stored under laboratory condition. Usually sampling bottles and containers were rinsed three times with River water at each sampling site before sample collection. The water samples were collected with graduated Von Dorn water sampler. The water sampler was rinsed for about six times at each sampling site before the collection of the samples. Each sample container was treated according to the analysis to be carried out on it on the field before they were transported to the laboratory.

## 2.3 Determination of Nutrients Loading in River Benue

### 2.3.1 Nitrate

Ten millilitres of the sample was measured and poured into the 10ml sample cell of the Data logging spectrophotometer. The programme number for the determination of nitrate by cadmium reduction method was selected (APHA, 1999). One minute timer was selected for the reaction period to begin. A Nitraver 5 powder nitrate reagent pillow was poured into the sample cell containing the sample. The cell was shaken vigorously until the timer expires and button was pressed again. A five minutes reaction was allowed to occur. The formation of amber colouration in the sample cell indicates the presence of nitrate in the sample when the timer expires. Another 10mL cell of the spectrophotometer was filled with the sample which serves a blank. The sample cell was wiped, inserted into the cell holder with the fill line facing right and the zero button was pressed on the spectrophotometer and the display shows 0.0mg/L $N0_3^-$ -N. After then the blank sample was removed from the cell holder and immediately the digested sample cell was inserted into the cell holder and covered back. The read button was pressed and the nitrate concentration in the sample was displayed and the reading was then recorded. This process was repeated for all the replicates throughout the study period.

### 2.3.2 Sulphate

The sample was filtered through a filter paper and 50 mL of the filtrate was taken in a conical flask. The programme number was selected for the test. The 10 mL sample cell of the spectrophotometer was filled with the sample. The content of sulfaVer 4 reagent powder pillow was added into the sample. The mixture was swirled vigorously to dissolve the powder into a homogenous solution. The formation of a white turbid solution indicates the presence of sulphate in the sample. The timer of the

spectrophotometer was selected at five minutes for the reaction period. There after another ten millilitre sample cell was filled with the sample as the blank sample. When the timer expires, the blank was wiped and inserted into the cell holder. The zero button was pressed and 0.00m/L $S0_4^{2-}$ was displayed. After then the digested sample was inserted into the cell holder with the fill line facing right and the read key was pressed. The concentration of the sulphate in the sample was displayed and recorded.

2.3.3 Phosphate

The stored programme for phosphate analysis was selected on the spectrophotometer. The content of phosVer 3 phosphate reagent powder pillow was added to 25mL cell sample. Immediately the cell was swirl vigorously 20-30 seconds for the pillow to mix and dissolve in the sample to form a homogenous solution. The development of blue colouration indicates the concentration of phosphate in the sample. The timer button was pressed and a two minute reaction period begun. When the timer expired, the sample cell with the blank (sample without digestion) is inserted into the cell holder with the fill line facing right. The zero button of the Spectrophotometer was pressed and the display 0.00mg/L $PO_4^{3-}$ was shown on the screen. The digested sample was wiped with a cotton wool and inserted into the cell holder with the fill line facing right. The read button was pressed and the concentration of the phosphate in the sample was displayed on the screen and recorded. This was performed for all the samples throughout the study period.

**2.4 Data and Statistical Analysis**

The mean, standard deviation and standard error were determined on the results obtained from the water samples collected. The environmental parameters data obtained during the study were also subjected to statistical analysis using Analysis of variance (ANOVA) to determine their variations at the sampling locations and across the season. Correlation analysis was carried out on the water quality parameters and benthos to verify if there is any significant relationship between the water quality and benthic fauna composition of River Benue at the study sites. Least Significant Difference (LSD) test was used to test significant alternate means at locations and seasons.

## 3. Result

The result presented in Fig 2 is the average monthly variation of nutrient load in River Benue within Makurdi at Station I. A perusal of the result revealed that phosphate load was the least among the nutrients while sulphate was the highest. A similar trend in the nutrient load in the River was recorded at Station II where the phosphate was still the lowest nutrient load and sulphate the highest during the month of May 2013(Fig 3). The data presented in in Fig 4 is the average monthly variation in the nutrient load in River Benue within Makurdi at Station III. The result indicate a slight difference between nitrate and phosphate load in the River across the studied months. However sulphate was noticed to be the nutrient with highest load at the station with the highest concentration in May 2103during the period of the study. The results of the nutrient load at stations IV and V in River Benue within Makurdi were presented in in Fig 5 and 6 respectively. The result of sulphate had highest load as compared to nitrate and phosphate(Fig 5). Similarly at Station v suphate still have the highest concentration and was increasing and decreasing across the months while there was slight difference between phosphate and nitrate (Fig 6).

Across the studied stations during the course of the study nitrate had the lowest concentration at Wadata market, station V while Benue brewery, station II and Mikap Nigeria Ltd, station III slightly differs in their nitrate concentration (Fig 7). The result in Fig 8 is the mean sulphate load across the stations in River Benue within Makurdi. The result depicts that during the study period the concentration of sulphate was lowest at Wadata market station V and highest at Mikap Nigeria Ltd station III. The data presented in Fig 8 is the mean phosphate concentration in River Benue within Makurdi. The result of the study reveal that Wadata market station V was still the lowest in phosphate content at this station and Mikap Nigeria Ltd station III was with the highest concentration of phosphate.

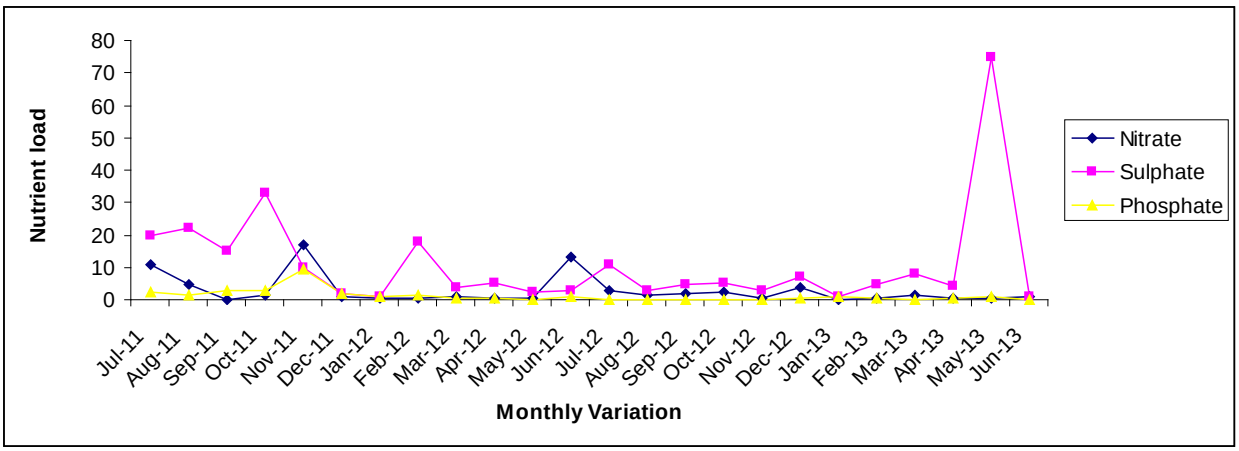


Fig 2: Average Monthly Variation of Nutrient load in River Benue at Station I

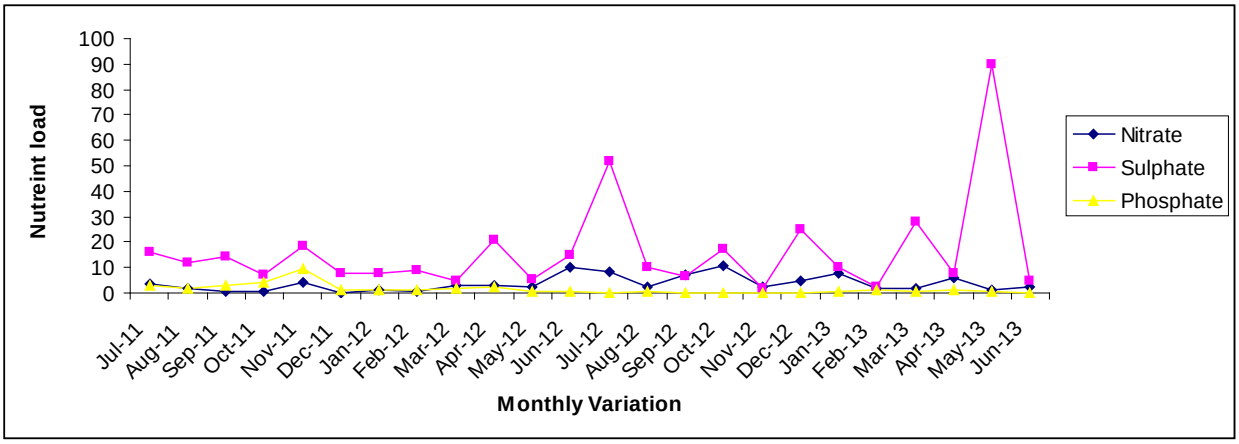


Fig 3: Average Monthly Variation of Nutrient load in River Benue at Station II

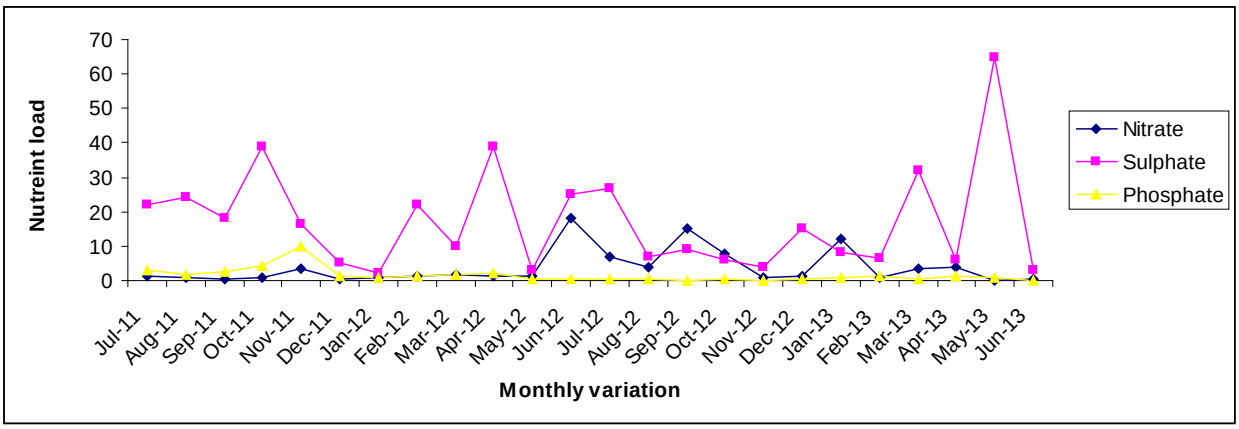


Fig 4: Average Monthly Variation of Nutrient load in River Benue at Station III

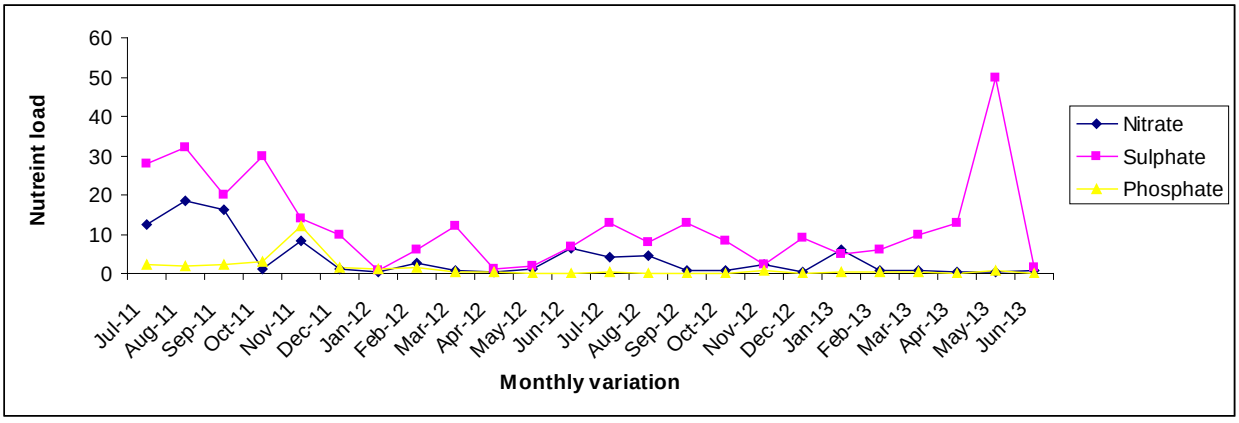


Fig 5: Average Monthly Variation of Nutrient load in River Benue at Station IV

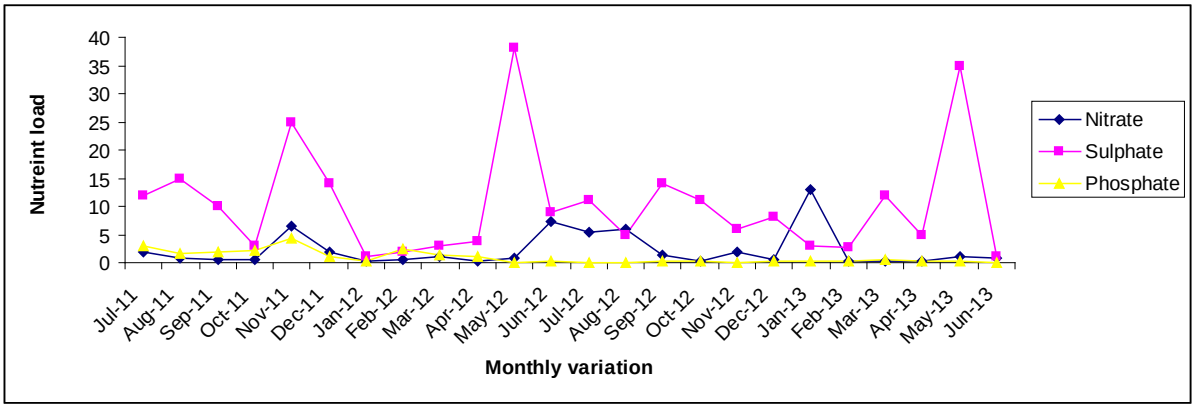


Fig 6: Average Monthly Variation of Nutrient load in River Benue at Station V

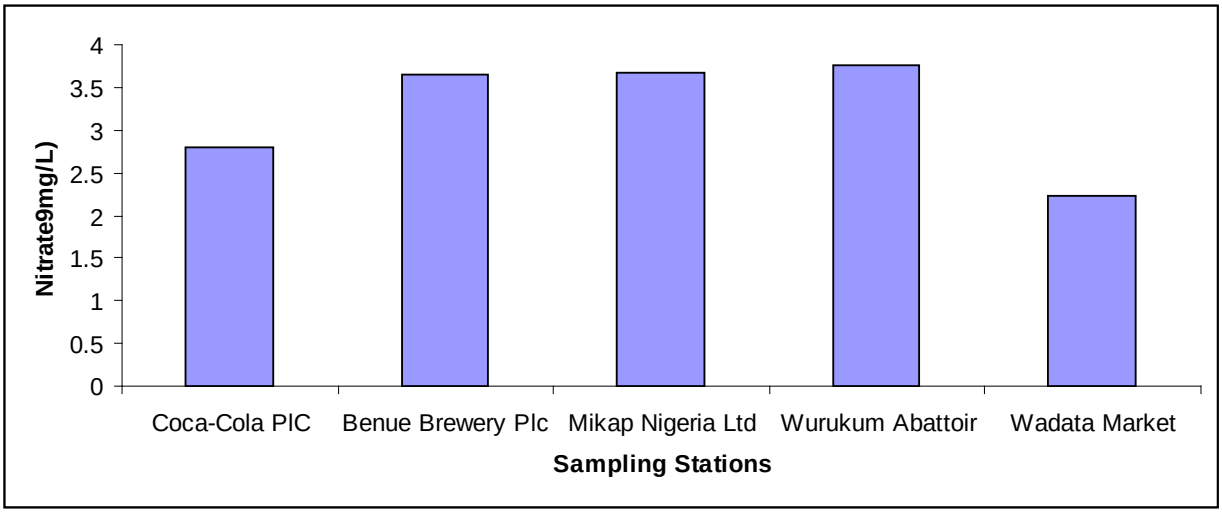


Fig 7: Mean Nitrate load at the sampling stations in River Benue at Makurdi

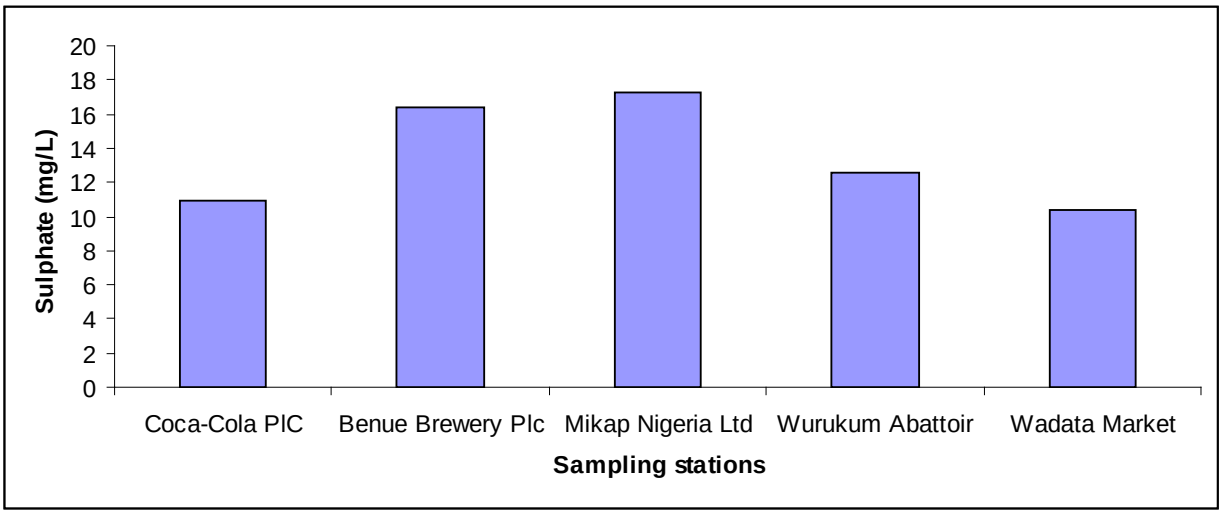


Fig 8: Mean Sulphate load at the sampling stations in River Benue at Makurdi

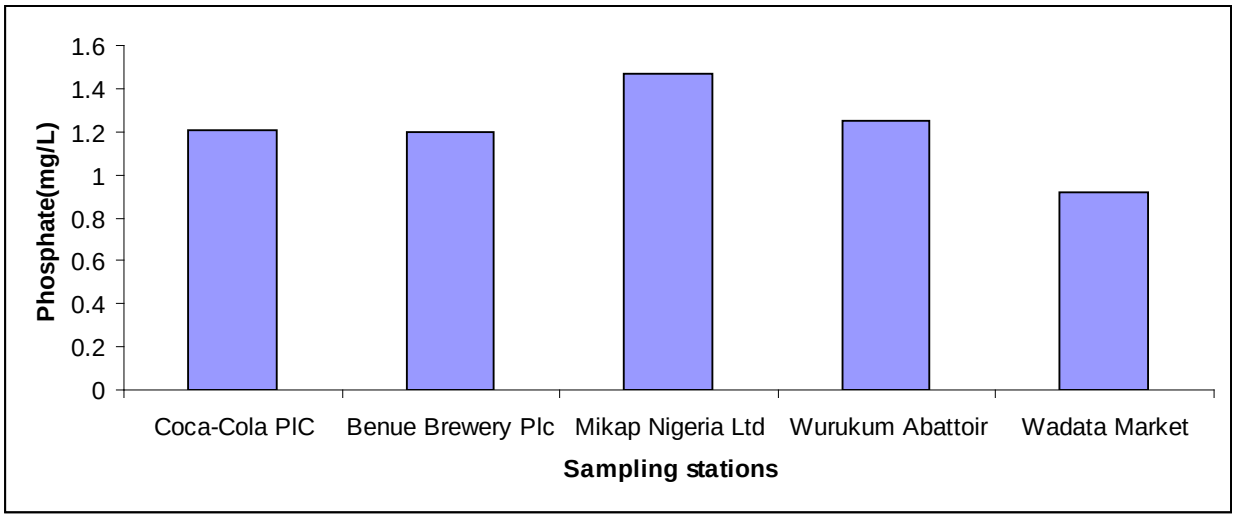


Fig 9: Mean Phosphate load at the sampling stations in River Benue at Makurdi

## 4. Conclusion

During the course this study the level load of the water samples in lower River Benue at Makurdi were observed to be within WHO acceptable guideline for drinking water quality (WHO 2004). In the surface water system, the nitrate load depends on the activities of nitrifying Bacteria in the water environment and the nature of the catchment area of the flowing water source which may be domestic, agricultural and industrial. In the present study the sample locations at brewery and Mikap Nigeria were of industrial activities while Coca cola and Wurukumm abattoir sampling locations were dominated with agricultural activities. However at the Wadata market sampling location the dominant activity was domestic. These sampling locations with their different anthropogenic activities on the catchment of the lower River Benue contribute to the varied nitrate load level in the River Benue. The mean concentration of nitrate at sampling locations in lower River Benue during the period of the study varied from 2.20±3.10 to 3.80±5.20 mg/L. The nitrate level was far below the WHO guideline value of 50mg/L recommended for drinking water (WHO2004). This result is similar to the findings of some earlier studies that reported low level load of nitrate in surface waters (Agbola and Denloye 2011, Ogidiaka *et al.*, 2012). Similarly the result of this study also conforms with the report of a study in Owabi reservoir feeder waters that reported very low nitrate level mean that ranged from 0.33-0.47±0.40mg/L( Badu *et al.*, 2013). Although there was a slight variation of nitrate load across the sampling stations during the study period, the ANOVA within and between the sampling locations was not significant ($P > 0.05$). The low level load of nitrate nutrient in lower River Benue may be attributed to less nitrate loading substances on the catchment of the River at the sampling stations. However the nitrate load of the present investigation differs

significantly from the result of an earlier study in the surface waters of Nwaja Creek, Port Harcourt Nigeria that reported higher mean values of nitrate load as compared to the present study ( Adesuyi *et al*., 2015).

The concentration of sulphate nutrient in surface water bodies like River Benue support the growth of planktons that forms the basis of primary productivity in the aquatic ecosystems. The plankton community also sustain the fish population and maintain the biodiversity in the aquatic environment. In the present study the mean load of sulpahate across the sampling sites ranged from 10.40±9.18 to 17.20±15.20mg/L. These results were below the 250mg/L guideline value of WHO for drinking water quality (WHO, 2004). Sulphate load in River Benue may be due to the agricultural activities observed on the shoreline of the River during the course of the study. This may also be linked to the surface runoff of sulphate containing compounds that were washed from non-point sources into the River. These observation are consistent with those of Shinde *et al* ., (2011). During the present study sampling station III the highest sulphate load while station V was the lowest. This may be attributed to agro allied waste discharged into the River at Station III as compared to the domestic wastes which are prevalent at station V. The findings of this study varied significantly from the report of an earlier study that reported lower values of sulphate in surface waters (Badu *et al*., 2013). All the same the result of this study disagree completely with the findings of a study that reported sulphate that ranged from 109.80-250.98mg/L in domestic springs in Kenya (Swarmy *et al*., 2013). The result of the sulphate load in river Benue also differs significantly from the sulphate concentration of some Rivers in Nigeria like: Otobi river, Imo river, Okpoka river, Onne river and Bonny river with mean sulphate concentration of 241.21, 212.21, 501.32, 385.00 and 625 .30mg/L respectively (Olode *et al.*, 2015). The concentration of sulphate in River Benue at the sampling sites indicates clearly that there are less sulphate loading substances in the River during the course of the study. There was a slight variation of sulphate load across the sampling stations and ANOVA across the sampling stations was not significant (P 0.05).

Phosphorus occurs as phosphate in the natural water system and it is usually in low concentrations. It is a fundamental nutrient required for algal growth and the bedrock of primary productivity in aquatic habitat for the sustaining the life of aquatic fauna. This assertion is similar with those of Shinde et al., (2011). During the course of this study the phosphate load in River Benue across sampling sites varied from 0.90±1.10 to 1.50±2.10mg/L. This low phosphate concentration is prevalent in the natural water system like River Benue at Makurdi. The findings of this study differs significantly with that of an earlier study that reported phosphate nutrient that ranged from 2.20-2.58mg/L with mean value 2.39±0.27mg/L in Owabi reservoir and its feeder waters( Badu *et al.*, 2013). Similarly Iyama *et al.*, (2014) reported lower values of phosphate concentration that varied from 0.03-0.19mg/ L with value of 0.09mg/L in Sombrero river Ahoada Rivers state, Nigeria. This report is consistent with the findings of the present investigation that reported low phosphate concentration

across sampling site in lower River Benue at Makurdi. Across other rivers in Nigeria low mean concentration of phosphate nutrient was obtained. The low mean phosphate level load were 0.271, 0.162, 0.288, 0.142 and 0.01172 mg/L in Otobi river Imo river, Okpoka river, Onne river and Bonny river respectively. These findings indicate clearly the low phosphate concentration is characteristics of most rivers as it is obtained in river Benue at Makurdi during the course of this study( Olode *et al*., 2015). There was slight variation in the phosphate load across the sampling stations and the result ANOVA was not significant ( P 0.05).

## 5. Conclusion

The level of nutrient load in River Benue were within the acceptable standard by WHO for drinking water quality. This indicate there was pollution of the nutrient in River and this was confirmed by the absence excessive growth of algal blooms that may result to eutrophication in the River during the course of the study.

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