ASSESSMENT OF SEASONAL VARIATION OF OXYGEN DEMANDS AS POLLUTION INDICATORS OF RIVER BENUE, NIGERIA

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ABSTRACT

The quality of a river dictates its application in the environment and also the health status. Water samples were collected monthly from five different locations of River Benue at Makurdi for a period of two years (July 2011-June 2013) and were examined for DO, BOD and COD using standard methods. The results of the pollution indicators of the water samples showed that across the stations: DO ranged from 3.09-4.47mg/L, BOD varied between 1.51 and 2.79mg/L and COD ranged from 2.89-4.80 mg/L. Similarly during the rainy season DO ranged from 3.99-5.76mg/L, BOD ranged from 1.51 to 2.79 mg/L and COD ranged from 3.51-6.21mg/L, while during the dry season DO ranged from 2.21-2.89 mg/L, BOD ranged from 0.95-1.34mg/L and COD ranged from 2.04 -2.89mg/L. The mean values of the pollution indicators during the rainy were high as compared to the dry season during the study period. The statistical analysis of result of shows that all the parameters were significant during the seasons and across the stations (P<0.05). It is recommended that the discharged of effluents and other waste into the River Benue should be controlled and enforced by the regulatory authority.

Keywords: Oxygen demands, Seasonal variation, Biochemical oxygen demand, Chemical oxygen demand.

INTRODUCTION

Oxygen demanding substances discharged into surface waters through human activities usually deplete the surface waters oxygen and creates anaerobic conditions (Narayanan, 2007).The dissolved oxygen (DO) and the biochemical oxygen demand (BOD) are two useful parameters in tracing pollution profile and natural purification of rivers (Garg, 2006). Dissolved oxygen is required for respiration by most aquatic animals. Apart from this, dissolved oxygen combined with other important elements such as carbon, sulphur, nitrogen, and phosphorous that could have been toxicants in the absence of oxygen in the water bodies to form carbonate, sulphate, nitrate and phosphate respectively that constitute the required compounds for aquatic organisms' survival (Araoye,2009). The determination of dissolved oxygen concentration relative to its saturation value and the rate of oxygen utilization measured as its BOD become a good measure for identifying the pollution status of a water body (Longe and Omole, 2008). Determination of the self-purification capacity of water bodies has been the subject of researchers by scientists around the world (Villeneuve *et al*., 1998; Rounds 2001, Radwan, *et al*; 2003; Agunwamba *et al;* 2006., Alam *et al.*, 2007). The biochemical oxygen demand (BOD) of a system is usually increased by the addition of both organic and inorganic substances to the environment (Ogunfowokan *et al.*, 2005). Chemical oxygen demand and BOD are two common measures of water quality that reflect the degree of organic matter pollution of a water body (UNEP, 2006). COD represents the total pollution load of the wastewater discharge (Ahmed *et al*., 2002. Latif *et al*.,2010). Decrease in dissolved oxygen is one the adverse effects of organic pollutants on a water body. The

dissolved oxygen is an essential factor for the survival of aquatic organisms (Narayanan, 2007). The primary cause of DO depletion is the presence of organic matter. Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) are quantitative measure for assessing the quality of a water body. This study aimed at determining the level of pollution indicators in river Benue at Makurdi and proffer solution in management of the aquatic ecosystem.

MATERIALS AND METHODS
Study Area

The River Benue with its source in the Cameroonian mountains flows westwards into Nigeria. It is the second largest river in Nigeria and measures approximately 310,000 Ha. It is about 1.488Km in length with alluvia fertile flood plains on either banks (Welcomme, 1986). The Benue River flows through Makurdi and confluence with River Niger at Lokoja the capital of Kogi state, Nigeria. Makurdi the capital city of Benue state is located on Latitude $7^0 41'$ N and Longitude 8^0 28' E. The size of the River Benue within Makurdi and major settlement runs through is approximately 671 meters (Udo, 1981). The rainfall seasons at 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 (Eneji *et al.,* 2012). High temperature values averaging 28-35^{0}C are recorded in Makurdi throughout the year, most notable from March to April. Harmantan winds are accompanied with cooling effects mostly during the nights of December and January (Eneji *et al.,* 2012). Five different stations were selected along the river course at Makurdi ,due the land based activities for this study as presented in Table 1.

Table 1: The study stations, their coordinates and Distance

| Station	Coordinates	Distances (m)	Human activities
Coca-cola	N07^0 43.663ꞌ E008^0 35.427ꞌ	1,500	Farming and fishing
Benue brewery	N07^0 43.615ꞌ E008^0 35.300ꞌ	5,000	Brewery effluents
Mikap Nigeria Ltd	N07^0 43.649ꞌ E008^0 35.302ꞌ	2,500	Rice milling effluents/industrial
Wurukum abattoir	N07^0 44.076ꞌ E008^0 32.840ꞌ	6,500	Abattoir effluent and sand dredging
Wadata market	N07^0 44.789ꞌ E008^0 30.624ꞌ	8.500	Domestic washing and refuse dump
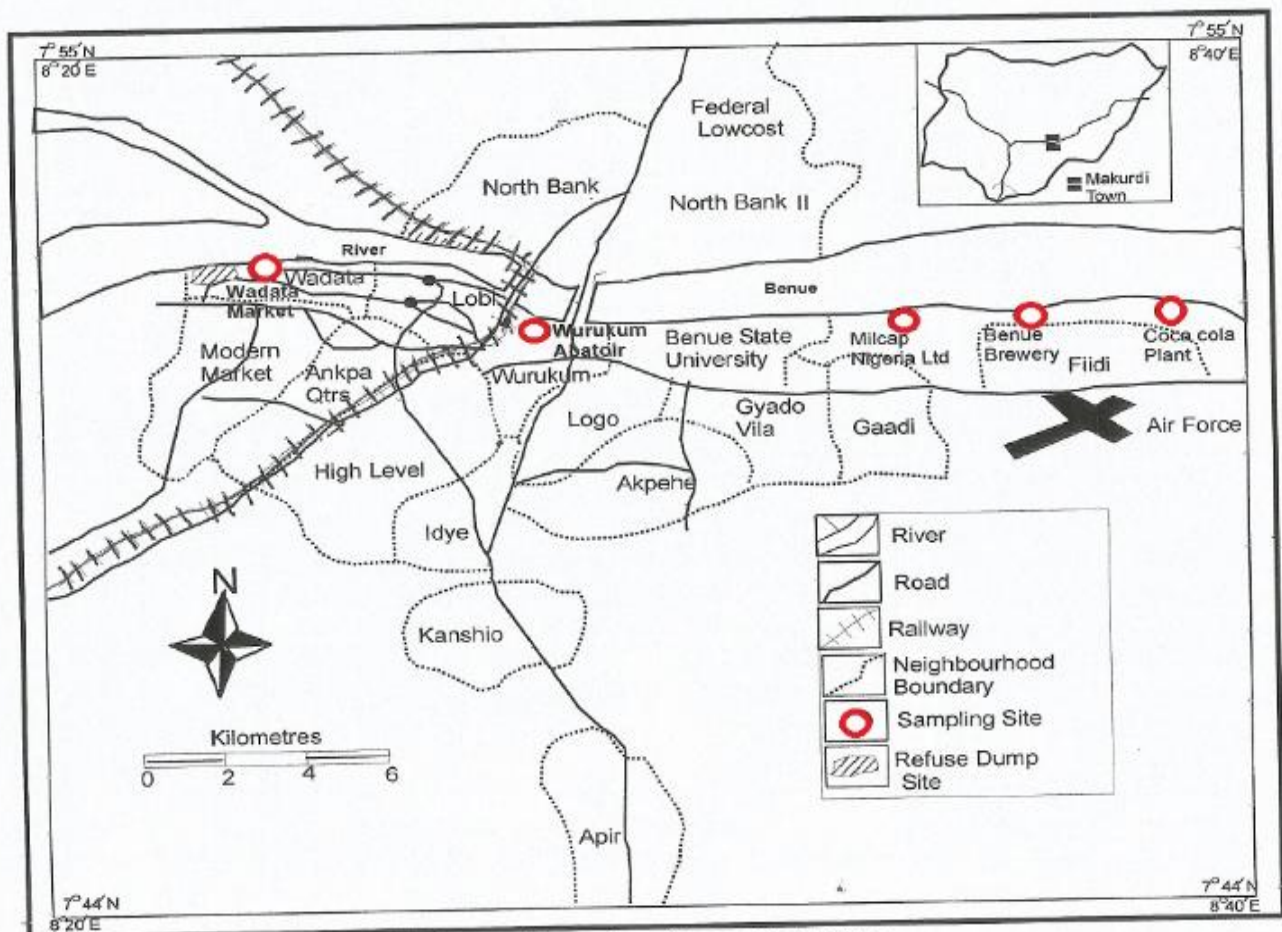
Figure 1: Map of Makurdi Town Showing Sampling Sites
Source: Ministry of Lands and Survey Makurdi

Water Sample Collection and Analysis

Water samples for physico-chemical 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. The water samples for BOD and COD analysis were collected in dark bottles of 1,500 mL capacity at the depth of 20cm. 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 DO was determined in situ on the field, while BOD and COD were examined in the laboratory using standard methods (APHA,1999).

Data Analysis

Microsoft excel 2007 was used for graphical illustrations. Means were determined using SPSS version 20.Statistical analysis was determined to test the significant difference among means of water quality parameters across stations and between seasons.

RESULTS AND DISCUSSION

The result presented in Table 2 is the pollution indicators in Rivers Benue at Makurdi. DO range from 3.09±1.71 to 4.47±2.18 mg/L, BOD ranged from 1.21±0.53 to 2.18±1.75 mg/L

and COD ranged from 2.89±2.27 to 4.80±4.21 mg/L. The data presented in Table 3 is the seasonal variation of pollution indicators in River Benue. During the wet season DO range from 3.71±1.81 to 5.76±2.42 mg/L, BOD ranged from 1.32±0.51 to 2.79±2.02 mg/L and COD range from 3.69±3.38 to 6.21±4.88 mg/L. Similarly during dry season DO range from 2.28±2.32 to 2.89±1.91 mg/L, BOD range from 0.95±0.77 to 1.34±0.75 mg/L and COD range from 2.04±1.54 to 2.89±2.02mg/L

Table 2 : Mean Values of Pollution indicators of River Benue at Makurdi at each Station

Parameter	Unit	Sample I	Station II	Codes III	IV	V
DO	mg/L	4.47±2.18	3.28±2.30	3.09±1.71	4.37±2.41	4.42±2.57
BOD	mg/L	1.95±1.35	1.28±0.92	1.21±0.53	1.74±1.38	2.18±1.75
COD	mg/L	4.43±2.91	2.89±2.27	3.16±2.74	4.15±3.23	4.80±4.21

Table 3: Seasonal Variation of pollution indicators in River Benue at Makurdi

Season	Station	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Wet	I	5.60±1.62	2.44±1.44	5.52±3.01
	II	3.99±2.09	1.51±0.97	3.51±2.54
	III	3.71±1.81	1.32±0.51	3.69±3.38
	IV	5.52±2.28	2.29±1.48	5.27±3.18
	V	5.76±2.42	2.79±2.02	6.21±4.88
Dry	I	2.89±1.91	1.27±0.89	2.89±2.02
	II	2.28±2.32	0.95±0.77	2.04±1.54
	III	2.21±1.12	1.07±0.57	2.41±1.24
	IV	2.77±1.55	0.98±0.76	2.59±2.72
	V	2.55±1.31	1.34±0.75	2.83±1.87

The data reported in Figure 2 is the average monthly variation of DO for a period of 24 months at five different locations in River Benue at Makurdi. The highest concentration of DO 10.6 mg/L was recorded at Station V in April 2013, while the lowest concentration of 0.50 mg/L was reported at Station I and II in February 2013 and May 2012 respectively. The result of statistical analysis of variance (ANOVA) between and within stations for the period of 24 months and within and across seasons was significant ($P < 0.05$). However the multivariate analysis (MANOVA) between stations and seasons was not significant ($P > 0.05$). This may be that the stations and seasons are not impacting on each others.
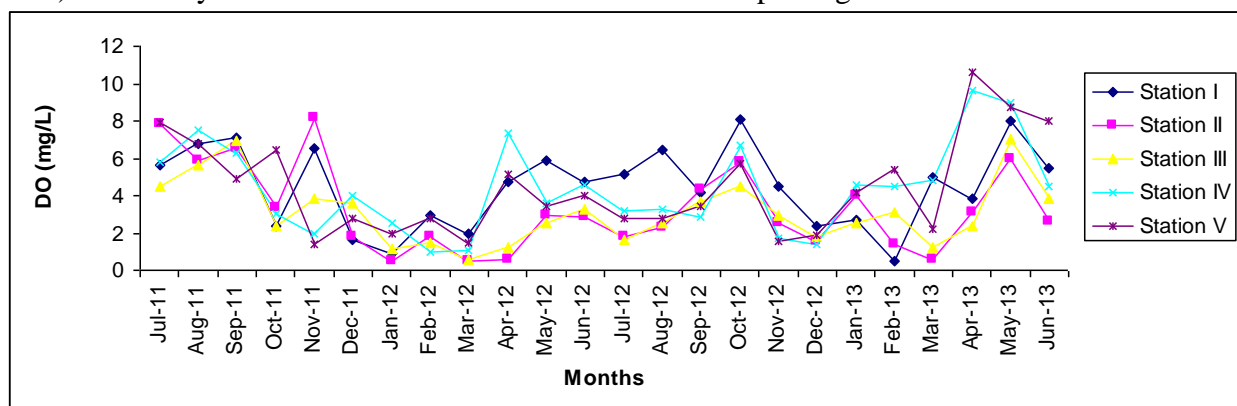

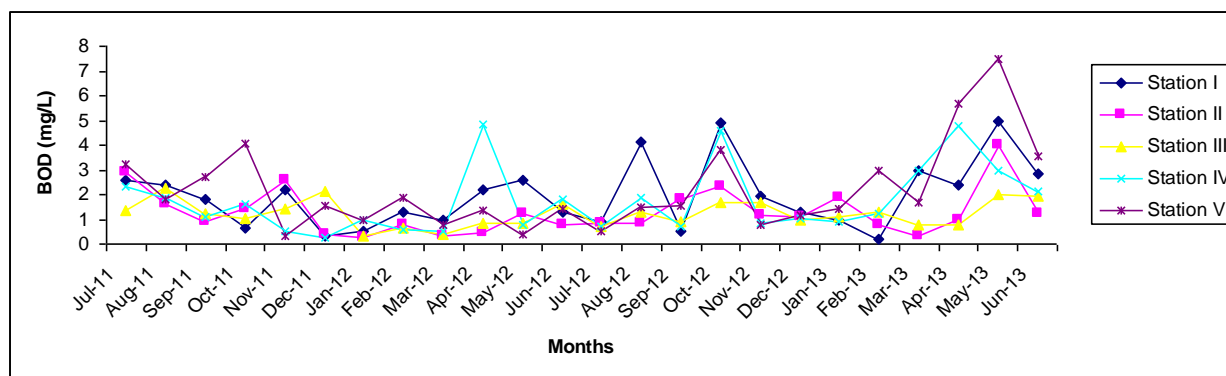Fig2: Average monthly values of DO in River Benue at Makurdi

Fig3: Average monthly values of BOD in River Benue at Makurdi

The highest concentration of 17.20 mg/L was reported at Station V in May 2013 and the lowest concentration of 0.49 mg/L at Station II in January 2012 (Figure4). The result showed a general increase in COD in all the locations in the month of May 2013. The COD was increasing during the rainy seasons and decreasing during the dry seasons. The statistical analysis of variance (ANOVA) result indicates that there was significant difference in mean COD concentration between and within stations during the study period ($P < 0.05$). Similarly ANOVA between and across the seasons was also significant ($P < 0.05$). The multivariate analysis of variance (MANOVA) between stations and seasons was significant ($P < 0.05$).
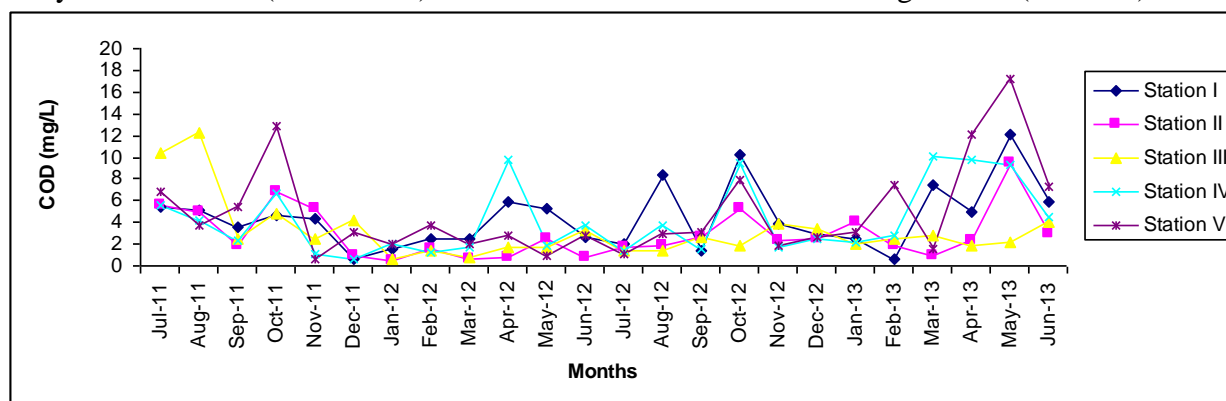

Fig4: Average monthly values of COD in River Benue at Makurdi

The result of this study is similar to one of an earlier study in River Benue that reported much lower mean value of DO (1.80 ± 0.06 mg/L) during the course of the study (Eneji *et al*., 2012). Maitera *et al*.(2010) reported higher values of DO in the range of 5.27 ± 0.24 to 6.41 ± 0.21 in River Benue at Adamawa State, Nigeria. Wazir and Ogugbuaja (2010) reported DO that varied from 5.87 ± 0.43 to 7.38 ± 0.43 in River Yobe, Nigeria. These findings are in disagreement with the result of this study. The low DO obtained in this study may be due to presence of oxygen consuming waste disposed in the river through the land based activities of man as was observed during the course of the research. Similarly, Agboola and Denloye (2011) reported DO in the range of 2.03 - 2.44 mg/L in Abesan River in Lagos, Nigeria. Okayi *et al.* (2011) reported DO in River Benue in the range of 3.6 - 4.9mg/L. Indabawa (2010) reported a mean DO value of 15.44 mg/L in the Challawa River in Kano. Abowei (2010) reported DO in the range of 3.2 ± 0.1 to 7.3 ± 0.16 mg/L in Nkoro, River Niger Delta Nigeria. These results disagree with the result of the current study. Biochemical oxygen demand is the rate at which oxygen is used up in aquatic systems. Perhaps it is even more important than the determination of DO. A very low rate of use would indicate either clean water or those available microorganisms are uninterested in consuming the available organic

compounds or that the microorganisms are dead or dying (Narayanan, 2007). The spatial variation of DO in River Benue during the present study was lowest at Station III throughout the study period .The lowest value of DO obtained at location III may be due to the impact of waste that is discharge into the River. This waste may depreciate the dissolved oxygen from the activities of micro organisms on the brake down of the wastes. The DO was increasing during the rainy season and could be ascribed to the fact that the impact of the waste discharged into the River is more pronounced during the dry season as compared to the rainy season due to the surface runoff. This result agrees with the findings of a study that reported higher values of DO during the rainy season as compared to the dry season (Jaji *et al.,* 2007). However, the result of this study disagrees with the finding of other studies that reported higher values of DO during the dry months as compared to the wet months (Adefemi *et al* ., 2007 Eneji *et al* ., 2012). Comparison of variation in DO depicted that the changes during the seasons and across the stations were significant (ANOVA- P<0.05). This may be that the seasons and the stations were impacting on the dissolved oxygen level of the River Benue during this study period.

BOD is not a specific pollutant but rather a measure of the amount of oxygen required by bacteria and other microorganisms engaged in stabilizing decomposable organic matter. BOD increases as the bio - degradable organic content increases in the water. Usually BOD increases where there is a decrease in the DO (Narayanan, 2007). The European Environment Agency (1994) compiled monitoring results from European rivers and found average BOD levels for near pristine rivers of about 1.6 mg/L. The agency concluded that river reaches slightly affected by human activities generally have a BOD value below 2.00 mg/L whereas a BOD exceeding 5.00mg/L generally indicates pollution. Degradation of organic matter by heterophic bacteria is one of the major processes controlling the oxygen level of aquatic ecosystems and thus their quality.

In this study a mean BOD value of 1.68 ± 0.12 mg/L was obtained. Based on the European Environmental Agency classification of rivers with BOD level, River Benue at Makurdi is a pristine aquatic system. This result disagrees with the result of an earlier study in River Benue at Makurdi that reported a mean BOD value of 8.23 ± 0.40 mg/L (Eneji *et al*., 2012). Nevertheless, the result of this study conforms to that of Maitera *et al*. (2010) who reported BOD in the range of $0.88 \pm 3.72 \pm 0.51$ mg/L in River Benue at Adamawa State. Similarly, Indabawa (2010) reported mean BOD value of 12.47 mg/L in River Challawa in Kano State. This result disagrees with the result of this present investigation. The low mean value of BOD obtained in this study may be attributed to the level of DO and may be as a result of oxygen consuming organic waste in the River Benue at Makurdi generally. BOD is a measure of oxygen use or oxygen potential use. High BOD values may be harmful to the biological community in the aquatic system if the oxygen consumption is great enough to cause anaerobic conditions. During this present investigation the highest value of BOD was obtained at Station V and the lowest was at Station III throughout the study period. This lowest value of BOD may be due to the impact of low DO concentration. This result is often reflected in the disruption of ecological process (Longe and Omole, 2008). Such distortion can be shown by development of septic or anaerobic conditions as observed in this study. The seasonal variation result of BOD in the present study showed that BOD like DO was increasing during the rainy season as compared to the dry season. This result agrees with the findings of other studies (Eneji *et al.,* 2012, Ishaq and Khan, 2013). Comparison of variation in BOD depicted that the changes during the seasons and across the different stations were significant (ANOVA- P<0.05). This may be that seasons and stations are impacting on the BOD concentration in River Benue during the study period.

COD is the measure of oxygen consumed during the oxidation of oxidizable organic matter by a strong oxidizing agent. High COD indicates presence of all forms of organic matter, biodegradable and non - biodegradable and hence the degrees pollution in waters. COD values are usually higher than BOD values. During this present investigation, a mean COD value of 3.89 ± 0.29 mg/L was recorded. This result disagrees with the result of an earlier study in River Benue at Makurdi that reported a mean COD value of 1.78 ± 2.85 mg/L. (Eneji *et al*., 2012). All the same, Maitera *et al.* (2010) reported COD in the range of 2.49 ± 1.47 to 3.72 ± 0.97 mg/L in River Benue at Adamawa state, which conforms to this study. The COD result of this present investigation may be due to the level of oxidisable organic waste in the River Benue at Makurdi. However, Longe and Omole (2008) reported higher COD mean value of 782.86 ± 166.54 mg/L in River Illo, Ota Nigeria. Similarly, EdoKpayi *et al.* (2010) also reported higher mean value of COD of 340.50 ± 54.6 mg/L in a coastal ecosystem impacted by land based activities. All the same COD range of 26.50 - 31.90 mg/L was reported in Betwa River India (Vishwakarma, 2013). The spatial variation of COD indicates the highest value of COD was obtained at Station V and lowest at Station II during the study period. Similarly the seasonal variation of COD during the study was observed to be increasing during the rainy season and decreasing during the dry seasons. This may be that during the dry season, the reduced water quantity result to decreased COD value. This result agrees with the findings of earlier study in River Benue (Eneji, *et al*., 2012).The result of comparison of variation in COD showed that the changes during the season and across the seasons were all significant (ANOVA- $P<0.05$). This may be that both season and stations are impacting on the COD during the study. The result of the seasonal variation of this study disagrees with the finding of earlier study in River Benue at Adamawa that reported higher values of COD during the dry season as compared to the wet season (Maitera *et al*.,2010). The low DO during the dry season may not be due to high temperature during this season.

CONCLUSION

Low DO and high BOD and COD values were determined at Station II and III which are an indication of organic pollution. Generally river Benue at was determined with poor values of pollution indicators as a sign that the river is polluted with organic waste. The effects of organic pollution in River Benue result in the decreased aquatic biodiversity and a compromised ecology.

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