

SEASONAL DISPARITY IN BIOTIC INDICES OF AQUATIC INVERTEBRATE'S POPULATION OF RIVER BENUE AT MAKURDI AS A MEASURE OF ECOLOGICAL INTEGRITY

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ABSTRACT

The dumping of wastes into rivers without recourse to the damage of the waste on the biodiversity is very common in the developing nations of the World as it is noticed in River Benue at Makurdi. To evaluate the ecological integrity of River Benue at Makurdi, sediments samples collected for two years (from July 2011-June 2013) monthly from five different stations on the shoreline of River Benue at Makurdi. A perusal at result of the biodiversity of benthic fauna in River Benue indicate that a total of 4,451 macro benthic fauna individuals comprising of 4 phyla and 21 taxa were obtained. More individuals were recorded during the dry seasons as compared to the rainy seasons. Benue brewery (570 individuals/m²) and Mikap Nigeria Ltd (649 individuals/m²) recorded low population as compared to the other locations: Coca cola (1,177), Wadata market (1,043 individuals/m²) and Wurukum abattoir (1,012 individuals/m²). Athropoda had the highest population of individuals as compared to the other phyla. The population of the benthic fauna were subject to six biotic indices to ascertain the ecological status of River Benue at Makurdi. Across the seasons the result of the ecological model showed that Shannon diversity varied from 2.06-3.25, Margelef diversity 2.98-4.36, Simpson diversity varied from 0.87-0.96 and Menhinick diversity ranged from 0.95-2.80. Similarly there mean values were 2.65, 3.61, 0.92 and 1.68 respectively during the 24 months across the seasons. All the same the Pielou evenness index varied from 0.81-1.00 and the Simpson dominance varied from 0.00-0.31 with the mean values of 0.91 and 0.41 respectively. At the studied location Shannon diversity varied from 1.81-3.00, Margelef diversity 2.10-4.44, Simpson diversity varied from 0.80-0.95 and Menhinick diversity ranged from 2.20-2.61. Similarly there mean values were 2.45, 3.44, 0.89 and 2.47 respectively during the 24 months across the seasons. The Pielou evenness and Simpson dominance ranged from 0.62-0.94 and Simpson dominance ranged from 0.28-0.47 in the course of the study. The biotic indices of river Benue at Benue brewery and Mikap Nigeria ltd showed clearly that theses location were impact by the anthropogenic activities and compromised the ecological integrity which indicate the perturbed nature of the study area. It is recommended that indiscriminate dumping of effluents and waste in the river should be discouraged.

Keywords: Biotic indices, River Benue, Aquatic Invertebrates.

INTRODUCTION

Biotic index is a scale for showing the quality of environment by indicating the type of organisms present in it. It is often used to assess the quality of water in rivers (Barbour *et al.*, 1999) They are applied to assess biological properties of mainly running waters, in most cases they are based on macro invertebrate communities (Dziock, *et al.*; 2006). Biotic indices have been used to measure various types of environmental stress, organic pollution, acid water, habitat degradation and the level of pollution load (Knobe *et al.*, 1995). Similarly biotic index account for the sensitivity or tolerance of the individual species or groups to pollution and assigned a value to them (Quareshi and Gargi, 2013). The sum of the value

gives an index of pollution for a site. This data may be quantitative (presence-absence) or qualitative (relative abundance and density). All the same the indices have been designed mainly to assess organic pollution (Quareshi and Gargi, 2013). Biotic metrics are very important in analysis biological data because they allow the Investigator to use meaningful attributes in assessing the status of assemblages and communities in response to environmental perturbation. The definition of a metric is characteristics of biota that changes in some predictable way with increased human impact (Barbour *et al.*, 1999). For most of the studies involving biological assessment, raw data are the list of taxa found at a sampling site (in a sample) and the number of individuals recorded for each taxon. Preparing those data for analysis involves converting them into metrics or other terms. Metrics calculation is a form of data reduction (Barbour *et al.*, 1995). Metrics used in indexes evaluate aspects of both element and process within a macro invertebrate assemblage. Although, these indices have been regionally developed, they are typically appropriate over wide geographic areas with minor modifications (Barbour *et al.*, 1995). The biotic index provides a simple means for communicating complex information to ecological risk managers and for correlating benthic responses with stressor data (Bilkovic *et al.*, 2006).

Macro invertebrates are the most commonly used element for biological classification of rivers in Europe (European Commission, 2006). In Nigeria, such classification is still scarce and there is need for the rivers to be classified. In the same vain macro invertebrate organisms form an integral part of aquatic environment. They maintain various levels of interactions between the community and the environment (Basu *et al.*, 2013). Studies have shown that they also contribute immensely to the functioning of the ecosystem in the breaking particular organic material (Vyas and Bhawsar, 2013). This study therefore is imperative and indispensable as it measures the ecological integrity of river Benue at Makurdi with respect to the biotic index of the macro benthic fauna.

MATERIALS AND METHODS

Study Area

The River Benue with its source from the Cameroon 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^o41' N and Longitude 8^o 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. High temperature values averaging 28-33^oC 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 (Nyagba, 1995). All the same the periodic dust plumes associated with this time of the year may encourage surface water pollution (Nyagba, 1995). Five stations were selected along the river course at Makurdi , Benue state for this study shown in Fig 1 as follows:

Station I(N07^o 43.663' E008^o 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 (N07⁰ 43.615' E008⁰ 35.300'): it is located directly behind Benue Brewery Plc along at Kilometer 5 along Gboko road. This site is impacted by the brewery effluents generated from the factory into the river.

Station III (N07⁰ 43.649' E008⁰ 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 (N07⁰ 44.076' E008⁰ 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 (N07⁰ 44.789' E008⁰ 30.624'): This site is located behind Wadata market along the river water course at Makirdi. Wastes from the heap refuse dumpsite behind the market are leached directly into the river.

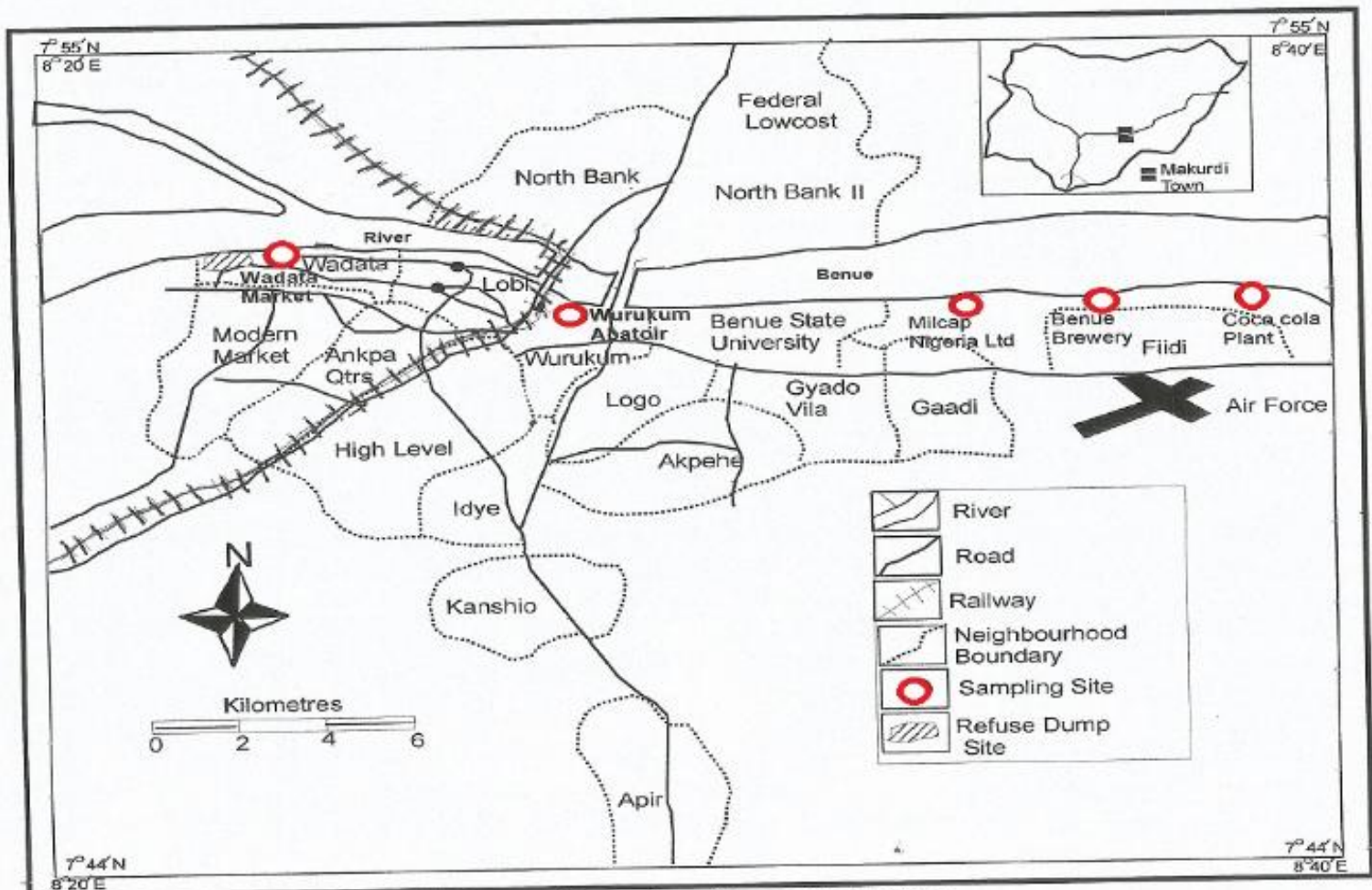


Figure 1: Map of Makurdi Town Showing Sampling Sites

Source: Ministry of Lands and Survey Makurdi

Sample collection and Analysis

Benthic sediment samples were collected between 8:00am and 12:00noon by means of a boat cruises in sampling stations along River Benue bank. The Van Veen grab of 0.1m² was used

for the collection of sediments and benthos at the bottom of designed sampling sites at the River Benue shoreline within Makurdi metropolis throughout the study period. The two shovels of the grab were held open by a small bar. The grab was then lowered into the river bed at the sampling sites. When the grab reaches the bottom of the river, the bar was automatically released. The graduated rope attached to the grab was then pulled from above. The two shovels of the grab sampler were closed tightly with sand and mud captured in it. The content of the grab were emptied into a polythene bags, labeled properly and taken to the laboratory for sorting and analysis. Three successful hauls of benthic samples were taken from each station using a van Veen grab (0.1m²) from an anchored boat with an out-board engine of 25 HP. The samples were then, taken to the laboratory for analysis. In the laboratory the samples were sieved in order to remove fine sediments and any other extraneous material. This process of sieving is very delicate and care was taken to avoid any damage to the fragile organisms and to secure all animals present in the samples collected. Each of the sediment sample collected was washed three times in the Laboratory through three sets of sieves, 1st 2mm, then 1mm and finally 0.5mm mesh size sieves to collect the macro benthos in them (Esenowo and Ugwumba, 2010). The retained macro benthos were poured into bottles and labeled properly. Prior to fixation, the retained benthos from the sieve were placed in 15% ethanol to relax the organisms and avoid unnecessary suffering. The benthic fauna samples were then fixed with 4% formaldehyde. The washed and preserved sediments with benthic invertebrates were poured into a white enamel tray and sorted out. The sorting was made effective by adding moderate volume of water into container to improve visibility (George *et al.*, 2009). Large benthic fauna were picked out using forceps while the smaller ones were pipette out. The preserved animals were identified under light and stereo dissecting microscope and counted. The identification was carried out using keys by Day (1967), Pennak (1978), Water and Rivers Commission, (2001) and Merit and Cummins (1996). The study lasted for 24 months and was moving from one season to another as presented below:

Season 1 (July 2011-October 2011) – Rainy Season 2 (November.2011-March2012)-Dry
Season 3(April 2012- October 2012)- Rainy Season 4(November 2012- March 2013)-Dry
Season 5(April 2013- June 2013) - Rainy.

Data Analysis

Biological indices such as Shannon and Weiner index (H^1); Margalef's index (d); Simpson diversity index ($1-\Delta$); Menhinicks diversity index (D); Pielou Evenness (J') and Simpson dominance index (C) were used in analysis the data. Relative abundance of the benthic fauna was determined at each site.

Shannon- Weiner diversity index (H^1)= $-\sum[(ni/N)\times\ln(ni/N)]$ (Shannon-Weiner, 1963).
Where:

H^1 = Diversity index , ni = total number of individuals belonging to i th species

N = total number of individuals for the site,

\ln = the natural log of the number

Margalef-value is the measure of specie richness. It is expressed as $d= S-1/\ln N$ (Margalef, 1967) Where: d = Margalef value, S = number species collected in a sample, N = total number of individuals in the sample

Simpson's diversity $(1-\Delta) = 1 - \sum n(n-1)/N(N-1)$ where: N = the total number of organisms of all species, n = the total number of organisms of a particular species

Menhinick's Index $(D) = S/\sqrt{N}$ Where:

S = Number of species in a population N = Total number of individuals in S species

Pielou's index measures how evenly the species are distributed in a sample community. It is expressed as: $J = H^1 / H_{max}$ (Pielou, 1969). Where: J = diversity evenness or Equitability index, H^1 = calculated Shannon –Weiner diversity index (Shannon- Weiner) $H_{max} = \ln S$
 S = total number of species in a population \ln = natural log of number

Simpson dominance index $(C) = \sum (n/N)^2$ (Ogbeibu, 2005). Where: n = the number of species in the i^{th} species N = Total number of individuals

RESULTS

The data presented in fig 2 is the variation of benthic fauna population at the studied locations across the seasons during the 24 months period of the study. The result showed that season 4 was recorded the highest population of benthic fauna at coca cola while lowest was during season 5 at Benue Brewery. Fig 3 is the seasonal variation of the Shannon diversity index across studies seasons was lowest at Benue brewery and highest at Coca cola. At the station Shannon diversity index increased from station I-V during the period of the study period (Fig4). During the course of this study Margelef diversity was lowest at Benue brewery in season 3 (Fig 5). Similarly at the stations, Margelef diversity index decreased from station I-V Fig 6). The Simpson diversity index was highest during season 3 at Mikap Nigeria Ltd location and lowest at Wurukum abattoir at the same season 3 (Fig 7). The result presented in Fig 8 showed that the lowest value of Simpson diversity index was obtained at station III and the highest at Station V. Menhick's diversity index was highest at Benue brewery during season 5 and lowest at Wadata market during season 4 in the course of the study (Fig 9). Across the studied stations the Menhinick's index increased from stations: I-V (Fig 10). Figure 11 depicts the variation of Pielou evenness during the 24 months study period in River Benue at Makurdi. Pielou evenness was lowest at Wadata market during season 3 and highest at Coca cola during season 1. During the study period the highest value of Pielou evenness was at station I and lowest at station II (Fig 12). The highest value of Simpson dominance was obtained at Benue brewery during season 5 (Fig 13). Similarly across the stations the lowest value of Simpson dominance was at station IV (Fig 14).

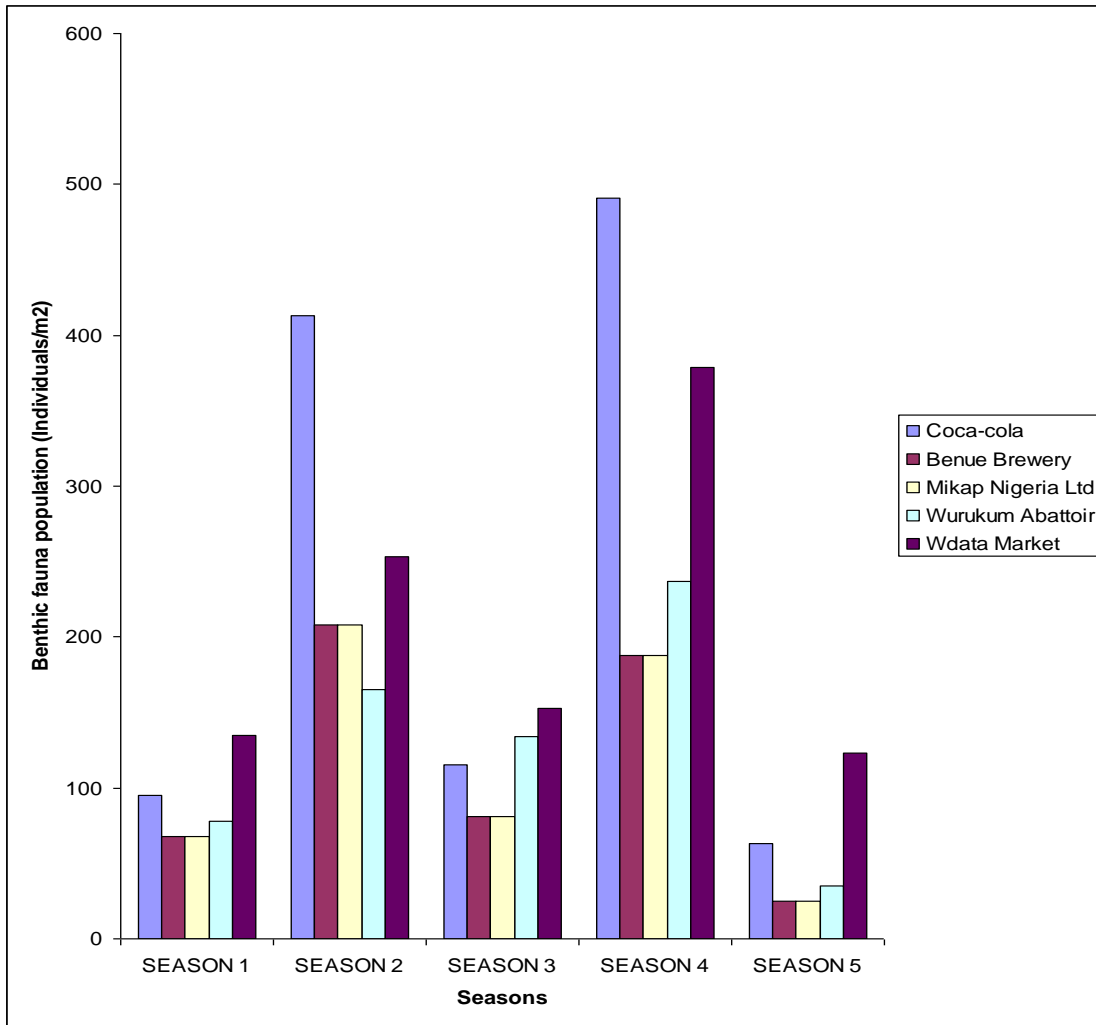


Fig2: Seasonal variation of Benthic fauna population along River Benue course at Makurdi

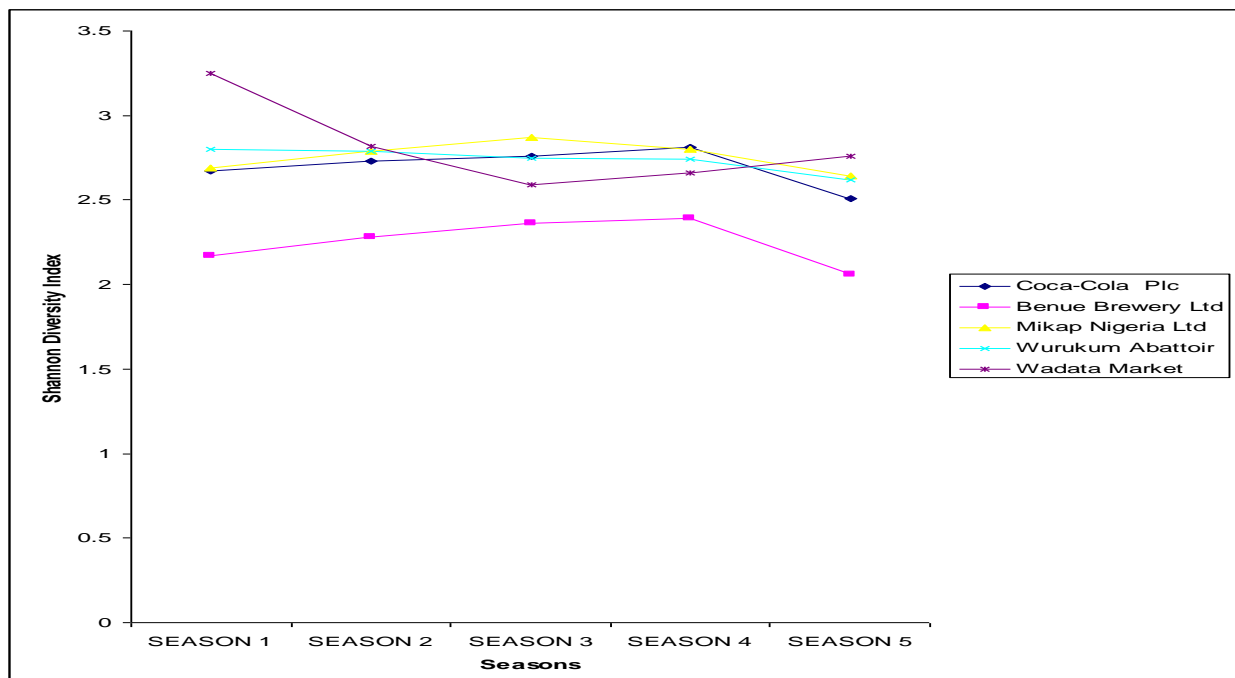


Fig3: Seasonal variation of Shannon Diversity Index along River Benue course at Makurdi

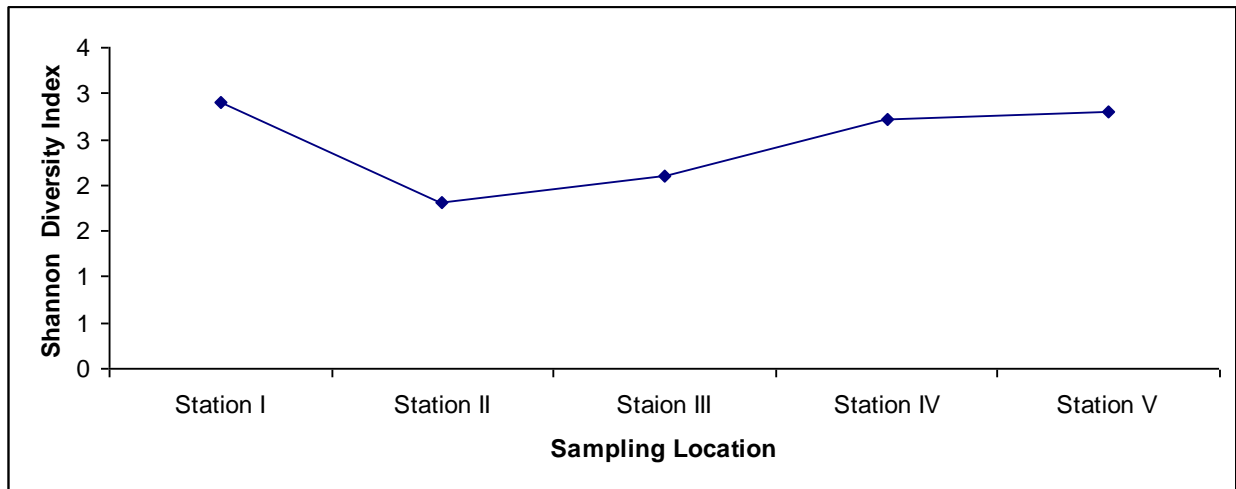


Fig 4: Spatial variation Shannon Diversity Index along River Benue course at Makurdi

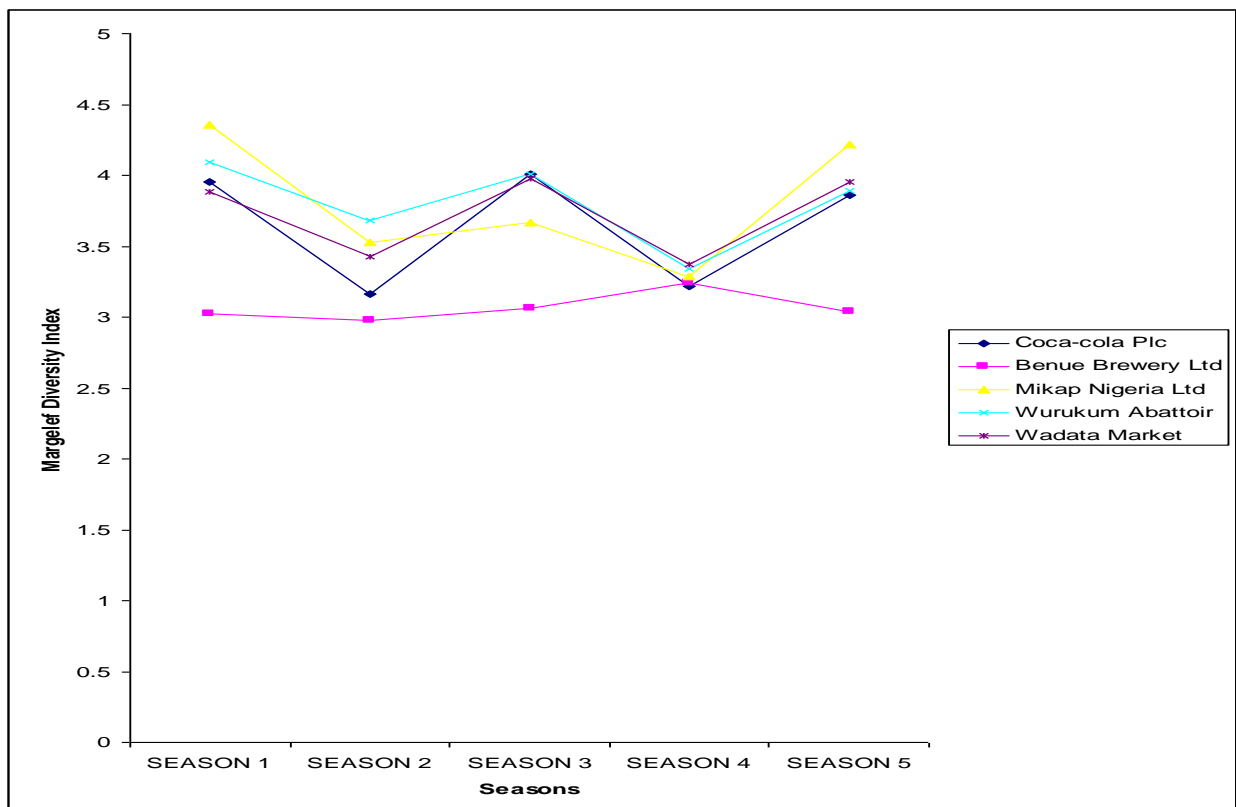


Fig5: Seasonal variation of Margelef Diversity Index along River Benue course at Makurdi

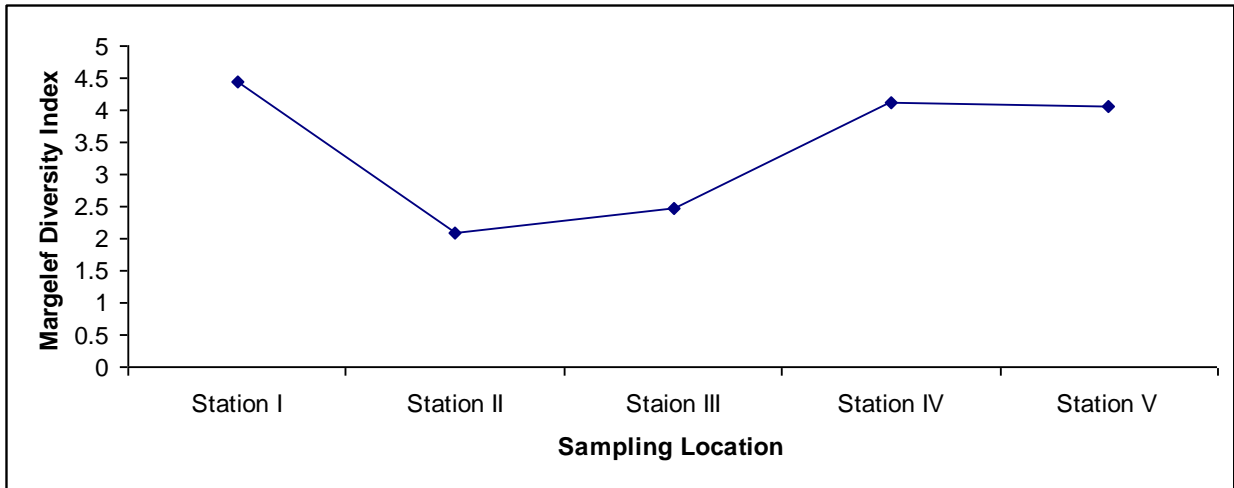


Fig 6: Spatial variation of Margalef Diversity Index along River Benue course at Makurdi

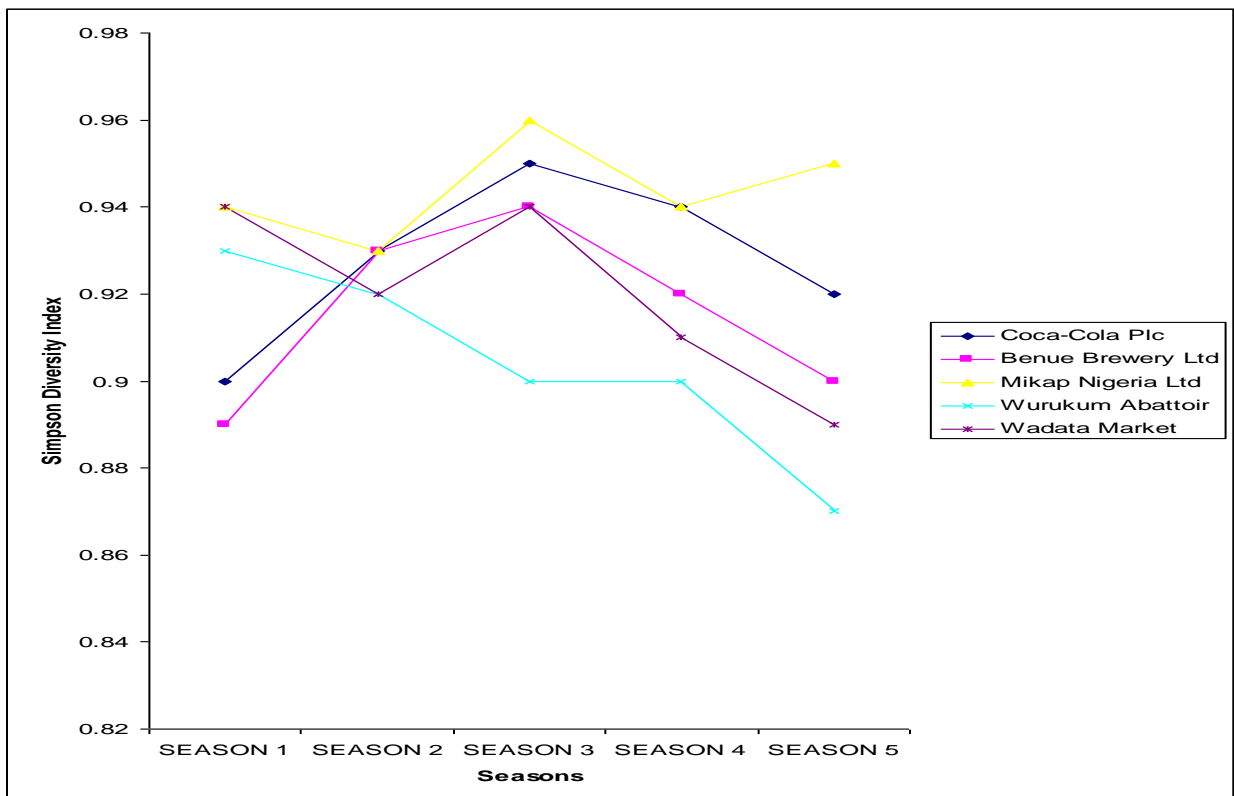


Fig7: Seasonal variation of Simpson Diversity Index along River Benue course at Makurdi

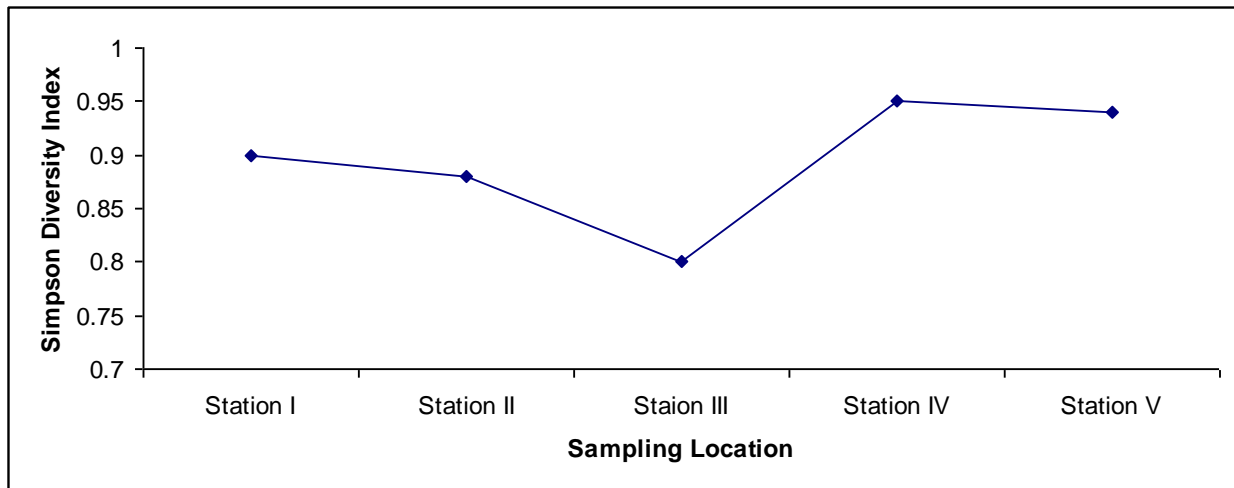


Fig8: Spatial variation of Simpson Diversity Index along River Benue course at Makurdi

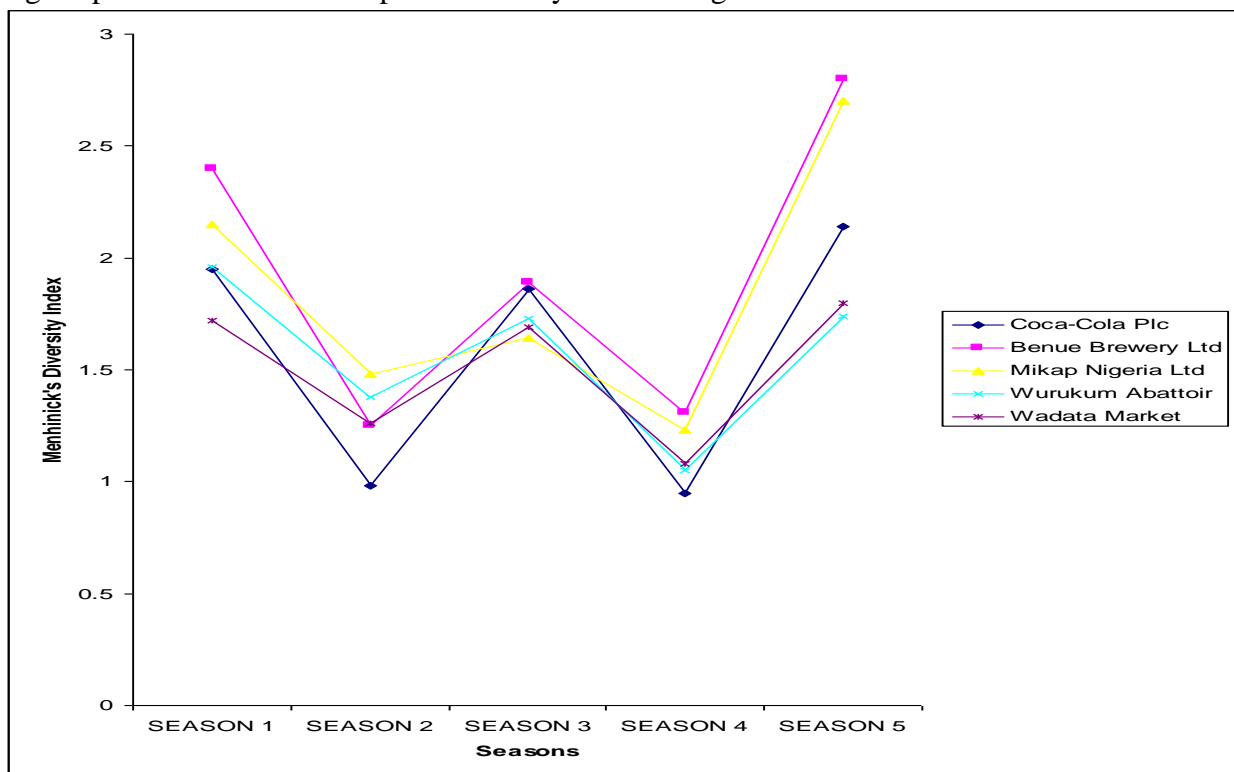


Fig9: Seasonal variation of Menhinick's Diversity Index along River Benue course at Makurdi

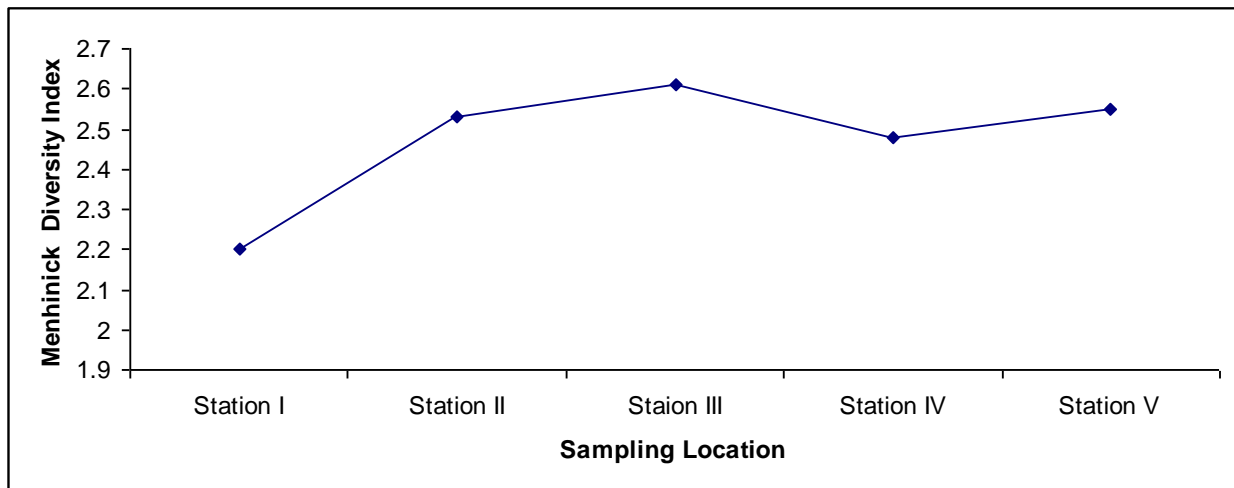


Fig10: Spatial variation of Menhinick's Diversity Index along River Benue course at Makurdi

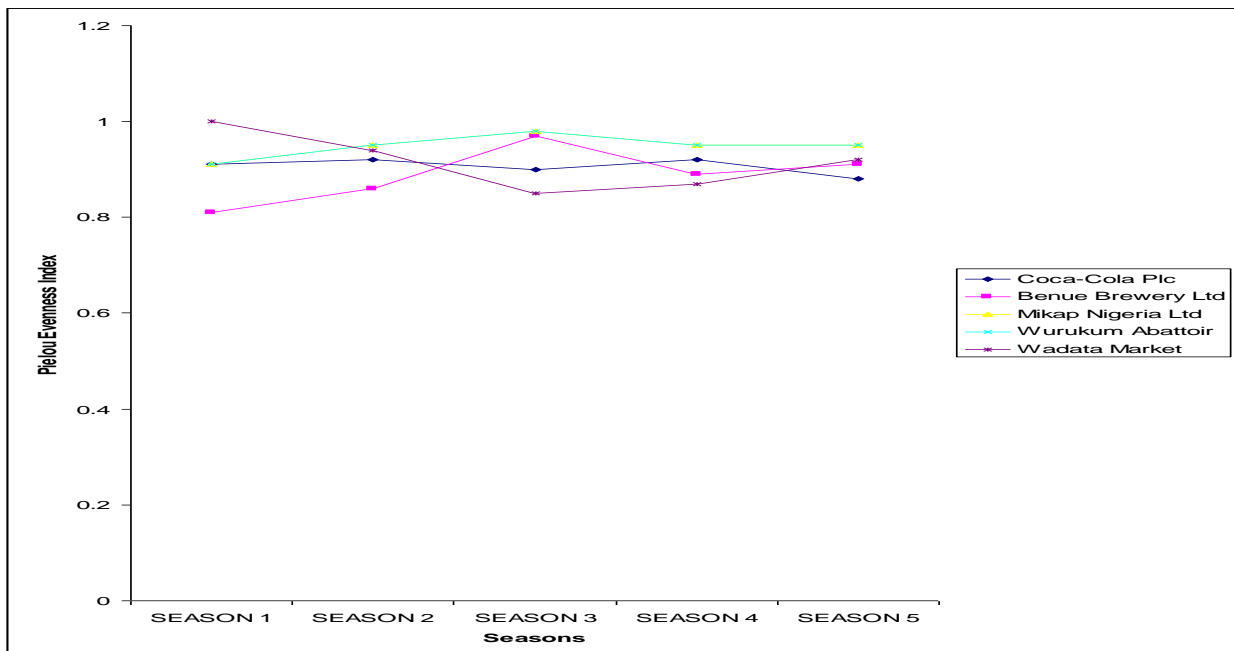


Fig11: Seasonal variation of Pielou Evenness Index along River Benue course at Makurdi

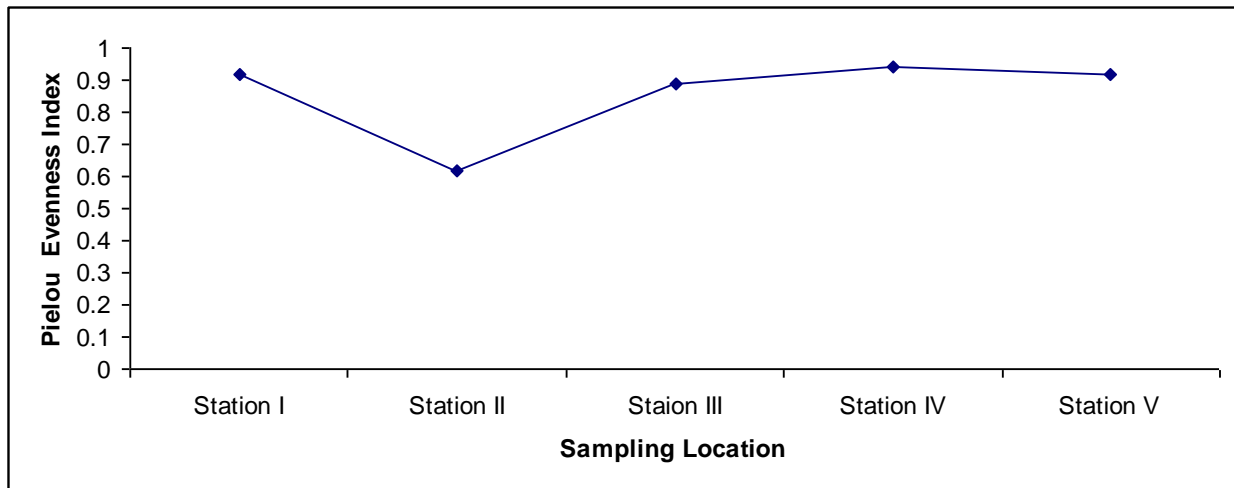


Fig12: Spatial variation of Pielou Evenness Index along River Benue course at Makurdi

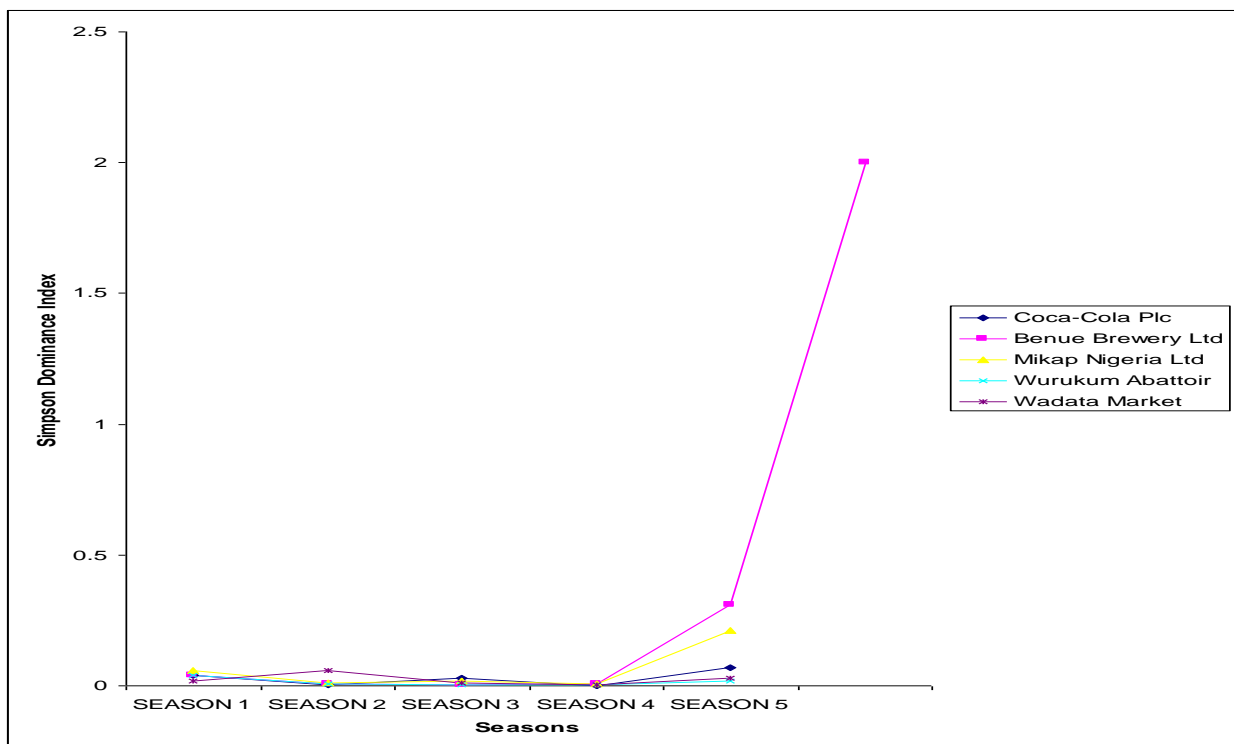


Fig13: Seasonal variation of Simpson Dominance Index along River Benue course at Makurdi

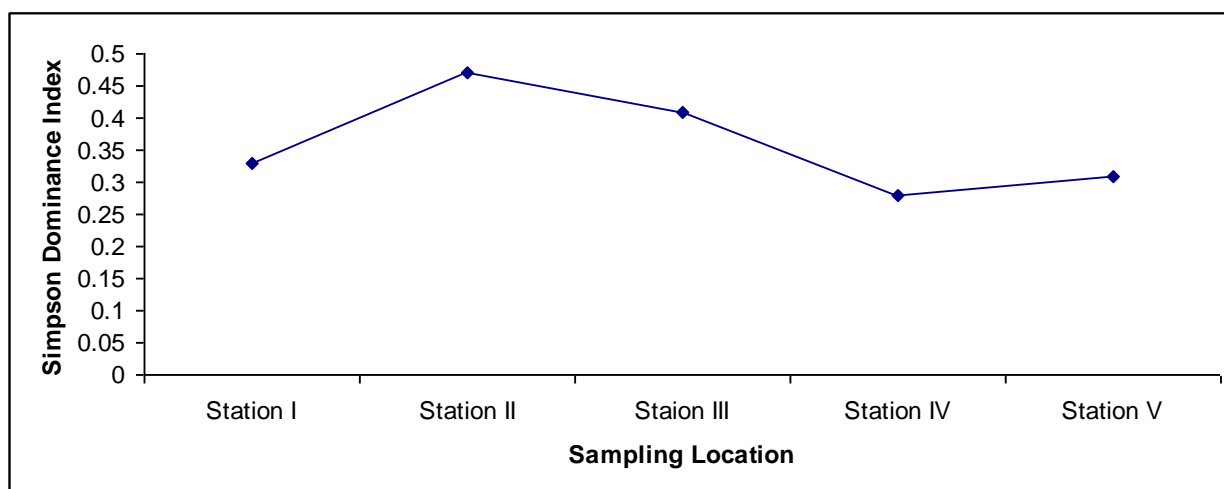


Fig14: Spatial variation of Simpson Dominance Index along River Benue course at Makurdi

DISCUSSION

The spatial variation of Shannon diversity index at five locations during the study period in River Benue at Makurdi varied from 1.81 - 2.91. The lowest value of 1.81 was obtained at Benue brewery Plc and the highest value of 2.91 was at Coca-Cola plc. Similarly the seasonal variation of the Shannon diversity ranged from 2.06-3.25. The highest value of 3.25 was determined at Wadata market during rainy season, while at Benue brewery location the lowest value was obtained. The result of the seasonal variation of Shannon diversity index during this study disagrees with the report of an earlier study that reported Shannon diversity that varied from 0.0 -1.60 during the dry season as compared to the wet season 0.0 – 1.41 (Nkwoji *et al.*, 2010). The spatial variation of Shannon diversity index of this study disagrees with the result of spatial variation of Shannon diversity of earlier studies (Esenowo and Ugwumba, 2010 Edokpayi *et al.*, 2010; Nkwoji *et al.*, 2010; , Aggrey-Fynn *et al.*, 2011 Andem *et al.*, 2012; Chowdhary and Sharma .,2013, Nkwoji and Edokpayi 2013, Teferi *et al.*, 2013). The overall Shannon diversity index of benthic community in River Benue at Makurdi during the study period is the product of all spatial and temporal changes affecting the benthic fauna community structure (Edokpayi *et al.*, 2010). The very low Shannon diversity index at Benue brewery is an indication of environmental perturbation at this location during the study period.

The spatial and temporal variation of Margalef diversity index varied from 2.10 – 4.44. The lowest value was obtained at Benue brewery while the highest was at Coca-cola. This variation is based basically on the number of species obtained at these locations during the study period. Lower species obtained at the Benue brewery may be as a result of the stressed environment in this area due to anthropogenic activities impact. This result also agrees with the findings of other studies that report lower values of Margalef diversity index at different locations (Edokpayi *et al.*, 2010; Sharma and Chowdhary, 2011 Chowdhary and Sharma 2013). However the result of this study disagree with the finding of studies that reported Margalef's index that varied from 0.79-2.57 in a Lagos Lagoon for two years and another that varied from 2.87-3.89 in a stream in southern Nigeria respectively (Nkwoji and Edokpayi 2013, Oribhabor and Enang 2013).

The Simpson's diversity index values obtained across the locations ranged from 0.80 – 0.95, the lowest value was at Mikap Nigeria Ltd and the highest value at Wurukum abattoir. Simpson's diversity index obtained in this study was generally high. This may be attributed to the less number of species that are obtained in River Benue during the study period. This observation was also reported by Shah and Pandit (2013). They also reported that stable communities have high diversity value (0.6 to 0.9). The Simpson's diversity index does not give true reflection of the benthic community structure in River Benue due to the emphasis of the diversity on the number of species. However, the seasonal and spatial variation of Simpson's diversity index obtained in this study disagrees with the results of earlier studies that reported lower range (Sharma and Chowdhary, 2011; Habib and Yousuf, 2012).

The spatial variation of Menhinick's index during the study period ranged from 2.20 – 2.61. Coca-cola had the lowest index value while Mikap Nigeria Ltd was the highest. The result of Menhinick's diversity index obtained during this study differs from the findings of an earlier study that reported Menhinick's diversity index that ranged from 0.06 – 0.87 (Nwankwo *et al.*, 2010). The low diversity associated with September 2012 may be ascribed to the effects of flood that occur in River Benue during the month of September 2012.

The spatial variation of the evenness ranged from 0.89 (Mikap Nigeria Ltd) to 0.94 (Wurukum abattoir) during the study period. This finding is at variance with the result of earlier study in River Tawi that reported evenness that ranged from 0.260-0.964 across study stations (Chowdhary and Sharma 2013). The values of Pielou evenness are between 0 – 1. When the value is getting closer to 1 it means that the individuals are equally distributed. During this study the individuals of the benthic fauna were seems to be evenly distributed throughout the study period. This is evident in the Pielou evenness values determined during this study. The taxa richness, general diversity and evenness all revealed the destruction of large population of benthic fauna in River Benue due to the impact of land based pollutants. Similar observations were reported in tropical coastal ecosystem (Edokpayi *et al.*, 2010).

In the course of this investigation seasonal and spatial Simpson's dominance index ranged from 0.001 – 0.31 and 0.003 – 0.06 respectively. The result of dominance across the locations of this study differs significantly from that of River Tawi that varied from 0.093-0.760(Chowdhary and Sharma 2013). The dominance of species with different levels of pollution tolerance at different locations and seasons during the present study in River Benue indicates distinct environmental conditions at the stations and in the course of the study.

CONCLUSION

It is clear from the diversity indices at the Benue Brewery and Mikap Nigeria Ltd showed the lowest diversity compared to the other locations during the course of the study. These location were located with low values of Shannon diversity index that is an indication of perturbed ecosystem.

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