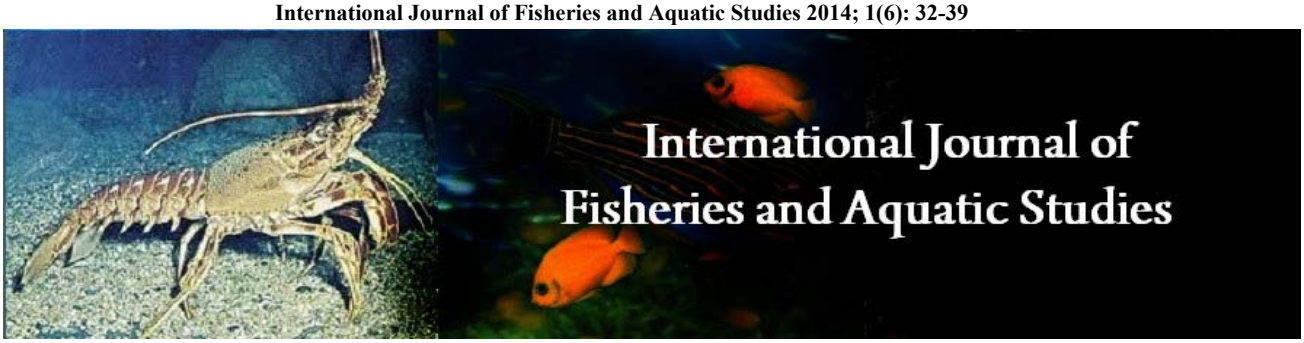

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Benthic fauna community structure in river Benue at Makurdi, Benue state, Nigeria

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ABSTRACT
Uncontrolled dumping of wastes into rivers without control measures is widely practiced in the developing nations of the World as it is observed in River Benue at Makurdi. To ascertain the health status and integrity of River Benue at Makurdi, sediments were collected monthly from five different locations on the shoreline of River Benue at Makurdi for a period of two years (July 2011-June 2013). The sediments were examined for the presence and absence of macro benthic fauna. The result of the sediments showed 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. Station II (570 individuals) and Station III(649 individuals) recorded low population as compared to the other locations: Station I (1,177 individuals), Station IV (1,043 individuals) and Station V (1,012 individuals). Athropoda had the highest population of individuals as compared to the other phyla. Pollution sensitive species of benthic fauna were not found at Station II and III which is an indication of polluted environment. There was generally low biodiversity of benthic fauna community which indicate the perturbed nature of the study area. Across the stations Shannon Diversity Index ranged from 1.81-2.91, Margelef Diversity Index ranged from 2.10-4.44, Simpson Diversity Index ranged from 0.80-0.95, Menhinick's Diversity Index ranged from 2.20-2.61, Pielou Evenness Index ranged from 0.92-0.94 and Simpson Dominance Index ranged from 0.28-0.47 during the study period. Diversity indices result showed a variation in the community structure of River Benue. It is recommended that the discharged of effluents and other waste into the River Benue should be controlled and enforced.

Keywords: Benthic fauna, Community Structure, River Benue, Shannon Diversity Index

1. Introduction
The population of macro zoo benthos is very sensitive to any environmental perturbation and is highly influenced by environmental change [1]. Organism's population and communities composed of different species make up of the biological diversity of aquatic ecosystems. These include: single – celled microbes such as viruses, bacteria, protist and fungi, to multi-cellular organisms such as vascular plants, aquatic invertebrates, fish and wild fowl. The community of organisms that reside within and near aquatic ecosystems simultaneously plays a vital role in regulating some biogeochemical fluxes [2]. Aquatic organisms are often considered as engineers' of aquatic ecosystems, not only react to physical and chemical changes in their environment, but they can also drive such changes and have important roles in cleansing and detoxifying their environment [3]. The Benthic fauna community includes several species of organisms which cut across different phyla including annelids, arthropods, mollusks [4]. These organisms play a vital role in circulation and recirculation of nutrients in aquatic ecosystems. They also constitute the link between the unavailable nutrients in detritus and useful protein materials in fish and shellfish [4].
Stable ecosystems are characterized by a great diversity of species, most of which are represented by relatively few individuals. However, where the range of habitats or riches is restricted by physical or chemical factors, high number of individuals of only a few species occur [5]. Benthic macro invertebrates can be used as a barometer of overall biodiversity in aquatic ecosystems [6]. The surveys of richness and species composition, the relative abundance of groups or species and the feeding relationships between the inhabiting organisms are the most direct measure to determine if a water body meets the biological standards for aquatic life [7]. The overall diversity of biological communities enables many ecosystem processes to function normally and in a stable state. Loss of diversity may lead to declines

in ecosystem function as well as shifts to alternate stable states [3, 8]. Changes in the environment will be reflected in changes in the species assemblage both spatially and Temporally. Therefore, these assemblages can be used to help assess environmental degradation from both single and cumulative sources [9]. The diversity of benthic community is the product of all spatial and temporal changes affecting the community [10]. According to [11] knowledge of the structure of the benthic macro invertebrate community provides precise and local information on recent events, which can be seen in the structuring. The populations of species differ in their poly functionality. They are difficult to use when the water body is polluted by organic substances or eutrophicated. The number of some communities will increase, while that of others will decrease. Therefore, final estimates are comparative and expressed in classes, points, scores and indices [12]. This work aim is to assess the ecological integrity of River Benue at Makurdi using the biodiversity indices.

2. Materials and Methods

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 [13]. 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 [14]. 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 1200-2000 mm [15]. High temperature values averaging 28-33 ^{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 [15]. All the same the periodic dust plumes associated with this time of the year may encourage surface water pollution [15]. Five stations were selected along the river course at Makurdi, Benue state for this study as follows:

Site 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

Site II (N07^0 43.615' E008^0 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.

Site 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

Site 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.

Site V (N07^0 44.789' E008^0 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.

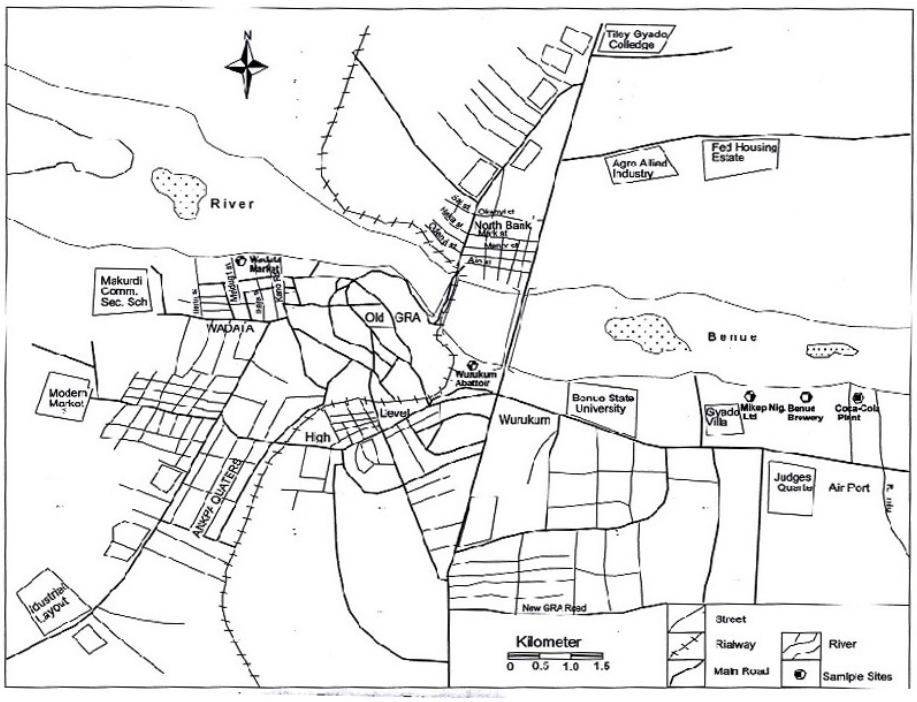

Fig 1: Map of Makurdi Town Showing Sample Sites.
Source: Ministry of Lands and Survey Makurdi (2011)

2.1 Benthic fauna Sample collection and Analysis
Three successful hauls of benthic samples were taken from each station using a van Veen grab(0.1 m^2) from an anchored boat with an out-board engine of 25 HP duering the 24 months 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 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. In the laboratory the samples were sieved in order to remove fine sediments and any other extraneous material. Each of the sediment sample collected was washed three times in the Laboratory through three sets of sieves, 1st 2 mm, then 1mm and finally 0.5 mm mesh size sieves to collect the macro benthos in them [16]. The retained macro benthos were poured into bottles and labeled properly. 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 [17]. Large benthic fauna were picked out using forceps while the smaller ones were pipette out. The preserved animals were identified under light and stero dissecting microscope and counted. The identification was carried out using keys by [18, 19, 20, 21].

2.2 Data Analysis
In this study diversity of the benthic fauna was determined using the Shannon-Weiner diversity index, Simpsons' diversity index, Margalef diversity index, Menhinick's diversity index. Pielou's index (J) of evenness and Simpson dominance was also calculated to determine the benthic fauna community structure. As the number and distribution of taxa (biotic diversity) within the community increases, so does the value of H^1 [22].

2.3 Shannon- Weiner diversity index

$(H^1)= -\sum[(ni/N)\times\ln(ni/N)]$ [23]. Where:

H^1= Diversity index, ni= total number of individuals belonging to ith species, N= total number of individuals for the site and ln= the natural log of the number

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

2.5 Margalef-value is the measure of specie richness. It is expressed as d= S-1/lnN [24], Where: d= Margalef value, S= number species collected in a sample and N= total number of individuals in the sample

2.6 Menhinick's Index (D) = $S/\sqrt{N}$ Where: S= Number of species in a population and N= Total number of individuals in S species

2.7 Pielou's index measures how evenly the species are distributed in a sample community. It is expressed as: $J= H^1/ Hmax$ [25]. Where: J= diversity evenness or Equitability index H^1= calculated Shannon –Weiner diversity index (Shannon-Weiner) Hmax = lnS S= total number of species in a population ln= natural log of number

2.8 Simpson dominance index (C) = $\sum(n/N)^2$ [26]. Where: n= the number of species in the i^{th} species and N= Total number of individuals

3. Results
The result presented in Table 1 is the spatial variation indices of benthic fauna in River Benue at Makurdi. The result indicates that H^1 ranged from 1.81-2.91, d ranged from 2.10-4.44, 1-Δ, ranged from 0.80-0.95, D ranged from 2.20-2.61, J' ranged from 0.92-0.94 and C ranged from 0.28-0.47 during the study period. The data presented in Figure 2 is the monthly benthic fauna population along River Benue course at Makurdi. The result showed that the benthic population was highest at Station I in most of the months during the research time. The result in Fig 3 showed that at all the stations and during the months, Shannon diversity index was above 1.5 except during August, 2012, when it falls between 1.5 at Station I which was the lowest throughout the study period. Figure 4 is the result of the monthly variation of Margelef diversity index at five different locations along River Benue water course. The result showed that the highest value of Margelef diversity index value was obtained at Station I during the month of September, 2011, while the lowest value was at Station II in September 2012. The result in Fig 5 depicts that the lowest value of Simpson diversity index was obtained at Station I in April 2013. The values of the Simpson diversity index generally differ slightly from one station to another throughout the 24 months of this study. The result indicates that among all the stations except at Station IV and III, the highest values of Simpson diversity Index were obtained during rainy season. Figure 6 is presented with the result of the monthly variation of Menhinick's diversity index value along River Benue water course for the period of 24 months. The result showed that highest value of the index was obtained at Station I in September 2011 while the lowest was at Station II in September 2012. The result indicates that the diversity index was decreasing during the dry season and increasing during the rainy season. The result in Fig 7 indicates that the Pielou evenness differ slightly from one location to another during the study period. All the same the lowest value of (0.76) was reported in December, 2011 at Station I during the period of study. The result in Fig 8 showed that the highest dominance value of 1.0 was obtained at Station I in June 2012 and August 2012, at Station II it was from June 2012 – September 2012, while at Station III and IV it was in September 20123 during the period of this study. The perusal of the result showed that during the dry months the dominance index had the lowest value at all the locations.

Table 1: Spatial Variation in Diversity indices of Benthic fauna of River Benue at Makurdi

Location	Total N0 of Individuals	N0. of species	H^1	d	1-Δ	D	J'	C
Station I	1177	21	2.91	4.44	0.90	2.20	0.92	0.33
Station II	570	18	1.81	2.10	0.88	2.53	0.62	0.47
Station III	649	19	2.11	2.48	0.80	2.61	0.89	0.41
Station IV	1012	21	2.72	4.13	0.95	2.48	0.94	0.28
Station V	1043	21	2.80	4.06	0.94	2.55	0.92	0.31

H^1: Shannon Diversity Index d: Margelef Diversity Index 1-Δ: Simpson Diversity Index
D: Menhinick's Diversity Index J': Pielou Evenness Index C: Simpson Dominance Index

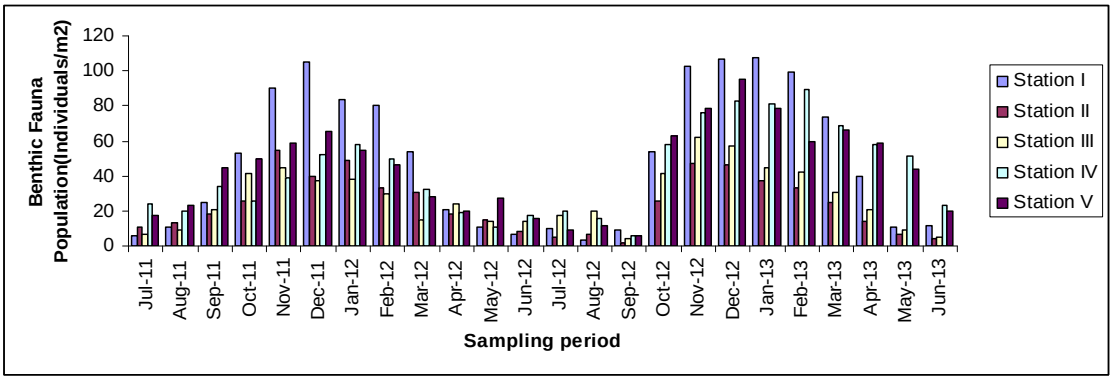

Fig 2: Monthly Variation of Benthic fauna population along River Benue course at Makurdi

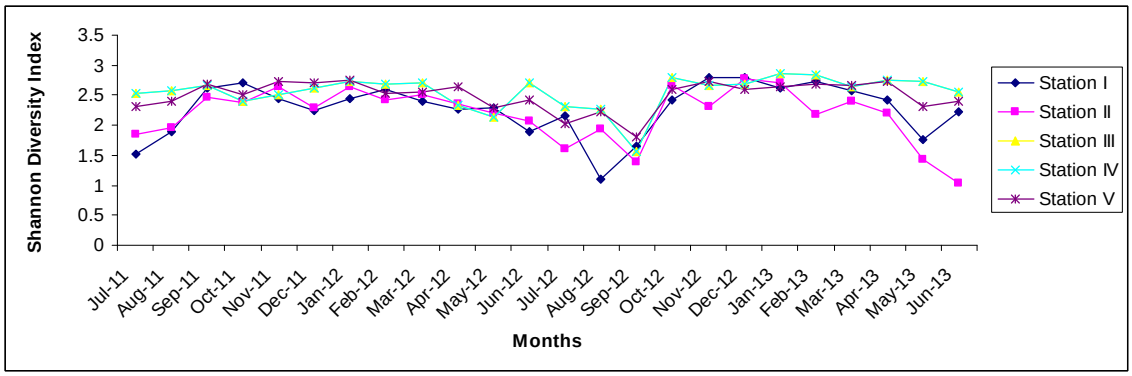

Fig 3: Monthly variation of Shannon Diversity Index along River Benue course at Makurdi

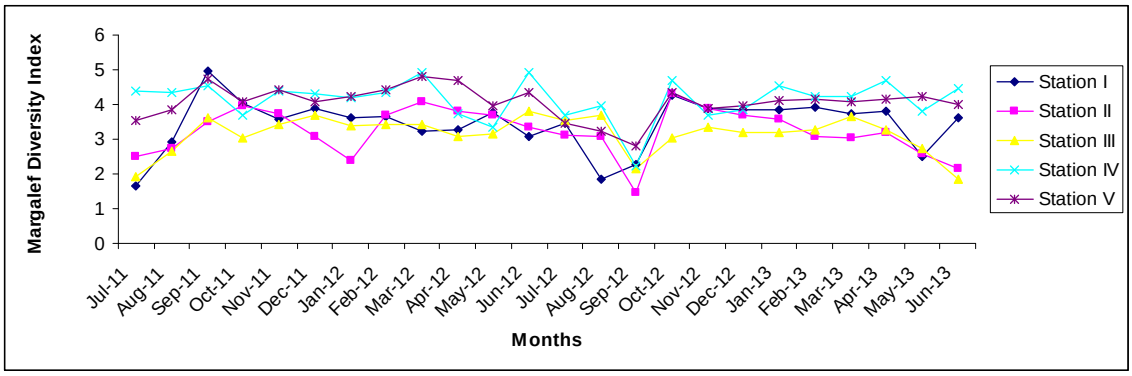

Fig 4: Monthly variation of Margalef Diversity Index along River Benue course at Makurdi

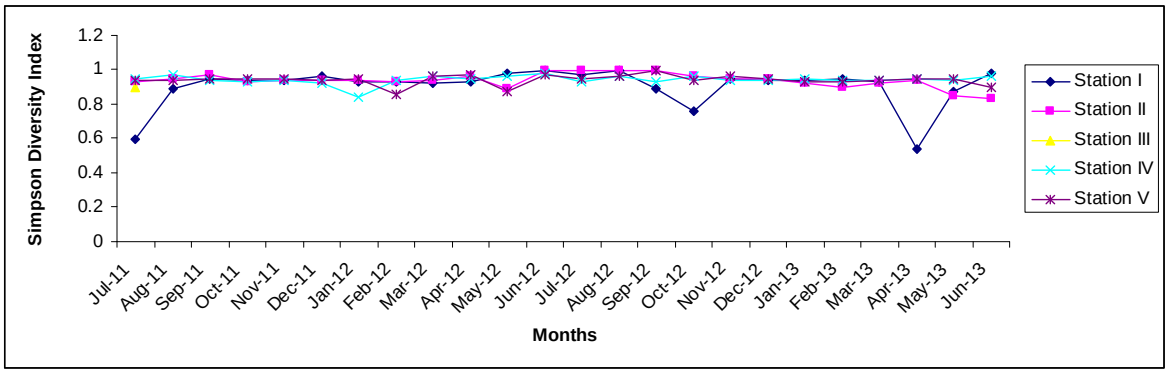

Fig 5: Monthly variation of Simpson Diversity Index along River Benue course at Makurdi

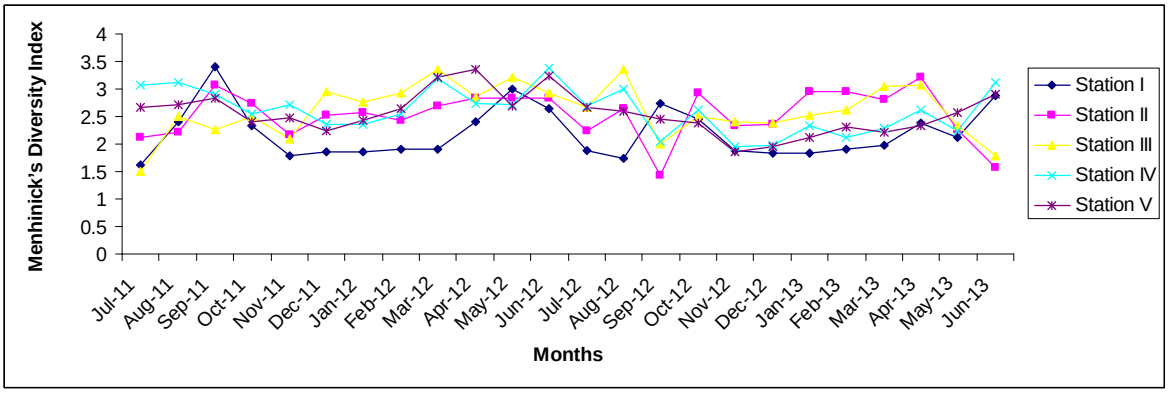

Fig 6: Monthly variation of Menhinick's Diversity Index along River Benue course at Makurdi

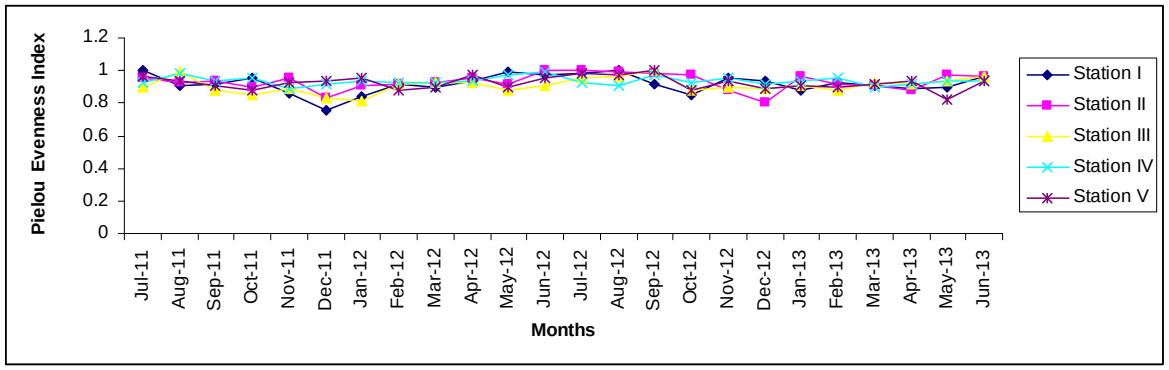

Fig 7: Monthly variation of Pielou Evenness values along River Benue course at Makurdi

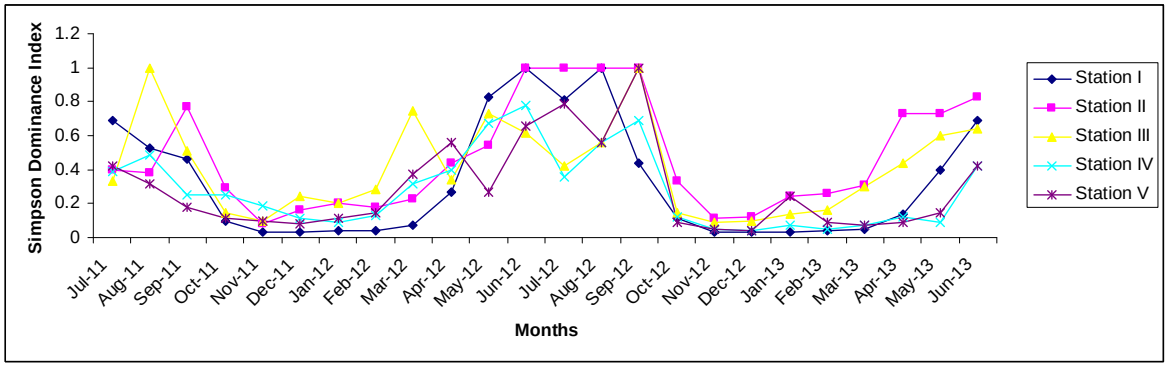

Fig 8: Monthly variation of Simpson Dominance along River Benue course at Makurdi

4. Discussion

The determination of diversity is another biological tool for assessing the pollution level of environments. The many diversity indices are all based on two assumptions. 1) Stable community structure has high diversity value while unstable ones have lower diversity value and, 2) Stability and thus diversity is an index of environmental integrity [27]. During this investigation the monthly Shannon and Wiener diversity index (H^1) ranged from 1.04 - 2.80 across all the locations in River Benue at Makurdi. The result of this study disagrees with the findings of an earlier study in Okpoka Greek, Niger Delta Nigeria that reported monthly variation Shannon diversity within one year study that ranged from 0.81 - 1.14 [28]. Sharma KK [7] reported monthly variation of Shannon diversity index in River Tawi that varied from 0.00 to 1.985 during their one year study period. This result differs with the findings of this study. Habib S [29] reported monthly Shannon Weiner diversity that varied from 0.978 - 2.58 in a Yousmarg stream, Himalaya India. Nwankwo DI [30] reported very low monthly Shannon - Weiner diversity index that ranged from 0.07 - 0.59 in a stressed tropical lagoon. The Shannon - Weiner index values are between 0.00-5.00. Results are generally between1.5-3.5 and very rarely exceed 4.5. The values above 3.0 indicate that the habitat structure is stable and balanced. The values of the index under 1.0 indicate that there is pollution and degradation of habitat structure [23]. Based on the above classification, the monthly variation of Shannon - diversity index during the 24 month period showed that the structure of the benthic community in River Benue was not stable and balanced. Also, the water quality during the month of June 2013 at Station II was much polluted with Shannon diversity index value of <2. However, the result of this present investigation reported the highest value of Shannon diversity of 2.80 during the month of November, 2012 at Station I. This finding agrees with the result of earlier studies that reported highest value of Shannon diversity during November [28, 7]. The monthly maximum value of Shannon diversity index was obtained when the number of species was high. This observation agrees with the findings of [31]. Generally based on the monthly variation of the Shannon - diversity index the water quality of River Benue was moderately polluted during the study period.

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 Station II and the highest value of 2.91 was at Station II. Similarly the seasonal variation of the Shannon diversity ranged from 2.06-3.25. The highest value of 3.25 was determined at Station IV during rainy season. The result of the seasonal variation of Shannon diversity index during this study disagrees with the report of an earlier study that reported highest Shannon diversity that varied from 0.0 -1.60 during the dry season as compared to the wet season 0.0 – 1.41 [31]. The spatial variation of Shannon diversity index of this study disagrees with the result of spatial variation of Shannon diversity of earlier studies [16, 10, 31, 32, 33, 34, 35, 36]. 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 [10]. The very low Shannon diversity index at Station II is an indication of environmental perturbation at this station during the study period.

During this present investigation, the monthly variation of Margalef diversity index varied from 1.45 – 4.96. The lowest value was obtained at Station II in September, 2012 while the highest value was at Station I in September, 2011. Similarly the seasonal variation of the Margalef diversity index ranged from 2.98 – 4.36. Margalef's water quality index values greater than 3.0 indicate clean water conditions and values less than 1.0 indicates severe pollution and intermediate values indicate moderate pollution [37]. With reference to this classification the waters at Station I and II during September, 2012 were clean during the rainy seasons. Generally the Margalef diversity index throughout the 24 months study period and across the seasons at all the locations showed slight variation. This may be attributed to the fact that this diversity shows variation depending on the number of species and not the population of the individual species. This observation was also reported by [31].

However, the monthly variation of Margalef's diversity index of this study disagrees with that of an earlier study that reported monthly values that varied from 3.80 – 5.62 [28]. All the same other studies also reported lower values of Margalef index 0.16 – 1.14 and 0.19 – 1.33 as their monthly variation respectively that still disagrees with the result of this investigation [31, 7]. The spatial and temporal variation of Margalef diversity index varied from 2.10 – 4.44. The lowest value was obtained at Station II while the highest was at Station I. This variation is based basically on the number of species obtained at these locations during the study period. Lower species obtained at the Station II may be as a result of the stressed environment in this area due to anthropogenic activities impact. This result also agrees with the finding of other studies that report lower values of Margalef diversity index at different locations [10, 7, 34]. 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 [35, 38].

The Simpson's diversity index places relative weight on rare species and more weight on common species [39]. Its values range from 0 indicating a low level of diversity, to maximum of 1-1/S where S, is the total number of taxa in the community. The Simpson's diversity index varied monthly from 0.54 – 1.00 during the 24 months period of this study at five locations along River Benue course at Makurdi. The lowest value was obtained in April 2013 at Station I. All the same, the seasonal variation of Simpson's diversity index varied from 0.68 – 0.96. The lowest value of 0.6 was obtained at Station IV during the dry season and the highest value was during rainy season at Station III and IV. The Simpson's diversity index values obtained across the locations ranged from 0.80 – 0.95, the lowest value was at Station III and the highest value at Station IV. 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 [40]. 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 monthly seasonal and spatial variation of Simpson's diversity index obtained in this study disagrees with the results of earlier studies that reported lower range [7, 29].

Menhinick's diversity index like Margalef's index attempts to estimate specie richness but at the same time independent of the sample size. During the present investigation the monthly variation of Menhinick's diversity index varied from 1.42 (Station II September 2012) to 3.40 (Station I, September 2011) throughout the 24 months study period. Similarly the seasonal variation varied from 0.95 to 2.80. The lowest value was obtained during dry season at Station I while, the highest value was obtained during rainy season at Station II. The spatial variation of Menhinick's index during the study period ranged from 2.20 – 2.61. Station II had the lowest index value while Station III was the highest. The result of Menhinick's diversity index obtained during this research differs from the findings of an earlier study that reported Menhinick's diversity index that ranged from 0.06 – 0.87 [30]. 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.

During this present investigation the monthly variation of Pielou's evenness index varied from 0.84 – 1.00. The lowest value of 0.84 was obtained in January 2012 at Station I and the highest value of 1 was obtained at Station I and other locations. Pielou evenness obtained from this study on monthly basis differs with the result of other studies [28, 7]. However, this result agrees with the monthly Pielou evenness that varied from 0.80 – 1.00 [29] The spatial variation of the evenness ranged from 0.89 (Station III) to 0.94 (Station IV) 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 [34]. 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 [10].

During the present study the monthly, seasonal and spatial Simpson's dominance index ranged from 0.03 – 1.00, 0.001 – 0.31 and 0.003 – 0.06 respectively. The result of dominance across the locations of this study disagrees with that of River Tawi that varied from 0.093-0.760 [34]. The dominance of species with different levels of pollution tolerance at different locations and months and seasons during the present study in River Benue indicates distinct environmental conditions at the stations during the time of the study. Individual species may vary in population density for a wide variety of seasons as observed in River Benue during this study indicating natural variation of biotic and abiotic factors. Similar observations were made in Florida streams [41]. The dominance result of this investigation disagrees with the dominance result of earlier studies that reported higher range of dominance 0.10 – 0.92 and 0.36 – 0.89 respectively during their different study periods [30, 31]. Studies have revealed that anthropogenic activities such as sand dredging results in substratum instability and increased siltation as it is commonly observed in River Benue at the study locations [10].

5. Conclusion

The relatively low benthic fauna community structure observed in River Benue during this study could be attributed to the continuous effect of dredging activities and other anthropogenic activities in River Benue during the study period.

6. Acknowledgement

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