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Variation of benthic fauna composition in river Benue at Makurdi, Benue State, Nigeria

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Abstract
Macro benthic fauna of River Benue at Makurdi, Benue State Nigeria was studied for two years from July 2011- June 2013 at five sampling stations along the river course. Sediments samples were collected monthly using Van Veen Grab and analyzed for the presence of macro benthic fauna at the five different sample stations. 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. Benue brewery (570, Individuals) and Mikap Nigeria Ltd (649 Individuals) recorded low population as compared to the other locations: Coca cola (1,177 Individuals), Wadata market (1,043 Individuals) and Wurukum abattoir (1,012 Individuals). Athropoda had the highest population of individuals as compared to Annelida, Mollusca and Platyhelminthes. Mosquito larvae was determined with the highest relative abundance of 10.8% throughout the period of the study at Wadata market while the lowest relative abundance of 0% was observed for Stone fly and May fly at Benue brewery and Mikap Nigeria Ltd stations throughout the period. There was generally low biodiversity of benthic fauna community which indicate the perturbed nature of the study area. 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: Macro benthic fauna, River Benue, Abundance, Diversity

1. Introduction
Benthic fauna are indispensable organisms in aquatic community. These organisms play important functions such as mixing of sediments, mineralization, flux of oxygen in the sediments, cycling of organic matter and monitoring of surface water quality (George *et al*., 2009) [11]. The type and distribution of benthic fauna have been used widely as an indicator of water quality and ecological disturbances (Ishaq and Khan, 2013) [16]. Macro benthic invertebrates are important and integral part of aquatic ecosystem as they form the basis of the trophic level and any negative effects caused by pollution in the community structure can in turn affect trophic relationships. These can include those that feed on them directly or indirectly such as fish and bird population respectively (Sharma and Chowdhary, 2011) [30]. In addition aquatic invertebrates have the ability to clean rivers as they utilize the organic and detritus matter (Sharma and Chowdhary, 2011) [30]. According to Carlisle *et al*., (2007) [5] macro invertebrates populations in streams and rivers can assist in the assessment in the overall health of the stream. Benthic organisms constitute an important part of the aquatic food chain especially for fish. Many of them feed on algae and bacteria, which are on the lower end of the food chain (Nystrom *et al*., 1996) [21]. Some shred and eat leaves and other organic matter that enters the water and because of their abundance and critical position in the aquatic food chain and play a major role in the natural flow of energy and nutrients in the aquatic system (Stockley *et al*., 1998) [32]. Benthic macro invertebrates of running waters are of value as long term indicators of water quality and can provide signs of impending water pollution and habitat fragmentation (Ogbeibu and Oribhabor, 2002) [23]. The structure of benthic communities in running water ecosystem is determined by a dynamic array of biotic and abiotic factors (Austen and Widdicombe, 2006) [3]. Olomukoro and Egborge (2003) [26] reported that species of polychaetae were restricted to a particular station of the same river because their occurrence may be governed by niche preference and feeding habit. Macro invertebrates therefore are heterogenic collections of various evolutionary taxa where their biotic and diversity indices are used to determine water quality and pollution changes in streams and rivers (Teferi *et al.,* 2013) [33]. Information on the structure and composition of

benthic fauna in river Benue at Makurdi is very scarce. The river Benue at Makurdi has been subjected to domestic, agriculture and industrial activities. The river serve as the major source of domestic water to the people living along it bank. This present study provides information that may bridge the gap on the composition, seasonal abundance and spatial distribution of the benthic fauna in river Benue at Makurdi, Benue state in relation to its environmental quality.

2. Materials and Methods

2.1. 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) [36]. 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) [34]. 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^{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 (Nyagba, 1995) [20]. All the same the periodic dust plumes associated with this time of the year may encourage surface water pollution (Nyagba, 1995) [20]. Five stations were selected along the river course at Makurdi, Benue state for this study shown in Fig 1 as follows:

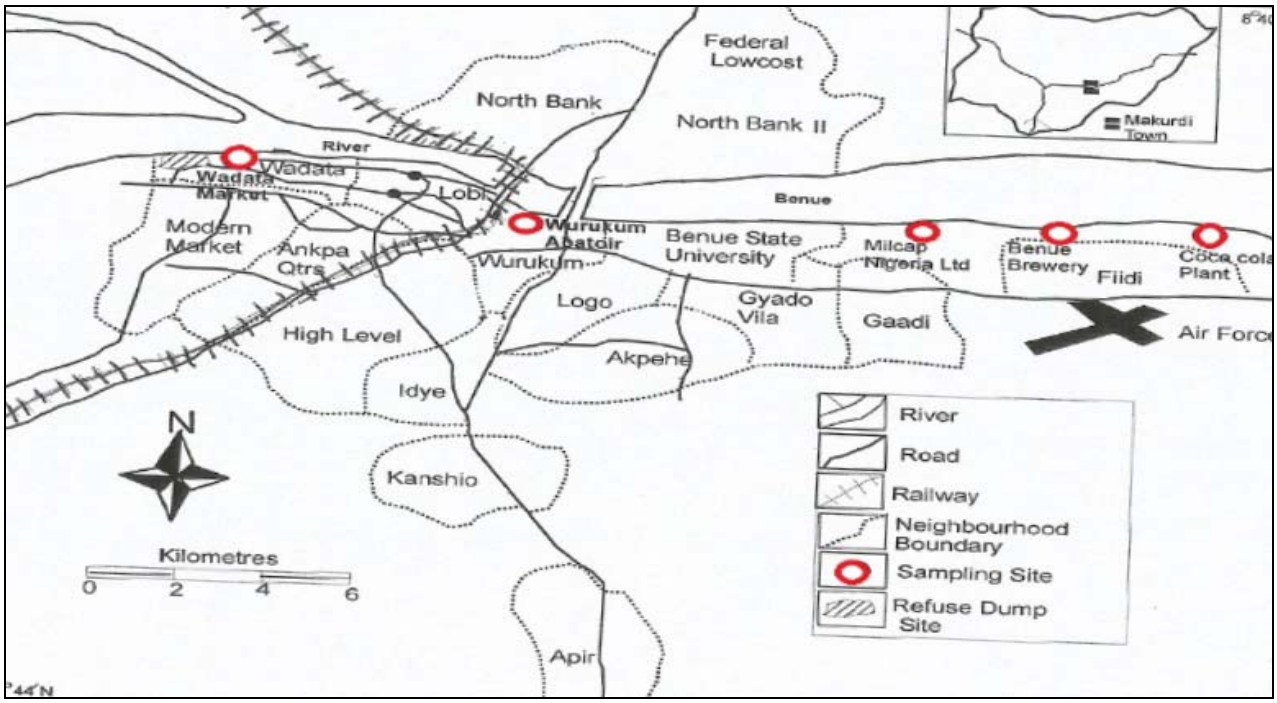
Site I(N07^0 43.663^1 E008^0 35.427^1): it is located behind Coca cola plc plant along Gboko road and it is approximate 1.5 kilometers away from Site II

Site II (N07^0 43.615^1 E008^0 35.300^1): 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 43.649^1 E008^0 35.302^1): 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 44.076^1 E008^0 32.840^1): 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 44.789^1 E008^0 30.624^1): This site is located behind Wadata mark*et al*ong the river water course at Makirdi. Wastes from the heap refuse dumpsite behind the market are leached directly into the river.



Source: Ministry of lands and Survey Makurdi

Fig 1: Map of Makurdi Town Showing Sampling Sites

2.2 Sample collection and Analysis

Benthic sediment samples were collected between 8:00 am and 12:00noon by means of a boat cruises in sampling stations along River Benue bank. The Van Veen grab of 0.1m^2 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 (0.1m^2) 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 2 mm, then 1mm and finally 0.5 mm mesh size sieves to collect the macro benthos in them (Esenowo and Ugwumba, 2011) [7]. 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) [11]. 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 Days (1967) [6], Pennak (1978) [27], Water and Rivers Commission, (2001) [35] and Merit and Cummins (1996) [18].

2.3. Data Analysis

Biological indices such as Shannon and Weiner index (H^1); Margalef's index (d); Simpson diversity index (1-Δ); 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) = -∑ [(ni/N) ×ln (ni/N)] (Shannon-Weiner, 1963) [29].

Where: H^1= Diversity index, ni= total number of individuals belonging to ith 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/lnN (Margalef, 1967) [17].

Where: d= Margalef value, S= number species collected in a sample, N= total number of individuals in the sample

- **Simpson's diversity** (1-Δ) = 1- ∑ 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/√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/ Hmax (Pielou, 1969) [28].

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

- **Simpson dominance index (C)** = ∑ $(n/N)^2$ (Ogbeibu, 2005) [22].

Where: n= the number of species in the i^{th} species N= Total number of individuals

3. Results and Discussion

The spatial variation in abundance of benthic fauna in River Benue at five locations within Makurdi is presented in Table 1. Among all the locations the highest abundance of 10.8% was reported at Wadata market for Mosquito larvae. Table 2 is the biological indices of the benthic fauna in river Benue at Makurdi. The result showed that Coca cola, Site I recorded the highest number of benthic fauna with the highest value of Shannon index. The data 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 Coca-cola in most of the months during the research time. Similarly Figure 3 depicts the seasonal variation between benthic fauna population. The result indicates that during the study period the dry seasons recorded more benthic fauna individual population as compared to the dry season at all the study stations. Figure 4 is the composition benthic group along River Benue water course at Makurdi. The result indicates that the phylum Arthropoda recorded the highest population among other phyla across the stations during the period of this research. At coca cola there was a slight difference between annelids, Mollusca and Platyhelminthes.

Table1: Abundance of Benthic fauna in River Benue at Makurdi

Macro invertebrate Taxa	Site I Total No Rel. Abun (%)		Site II Total No Rel. Abun (%)		Site III Total No Rel Abun (%)		Site IV Total No Rel. Abun (%)		Site V Total No Rel. Abun (%)	
Stonefly larvae	113	9.6	0	0	0	0	37	3.6	42	4.0
Mayfly nymph	114	9.7	0	0	0	0	18	1.8	49	4.7
Caddisfly larvae	116	9.8	0	0	14	2.1	53	5.2	65	6.2
Dragonfly larvae	94	7.9	7	1.2	12	1.8	65	6.4	51	4.9
Damselfly larvae	108	9.2	5	0.9	17	2.6	43	4.2	48	4.6
Water boatmen	50	4.2	33	5.8	29	4.5	68	6.7	50	4.8
Backswimmers	63	5.3	43	7.5	43	6.6	36	3.5	57	5.5
Water measurer	17	1.4	10	1.7	33	5.1	28	4.3	54	5.2
Water strider	57	4.8	52	9.1	45	6.9	49	4.8	63	6.0
Riffle Beetle/larvae	32	2.7	50	8.8	30	4.6	59	5.8	47	4.5
Predacious diving beetle adult/larvae	53	4.5	39	6.8	39	6.0	47	4.6	75	7.2
Water scavenger beetle adult/larvae	55	4.7	37	6.5	55	8.5	76	7.5	61	5.8
Whirligig beetle adult/larvae	65	5.5	33	5.8	48	7.4	80	7.9	48	4.6
Mosquito larvae	66	5.6	35	6.1	46	7.1	91	8.9	113	10.8
Blackfly larvae	15	1.3	32	5.6	26	4.0	35	3.4	23	2.2
Biting midge larvae	57	4.8	47	8.2	45	6.9	43	4.2	57	5.5
Non biting midge larvae	61	5.2	37	6.5	49	7.5	85	8.4	70	6.7
Freshwater snail	14	1.2	16	2.8	37	5.7	46	4.5	38	3.6
Segmented worms	6	0.5	36	6.3	42	6.5	20	1.9	11	1.0
Leeches	9	0.8	34	5.9	20	3.1	18	1.7	15	1.4
Flat worms	12	1.0	24	4.2	19	2.9	15	1.5	6	0.6

Table 2: Variation in Diversity indices of benthic fauna in River Benue at Makurdi

Station	Total No. 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 and Wiener Diversity Index d: Margalef Diversity Index 1-Δ: Simpson Diversity Index D: Menhinick's Diversity Index J': Pielou Evenness Index C: Simpson Dominance Index

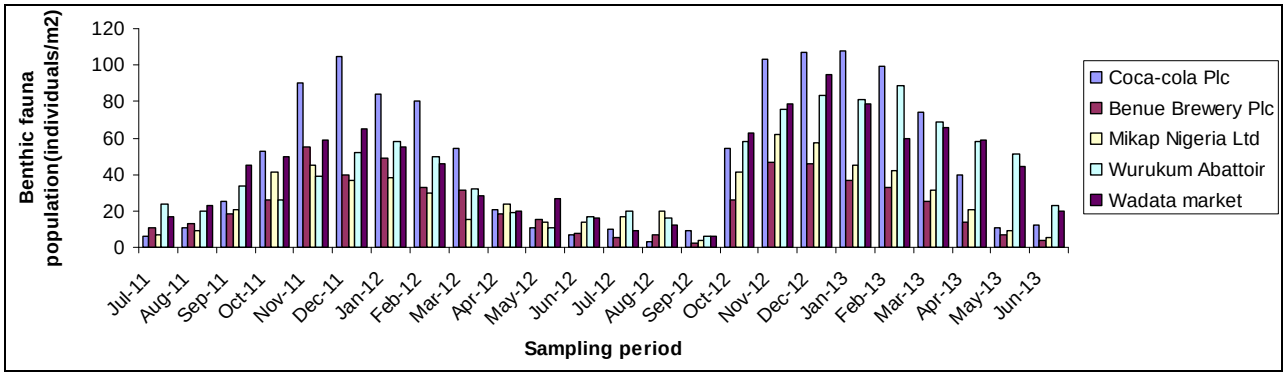


Fig 2: Monthly variation of benthic fauna population in River Benue at Makurdi

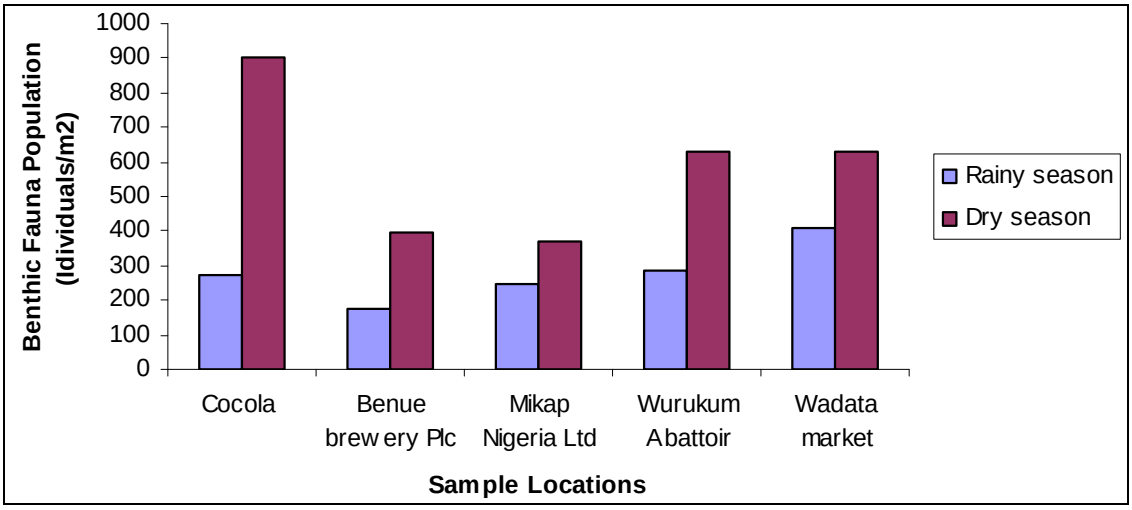


Fig 3: Seasonal Variation of Benthic fauna population in River Benue at Makurdi

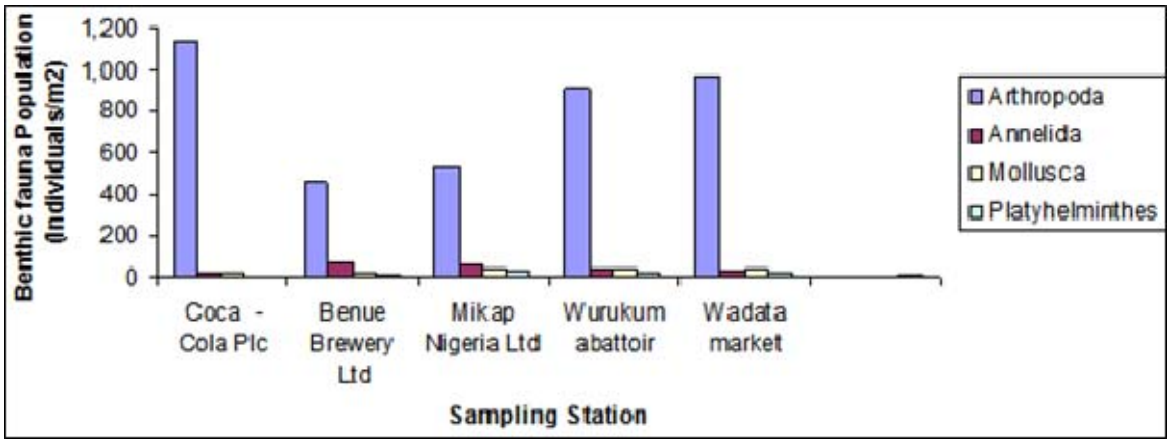


Fig 4: Composition of Benthic fauna group along River Benue water course at Makurdi

Generally, the number of recorded benthic fauna population was low. This may be because of some ecological imbalance arising from alterations of some important factors governing the abundance and distribution of benthic communities during the 24 months study period of this investigation. This finding agrees with the report of some studies that recorded low benthic population in surface waters at different places in their studies (Emere and Nasiru, 2007, Indabawa, 2010, Ogidiaka *et al.,* 2012; Okorafor *et al.,* 2012, Sharma *et al.,* 2013) [8, 15, 24, 25, 31]. All the same the result of this study disagrees with the

findings of Adakole and Anuune (2003) [1] that reported a high abundance of benthic fauna in an urban stream, Zaria Nigeria as compared to this study.

Similarly, at all the locations during the period of this study Arthropoda was the dominant benthic fauna group. The month of September 2012 was recorded with the lowest population of benthic fauna throughout the 24 months study period. This may be due to the flood that occurred in the River Benue during this period. Hussain and Pandit. (2012) [14] reported that flood reduces the population of benthic fauna greatly as was observed in River Benue during this present investigation. The low populations of benthic fauna at Wurukum abattoir and Wadata market locations may be attributed to the sandy bottom prevalent at these two locations. Studies have shown that unstable fine sediments characteristics of many larger Rivers support few benthic fauna populations as was even noticed in this study at some instances (Allan, 1995) [2]. Human activities may change the normal development of the river ecosystem as was observed at the Benue brewery and Mikap Nigeria Ltd locations of River Benue during the present investigation. The poorer water quality at these locations could be attributed to several man induced activities such as urban runoff into the surface river water due to direct and unregulated discharged in the River Benue.

A marked difference in the bottom fauna was noticed during the seasons throughout the 24 months study time. Across the seasons, the population of benthic fauna group during the dry season was higher compared to the wet season. This finding agrees with the result of other studies that reported higher population of benthic macro fauna during dry months as compared to the wet months (Nkwoji *et al.*, 2010, Ezekiel *et al.*, 2011, Habeeba *et al.,* 2012, Ishaq and Khan 2013) [19, 10, 13, 16]. Prevalent environmental conditions may also be responsible for the variation. Also during the rains the bottom sediments become unstable resulting in the eroding and dislocation of the benthic macro fauna and may affect their population. Another plausible reason may be that during the dry season the quantity of water in the River become reduced and clearer, the substrate also get stabilized and the population of the benthic fauna increased. However, the result of other studies disagreed with the findings of this present investigation that reported higher population of benthic fauna during the rainy season as compared to the dry season (George *et al.,* 2010, Edward and Ugwumba 2011) [12, 7]. The spatial distribution pattern of benthic animals at all the locations in the River Benue at Makurdi showed slight differences at perturbed locations of Benue brewery and Mikpa Nigeria Ltd has revealed by the present investigation. The high abundance of species at Coca - cola, Wurukum abattoir and Wadata Market compared to Benue brewery and Mikap Nigeria Ltd locations respectively was associated with un-impacted or unpolluted conditions at these locations. Nevertheless, the lower species biodiversity often signified environmental disturbance due to anthropogenic activities as it is observed at Benue brewery and Mikap Nigeria Ltd locations during this present investigation. The members of the order Ephemoroptera are considered to be sensitive to environmental stress and their presence marked a relatively positive condition (Merritt and Cummins, 1996) [18]. This order was present in all the locations except at Benue brewery Plc and Mikap Nigeria Ltd. Barbour *et al.* (1999) [4] reported that sensitive species of benthic macro fauna found at any station in tropical ecosystem indicate a pristine environment. Based on the above assertion the waters at Coca - cola, Wurukum abattoir and Wadat Market locations during the present investigation are considered to be clean. Conversely, Benue brewery and Mikap Nigeria Ltd were dominated with Oligochaetae compared to the other locations. This worm species is known to be able to tolerate unfavourable conditions such as low DO and high pollutant concentration as may be the situation in River Benue at Benue brewery and Mikap Nigeri Ltd locations during the course of this study (Barbour *et al.,* 1999) [4]. The hydrology of the river along the length of the water shed could be changed as observed in River Benue during the study period. All the same, the more significant factor in changing the distribution of benthic animal community is the anthropogenic inputs has observed at the different locations in River Benue during the time of this study (Yap *et al.,* 2003) [37]. The obvious change in the presence/absence of the macro benthic group during the 24 consecutive months of sampling showed that River Benue was highly fluctuating. This fluctuation was with regard to seasonality of rainfall and dilution factor. This may lead to some of the benthic animals not to be found in an area. Natural variation in river conditions also played major roles in the distribution of benthic animals' community (Yap *et al*., 2003) [37]. More so, the assemblages and distribution of the benthic macro invertebrates frequently change in response to pollution stress in predictable ways as was even observed in this study (Barbour, *et al*., 1999) [4].

4. Conclusions

The benthic fauna of river Benue at Makurdi during the study period was dominated by members of the phylum Arthropoda. The absence of pollution sensitive species at the Benue brewery and Mikap Nigeria Ltd stations is indication of the stresses environmental conditions at these stations as a result of human impact. Dry season recorded more benthic fauna as compared to the rainy season during the study. Flood and the type of substratum were observed to affect the distribution of benthic fauna during the study. Increase in the in human population will continue to contribute significantly to the process of river biodegradation, therefore there is need for government and regulatory authorities to enforce pollution abatement law to preserve biodiversity and protect the environment for healthy living.

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