Studies on Benthic Fauna as Bio Indicators of Pollution 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 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 V (1,043 Individuals) and Station IV (1,012 Individuals). Pollution sensitive benthic fauna specie like Stonefly and Mayfly were not observed at stations II and III throughout the period. This is indication that these stations are polluted with organic waste through the human impact on the river at these stations. 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, Bio indicators.

Introduction

Benthic macro invertebrates in running waters are of value as long term indicators of water quality and can provide signs of impending water pollution and habitat fragmentation[1]. Benthic macro invertebrates show high variability and are able to integrate the effects of short term environmental variations which have been used in characterizing rivers and streams in many parts of the world[2,3] reported that organic pollution of Bindare stream caused a decrease in benthic macro invertebrates' species richness and a decrease in density species richness. Environmental modifications or pollution can alter macro invertebrate communities[4]. Since macro invertebrates have limited mobility and can stay in an area without moving away easily the type of the macro invertebrate fauna obtained, may be used as indicator of the status of the water quality of aquatic system at that location. Similarly the lifecycles of macro invertebrate fauna may last for a year or more and this is reflected in the type of the benthic fauna in aquatic system due to the effect of the pollutant rather than chemical analysis of the water[5]. The long term impacts of pollutant in aquatic ecosystem may be shown in the type of macro invertebrate found in that system. This may be used in the classification of the ecological integrity of that aquatic environment[6].

The structure of benthic communities in running water ecosystem is determined by a dynamic array of biotic and abiotic factors[7,8] 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. However, outstanding investigations, which deal with the bottom fauna of some rivers in Southern Nigeria have also been studied such bottom studies are rare in the Benue river[9,10]. 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[11]. This study is aimed at using benthic fauna as bio indication of pollution in river Benue at Makurdi.

Material 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[12]. 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[13]. 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[14]. 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[14]. All the same the periodic dust plumes associated with this time of the year may encourage surface water pollution[14]. Five stations were selected along the river course at Makurdi, Benue state for the studies 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.
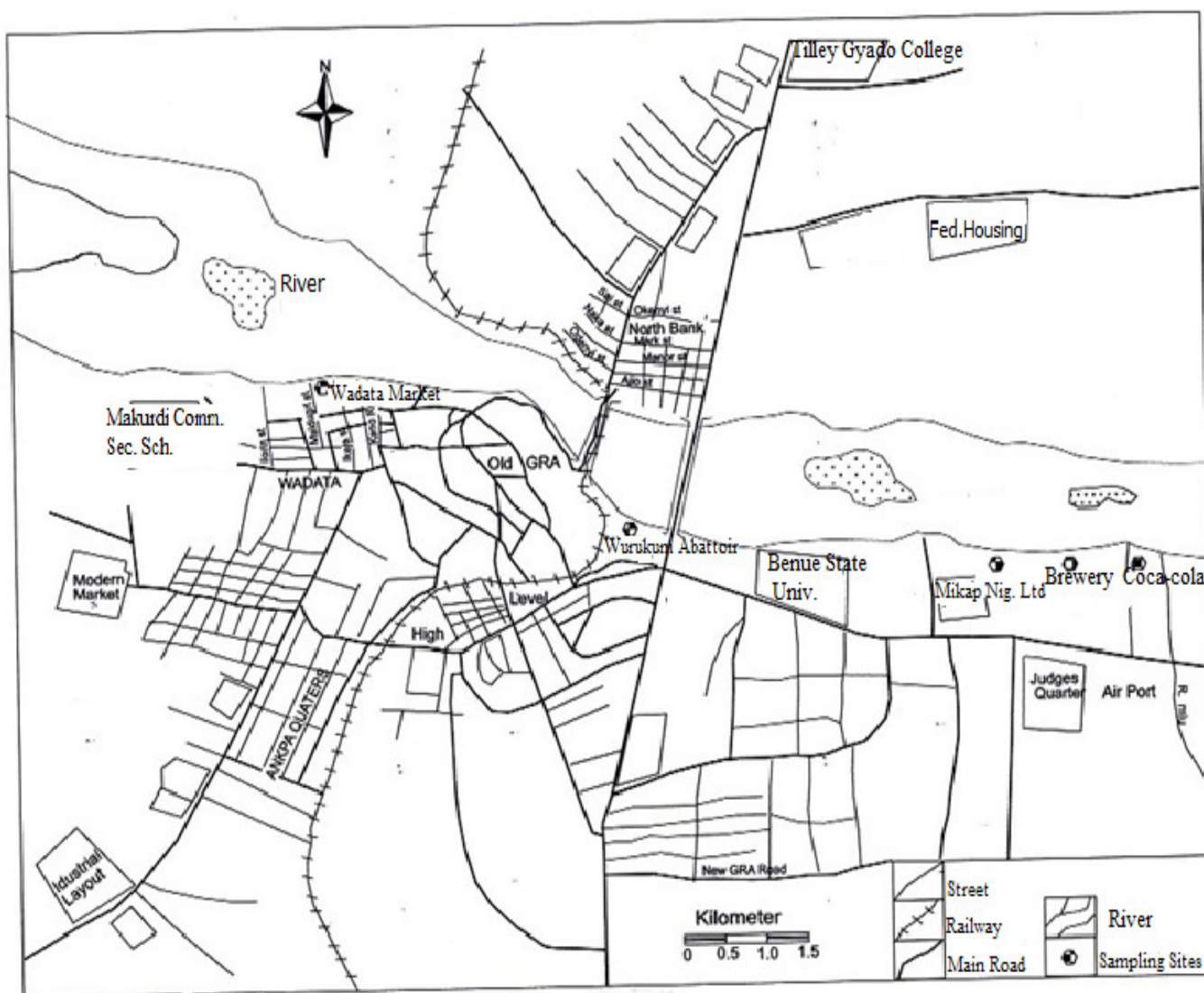

Figure-1
Map of Makurdi Town Showing Sample Site
Source: Benue State Lands and Survey

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 $0.1m^2$ 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 2mm, then 1mm and finally 0.5mm mesh size sieves to collect the macro benthos in them[15].

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[16]. 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 Day [4,17-19].

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 $(H^1) = -\sum[(ni/N)\times ln(ni/N)]$ [20]. 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 $d= S-1/lnN$[21]., 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: $J= H^1/ Hmax$[22]. 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) $= \sum(n/N)^2$ [23]. Where: n= the number of species in the ith species N= Total number of individuals.

Results and Discussion

Table 1 is the biological indices of the benthic fauna in river Benue at Makurdi. The result showed that Coca cola, (Station I) recorded the highest number of benthic fauna with the highest value of Shannon index. The result presented in figure 2 is the specie composition of benthic fauna obtained in River Benue at five sampling locations during the period of this study. Station I was reported to have the highest specie composition while Station II had the lowest. Stonefly and May fly were not recorded at Stations II and III during the period of the study.

The data in figure 3 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 4 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.

During the present investigation, Coca-cola (Station I) location was reported with highest population or specie composition of benthic fauna, while Benue brewery was the lowest. The lowest benthic fauna specie composition at Station II may be attributed to the impact of the industrial waste from the factory that are discharged into the river at this location is indicated in the water quality result of this study. This result conforms to the finding of an earlier study that reported low diversity of benthic fauna of a coastal lagoon, Lagos Nigeria as a result of industrial effluents impact[24].

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

| Station	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 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
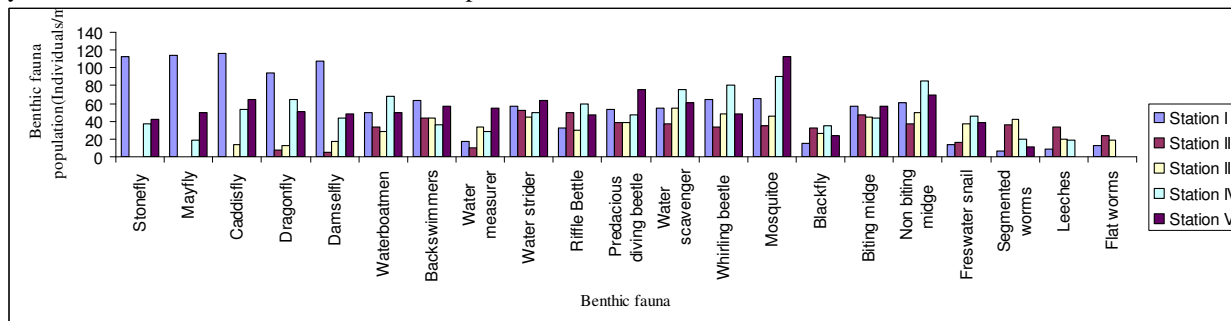
Figure-2
Specie composition of Benthic fauna along River Benue course at Makurdi
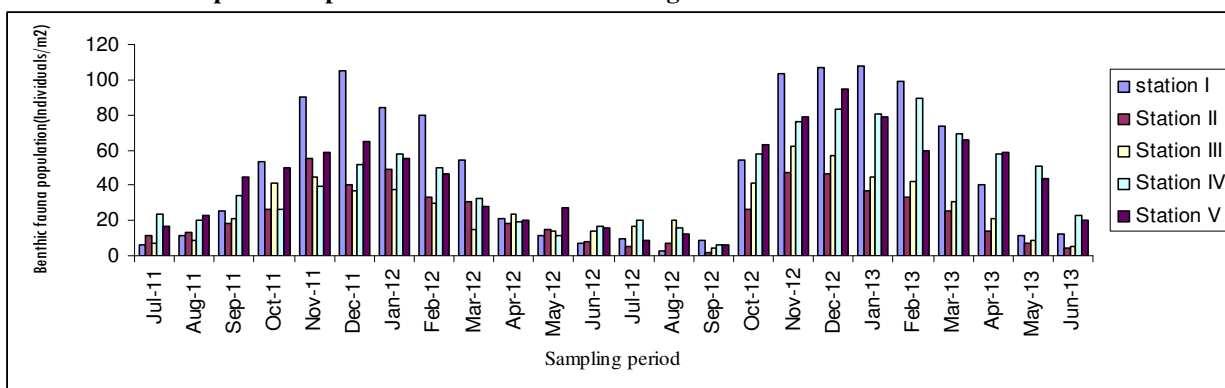
Figure-3
Monthly Variation of benthic fauna population in River Benue at Makurdi
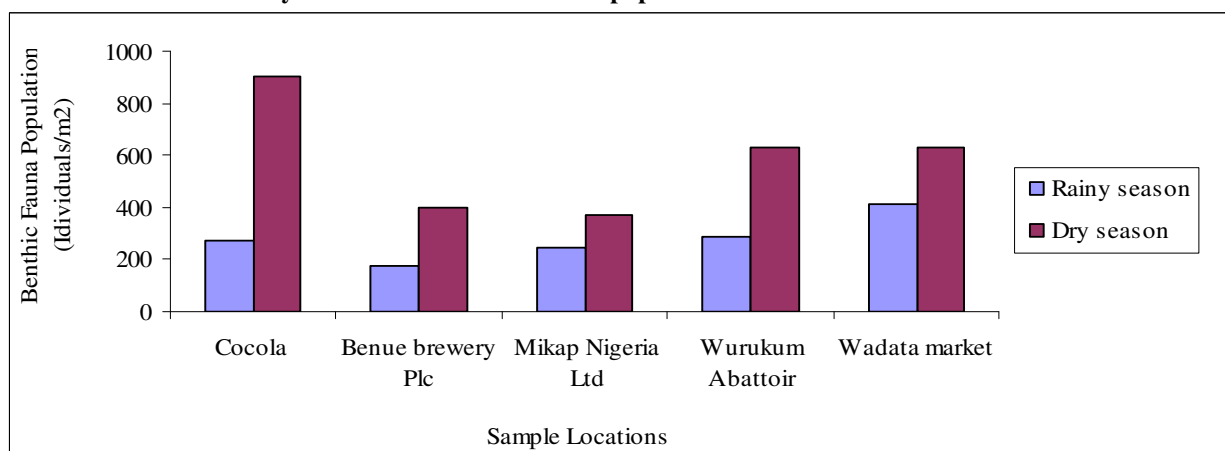
Figure-4
Seasonal Variation of Benthic fauna population in River Benue at Makurdi

The month of September 2012 was recorded with the lowest population of benthic fauna at all the locations during the period of this study. This may be due to the effect of the flood on River Benue during this month. Studies have shown that periods of high water quantity reduce the invertebrate fauna in rivers and streams[25]. Variations in the flow of water are frequently related with changes in the community structure of fluvial organisms[26]. The seasonal variation of benthic fauna showed that at all the locations in River Benue during the period of this study, the populations of benthic fauna during the dry season were higher than that of the rainy seasons. Hussan and Pandit[25] reported that streams and rivers that are more likely to spate, have less abundant and varied fauna than others that are not likely to have high quantity of water as was observed in River Benue during the course of this study. Similarly, population of macro invertebrates reduces when the water level is high as it is observed during the rainy season in River Benue[25]. However[27] reported more individuals of benthic fauna during the wet months as compared to the dry months in their 24 months research period in Lagos Lagoon which disagrees with the findings of this investigation.

The major factor that affects the occurrence and distribution of benthic fauna in lotic and lentic systems include, physico-chemistry, the nature of the substrate, (bed material), water current, food availability, flood, drought, vegetation and shade[25]. In this present investigation the benthic fauna obtained at Stations II and III may be ascribed to the industrial and human wastes discharged in the river at these locations. This scenario appeared to be responsible to the sparse distribution and population of benthic faun at these locations. This result is evident in the absence of pollution sensitive species of Stonefly, Mayfly and Caddisfly at these locations throughout the period of this study. This observation agrees with the finding of [28]. Also, the addition of high human activities around the sampling locations which released wastes into the river could also be possible explanation to the poor population of benthic fauna during the period of this study. The most significant characteristics of a lotic water system like River Benue, is water current. Thus current affects the population of benthic fauna in a water system as was noticed in River Benue during the course of this study[25].

Conclusion

The absence of sensitive benthic fauna species at Stations II and III during the course of this study is an indication of pollution. Uncontrolled discharge of industrial and municipal waste into the river should be enforced to protect human health and bio diversity.

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