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Plankton and Microbenthos Communities of Freshwater Habitats in Kogi State, North-Central Nigeria.

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Abstract

Three different rivers the Okpo, Idebu and parts of the Niger River were investigated for both micro and macro biota. The pH of the water showed neutral (7.07) water body with salinity of 0.03% and high dissolved oxygen content (5.1 mg/l). In the dry season, sulphate, Phosphate-phosphorus and Nitrate-nitrogen recorded 3.0, 0.003 and 0.138 mg/l respectively while 2.0, 0.005 and 0.210 mg/l were recorded in the wet season. The divisions, Bacillariophyta, Chlorophyta and Cyanophyta were recorded with pennate diatoms dominating the phytoplankton spectrum. The phyla; Cladophora, Copepoda and Rotifera represented the zooplankton with rotifers being the frequently encountered group. The macrobenthos recorded were Mollusca, Insecta, Hirudinea, Crustacea and Oligochaeta. High species in terms of number were recorded in wet season; this may be a pointer to environmental conditions such as rainfall and nutrients as major factors controlling the plankton abundance. Community structure analysis showed a relatively stressed environment.

Introduction

Plankton are the starting point of energy transfer in the aquatic ecosystem and are very sensitive to the environment they live in and any alteration in the environment leads to the change in the plankton communities in terms of tolerance, abundance, diversity and dominance in the habitat. Phytoplankton represent the base of food webs in any ecosystem and play a major role in the global cycling of carbon, nitrogen, phosphorus and other elements and the regulation of earth's climate. The biomass distribution and species composition of phytoplankton have important effects on carbon fixation rates and on transfer of energy in food webs. Therefore, plankton population observation may be used as a reliable tool for biomonitoring studies to assess the pollution status of aquatic bodies (Mathivanan and Jayakumar, 1995). The knowledge of plankton species composition and distribution to time and space are of great value especially in any running water system. As growing populations, progressive industrialization and intensification of agriculture are leading to increased pollution of our surface waters, there is a need for conservation of our resources especially water. According to Biddanda and Benner (1997), one of the main sources of carbohydrates in many aquatic systems is phytoplankton, where biomass is typically made up of from 15 to 35% carbohydrate. Townsend *et al*. (2000) stated that the distribution, abundance, species diversity and composition of the phytoplankton can be used to assess the biological integrity of a water body. Peerapornpisal *et al*. (2004) opined that species composition of the phytoplankton community is an efficient bioindicator for water quality. In Nigeria, some recent phytoplankton and macrobenthic fauna work are those of Abdullahi and Indobawa (2005) who worked on the phytoplankton of Hadeija river, Jigawa; Abubakar (2007) reported phytoplankton community of Lake Nguru, Kano; Adesalu and Nwankwo (2005, 2008) reported on Olero and Abule-Eledu creeks respectively; Adesalu *et al*. (2008) worked on Ogbe creek; Aneni and Hassan (2003) observed the abundance of plankton at Kudeti and Onireke stream Ibadan; Chindah and Pudo (1991) worked on Bonny river, Niger Delta; Dimowo (2013) reported on River Ogun; Edokpayi *et al.*, investigated macrobentic fauna of Kuramo water, Lagos; Ekwu and Sikoki (2005) worked on Cross River estuary; Emmanuel and Onyema (2007) investigated the Abule-Agege creek; New Calabar river phytoplankton was analysed by Erondu and Chindah (1991), Imoobe (2011) observed the Okhuo river while Mohammad and Saminu (2012) gave report on Salanta River Kano. Studies of the abundance, distribution and composition of phytoplankton communities are, therefore, a fundamental contribution to our understanding of the structure and function of ecosystems hence this study was carried out to know the status of these water bodies using plankton and microbenthos as indicators of the environment.

Materials and Methods

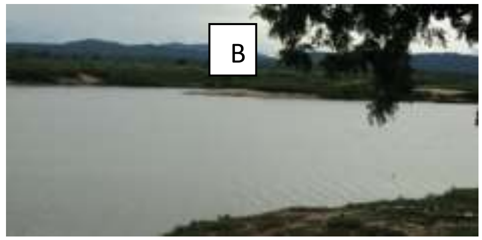
Description of study sites

Kogi State is situated in the savannah region with the State capital at Lokoja, located at the confluence of the two major Rivers, Niger and Benue. The State is bordered to the East by Benue State, to the South by Edo, Enugu and Ondo States, to the North by Niger and Nasarawa States and to the West by Kwara and Ekiti States. There are two main seasons, dry and wet. The wet season begins in May and stops towards the end of October. The ranges in mean monthly minimum and maximum temperatures during wet and dry seasons in the region were 21.9-26.5 and 30.7-36.7°C, respectively.

Okpo River a seasonal river, has an average width of about 6m with an average depth of about 0.3m during the dry season. Its depth increases to A maximum of about 1.2m during the wet season. It drains into River Niger.

Idebu River also a seasonal river has an average width of about 6.3m with average depth of about 0.5m during the dry season. Its depth increases to a maximum of about 1.2m during the wet season. The two river systems have no significant flow during dry season. It drains into River Niger.

River Niger: The River Niger, according to Goulden and Few (2011) is a transboundary river, originating from Guinea, flowing through Mali, Niger, forming the border with Benin and discharging into the Atlantic Ocean in Nigeria. The River Niger is a source of drinking water, hydro-electric power, irrigation, transportation, fishing among other uses (Ali *et al*., 2013). The study was carried out in the portion of the lower River Niger that falls in Ofu local government area of the State and its geographical coordinate at the access point is given as 07^{O} 24’ 46.518’’N, 06^{O} 44’ 42.081’’E which is approximately 60km to Lokoja, 260km to Abuja, approximately 120km to Kabba.



Part of Idebu River at Itobe Section of River Niger at Itobe

Collection of samples

Plankton: Samples were collected twice to denote the seasons (Wet and Dry). Due to the shallowness of the study site, a water sampler was used to collect the water samples directly which were transferred into well labeled 500ml plastic containers with screw caps and preserved with 4% unbuffered formalin. Surface water samples for physico-chemical analysis were collected in 1.5ml containers. Some analyses (pH and salinity) were done in-situ before taking the water samples in an ice chest to the laboratory for further analysis. Quantitatively, various plankton species were computed by calculating average cells (±5%) per transect following the method described by Vollenweider (1996). All identifications of plankton taxa were done using keys and illustrations presented in Davis (1955); Desikachary (1959); Hendey (1964); Patrick and Reimer (1966, 1975); Olaniyan (1968, 1969, 1975); Wiafe and Frid (2001); Hustedt (1930–1937) Whitford and Schumacher (1973); Krammer and Large-Bertalot (1986); Adesalu 2008; Nwankwo (1984) and Wimpenny (1966).

Macrobenthos: At each station, soil samples were scooped directly at the sampling points due to shallowness of the sites. The sediments were sieved through a 0.5mm mesh size stainless sieve. The sieve and its contents were immersed in the native water and gently agitated until organisms debris matrix were removed. The sieve contents were transferred into properly labeled, wide mounted glass jars containing 4% unbufferred formalin solution for preservation. The macrobenthos was observed under the Olympus microscope at different magnifications and biological species documented. Identifications were made using appropriate keys (Needham and Needham, 1962; Quigley, 1977; Atobatele, *et al*., 2005; Ibemenuga and Inyang, 2006). All bio-statistical methods used were according to Ogbeibu (2005).

Physico-chemical analysis: Surface water samples were analysed using APHA 1998 methods. Air and water temperatures were measured in-situ using mercury in glass thermometer while the pH was determined with Electronic Cole Parmer Testr3. Salinity was measured using a handheld refractometer. Gravimetric method was applied for both total dissolved and suspended solids. Dissolved oxygen and chemical oxygen demand were determined using titrimetric method while Winkler's method was applied for the determination of biological oxygen demand. Colorimetric method was applied for the nutrients contents (nitrate-nitrogen and phosphate-phosphorus) while turbidimetric method was used for sulphate (APHA 1998).

Community structure analysis: To obtain the estimate of species diversity, three community structure indices were used: Margalef's diversity index (d), Shannon-Weaner Index (H^1) (Shannon & Weaver 1963) and Species Equitability (j) or Evenness (Pielou 1975).

Results

Physico-chemical

The pH value was 7.07 in the dry season and 7.54 was observed in wet month while the salinity was between 0.02%. - 0.03%. In the dry season, Sulphate, Phosphate-phosphorus and nitrate-nitrogen recorded 3.0, 0.003 and 0.138 mg/l respectively while 2.0, 0.005 and 0.210 mg/l were recorded in the wet season. Highest value (24.0 mg/l) of total suspended solids was measured in dry season while 38.1 mg/l was observed for total dissolved solids in wet months. Oil and grease were detected only in wet season with 0.02 mg/l recorded. Dissolved oxygen value was high with 5.1mg/l and 4.5mg/l recorded in dry and wet seasons respectively while biological oxygen demand and chemical oxygen demand recorded 4.0mg/l and 6.0mg/l for both seasons respectively.

Plankton

Three classes of the microalgae group were represented in these rivers namely bacillariophyceae, Chlorophyceae and Cyanophyceae with the diatoms dominating the phytoplankton spectrum with total number of 41 taxa belonging to 16 genera out of the 59 taxa identified and most of it recorded in the wet season (Table 1). Green algae recorded 9 genera spread across the order zygnematales (*Spirogyra*) and desmidiales (*Cosmarium*)

Centrepoint Journal Volume 21. No. 1 (2015)

while blue green was represented by 3 genera; *Anabaena*, *Oscillatoria* and *Spirulina*. Higher phytoplankton individuals (cells/ml) was recorded in Okpo River (Figure 1). The zooplankton were represented by three phyla, Cladocera, Copepoda and rotifera with *Bosmina longirostris* recording the highest number of species (17cells/ml) at Okpo River in the wet months with rotifers being the frequently encountered species (Table 2). Species evenness (j) and Shannon-Weiner (H^1) indices followed almost the same pattern for phytoplankton as the highest and lowest values (1.38; 0.38) for Shannon-Weiner coincided with the highest and lowest values (0.50; 0.14) for species evenness and these values were recorded in wet and dry seasons respectively at Okpo river (Figure 2). For zooplankton, highest Shannon-Weiner value (1.12) and species evenness (0.99) were recorded at Okpo River while the Margalef index recorded the highest value (1.12) at Idebu River during the dry season (Figure 3).

Table 1: Phytoplankton composition of Idebu, Okpo and Lower parts of River Niger (cells/ml).

	Lower Part of River Niger		Okpo River		Idebu River	
CLASS: BACILLARIOPHYCEAE	Wet	Dry	Wet	Dry	Wet	Dry
Achnanthes sp (pennate)					**2**	
Cymbella affinis Kut	_		1			_
C. ehrenbergii Kutz	1		_			_
C. gracilis (Rabh.) Cleve	_		_			3
C. minuta Hilse	_		5			6
C. obscura Krasske	10		_			_
C. prostrata (Berkeley) Cleve	1		_			_
C. silesiaca Bleisch	2		_			2
Navicula bergenenis Hoh				3		
N. decussis Oestrup		1				
N. exigua(Greg.) O. Muller		1			2	
N. laevissima Kutzing		1				
Navicula sp.				6	5	
Surirella elegans Ehrenberg		1		1		
Surirella sp.				4	1	
Amphora aequalis Krammer				**5**		
A. coffeaeformis (Agardh) Kutzing	1		12		5	–
A. commutata Grunow				2		
A. holsatica Hustedt				3		
A. normanni Rabenhorst	2		_			_
A. ovalis Kutz		4				
A. veneta Kutzing	_		1	2		2
Amphora sp				2		
Anomoeoneis sp				2		
Caloneis ventricosa (Ehr.) Meister	1		1			_
Cocconeis scutellum Ehr.	_		1			4
Cocconeis sp.	2		_			_

Cyclotella meneghiniana Kutz	2		_			_
Diatoma sp.	_		1			_
Gonatozygon kinahanii (Arch.) Rabenhorst		5				
Gyrosigma scalproides (Rabenhorst) Cleve					1	
Mastogloia braunii Grunow		1		2	3	
M. smithii Thwaites					2	
Neidium ampliatum (Ehrenberg) Krammer				3		
N. minutissimum Krasske		2				
N. septentrionale Cleve – Euler		7		1		
Nitzschia kutzingiana Hilse					2	
P. gibba Ehrenberg		1				
*P. interrupta*W. Smith		4				
P. lundii Hustedt					4	
P. maior(Kutzing) Rabenhorst		1				
CLASS: CHLOROPHYCEAE						
Ankistrodesmus sp.	_		1			_
Chlorella vulgaris Beyerinck	_		2			_
C. ellipsoida Gerneck	_		2			_
Closterium archerianumi Cleve	3		_			_
C. ehrenbergii Menegh	_		1			_
C. moniliferum Ehrenb.	1	2	3		3	_
C. pseudodianae Roy	2		_			_
Closterium sp.	2		_			_
Cosmarium botrytis Meneg.	1		_			_
Cosmarium sp.	_		55	3		_
Desmodesmus quadricauda (Turp) Brebisson	2		_			_
Euasturm sp.	1		_			_
Microspora sp.	30		_			_
Scenedesmus bijuga (Turp.) Lagerherm	_		1			_
Spirogyra sp.	_		1			_

CLASS: CYANOPHYCEAE						
Anabaena sp.	_		2			_
Oscillatoria sp.					5	
Spirulina sp					1	
Total number of species	17	13	16	14	13	5
Total number of individuals	64	31	90	39	36	17
Margalef species diversity (d)	3.85	3.49	3.33	3.55	3.35	1.41
Shannon-Weiner (H^1)	0.81	0.48	1.38	0.38	0.43	0.71
Species evenness (j)	0.29	0.19	0.5	0.14	0.17	0.44

Table 2: Zooplankton composition at Idebu, Okpo and Lower parts of River Niger

	Lower Part of River Niger		Okpo River		Idebu River	
	Dry	Wet	Dry	Wet	Dry	Wet
Cladocera						
Bosmina longirostris	_	8	2	17	2	2
Copepoda						
Eucyclops agiloides	2	5	6	2	2	10
Rotifera						
Kellicortia longispina.	4	4	6	6	2	
Branchionus diversicornis	6	2		7		5
Total number of species	3	4	3	4	3	3
Total number of individuals	12	19	14	32	6	17
Margalef species diversity (d)	0.80	1.02	0.76	0.87	1.12	0.71
Shannon-Weiner (H^1)	1.01	0.94	1.09	1.12	0.91	0.68
Species evenness (j)	0.92	0.68	0.99	0.81	0.83	0.62

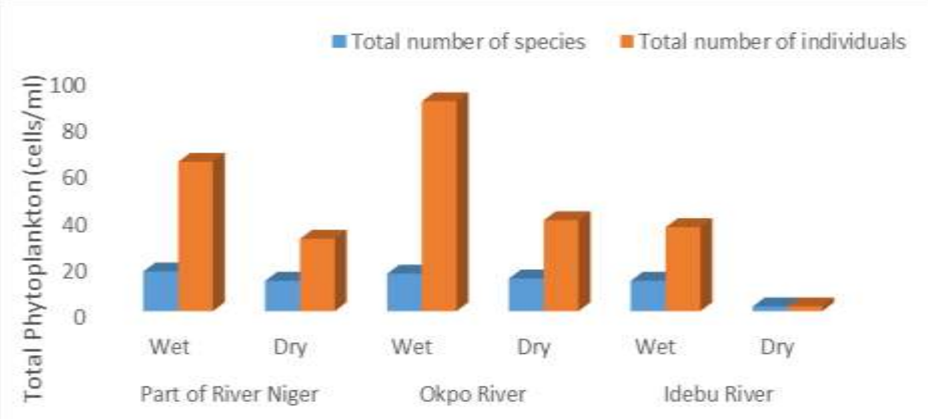


Figure 1: Total phytoplankton (cells/ml) at Idebu, Okpo and part of River Niger

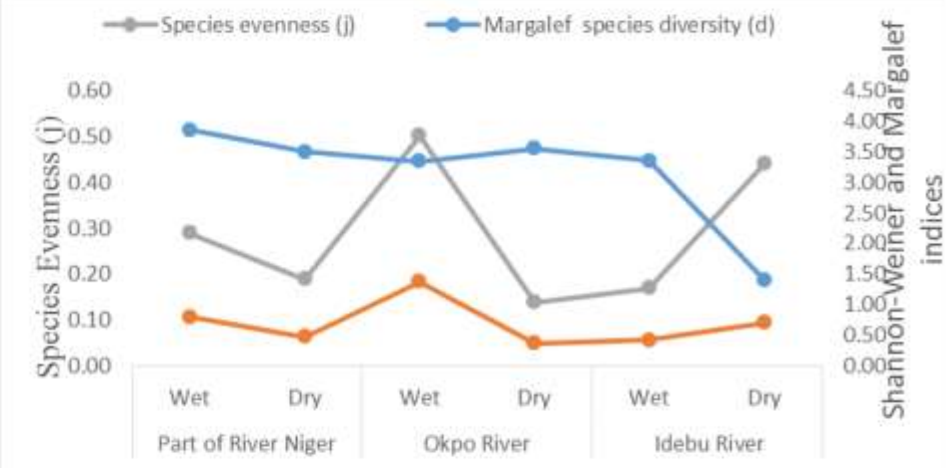


Figure 2: Diversity indices of phytoplankton at Rivers Idebu, Okpo and part of River Niger

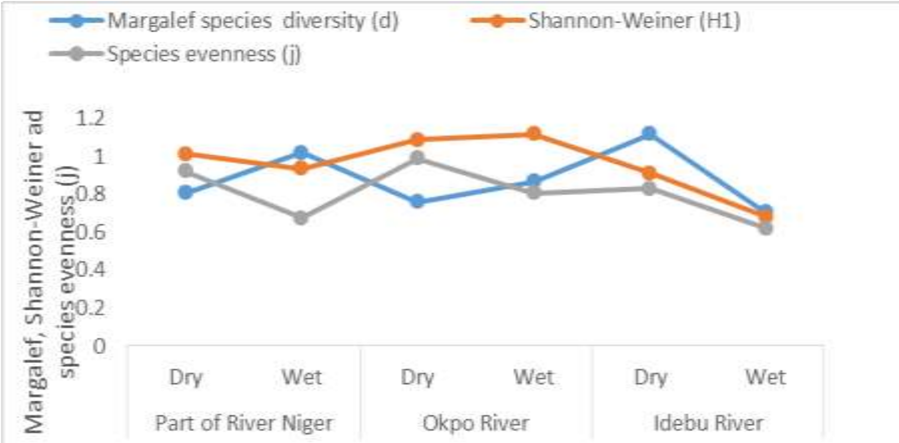


Figure 3: Diversity indices of zooplankton at Rivers Idebu, Okpo and part of Niger River

Macrobenthos

The spatial distribution, species composition and diversity of macro-benthic fauna are presented in Table 3. Oligochaeta accounted for 37.27% of the total individuals with dominant taxon being *potamopyrgus* sp. followed by Hirudinea (19.09%); insect and mollusca had 16.36% each; and crustacean recorded 10.91%. Shannon-Weiner index (H^1) and species richness (d) highest values (1.33; 1.48) were recorded at Idebu River while lowest values (0.75; 0.72) were observed at Okpo and a part of River Niger respectively (Figure 4). The part of River Niger during dry season recorded the highest (0.94) species evenness (j) value (Figure 4).

Table 3: The distribution, occurrence and diversity indices of macrobenthic invertebrate Community.

	Lower Part of River Niger		Okpo River		Idebu River	
	Dry	Wet	Dry	Wet	Dry	Wet
Mollusca						
Potamopyrgus sp.			14		4	
Hirudinea						
Glossiphonia complanata	6	1		2	8	4
Insecta						
Chrysops sp.	4		9		3	2
Crustacea						
Palaemonetes spp.			2	6		4
Oligochaeta						
Lumbriculus sp.		12	7	8		4
Tubifex sp.	2	4			3	1
Number of species	3	3	4	3	4	5
Number of individual	12	17	32	16	18	15
Margalef index diversity (d)	1.14	0.71	0.87	0.72	1.04	1.48
Shannon-Weiner (H^1)	1.31	0.75	1.22	0.97	0.99	1.33
Species evenness (j)	0.94	0.69	0.88	0.89	0.72	0.82

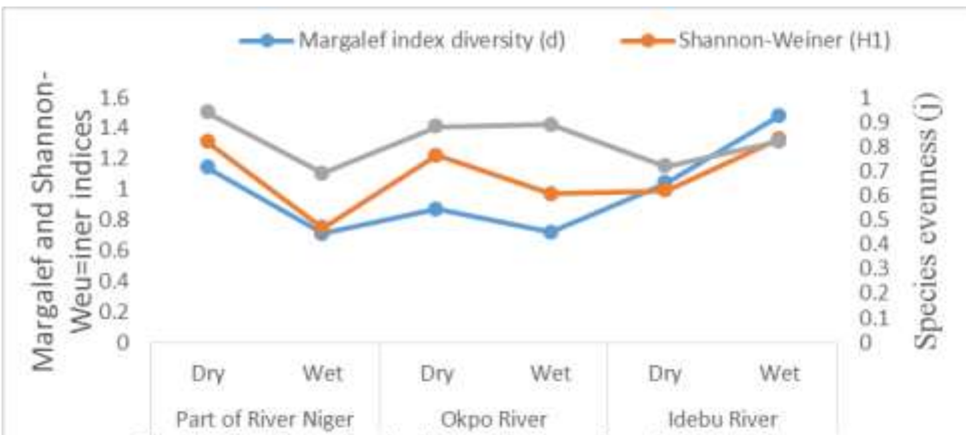


Figure 4: Diversity indices of macrobenthos at Rivers Idebu, Okpo and part of Niger River...

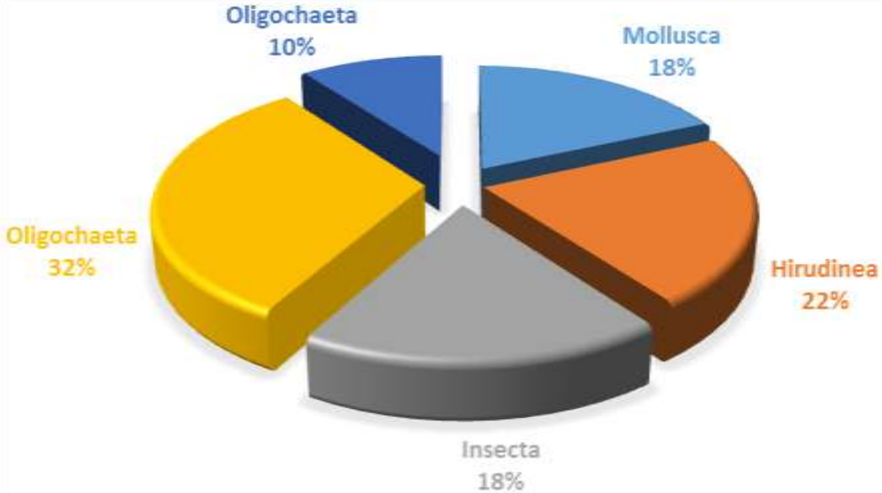


Figure 5: Percentage composition of macrobenthos at the study sites

Discussion

The relative abundance of diatoms in these rivers may be because they are able to grow at low light levels. The present observation that diatoms dominate the phytoplankton community confirms earlier reports made by Nwadiaro (1990) in the chanomi creek system of the Niger Delta; Chindah and Pudo (1991) in Bonny River; Erondu and Chindah (1991) in the new Calabar River, Niger Delta; Adesalu (2008) in Lekki lagoon; Adesalu and Nwankwo (2005, 2008) in Olero and Abule Eledu creek respectively; Adesalu *et al.* (2008, 2014) in Ogbe and Ipa-Itako creeks, and Nwankwo (1986, 1991) in the Lagoons of South western Nigeria. Many factors may have contributed to the dominance of pennate forms, which probably may be a confirmation of the shallow nature of these rivers. Differences in abundance of most species during the two sampling periods could be attributed to significant variations in the physico-chemical variables and nutrients levels within these periods. High number of individuals (cells/ml) recorded for these rivers in the wet season, could be because the rivers are seasonal and are almost getting dry during the dry season and getting flooded in the wet season. The flooding will bring along with it flood water from the riparian vegetation and this probably explains the high cells/ml recorded during the wet season in this study. However, the number of zooplankton recorded in this study was scanty which may be as a result of the seasonal characteristics of these rivers as more, in terms of number, was recorded in the wet season. This is in conformity with Imoobe (2011) who stated that flooding during the rainy season may have contributed positively to zooplankton population growth as a result of species recruitment from other flooded waterbodies and the inflow of nutrients from the drainage basin that will trigger off increase in phytoplankton production and consequently zooplankton productivity. Higher number of zooplankton species richness recorded in the rainy season agreed with the findings of Imoobe (2011). According to Akinbuwa & Adeniyi, (1996); Imoobe and Akoma, (2009); and Imoobe (2011) the dominant status of rotifer species in rivers comparative to the cladocerans and copepods is characteristic of tropical lakes and rivers which this study conformed with. However, seasonal dynamics of zooplankton communities in the tropics has been attributed to a number of other factors such as the environmental characteristics of the water, predation, quality and quantity of edible algae and competition (Ovie and Adeniji 1994).It is obvious from this study that the environmental conditions especially rainfall were the main factors controlling the abundance of zooplankton. Macro-benthic communities play important roles in ecosystem processes such as recycling nutrients, detoxifying pollutants and secondary production (Snelgrove, 1997). However, the present study showed a dearth in number and composition of species.The family, lumbriculidae, has been reported to dominate aquatic benthic invertebrates' communities because they hardly show any habitat restriction (Victor and Ogbeibu, 1991) and are known to replace other invertebrate taxa in aquatic habitat perturbed by human activities. This probably indicates the extent of human activities around these rivers. The presence of oligochaetes supported Ogunwenmo and Kusemiju (2004) who reported that oligochaetes preferred polluted tropical waters and soft sediments rich in organic matter as observed in this study. Furthermore, the dominance by the deposit –feeding gastropod, *Potamopyrgus* sp. which are common in all types of running water and are found in vast numbers on stones, vegetation or mud shows, a clearly opportunistic behavior (Bemvenuti *et al.*, 1992) which is also an indication of a stressed environment. However, the low number in the population of macro-benthic invertebrates recorded at the study stations could be due to the developmental rate of small macro-invertebrates, since most aquatic invertebrates are benthic only at larval stages while their adult lives are spent outside aquatic environments (Ibemenuga and Inyang, 2006).

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