COMMUNITY STRUCTURE AND DIVERSITY OF MACROBENTHIC INVERTEBRATES IN RELATION TO SOME WATER QUALITY PARAMETERS IN A MUNICIPAL RIVER IN SOUTHERN NIGERIA

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Abstract

Macrobenthic invertebrates' community structure and diversity in relation to some water quality parameters of Owan River; Edo State, was investigated from March 2011 to August, 2011. The study was aimed to determine the water-quality and their relationship with the community structure and diversity of macro-invertebrates in the river. Two sampling stations were selected along the river course (Ogute; Station 1 and Evbiamen; Station 2). Quantitative physico-chemical parameters and macro-invertebrates were collected monthly at the two stations. The range of the physico-chemical parameters obtained were Temperature (23.2-26.5^{o}C), Depth (0.55-2.05 m), flow velocity (0.05-0.48 m/s), conductivity (25.42- 30.94 µS/cm), pH (6.3-7.8), DO (5.2-7.8 mg/l), BOD (1.78-2.4 mg/l), phosphate (0.03-0.58 mg/l) and sulphate (7.8-9.4 mg/l). Analysis of variance (ANOVA) revealed that there were significant difference (p<0.05) in conductivity, temperature, pH, phosphate, BOD, depth and flow velocity between the sampled stations and months, while DO showed significant difference (p<0.05) in the sampled months but not significant (p>0.05) in the sampled station. Sulphate showed no significant difference in the sampled months (p>0.05) but showed significant difference in the sampled stations (p<0.05). A total of 26 taxa of 591 individual were collected. The most abundant taxon was Mollusca (180). The highest number of macroinvertebrates was recorded in Station 2. The Canonical Correspondence Analysis showed a fairly good relationship between some macrobenthic invertebrates' species distribution and some measured environmental variables. Water depth, pH and DO were negatively correlated with sulphate and flow velocity. *Melanoides moerchi* was slightly affected positively by phosphate while *Stenophylax* sp., *Potadoma moerchi* were fairly associated with increased conductivity. Analysis of species diversity revealed that the highest number of taxa richness was recorded in Station 2, while Station 1 had the highest species diversity. Simpson dominance (D) was higher in Station 2 compared to Station 1. From the physico-chemical parameters and macrobenthic structure-showed that the river may be subjected to perturbation in the nearest future as a result of the various level of anthropogenic activities carried on in the river.

Keywords: macrobenthic invertebrates, mollusca, Owan River, diversity and southern Nigeria.

Accepted: 8 December, 2014.

Introduction

Aquatic macrobenthic invertebrates have been used as indicators of stream and riparian health for many years (Karr, 1999 and Smith *et al,* 1999). Perhaps more than any other taxa they are closely tied to both aquatic and riparian habitats. Their life cycles usually

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Zoological Society of Nigeria.

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include periods in and out of the water, with ties to riparian vegetation for feeding, pupation, emergence, mating, and egg laying (Erman, 1991, Edegbene *et al,* 2014). It is often necessary to look at the entire assemblages of aquatic invertebrates as an indicator group. Impacts on a stream often decrease diversity, but can increase the abundance of some species (Wallace and Gurtz, 1986).

Most rivers in developing countries like Nigeria are subjected to increasing pollution load as a result of various kinds of human activities, which have become a foremost threatening factor to the quality of water (Arimoro and Osakwe, 2006, Arimoro and Ikomi, 2008). These activities cause diversity of stresses to aquatic systems and may affect aquatic organisms including the macro-invertebrates at different temporal and spatial scales. Some of these human influences activities include: defaecating in the water bodies, car washing, use of organic chemicals for fishing, agricultural waste such as cassava peels, abattoir wastes, wood wastes, just to mention a few (Mathooko, 2001; Walsh *et al,* 2002, Wade *et al,* 2002; Kirkagac *et al,* 2004; Arimoro and Osakwe, 2006; Arimoro *et al,* 2008; Edegbene and Arimoro, 2012). In view of this aforesaid detrimental effect of human activities in water bodies in this part of the world, this study was aimed at the present water quality status and their relationship with the community structure and diversity of macro-invertebrates in Owan River.

Materials and methods

Study area

Owan River is one of the numerous freshwater bodies that abound in the southern part of Nigeria. Owan River is located between the interception of Latitude 5.43°N and Longitude 6.48°E of the Equator (Figure 1). It is a tropical municipal river, which serves as portable water for most of the riparian communities. The river takes its source from Otuo in Owan East Local Government Area of Edo State and flows south-ward passing through Aken, Uokha, Ovbiowun, Afuze, Ogute, Evbiamen, Okpokhumi, Ojavun, Sabon-gidda Ora, Uhonmora in Owan West to Uzebba where it joins River Ose.

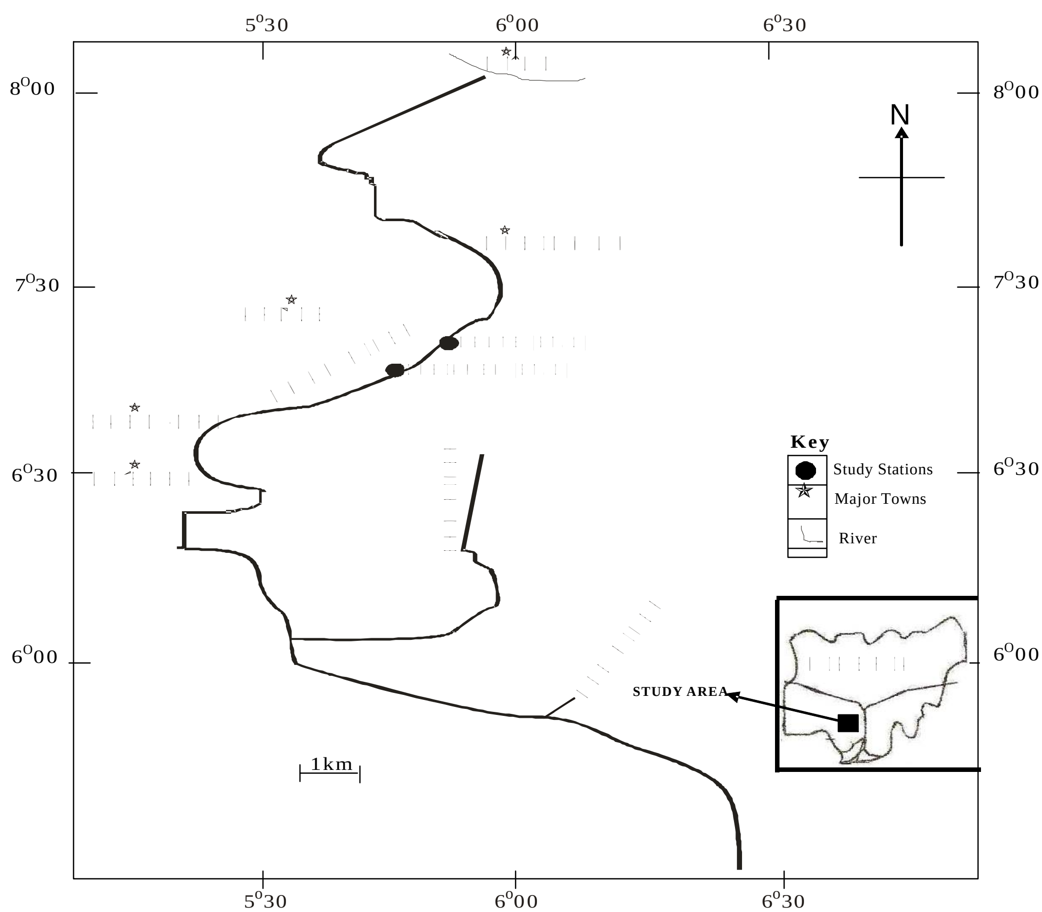

Figure 1. Map of the study-area showing the sampling stations.

Sand-dredging is also carried out in almost all the reaches of the river all year round which serves as source of building material for the people of this area. The water also serves as a means for subsistence fish-farming, bathing, washing of clothes and other households use. Furthermore, the river is also influenced by frequent disturbance of humans and domestic activities aside the ones earlier mentioned. These influences include pollution of the water body by chemicals used for fishing at least once in a year, run-off of pesticides, and fertilizers from near by farm settlements.

The study-area shows the characteristics tropical climate of two distinct seasons, the dry season (November-April) and wet season (May-October). The stream-bed consists mainly of fine sand, mud in some areas, occasionally with coarse sand, decaying debris of macrophytes, rocks, logs of wood. The river is principally fed with precipitation, municipal effluence and surface run off from the riparian communities. For the purpose of this study, two sampling stations were chosen.

Physico-chemical parameter sampling

Water samples were collected monthly from each station for 6 months (March, 2011-August, 2011). Water temperature was measured *in-situ* at each sampling time using mercury-in-glass thermometer. Flow velocity was measured in midchannel on three occasions by timing a float (average of three trials) as it moved over a distance of 10m (Gordon *et al* 1994). Water depth and width were measured in the sample-area using a calibrated stick. Dissolved oxygen (DO), biochemical oxygen demand (BOD), pH and alkalinity were determined according to APHA (1992) method. Phosphate and sulphate were measured spectro-photometrically after reduction with appropriate solutions (APHA, 1992).

Macrobenthic invertebrates sampling

Kick samples of macrobenthic invertebrates were collected monthly (March, 2011-August, 2011) with D-frame net (800 mm mesh) within an approximately 25 m wadeable portion of the river. Four 3-min samples were taken on each sampling visit to include all different substrate and flow regime zones. This sampling strategy was evaluated (a semi-quantitative sample (0.5 m^2 quadrant) was collected with a modified kick net (Lazorchak *et al*, 1998) Samples collected from the net were preserved in 70% ethanol and transferred to the laboratory. At the laboratory samples were washed in a 500 mm mesh sieve to remove sand and macrobenthic invertebrates were then picked from the substrate with aid of a forceps and microscope. All animals were enumerated and identified under a binocular dissecting microscope following keys by (Durand and Leveque, 1981; Merritt and Cummins, 1996) and Gerber and Gabriel (2002).

Data analysis

Community attributes and physico-chemical parameters of the sampling stations were compared using two ways analysis of variance (ANOVA). The components metrics used in assessing the macrobenthic invertebrates of Owan River were species composition and community structure. Canonical correspondence analysis (CCA) was used to evaluate relationships between macrobenthic invertebrates' communities and some environmental variables with *Brodgar Statistical Package* (Version 2.0, Highland Statistics Ltd., 2000). Taxa richness (Margalef index), diversity (Shannon-Wiener index), evenness and dominance indices were calculated using the computer BASIC program SP DIVERS (Ludwig and Reynolds, 1988).

Results

Physico-chemical variables

The mean, standard deviation, minimum and maximum value, ANOVA (*f*-values of physical and chemical parameters of the different stations in Owan River are summarized in Table 1). Conductivity, water temperature, pH, phosphate, BOD, depth and flow velocity were significantly different ($p<0.05$) between the sampling stations and months, while DO was statistically significant ($p<0.05$) between the sampling months but not significant ($p>0.05$) in the sampling stations. Sulphate shows statistical significant between the sampling stations ($p<0.05$) but not significant between the sampling months ($p>0.05$).

Benthic macro-invertebrates community structure

A total of 591 individuals of macro-invertebrates were collected from Owan River, with 26 taxa identified belonging to 20 families. Station 2 had the highest number of macro-invertebrates (312 individuals). Mollusca were the dominant macro-invertebrates in Owan River represented by 151 individuals with *Potadoma moerchi,* well represented in the two stations. *Melanoides tuberculata* and *Melanoides morechi* were absent in Station 1 and fairly represented with 9 and 2 individuals respectively in Station 2.

Ephemeroptera was sparsely represented in the two stations. Station 2 had the highest Ephemeroptera composition of 12 individuals. *Centoptilum* species was absent in Station 1.

Table 1: Summary of physico-chemical parameters of the study stations of Owan River, (March, 2011-August, 2011), Niger Delta, Nigeria.

Parameter	Station 1	Station 2	Months		Stations	
			F-values	*p*-value	*F*-values	*p*-value
Water Temperature (^oC)	25.2 ± 0.98 (24.2 – 26.5)	24.7 ± 1.16 (23.2 – 26.2)	24.7	$p<0.05$	23.2	$p<0.05$
Flow velocity (m/s)	0.38 ± 0.21 (0.10 – 0.48)	0.26 ± 0.18 (0.080 – 0.44)	50.9	$P<0.05$	31.7	$p<0.05$
Water depth (m)	1.23 ± 0.63 (0.63 – 1.84)	1.29 ± 0.79 (0.55 – 2.05)	77.2	$p<0.05$	8.80	$p<0.05$
Conductivity (µS/cm)	27.40± 2.20 (25.4 – 29.8)	29.9± 0.89 (28.9 – 30.9)	3.29	$p<0.05$	635.1	$p<0.05$
Biochemical Oxygen Demand ($BOD_{5)}$ (mgl^{-1})	2.04 ± 0.15 (1.84 – 2.20)	2.06 ± 0.25 (1.78 – 2.40)	19.2	$p<0.05$	2.90	$P<0.05$
pH	6.95 ± 0.48 (6.50 – 7.60)	6.88±0.53 (6.3 – 7.60)	50.0	$p<0.05$	11.3	$p<0.05$
Phosphate (mgl^{-1})	0.036 ± 0.007 (0.030 -0.046)	0.049 ± 0.006 (0.04 – 0.058)	5.70	$p<0.05$	80.7	$p<0.05$
Sulphate (mgl^{-1})	9.33 ± 0.05 (8.84 – 10.20)	8.37 ± 0.59 (7.80 – 9.20)	1.40	$p>0.05$	23.1	$p<0.05$

Note: Values are means± standard deviation. Maximum and minimum values in parenthesis. The *f*-values indicate ANOVA and *p*-value indicating the level of probability.

Odonata was represented by 3 families also predominantly present during the study-period except the family Macromidae represented by *Caenis aenum* which was absent in Station 1 and represented only by 1 individual in Station 2. The family Libellulidae was the most diverse Odonata in the study-stations. Coleoptera was relatively higher in Station 1 with *Gyrinus* species having the highest number of individuals (30). Elmidae was sparsely represented by 7 individuals in the two stations.

Hemiptera had four families. *Nepa* species was represented by 24 individuals being the highest while *Notonecta* species had just 2 individuals in Station 2. Trichoptera was absent in Station 1 and sparsely represented by 4 individuals in Station 2. Diptera was represented by three families and 5 taxa and they were well represented in the two stations. *Chironomus transvaalensis* was the most diverse Diptera. Crustacea was represented by only one family Sudanodidae and one species and it recorded 17 individuals being the less diverse macroinvertebrates group in Owan River.

Relationship between macrobenthic invertebrates and some environmental variables

The Canonical Correspondence Analysis (CCA) ordination plot for sites, environmental variables and species is shown in Figure 2. The CCA ordination showed a fairly good relationship between some macrobenthic invertebrates' species distribution and some measured environmental variables (DO, flow velocity and pH). The weak environmental factors were BOD, water temperature, water depth, conductivity and phosphate. DO showed a very weak correlation with conductivity and phosphate. Water depth, pH and DO were negatively correlated with sulphate and flow velocity. *Chironomus transvaalensis*, *Hydrophilus* sp, *Caenis aenum, Naucoris* sp., *lestinogomphus* sp., *Culex* sp., were associated with Station 2 in March, April, May, June and August. *Melanoides moerchi* was slightly affected positively by phosphate while *Stenophylax* sp., *Potadoma moerchi* are fairly associated with increased conductivity. Flow velocity negatively affected *Caenis aenum* and *Sudanonautes floweri*.

Table 2. Composition and distribution of macro-invertebrates of Owan River (March 2011-August, 2011).

Taxa/Order	Family	Species	Codes	Stations		
				1	**2**	**Total**
Mollusca	Thiaridae	*Potadoma moerchi*	PTM	40	111	151
		Melanoides tuberculata	MET	–	9	9
		Melanoides moerchi	MEM	–	2	2
	Unionidae	*Pseudospatha sp.*	PSS	7	11	18
Ephemeroptera	Baetidae	*Baetis* sp.	BAS	3	1	4
		Cloeon sp.	COS	2	5	7
		Centroptilum sp.	CES	–	1	1
	Caenidae	*Caenis aenum*	CAA	5	4	9
Odonata	Macromidae	*Macromia* sp.	MAS	–	1	1
	Gomphidae	*Lestinogomphus* sp.	LES	8	12	20
	Libellulidae	*Libellula* sp.	LIS	39	35	74
Coleoptera	Hydrophilidae	*Hydrophilus* sp.	HYS	25	12	37
	Gyrinidae	*Gyrinus* sp.	GYS	30	5	35
	Elmidae	*Promerisia* sp.	PRS	4	3	7
Hemiptera	Nepidae	*Nepa* sp.	NES	20	24	44
	Gerridae	*Gerris* sp.	GES	9	13	22
	Notonectidae	*Notonecta* sp.	NOS	2	3	5
	Naucoridae	*Naucoris sp.*	NAS	18	22	40
Trichoptera	Limnephilidae	*Stenophylax* sp.	STS	–	3	3
	Hydroptilidae	*Leptonema* sp.	LPS	–	1	1
Diptera	Chironomidae	*Chironomus transvaalensis*	CHT	26	11	37
		Pentaneura sp.	PES	19	5	24
		Polypedilum sp.	POS	3	4	7
	Culicidae	*Culex* sp.	CUS	4	4	8
	Tabanidae	*Tabanus* sp.	TAS	3	4	7
Crustacea	Sudanonidae	*Sudanonautes floweri*	SUF	12	5	17
Total				**279**	**312**	**591**

Macroma sp., *Gerris* sp., *Tabanus* sp., *Melanoides tuberculata* were isolated organisms but slightly associated with Station 2 in March. Monte Carlo permutation test revealed that there were no significance difference in axes 1 and 2, 0.2871 and 0.9109 respectively. Axis 1 explained more of the relationship between the physicochemical variables and the macroinvertebrates (43.47%). The total Eigen value of axis 1 (0.187) and 2 (0.0684).

Diversity and dominance of macroinvertebrates in the study stations of Owan River

Taxa richness (d) was highest in Station 2 (4.35). Station 1 had the highest Shannon Weiner diversity (H) with a value of 1.142. Maximum species diversity (Hmax) showed no marked difference in Station 1 and 2. Station 1 (0.38) and station 2 (0.33).

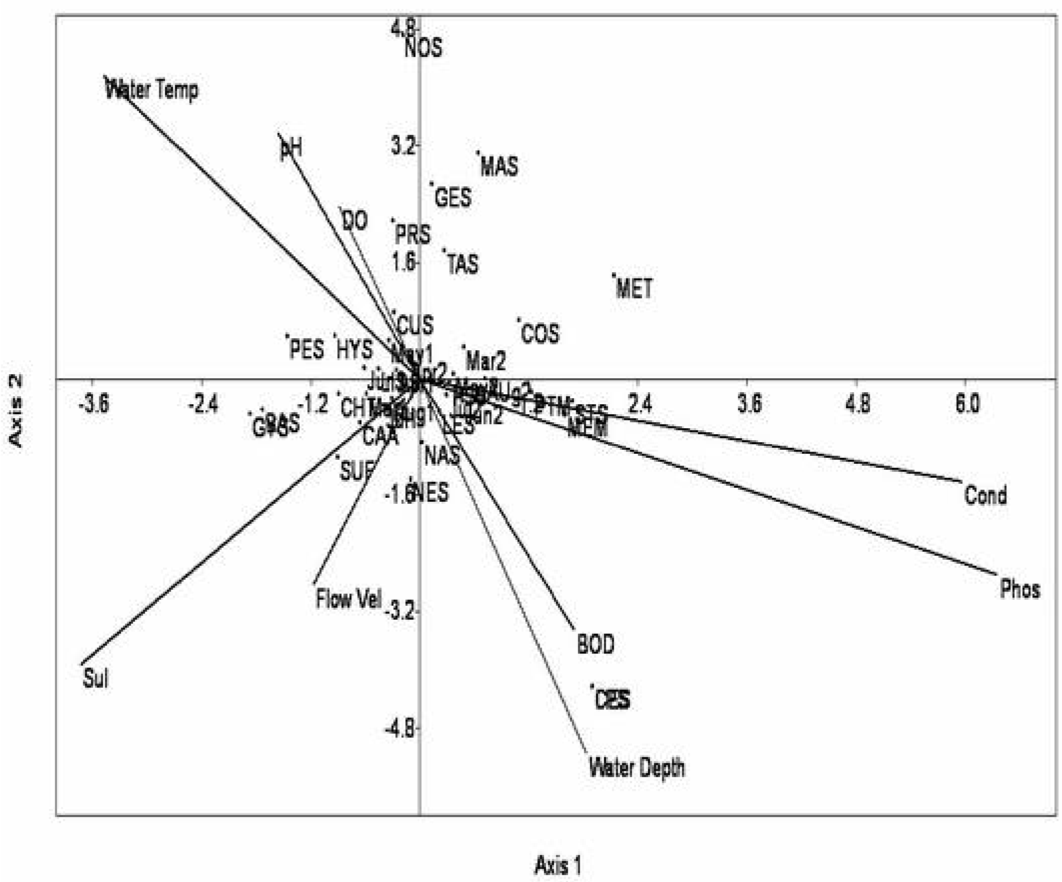

Figure 2. Canonical Correspondence Analysis (CCA) ordination for sites and environmental variables, macrobenthic invertebrates species code in Table 2 (Monthly codes are Mar, March; Apr, April; May, May; Jun, June, Jul, July and Aug, August Sites are 1 and 2.

Table 3. Diversity and dominance of macro-invertebrates in the study-stations of Owan River (March 2011-August, 2011).

	Stations	
	1	2
No. of taxa	20	26
No. of individuals	279	312
Margalef's index (d)	3.37	4.35
Shannon weiner index (H)	1.142	1.071
Maximum species diversity (Hmax)	2.99	3.26
Evenness index (E)	0.38	0.33
Simpson's dominance (D)	0.084	0.269

Discussion

Owan River showed two characteristic seasons, a dry season (November to April) and rainy season (May to October) typical of the tropical countries (Imoobe and Oboh, 2003 and Edegbene *et al,* 2012).

The water temperature (24.2-26.5^{o}C) observed in this study is typical of most tropical waters, similar to the study carried out by (Edokpayi *et al,* 2000; Arimoro *et al,* 2007 and Edegbene *et al,* 2012). Station 1 had the highest water temperature in most during the study-period. This may primarily be as a result of few tree cover and heat exchange in air. This observation is in agreement with the findings of (King and Nkanta, 1991 and Arimoro and Ikomi, 2008).

Flow velocity is a function of the amount and width of the water channel (Nelson and Liebermann, 2002). There was a great distinction in the flow velocity of Owan River. Station 1 also had the highest value of flow velocity and this can be attributed to surface run-off and storm water from town around the station, probably due to few tree cover which may not be good enough to act as wind and erosion breaker.

The high value of water depth observed in the two stations sampled in some months was associated with the number of rainy days especially from June to August. The increased water level was as a result of run-off upland during the raining season. Similar seasonal patterns in water level have been documented for other Nigerian water bodies (Ikomi *et al,* 2005; Arimoro *et al,* 2007).

Dissolved oxygen concentration of the stations sampled showed that they were slightly aerated site. Dissolved oxygen ranged from 5.2-7.8 mg/l in this study area. Similarly, (Ikomi *et al,* 2003); Olomukoro and Egborge 2004), in Warri River, Delta State; (Edokpayi *et al,* 2004) in Kuramo water body in Lagos State; (Ikomi *et al,* 2005) in Ethiope River, Delta State; (Arimoro and Ikomi, 2008; Arimoro and Muller, 2010) in Orogodo River, Delta State had earlier reported the same value range of dissolved oxygen in their studies. This they attributed to the increased primary production of macrophytes and the level of organic suspended solids.

Biochemical oxygen demand (BOD_5) values indicates the extent of organic pollution in water quality (Jonnalagadda and Mhere, 2001). At station 2 BOD_5 values was 1.78-2.40 mg/l which showed that the water in this station was becoming stressed as a result of organic pollution and anthropogenic activities. This observation is in accordance with the findings of (Silvia *et al,* 2006) in Southern Brazilian River, (Ogbeibu and Oribhabor, 2002) in Ikpoba River.

The pH values in this study were slightly acidic with little tendency towards neutrality which is typical of forest stream. The pH value ranged from 6.5-7.6 which was in accordance with similar range of 6.60-8.22 recorded by (Arimoro *et al,* 2008) in Warri River. The range recorded in this study is very close to those recorded in many Nigerian and other African water bodies (Jonnalagadda and Mhere, 2001; Imoobe and Oboh, 2003; Olomukoro and Egborge, 2004; Arimoro and Osakwe, 2006). The low pH recorded here may be due to the growth of aquatic macrophytes, reduced photosynthetic activity by submerged macrophytes and influx of acidic ions from the riparian community.

A total of 591 macro-invertebrates classified into 26 taxa was recorded in Owan River compares favourably with 27 taxa reported by (Arimoro *et al,* 2007) in River Orogodo. *Potadoma moerchi* were the most dominant macro-invertebrates during the study comprising of 151 inidviduals. This may be that the river presented unique characteristics that favoured the survival and dominance of the mollusca. Edokpayi *et al* (2004) worked on Kuramo Water in Lagos State of Nigeria reported only one family of gastropods (Viviparidae) represented by 59 individuals which they attributed to low salinity value recorded during their study. Ikomi *et al* (2005) while working on River Ethiope in Niger Delta area of Nigeria reported 36 gastropods individuals consisting of 3 families. Also in a similar report by (Olomukoro and Ezemonye, 2007) recorded four species of molluscs (*Lanistes sp., Mutela cf. dibia, Hydrob*ia sp. and *Potadoma* sp.) which were only sparsely present in two rivers of the 20 rivers studied in Edo State Ecozone in southern, Nigeria. Elsewhere in India (Garg *et al,* 2009) reported gastropods as the dominant class of Molluscan studied in Ramsagar reservoir between March, 2003 and April, 2005. They also reported that gastropods were positively correlated with conductivity, pH, total alkalinity, phosphate, sodium and potassium.

The Order Ephemeroptera includes species that are tolerant as well as those that are intolerant to various forms of pollution (Menetrey *et al,* 2008). In accordance with this, the family Baetidae represented by *Baetis* sp., *Cloeon* sp. and *Centoptilum* sp. while the family Caenidae represented only by *Caenis aenum* showed that the river is becoming stressed with organic pollution. This is in consonant with Arimoro (2009) report in Adofi River, Delta State. Other studies have also reported that the genera *Baetis* are tolerant to organic pollution (Timm 1997; Menetrey *et al,* 2008).

Trichoptera was present in Station 2 and absent in Station 1. The assemblage of Trichoptera in Station 2 may be attributed to the relatively stable water quality of Station 2 (Arimoro and Ikomi, 2008 and Edegbene and Arimoro, 2012).

Hemiptera was represented by 21 individuals consisting of four species. (Edegbene and Arimoro, 2012) reported six species in the same Owan River while (Ikomi *et al,* 2005) reported nine species in Ethiope River, Delta State.

Odonata was represented by three families and three species namely *Macromia* sp., *Lestigomphus* sp. and *Libellula* sp. These species are well represented except *Macromia* sp. that was absent in station 1 and only having one representative in Station 2. The abundance and distribution of Odonata in this study may be attributed to the presence of macrophytes in the study-area as most nymphs of Odonata are usually associated with macrophyte (Carchini *et al,* 2004).

Coleoptera was represented by five families including Hydrophilidae, Gyrinidae and Elmidae which were well present in the two stations. Abundance of Coleoptera like *Gyrinus* sp. indicates that the water is relatively free from gross pollution (Arimoro *et al,* 2007). Related studies conducted in similar freshwater bodies in Nigeria (Edokpayi *et al,* 2000; Edema *et al,* 2002) and elsewhere (Nelson and Roline, 2003) have associated the presence of these organisms to clean water condition.

The high abundance of Diptera, owing to the presence of the chironomidae family with four species most especially lend credence to the fact that the study-area in a matter of time may be subjected to perturbation, probably due to the slight level anthopogenicities going around the riparian community (Edegbene and Arimoro, 2012). More chironomids were recorded in Station 1 were flow velocity was less. This is in accordance with the findings of (Doisy and Rabeni 2001) who reported that chironomids abundance is related to the amount of detritus, which in turn is negatively correlated with flow velocity.

Canonical Correspondence Analysis (CCA) ordination biplot showed that some of the environmental variables had good relationship with the macro-invertebrates. DO, flow velocity and pH. The water quality is relatively unperturbed judging from the range of DO and pH recorded during the course of this study. Earlier, (Jonalagadda and Mhere, 2001) had opined that, pH of an aquatic system is an indicator of water quality and the extent of pollution in a watershed. They stated that the pH of unpolluted water system normally show a near neutral or slightly alkaline pH. From this present study the mean pH of Station 1 was 6.95 +0.48 (6.50-7.6) and Station 2, 6.88+0.53 (6.3-7.6), which showed that the pH of the study-area were near neutrality to slightly alkaline. These value ranges lend credence to the fact that the water is relatively unperturbed as revealed by CCA biplot analysis. This also further buttresses the findings of (Arimoro *et al,* 2009) in River Orogodo, Niger Delta Area of Nigeria. Again, the DO value were within the permissible limit recommended by the World Health Organization for aerated water body which is 5.0-6.0 mg/l (Oluyemi *et al,* 2010), because, DO value range for this present study was between 5.2-7.8 mg/l, which attested to the fact that most of the macro-invertebrates like *Pseudospatha* sp., *Gerris* sp., *Tabanus* sp., *Culex* sp. and *Macromia* sp. were associated with the region with relatively high DO value, from the CCA analyzed. Also, increase in phosphate affected *Melanoides moerchi*. This showed that *M. moerchi* strive better in nutrient laden environment.

Owan River contains an abundant species of macro-invertebrates. Consequently, this study has enhanced the knowledge of the community structure of macrobenthic invertebrates in Nigeria and Edo State in particular.

The over-abundance of Mollusca in this study called for more detailed study to be carried out along the stretch of Owan River to ascertain if Mollusca are widely distributed in the river. This will be significant because some species of Mollusca, for example *Melanoides* sp., which was one of the species discovered in this study is an intermediate host of various parasites affecting human and livestocks like schistosomiasis (Edegbene and Arimoro 2014). For the communities selected as sampling stations, measures should be taken to reduce or eradicate the Mollusca such as maintaining thick dense vegetation around the river which may help to form adequate shed which is unfavourable to the intermediate hosts of schistosomiasis.

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Zoological Society of Nigeria.