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Research Paper

SPATIAL EVALUATION OF BENTHIC MACRO-INVERTEBRATES ALONG THE UPPER COURSE OF OTAMIRI RIVER, IMO - STATE, NIGERIA

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Abstract

The physico-chemical parameters and benthic macro-invertebrates along the upper-course of Otamiri River, Imo State, Nigeria was conducted between the months of July to September, 2017 to determine the impact of the recent dredging and other anthropogenic activities on and around the river. Bi-monthly surface water samples and sediments were collected from three sampling stations along the river between July-September, 2017. Water temperature, current, and transparency were determined *in-situ*, while other physico-chemical parameter were analyses using conventional field and standard laboratory techniques. Ammonia, Carbon dioxide (CO_2) and total suspended solid (TSS) were observed to be above the permissible limits, conductivity and CO_2 show spatial significant differences at $P < 0.05$, total dissolved solid (TDS) shows a positive significant correlation with ammonia, and TSS with TDS at $P < 0.01$. Nine (9) taxa of benthic macro-invertebrates were recorded comprising of two (2) phyla: Annelida, and Arthropoda. *Chironomus sp* recorded the highest percentage abundance (83.6%) and the highest Shanon weinner's diversity index (H=2.516), while Aquatic Earthworm, and *Hilipus unifasciatus* recorded the least percentage abundance (0.3%) respectively. Sampling station one recorded the highest percentage abundance and dominated by *Chironomus* sp. Thus, though dredging and clearing of weeds caused habitat destruction and elimination of macro-invertebrates in station 2 and 3, but had enhance the water current and reduce accumulations of wastes around these stations. Dredging can be extended to other course of the river as a combating measure to reduce waste accumulations on the river.

Key words: macro-invertebrates, physico-chemical parameters, anthropogenic activities, dredging.

INTRODUCTION

Many groups of organisms have been used as indicators of water quality or environmental changes in fresh water bodies, including Plankton, Macrophytes, protozoan, fish and other animals (Atobatele *et al,* 2005); of these, benthic macro-invertebrates have been most extensively used to monitor and assess overall health of the aquatic environment, as they serve as good candidates for long term monitoring program relating to anthropogenic impacts (Spaak and Bauchrowitz, 2010, and Adebayo *et al,* 2016a). They are reliable indicators because they spend all or most of their live cycle in water; they are easy to collect, identified in the laboratory and, unlike fish, have limited mobility. Because of their inability to escape pollution, macro-invertebrates have the capacity to integrate the effects of the stressors to which they are exposed, in combination and over time.

However, benthos macro-invertebrates vary greatly in their response to variation in water quality, which ranges between relatively tolerant (e.g. Chironomus larvae, Tubifex larvae, Leehes, *Physa spp, Bulinus spp, Indoplanobis spp,* etc), to sensitive species (Stone flies, Mayflies, Water beetles, etc.). Therefore, examining shifts in the benthic communities over time could provide understanding into the major environmental events and process affecting the resident biota (Woke and Wokoma, 2007). Thus, this study aimed at: a) To assess the benthic macro-invertebrate composition of the upper course of Otamiri River; b) To draw the likely effects of the recent dredging activities and other anthropogenic discharges on and around the river.

2. MATERIALS AND METHODS

Study Area Description: Otamiri River is located within the tropical rainforest belt of Nigeria and lies between latitude 05^{o} 23'N to 05^{o} 30'N, and longitude 6^{o} 58' E to 7^{o} 04' E (Figure 1). The area is low lying being generally about 300m above sea level. The river runs from Egbu, where it has its major recharge resource and cuts through Nekede, Ihiagwa, Eziobodo, Olokwumuisi, Mgbirichi, Umuagwoand finally to Ozuzuin Etche town of river state of Nigeria, where it finally joins to the Atlantic ocean(Anyanwu 2009). The region experiences a mean annual temperature of 27^{o}C and an annual rainfall of 200-300mm, with most of the months (April to November) characterized with high rainfall. The river serves the aforementioned transverse communities as main sources of water for Industrial, Agricultural, and Domestic use.

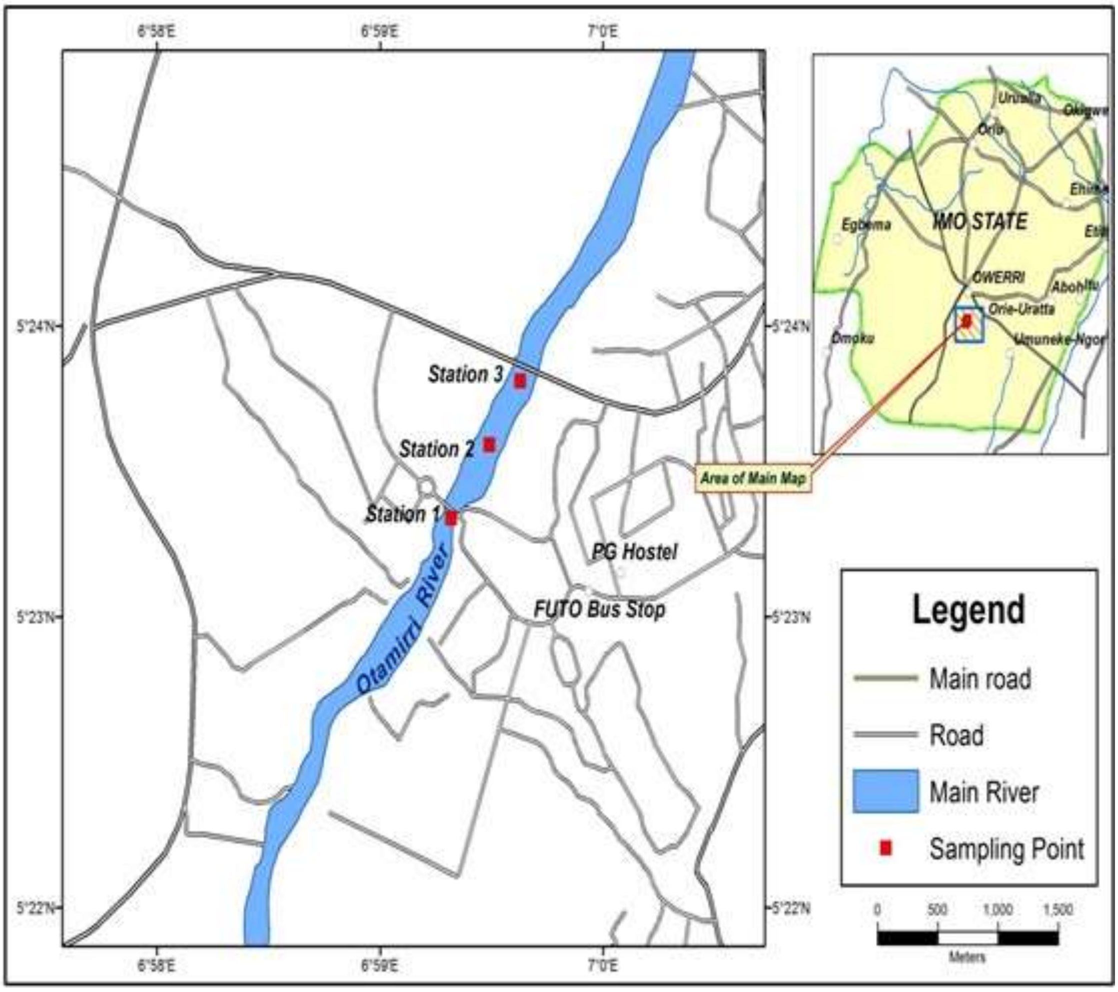

Figure 1: Map of Otamiri River showing the Sampling Stations **(Source: Cartographic Unit, Uni. Of Ibadan, Ibadan, Feb., 2017)**

Sampling Design and Analysis

Three (3) sampling stations were selected for study on the river based on their proximity to the different anthropogenic activities around the river. Surface water sampling for physico-chemical parameters was done twice monthly for three months (July to September, 2017) between 08:00-11:00 hours on each sampling days across the three sampling stations. Field measurements of temperature, current, and transparency were determined using mercury- in-glass thermometer, floater and stop-watch, and Secchi-disc (Ruttner, 1963, and Wetzel and Likens, 2000), respectively. Surface water samples for chemical parameters were collected in 1L plastic bottles and kept in a refrigerator prior its analysis. Water sample for dissolved oxygen was collected in 250ml glass sampling bottles and fix immediately with 2ml each of Winkler's solutions A & B accordingly, as described by Mackereth (1963). Also, sediment samples for benthic macro-invertebrates sample from each sampling stations was hauled using Eckman grab. Three random replicate samples from each station were hauled into a pre-label sterile polythene bag and transported to the laboratory for sorting, identification and recording.

Laboratory Analysis

Water samples for chemical parameters were analysed in Central Research Laboratory, Federal University of Technology Akure, Ondo State, Nigeria using standard method (APHA, 1998). While the sediments sample were washed through graduated sieves of

0.5mm in the laboratory, department of Fisheries and Aquaculture Technology, Federal University of Technology Owerri, Imo State. Sorting of the macro-invertebrates in the sediment sample was enhanced by staining the washed sediment samples with Rose Bengal solution. The macro-invertebrates were identified using identification guides of Needham and Needham (1975), Odiete (1999), and Hawkin (2000). Each identified taxon was counted and the number of individuals recorded. The samples were preserved using 10% formalin.

Statistical Analysis of Data

Bivariate and multivariate statistics as provided by the SPSS Version 22.0, and MS Excel 2010 software were used in the analysis of the data on the physico-chemical parameters. The determination of spatial variance equality (homogeneity) in the means of the physico-chemical parameters was made with one-way analysis of variance (ANOVA), further mean separation was made with the Duncan Multiple Range Test (DMRT). The analysis of the biological data was made with a combination of indices. Species diversity and evenness was determined with Shanon-Wiener's index (H), Margalef's index (D), and Equitability (J) using PAST Version 3.

RESULTS AND DISCUSSION

The descriptive results of the physico-chemical parameters of the upper course of Otamiri River, Imo State is shown in Table 1. Of all the parameters measured, ammonia, total suspended solid (TSS), and carbon (iv) oxide exceeded the NESREA (2011) recommended limit for aquatic organisms, while ammonia, and total suspended solid were observed to exceed the WHO (2008) standard limit for drinking water.

Table 1: Descriptive statistics of the Physico-chemical Parameters of Otamiri River during the study period

Parameters	Mean±SE	NESREA (2011)	WHO (2008)
Temperature (^{0}C)	26.878±0.209	a	30-32
Transparency (m)	0.901±0.085	NS	-
Current (m/s)	0.244±0.056	NS	-
pH	5.111±0.409	6.5-8.5	7.0-8.5
Alkalinity (mg/L)	22.667±1.073	NS	-
Conductivity (µS/cm)	26.444±2.930	NS	≤1,000
Ammonia (mg/L)	0.623±0.085	< 0.1	< 0.1
Total Dissolved Solid (mg/L)	13.611±1.625	NS	≤200.0
Total Suspended Solid (mg/L)	5.597±0.320	0.25	≤5.0
Nitrate-Nitrogen (mg/L)	0.053±0.003	9.1	≥10.0
Dissolved Oxygen (mg/L)	6.653±0.323	Not <6.0	≥5.0
Hardness (mg/L)	34.000±2.452	NS	-
Carbon IV Oxide (mg/L)	45.528±4.101	<20.0	-
Chloride (mg/L)	49.056±2.084	300	-

SE = standard error of mean, NS = Not Specified, and a = [a] except in mixing zones, temperature increase by a 7-Day Average of the Daily Maximum temperatures (7-DADMax) shall not be more than 0.3 ºC above natural background conditions

The exceeding concentrations of ammonia in the river could be the resultant effects of the activities of the degradable bacterial on organic wastes that was brought into the river from the run-off of the environment, which explain the recorded correlations at p< 0.01 between ammonia and total dissolved solid. This was observed to be higher at the onset of the rainy season when the river current was low. Similar trend of higher ammonia concentration have been previously reported by Adebayo, *et al* (2016a and 2016b), where the authors observed that higher ammonia concentrations coincides with the high influx of rain that brought wastes into the river and get accumulated in the process due to low current of the river. The recorded reduced ammonia concentration (0.623±0.085mg/L) in this studies compare with the previously reported higher concentration of 1.36±0.112mg/L by Adebayo, *et al* (2016b) in the river could be due to the dredging activities on the river that enable more free flowing of the river and the subsequent reduction of waste accumulations in the river. Likewise suspension of solid waste particles in the water that was brought into the river by run-off and erosion of solid waste from the adjourning lands could be responsible for the recorded high concentration in TSS of the river. The period of the highest TSS in Otamiri River that coincides with the recorded period of least water current in the river was not an accident as water current prevents accumulations of suspended matters in the water bodies. The tendency for TSS to impair light penetration into the river and subsequent effect on water transparency was established in this study, as period of high TSS coincides with the period of low transparency of the river. High TSS is capable of clogging fish gill which could further result into fish stress, reduced growth, suppressed-immune system leading to increased susceptibility to disease and osmotic dysfunction and death, as earlier suggested by Bilotta and Brazier (2008). This agreed with the previous report on high TSS concentration and its subsequent effects by Ajibade (2004) in Asa Dam (Kwara State), Osibanjo *et al.* (2011) in Rivers Ona and Alaro in Ibadan, and Adebayo and Ayoade (2017) in Itapaji Reservoir.

Furthermore, the observed monthly variations in some of the physic-chemical parameters measured as shown in Figure 1 to 4, as well as the recorded spatial variations in conductivities and carbon (iv) oxide that differs significantly at $p< 0.05$ across the sampling stations could be attributed to rain inducement and run-off from the adjourning lands.

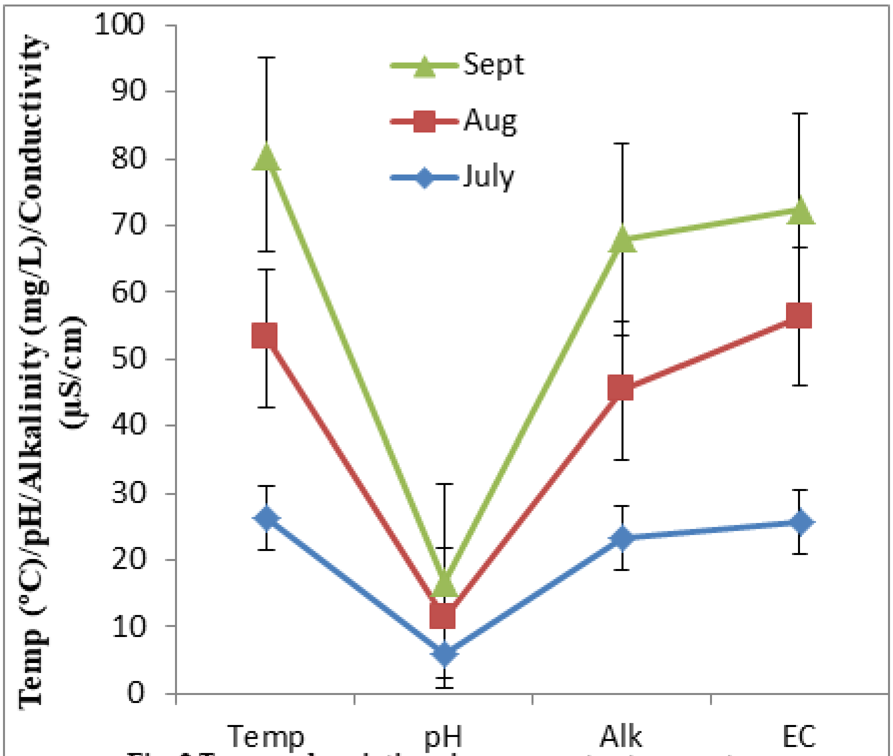

Fig. 2 Temporal variations in mean water temperature, pH, total alkalinity and electrical conductivity of the Otamiri River

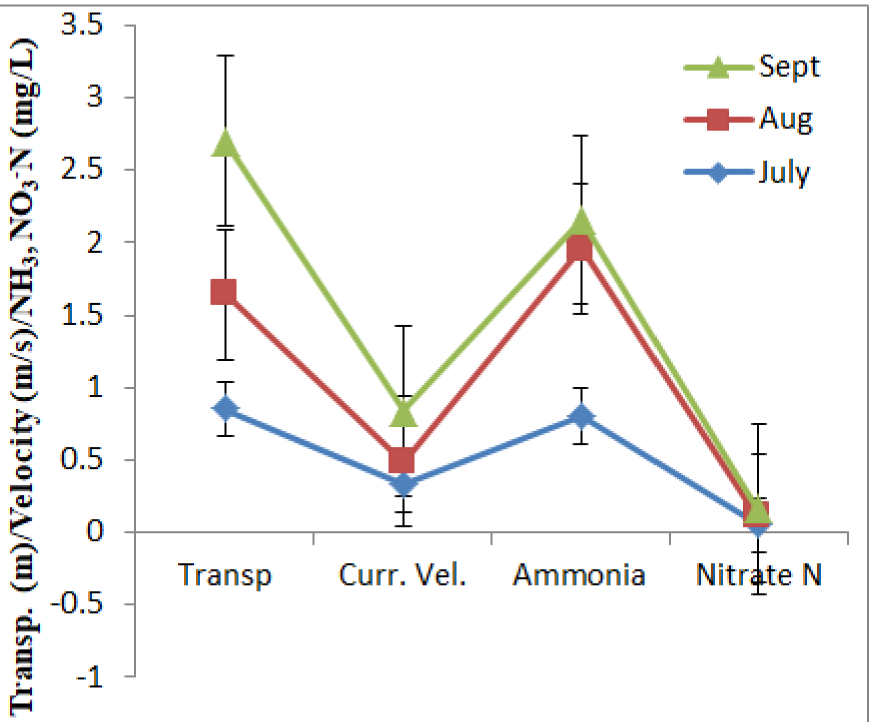

Fig. 3. Temporal variations in mean transparency, current velocity, Ammonia and nitrate-nitrogen contents of the Otamiri River

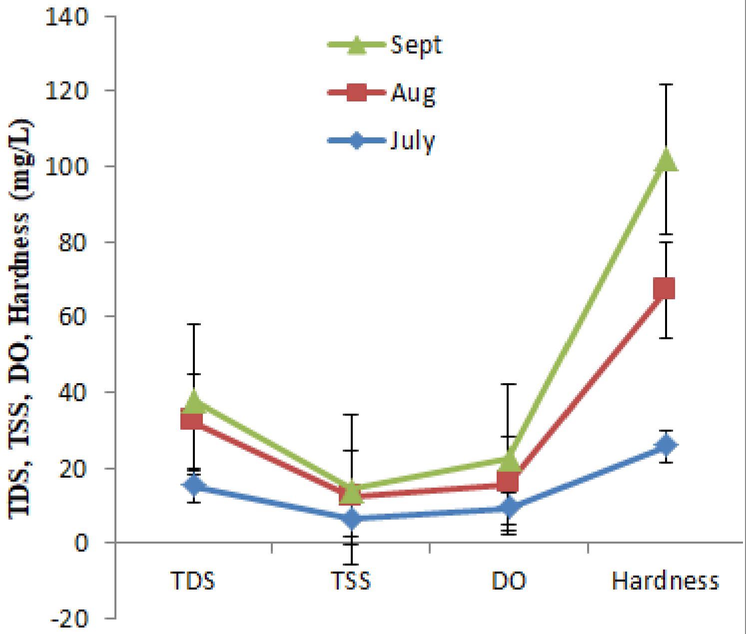

Fig. 4. Temporal variations in mean total dissolved and suspended solids, dissolved oxygen and total hardness of the Otamiri River

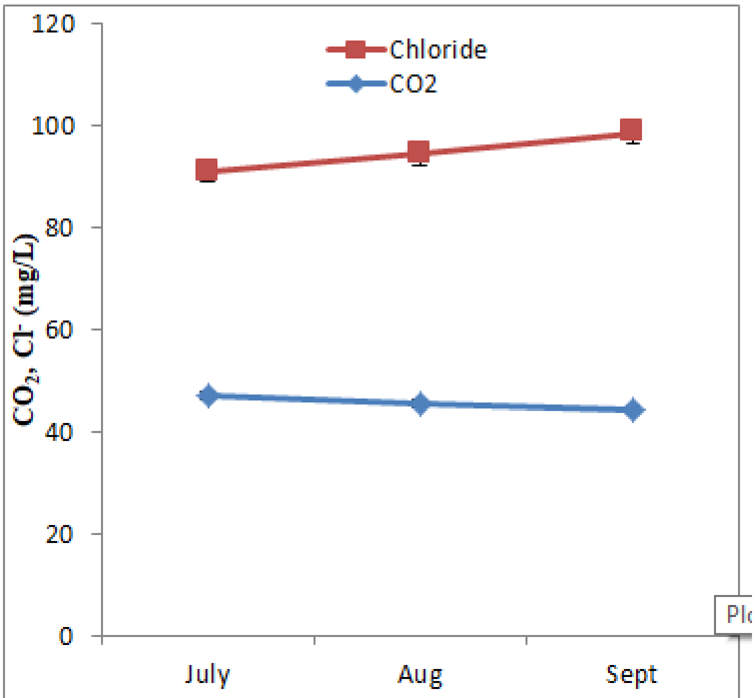

Fig. 5. Temporal variations in mean dissolved carbon (IV) oxide and chloride ion concentration of the Otamiri River

Table 2. Spatial variation in Physico-chemical parameters of Oguta Lake between July and September, (P< 0.05)

Parameters	STATIONS 1	2	3
Temperature (^{0}C)	27.35^{a}	26.10^{a}	27.18^{a}
Transparency (m)	0.89^{a}	0.97^{a}	0.85^{a}
Current (m/s)	0.24^{a}	0.14^{a}	0.46^{a}
pH	6.00^{a}	5.33^{a}	5.50^{a}
Alkalinity (mg/L)	23.00^{a}	20.67^{a}	24.33^{a}
Conductivity	25.83^{ab}	11.83^{b}	34.67^{a}
Ammonia (mg/L)	1.04^{a}	0.39^{a}	0.74^{a}
Total Dissolved Solid (mg/L)	14.17^{a}	6.00^{a}	17.83^{a}
Total Suspended Solid (mg/L)	5.92^{a}	4.05^{a}	6.25^{a}
Nitrate-Nitrogen (mg/L)	0.06^{a}	0.05^{a}	0.05^{a}
Dissolved Oxygen (mg/L)	9.81^{a}	5.18^{a}	7.30^{a}
Hardness (mg/L)	30.67^{a}	33.67^{a}	37.67^{a}
Carbon IV Oxide (mg/L)	32.00^{b}	62.83^{a}	41.75^{b}
Chloride (mg/L)	46.67^{a}	48.50^{a}	52.00^{a}

N.B: Values with the same superscript along same row are not significantly different at P<0.05

The multivariate analysis shows that TDS had significant positive correlation with conductivity, and ammonia at p< 0.01, while ammonia had positive significant correlations with conductivity, and TSS had positively significant correlated with ammonia at p< 0.05 (Table 3), further affirms that rainfall and the generated run-off of the surrounding enhance drifts in the concentrations of these parameters.

Table 3: Correlation between the physic-chemical parameters of Otamiri River

	Temp	Trans	Curr	pH	Alkal.	EC	Amm.	TDS	TSS	N-NO_3	DO	Hard.	CO_2
Transp	**0.192**												
Curr	**0.430**	**0.346**											
pH	**0.109**	**-0.368**	**0.042**										
Alkalinity	**0.120**	**-0.376**	**0.203**	**0.521**									
EC	**0.261**	**-0.622**	**0.250**	**0.209**	**0.549**								
Ammonia	**0.087**	**-0.543**	**-0.035**	**0.400**	**0.139**	**0.703***							
TDS	**0.119**	**-0.648**	**0.202**	**0.252**	**0.438**	**0.968****	**0.799****						
TSS	**0.042**	**-0.536**	**0.246**	**0.402**	**0.549**	**0.901****	**0.776***	**0.953****					
Nitrate_N	**0.517**	**0.145**	**-0.009**	**0.350**	**-0.090**	**-0.414**	**-0.395**	**-0.486**	**-0.507**				
DO	**0.108**	**-0.256**	**0.032**	**0.557**	**0.501**	**0.421**	**0.224**	**0.454**	**0.591**	**0.112**			
Hardness	**0.365**	**-0.244**	**-0.145**	**-0.451**	**-0.189**	**0.211**	**0.124**	**0.086**	**-0.181**	**0.000**	**-0.612**		
CO_2	**-0.595**	**0.331**	**-0.217**	**-0.774***	**-0.718***	**-0.532**	**-0.423**	**-0.445**	**-0.509**	**-0.337**	**-0.538**	**0.048**	
Chloride	**0.498**	**0.380**	**0.224**	**-0.387**	**0.267**	**-0.091**	**-0.525**	**-0.296**	**-0.339**	**0.195**	**-0.261**	**0.382**	**-0.107**

***. Correlation is significant at p<0.05 level (2-tailed), and **. Correlation is significant at p< 0.01 level (2-tailed).**

Temp= Temperature, Trans.= Transparency, Curr.= Current, Alkal.= Alkalinity, EC= Electric conductivity, Amm.= Ammonia, TDS= total dissolved solid, TSS= total suspended solid, DO= dissolved oxygen, and Hard.= hardness,

Benthic macro-invertebrate Composition and Abundance of Otamiri River

The macro-invertebrates of Otamiri River were constituted by nine species (Table 4) and 366 organisms during the study (Figure 6). Two phyla namely; Arthropoda and

Phylum Annelida were recorded, with phylum Annelida constituted the higher percentage abundance of 90.1%. *Chironomus* specie was observed to dominate the annelids as well as having the overall highest percentage (83.6%) abundance, followed by *Tubifex* species (9.6%), while *Hilipus unifasciatus* larvae and aquatic earth worm recorded the least percentage abundance of 0.3% respectively. The low number of Macro-invertebrates encountered in the study area could be due to some ecological imbalance arising from alterations of some important factors such as water current, TSS, ammonia, transparency and food availability that govern the abundance and distribution of the benthic communities. The recorded high percentage abundance in *Chironomus* specie and *Tubifex* specie could be as a result of their ability to withstand and survive in a perturbed environment, similar to the earlier report of Adakole and Annune (2003), and Adeogun and Fafioye (2011).

Table 4: Checklist of Benthic Macro-invertebrate Taxa in Otamiri River, during the study period

PHYLUM	CLASS	ORDER	SPECIES
Annelida	Clitellata	Oligochaeta	*Tubifex sp******
	Oligochaeta	Megadrilacea	Aquatic Earthworm**
Arthropoda	Insecta	Odonata	*Aphila sp* (dragon fly nymph)**
		Diptera	*Sybiocladius sp* (Chironomus)***
		Ephemeroptera	*Potamantthus sp* (may fly larva)*
		Coleoptera	*Heterelmis stephani* (Riffle beetle larva)*
		Coleoptera	*Hilipus unifasciatus.**
	Arachnida	Trombidiforms	*Hydrachnidia sp* (Water mite)**
		Araneae	*Argyroneta aquatic* (Water Spider)**

= Sensitive/Intolerant species, **= Moderately Intolerant species, ***= Fairly tolerant species, *= Very tolerant species (Source: Hoosier Riverwatch Biological Monitoring Data Sheet. www.idem.IN.gov/riverwatch)**

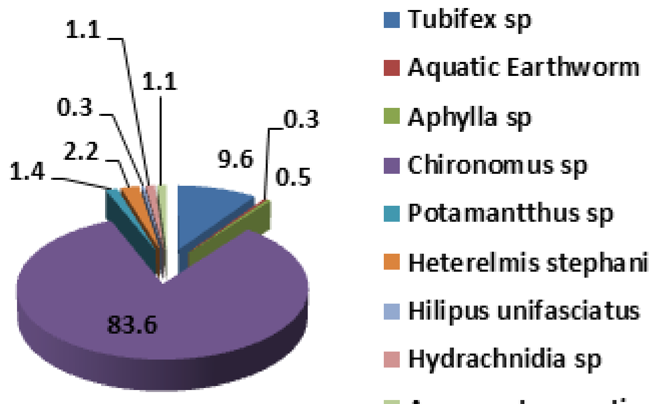

Figure 6. Percentage abundance of macro-invertebrates of Otamiri River during the study period

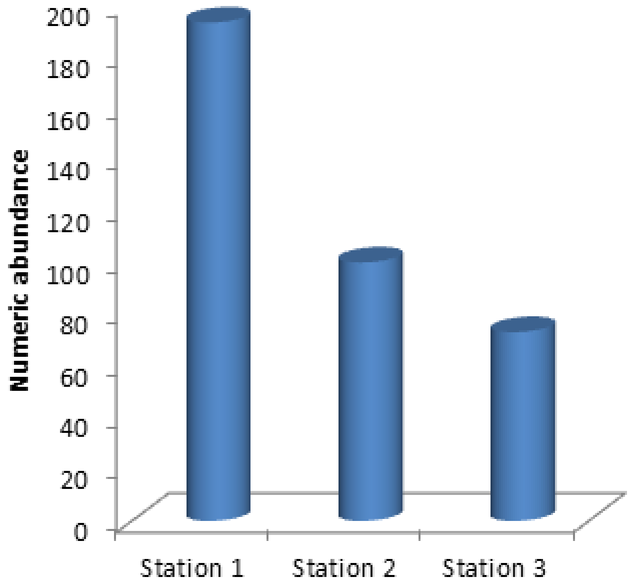

Figure 7: Spatial abundance of Macro-invertebrates of Otamiri River during the sampling period

Furthermore, *Chironomus* and *Tubifex* specie were equally observed to dominate the species abundance across the sampling station, with sampling station 1 having the highest total abundance of macro-invertebrates (Figure 7). The observed spatial variations in the abundance of the macro-invertebrates could be traced to the varying environmental conditions as well as the effect of the dredging activities on the river. Dredging activity which is capable of habitat destruction, disruption of reproduction cycles, and subsequent reduction of the macro-invertebrates could have been responsible for the low population in station 1 and 2 respectively.

Diversity indices of the benthic macro-invertebrate taxa of Otamiri River

Chironomus sp generally had the highest diversity index (H = 2.516) in the overall sampling (Table 5). Similar trend was observed across the sampling stations where the species has the highest diversity index in all the sampling stations (Table 6). This could be due to their ability to utilize atmospheric oxygen in adverse environmental conditions.

The dominance of *Chironomus sp* in this study is similar to that reported by Atobatele and Ugwumba (2010). During the period of study, the study area is usually characterized by natural and induced stresses as a result of indiscriminate dumping of wastes along the water channel,

Table 5: Diversity Index of Benthic Macro-invertebrate Taxa in Otamiri River

TAXA	H	D	J
Chironomus sp	2.516	2.621	0.774
Tubifex sp	1.308	1.406	0.617
Aphylla sp	0.693	1.443	1.000
Argyroneta aquatic	0.693	0.721	1.000
Heterelmis stephani	1.494	1.924	0.891
Potamanthus sp	0.500	0.621	0.825
Aquatic Earthworm	0.000	0.000	1.000
Hilipus unifasciatus	0.000	0.000	1.000
Hydrachnidia sp	0.693	0.721	1.000
MEAN (ẋ)	0.790	0.946	0.901

H = Shanon-Weiner's index, D = Margalef's index and J = Evenness.

Table 6: Diversity Value of Benthic Macro-invertebrate Taxa in Otamiri River

TAXA	STATION 1			STATION 2			STATION 3		
	H	D	J	H	D	J	H	D	J
Chironomus sp	1.575	0.984	0.895	1.570	1.132	0.802	1.216	0.727	0.844
Tubifex sp	0.652	0.629	0.640	0.500	0.434	0.825	0.000	0.000	1.000
Aphylla sp	0.693	1.443	1.000	0.000	0.000	0.000	0.000	0.000	0.000
Argyroneta aquatic	0.693	0.721	1.888	0.000	0.000	0.000	0.000	0.000	0.000
Heterelmis stephani	0.693	1,443	1.000	0.000	0.000	1.000	0.673	0.621	0.980
Potamanthus sp	0.000	0.000	0.000	0.500	0.624	0.825	0.000	0.000	0.000
Aquatic Earthworm	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
Hilipus unifasciatus	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
Hydrachnidia sp	0.000	0.000	0.000	0.000	0.000	0.000	0.693	0.721	1.000
MEAN (ẋ)	0.861	0.844	0.889	0.428	0.365	0.809	0.516	0.414	0.965

H = Shanon-Weiner's index, D = Margalef's index and J = Evenness.

effluents from nearby mechanic workshop and dredging of the river bottom which consequently results in the release of concentrated ions and trapped nutrients in the water body.

Conclusion and Recommendation

Thus, following the Shannon-Weiner diversity index values above 3.0 indicating that the structure of the habitat is stable, while values less than 1.0 indicate that there are pollution and degradation of the habitat structure (Shannon, 1948; Mandaville, 2002), and Margalef's water quality index values greater than 3.0 indicate clean condition, values less than 1.0 indicate severe pollution and intermediate values indicate moderate pollution (Margalef, 1974, and Lenat *et al.,* 1980); Otamiri River is having poor habitat structure. Further dredging of the entire course of the river will be of added advantage as this will further enhance a better current on the water and quick dislodge of the eroded materials into the river body, resulting in a fairly clean environment.

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