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Macroinvertebrate Community and Pollution Tolerance Index in Edion and Omodo Rivers in Derived Savannah Wetlands in Southern Nigeria

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Abstract

We carried out a study of the macroinvertebrates community and pollution tolerance index (PTI) in Edion and Omodo Rivers in Agbede wetlands for eight months (from March to October, 2010). Two stations, upstream and downstream, were chosen for each river. Benthic fauna was sampled fortnightly, using the modified Ekman Grab designed for shallow waters. Eight major taxonomic groups comprising 33 taxa were collected in this study. The dominant groups by percentage density occurrence were Ephemeroptera (45.4%) > Diptera (24.7%) > Decapoda (24.03%). The number of taxa was least for station 2 (14) and was highest (23) for station 4, with highest population density recorded for station 1 (211 individuals). The heterogeneity indices revealed higher values for evenness across the stations except, for station 1 (0.3574). Meanwhile, PTI values showed moderate water quality with range of values from 7 to 16.

Keywords: Macroinvertebrate, Biological Diversity, Tolerance Index, Aquatic regimes.

1. Introduction

In the last few decades, aquatic ecologists have focused more on water quality, resources management and sustainable utilization. Research in aquatic ecology becomes more challenging when coupled with climate change phenomena. Inundation, siltation, agriculture and deforestation outside industrialization and urbanization, pose greater challenges to aquatic regimes.

The use of benthic macroinvertebrates to ascertain the overall health status of aquatic environments remains the most suitable, reliable, and the most widely acclaimed method globally. In this study, we attempt to define pollution tolerance index (PTI) as a method of measuring the overall health status of aquatic bodies through the use of macrobenthic invertebrates. Macrobenthic invertebrates are useful bio-indicators in understanding the ecological health of an aquatic ecosystem, rather than using chemical and microbiological data, which at least give short-term fluctuations (Ravera, 2000; Ikomi *et al.*, 2005; George *et al.*, 2009). Odiete (1999) discussed the use of benthic macroinvertebrates in the assessment of freshwater bodies. Benthic invertebrates were used as bio-indicators for studies of impact of environmental perturbations on the aquatic ecosystems (Lenat *et al.*, 1981; Victor and Ogbeibu, 1985). They are considered important because they reflect the cumulative effects of the present and past conditions; also they have low mobility (i.e. are sedentary or sessile or nearly) and life cycles of several weeks and or years.

Biomonitoring studies and the use of macroinvertebrates to rate the quality of water bodies which include both lotic and lentic types have been widely reviewed elsewhere (Ogbeibu and Oribhabor, 2002; Imoobe and Ohiozebau, 2009; Omoigberale and Ogbeibu, 2010; and Olomukoro and Dirisu, 2012). Macroinvertebrates, which were utilized in aquatic pollution studies, included: Mayflies (Ephemeroptera), caddisflies (Trichoptera), stoneflies (Plecoptera), beetles (Coleoptera), crayfish and amphipods (Crustaceans), aquatic snails (Mollusca), biting midges (Chironomids) and leeches (Hirudinea) in Nigeria, North America and Europe.

Existing works on the benthic fauna of Agbede wetlands are quite scanty and included: Olomukoro and Dirisu (2012) who dealt with the macroinvertebrate community of a post lindane treated stream with a

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record of 43 taxa comprising 532 individuals, and Olomukoro *et al.* (2013) on the ecological survey of macrobenthic invertebrates of selected ponds in Agbede flood plain, where they encountered 10 groups and 1,031 individuals.

The purpose of this study is, firstly, to present a general account of the benthic macroinvertebrates species composition and diversity as well as determining the water quality using the benthic fauna, and, secondly, to establish the pollution tolerance index (PTI) for the water bodies. So this study would hopefully be a reference archive for future studies of the water bodies in the subject area.

2. Materials and Methods

2.1. Study Area

Agbede wetlands are situated within a derived savannah ecozone that lies between 06o16.3E, 06o 18.7E and 06o52.2N, 06o55.4N. The climate of Agbede and its environs is not stable. It is comparatively like that of Benin and its environs as a rhythm of rainfall occurs in conjunction with the movement of the Southern-West monsoon wind across the Atlantic Ocean and the timing of this movement varies from year to year. There are two distinct annual seasons associated with this region: the rainy season which begins in April and terminates in October, and the dry season which starts from November and terminates in March. Rainfall for 2010, ranged from 158.4 – 608.7mm with the lowest recorded in the month of May (158.4mm) and the peak recorded in the month of September (608.7mm). The mean rainfall value was (356.76mm).

Station 1: This station (06o55.4N and 06o16.4E) is directly located on the Benin and Auchi/Abuja high way by Edion River bridge. There was an occasional inundation of the surrounding banks in the months of July, August, and September. The station is surrounded by a number of ponds on its banks as well as settlements. It is subjected to all forms of human activities. The velocity of flow was determined to be 0.372m/s and the average depth 76cm. Lemna pausicostata (duckweed) was found floating here.

Stations 2: This station (06o55.4N and 06o16.4E) is located about 1,050m downstream of the same river Edion. There are lots of aquatic macrophytes (Lemna pausicostata) and algae (Chlorophyta sp.) here. There is vegetation of shrubs and trees like Bambusa bambusa and Anacadium occidentalis on the banks. Cattle dung is commonly associated with this station. The velocity of flow was 0.24m/s and the depth was 82cm.

Station 3: This station (06o52.2N and 06o16.8E) is the upstream of River Omodo at Odighie community, by Ewora-Idegun Road. It is surrounded by Bambusa bambusa tickets. Macrophytes are rare here. Velocity of flow was 0.27m/s and the depth was less than 35cm. In dry season, it flows in South–North direction. Human activities in this station include washing, bathing, fishing and fermentation of starch (cassava). It is the only source of domestic water to the immediate communities.

Station 4: This station (06o52.2N and 06o18.7E) is located about 840m downstream of stations 3. Here, features and human activities are similar to those in station 3 except the fermentation of starch activities. Current velocity was equally high here (0.29m/s) and the water depth did not exceeded 35cm.

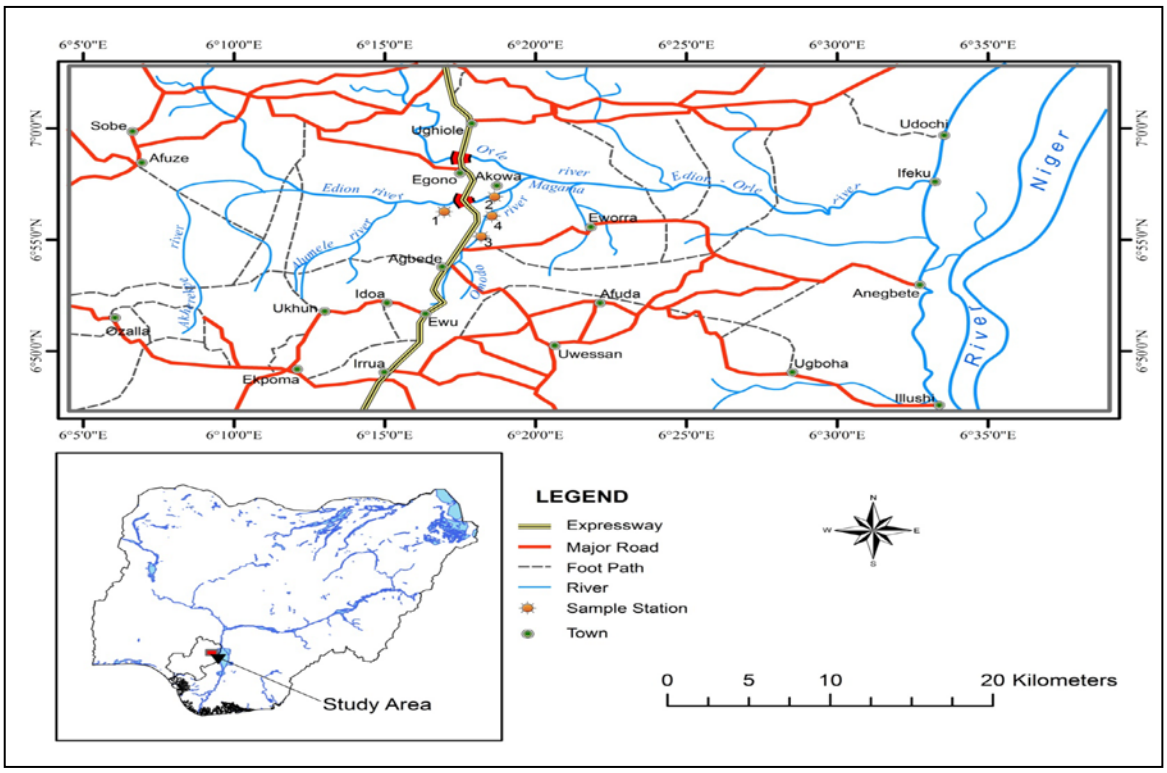

Figure 1. Map of the study area.

2.2. Benthic Fauna

Macrobenthic fauna were collected by sampling the rivers substratum using an Ekman grab (made by Hydrobios, West Germany) as recommended for sand and silt (Hynes, 1961) as well as on the Bank-roots and Macrophytes (Olomukoro and Dirisu, 2012). Contents trapped by the grab were processed as described by Olomukoro and Ezemonye (2000). For the bank-roots and macrophytes, benthos was collected using a hand net made of mesh bolting silk of 100µM. The sediment was collected in a plastic container of 15 liters volume; water was added and stirred vigorously while the floating fauna were sieved using 150, 250 and 500 micron sieve sizes and the unfloated fauna were handpicked. The benthic macroinvertebrates were identified using the literature (Olomukoro, 1996).

2.3. Determination of Pollution Tolerance Index (PTI)

Pollution tolerance Index (PTI) was determined and computed by utilizing the methods earlier used by Klemm *et al.* (1990) and Izaak Walton League of America (1994). Three groups of macroinvertebrates were chosen and assigned a multiplication factor of 3 for the pollution sensitive group (Ephemeroptera, Trichoptera and Coleoptera), 2 was assigned to the facultative or somewhat tolerant group (Anisoptera, Zygoptera and Decapoda) and 1 to the pollution tolerant group (Pond snails, Oligochaetes and Leech) as utilized in this study after which they were sum to get the PTI values for the four stations and the same was done for the monthly, and spatial variations. Values obtained were thereafter compared with established standard values. Unpolluted water had values between 23 and above, excellent, 17-22 good. Polluted water had 11-16 fair and < 10 poor.

The water quality of stations 2, 3 and 4 had different results. Although station 1 had a PTI value of 16; PTI values of stations 2 and 3 were 7 for each; station 4 had 10.

2.4. Statistical Analysis

Biological indices, such as taxa richness, evenness (E) and Shannon-Weiner diversity, were computed using paleontological statistics software (PAST). The graphs were plotted with MS-Word Excel.

3. Results

3.1. The Macrobenthic Fauna

A total of 33 macroinvertebrate taxa composed of 1 species each of Oligochaeta, and Decapoda (crab), 3 species of Crustaceans (shrimps), 6 species of Ephemeroptera, 3 species of Anisoptera and 3 species of Zygoptera. Others include; Coleoptera 1 species, Trichoptera 3 species, Ceratopogonidae (Diptera) 1 species, Chironomidae (Diptera) 8 species, Cullicidae (Diptera) 2 species, Mollusca 2 species. The relative percentage composition of the taxonomic groups collected from the four stations were: Oligochaeta (0.972%), Decapoda (24.027%), Ephemeroptera (45.420%), Odonata (3.611%), Coleoptera (0.139%), Trichoptera (0.833%) Diptera (24.722%) and Mollusca (0.277%). (Table1 and 2).

Table 1. Summary of macrobenthic invertebrate communities present in Edion and Omodo Rivers of Agbede Wetlands, Edo State (March to October, 2010).

	Stations				
Taxa	STN1	STN2	STN3	STN4	Total
OLIGOCHAETA					
Nais sp.				7	1
DECAPODA					
Unidentified crab larva	-	-	-	2	2
Caridina africana	14	15	40	21	90
Caridina gabonensis	14	17	8	14	53
Desmocaris trispinosa	17	8	2	1	28
EPHEMEROPTERA					
Adenophlebiodes sp.	1	2	-	-	3
Baetis sp.	45	31	32	16	124
Centroptilum sp.	10	14	2	6	32
Cloeon sp.	84	49	21	6	160
Cloeon bellum	-	-	1	2	3
Ephemerella ignita	2	2	-	1	5
ODONATA					
Anisoptera					
Aeschna sp	1		5		6
Libellula sp.	1	1	3	4	9
Aphylla sp			3	4	7
Zygoptera					
Coenagrion sp.	1				1
Enallagma sp.	1			1	2
Lestes sp.				1	1
COLEOPTERA					
Dytiscus marginalis	1				1
TRICHOPTERA					
Hydroptila sp.	1				1
Limnophilus sp.	2				1
Unidentified larva		1		2	3
DIPTERA					
Anopheles sp.		10		1	11
Ceratopogonidae					
Palpomyia sp.	2				2
Chironomidae					
Chironomus fractilobus	6	4	18	22	50
Chironomus travalensis	6	1	8	4	19
Chironomus sp.		5	17	32	54
Tanypus sp.			5		5
Tanytarsus sp.			13	12	25
Clinotanypus sp.				7	7
Pentaneura sp.			1	3	4
Insect larva				1	1
MOLLUSCA					
Hydrobia sp.	1				1
Planorbis crista	1				1
Total no. of individuals	211	160	179	170	720
Total no. of species	20	14	16	23	
Pollution Tolerance Index (PTI)	7	4	3	5	

Table 2. Relative percentage composition of taxonomic groups including; the dominant and subdominant, in the study area**.**

Groups	Taxa (%)	Number of Individuals	% Occurrence
Oligochaeta	3.03	7	0.972
Decapoda	12.12	173	24.027
Ephemeroptera	18.18	327	45.420
Odonata	18.18	26	3.611
Coleoptera	3.03	1	0.139
Tricoptera	9.09	6	0.833
Diptera	30.30	178	24.722
Mollusca	6.061	2	0.277
Total	33	720	100

A total of 720 individuals belonging to 33 species were recorded during this study. At station 1, the total numbers of taxa were 20, and the number of individuals was 211. At station 2, the numbers of taxa and individuals were 14 and 160, respectively. While, at stations 3 and 4, the numbers of taxa and individuals were 16 and 179, and 23 and 170, respectively. (Table 3)

3.2. Diversity Indices

Diversity indices were applied to the macroinvertebrates using the computer software package tool called PAST (Palaeontological Statistics) to determine taxa richness, evenness, Shannon diversity, dominance index and Margelef index (Table 3).

Table 3. Diversity of the macroinvertebrate community of the selected rivers, in Agbede Wetlands

Description (Indices)	Station 1	Station 2	Station 3	Station 4
Number of samples	16	16	16	16
Number of Taxa	20	14	16	23
Number of Individuals	211	160	187	170
Taxa Richness (d)	0.2236	0.1675	0.1170	0.0965
Shannon diversity (H)	1.967	2.082	2.414	2.625
Evenness (E)	0.3574	0.5729	0.6210	0.6003
Dominance Index (C)	0.7764	0.8325	0.8830	0.9035

Taxa richness was highest in station 1 (0.2236) and least in station 4 (0.0965). Station 2 and 3 had very close values. There was a gradual decrease from station 1 to 4.

Station 4 had the highest general diversity value (2.625), while, station 1 recorded the least value (1.967). An increasing order from station 1 to 4 was observed here. The evenness of these species was fairly low across the stations. The values were < 1 in each station. However, it was lowest in station 1 (0.3574). Station 4 had the highest value (0.9035) for dominance when compared with station 1 (0.7764).

3.3. Pollution Tolerance Index (PTI)

PTI was utilized to assess the overall health status of the study stretch to ascertain the extent of human impact on rivers (Table 4). Unpolluted water would have values between 23 and above, excellent, 17 – 22, good. While polluted water would have 11 –16 fair and < 10 poor.

The water quality of stations 2, 3 and 4, had different results. Although station 1 had a PTI value of 16, stations 2 and 3, PTI values of 7 each and station 4 had 10.

Table 4. Summary of the overall health status of the water quality in the wetlands

Rivers/Stations		PTI	Water Quality Status
Edion	1 (Upstream)	16	Fair
	2 (Downstream)	7	Poor
Omodo	3 (Upstream)	7	Poor
	4 (Downstream)	10	Poor

At stations 2, 3 and 4, the pollution tolerance Index values were low, indicating a poor water quality status (Table 5). This is an indication that organisms such Odonata (Zygoptera and Anisoptera), Oligochaeta, Chironomids among others were dominant. The monthly pollution tolerance indices (Figure 2) for all the stations generally recorded low water quality values. But, PTI values were generally higher in the month of September throughout the sampling period and generally lowest in the month of March. Meanwhile the PTI value (11) was highest at station 1 (Edion River), in the month of June and least in March. At station 4, PTI (9) was highest in the month of September.

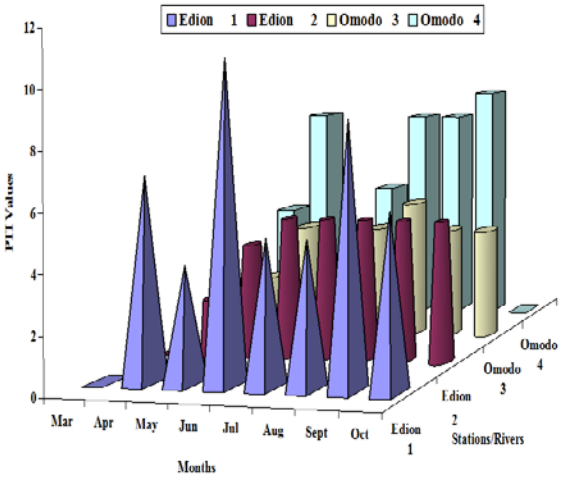

Figure 2. Monthly fluctuation of pollution tolerance index at the stations.

4. **Discussion**

All the organisms found in this study have been variously reported elsewhere in Africa and in the tropics at large (Green, 1979; Olomukoro and Ezemonye, 2000; Imoobe and Ohiozebau, 2009; and Olomukoro and Dirisu, 2012).

Oligochaeta were very poorly represented (3.030% by taxa and 0.972% by individual). Olomukoro (1996) recorded several species of Oligochaetes in Warri River including *Nais* sp. It was reported that the abundance of Oligochaeta was due to the richness of the immediate substrate in organic matter. This may be due to their feeding habits as they are deposit feeders and they are

tolerant to silting, decomposition and flow rate than other macrobenthic groups.

Among the Decapoda, a high abundance of shrimps was recorded. Three species of shrimps (*Caridina gabonensis*, *Caridina africana*, and *Desmocaris trispinosa*) were recorded. The diversity and high population density of shrimps have been widely reported in Nigeria (Ogbeibu and Victor, 1989; Olomukoro, 2002; and Omoigberale and Ogbeibu, 2010).

Ephemeroptera showed relatively high diversity. Three families (Leptophlebiidae, Baetidae and Ephemiridae) and six species which include *Ademophleboides* sp., *Baetis* sp., *Centroptillum* sp., *Cloeon* sp., *Cloeon bellum* and *Ephemerella ignita* were recorded. The abundance of these species is an indication of good water quality and may be due to habitat preference and availability of food.

Odonata are known to be facultative animals as they are mostly associated with moderately polluted waters. A total of six species of Odonata was recorded. The diversity of Odonata has been utilized in biomonitoring of fresh water bodies. Generally, the diversity was poor except in station 3 where, *Aeschna*, *Libellula* and *Aphylla* sp. (members of the suborder Anisoptera) had a little higher numbers and in station 4, respectively.

Only one species of Coleoptera (*Dytiscus marginalis*) was represented in this group. Coleoptera are known to be mostly associated with lentic water bodies such as ponds and lakes. They are sheltered by macrophytes. Only two species of Trichoptera were recorded in the month of June and high density is indicative of good water quality. The density was very low when compared with the work of Imoobe and Ohiozebau, (2009) for Okhuo River in Benin City. This may be as a result of the fact that they are mostly present in well oxygenated and fast running waters.

Diptera was the second largest group after Ephemeroptera. Three families (Ceratopogonidae (1 species), Chironomidae (8 species) and Culicidae (1 species)) were recorded throughout the study. *Chironomus* sp., *Chironomus fractilobus* and *Chironomus travalensis* were dorminant with the highest occurrence in stations 3 and 4, respectively. *Tanypus* sp., *Pentaneura* sp., *Clinotarnypus* sp. and unidentified insect larva recorded a low density and were restricted to stations 3 and 4 only. The relative abundance of these taxa has been emphasized by Wallace and Hynes (1981). They may have been so favored by the conditions of the immediate substrates, which include the alkaline pH in the study area.

Mollusca were poorly represented with two species (*Hydrobia* sp and *Planorbis crista*). The younger life forms inhabit polluted environment, hence their great importance in monitoring pollution stress of wetlands. The two species and two individuals Mollusca recorded were restricted to station 1 only. Molluscs are mostly associated with lentic ecosystems, so that the restriction may be attributed to sampled station type, with an element of backwaters during the dry season months.

The diversity of the macroinvertebrates fauna was low when compared with the number of taxa recorded in some other water bodies. Victor and Ogbeibu (1985) recorded 55 taxa in Ikpoba River, Olomukoro and Egborge (2003) recorded 138 taxa in Warri River, and Omoigberale and Ogbeibu (2010) recorded 57 taxa in Osse River. The low taxa and the total number of individuals recorded for these two Rivers in Agbede – wetlands may be very surprising. This is in contrast with the report of Victor and Victor (1992) who stated that brackish water are known to record low number of taxa. However, the low number of taxa may be due to the choice of sampling stations such that the activities impacting such habitats are colossal, and hence, do not support the ecology of benthos.

The use of pollution tolerance index was subject to problems of the inherent variations in the nature of the aquatic communities in the study area and it was observed that the list of groups of organisms had different degrees of tolerance to their environments. A high pollution tolerance index of 16 was recorded for station 1 (upstream of Edion River) in the wetlands, where organisms, such as Ephemeroptera, Coleoptera and Trichoptera, which are least tolerant to pollution, were represented in a variety of species. It obviously indicated that the waters at station 1 were of low pollution (fair), which could be described as Oligosaprobic in quality. Pollution sensitive organisms such as Trichoptera and Coleoptera had no species recorded outside station 1 and Ephemeroptera density was lower. However, Odonata and Decapoda had relatively high abundance and high species diversity; and densities in stations 2, 3 and 4. The high density of Chironomidae in these stations 2, 3 and 4 was an indication that the waters were relatively polluted or mesosaprobic in quality. The relatively high diversities of Ephemeroptera, Coleoptera and Trichoptera as utilized in this study may be due to habitat preference resulting from presence of very low pollutants/contaminants levels, as directly impacted into the immediate substrates. Trichoptera are mostly present in uplands streams or rivers which are well oxygenated when compared to low land fresh waters like in this case.

In conclusion, organisms, which are most sensitive to pollution, such as Coleoptera and Trichoptera as utilized in this study, were completely absent in stations 2, 3 and 4, an indication that the waters were relatively poor in the above stations, considering the PTI values (7, 7 and 10). Thus, the density of the families of the Ephemeroptera group in stations 2, 3, and 4 dropped when compared with that at station 1. One peculiar observation is that some of the insects like Ephemeroptera prefer slow running water environment with macrophytes, which support their ecology. We strongly advocate that organic farming should be encouraged and practiced as run-off from agricultural sites contains lots of contaminants; and washing of all kinds and channeling of industrial effluence be discouraged. Nomadic agriculture should be restricted to designated sections along the rivers catchment. The need for long-term hydrobiological investigation, with elaborate emphasis on water quality monitoring and the ecology of macrobenthic fauna is so much

recommended for the safety and conservative use of our fresh water bodies and the resources.

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