Biotic Index Assessment of Human Perturbations in Qua Iboe River Estuary Using Macro-Benthic Invertebrate as Indicator Organisms

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Abstract: Studies on Biotic index assessment of human perturbations in Qua Iboe River Estuary using macro-benthic invertebrate as indicator organisms was conducted for 12 months (between May 2015 and April 2016) with the aim of Understanding the ecological status of the system and provide measures which allows policy makers and local actors to design programs and policies to improve the existing practices and mitigate future problems. Macro invertebrates were collected monthly at five different stations across the study area using a van Veen grab sampler. For each sampling station, 3 or 4 hauls were made by sending the grab down into the bottom. The content of the grab was emptied into 3 sieved of 2mm, 1mm and 0.5mm mesh sizes and sieved in-situ to collect the benthos. Sieved samples were poured into 500 ml wide-mouth plastic containers in each of the sampling station, labelled and preserved in 4% formaldehyde solution prior to identification in the laboratory using the relevant identification keys. A total of thirteen thousand eight hundred and ninety-seven (13897) macro-benthic invertebrate individuals, which was made up of twenty six (26) species belonging to three (3) phylum and five classes (5) were observed in the Qua Iboe River Estuary. Macro-invertebrates were represented by Phylum Arthropoda, Mollusca and Annelida. The classes of macro-invertebrate recorded were crustacean, insecta, gastropoda, polychaeta and oligochaeta. The dominant phylum in terms of macro-benthic invertebrate species composition was Arthropoda (13 species); this was closely followed by the phylum Mollusca (11 species) while the phylum with the least species composition was Annelida (2 species). In regards to macro-benthic invertebrate's abundance, the phylum mollusca which was represented by gastropod accounted for 7351 individuals forming 52.90 % of the total macro-benthic invertebrates while the least abundance was Annelida represented by Oligochaeta which contributed 370 individuals forming 2.66 % of the total population encountered during the study. Through-out the study, the most abundant macro-benthic invertebrate species was *Uca tangeri* (1707 individuals), while the least were *Atractomorpha acutipennis* (18 individuals). Ecological indices such as, Shannon, Simpson and equitability indices were higher in station 1 and station3 when compared to other stations. Species dominance was low in all the stations throughout the study. Macro-invertebrates were more abundant during the dry season (7235 individuals) than rainy season (6662 individuals). The results obtained from the family biotic index (FBI) showed that the water quality ratings across the stations were fairly poor to good. Station 1 to 4 had a fairly poor water quality while station 5 had a good water quality. This indicates significant organic pollution going on within the study area. In the light of this study, awareness should be created by the Government, NGO'S and concerned stakeholders in educating the public on the ills and detrimental effects of water pollution.
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1. Introduction

Benthic macro fauna are those organisms that live on or inside the deposit at the bottom of a water body (Idown & Ugwumba, 2005). Numerous species of organisms which cut across different phyla of annelids, coelenterates, mollusks, arthropods and chordates are found in diverse water ecosystems, where they play a fundamental role in the allotment of nutrients (Mann, 2000). They form the connection between the unavailable nutrients in detritus and valuable protein materials in fish and shell fish. Most benthic organisms feed on detritus that settle underneath the water and in turn serve as food for a wide range of fishes (Idowu and Ugwumba, 2005). They hasten the breakdown of decaying organic matter into simpler organic forms such as phosphates and nitrates (Gallep *et al.,* 1978). All forms of aquatic plants, which are the first link of several food chains existing in aquatic environments, can utilize the nutrients (Castro & Huber, 2005). These organisms therefore form a major link in the classic food web as most estuarine and marine fishes, birds and mammals depend directly or indirectly on the benthos for their food supply (Ikomi *et al.,* 2005).

Marco- Benthic invertebrates are useful bio-indicators providing a more accurate understanding of changing aquatic conditions than chemical and microbiological data, which at least give short-term fluctuations (Ikomi *et al.* 2005). The most popular biological method in assessment of water bodies receiving domestic and industrial wastewaters perturbation is the use of benthic macro-invertebrates (Odiete, 1999). The composition, abundances and distribution of benthic macro-invertebrates can be influenced by water quality (Haslam, 1990; Greenberg *et al.,* 1998; Odiete, 1999). These authors reported that variations in the distribution of macro-benthic organisms could be as a result of differences in the local environmental conditions resulting from anthropogenic influences.

In terms of pollution status through bio-monitoring, bio-indicators such as the benthos are usually used instead of zooplankton as the former are known to provide more reliable long term pollution information than the latter (Ali *et al.,* 2003). The long life cycles and their inability to move about to escape from pollutants have made the benthos more suitable for such long term studies unlike the zooplankton which have short lifecycles though they are capable of producing large number of off-springs at shorter time period than the benthos to compensate their short-lived life cycles (Naz & Turkmen, 2005).

This research is aimed at understanding the status of Qua Iboe River Estuary through evaluation of the macro-benthic invertebrate's diversity and abundance using indices such as the biotic index.

2. Materials and Methods

2.1 Description of study area

Qua Iboe River estuary is located on the South Eastern coast in the Niger Delta region of Nigeria where it empties into the Atlantic Ocean. It lies within latitude 4º 40´30´´N and longitude 7º 57´0´´E on the south Eastern Nigeria Coastline. It is mainly characterized by the presence of species of *Avicennia, Rhizophora* and *Nypa*. The coastal vegetation of the area is mainly thick mangrove swamp. Human activities along this estuary include fishing, farming, washing of cloths and cars, disposal of excreta, bathing, swimming and dredging. It was common to observe canoes filled with timber plying this route. Five sampling stations were selected as shown in Fig. 1.

2.2 Collection of samples and identification of Macro-Benthic Invertebrate species

Benthic samples were collected monthly from May, 2015 to April, 2016 at five different stations within the study area using a van Veen grab sampler, usually between 7:00 am and 10:00 am. For each sampling station, 3 or 4 hauls were made by sending the grab down into the bottom. The content of the grab was emptied into 3 sieved of 2mm, 1mm and 0.5mm mesh sizes and sieved in-situ to collect the benthos following Andersin *et al.,* (1976). Sieved samples were poured into 500 ml wide-mouth plastic containers in each of the sampling station, labelled and preserved in 4% formaldehyde solution as recommended by Andersin *et al.,* (1976). All benthic fauna were transported to the laboratory for further analysis.

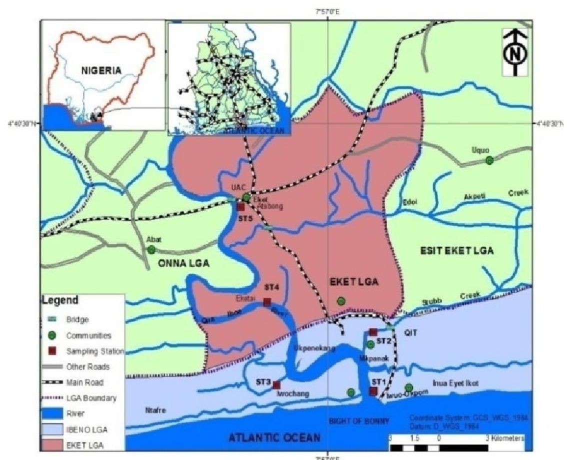

Fig.1: Map of Study area showing sampling location

2.2 Sampling Stations

The longitude and latitude of the sampling station are delineated below,

Stations	Longitude	Latitude
Station 1	7^{0}'58' E	4^{0} 32´ N
Station 2	7^{0} 58' 32.8'' E	4^{0} 34´ 09.9'' N
Station 3	7^{0} 55'E	4^{0} 32´ N
Station 4	7^{0} 54'E	4^{0} 35' N
Station 5	7^{0} 54' E	4^{0} 38' N

In the laboratory benthos were analyzed by addition of 10 mls of Rose Bengal solution (stain) to the samples in a white laboratory tray following Edmunds (1978). The benthos picked up the Rose Bengal solution stain and became conspicuous for sorting and identification. They were then identified under a compound microscope based on identification guides and schemes provided by (Edmunds, 1978; Prasad, 2000; Castro and Huber; 2005 and Sverdrup *et al.,* (2006). Identification was carried out to the nearest possible taxonomic level and then followed by counting of individual taxa.

2.3 Determination of relative abundance (%)

Macro-benthic invertebrate's species were identified, sorted and counted individually. The sum of each individual macro-benthic invertebrates species from each sampling station for the twelve (12) sampling months were added together in order to determine the numerical abundance of each species. The Relative abundance (%) of Macro-benthic invertebrate's species was calculated according to Ali *et al*., (2003) as follows:

$$\% Ra = n/N \times 100$$

Where;

n = the total number of individuals in each macro-benthic invertebrates taxonomic group.

N = the total number of individuals in the entire macro-benthic invertebrates taxonomic.

2.7 Ecological diversity Indices

The occurrence and relative numerical abundance of macro-benthic invertebrate's species was calculated using biotic indices such as Shannon and Weiner's index, Dominance, species evenness and Simpson index in order to determine distribution, abundance and diversity of species.

2.7.1 Shannon and Weiner's index (H): is a measure of species abundance and evenness and was expressed as:

$$H = \sum_{i=1}^{S} - (P_i * \ln P_i) \text{ (Shannon and Weiner, 1949)}$$

Where:

H = the Shannon diversity index

P_i = fraction of the entire population made up of species i

In = natural logarithm

S = numbers of species encountered

∑ = sum from species 1 to species S

2.7.2 Species evenness (E) was determined by using the equation:

$$E_H = \frac{H}{H_{max}} = \frac{H}{\ln S} \text{ (Pielou, 1966)}$$

Where:

H = Shannon and Wieners index.

S = Number of species in samples

2.7.3 Dominance (D) was determined using the equation:

$$(n/N)^2$$

Where:

n = total number of organisms of a particular species within the population

N = total number of organisms of all species

2.7.4 Simpson index was expressed as:

$$1 - D$$

Where:

$$D = (n/N)^2$$

n = total number of organisms of a particular species within the population

N = total number of organisms of all species

2.8 Determination of Biotic Index

The assessment of the water was done using biotic index. Biotic index gives numerical scores to specific "indicator" organisms at a particular taxonomic level (Armitage *et.al*., 1983). Family Biotic Index (FBI) was calculated using the modified Hillsenhoef biotic index (1988) by Bode *et al.* (1996). The formular is shown below:

$$BI = \frac{\sum x_i t_i}{n}$$

Where

x_i = number of individuals within a species

t_i = tolerance value of species

n = total number of organisms in the sample.

The rating of the water quality of the estuary using biotic index values is presented in table 1 below

Table 1: Evaluation of Water Quality using the family-level Biotic Index (Hilsenhoff, 1988)

Biotic Index	Water quality	Degree of Organic Pollution
0.00 – 3.50	Excellent	No apparent organic pollution
3.51 – 4.50	Very good	Possible slight organic pollution
4.51 – 5.50	Good	Some organic pollution
5.51 – 6.50	Fair	Fairly significant organic pollution
6.51 – 7.50	Fairly poor	Significant organic pollution
7.51 – 8.50	Poor	Very significant organic pollution
8.51 – 10.00	Very poor	Severe organic pollution

2.9 Statistical analysis

Data obtained was subjected to paired sample t-test to compare seasonal difference. The probability level was set at p = 0.05. Biological indices, such as Equitability (E), Simpson index, Dominance and Shannon-wiener's diversity indices was computed using paleontological statistics software (PAST) (version 3.0).

3. Results

3.1 Macro-benthic Invertebrate Composition

A total of thirteen thousand eight hundred and ninety-seven (13897) macro-benthic invertebrate individuals, which was made up of twenty six (26) species belonging to three (3) phylum and five classes (5) were observed in the Qua Iboe River Estuary. Macro-benthic invertebrates were represented by the phylum Arthropoda, Mollusca and Annelida. The dominant phylum in terms of macro-benthic invertebrate species composition was Arthropoda (13 species); this was closely followed by the phylum Mollusca (11 species) while the phylum with the least species composition was Annelida (2 species) (Table 2). In regards to macro-benthic invertebrate's abundance, the phylum mollusca which was represented by gastropod accounted for 7351 individuals forming 52.90 % of the total macro-benthic invertebrates while the least abundance was Annelida represented by Oligochaeta which contributed 370 individuals forming 2.66 % of the population encountered during the study (Table 3 and Fig. 2).

In the phylum Arthropoda, two (2) classes were represented namely; Crustaceans and Insecta. The most abundant Crustacean species was *Macrobrachium vollenhovenii* which had 1356 individuals, while the least abundant Crustacean was *Hemigrapsus species* with 124 individuals. The most abundant Insecta species was *Chironomus larvae* which had 458 individuals while the least abundant species in this class was *Atractomorpha acutipennis* with only 18 individuals (Table 2).

The phylum Mollusca was represented by Gastropoda. The most abundant species in the class Gastropoda was *Tympanotonus fuscatus* with 1707 individuals while the least abundant was *Potadoma species* with 23 individuals (Table 2).

Phylum Annelida was represented by the classes Polychaeta and Oligochaeta. Polychaeta was represented by *Glycera species* 375 individuals while Oligochaeta was represented by *Tubifex tubifex* which had 370 individuals (Table 2).

A temporal variation of the abundance of macro-benthic invertebrates in Qua Iboe River Estuary is presented in Table 3. Higher abundance was observed in the dry season than in the wet season. Although, there were variations in the seasonal composition of the macro-benthic invertebrates during the study, no significant (p=0.05) seasonal variation was observe.

Summary of ecological indices calculated for the five (5) stations is presented in Table 4. Taxa richness calculated as Shannon diversity index (H) was least in S5 (2.12) which is the upstream station while S1 and S3 accounted for the highest diversity (2.83). The pattern was similar for Simpson diversity index (1-D), S5 accounted for the lowest diversity (0.84) while S1 and S3 had the highest diversity (0.93). Equitability was least in S4 (0.84) and high in S1 and S3 (0.89) respectively. The five stations had low dominance level with insignificant different indices value (p=0.05).

3.2 Water Quality

Family biotic index (FBI) value calculated from the pollution tolerance score value of the major macro-benthic invertebrates encountered during the study were as follows; station 1 to station 4 had a biotic index rating which range from 6.68 – 7.18 and was therefore classified as fairly poor water quality (Significant organic pollution) while station 5 had a biotic index rating of 5.13 and was considered as good water quality which shows evidence of organic pollution within the study area (Table 5).

Table 1. Macro benthic-invertebrates Species

S/N	Macro benthic-invertebrates Species	S1	S2	S3	S4	S5	Total
	Arthropoda						
	Crustaceans						
	Decapoda						
1	*Uca tangeri*	244	132	184	22	-	582
2	*Callinectes amnicola*	308	287	298	34	2	929
3	*Macrobrachium vollenhovenii*	486	402	456	12	-	1356
4	*Pinaeus notialis*	392	247	361	14	-	1014
5	*Pinaeus monodon*	344	131	205	9	-	689
6	*Hemigrapsus species*	60	18	36	9	1	124
7	*Sesarma angolense*	187	112	167	24	-	490
	Insecta						
	Diptera						
1	*Chironomus larvae*	183	122	153	-	-	458
2	*Tabanus species*	18	3	11	6	4	42
3	*Psychoda larvae*	17	6	8	4	7	42
4	*Similium species*	11	7	9	2	1	30
	Ephemeroptera						
1	*Stenonema species*	-	-	-	8	19	27
2	*Atractomorpha acutipennis*	-	-	-	4	14	18
	Mollusca						
	Gastropoda						
1	*Pachymelania fusca*	387	287	402	19	4	1099
2	*Pachymelania aurita*	312	198	256	22	-	788
3	*Pachymelania byronensis*	239	188	256	15	4	702
4	*Potadoma species*	10	4	7	2	-	23

S/N	**Macro benthic-invertebrates Species**	**S1**	**S2**	**S3**	**S4**	**S5**	**Total**
5	*Tympanotonus fuscatus*	593	486	512	112	4	1707
6	*Thais callifera*	31	11	17	-	-	59
7	*Neritina afra*	251	152	192	4	5	604
8	*Neritina rubricate*	284	197	212	89	-	782
9	*Lymnaea species*	48	-	212	98	2	360
10	*Melanoides tuberculata*	458	312	387	23	-	1180
11	*Turritella annulata*	22	11	14	-	-	47
	ANNELIDA						
	Polychaeta						
1	*Glycera species*	112	98	128	37	-	375
	Oligochaeta						
1	*Tubifex tubifex*	118	111	117	24	-	370
	Total Number of Species	**24**	**23**	**24**	**23**	**12**	**26**
	Total Number of Individual	**5115.0**	**3522.0**	**4600.0**	**593.0**	**67.0**	**13897.0**

Table 2: Taxonomic Checklist of Macro-benthic Invertebrates Species Encountered in Qua Iboe River Estuary during the study period (May, 2015 - April, 2016).

S/N	Macro benthic-invertebrates Species	S1	S2	S3	S4	S5	Total
	Arthropoda						
	Crustaceans						
	Decapoda						
1	*Uca tangeri*	244	132	184	22	-	582
2	*Callinectes amnicola*	308	287	298	34	2	929
3	*Macrobrachium vollenhovenii*	486	402	456	12	-	1356
4	*Pinaeus notialis*	392	247	361	14	-	1014
5	*Pinaeus monodon*	344	131	205	9	-	689
6	*Hemigrapsus species*	60	18	36	9	1	124
7	*Sesarma angolense*	187	112	167	24	-	490
	Insecta						
	Diptera						
1	*Chironomus larvae*	183	122	153	-	-	458
2	*Tabanus species*	18	3	11	6	4	42
3	*Psychoda larvae*	17	6	8	4	7	42
4	*Similium species*	11	7	9	2	1	30
	Ephemeroptera						
1	*Stenonema species*	-	-	-	8	19	27
2	*Atractomorpha acutipennis*	-	-	-	4	14	18
	Mollusca						
	Gastropoda						
1	*Pachymelania fusca*	387	287	402	19	4	1099
2	*Pachymelania aurita*	312	198	256	22	-	788
3	*Pachymelania byronensis*	239	188	256	15	4	702
4	*Potadoma species*	10	4	7	2	-	23
5	*Tympanotonus fuscatus*	593	486	512	112	4	1707
6	*Thais callifera*	31	11	17	-	-	59
7	*Neritina afra*	251	152	192	4	5	604
8	*Neritina rubricate*	284	197	212	89	-	782
9	*Lymnaea species*	48	-	212	98	2	360
10	*Melanoides tuberculata*	458	312	387	23	-	1180
11	*Turritella annulata*	22	11	14	-	-	47
	ANNELIDA						
	Polychaeta						
1	*Glycera species*	112	98	128	37	-	375
	Oligochaeta						
1	*Tubifex tubifex*	118	111	117	24	-	370
	Total Number of Species	**24**	**23**	**24**	**23**	**12**	**26**
	Total Number of Individual	**5115.0**	**3522.0**	**4600.0**	**593.0**	**67.0**	**13897.0**

Table 3: Seasonal Variation of Macro-benthic Invertebrates in Qua Iboe River Estuary (May, 2015 – April, 2016).

Seasons							
Taxanomic		**Wet**		**Dry**		**Total**	
S/N	**Class**	**NA**	**RNA**	**NA**	**RNA**	**NA**	**RNA**
1	Crustaceans	2500	37.53	2684	37.10	5184	37.30
2	Insecta	329	4.94	288	3.98	617	4.44
3	Gastropoda	3498	52.51	3853	53.26	7351	52.90
4	Polychaeta	168	2.52	207	2.86	375	2.70
5	Oligochaeta	167	2.51	203	2.81	370	2.66
Total		**6662.0**	**100.0**	**7235.0**	**100.0**	**13897.0**	**100.0**

Where,
NA = Numerical Abundance
RNA = Relative Numerical Abundance

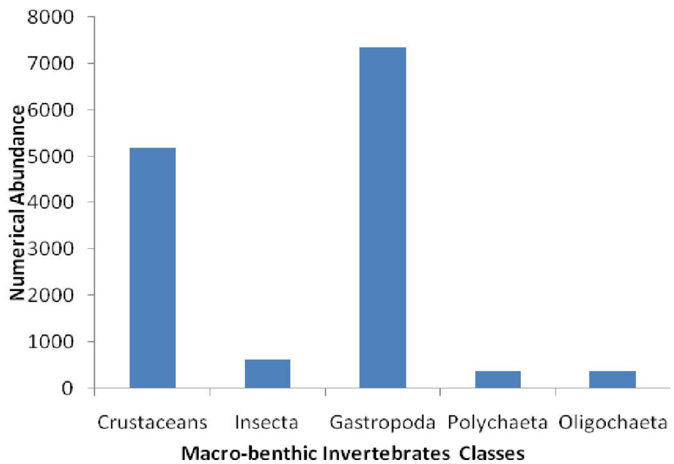

Fig 2: Numerical Abundance of Macro-benthic invertebrates Classes in Qua Iboe River Estuary during the Study Period (May, 2015 – April, 2016).

Table 4: Ecological Diversity Indices of Macro-benthic Invertebrates of Qua Iboe River (May, 2015 – April, 2016)

Ecological diversity indices	S1	S2	S3	S4	S5
Dominance	0.07	0.08	0.07	0.10	0.16
Shanon index	2.83	2.73	2.83	2.60	2.12
Simpson index	0.93	0.92	0.93	0.90	0.84
Equitability	0.89	0.87	0.89	0.83	0.85
Total No. of Species	**24**	**23**	**24**	**23**	**12**
Total No of Individual	**5115**	**3522**	**4600**	**593**	**67**

Table 5: Water Quality Assessment Using Pollution Score of the Encountered Macro-benthic Invertebrates during the Study

			Station 1			**Station 2**			**Station 3**			**Station 4**			**Station 5**		
Class	**Family**	**Species**	**x_i**	**t_i**	**x_it_i**	**x_i**	**t_i**	**x_it_i**	**x_i**	**t_i**	**x_it_i**	**x_i**	**t_i**	**x_it_i**	**x_i**	**t_i**	**x_it_i**
Crustaceans	Ocypodidae	*Uca tangeri*	244	6	1464	132	6	792	184	6	1104	22	6	132	0	6	0
	Portunidae	*Callinectes amnicola*	308	6	1848	287	6	1722	298	6	1788	34	6	204	2	6	12
	Palaemonidae	*Macrobrachium vollenhovenii*	486	6	2916	402	6	2412	456	6	2736	12	6	72	0	6	0
	Penaeidae	*Pinaeus notialis*	392	6	2352	247	6	1482	361	6	2166	14	6	84	0	6	0
	Penaeidae	*Pinaeus monodon*	344	6	2064	131	6	786	205	6	1230	9	6	54	0	6	0
	Varunidae	*Hemigrapsus species*	60	6	360	18	6	108	36	6	216	9	6	54	1	6	6

			Station 1			**Station 2**			**Station 3**			**Station 4**			**Station 5**		
Class	**Family**	**Species**	x_i	t_i	x_it_i	x_i	t_i	x_it_i	x_i	t_i	x_it_i	x_i	t_i	x_it_i	x_i	t_i	x_it_i
	Sesarmidae	*Sesarma angolense*	187	6	1122	112	6	672	167	6	1002	24	6	144	0	6	0
Insecta	Chironomidae	*Chironomus larvae*	183	8	1464	122	8	976	153	8	1224	0	8	0	0	8	0
	Tabanidae	*Tabanus species*	18	5	90	3	5	15	11	5	55	6	5	30	4	5	20
	Psychodida	*Psychoda larvae*	17	8	136	6	8	48	8	8	64	4	8	32	7	8	56
	Simuliidae	*Similium species*	11	6	66	7	6	42	9	6	54	2	6	12	1	6	6
	Heptageniidae	*Stenonema species*	0	3	0	0	3	0	0	3	0	8	3	24	19	3	57
	Pyrgomorphidae	*Atractomorpha acutipennis*	0	3	0	0	3	0	0	3	0	4	3	12	14	3	42
Gastropoda	Thiaridae	*Pachymelania fusca*	387	7	2709	287	7	2009	402	7	2814	19	7	133	4	7	28
	Thiaridae	*Pachymelania aurita*	312	7	2184	198	7	1386	256	7	1792	22	7	154	0	7	0
	Thiaridae	*Pachymelania byronensis*	239	7	1673	188	7	1316	256	7	1792	15	7	105	4	7	28
	Pachychilidae	*Potadoma species*	10	7	70	4	7	28	7	7	49	2	7	14	0	7	0
	Potamididae	*Tympanotonus fuscatus*	593	7	4151	486	7	3402	512	7	3584	112	7	784	4	7	28
	Muricidae	*Thais callifera*	31	7	217	11	7	77	17	7	119	0	7	0	0	7	0
	Neritidae	*Neritina afra*	251	7	1757	152	7	1064	192	7	1344	4	7	28	5	7	35
	Neritidae	*Neritina rubricate*	284	7	1988	197	7	1379	212	7	1484	89	7	623	0	7	0
	Lymnaeidae	*Lymnaea species*	48	7	336	0	7	0	212	7	1484	98	7	686	2	7	14
	Thiaridae	*Melanoides tuberculata*	458	7	3206	312	7	2184	387	7	2709	23	7	161	0	7	0
	Turritellidae	*Turritella annulata*	22	7	154	11	7	77	14	7	98	0	7	0	0	7	0
Polychaeta	Glyceridae	*Glycera species*	112	6	672	98	6	588	128	6	768	37	6	222	0	6	0
Oligochaeta	Tubificidae	*Tubifex tubifex*	118	10	1180	111	10	1110	117	10	1170	24	10	240	0	10	12
Total			**5115**		**34179**	**3522**		**25289**	**4600**		**30846**	**593**		**4004**	**67**		**344**
			6.68			**7.18**			**6.71**			**6.75**			**5.13**		
Remark			**Fairly Poor**			**Fairly Poor**			**Fairly Poor**			**Fairly Poor**			**Good**		

4. Discussion

The Twenty-six (26) macro-benthic invertebrates species recorded in this study were less than values recorded in other river bodies within the Niger Delta. Hart (1994) reported forty-three species from mangrove swamp of Port Harcourt area of the Niger Delta, Ezekiel, *et al*. (2011) reported 28 species in Sombreiro River while Hart & Zabbey (2005) reported 30 species in Woji Creek. However the low species recorded in this study is similar to other findings of benthic macro-invertebrates reported from other water bodies in Nigeria. Yakub & Igbo (2014) recorded 18 species in coastal bodies in Lagos lagoon; George *et al*. (2010) reported 19 species from Okpoka creek sediments; Umeozor (1995) reported 23 species from New Calabar River while Victor & Dickson (1985) recorded only 9 species from Ikpoba River. The differences in benthos composition may be attributed to the ecological differences of the different habitat, locations and the period of investigation. Also the water quality, sediment characteristics, shelter and food availability might have also affected the abundance and distribution of the benthos communities. This conforms to the reports of Dance & Hynes (1980).

The class gastropoda was observed as the most dominant group while the least dominant group was oligochaeta during the study. The dominance of the class gastropoda in this study also conforms to the reports of Olomukoro & Azubuike (2009) for Ekpan creek, Warri, Nigeria and Shailendra *et al*. (2013) for Kunda River**,** India. The occurrence and dominance of gastropods throughout the sampling period confirms their ubiquitous nature in an alkaline environment which is unique for brackish ecosystem (Olomukoro & Azubuike, 2009)). Gastropods are relatively tolerant to physical and chemical variations in the environment and are usually found in broad range of habitats (Ajao & Fagade, 2002).

The least occurrence of benthos belonging to the class oligochaeta may reflect their inability to survive in wide ecological amplitudes. Also their restriction to various habitats may also account for the low benthos abundance in this class.

The conspicuous abundance of pollution-tolerant taxa in station 1 to station 3 is an indication of pollution, deteriorating water quality and the impact of anthropogenic stressors in the water body (Wang *et. al*., 2007). The high occurrences of these species in station 1to station 3 is not unprecedented because these species have been reported to occur in polluted and contaminated water bodies and have a high tolerance limit ranging from 6 – 10 (Bode *et al*., 1996).

The determination of diversity is another biological tool for assessing the pollution level of environments. The diversity indices are all based on two assumptions (Ishaq, 2013). Stable community structure has high diversity value while unstable ones have lower diversity value (UNEP, 2006). Thus, Stability and diversity is an index of environmental integrity.

According to Kumara *et al*. (2011), numerical quantification of biological diversity and (or) its elements can be of great value in studies like this because of its objective which enables comparison of current biodiversity status between similar habitats. Their views tangle with this research in that diversity index such as dominance, Shannon, Simpson and equitability indices computed for the different stations vary considerably across the stations. These differences could be attributed to the ecological differences in the geographical locations and periods (Shah & Pandit, 2013). According to Shah & Pandit, (2013), the active natures of events, natural series of disorderliness and anthropogenic pressures leads to a marked variation in the allocation of aquatic biotic communities both in temporal and spatial scales.

High Shannon, Simpson and equitability values were recorded in station 1 and station3 while low values of these indices were recorded in station 5. The high values in these diversity indices in station 1 and station 3 impacted with anthropenic activities is not clearly understood but contradicts the findings of MacArthur (1965) and Olomukoro (1996) which reported that low diversity is an indication of stress in the environment while high diversity is a reflection of a stress free environment. This assertion deviates remarkably from this study were high diversity were associated with sites grossly polluted with organic matter, heavy metals and petroleum hydrocarbons. This finding conform to the earlier assertion reported by Ajao & Fagade (1990 and 2002). Wilhm & Dorris (1968) had set the diversity index of less than 1 for highly polluted water bodies, 1-3 for moderately polluted, and greater than 4 for unpolluted water bodies. Based on this station 1 to 5 could be considered as moderately polluted water body. Macro-benthic invertebrate diversity in Qua iboe River Estuary could have been affected by ongoing human activities resulting in significant organic pollution in the system.

The apparent lack of seasonality in the richness and diversity of macro-benthic invertebrates in Qua iboe River Estuary could mean the presence of active and growing benthic invertebrate populations during the entire year. This finding synchronizes with the findings of Ramirez & Pringle (1998) in a related study of invertebrates in a lowland neotropical stream in Costa Rica, suggesting that benthic communities are subject to similar stresses throughout the year, and that populations grow and reproduce continuously. Macro invertebrates' composition was higher in the dry season than in the wet season. This is not unprecedented as several researchers have reported a similar trend in Nigerian rivers (Ramirez & Pringle, 1998; Yakub & Igbo, 2014).

Carvalho & Fernandes (2006) explained that survey of macro-benthic fauna is a useful guide in explaining changes in ecological conditions. Water quality assessment using the Family Biotic Index (FBI) developed by (Hilsenhoff, 1988) summarizes the various tolerances of the macro-benthos community with a single value. The aim of this assessment was to detect organic pollution within the water body.

The results showed that the water quality ratings across the stations were fairly poor to good. Station 1to 4 had a fairly poor water quality while station 5 had a good water quality. Going by the rating proposed by Hilsenhoff (1988), the good water quality status observed in station 5 is a reflection of some degree of organic pollution in the station. Also the fairly poor water quality statuses of stations 1 to 4 may indicate significant organic pollution going on in the stations. This is not unprecedented but is directly linked with the consistent anthropogenic activities such as sewage discharge, domestic waste discharge and open defecation witnessed in this station. These activities lead to massive depletion of the dissolved oxygen owing to the enormous amount of organic materials discharged into this station requiring high levels of oxygen for chemical oxidation, decomposition or break down by microbial organisms (Mason, 1992; Yakub, 1998). This breakdown requires the use of oxygen and its effect is evident as a sharp decline in dissolved oxygen values also known as the oxygen sag curve. This verifies the result obtained in this study where stations 1 to 4 were dominated with pollution tolerance species which are known to tolerate very low oxygen and high pollutant concentrations (Zadory & Müller, 1981). In line with this, Bashnet, 2013 reported strong negative correlation of Tubificidae with dissolved oxygen (DO). Concurrently, Tyokumbur, *et. al*. (2002) argued that strong negative correlation values between Tubificidae and dissolved oxygen indicated an affinity for anoxic conditions and this may probably be because of their possession of haemoglobin, a pigment that transports dissolved oxygen.

5. Conclusion

This study has been able to fulfill its objectives of assessing the pollution level of the Estuary using the family biotic index (FBI) and also, in assessing the diversity and abundance of macro- benthic invertebrates in Qua Iboe River Estuary. Conclusively, this study will provide baseline information as regards the pollution status of water quality of Qua Iboe River Estuary. In the light of this study, awareness should be created by the Government, NGO'S and concerned stakeholders in educating the public on the ills and detrimental effects of water pollution.

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