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Assessment of the Water Quality of a Southern Nigeria Estuary using Biotic Indices

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Abstract
The water quality of the Koko section of Benin River was assessed at four study stations using HBI (Hilsenhoff Biotic Index), TR (Taxa Richness), EPT (Ephemeroptera, Plecoptera, and Trichoptera) index, BMWP (Biological Monitoring Working Party) score and ASPT (Average Score Per Taxon). Except for station 1, the other study stations were inunadated with high human activities such as disposal of industrial and municipal and human wastes, bathing, industrial activities, sand mining and transportation. Station 3 was identified as the most impacted by all the biotic indices employed. TR, HBI and EPT disclosed station 1 as the least polluted site while BMWP and ASPT differed slightly. Dredging and industrial activities were found to be the chief causes of the degredation of this section of the river.

Keyword: Water quality, biotic indices, assessment, Koko

Introduction
Biotic indices are mathematical expressions used to assess water quality, based on the community structure of organisms. Macroinvertebrates are the most popular biotic indicators of water quality because they are mostly ubiquitous, they integrate both long term and short term environmental variations, they are relatively easy to sample and identify to family level, and their sedentariness predisposes them to impacts from xenobiotic compounds and other aquatic stressors (Chaphekar, 1991). For correct use of these organisms, the community structure of the local fauna in a region must be appropriately known. Following this, the biotic indices might be modified using members of the local fauna and then the regional index can be adapted (Kazancig*et al.,* 1997; Duran, 2006). Many authors have utilised macrobenthic invertebrates in assessing the quality of surface water all over the world (Hilsenhoff, 1988; Duran, 2006; Ogbeibu and Oribhabor, 2002; Olomukoro, 2008; Omoigberale and Ogbeibu, 2010; Olomukoro and Dirisu, 2014).
Considerable growth in the African population over the years has brought an increase in urbanization, industrial and agricultural land use. This has entailed an increased discharge in a noticeable heterogeneity of pollutants to receiving water bodies and has caused undesirable effects on the different components of the aquatic environment and on fisheries (Saad *et al.,* 1984). The Koko section of the Benin River in Delta State, Nigeria is a typical example of a stream receiving a lot of wastes from human activities. Benin River, which serves as a drainage to many creeks such as Mayuku, Nana, Robbins and Olague creeks as well as the Ethiope and Osse Rivers (Udo, 1970); receives wastes from the many industries lining its banks and hence the importance of constant monitoring. This paper presents the assessment of the Koko section of the Benin River using various biotic indices.

Study Area
The study area (the Koko section of Benin River) is situated in the North Central part of Delta State (Lat $05^0$59'15.1" – $05^0$59'20.1"N; Long $005^0$28'41.5"- $005^0$24'41.3"E). The stretch of the study area is approximately 5km long and here the river flows through a mangrove swamp forest (Fig. 1). The present study was conducted at the lower brackish water reaches of Benin River. Four sampling stations were selected along the course of the river from upstream (station 1) to the downstream (station 4). There were no noticeable human activity at station 1 except fishing, while stations 2-4 had lofty human activities like disposal of industrial and municipal wastes, bathing, disposal site for human wastes, industrial activities, sand mining and transportation. Industries located along the study areas include EBENCO NIG. LTD. (crude oil retrieval from sludge), TOTAL NIGERIA (Bitument blending) and OPTIMA ENERGY (Storage facility).
Geologically, the sedimentary formation of Koko area is quatenary and the specific age of this formation is holocene. This area is the alluvium of lower Delta made up of a combination of sand, clay and gravel (BSRDP, 1977). The predominant vegetation encountered at the sampled stations include; *Nymphaea lotus,Echinochloa pyramidalis, Pandanus candelabrum, Eichorrnia crassipes,Pistia stratiotes, Elaeis guineensis, Cocos nucifera, Bambusa oldhami*, *Pennisetum purpureum* and *Rhizhophora mangle.*

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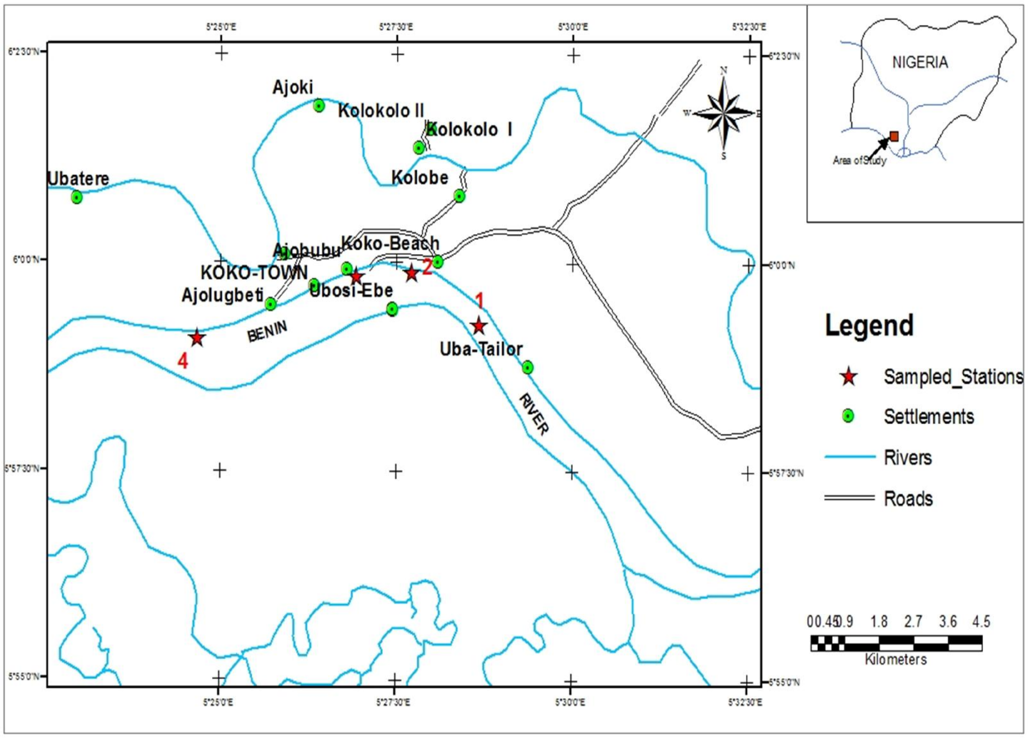

FIG. 1: MAP OF STUDY AREA SHOWING THE SAMPLED STATION ALONG BENIN RIVER

Materials and Methods

Sampling

The stations were sampled monthly from June, 2012 to January 2013, amounting to 8 months of study. Standard methods were employed in sampling and analysis of the physicochemical aspect of the water (Rasmussen, 1976; Berthou *et al.,* 1981; APHA, 1998; Radajevic and Bashkin, 1999; Parageau et al., 2004).

Two biotopes were sampled for macrobenthic invertebrates. Sediment samples were collected with the use of Van-veen grab. For each sampling station, 2 or 3 hauls were made by sending the grab down into the bottom. The sediments collected were processed following the procedure described by Andem*et al.*(2013). The bankroots were sampled using the kick sampling technique (Hynes, 1972). All collected benthic macroinvertebrates were fixed with 4% formaline and taken to the laboratory for sorting and identification using standard procedures (Pennak, 1953; Ward and Whipple, 1959; Mellanby, 1963; Lenat*etal.*, 1981; Needham and Needham, 1982;Ogbeibu, 1991).

Data Analysis and Biotic Assessment

Diversity indices were determined using the windows computer programe, PAST version 1.99. Analysis of variance (ANOVA) was used to test for significantdifferences between the means of the physico-chemical parameters of the 4 sampled stations, using windows computer programe, SPSS version 20.0. Where significant difference ($P<0.05$) was observed, Duncan Multiple Range (DMR) test was performed to locate the site of the variation.The following biological metrics were adopted in the study stations:

Hilsenhoff's biotic index (HBI)which is based on categorizing macroinvertebrates into categories depending on their response to organic pollution:

$$HBI = \frac{\Sigma\, niai}{N}$$

Where ni is the number of specimens in each taxonomic group, ai is the pollution tolerance score for that taxonomic group, and N is the total number of organisms in sample.Macroinvertebrates are given a numerical pollution tolerance score (ai) ranging from 0 to 5 (Hilsenhoff 1988).

Taxa Richness (TR) which indicates the health of the community through its diversity and increases with increasing habitat diversity, suitability, and water quality (Plafkin*et al*., 1989). TR equals the total number of taxa represented within the sample. The healthier the community is, the greater the number of taxa found within that community.

Ephemeroptera, Plecoptera, and Trichoptera Index (EPT), which is a count of the number of EPT that are found in a sample is a useful index since most of the taxa found within these orders are very sensitive to environmental change and pollution. In general,higher numbers of EPT in relation to other benthic invertebrates indicates a stable streamenvironment that has not been exposed to a lot of pollution.

The Biological Monitoring Working Party score (BMWP) provides single values, at thefamily level, representative of the organisms' tolerance to pollution. The greater their tolerance towards pollution, the lower the BMWP scores. BMWP was calculated by adding the individual scoresof all families, and order Oligochaeta (Friedrich *et al*., 1996), represented within the community.

Average Score Per Taxon (ASPT) represents the average tolerance score of alltaxa within the community, and was calculated by dividing the BMWP by the number of familiesrepresented in the sample (Friedrich *et al*., 1996).

Results

A summary of the physico-chemical characteristics at the study station is shown in Table 1. Except for COD, PO_4^{3+}, Mg and the heavy metal V, there was no significant difference ($P<0.05$) observed among the study stations. Duncan Multiple Range (DMR) test revealed that station 3 was significantly higher than the other stations.

A total of 3, 500 individuals comprising 13 orders and 28 families of macrobenthic invertebrates were encountered in this study (Table 2; Fig. 2-5). The highest density was recorded at station 4 (28.6%), followed by station 2 (27.83), then staion1 (25.57%). The lowest density wsa observed at station 3 which accounted for 18% of the total density of macrobenthic fauna encountered.

The Decapoda (74.89%) and Ephemeroptera (16.97%) were the dominant group, while the Mesogastropoda (3.91%), Diptera (2.17%), Odonata (0.54%), Errantia (0.37%), Plesiopora (0.34%), Archioligochaeta (0.29%), Coleoptera (0.2%), Plecoptera (0.09%), Hemiptera (0.09%), Araneida (0.09%) and Arynchobdellida (0.03%) constituted the rare group in this study (Fig.2 -5).

The values of the biometric meterics: Taxa richness, EPT taxa richess,modified HBI, BMWP and ASPT used in the assessment of the water quality is shown in Table 4 and Fig. 6.

Taxa richness scores designates stations 1, 2 and 4 non-impacted, while station 3 withe a score of 22 was designated slightly impacted. The EPT scores ranged from 3-7, with station 1 recording the highest value. The lowest values were recorded at stations 3 and 4 which were numerically equal, while HBI scores of 4.79 (good water quality), 6.07 (fair water quality), 5.94 (fair water quality) and 5.86 (fair water quality) were recorded for stations 1, 2, 3 and 4 respectively. The lowest BMWP value was recorded at station 3 (39), while station 2 recorded the highest value (65), followed closely by station 4 (64). Station 1 showed a BMWP metric score of 53. In terms of ASPT, the water quality of stations 1 and 3 were designated 'poor' with metric scores of 3.53 and 3.25 respectively, while those of stations 2 and 4 were adjudged 'moderate' with scores of 3.83 and 3.76 respectively.

The diversity indices calculated at the study stations are presented in table 3. The highest values as determined by Shannon (H'), Margalef (R'), and Evenness (E) was recorded at station 1. However, Dominance (D) was highest at station 2 and the lowest value recorded at station 1.

Table 1: A summary of Physical and Chemical Characteristics of Water from Benin River at Koko

Parameters	Unit	Station 1 $\bar{x} \pm$ SD (Min- Max)	Station 2 $\bar{x} \pm$ SD (Min- Max)	Station 3 $\bar{x} \pm$ SD (Min- Max)	Station 4 $\bar{x} \pm$ SD (Min- Max)	P-alue	FMEnv. Permissible Limits
Ambient Temperature	^0C	31.20±1.16 (29.6-32.9)	31.14±1.06 (29.9-33)	31.25±1.20 (29.9-33.2)	31.56±1.24 (29.8-33)	P>0.05	NA
Water Temperature	^0C	29.63±1.51 (27.8-32.3)	29.79±1.34 (28-31.5)	30.5±1.08 (29-31.7)	30.13±1.53 (28-31.6)	P>0.05	35^0C
pH		5.93±0.28 (5.66-6.46)	5.90±0.45 (5.46-6.53)	5.84±0.34 (5.54-6.43)	5.95±0.53 (5.44-6.61)	P>0.05	6.5-8.5
Electricalconductivity (EC)	uS/cm	266.76±142.40 (71.00-421.00)	299.54±144.18 (87.00-463.00)	391.88±208.81 (95.00-611.00)	386.48±246.56 (76.00-674.00)	P>0.05	N/A
Totaldissolved Solid (TDS)	mg/l	133.38±71.20 (35.50-210.50)	149.77±72.09 (43.50-231.50)	195.94±104.40 (47.50-305.50)	193.24±123.28 (38.00-337.00)	P>0.05	500
Total suspended Solids (TSS)	mg/l	1.87±1.00 (0.50-2.95)	2.10±1.01 (0.61-3.24)	2.74±1.46 (0.67-4.28)	2.71±1.73 (0.53-4.72)	P>0.05	<10
Total solids (TS)	mg/l	135.25±72.20 (36.00-213.45)	151.87±73.10 (44.11-234.74)	198.68±105.87 (48.17-309.78)	195.95±125.00 (38.53-341.72)	P>0.05	NA
Turbidity	NTU	0.56±0.30 (0.15-0.88)	0.63±0.30 (0.18-0.97)	0.82±0.44 (0.20-1.28)	0.81±0.52 (0.16-1.42)	P>0.05	5.0
Chloride (Cl^-)	mg/l	75.98±39.65 (21.30-126.30)	85.69±40.91 (26.10-138.90)	111.88±59.13 (28.50-183.30)	109.97±69.93 (22.80-202.20)	P>0.05	200
Dissolved oxygen (DO)	mg/l	5.38+0.18 (5.14-5.69)	5.34±0.33 (4.77-5.86)	5.56±0.26 (5.12-5.86)	5.48±0.21 (5.21-5.83)	P>0.05	5.0
Biological oxygen demand (BOD_5)	mg/l	2.27±0.50 (1.80-3.08)	2.29±0.51 (1.79-3.08)	2.53±0.82 (1.79-3.73)	2.67±0.84 (1.86-3.71)	P>0.05	NA
Chemical oxygen demand (COD)	mg/l	37.76±5.43 (29.11-46.31)[c]	43.87±6.22 (35.67-52.08)[bc]	59.89±14.15 (38.95-79.43)[a]	55.97±20.58 (31.16-87.62)[ab]	P<0.01	40
Sulphate (SO_4^{2-})	mg/l	4.97±2.60 (1.35-8.00)	5.59±2.66 (1.65-8.80)	7.30±3.85 (1.81-11.61)	7.19±4.56 (1.44-12.81)	P>0.05	500
Nitrate (NO_3^-)	mg/l	3.20±1.71 (0.85-5.05)	3.59±1.73 (1.04-5.56)	4.70±2.50 (1.14-7.33)	4.64±2.96 (0.91-8.09)	P>0.05	10
Phosphate (PO_4^{3-})	mg/l	0.92±0.57 (0.36-2.03)[b]	1.04±0.58 (0.44-2.09)[ab]	1.96±1.04 (0.48-3.06)[a]	1.93±1.23 (0.38-3.37)[a]	P<0.05	<5
Sodium (Na^+)	mg/l	2.52±1.28 (0.78-4.46)	2.84±1.28 (0.96-4.59)	4.31±2.30 (1.05-6.72)	4.25±2.71 (0.84-7.41)	P>0.05	200

Potassium (K^+)	mg/l	4.25±2.16 (1.28-7.29)	4.78±2.15 (1.57-7.51)	7.06±3.76 (1.71-11.00)	6.96±4.44 (1.37-12.13)	P>0.05	NA
Calcium (Ca^{2+})	mg/l	2.04±0.88 (0.78-3.39)	2.33±0.93 (0.96-3.97)	4.03±2.16 (1.05-6.72)	3.95±2.54 (0.84-7.41)	P>0.05	NA
Magnesium (Mg^{2+})	mg/l	1.31±0.79 (0.50-2.84)^{b}	1.49±0.80 (0.61-2.92)^{ab}	2.74±1.46 (0.67-4.28)^{a}	2.71±1.73 (0.53-4.72)^{a}	P<0.05	NA
Iron (Fe)	mg/l	1.71±1.01 (0.64-3.65)	1.93±1.03 (0.78-3.76)	3.53±1.88 (0.86-5.50)	3.48±2.22 (0.68-6.07)	P>0.05	1
Zinc (Zn)	mg/l	0.21±0.11 (0.06-0.36)	0.24±0.11 (0.08-0.38)	0.35±0.19 (0.09-0.55)	0.35±0.22 (0.07-0.61)	P>0.05	1.0
Manganese (Mn)	mg/l	0.51±0.30 (0.19-1.09)	0.58±0.31 (0.23-1.13)	1.06±0.56 (0.26-1.65)	1.04±0.66 (0.21-1.82)	P>0.05	0.05
Copper (Cu)	mg/l	0.38±0.20 (0.13-0.73)	0.43±0.20 (0.16-0.75)	0.70±0.37 (0.17-1.10)	0.70±0.44 (0.14-1.21)	P>0.05	0.1
Nickel	mg/l	0.78±0.46 (0.18-1.62)	0.88±0.47 (0.22-1.67)	1.55±0.86 (0.24-2.44)	1.53±1.01 (0.19-2.70)	P>0.05	0.05
Cadmium	mg/l	0.03±0.02 (0.00-0.06)	0.04±0.02 (0.00-0.06)	0.05±0.04 (0.00-0.09)	0.05±0.04 (0.00-0.10)	P>0.05	0.01
Vanadium	mg/l	0.05±0.04 (0.02-0.12)^{b}	0.06±0.04 (0.02-0.13)^{ab}	0.12±0.07 (0.02-0.18)^{a}	0.11±0.07 (0.02-0.20)^{a}	P<0.05	0.01
Chromium	mg/l	0.06±0.03 (0.02-0.10)	0.07±0.03 (0.02-0.10)	0.09±0.05 (0.02-0.15)	0.09±0.06 (0.02-0.16)	P>0.05	0.05
Lead	mg/l	0.03±0.02 (0.00-0.05)	0.03±0.03 (0.00-0.06)	0.09±0.13 (0.00-0.40)	0.09±0.14 (0.00-0.42)	P>0.05	0.05

P < 0.01 – Highly significant difference; P < 0.05 – Significant difference;P > 0.05 – No significant difference; Means with the same superscript in the same row are not significantly different.

Table 2: Abundance and Distribution of Macrobenthic Invertebrates across the study stations in Benin River at Koko.

	Taxa	Station 1	Station 2	Station 3	Station 4
Oligochaeta					
Lumbricidae	*Eiseniella tetrahedra*	-	1	-	1
Enchytraeidae	*Enchytraeus* sp.	1	1	1	2
Lumbriculidae	*Lumbriculus sp.*	-	-	2	3
Naididae	*Aulophorus sp.*	-	-	1	-
	Nais sp.	5	4	-	-
Hirudidae	*Haemopsis marmorata*	-	1	-	-
Polychaeta					
Nereidae	*Nereis sp.*	2	4	1	2
	Pisione africana	-	-	2	-
	Pisionidens indica	-	-	1	-
Glossiphoniidae	*Placobdella sp*	-	1		-
	Unidentified sp	-	2		-
Decapoda					
Palaemonidae	*Potamalpheops monodi*	262	741	469	726
Alpheidae	*Euryrychina edingtonae*	5	11	10	18
	Macrobrachium machrobrachion	28	29	33	4
	M. vollenhovenii	7	66	45	130
	M. felicinum	1	3	10	1
Grapsidae	*Sersama alberti*	6	1	6	2
	Sersama sp.	1	4	2	-
Araneida					
Cybaeidae	*Argyroneta aquatica*	-	-	-	3
Coleoptera					
Chrysomelidae	*Donacia sp*.	-	1	-	-
Elimidae	*Heterlimnius* sp.	-	-	-	1
Pyralidae	*Nymphula nympheata*	1	-	-	-
	Unidentified sp	-	-	-	1
	Unidentified sp	1	-	-	-
	Unidentified sp	-	-	-	2
Ephemeroptera					
Baetidae	*Baetis tricaudatus*	1	-	8	-
	Centroptilum sp..	42	5	7	7
	Cloeon sp.	82	1	-	6
	Cloeon bellum	9	-	-	-
	Cloeon cylindroculum	373	12	14	27
Diptera					
Ceratopogonidae	*Palpomyia* sp	-	-	-	1
	Probezzia sp	1	-	-	1
Chironomidae	*Corynoneura* sp	4	-	-	-
	Stictochironomus sp	1	-	-	-
	Cricotopus sp.	8	2	-	-
	Cricotopus scottae	2	1	-	2
	Tanytarsus balteatus		1	1	-
	Pentaneura nilotica	15	4	11	12
	Polypedilum sp	2	1	1	-
	Pseudochironomus sp.	1	-	-	3
Tanypodinae	*Clinotanypus maculatus*	1	-	-	-
Hemiptera					
Belostomatidae	*Lethocerus* sp	-	1	-	1
Naucoridae	*Pelocoris femoratus*	-	-	-	1

Odonata					
Corduliidae	*Oxygaster curtisii*	-	1	-	-
Gomphidae	*Gomphus* sp.	-	1	-	-
Libellulidae	*Libellula* sp.	1	-	3	2
	Sympetrum sp	1	1	-	1
Zygoptera					
Coenagrionidae	*Ceriagrion tenellum*	2	2	-	-
	Coenagrion scitulum	1	-	-	-
	Enallagma sp.	-	1	-	1
	Pseudagrion sp.	-	-	1	-
Tricoptera					
Polycentropodidae	*Polycentropus* sp	3	-	-	-
Mesogastropoda					
Hydrobiidae	*Potamopyrgus ciliatus*	6	-	-	24
Potamididae	*Pachymelania* sp.	1	1	-	1
	Tympanotonus fuscatus	10	62	-	9
	T. radula	3	4	-	-
Neritidae	*Neritina fluviatilis*	2	3	-	5
	N. glabrata	3	-	2	1
	Total	**895**	**974**	**630**	**1001**

Table 3: Diversity Indices

	Station 1	**Station 2**	**Station 3**	**Station 4**
Dominance (D	0.2719	0.5888	0.562	0.5449
Shannon (H')	1.821	1.102	1.169	1.176
Simpson (D)	0.7281	0.4112	0.438	0.4551
Eveness {E}	0.1671	0.0912	0.1463	0.1013
Margalef (R')	5.297	4.65	3.257	4.487

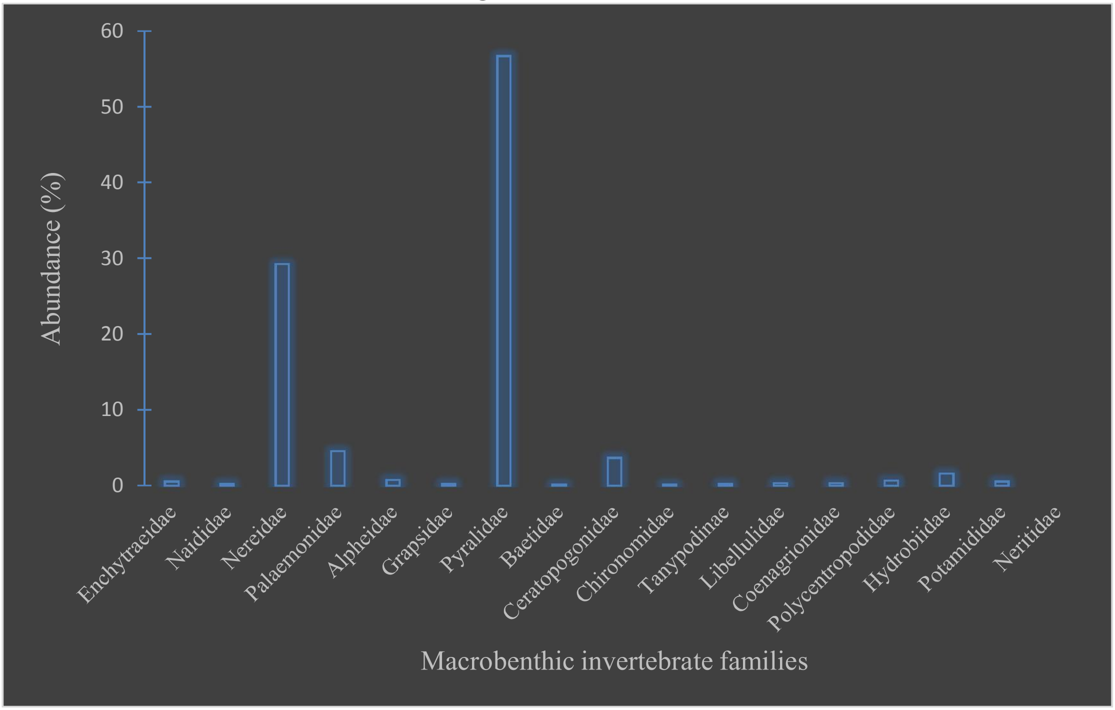

Fig. 2: Relative abundance of macrobenthic invertebrate fauna at station 1

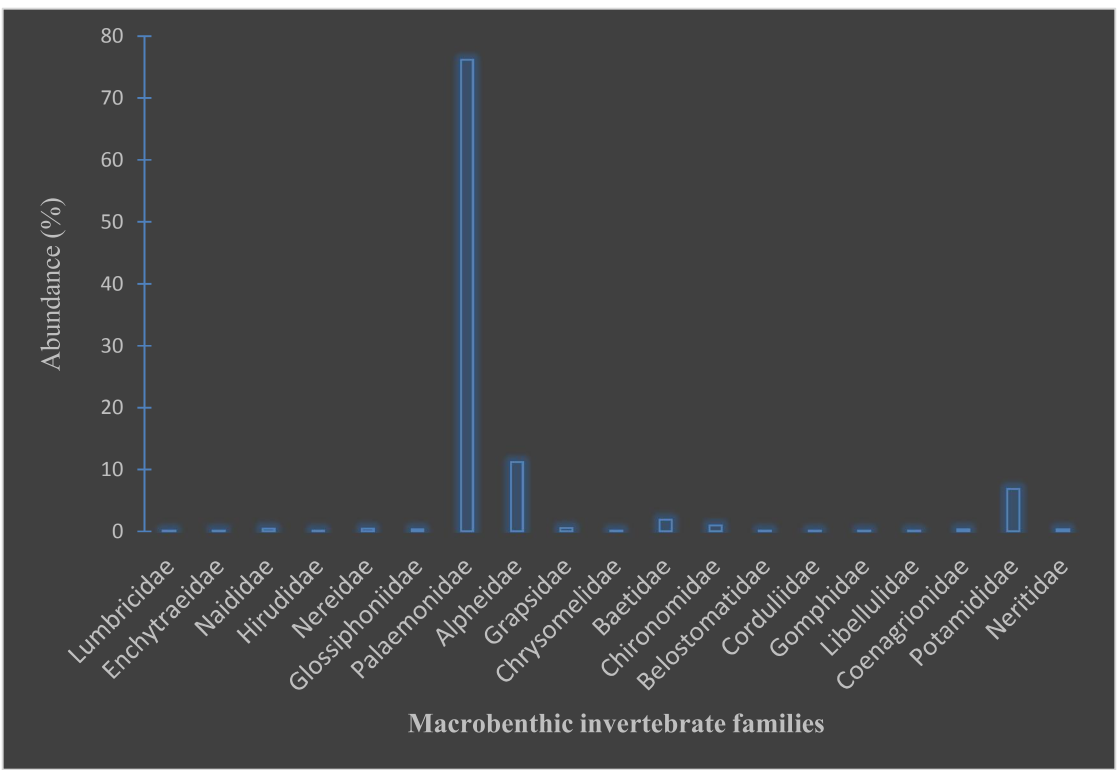

Fig. 3: Relative abundance of macrobenthic invertebrate fauna at station 2.

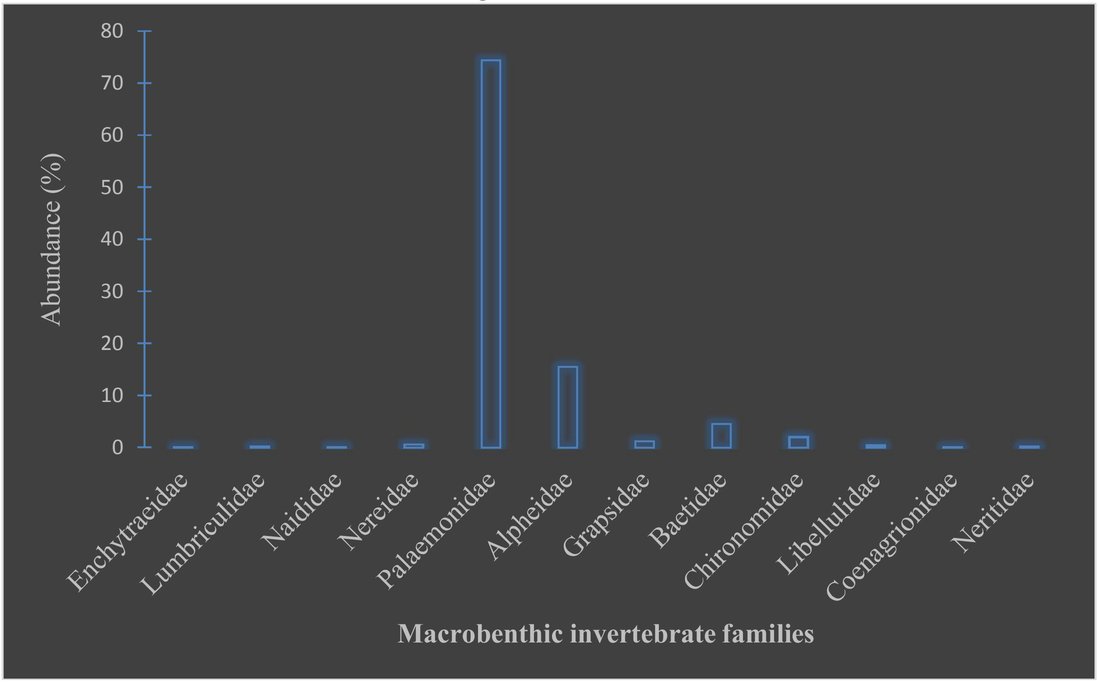

Fig. 4:Relative abundance of macrobenthic invertebrate fauna at station 3.

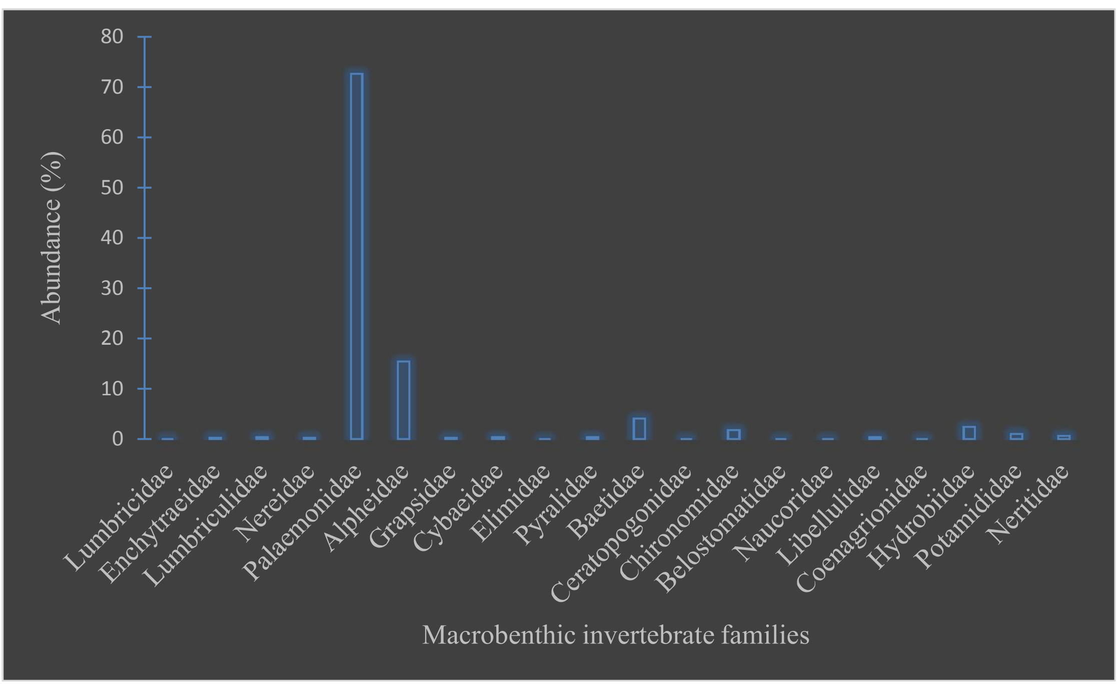

Fig. 5: Relative abundance of macrobenthic invertebrate fauna at station 4

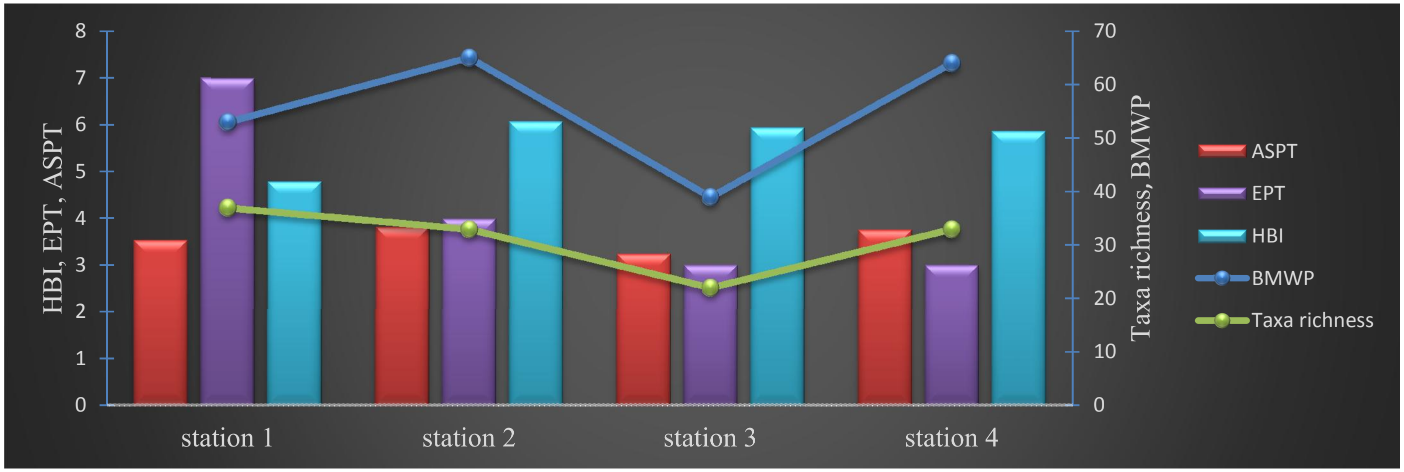

Fig. 6: Spatial variation in biotic Indices (Taxa richness HBI, EPT, BMWP and ASPT) at the study stations.

Table 4: Biotic Indices Assessments of theBenin River at Koko

Biotic index	**Station 1**	**Station 2**	**Station 3**	**Station 4**
Taxa richness	37 (Non impacted)	33 (Non impacted)	22 (Slightly impacted)	33 (Non impacted)
EPT	7 (Slightly impacted)	4 (Moderately impacted)	3 (Moderately impacted)	3 (Moderately impacted)
HBI	4.79 (Good)	6.07 (Fair)	5.94 (Fair)	5.86 (Fair)
BMWP	53 (Contaminated)	65 (Medium contaminated)	39 (Contaminated)	64 (Medium contaminated)
ASPT	3.53 (Poor)	3.83 (Moderate)	3.25 (Poor)	3.76 (Moderate)

Discussion

The EPT index displays the taxa richness only within the insect groups which are considered to be pollution sensitive, and as such increases with increasing water quality. This metric measures the total number of taxa within the orders Ephemeroptera, Plecoptera and Trichoptera. The occurrence of these organisms in rivers have long been used as indication of good water quality (Williams and Feltmate 1992; Omoigberale and Ogbeibu, 2010; Olomukoro and Dirisu, 2014). Designation of station 1as slightly impacted could be attributed to the paucity in human activities at this station. The only noticeable anthropogenic activity at this station was fishing. This agrees with the observation that this station was the most preserved site in terms of the physico-chemical characteristics. The "moderately impacted" station 3 was inundated with human activities such as dredging, sewage disposal, open defaecation and bitumen blending. These activities at this station, in conjuction with sand mining and fishing activities downstream, were probably responsible for the 'moderately impact' status of station 4, although a slight recovery was observed in the physico-chemical characteristics.

Taxa Richness (TR) index is similar to EPT taxa richness; differing in the fact that while EPT utilises only Ephemeroptera, Plecoptera and Trichoptera in the computation of its index scores, taxa richness utilises all macrobenthic invertebrates encountered at the site under study. In terms of Taxa richness, station 1 was also of the best water quality (non impacted). This is unsurprising because this station recorded the highest Evenness as well as the lowest Dominance index scores. Taxa Richness bespeaks the health state of the community through its diversity. According to Plafkin *et al*. (1989), the diversity of macrobenthic invertebrates increases with increasing habitat diversity, suitability, and water quality. That is, the healthier the community is, the greater the number of taxa found within that community. In terms of taxa richness, stations 1 and 2 were non impacted but station 3 (slightly impacted) showed a sharp decrease in diversity which is attributable to the heightened anthropogenic activities at this station. Station 4 (non impacted) however, reaffirmed the high recovery rate of this river. This is attributable to the high flow rate of this river, which encourages aeration, and hence increasing microbial breakdown of pollutants.

The modified HBI also disclosed good water quality at station 1, while the other stations were adjudged 'fair'. The HBIis based on an organism's relative sensitivity to water quality. Values ranging from 0 to 10 are assigned to individuals; 0 being for the least tolerant of organic pollution, and 10 for organisms most tolerant of organic pollution. Species intermediate in their tolerance of organic pollution are assigned intermediate values (Hilsenhoff, 1982). The sharp increase in HBI observed at station 2 may not be unconnected with heightened industrial activitties at this station in the month of September, which saw crude oil floating on the surface of the water. This probably led to the lowest dissolved oxygen (DO) value (4.77 mg/L) recorded in this study. Low DO values may have led to low evennes and high dominance here. HBI is prefered by a lot of biologists because it is the most comprehensive in approach. Unlike other indices which uses only the number of taxa, HBI employs both the number of taxa and the number of individuals in the community in computation of its index scores.

A slight variation from the conclusions of EPT, TR and HBI was observed in the BMWP and ASPT assessments. In terms of BMWP and ASPT, stations 2 and 4 were healthier than station 1. This was occasioned by the absence of Corduliidae and Gomphidae (Odonates) at station 1. Conversely, these two groups with high BMWP tolerance scores, were represented at station 2. The absence of these organisms at station 1 may have been due to the availability of vertebrate predators as well as reduced aquatic macrophytes at this station (Bidwell and Clark, 1977; Omoigberale and Ogbeibu, 2010). BMWP is a biometric assessment based on the provision of single values, at the family level, representative of the organisms' tolerance to pollution. The greater their tolerance towards pollution, the lower the BMWP score (Mackie, 2001). However, this metric does not measure other attributes of communities, such as species composition, richness and ecological preferences (Pinto *et al.,* 2004). ASPT represents the average tolerance score of all taxa within the community. Like BMWP, ASPT identified station 3 as the most polluted followed by station 1, while station 2 was adjudged to be of the best quality among the study stations.

The importance of benthic macroinvertebrate biometric indices in water quality assessments cannot be over emphasized. Many species however, are not ubiquitous, hence a wide variability in taxonomic compositions and in indicator organisms as well. The interpretations of tolerance and sensitivity by water quality experts are often based on local conditions,therefore, biotic indices are likely to be geographically specific. There is need to formulate a biotic index for the Nigerian ecozone as there is none at the moment.

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