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Heavy Metals and Macroinvertebrate Communities in Bottom Sediment of Ekpan Creek, Warri, Nigeria.

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Abstract

The macrobenthic fauna in bottom sediments of Ekpan Creek was studied from January to June 2007. Analyzed heavy metals were Lead, Iron, Zinc, Copper, and Chromium. Variations in chemical parameters showed that station 2 had the highest values recorded in all parameters except for Iron and Zinc, where they were higher at station 1. A total of 1135 individual organisms were recorded. Nineteen (19) macroinvertebrate taxa belonging to four major groups were identified. Mollusca were the most dominant and constituted 92.51% density occurrence, while insecta, crustacean, and polychaeta constituted 1.94, 2.29, and 3.26% respectively. Diversity varied at the study stations, with the highest taxa richness recorded at station 1. Mollusca were positively significantly correlated with lead ($P < 0.05$, $r = 0.836$), and Zinc ($P < 0.05$, $r = 0.96$). Sorenson index indicates similarity in species composition between the stations.

التلخيص

تمت دراسة الحيوانات القاعية الموجودة في خور اكبان في الفترة ما بين كانون ثاني وحزيران 2007. وتم كذلك دراسة تراكيز المعادن الثقيلة وتشمل الرصاص والحديد والزنك والنحاس والكروميوم. وتوضح التحاليل الكيميائية ان المحطة رقم 2 فيها أعلى النسب من المعادن باستثناء الحديد والزنك حيث كان أعلى ما يمكن في المحطة رقم 1. وقد تم جمع 1135 حيوانا في تلك الفترة تنتمي الى 19 نوعا من الحيوانات القاعية في اربع مجموعات وهي الرخويات وتشمل 92.51%. بينما تشمل الحشرات والقشريات وعديدة الاشواك 1.94%و2.29%و 3.26% على الترتيب. اختلف مقياس التنوع بين المحطات وكان اعلاها في المحطة رقم 1. وتبين من مؤشر سورسن ان التشابه في الانواع بين المحطات كبير.

Keywords：Macrobenthic Fauna; Sediment; Heavy Metals; Diversity Creek; Nigeria

1. Introduction

Benthic studies of the brackish aquatic environment in Nigeria have been very scanty. The difficult terrain of the creeks, creeklets, and estuaries has restrained many ecologists from the survey of Nigerian coastal areas. Olomukoro and Egborge(2003) investigated the macrobenthic fauna of Warri River, and reported an array of benthic organisms in their preliminary publication of the fresh / brackish zones of the river catchment area. A total of 138 macroinvertebrate taxa were reported from the River, among the species collected are *Diplogaster* sp, *Naidium bilongata, Nais obstuse, Nais Simplex, Placobdella monifera, Megapus* sp., *Mediopsis* sp., *Baetis bicaudatus,* and *Procladius* sp. The most dominant benthic groups were Decapoda, Ephemeraoptera, Diptera, and Mollusca.

Other notable works of interest were those of Olomukoro and Victor(2001) on a tributary of Ikpoba River, Hart and Chindah (1998), who identified 43 species of benthos from the mangrove forest of the Bonny estuary, Egborge and Okoi (1987) who reported on the biology of a community swamp farm in Odetsekiri, Warri and Victor and Onomivbori (1996) on the effects of urban perturbation on the benthic macroinvetebrates of a southern Nigerian stream.

The structure of benthic communities in running water ecosystem is determined by a dynamic array of abiotic and biotic factors (Kumar, 1995, Austen and Widdicombe 2006). Wharfe (1977) observed that the finer clay/ silk particles had a higher water retaining capacities (42 to 66% water content) compared with more coarse sediments (28 to 49% content). The water retaining capacity can be important for burrowing invertebrates during periods of exposure. Olomukoro and Egborge, 2003 reported that species of polychaeta were restricted to a particular station because their occurrence may be governed by niche preference and feeding habit. Polychaeta are also known to be tolerant to silting and velocity of flow, than most groups of benthic organisms (Bishop, 1973), as they are deposit feeders; and live in the mud.

However, outstanding investigations, which deal with the bottom fauna of some rivers in Southern Nigeria, have also been studied (Victor and Dickson, 1985; Victor and Ogbeibu, 1985; 1991; Olomukoro and Ezemonye, 2000; Olomukoro, Ezemonye and Igbinosun, 2004).

Investigation of macrobenthic fauna of Ekpan-Creek Warri has not been carried out.

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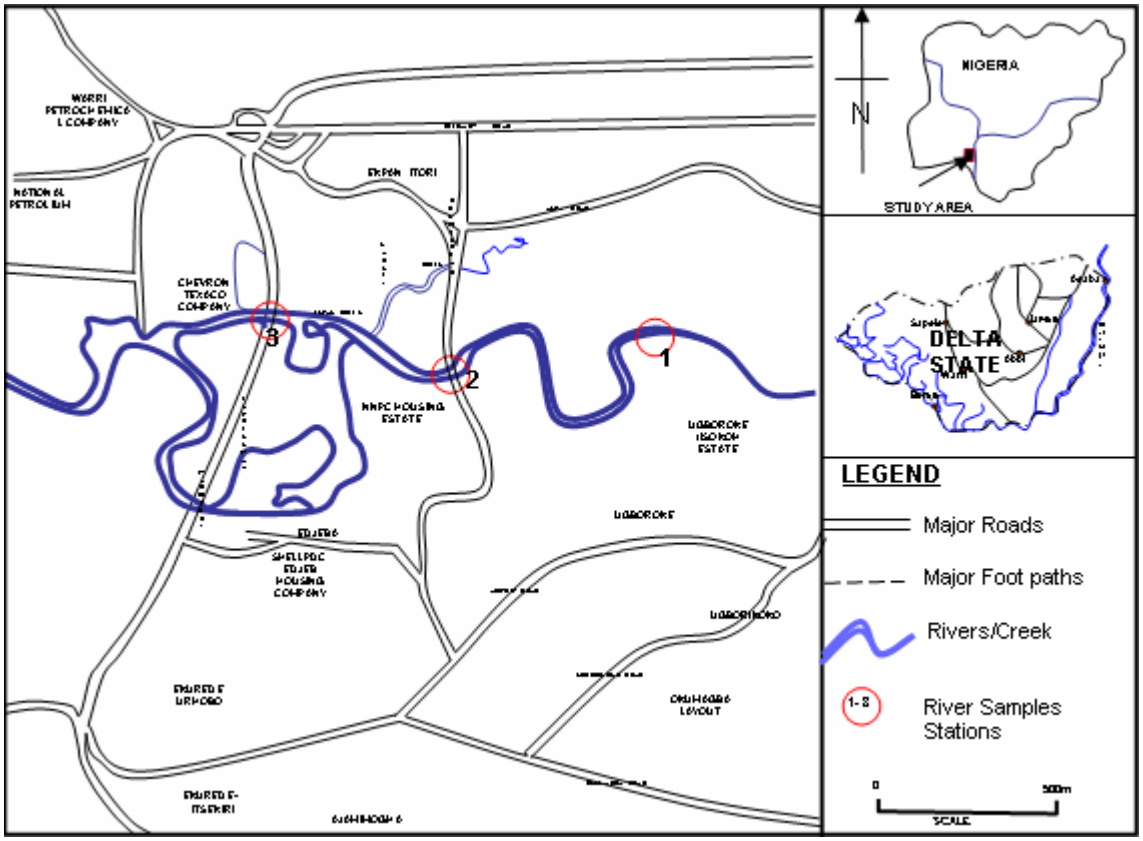

Figure1. Map of Warri Showing the Sampled Stations.

The bottom sediment fauna study is to provide baseline information on which subsequent works would be based. The objectives are to examine the composition, abundance, diversity of benthos, and the heavy metals of the bottom sediment of Ekpan Creek, Warri.

2. Study Area

Ekpan Creek is located within Effurun-Warri of Delta State in Southern Nigeria (Latitude $5^{0}3^{011}$-$5^{0}3^{011}$ and longitude $5^{0}40^{11}$- $5^{0}44^{11}$E). The Creek, which is about 12km long, takes its source from Effurun. It flows through the city (westernly) into Tori Creek at NNPC Jetty, and empties into Warri River at Bennet Island.

a. Sampling Location

Three sampling stations were chosen (Figure1) for their proximity to facilities, structures or human activities that could potentially affect water quality and biodiversity. Station I is located close to the creek source. Water depth is 2.20 ± 3.74m, and the velocity of flow (1.07 ± 0.46m/S) is minimal and the bank is flanked with red mangrove, *(Rhizophora racemosa*), plantain tree (*Musa* sp.) and some shrubs. This water is murky and turbid, and the substratum is made of clay and mud. Human activities include fishing, bathing, and laundry.

Station II is about 4km from station one. It is located at the bridge, close to NNPC housing complex. Water depth is 4.10 ± 7.72, and the flow rate (1.49 ± 0.11m/S) is faster than station I. The substratum is a combination of sand, silt, and clay. Marginal vegetation consists of *Rhizophora recemosa* (red mangrove), few grasses. Human activities include fishing, and the use of the water for construction.

Station III is located at the Chevron-Texaco company bridge site, 5km from station II. The substratum is a mixture of sand and silt. Water depth is 6.50 ± 8.46m/S, and the velocity of flow is very fast, about 1.48 ± 0.14m/S. Oil film dots the water surface.

3. Material and Methods

a. Sampling Techniques

Benthic samples were collected fortnightly from the study stations from January to June 2007, using an Ekpan grab operated by hand in shallow water. It is recommended for sand and silt (Hynes, 1971). A 6-inch Ekman grab was forced into the substratum to depth of 15-20cm. Contents trapped by the grab were processed using the technique, earlier described by Hynes 1971. Sieved and sorted organisms were preserved in 4% formalin. Bottom sediment samples were collected with grab at monthly intervals in polythene bags for heavy metals analysis.

b. Digestion and Sediment Analysis

Sediment samples were digested, using the nitric acid, perchloric acid method (APHA 1997). An atomic absorption spectrophotometer (model pycunicam sp. 2900) was also used for the analysis of lead, Iron, Zinc, copper and Chromium. Identification of organisms was possible by using appropriate keys and works of Mellanby, 1963; Needham & Needham, 1962; Pennak 1978, and Olomukoro, 1996.

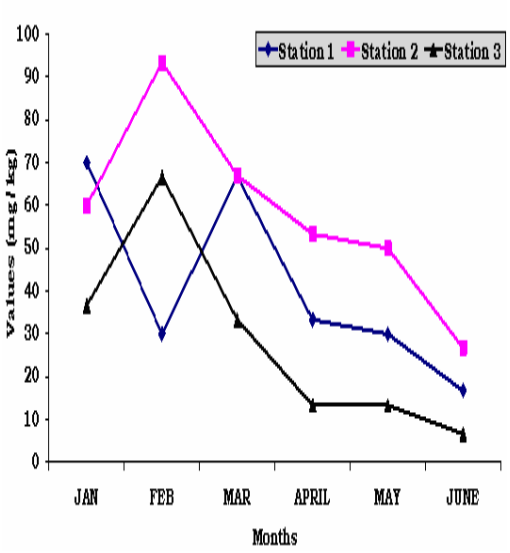

Figure2. Monthly variation in iron concentrations in Ekpan Creek.

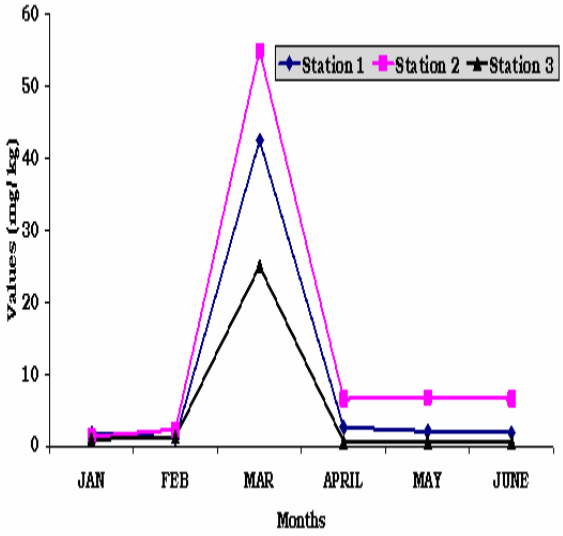

Figure 3. Monthly variation in lead concentrations in Ekpan Creek.

c. *Statistical Analysis*

Biological indices, Margalef's index (d); Shannon–Weiner index (H), and Evenness E were used in the calculation of taxa richness, general diversity. and evenness (Green, 1971 and Robinson and Robinson, 1971). The faunal of the stations were compared. using Sorenson's quotient (Sorenson 1948) of similarities. Both, the correlation coefficient of chemical variables and benthic organisms were computed. ANOVA DUNCA combined test was used in calculating the mean value of the heavy metals of the stations. One way Analysis of variance and Pearson's correlation coefficient were used in the statistical analysis of chemical variables at 5% level of significance.

4. Results

a. *SEDIMENT*

The summary of the heavy metals concentration values of the sediment of Ekpan creek study stations is presented in Table 1.

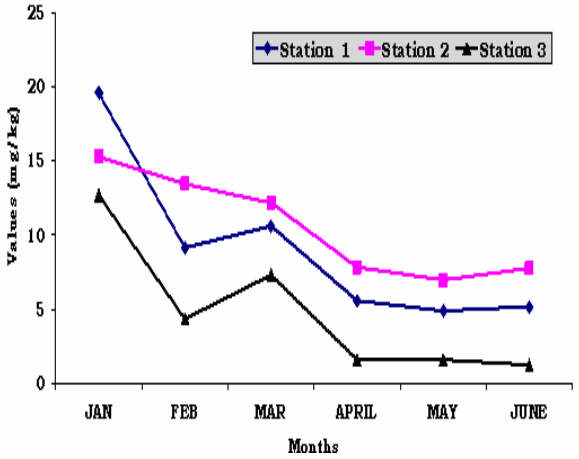

Figure 4.Monthly variation in zinc concentrations in Ekpan Creek.

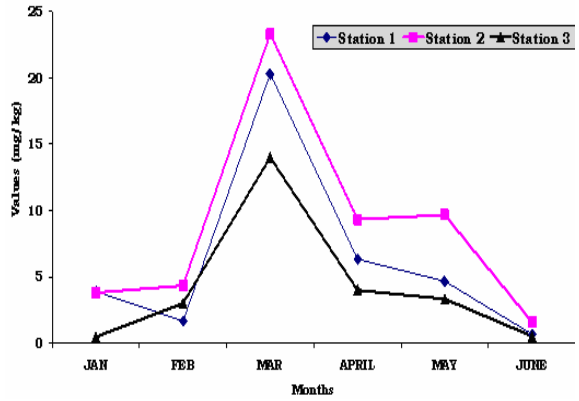

Figure 5.Monthly variation in copper concentrations in Ekpan Creek.

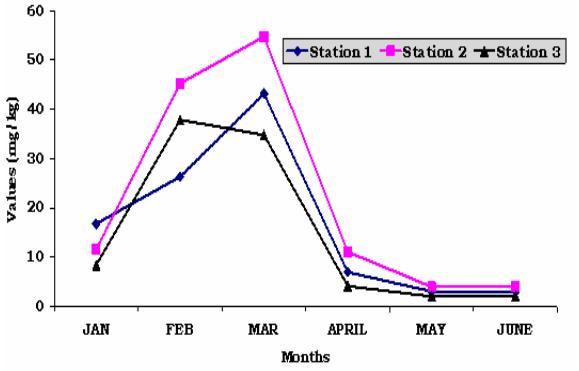

Figure 6. Monthly variation in chromium concentrations in Ekpan Creek.

Iron and Zinc concentration values were higher in January at stations II and I than in station III (Figs 2 and 3). The values of these metals ranged from 6.67 to 93.33 mg/kg and 1.21 to 19.60mg/kg in the stations.

However, the increases in Lead (ranged from 0.59 to 55.00mg/kg), Copper (0.47 to 23.30mg/kg) and Chromium (02.02 to 54.74mg/kg) concentration values were high in the month of March in all the stations, but very low in May, particularly at station III (Figs. 4, 5 and 6)

b. Macrobenthic Invertebrate Fauna

A total of 19 macro invertebrate taxa comprising 1,135 individuals include 3 species of polychaeta, 1 species of Decapoda, 3 species of Diptera, 1 species of Lepidoptera and 11 species of Mollusca.

Table 1. The summary of chemical parameters in the three study stations of Ekpan Creek.

			STATION 1		STATION 2		STATION 3	
Parameter	**Units**	N	Mean ± S. E	Min - Max	Mean ± S. E	Min – Max	Mean ± S. E	Min – Max
Lead	mg/kg	6	8.52 ± 6.79	– 42.50	13.09 ± 8.44	1.30 – 55.00	4.85 ± 4.03	0.59 – 25.00
Iron	mg/kg	6	41.11 ± 8.93	16.67 – 70.00	58.39 ± 8.94	26.67 – 93.33	28.33 ± 9.10	6.67 – 66.67
Zinc	mg/kg	6	9.16 ± 2.29	4.87 – 19.60	10.58 ± 1.43	6.96 – 15.30	4.78 ± 1.85	1.21 – 12.70
Copper	mg/kg	6	6.26 ± 2.93	0.69 – 20.30	8.67 ± 3..21	1.59 – 23.30	4.22 ± 2.05	0.47 – 14.00
Chromium	mg/kg	6	16.51 ± 6.49	2.98 – 43.16	21.79 ± 9.10	4.00 – 54.74	14.89 ± 6.86	2.02 – 37.89

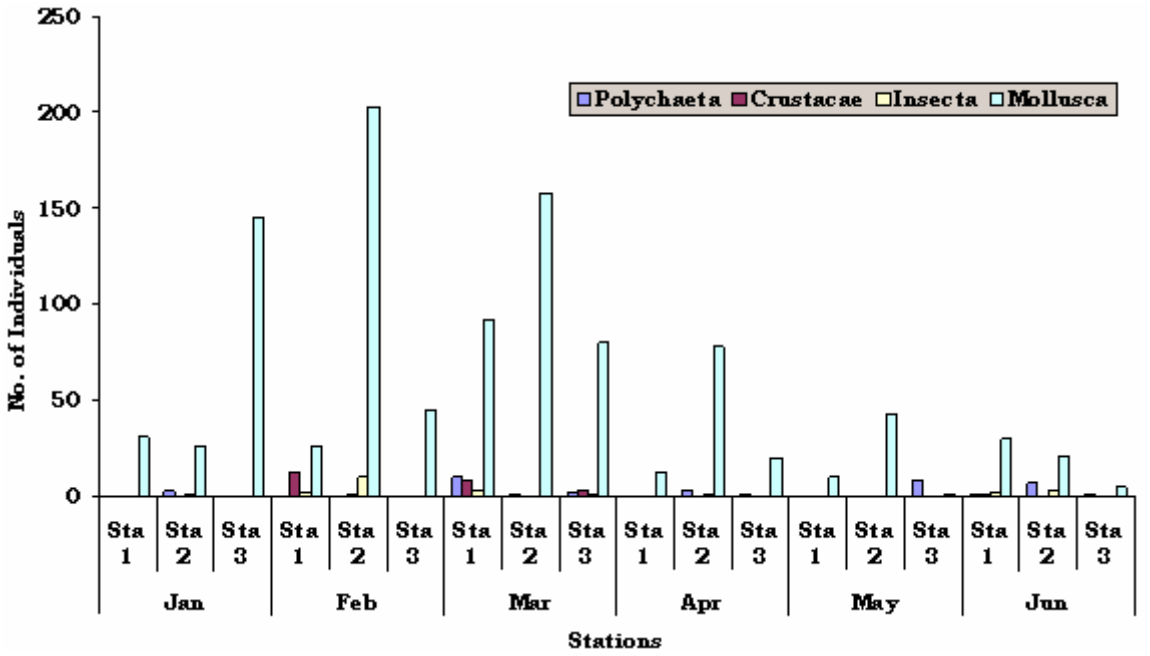

Figure 7. Monthly variation in the distribution of macrobenthic invertebrate groups.

The overall taxa composition, distribution, and abundance of macrobenthic invertebrates collected during the study period are presented in Table 2. Individuals organisms were dominated by Mollusca, which constituted 92.51% density occurrence, while polychaeta, crustacea and insecta made up of 3.26, 2.29 and 1.94% respectively Table 3. as also found in station 2.

Ampullariidae (Pilidae) had Pila ovata at station 3 in the month of February as a single record.

Assimineidae was represented by the *Assiminea hessei*

Polychaeta was represented by *Namanereis hawaiiensis, Lycastopsi* sp and *Nereis* sp. This was represented in the months of March, June, January, April, and May in all the stations (Figure 7)

Potamalpheops monodi (Apheidae, Crustacea) occurred in all stations with highest occurrence in station I, and it was recorded in February, March, and June (Figure 7).

Chironomidae (Diptera) was represented by *Chironomus* sp. *Tanytarsus* sp. and *Tanypus* sp., and were recorded in all stations in February, March, April, and June.

A single Lepidopteran larva was found in the month of February in station 2.

Gastropoda recorded in the Creek consists of five families viz Neritidae, Hydrobiidae., Potamididae, Pilidae, and Assimineidae. Neritidae was represented by *Neritina glabrata* and *Nerita senegalensis*, and was recorded in all stations throughout the sampling period (Figure 7).

Hydrobiidae has its highest occurrence in station 2, although it was recorded in all the sampling stations in February and March. Representatives of this group are *Hydrobia* sp., *Potamopyrgus* sp. and *Argyronecta aquatica* (Figure7). Potamididae (*Tympanotonus* sp) w in station 3 in the month of March.

Lamelibranchia (Ancylidae) was represented by *Macoma cumana*. It occurred in all stations in the months of January, February, and May (Figure 7).

i. Diversity

Figure 8 shows taxa richness (D), Shanon – Weinner's index (H), and Evenness (E) estimated for the study stations. The highest taxa richness was recorded in station 1, while the least was recorded in station 3.

Figure 9 shows spatial and temporal variation in species richness of benthic macroinvertebrates in the study area. The highest general diversity was recorded in station 3 while the least in Station 2. Also the highest evenness was recorded in station 3, and the least was in station 2.

The faunal similarity showed that all the three stations were similar in species composition, but the highest similarity was between stations II and I, and the lowest was between III and II (Table 4).

ii. Correlation Coefficient Analyses

The correlation coefficient analyses of Mollusca variables and chemical parameters of station 1 were computed. Mollusca were inversely insignificantly correlated with chromium, but positively insignificantly correlated with copper. However, they were positively significantly correlated with lead ($P < 0.05$, $r = 0.836$), and Zinc ($P < 0.05$, $r = 0.96$) but inversely significantly correlated with iron ($P < 0.05$, $r = -0.58$).

Table 2. Composition, Distribution and Abundance of Macrobenthic Invertebrates in Ekpan Creek, Warri January – June 2007.

	STATION 1	STATION 2	STATION 3
POLYCHAETA			
Namanereis hawaiiensis		1	
Lycastopsi sp	1	2	
Nereis sp	10	11	
DECAPODA			
Potamalpheops monody	22	1	3
DIPTERA			
Chironomus sp	3	2	
Tanytarsus sp	2		
Tanypus sp	2	10	1
LEPIDOPTERA			
Lepidopteran larvae		2	
ARCHAEOGASTROPODA			
Neritina glabrata	14	69	72
Nerita senegalensis	5	20	18
MESOGASTROPODA			
Hydrobia sp	4		
Potamopyrgus sp		1	
Potamopyrgus ciliatus	87	103	22
Argyronecta aquatica			1
Tympanotonus furscatus radula	138	271	85
Tympanotonus furscatus furscatus	5	64	36
Pila ovata			1
Assiminea hessei			2
Macoma cumana	9	2	21
Total	**302**	**559**	**274**

5. Discussion

The high heavy metals concentration in the bottom sediment of Ekpan creek confirms the previous reports on some aquatic studies (Gibbs, 1977; Ezemonye 1992). Metal enrichment of sediment is reflected by the sedimentation of metals ions when they compete with H^+ ions sorption sites in the aquatic environment (Oguzie, 2002). The physical process in the area could help the release of solutions rich in heavy metals into the bottom sediment of the creek, similar to what was reported for Canadian waters by Sly (1977). These metals, according to Edginton and Callender (1970) and Choa (1977), have high content of detrital mineral bonds and forms complexes that's precipitate at river bottom.

The high concentration of iron in the sediment might suggest the influx of industrial effluents. The observed higher concentration of heavy metals such as iron, zinc, and chromium in the sediment at the stations during the dry season than the rainy season shows the possible dilution effects by run-off. Thus there was a clear pattern of seasonal variation. However, lead and copper did not reflect the two seasons; they fluctuated throughout the duration of the study.

Table 3. Percentage abundance of species and individuals of the major groups.

Groups	Taxa	% Taxa	Individual	% Individual
Polychaeta	3	15.79	37	3.26
Crustacean	1	5.26	26	2.29
Insecta	4	21.05	22	1.94
Mollusca	11	57.89	1050	92.51

Macrobenthic fauna of Ekpan creek appear to be unique in its community structure. A total number of 1, 135 individuals, belonging to four major groups of organisms, included polychaeta (3 taxa), crustaceans (1 taxon), insecta (4 taxa) and Mollusca (11 taxa). The low number of taxa recorded is not surprising. According to Victor and Victor (1992), the number of taxa in brackish waters has been known to be fewer than that of freshwater and marine habitat. The configuration of immediate substrate of occupation, both as a refuge and more critically, as a source of food, is often the paramount factor governing distribution of macroinvertebrate fauna, and the bottom sediment of aquatic ecosystems are known to serve as shelter for macrobenthic invertebrates and direct or indirect food source for detritus and grazers (Bishop, 1973).

Table 4. Faunal similarities in the study stations of Ekpan Creek, Warri.

	STATION I	STATION II	STATION III
STATION I	*	81.48	72.00
STATION II	81.48	*	69.23
STATION III	72.00	69.23	*

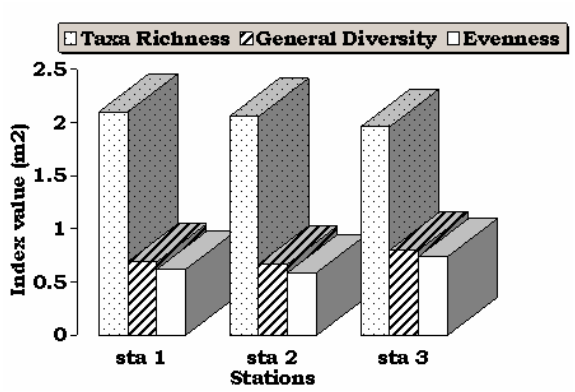

Figure 8. *Diversity of macrobenthic invertebrates in the study stations.*

Recorded Polychaetes, except for Nereis sp, were restricted to station 1 and 11, which have muddy bottom compared to the more sandy station III. The restriction of these species is known to be associated with muddy substratum rich in organic matter (Carter, 1981). They are also deposit feeders and are known to be tolerant to silting and velocity of flow than most groups of benthic organisms (Bishop, 1973).

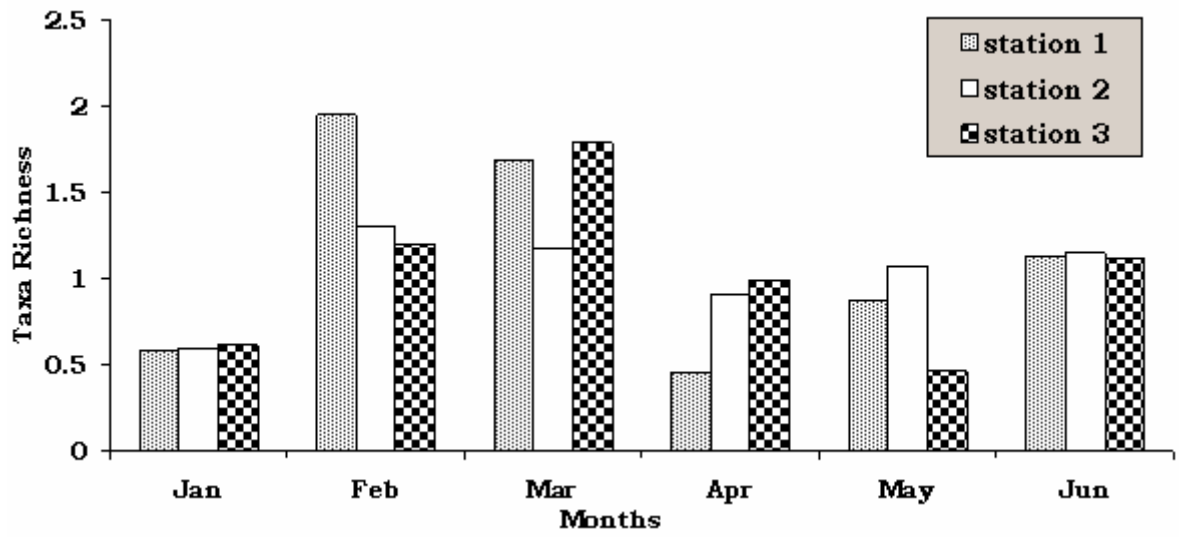

Figure 9. Spatial and temporal variation in species richness of benthic macroinvertebrate in the study area.

High abundance and distribution of mollusc in Ekpan creek could be attributed to the level of pH in the creek. Slight decrease in acidity and the corresponding slight increase in alkalinity may account for the abundance of mollusc. Beadle (1994), has reported that acidity is one of the major factors limiting the distribution of the mollusc in water bodies and in support of this, Nwadiaro (1984), reported that the distribution of mollusc in the lower Niger Delta was limited to the neutral to slightly alkaline brackish water zone. Of all the molluscan recorded in this study, six species; *Neritina glabrata, Nerita senegalensis, Potamopyrgus ciliatus, Tympanotonus furscatus radula, Tympanotonus furscatus furscatus* and *Macoma cumana* were present in all the stations. Mollusca were positively significantly correlated with lead, and zinc.

The distribution pattern of insecta shows that they were restricted to stations 1 and 2. Awachie (1981) observed that the Insecta usually does not show habitat restrictions, but the dominance of chironomids at station 2 compared to other stations may indicate pollution stress in the station.

The crustaceans were represented by single specie, *Potamalpheops monodi*. This was mostly found at station 1 and its abundance in that station may be due to factors other than food and shelters.

The seasonal variation of the macroinvertebrates reveals that, mollusca occurred in all the months. They were more abundant in the months of January to March (dry season) compared to April to June (rainy season). Other species occurred randomly throughout the duration of the study.

6. Conclusion

The effects of human activities on heavy metals concentration values were predominant during the dry season, and much of water dilution in the rainy season lowered the concentrations of metals. On the abundance and diversity of invertebrates, only few representative taxa of Polychaeta, Lepidoptera, Diptera, and Mollusca were recorded in the bottom sediment of the creek.

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