THE IMPACT OF LAND BASED POLLUTION ON THE HYDROCHEMISTRY AND MACROBENTHIC COMMUNITY OF A TROPICAL WEST AFRICAN CREEK

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ABSTRACT
The impact of land based pollution on the hydrochemistry and macrobenthic community of Porto Novo Creek Lagos, Nigeria was investigated between 1999 and 2000. The surface water of the creek was characterised by high total suspended solids(>140mg/l),moderate biochemical oxygen demand (BOD_5) values (<5.80mg/l); low total dissolved solids (<23.0mg/l), low dissolved oxygen content (<2.80mg/l) and low transparency (<0.18m). With the exception of pH and surface water temperature, all other parameters differed significantly ($p<0.01$) among the study stations. A high level of organic pollution was evident in the creek in the dry months. Sediment type was predominantly muddy sand with rapid change in the nature of the substratum within relatively short distances. The macrobenthic faunal abundance and composition were low and the more dominant taxonomic groups were annelids. Faunal similarities upstream were significantly different ($p<0.01$) from stations downstream. The low faunal abundance and low diversity were attributed to stress imposed by effluents from land based sources as well as substrate instability.

Keywords: creek, hydrochemistry, impact, landbased, macrobenthos, pollution.

INTRODUCTION
There are several published work on the species distribution and aspects of ecology of benthic fauna of Lagos Lagoon and harbour (Webb and Hill, 1958; Sandison, 1966, Yoloye, 1969, Oyenekan, 1975; Brown, 1991). Recently, interest has centred on the distribution, population dynamics, secondary production and the effects of pollution on benthic macrofaunal communities (Ajao, 1989; Ajao and Fagade, 1990; Brown and Oyenekan, 1998; Chukwu, 2002). There is presently a dearth of information on the community structure and effects of pollutants on the macrobenthic community in the associated tidal creeks.

The lagoons and creeks of South Western Nigeria are linked to the sea through the Lagos harbour (Nwankwo and Akinsoji, 1992). Owing to seasonal distribution of rainfall, the lagoon system and creeks experience seasonal flooding which introduces a lot of detritus, nutrients as well as pollutants from land. Such pollutants arising from land based activities include domestic and industrial effluents, urban storm run-off; agricultural land run off shipping activities; coastal habitat modification coupled with contaminants from garbage and solid waste dump (Portmann *et al* 1989).

This paper aims at investigating the impact of land based pollution on the hydrochemistry and macrobenthic community in Porto Novo Creek with a view to complementing data already reported for the Lagos Lagoon.

DESCRIPTION OF STUDY SITE
The Porto Novo Creek (Fig. 1) is one of the three tidal creeks that flows into the Lagos Lagoon on the highly industrialised western axis. It has an average depth of 3.8m except the areas that are dredged for marine traffic. It is subject to strong maritime influence from the adjacent Lagos harbour and eutrophic effluents from the FESTAC creek that opens into it. The proliferation of urban and industrial establishments as well as upstream poor agricultural land use practices along the shores of the creek has resulted in additional anthropogenic input.

The study section is approximately 8km long and four sampling stations were created based on accessibility. Station 1 was located approximately 2km from the entrance of the creek into the Lagos harbour through Apapa wharf. Station 2 was located about 2km upstream of station 1 at the confluence of Badagry and Porto Novo Creeks. Station 3 was located 2.0km upstream of station 2 and about 1.5km downstream of the entrance of the Festac creek. Station 4 was located 4.0km upstream of station 3.

METHODS
Sampling for water quality parameters and benthic fauna was carried out in the four study stations at fortnightly interval between December 1999 and May 2000 covering parts of the rainy and dry seasons.

Physico-Chemical Characteristics
Duplicate water samples for hydrochemical analysis were collected using a 2.01 non-metallic Hydrobios water sampler, 0.5m below the water surface and 3.0m from shoreline from each sampling station. In situ measurements of surface water temperature (^0C), salinity ($^0/_{00}$), pH, dissolved oxygen (mg/l) and electrical conductivity ($mscm^{-1}$) were determined, using battery operated Horiba U^{10} model water quality checker model. Transparency was determined using a 20cm diameter Secchi disc. Total suspended solids (TSS), total dissolved solids (TDS) and nutrient elements were determined according to the methods described in APHA (1985).

Sediment and Macrobenthic fauna

At each station, five replicate samples of $0.1m^2$ Van veen Grab hauls were taken with the boat anchored. The top 10cm of each haul was used for sediment analysis. On deck, each sample was washed through 0.5mm stainless steel sieve and the material retained was preserved in 4% formalin and stained with Rose Bengale (2g/l) to facilitate sorting. In the laboratory, the retained specimens were sorted, counted and identified into taxonomic groups using appropriate texts (Longhurst, 1958; Edmunds, 1978).

Sediment particle size analysis was done using the method described by Brown, (1991), and total organic matter determined by the rapid ash method employed in Oyenekan (1975). All statistical methods used were adapted from Zar, (1974). Macrobenthic community structure was estimated using the Margalef's species richness index (d) (Margalef, 1951); Shannon – Weiner Information function (HS) (Shannon and Weaver, 1963) and Equitability index or Evenness (Lloyd and Ghellardi, 1964).

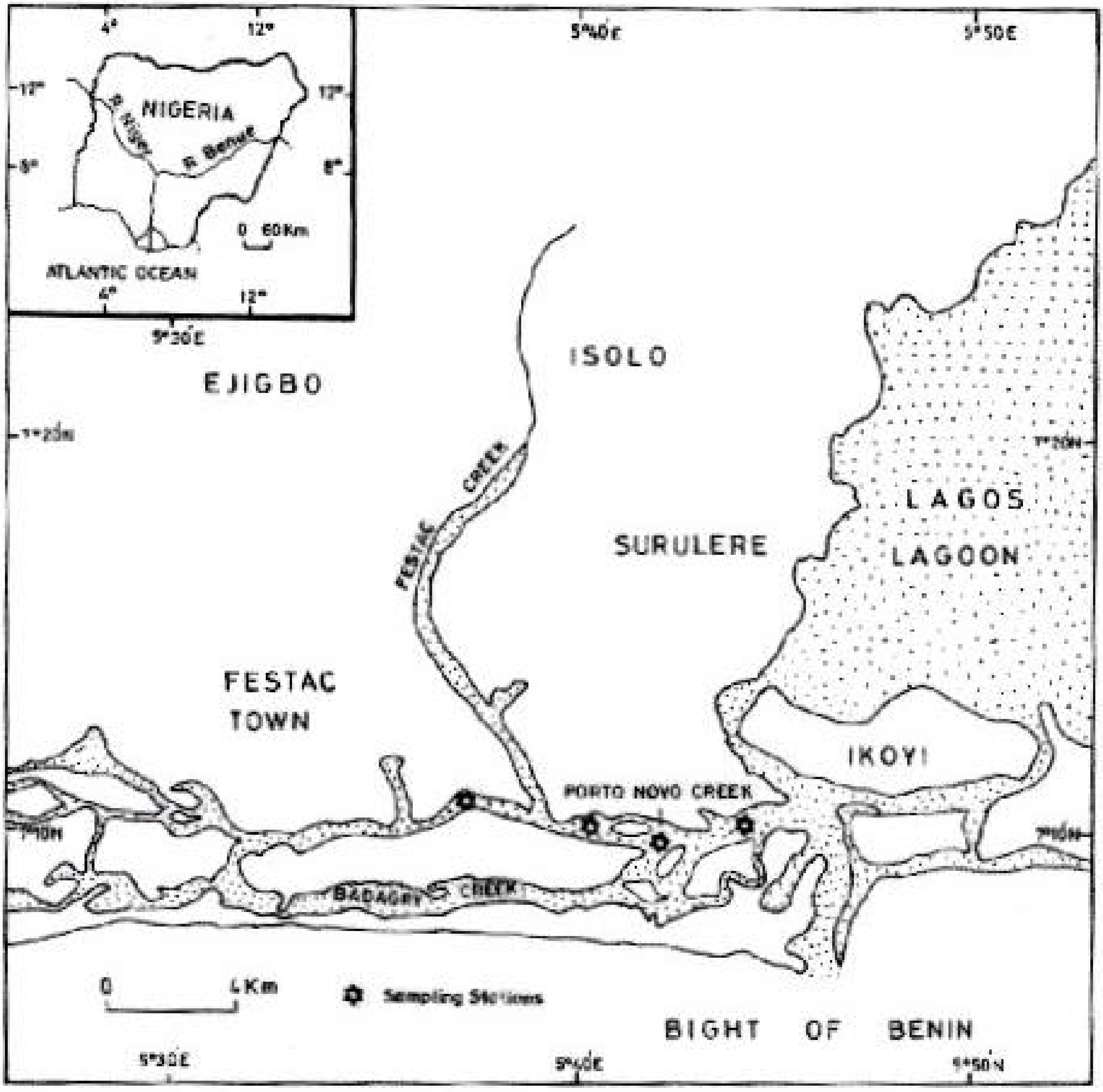

Figure 1 Map of Porto Novo Creek showing sampling stations (asterixs)

RESULTS AND DISCUSSIONS

Water Physico-Chemistry

The physico-chemical characteristics of the study stations is summarised in Table 1. The surface water of the creek was characterised by high total suspended solids (>140mg/l); moderate biochemical oxygen demand (BOD_5) values (<5.80mg/l) low total dissolved solids (<23.0mg/l); low dissolved oxygen content (<2.80mg/l) and low transparency (<0.18m). Nutrient elements, phosphate – phosphorus (PO_4 – P) and nitrate – nitrogen (NO_3 – N) recorded average values of >0.40µg/l and >0.45µg/l respectively. With the exception of pH and surface water temperature, all other parameters differed significantly ($p<0.01$) among the study stations.

All physico and chemical conditions indicative of water quality, except surface water temperature and pH were significantly ($p<0.01$) different among the stations. Temperature values were high and remained relatively stable throughout the sampling period. Since significant changes in water quality parameters directly influence the community structure of macrobenthic invertebrates (Victor and Onomivbori, 1996), surface water temperature probably had no effect on the distribution of benthos in this study. This observation agrees with those of previous workers. (Olaniyan, 1969; Yoloye, 1969; Oyenekan 1975; Ajao, 1989; Brown and Oyenekan 1998), who reported that the distribution, abundance, production and population dynamics of benthic macro-invertebrates in Lagos Lagoon and harbour were not affected by water temperature. The high variability in the other water quality parameters may be due to the impact of extrinsic factors (e.g. rainfall and surface run-off) and sub intrinsic factors (e.g. sedimentary or depositional nature) which prevailed during the rainy and dry seasons respectively. The proximity of the Porto Novo Creek to the Lagos harbour may have accounted for the maritime influence while the distance from the Lagos harbour may have accounted for the salinity gradient among the study stations.

Table 1: Summary of the Physico-chemical parameters of the study stations, Porto Novo Creek, December 1999 – May 2000 (n = no of samples = 12)

Parameters	Station 1			Station 2			Station 3			Station 4		
	Mean ± S.E	Min	Max	Mean ± S.E	Min	Max	Mean ± S.E	Min	Max	Mean ± S.E	Min	Max
Physical												
Air temperature (^{0}C)	29.6±0.68	26	30	30.1±0.26	27	31	30.5±0.56	27	31	28.9±0.42	27	31
Water temperature (^{0}C)	28.2±0.27	25	29	29.3±0.34	26	29	28.9±0.46	26	29	27.8±0.52	25	28
Transparency (m)	0.16±0.04	0.13	0.21	0.18±0.03	0.16	0.28	0.22±0.05	0.18	0.31	0.27±0.06	0.22	0.30
Total Dissolved Solids (mgl^{-1})	23.0±1.3	18.0	28.0	18.0±1.50	10.8	24.6	16.0±1.40	11.2	21.4	11.0±1.50	8.40	18.60
Total Suspended Solids (mgl^{-1})	138.8±8.4	118.8–	141.2	134.6±12.6	121.2	140.5	140.0±11.8	129.6	148.6	114.0±10.8	112.8	132.6
Chemical												
pH	7.6±0.2	6.5	7.8	7.4±0.3	6.8	7.7	7.2±0.2	6.4	7.6	7.4±0.3	6.6	7.6
salinity ($^0/_{00}$)	17.6±0.79	15.8	22.4	13.6±0.01	11.1	17.2	9.8±1.07	5.80	13.6	5.6±0.67	4.50	9.60
Dissolved oxygen (mgl^{-1})	3.38±0.43	3.27	3.89	3.35±0.46	3.11	3.90	3.8±0.38	3.20	4.13	5.5±0.36	4.4	5.98
BOD_5 (mgl^{-1})	3.46±0.86	2.25	6.80	3.82±0.74	3.26	6.60	5.80±0.53	4.50	9.60	2.60±0.48	1.80	4.80
Nitrate–Nitrogen (NO_3-N) μgl^{-1}	0.59±0.04	0.18	0.64	0.52±0.05	0.19	0.72	0.75±0.05	0.23	0.94	0.45±0.03	0.18	0.68
Phosphate-Phosphorus (PO_4-P) μgl^{-1}	0.50±0.34	0.98	2.10	2.40±0.33	1.88	3.40	3.50±0.27	1.74	4.22	0.40±0.31	0.08	2.40
TOM (%)	28.43±8.8	18.0	32.14	24.40±11.2	15.6	26.5	18.20±6.5	11.2	22.60	2.31±1.20	0.80	8.80
% Silt Clay Fraction	11.0±1.2	5.20	14.60	8.70±1.4	6.60	13.86	37.80±3.86	21.6	44.2	54.0±8.40	44.80	68.40

Station 1 had the lowest dissolved oxygen values when compared with other stations. The biochemical oxygen demand values (BOD_5) at station 3 were significantly higher than those at all other stations ($p<0.01$). Station 3 had significantly higher contents of phosphate – phosphorus (PO_4 – P) and nitrate nitrogen (NO_3 – N) than all three stations ($p<0.01$).

The high level of total suspended solids, low dissolved oxygen content and low transparency recorded in the study stations could be an indication of the deteriorating water quality and probably resulted from the discharges of industrial and domestic wastes into the creek through the Festac creek and other land based anthropogenic inputs. Similarly, Ajao and Fagade, (1990); Akpata *et al;* (1993), recorded high total suspended and dissolved solids, high biochemical oxygen demand, low dissolved oxygen content and heavy microbial load at organically polluted sites in the Lagos Lagoon. The moderate BOD_5 and low dissolved oxygen recorded in this study may be due to bacterial degradation of the organic load mainly from biodegradable wastes which drain into the creek.

Most tropical waters have low nutrient values a feature considered common for natural and polluted waters (Edokpayi, 1988). The level of PO_4–P (>0.40µg/l) and NO_3–N (>0.45µg/l) recorded in this study is suggestive of organic pollution and nutrient enrichment. The higher levels of PO_4–P and NO_3–N in the wet season may be due to the effect of direct discharges into the creek, enrichment of surrounding wetlands and subsequent run-offs are consistent with the observations of Nwankwo (1993) for coastal waters of South Western Nigeria.

Faunal Composition, Abundance and Distribution

The composition, abundance and distribution of the macrobenthos as well as relative abundance of major benthic fauna in the study area are presented in Table 2 and Fig.2. Eight taxa were identified from a total of forty-five individuals collected. The macrobenthic abundance and composition were low and the more dominant taxonomic groups were annelids. Station 1 had three taxa, while stations 2, 3 and 4 had four, five and six taxa respectively. Of all the individuals collected, stations 1 and 2 accounted for 13.33% and 11.11% respectively while stations 3 and 4 contributed 31.11% and 44.44% respectively. Polychaeta accounted for 66.67% of all individuals collected from all stations contributing 13.33% at station 1 and 8.89%, 17.78% and 26.67% respectively at stations 2, 3 and 4.

The macrobenthic abundance and composition at the study stations were low. Some important factors governing the abundance and distribution of macro-invertebrate benthic communities includes, water quality, immediate substrates for occupation and food availability (Dance and Hynes, 1980). Any ecological imbalance arising from any severe alterations of these factors may affect the macrobenthos. Therefore, it appears that the low macrobenthic invertebrate community abundance, composition and diversity may have been greatly affected by stress imposed by land based pollutants, as well as substrate instability possibly arising from frequent dredging of the creek for marine traffic. In comparison with the upstream station 4, there was a significant reduction in macrobenthic, abundance and diversity of downstream stations in the creek. Similar observations were made by Ajao and Fagade, (1990), that the bivalve *Aloidis trigona* (Hinds) and the gastropod, *Neritina glabrata* were virtually absent from the western industrialised parts of Lagos Lagoon which received a complex mixture of domestic and industrial wastes.

The distribution and abundance of specific taxa could be used in assessing the levels of impact in the study area. Of the eight taxa recorded in this study, three (37.5%) were annelids, dominated by the Polychaeta in terms of species richness and diversity. The presence of polychaetes, *Nereis sp* and *Polydora ciliate* in high density within the creek may be indicative of organic enrichment. Brown and Oyenekan (1998) suggested that *P. ciliata* could be as opportunistic as *Capitella capitata*, a universal indicator of organic pollution.

Species Richness, General Diversity and Faunal Similarities of Study Station

The most striking features of the study area is the overall low diversity of macrobenthic invertebrates. The Margalef's species richness (d) was highest in station 4 and lowest in station 1, while station 3 had a higher species richness than station 2. The species diversity measured by Shannon and Weaver diversity index (H) followed the same trend. The Evenness Index (E) in the study stations ranged from 2.58 in station 1 to 4.32 in station 4. The species richness was highest in December in all stations (Fig. 3). Station 4 had the highest value in all the sampling months except in May. Faunal similarities between sampling stations were evaluated by Jaccards coefficient and the results showed that upstream station 4 was significantly dissimilar to downstream stations 3, 2 and 1.

Table 2:Macrobenthic fauna abundance composition in Porto Novo Creek (December 1999 – May 2000)

	Stations			
Taxa	**1**	**2**	**3**	**4**
Phylum: Mollusca **Class: Gastropoda**				
Neritina glabrata (Sowerby)	-	-	1	-
Pachymelania aurita (Muller)	-	1	2	2
Class: Bivalvia				
Diplodonta diaphana	-	-	3	-
Dreissenia africana	-	-	-	2
Phylum: Arthropoda				
Class Crustacea				
Clibanarius africana (Orvivillius)	-	-	-	4
Phylum: Annelida				
Class: Polychaeta				
Nereis succinea	3	1	4	2
Polydora ciliata	1	2	2	4
Capitella capitata (Fabricius)	2	1	2	6
Total number of individuals	**6**	**5**	**14**	**20**
Total number of species	**3**	**4**	**4**	**6**
Margalef's index (d)	0.821	1.202	1.243	1.674
Shannon Weaver Index (H)	1.0117	1.3322	1.7100	1.6959
Evenness Index (E)	2.5848	2.3218	3.8071	4.3216

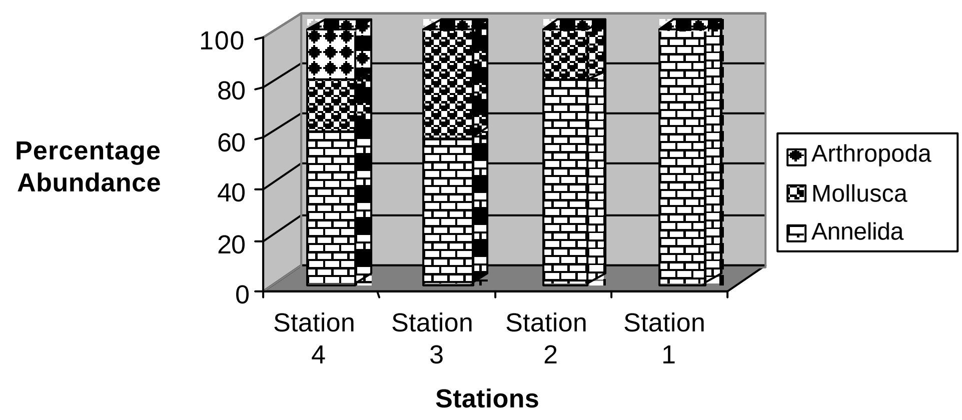

Fig. 2: Relative abundance of major macrobenthic fauna in Porto-Novo Creek

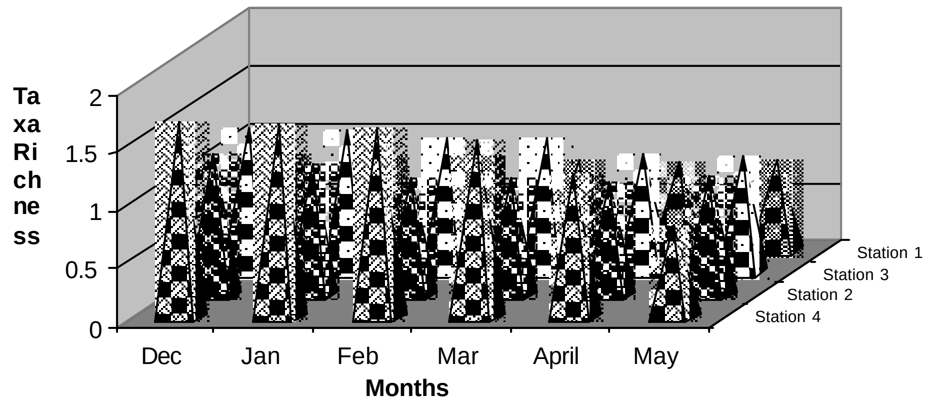

Fig. 3: Spatial and temporal variations in the species richness of benthic macro-invertebrates in Porto Novo Creek

The low species richness (d) and Shannon's Diversity indices may be a further indication of the impact of the perturbational stress on the macro-invertebrate benthic communities. The reduced values of species richness and general diversity of fauna in downstream stations may indicate pollution. However, the higher diversity in upstream stations could be a reflection of its substratum heterogeneity and stability.

Sediment Profile

The bottom deposits of the Porto Novo creek varied between muddy sand and sandy mud as one moved from the lower reaches to the upper reaches of the creek. Silt-clay fraction content was low (<50%) while the total organic matter (TOM) ranged from 1.93% to 28.43% in the study area. The highest value of total organic matter (TOM) recorded was 28.43% in January. There were no significant differences ($p>0.01$) in values of TOM between sampling stations. The presence of varying sediment types was reflected in organic matter distribution which have been shown (Ajao and Fagade, 1990) to be highly related to anthropogenic inputs and to sedimentary or depositional nature.

CONCLUSIONS

The hydrochemical features of the creek were largely determined by the interplay of diffuse pollution from land based activities and the incursion of tidal seawater through the Lagos harbour. The impact of direct discharges of industrial and domestic wastes, enrichment of surrounding wetlands and subsequent run-offs associated with rainfall ushered in low dissolved oxygen, higher total solids, reduced transparency, and consequently affected the water quality. The macrobenthic invertebrate community abundance, composition and diversity have been greatly affected by perturbational stress from land based activities as well as substrate instability. The presence of Polychaetes in high density within the creek indicated the increasing level of organically related pollution.

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