Non-insect benthic phytomacrofauna and organism-water quality relations in a tropical coastal Ecosystem: impact of land based pollutants.

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Abstract. The impact of land based pollutants on the non-insect benthic phytomacrofauna and water quality in Epe lagoon was investigated between September, 2004 and February, 2005. Five study stations impacted by land based pollutants were selected upstream along the course of the Lagoon. The study showed that land based pollutants caused a decrease in dissolved oxygen and pH and an increase in biochemical oxygen demand (BOD) and phosphates. Significant differences in these parameters were established among the stations sampled. A post hoc test indicated that stations 2, 3, and 4 were mostly impacted by pollutants. A generally low taxa population and diversity were recorded in this study. Eight taxa were identified from a total of 65 individuals collected from the five stations along the lagoon. No organism was recorded in station 3.The analyses showed that the overall abundance of fauna differed significantly among the stations. Analysis of variance showed that the abundance of Lymnaeidae was significantly higher ($P<0.05$) than those of the other families. The dominance of the taxa Lymnaeidae was a clear indication of pollution which resulted in a decline and total elimination of other benthic macroinvertebrates, which are intolerant of the effects of polluting effluents. This study suggests that the response of benthic phytomacrofauna is important in the study of impacted aquatic systems. [Journal of American Science 2010;6(7):213-220]. (ISSN: 1545-1003).

Keywords: phytomacrofauna, water quality, tropical coastal ecosystem.

Introduction

Water demands in Nigerian coastal urban areas coupled with increased human populations and the concomitant changes in land use have made aquatic systems vulnerable to pollution. Human population levels have been increasing at a high rate in the metropolitan city of Lagos and the neighboring cities like Epe (OFFICIAL GAZATTE: FGP, 2006 Census) with potentially negative effects on water quality due to typical stressors associated with urbanization. In addition, historical expansion of agriculture in most of the cities have not only put strains on local water supplies but have led to present day regional changes in ecosystem dynamics, such as the transport of pollutants from the inland waters and adjourning lands. Runoff from urban areas can be extensive, contain numerous chemicals and cause increased sediment loads in receiving water bodies (Edokpayi *et al*., 2000; Rueda *et al*., 2002).

Relative to agricultural lands, urban areas can have similar land applications of some chemicals (e.g., phosphorus and herbicides) and the runoff from urban areas can contain a much greater variety of pollutants (Walsh *et al*., 2002). Untreated storm water runoff from urban areas can contain levels of some parameters (e.g., total solids) that exceed those found in untreated wastewater (Walsh *et al*., 2002). These pollutants entering water bodies as a result of urbanization can be harmful to aquatic organisms.

Numerous industrial and domestic wastes find their way into the Nigerian coastal aquatic systems. According to Singh *et al* (1995), an estimated $10{,}000m^3$ of industrial effluents are discharged into the Lagos lagoon systems per day. In addition, 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, sediment and contaminants from garbage and waste dump (Portmann *et al.,* 1989). The most notable point source arises from the dumping of untreated or partially treated sewage (Nwankwo and Amuda; Ogbuogu and Akinya, 2002; Adakole and Anunne, 2003), and discharge of bio-degradable wood wastes from sawmill located along the stretch of the lagoons (Nwankwo, 1998). Wood shavings and leachates are sources of inert solids as well as toxic pollutants that directly clog gills of aquatic animals

(Nwankwo, 1998) and indirectly reduce light penetration (Nwankwo, 1998) which limits productivity.

Contamination of the aquatic environment, makes aquatic organisms vulnerable (Uwadiae, 2009). Aquatic fauna are impacted by pollutants primarily as a result of changes in primary production and in the chemistry of water column and sediment. These changes potentially lead to reduced diversity and abundance (Ofojekwu *et al.*, 1996; Zabbey and Hart, 2006), shifts in community composition, physiological changes and mass mortality. The sensitivity of aquatic fauna to conditions of pollution varies with individual organisms due to differences in feeding habits, mobility, and life cycle (Rueda *et al.*, 2002). As a result, measures of the structure of faunal communities can be used to assess the impacts of pollution on aquatic ecosystems (Rosenberg and Resh, 1993). Benthic macroinvertebrates, in particular, are widely accepted as useful biomonitoring tools for assessing impacts of pollution in aquatic ecosystems.

Although, a number of publications on benthic macroinvertebrate communities of the lagoon systems of southern Nigeria have demonstrated relationships between macroinvertebrate community structure and water quality, not much have investigated the impact of pollutants on benthic phytomacrofauna.

The overall objective of this work was to examine the impacts of land based pollutants on Epe lagoon using non-insect benthic phytomacrofauna community as bioindicators. Phytomacrofauna composition and community structure were assessed to identify possible influences of pollutants. The specific hypothesis being tested was that the structure of benthic phytomacrofauna communities is a reflection of water quality.

Materials and Methods

Description of study area

The study was conducted in a stretch of Epe lagoon (Figure 1), Nigeria, located between longitudes 5°30' – 5°40'E and latitudes 3°50' – 4°10'N. The lagoon receives river Oshun (which drains a number of cities and agricultural lands) in the North -West end. The study area is bordered on the west by a number of cultivated lands and receives wood wastes from local wood processing outfits located at the bank of the lagoon. The lagoon is used for transportation of timber logs (possible source of wood particles and leachates) from the villages to the city of Lagos. The lagoon houses a major jetty at Epe (Station 2), where different forms of wastes from human activities in and around the jetty are deposited indiscriminately. The absence of toilet and other sanitary facilities in most of the villages along the bank of the lagoon, result in the deposition of untreated sewage into the lagoon. Washing of clothes is a common practices in all the stations used for this study.

Large amounts of terrigenous particulate matter, nutrients and sediments are introduced into the lagoon from adjourning forested and agricultural lands which could strongly influence the physical, chemical and geological features of the lagoon. Thick mat of aquatic macrophytes covers a large part of the lagoon inhibiting boat traffic. Notable among these plants are water hyacinth (*Eichornia crassipes*), water letus (*Pistia stratiotes, Ipomea aquatica, Salvinia nymphellula, Lemna sp. and Hydrocharis marsus-renae.* The wide spread distribution and luxuriant growth of these aquatic macrophytes in the study area was reported as an indication of pollution (Uwadiae, 2009). Brief descriptions of the stations used for this investigation are presented in Table 1.

Table 1. Description of the study stations

Station	Dept (m)	Coordinates	Major land based Human activities
1	2.6	(06^{O}34.729'N and 004^{O}03.710'E)	Domestic washing, bathing
2	2.0	06^{O}34.658' N and 003^{O}58. 719'E)	Domestic washing, bathing, Jetty operations, defecation, domestic wastes disposal
3	4.7	(06^{O}36.564'N and 003^{O}58.799'E)	Domestic washing, bathing, defecation, agricultural activities, domestic wastes disposal, deposition of organic debris
4	1.7	06^{O}36.929'N and 003^{O}44.800'E)	Domestic washing, bathing, domestic wastes disposal
5	0.7	(06^{O}36.799'N and 003^{O}42. 568'E)	Domestic washing, bathing, Jetty operations, domestic wastes disposal

Figure 1: Map of Epe Lagoon Showing the Sampling Stations.

Sampling Protocol

Sampling for water quality parameters and benthic fauna was carried out in five study stations at monthly intervals between September, 2004 and February, 2005 covering parts of the rainy and dry seasons.

In situ measurements and collection of samples

In situ measurements of surface water temperature (^{0}C), pH, dissolved oxygen (mg/l) and electrical conductivity (mScm-1) were was carried out using battery operated Horiba U10 water quality checker model.

Water samples for physico-chemical analysis were collected using 1 litter plastic sampling bottles at approximately 0.5m below the water surface and 3.0m from the shoreline in each sampling station. Collection of phytomacrofauna samples was carried out as reported in Edokpayi *et al* (2008).

Sample Analyses

Total dissolved solids (TDS) and nutrient elements were determined according to the methods described in APHA (1985).The methods used by Edokpayi *et al* (2008) was adopted in the laboratory processing of phytomacrofauna samples.

Results

Water quality conditions

A summary of some of the water quality parameters investigated at the study stations is given in Table 2. Of all parameters BOD, DO and phosphate were significantly different ($P<0.05$) among the study stations. The BOD of stations 1 and 5 were significantly lower ($P<0.05$) than those of stations 2, 3 and 4, which were not different from each other. The dissolved oxygen of stations 4 and 5 were significantly lower ($P<0.05$) than those of stations 1, 2 and 3, which were not different from each other.

The values of phosphate in water of stations 1, 2, 3 and 5, were similar and significantly lower

(P<0.05) than that of station 4. The pH of stations 2 and 4 were relatively lower than those of stations 1, 3 and 5.

Faunal composition, abundance and distribution

Figure 2 shows the taxa composition, abundance and distribution of non insect phytomacrofauna in the study area. Eight taxa were identified from a total of 65 individuals collected. Station 1 had one taxon, while stations 2, 4 and 5 had 3, 2 and 3 taxa respectively. No fauna was collected in station 3. Of l the total number of individuals collected, stations 1 and 2 accounted for 1.54 and 50.7% respectively while stations 4 and 5 contributed 21.54 and 10.77% respectively. A summary of the relative contribution of the major groups in the study area is presented in Figure3.

Lymnaeidae was most important at stations 1 and 4 where it contributed 72.72 and 78.54% of the total abundance in these stations respectively. At station 5, it made no contribution. *Lymnaea auriculata* was the representative of the Lymnaeidae group. The family Eleotridae occurred in stations 1 and 4 where it accounted for 27.27 and 14.29 % respectively. It was represented by one taxa; *Eleotris* sp. In station 5, three groups were represented; Eulimidae, Neritidae, and Hydrobiidae. They accounted for 14.29, 28.57 and 57.14% respectively of the total non – insect phytomacrofauna population in these stations. Analysis of variance showed that the abundance of Lymnaeidae was significantly higher (P<0.05) than those of the other groups.

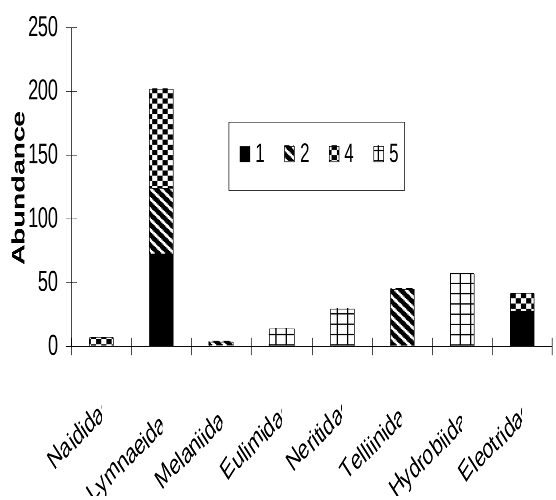

Figure 2. Relative contribution of major non insect phytomacrofauna families to the overall faunal abundance at study stations

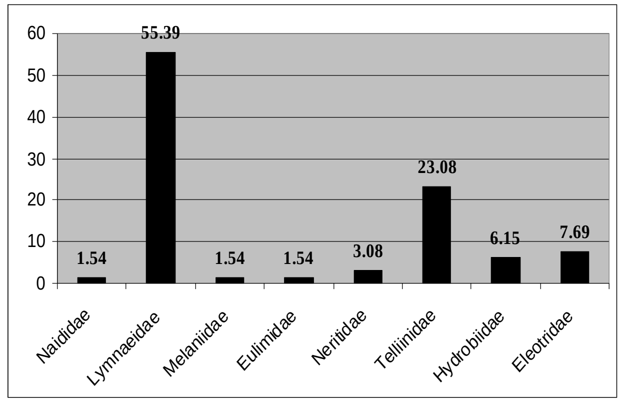

Figure 3. Relative contribution of major groups of phytomacrofauna in the study area.

Diversity and dominance

Diversity and dominance indices calculated for the five stations are summarized in Tables 3 and 4. The taxon richness (d) was highest in station 5 and the lowest in station 3. Station 4 had higher taxon richness than station 1. Shannon diversity (H) was significantly higher in station 5 than in the other stations (P<0.05), which were not different from one another. Evenness index (E) followed the same trend.

Lymaeidae recorded the highest dominance values in stations 1, 2 and 4. Hydrobiidae whose occurrence was restricted to station 5 recorded the highest dominance value in that station. Melaniidae, Eulimidae, and Naididae recorded 3.03, 14.29 and 7.14 respectively as dominance values in their different single station representation at stations 2, 4 and 5 respectively.

Faunal similarity of sampling stations

Table 5 summarizes the fauna similarities of the study stations. Renkonen similarity indicated that the faunal at station 1 was significantly similar (>50%) to those of stations 2 and 4. The faunal of station 2 was also significantly similar (>50%) to the faunal of station 4.

Table 2: Summary of the physico – chemical properties of the study stations in Epe lagoon.

* Indicates significant difference

Parameter	Station 1			Station 2			Station 3			Station 4			Station 5			
	Max	Min	Mean ± SE	Max	Min	Mean ± SE	Max	Min	Mean ± SE	Max	Min	Mean ± SE	Max	Min	Mean ± SE	Probability
Ph	7.3	6.9		7.0	6.7		7.4	6.9		7.2	6.5		7.4	7.1		
TDS (mg/L)	218	70	142.3 ± 26.76	220	110	174. ± 15.98	1860	50	506 ± 81.81	583	100	273. ± 72.64	955	100	365 ± 50.77	> 0.05
Conductivity (mg/L)	555	185	347 ± 53.49	700	310	550.5 ± 8.06	462	230	368.6 ± 32.8	1013	150	560.3 ± 144.4	1089	318	650 ± 161.8	> 0.05
(DO (mg/L)	5.4	4.0	4.9 ± 0.24	5.9	3.7	4.8 ± 0.30	6.1	4.3	5.3 ± 0.28	5.9	3.2	4.6 ± 0.42	4.9	2.4	3.6 ± 0.45	< 0.05*
BOD_5 (mg/L)	29.6	9.6	16.08 ± 3.15	66.4	11.1	32.3 ± 8.26	40.7	14.6	25.8 ± 3.73	42.4	10.8	24.3 ± 4.73	27.0	8.9	14.8 ±2.77	< 0.05*
COD (mg/L)	432	214	313.8 ± 37.72	547	69.6	253 ± 66.23	382	109.3	184.4 ± 41.0	405	111.6	249.1 ± 47.14	514	167	340.5 ± 54.6	> 0.05
PO_4-P (mg/L)	1.20	0.25	0.8 ± 0.13	1.0	0.42	0.64 ± .02	1.6	0.33	1.02 ± 0.21	4.88	0.38	1.59 ± 0.67	2.4	0.08	0 8 ± 0.35	< 0.05*
NO_3-N (mg/L)	5.00	0.6	2.67 ±0.69	4.15	0.8	2.6 ±0.51	6.50	0.4	3.4 ±1.06	12.20	0.9	3.8 ± 1.75	1.65	0.56	1.38 ± 0.10	>0.05

Table 3 Diversity of non-insect benthic phytomacrofauna in Epe lagoon.

	Stations				
	1	2	3	4	5
Number of sample	6	6	6	6	6
Number of Taxa	2	3	-	3	3
Number of individuals	11	33	-	14	7
Margalefs index (d)	0.96	1.31	-	1.74	2.36
Shannon Wieners Index (H’)	0.2545	0.3501	-	0.2849	0.4150
Evenness (E)	0.8455	0.7338	-	0.5971	0.8698

Table 4: Dominance of non – insect benthic phytomacrofauna major groups in the study stations. xx = Dominant; x = Subdominant

	Station				
Taxa	1	2	3	4	5
Naididae	-	-	-	7.14*	-
Lymaeidae	72.72^{xx}	51.56^{xx}	-	78.57**	-
Melaniidae	-	3.03*	-	-	-
Eulimidae	-	-	-	-	14.29*
Telliinidae	-	45.45^{xx}	-	-	-
Neritidae	-	-	-	-	28.57**
Hydrobiidae	-	-	-		57.14^{xx}
Eleotridae	27.27^{**}	-	-	14.28*	-

Table 5. Renkonen similarity faunal comparison of non-insect benthic phytomacrofauna in the study stations of Epe lagoon. *Significant similarity ≥50%.

	1	2	3	4	5
1	100	51.51*	-	87.02*	-
2		100	-	51.51*	-
3			100	-	-
4				100	-
5					100

Discussion

The values of water quality parameters reported in this study are obvious reflection of a degraded aquatic system, and these have direct influence on the structure of the benthic phytomacrofauna. Addition of land based pollutants to aquatic systems changes the hydrological, chemical, physical and biological characteristics of an aquatic ecosystem. Siltation resulting from the inflow of sediment from cultivated lands increases the amount of suspended solids in water, which in turn reduces light penetration and water transparency. Siltation also results in alteration of the depth and general characteristics of the bottom sediment. Decrease in depth and the absence or reduction of water current resulting from siltation could lead to poor oxygen circulation, which could affect the growth and development of aquatic macrophytes. The generally low level of dissolve oxygen and high BOD recorded at the sampling stations indicated deteriorating water quality and probably resulted from the deposition and decomposition of organic waste from domestic sources at the study stations.

The overall community composition of the study area is poor when compared to records of similar studies in the lagoon systems of southern Nigeria. The taxa recorded in this study is lower than that reported by Edokpayi *et al.* (2008; 2009) for phytomacrofauna arthropod community in the same lagoon and for phytomacrofauna communities in a non – tidal creek in south-western Nigeria, respectively, and that recorded by Saliu (1989).

The non-insect benthic phytomacrofauna community composition structure, abundance and diversity were greatly affected by water quality. Pollutants create uncondusive environment for plant growth and general development. Poor growth of aquatic macrophytes diminishes the amount of space available for attachment of phytomacrofauna groups and this subsequently reduces the number of colonizing taxa (Cyr and Downing, 1988a; 1988b). No taxon was recorded in station 3; this observation is similar to that reported by Uwadiae *et al.* (2009). This is not unusual since reduction or complete decimation of benthic population has been observed as a response of benthic communities to pollution and habitat alteration (Uwadiae, 2009). Station 3 is a deposition site for organic wastes from a number of domestic and agricultural operations.

The distribution and abundance of specific taxa could be used in assessing the levels of impact in the study stations. Lymnaeidae gastropod molluscs respond to polluted environment by increase in abundance (Bouchard, 2004). Their significantly higher overall abundance in this study could be attributed to opportunistic condition created by pollution. Naidid oligochaetes respond to organic pollution by increase in abundance. Their wide spread distribution in the study area could be an indication of organic enrichment. They can live in extremely polluted waters with very low oxygen levels (Bouchard, 2004).

The taxa richness (d), general diversity (H') and evenness (E) all revealed the decimating impact of land based pollutants on non-insect benthic phytomacrofauna communities. The absence of any taxa in station 3 and the generally low taxa recorded in the other study stations are similar to the typical response of benthic communities to pollutants. Two theories have been propounded to explain this response; theory of habitat reduction and theory of habitat change (Lenat *et al*., 1981; Ogbeibu and Oribhabor, 2004). If habitat reduction were most important in this instance; one would expect all groups to have been equally affected (Ogbeibu and Oribhabor, 2004). In this study all the groups were not equally affected, there was a significant reduction in the abundance of all groups except molluscs and oligochaetes which had relatively higher populations in station 2. The overall change displayed in this study is a demonstration of a typical response of a community to environmental alteration.

The overall diversity of benthic community is the product of all spatial and temporal changes affecting the community. The absence of taxa in station 3 and the generally low taxa metrics in all the stations are reflections of community instability in these stations. Renkonen similarity indicated that the faunal of study stations (except stations 3 and 5) were similar and showed close affinity and shared pollutant tolerant taxa.

A more elaborate study with more stations across the length of the lagoon involving a comprehensive analysis of water quality parameters is imperative to fully understand and establish the impact of pollutants on the water quality and community structure of benthic macro-invertebrates of the coastal lagoon.

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