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Physico-chemical and macrobenthic faunal characteristics of Kuramo Water, Lagos, southern Nigeria

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A five-month study in 2001 of an enclosed lagoon, Kuramo Water in southern Nigeria, exposed to urban perturbation describes its physical, chemical and macrobenthic invertebrate characteristics. Of the 16 physical and chemical conditions studied at four sites within the bank-root biotope, only BOD and TDS content were significantly different between sites. The elevated level of these perturbation indicators could be related to the raw and treated domestic sewage released directly into Kuramo Water from point and non-point sources. A total of 16 taxa and 691 macrobenthic individuals belonging to 11 families were recognised at the study sites. A naidid and a chironomid species were the most abundant, occurring in high numbers throughout. Other invertebrate groups occurred in low numbers. The diversity indices calculated supported this trend. The generally low diversity further supports the observation that Kuramo Water is a disturbed environment. The absence of molluscs in the benthic invertebrate samples of this study, compared to their dominance in earlier studies of Kuramo Water, reflects a modification in the habitat resulting from a change in the salinity from brackish to freshwater.

Keywords: enclosed lagoon, habitat modification, Kuramo Water, macrobenthos, Nigeria

Introduction

Ecological interest in West African lagoons is mainly due to their wide salinity fluctuations and the effects this has on fauna and flora distributions. The marginal lagoons of western Nigeria, particularly the biologically diverse and highly productive brackish lagoon systems surrounding the island of Lagos, are highly subjected to urban and industrial pollution. This results in the loss of biodiversity, either through habitat fragmentation, over-exploitation, pollution, the introduction of exotic species or direct habitat loss/modification, or a combination of these factors (Nwankwo 1996). Previous studies on the lagoon systems in Lagos, mainly the Lagos lagoon, concentrated on their pollution load (Akpata and Ekundayo 1978, Ajao 1996), algae (Nwankwo 1986, 1988, 1993, Nwankwo and Akinsoji 1992), benthic invertebrates (Oyenekan 1988, Ajao and Fagade 1990a, 1990b, 1990c, Brown 1998, Brown and Oyenekan 1998) and fish communities (Fagade and Olaniyan 1974, Kusemiju and Olaniyan 1989, Solarin 1998). Kuramo Water, the only inland lagoon among the Lagos lagoon systems, is poorly studied. The only available publications are those of earlier workers on the West African lagoons (Hill and Webb 1958, Yoloye 1976). The paucity of literature and the apparent habitat modification of Kuramo Water prompted this study. This paper describes the current state of the physical, chemical and macrobenthic invertebrate characteristics of Kuramo Water and attempts to use these characteristics to assess the degree of habitat modification in the lagoon over time.

Methods

Study area

Kuramo Water, 3°25'E to 3°28'E and 6°25'N to 6°27'N, is a long, narrow lagoon lying immediately behind the barrier beach east of Lagos harbour (Figure 1) and is connected to Five Cowrie creek by a narrow, twisting channel. The mangrove trees formerly reported to line this channel (Hill and Webb 1958) have now been replaced by freshwater shrubs and grasses and the channel is partially blocked by floating vegetation and silt. Kuramo Water is about 1.5km long and has an average depth of 2.96m. The water is greenish, is characterised by floating debris, and is used as a dump for human wastes, notably by an hotel, by commercial and residential buildings along the northern boundary of the lagoon and by the littoral shanty settlements scattered along the barrier beach separating the lagoon from Victoria Beach. The hotel pipes macerated human sewage to the middle of the lagoon where the bottom sediment is covered with a thick coat of slimy, decaying human waste. Other non-point sources of human and domestic wastes discharge occur along the banks of Kuramo Water. Four study sites were selected amongst the bank-root biotope. The dominant

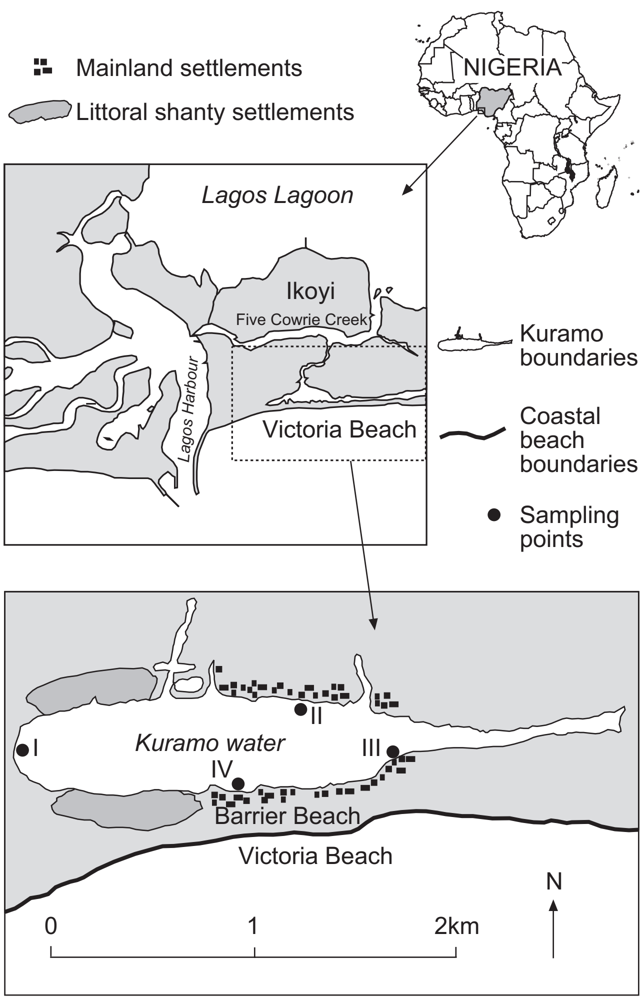

Figure 1: Location of the Kuramo Water and the study stations

aquatic vegetations are floaters such as *Paspalum vaginatum* and weeds like *Typha australis, Ipomoea aquatica* and *Luffa aegyptiaca*.

Field sampling

Water and macroinvertebrate samples were collected monthly from June to October 2001 between 09h00 and 12h00 on each sampling day. Water samples were collected approximately 0.5m from the bank and 10cm below the surface. Samples for dissolved oxygen (DO) and biochemical oxygen demand (BOD_5) determination were collected in two pre-washed 250ml glass bottles, those for other chemical analyses in pre-washed one-litre polythene bottles.

Samples of benthic macroinvertebrates from the bank-root biotope (Bishop 1973) were collected by the modified kick method (Lenat *et al*. 1981, Victor and Ogbeibu 1985). Small quantities of 40% formaldehyde were used to kill the invertebrates, which were preserved in 70% ethanol after sorting.

Sample analysis

Air and water temperatures were measured using a mercury thermometer graduated in °C. A pH meter (Griffin Model 50) standardised with appropriate buffers was used to determine the hydrogen ion concentration. A turbidity meter (Hach Model 2100A) was used to estimate turbidity in NTU. Dissolved and suspended solids mg l^{-1} were estimated using the procedure recommended by APHA (1992). Conductivity was determined using a portable conductivity meter (Ciba Corning Model PPS/1604). Mohr titrations (APHA 1992) were used to determine the salinity of the water. Dissolved oxygen and BOD_5 (mg l^{-1}) were determined following Winkler's iodometric method (APHA 1992). Total alkalinity ($mgCaCO_3l^{-1}$), phosphate, nitrate, calcium and sodium content of the water were estimated in the Lagos State Environmental Protection Agency laboratory, Lagos, Nigeria using the APHA (1992) standard methods.

The laboratory procedures for studying stream macrobenthos from the bank-root biotope have been described by Victor and Ogbeibu (1985, 1991). Because of the difficulty of identifying Nigerian macrobenthic fauna, using the keys in Ogbeibu and Victor (1989), some invertebrates were identified only to generic level. However, the taxa recognised were distinct morphological units.

Results

Table 1 summarises some of the physical and chemical parameters of the study stations. Only BOD_5 and TDS were significantly different (ANOVA, $P < 0.05$) among the stations. *A posteriori* comparison using Duncan's Multiple Range test showed variable dissimilarities in TDS and BOD_5 among the study sites. The TDS levels at stations III and IV were similar ($P > 0.05$) and were significantly higher ($P < 0.05$) than those at stations I and II. The BOD_5 values at station I were significantly higher ($P < 0.05$) than those observed at the other three stations, which were similar ($P > 0.05$).

The overall benthic macroinvertebrate composition, abundance and distribution at the study stations are summarised in Table 2 as numbers of taxa for each group. Aquatic insect larvae dominated the 14 taxa recorded, accounting for 63% and 51% of the total number of taxa and individuals, respectively. Naididae, Platycnemididae, Chironomidae and Viviparidae were recorded at all the study stations. The overall abundances of macroinvertebrates were not significantly different at the four sites (Kruskal-Wallis test, $P > 0.05$).

Figure 2 presents the relative contribution of major benthic invertebrate families and taxa at the study sites. Only those families which contributed 5% and above were used. Generally, the Naididae and Chironomidae occurred in high numbers in the study area, with both families contributing more than 50% of the total number of individuals at each site (Figure 2). Naididae were represented by two genera, *Nais* and *Stylaria*. Both genera occurred at all sites, with *Nais* occurring in higher numbers (37–46 individuals/0.25m^2; >20% of individuals/station) except at station II where it comprised less than 20% of the total individuals (Table 2). *Stylaria* generally comprised less than 20% of the total number of individuals throughout. Chironomidae were also represented by two genera, *Chironomus* and *Pentaneura*. *Chironomus* occurred in high numbers at all sites (Table 2), while *Pentaneura* was recorded in low numbers only at sta-

Table 1: Summary of physical and chemical characteristics at the Kurarmo Water study stations, June–October 2001 (number of samples: 6/station)

	Station I			Station II			Station III			Station IV			
Parameters	Mean ± SD	Min.	Max.	Mean ± SD	Min.	Max.	Mean ± SD	Min.	Max.	Mean ± SD	Min.	Max.	F–values
Air Temperature (°C)	29 ± 2.26	26.5	31.5	28.7 ± 1.15	27.5	30.5	30.3 ± 2.10	27	32	29.9 ± 1.43	28	31.5	0.868
Water Temperature (°C)	26.7 ± 1.04	26	28.5	28.3 ± 1.71	26.5	31	28.8 ± 0.91	27.5	30	28.4 ± 0.65	27.5	29	3.24
pH		8	10.2		9	10.1		8	9.3		8	9.3	
Turbidity (NTU)	9.14 ± 0.47	8.5	9.7	8.96 ± 0.67	8	9.5	8.82 ± 0.45	8.2	9.3	8.62 ± 0.83	7.2	9.2	0.616
TDS (mg l^{-1})	12.6^{b} ± 1.85	10.5	15	11.7^{b} ± 1.96	10.5	15	15.9^{a} ± 2.61	12.5	18.5	15.8^{a} ± 2.71	12	18.5	4.39*
TSS (mg l^{-1})	10.1 ± 1.08	8.5	11.5	9.94 ± 0.87	8.5	10.5	13.8 ± 8.50	9.5	29	10.68 ± 1.62	9.4	13.5	0.85
Conductivity (mS cm^{-1})	2.55 ± 0.68	1.92	3.45	3.02 ± 0.34	2.51	3.4	3.01 ± 0.35	2.49	3.4	3.14 ± 0.52	2.41	3.7	1.39
Salinity (‰)	1.87 ± 0.09	1.77	1.98	1.84 ± 0.07	1.79	1.93	1.93 ± 0.17	1.79	2.23	1.9 ± 0.05	1.83	1.98	0.61
DO (mg l^{-1})	4.52 ± 0.49	4	5.1	4.8 ± 1.45	3	6.5	3.98 ± 0.70	3.2	5	4.18 ± 0.51	3.7	4.8	0.849
BOD (mg l^{-1})	10.5^{a} ± 0.86	10.05	12.05	9.23^{b} ± 0.68	8.5	10	9.03^{b} ± 0.68	8.5	10	8.64^{b} ± 0.41	8.05	9.05	7.90*
COD (mg l^{-1})	70 ± 5.0	65	75	65.8 ± 3.49	60	68	70 ± 3.53	65	75	66.4 ± 4.72	60	70	1.425
Alkalinity (Mg CaCO3l^{-1})	160 ± 14.14	140	170	138 ± 22.24	105	155	148 ± 5.70	140	155	159.1 ± 13.10	140	175.5	2.404
Phosphate (mg l^{-1})	0.536 ± 0.46	0.17	1.06	0.594 ± 0.47	0.18	1.11	0.578 ± 0.42	0.2	1.09	0.616 ± 0.43	0.22	1.09	0.028
Nitrate (mg l^{-1})	3.35 ± 0.75	2.52	4.5	3.146 ± 1.01	1.62	4.21	3.234 ± 0.92	1.82	4.05	2.99 ± 0.82	1.8	4.1	0.148
Sulphate (mg l^{-1})	321.8 ± 32.81	291	360	357.8 ± 44.68	311	410	367 ± 45.39	318	415.5	372.44 ± 46.39	292	410	1.425
Calcium (mg l^{-1})	92.3 ± 4.31	90	100	98.1 ± 12.57	85	110	83.6 ± 2.33	80	85.5	93 ± 13.96	80	110	1.92

$^{a, b}$ – means indicated with same letters are not significantly different ($P > 0.05$); ANOVA and subsequent apostriori comparison using Duncan's Multiple Range test.
* Indicates significant difference ($P < 0.05$).

Table 2: The overall composition and distribution of macrobenthic invertebrates at the Kuramo Water study stations, June–October 2001

	STATION I		STATION II		STATION III		STATION IV		ALL SITES	
	No. of Taxa	No. of individuals	No of Taxa	No. of individuals	No. of Taxa	No. of individuals	No. of Taxa	No. of individuals	No. of Taxa	No. of individuals
ANNELIDA										
Oligochaeta										
Naididae	2	68[a]	2	71[a]	2	56[b]	2	60[a]	2	255
Tubificidae	–	–	1	6	–	–	–	–	1	6
Polychaeta										
Nereidae	–	–	1	3	–	–	–	–	1	3
INSECTA										
Coleoptera										
Dysticidae	1	1	1	3	1	4	–	–	1	8
Elmidae	–	–	–	–	1	1	–	–	1	1
Odonata										
Zygoptera	1	1	1	29	1	10	1	9	1	49
Plecoptera										
Nemouridae	–	–	1	2	2	3	–	–	2	5
Hemiptera										
Nepidae	–	–	–	–	1	1	–	–	1	1
Diptera										
Culicidae	–	–	–	–	2	4	1	24	2	28
Chironomidae	2	78[a]	1	52[b]	2	46[b]	2	82[a]	2	258
GASTROPODA										
Prosobranchiata										
Viviparidae	1	3[c]	1	39[a]	1	11[b]	1	6[b]	1	59
NEMATODA	1	9	1	8	–	–	1	13	1	30
Total	8	160	10	213	13	136	8	194	16	703

[a, b, c] – means indicated with same letters are not significantly different (P > 0.05); Kruskal-Wallis test

tions II and III (Table 2). All other taxa were recorded below 10% of the total individuals per site, except for *Pyrrhosoma* (Platycnemididae) and *Viviparus viviparus* (Viviparidae) which occurred at above 10% only at station II.

The system of Slack *et al*. (1979), which defines dominants as taxa constituting 15% or more of the total number of individuals and subdominants as those comprising at least 5% of the total number, was used to identify the dominant and subdominant taxa in the study area (Table 3). Annelid worms and dipteran larvae were dominant at all four sites; odonata nymphs and prosobranchiata were dominant at station II but subdominant at station III. Nematode worms were subdominant at stations I and IV (Table 3). Among the annelid genera, *Nais* was dominant at all stations. *Stylaria*, which was dominant at station II, was subdominant at the other three stations. Among the aquatic insects *Chironomus* (Chironomidae) was dominant at all four stations, while *Culex* (Culicidae) and *Pentaneura* (Chironomidae) were both subdominant only at station IV. *Pyrrhosoma* (Platycnemididae) was subdominant at stations II and III, while *Viviparus viviparus* (Viviparidae, Prosobranchiata) was dominant at station II but subdominant at station III.

Diversity indices used to analyze macrobenthic invertebrate diversity at the study stations included Margalef's (D), Shannon-Wiener (H) and Hmax, the maximum expected diversity (Odum 1971, Krebs 1978, Zar 1984, Victor and Ogbeibu 1991, Ogbeibu 2001). The results presented in Table 4 indicate that the taxa richness was higher at station III than at other stations, while the general diversity and evenness were almost identical at all four stations. There was no significant difference in the general diversity (Hutcheson's t-test; P > 0.05) at the four stations.

Discussion

Since the literature on Kuramo Water is limited to the early reports of Hill and Webb (1958) and Yoloye (1976, 1977), the discussion of the findings of this study is restricted mainly to the comparison of the current status of the lagoon with those reports, in order to assess the ecological changes over time.

The water chemistry of an aquatic ecosystem is dependent on the physical and geological features of its drainage basin (Bishop 1973, Victor and Al-Mahrouqi 1996). Most of the physical and chemical characteristics of Kuramo Water were similar to those reported for this water body by earlier workers (Hill and Webb 1958, Yoloye 1976, 1977) and to those of the adjacent Lagos lagoon (Nwankwo and Akinsoji 1992). The water chemistry appears homogeneous, with inter-station differences only in TDS and BOD concentrations. The main form of habitat modification detected in this study is reflected in the current levels of salinity and BOD, as compared to those reported by earlier workers. These modifications are discussed below.

The present salinity range (0.95–1.98‰) is lower than that (15–24‰) given previously for the same lagoon (Hill and Webb 1958, Yoloye 1976). The elevated salinity of Kuramo Water at that time was attributed mainly to seawater occasionally spilling over the numerous narrow patches of the barrier beach separating the lagoon from the sea dur-

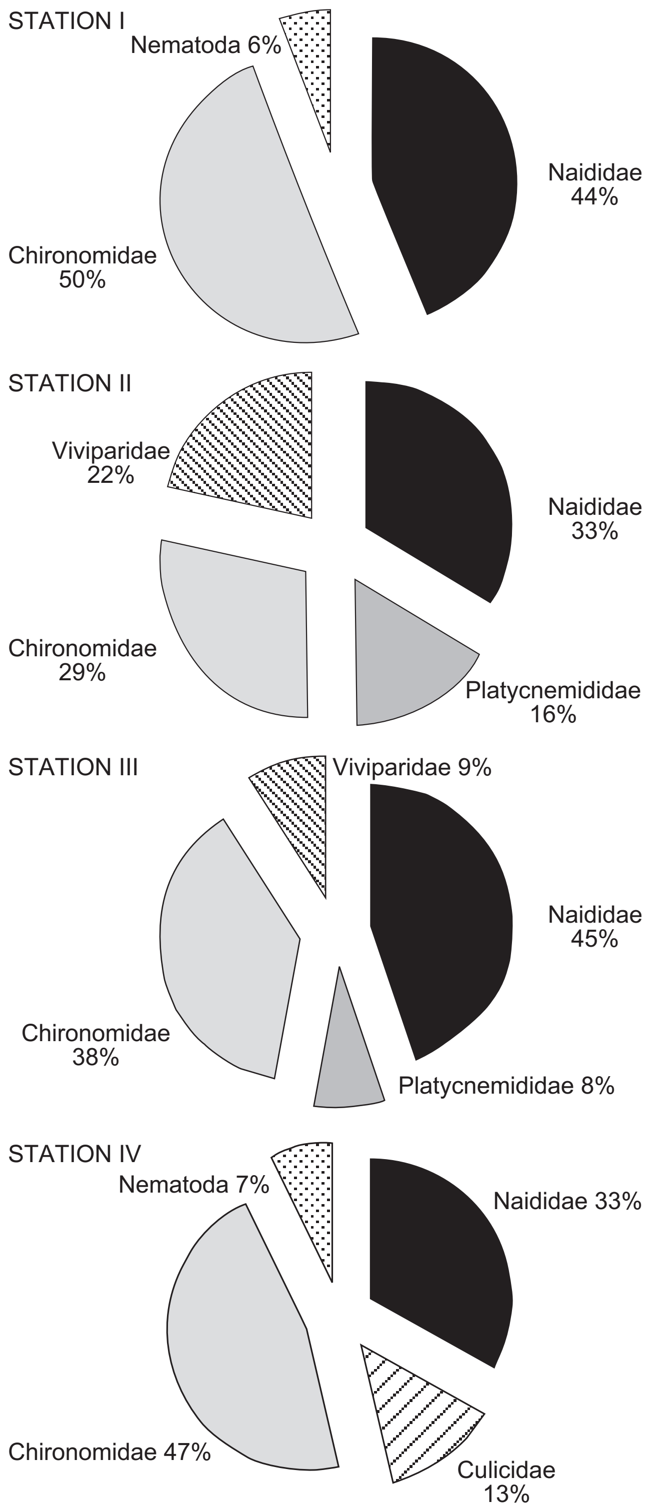

Figure 2: Relative contribution of major macrobenthic families and order (>5%) in the study stations

ing rough weather at high tide. As one of the measures taken by the Nigerian government to solve the problem of the frequent upsurge of seawater into the urban area, the bar beach, including the barrier beach separating Kuramo Water from the sea, has been raised and widened by sand filling. Also, the long and narrow creek connecting the lagoon to the Five Cowrie creek (Figure 1) has become blocked by silt and thick vegetation growth, thus preventing the inflow of salt water from the Lagos harbour during high tide. A combination of all these factors, in addition to the contribution of freshwater from surface run-off, especially during the rainy season (June–September), is responsible for the reduction in the salinity of the lagoon water from brackish to freshwater levels.

Biochemical oxygen demand (BOD) is a measure of the potential of biologically oxidisable matter for de-oxygenating water, and thus provides a measure of the effect of pollution on a receiving water body (Mason 1991). The observed BOD levels of Kuramo Water (8.05–12.05mg l^{-1}) were higher than those (0.42–8.0mg l^{-1}) reported for most other Nigerian waters (Victor and Onomivbori 1996, Edokpayi and Osimen 2001, Ogbeibu and Oribhabor 2002), but lower than the 90–370mg l^{-1} reported for water bodies exposed to urban run-off elsewhere (Mason 1991). The Kuramo water is being used as a sink for treated and untreated human sewage from residential areas and hotels situated along its northern boundary. Also, the inhabitants of the littoral shanty settlements along the elevated barrier beach deposit their domestic and human wastes directly into the water. This high level of organic waste is responsible for the high BOD levels observed. Higher BOD levels were recorded for Station I than for the other sites. The local conditions at Station I may have encouraged a higher rate of mineralisation and decomposition of the organic wastes discharged into the study lagoon. Compared to the other sites, Station I is calm with a thick growth of emergent aquatic plants and no human activities such as boating, bathing and fishing. Human excreta can mineralise rapidly in water and release high proportions of nutrient elements into the water. These elevated nutrient levels, especially nitrate and sulphate, may have encouraged the bloom of algae, especially *Microcystis* sp. (Nwankwo 1996), characteristic of Kuramo Water. The dissolved oxygen released by these algae through photosynthetic process may have helped to maintain a rather moderate oxygen level, despite the stressed conditions reflected by the high BOD levels. The DO levels reported were within the range (6.8–8.6mg l^{-1}) given for the Lagos lagoon (Nwankwo and Akinsoji 1992) and those observed (1.20–9.40mg l^{-1}) for some polluted water bodies in Nigeria (Victor and Onomivbori 1996, Edokpayi and Osimen 2001).

It is usually desirable to identify environmental factors capable of structuring aquatic communities in a given stretch (Richards *et al*. 1993), as changes in water quality conditions directly influence the structure of benthic communities (Battegazzore *et al.* 1992, Bunn and Davies 1992, Camargo 1992). Changes in the salinity regimes from estuarine to freshwater levels and the elevated BOD levels due to human and domestic sewage discharges appear to be responsible for the structure of the benthic invertebrate community of Kuramo Water.

The benthic macroinvertebrate community of Kuramo Water recorded in this study was dominated by Chironomidae and Naididae. This differed from the mollusc-dominated community reported earlier for this lagoon

Table 3: The distribution of major macroinvertebrate groups at the Kuramo Water study stations, June–October 2001; the values are in percentages; >15% dominant, >5% to <15% subdominant

	Station I	Station II	Station III	Station IV
Annelida	42.5	34.48	40.3	30.93
Col;eoptera	0.63	1.48	3.73	–
Odonata	0.63	14.28	7.46	4.64
Plecoptera	–	0.99	2.24	–
Hemiptera	–	–	0.75	–
Diptera	48.75	26.62	37.31	54.64
Prosobranchiata	1.88	19.2	8.21	3.09
Nematoda	5.63	3.94	–	6.7

Table 4: Diversity of benthic macroinvertebrates at the Kuramo Water study stations, June–October 2001

	Station I	Station II	Station III	Station IV
No. of samples	5	5	5	5
No. of taxa	8	10	13	8
No. of individuals/0.25m^2	160	213	136	194
Taxa richness (D)	3.18	3.9	5.64	3.06
Shannon diversity (H)	0.44	0.74	0.66	0.62
Equitability index (E)	0.49	0.74	0.59	0.69

(Yoloye and Adegoke 1977, Oynekan 1988). The change in the salinity levels has resulted in the replacement of the mangrove trees along the banks, which provided a microhabitat for molluscs, by freshwater shrubs and grasses. This resulted in the elimination of the brackish water species, including a newly-described mollusc species *Neritina kuramonensis* (Yoloye 1977) from the lagoon.

A characteristic feature of chironomids is that they usually have no habitat restrictions (Awachie 1981). However, they are known to replace other invertebrate taxa in water bodies polluted by agricultural and domestic activities (Victor and Ogbeibu 1985). The high load of organic matter in the Kuramo Water sediment was responsible for the dominant status of a chironomid taxon, *Chironomus*, at the study sites. Also dominant at all the four stations was a naidid taxon, *Nais*. Naidid oligochaetes have been reported in polluted tropical waters (Bishop 1973, Victor and Dickson 1985) and prefer soft sediments rich in organic content (Mellanby 1962, Crothers 1997), a feature characteristic of the Kuramo Water sediment. In addition, naidid worms have been observed to respond to organic pollution by increasing in abundance (as observed here) in water bodies in southern Nigeria and elsewhere (Learner *et al*. 1978, Victor and Dickson 1985, Victor and Onomivbori 1996).

There was no significant difference in the Shannon diversity at the study stations. The general diversity indices recorded were similar to those reported for water bodies impacted by urban perturbations (Victor and Onomivbori 1996) or physically stressed aquatic environments (Ogbeibu 2001), but lower than those of most water bodies in southern Nigeria (Victor and Ogbeibu 1991, Edokpayi and Osimen 2001, Ogbeibu and Oribhabor 2002). The low general diversity further highlights the perturbed status of the lagoon.

In summary, the rich biodiversity and high aquatic productivity of the West African coastal waters is constantly undergoing bio-modification due to the adverse impact of human activities, especially in overpopulated cities like Lagos, Nigeria. An effective biodiversity-monitoring programme should be developed to check this ever-increasing threat in order to protect the coastal ecosystem.

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