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Full Length Research Paper

The hydrochemistry and macrobenthic fauna characteristics of an urban draining creek

Clement A. Edokpayi[1]*, Aveez O. Olowoporoku[2] and Roland E. Uwadiae[1]

[1]Department of Marine Sciences, University of Lagos, Akoka, Yaba, Lagos State, Nigeria.
[2]University of West of England, Bristol, United Kingdom.

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Lagos lagoon is the largest of the eight lagoons that make up the lagoon systems of Nigeria and probably the most exposed to anthropogenic influence. The pollution status of the Lagos lagoon is generally attributed to the direct discharge of waste (domestic and industrial) and the contribution from rivers, creeks and drainage canals that empty into the Lagoon at different points. The paucity of information on the pollution status of water bodies that feeds the Lagos lagoon informed this present study. Investigation into the hydrochemistry and benthic macrofauna of Ogbe creek that drains through the main land of Lagos and empty into the Lagoon was carried out. Fortnightly, sample collections between March and August 2002 at three stations along a 2 km stretch of the creek within the University of Lagos were used for the study. The hydrogen ion concentration ranged from 5.4 to 9.4. The electrical conductivity, salinity, alkalinity, nitrate, phosphate, dissolved oxygen and biochemical oxygen demand ranged between 3.65 ± 3.07 to 3.96 ± 3,22 Sµcm^{-1}; 0.51 ± 0.64 and 1.01 ± 0.96 ‰; 33.3 ± 23.2 and 60 ± 32.79 mgl^{-1}; 4.12 ± 0.17 and 7.46 ± 1.02 mgl^{-1}; 1.93 ± 0.53 and 3.65 ± 1.02 mgl^{-1}; 2.83 ± 1.42 and 4.65 ± 0.59 mgl^{-1} and 7.96 ± 1.99 and 8.13 ± 1.61 mgl^{-1}, respectively. The high BOD_5, nitrates and phosphates values are indicative of a perturbed environment. A total of 246 organisms belonging to 16 benthic taxa, 13 genera, 12 families, 8 orders and 4 phyla were collected during the study period. Chironomid larvae and the Naidid worms were the most abundant groups. They accounted for 25.61 and 22.76%, respectively, of the total macrobenthic count. The low number of taxa and numerical abundance of pollution indicator macrobenthos in the study area reflected a perturbed creek.

Key words: Hydrochemistry, benthos, University of Lagos, Ogbe creek, Nigeria.

INTRODUCTION

Many freshwater resources draining urban settlement are usually contaminated through input associated with human activities. Nigerian aquatic systems are subjected to pollution pressures associated with urbanization and population growth (Edokpayi et al., 2000; Nkwoji et al., 2010). Many of the rivers and creeks are used for irrigation, flood control, fisheries development and provision of potable water to towns and the surrounding rural areas. Along the approximately 853 km coastline of Nigeria are estuaries and lagoons receiving effluents from many rivers and creeks most of which are routes for the introduction of pollutants.

Owing to the seasonal distribution of rainfall, the lagoon systems and creeks experience seasonal flooding which introduces a lot of detritus, nutrients as well as other land based pollutants (Ogunwenmo and Osuala, 2004; Edokpayi et al., 2008). Such pollutants arising from land-based activities include domestic and industrial effluents, urban storm and agricultural run-offs. The introduction of these pollutants into aquatic systems flowing through Nigerian cities and villages constitute a major threat to hydrochemical and faunal characteristics of the aquatic ecosystems (Edokpayi et al., 2004; Edokpayi and Nkwoji, 2007). Also of significant impact to the hydrochemistry and hydrobiology of these water bodies are coastal habitat destruction and contamination from garbage and solid waste dump, which are common features along the Nigeria coastal waters (NEST, 1991).

The disappearance of benthic species, notably *Neritina kuramoensis* from the Kuramo water (Edokpayi et al., 2004), and the prolific growth of a cyanobacterium *Micocystis aeruginosa* Kutzing in parts of Ogun River

*Corresponding author. E-mail: klemedokpayi@gmail.com

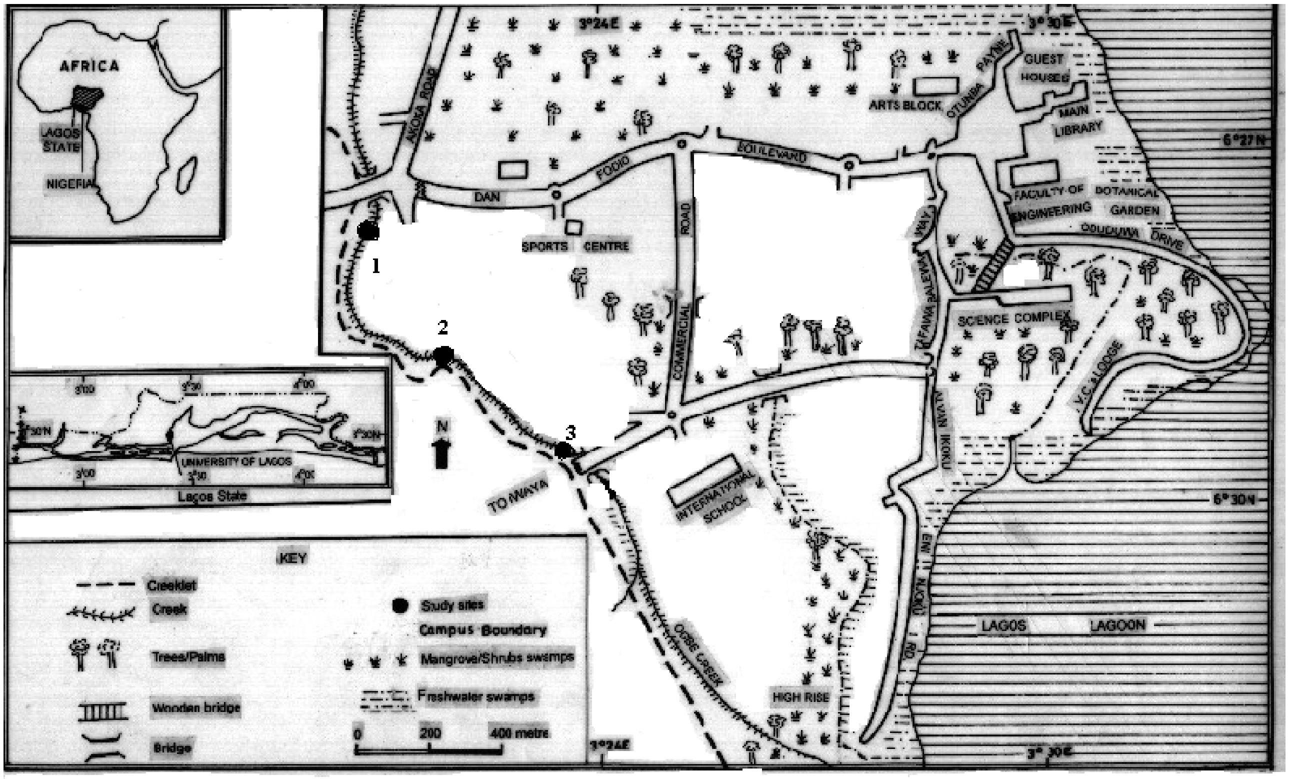

Figure 1. Map of the study area showing the sampling points on the Ogbe creek.

(Nwankwo, 1993), reflects the alteration of the hydro-dynamic and hydrobiological characteristics of most aquatic systems in South-western Nigeria due to perturb-bation stress.

The increasing levels of anthropogenic perturbation in Ogbe creek (Chukwu and Nwankwo, 2003) underscores the need for this study as there is scanty information on the hydrochemistry and fauna characteristics of this creek. This paper presents the results of the investigation on the hydrochemistry and benthic macrofauna of the creek.

MATERIALS AND METHODS

Description of study area

Ogbe creek is in South-western Nigerian and it empties into the Lagos lagoon (Figure 1). The Lagos lagoon is the largest of the eight lagoons (Yelwa, Badagry, Ologe, Iyagbe, Lagos, Kuramo, Ekpe, Lekki and Mahin) that make up the lagoon system of Nigeria. The creek is non-tidal and experiences flooding in the wet season as a result of surface run-offs (Nwankwo and Akinsoji, 1992). The creek drains the Lagos metropolis and thus carries urban run-off, sewage and other domestic waste from adjoining areas to the Lagos lagoon. Along the bank of the creek are farmlands, waste dumps sites, public toilets and bathroom structures. Other prominent features along the bank of the creek are mechanics and car wash shops. The water had a foul odour and deep dark colour, which suggests a pollution condition during the sampling period. Pockets of aquatic macrophytes at different locations along the creek covered the water surface; notable among them are *Lemna paucicosta, Salvinia molesta, Eichhornia crassipes, Dryopteris* sp., *Vernonia amygdalina, Emilia* sp., *Fucus* sp. and *Pistia stratiotes.* Three sampling stations were purposively selected based on accessibility (Figure 1).

Field studies

Water and benthic macrofauna samples were collected fortnightly between 0800 h and 1200 h on each sampling day. Water samples for dissolved oxygen (DO) and biochemical oxygen demand (BOD_5) determination were collected in two pre-washed 250 ml transparent and amber colored glass bottles respectively. Those for other chemical analyses were collected in one litre plastic bottles.

Three grab hauls for benthic samples were taken from each station; the collected materials were washed through a 0.5 mm mesh sieve in the field. The residue in the sieve was preserved in 10% formalin solution and kept in labeled plastic containers for onward transportation to the laboratory.

Laboratory investigation

The DO, BOD5, alkalinity, pH, nitrate, phosphate, salinity and conductivity of the surface water were determined using the methods recommended by APHA (1980). Preserved benthic samples were washed with tap water to remove the preservative and any remaining sediment in order to facilitate easy sorting.

Invertebrate fauna were sorted on a white tray into taxonomic groups using suitable texts (Michael, 1977; Barnes et al., 1988). The number of species and individuals for each station were counted and recorded. The methods of Slack et al. (1973) and

Table 1. Summary of the physico-chemical characteristics of the Ogbe Creek surface water.

Parameter	Station 1				Station 2				Station 3			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Conductivity (mg/l)	3.85	3.11	0.45	7.50	3.65	3.07	0.47	7.30	3.96	3.22	0.50	7.60
pH			5.1	8.8			5.6	9.2			7.5	9.4
Salinity (‰)	0.88	0.89	0.08	2.62	1.01	0.96	0.06	2.56	0.51	0.64	0.04	1.97
Alkalinity (mg/l)	33.3	23.2	10	80	60	32.79	10	100	44.6	24.58	8.00	83
Nitrate (mg/l)	7.46	1.02	6.00	9.00	6.05	1.54	4.10	8.00	4.12	0.17	3.80	4.42
Phosphate (mg/l)	3.68	1.02	1.80	5.00	1.93	0.53	0.90	2.80	2.76	0.76	1.90	3.95
DO (mg/l)	4.17	1.03	2.5	5.9	2.83	1.42	1.0	5.2	4.65	0.59	3.8	5.6
BOD_5 (mg/l)	7.96	1.99	4.3	9.8	8.13	1.61	5.0	9.9	7.98	1.14	5.6	9.5

Victor and Ogbeibu (1991) were used to define the dominant and subdominant groups. Diversity (Zar, 1984) of benthic macrofauna was estimated using Margalef's taxa richness (d), Shannon-Weiner's index of general diversity (H) and equitability using evenness index (E).

RESULTS

Physical and chemical conditions

Summary of the values measured for the physico-chemical parameters are summarized in Table 1. The highest value of DO (5.9 mgl^{-1}) was recorded in March at Station 1, while the least value (1.0 mgl^{-1}) was observed in station 2 in August. The values of BOD_5 ranged between 4.3 mg/l at station 1 and 9.9 mgl^{-1} in August at station 2. Station 2 had the highest values (100 mgl^{-1}) for alkalinity, while the least value (6 mgl^{-1}) was recorded at station 3 in August. The pH range for the period of study was 5.1 – 9.4. The water was acidic at station 1 in the dry months and alkaline in the wet months. The highest pH value (9.4) was recorded in March at station 3.

The lowest value of nitrate (3.8 mgl^{-1}) was observed in July at station 3 while the highest value (9.0 mgl^{-1}) was in July at station 1. Generally, nitrate concentrations were higher at station 1 than stations 2 and 3.The highest value (3.95 mgL^{-1}) of phosphate was recorded in July at station 3, while the lowest (0.9 mgL^{-1}) was recorded at station 2 in April. Salinity was high in the dry months and generally low in the rainy months. However, there was an increase in the values of the salinity in late July and August at the study sites except in station 3 that recorded a slight decline in August. The maximum value of 2.62‰ was recorded in March in station 1 while the minimum value of 0.1‰ was recorded also at station 1 in June. Electrical conductivity was low for all stations from March to May. There was an increase in the values of this parameter in all the stations in June after which it followed a steady pattern till the end of the sampling. Station 3 recorded the highest value of 7.6 μScm^{-1} in June while the least value of 0.26 μScm^{-1} was recorded in station 1 in May.

Benthic macrofauna

Community structure

A total of 246 organisms belonging to 16 benthic taxa, 13 genera, 12 families, 8 orders and 4 phyla were collected during the study period. The benthic faunal list is presented in Table 2. Of all the phyla encountered, the Arthropoda represented by insects were the most abundant in the study stretch. They accounted for 60% of the taxa and 58% of benthic animals enumerated. The family Chironomidae was the most abundant group contributing 63 individuals (26%) of total benthic macrofauna count. The Naididae, of the phylum annelida ranked second in abundance with the 56 individuals, which accounted for 23% of the total benthic macrofauna count. The phylum mollusca and platyhelminthes contributed 14 (5.69%) and 4 (1.62%) individuals, respectively (Figures 2, 3 and Table 2).

Composition and distribution

The plathyhelminthes was represented by 4 individuals of *Crenobia alpine* of the family Planaridae that occurred in stations I (3 individuals) and 3 (1 individual). The Annelida was represented by *Nais* sp and *Dero* sp of the Naididae and *Tubifex* sp of the family Tubificidae. They occurred in all the study stations. Also encountered in this study are 7 members of the Arthropoda which include *Chironomous* sp of the family Chironimidae, *Anopheles* sp, *Culex* sp and *Aedes* sp of the family Culicidae, *Arthripsodes aterrimus* (leptoceridae) and *Platambus maculatus* of the family Dysticidae. Arthropoda was represented in all the stations studied except the non occurrence of the family Dysticidae in stations 2 and 3, and leptoceridae in stations 1 and 3. The phylum mollusca were represented by 3 families (hydrobiidae, lymnaeidae and unionidae), and each of the 3 families had a single representative species, these were *Potamopyrgus jenkinsi*, *Limnaea truncatatula* and *Unio pictorum* respectively. Hydrobiidae was recorded in stations 1

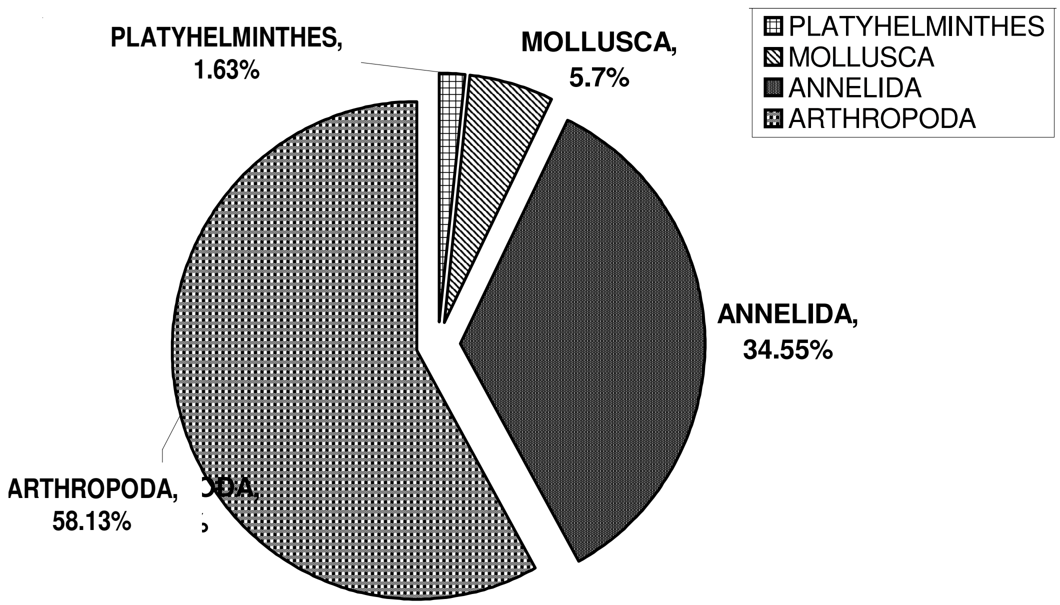

Figure 2. Overall percentage abundance of benthic macrofauna in the study area.

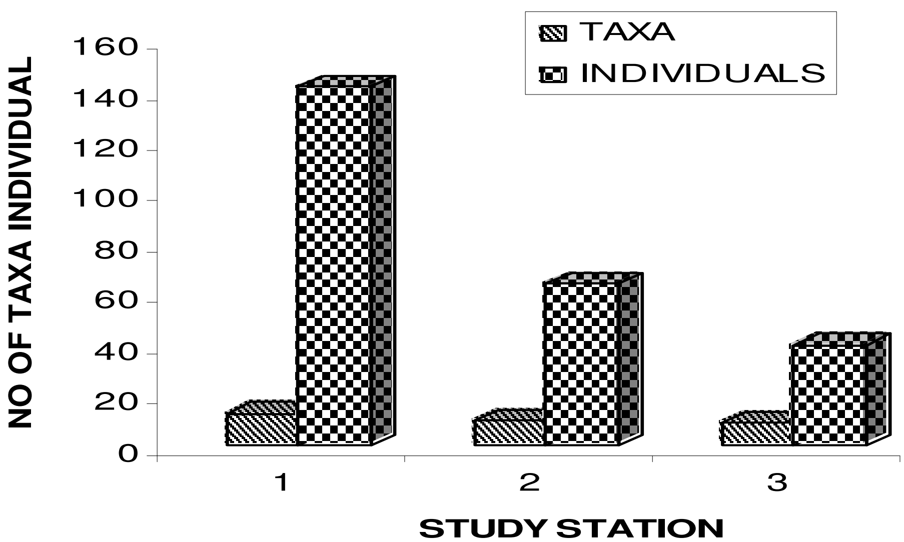

Figure 3. Overall number of individuals and taxa at the study stations in Ogbe creek.

and 2 while, lymnaeidae and unionidae occurred only in stations 1 and 3, respectively.

The distributions of individuals and taxa at the study stations are presented in Figure 2. Station 1 had the highest number (13) of taxa and individuals (142). This station accounted for 58% of the total number of individuals. Station 2 which recorded 64 individuals comprising of 10 taxa accounted for 26%. Station 3 had the least number (9) of taxa and individuals (40), and accounted for 16% of the total number of individuals found during the sampling period.

Dominant and subdominant groups

The percentage contributions of major macrobenthic order at the study stations are presented in Figure 4. Plesiopora (annelida) and Diptera (Arthropoda) constituted the dominant groups in all the stations sampled in the study area (Table 3). Coleoptera was dominant in station 1 but recorded a subdominant status in stations 2 and 3. Order Triclidida of the plathyhelminths was subdominant in stations 1 and 3, while Prosobranchia (mollusca) was subdominant in stations 1 and 2.

Table 2. Abundance of macrobenthic invertebrates in Ogbe creek.

Fauna	Station 1		Station 2		Station 3		Total	
	No. of Taxa	No. of individuals	No. of Taxa	No. of individuals	No. of Taxa	No. of individuals	No. of Taxa	No. of individuals
Platyhelminthes								
Planariidae	1	3			1	1	1	4
Annelida								
Naididae	2	27	2	17	2	12	2	56
Tubificidae	1	12	1	10	1	7	1	29
Arthropoda								
Dysticidae	1	16					1	16
Gyrrinidae	1	27	1	7	1	3	1	37
Chironomidae	1	39	1	17	1	7	1	63
Culicidae	4	9	2	5	2	6	4	20
Leptoceridae			1	2			1	2
Hydroptilidae			1	5			1	5
Mollusca								
Hydrobiidae	1	3	1	1			1	4
Limnaeidae	1	6					1	6
Unionidae					1	4	1	4
Total	13	142	10	64	9	40	16	246

General diversity (H) and equitabilty

The values of taxa richness, diversity and equitability are presented in Table 4. Taxa richness was highest at station 1 and lowest at station 3. Diversity was highest at station 1 and lowest at station 3, while equitability was highest at station 3 and lowest at station 5.

DISCUSSION

Physical and chemical parameters

Conductivity of a water body is an index of the total ionic content, therefore it can be used to indicate the freshness or otherwise of the water. Egborge (1993) reported that for many Nigerian inland water bodies, the conductivities are much less than 500 μScm^{-1} at the peak of dry season. In this study, a range of 5.1 – 9.4 μScm^{-1} was recorded. This indicates low ionic concentration of the water during the study period. Also, the sharp increase in the value of conductivities observed in June can be attributed to the flushing terrain during the rainy season, which increases the allochthonous input into the creek.

The pH range (5.1 – 9.4) at the study stations generally falls within ranges reported for rivers flowing through areas with thick vegetation (Awuchie, 1981; Osimen, 1997; Uwadiae et al., 2009). The increase in acidity in station 2 during the rainy months may be attributed to the allochthonous input consisting mainly of wash back of the spoils and chemical wastes from auto-mechanic and car wash shops at the bank of the creek. Pidgeon and Cains (1987) observed that organic acids resulting from decaying vegetation might be responsible for the low pH in most aquatic ecosystems.

Salinity range (0.1 - 2.62‰) observed in this study was slightly brackish and fell within the range reported by other workers within the vicinity (Edokpayi et al., 2008; Onyema and Nkwoji, 2009). The salinity values of the study stations were relatively higher during the dry months; this may be due to dilution of the water by the increase freshwater input during these raining months. Alkalinity of a water body is a measure of its capacity to neutralize acids to a designated pH (APHA, 1980; Edokpayi, 2005). High alkalinity results in physiological stress on aquatic organisms and may lead to loss of biodiversity.

The levels of nitrate observed here are within the ranges reported for some Nigerian waters (Edokpayi and Nkwoji, 2007; Onyema et al., 2009). The values of phosphate recorded were higher during the rainy season and lower during the dry months. This observation is supportive of the claims of Stewart et al., (1975) and Osimen (1997) for most tropical waters. This can be

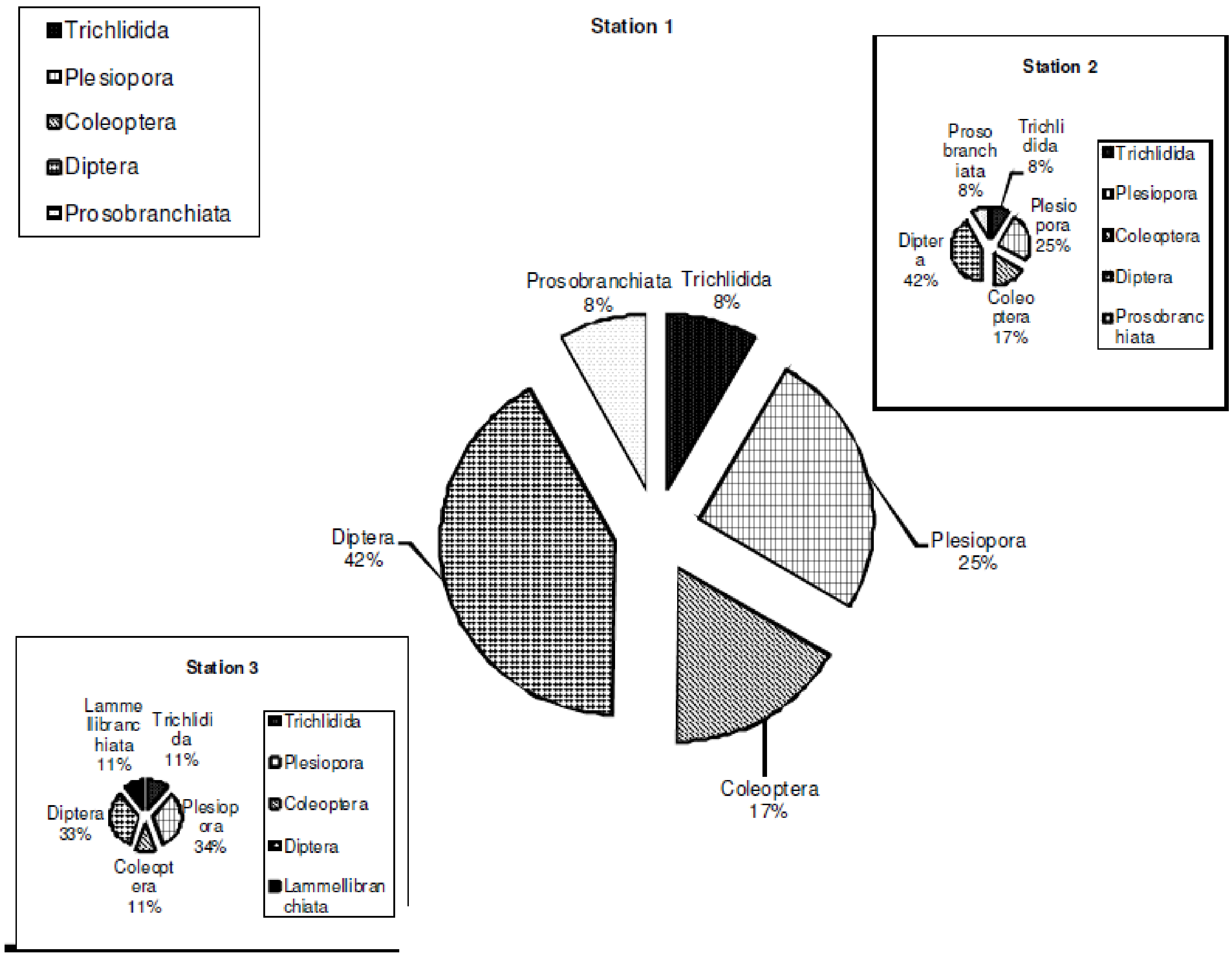

Figure 4. Percentage contribution of major macrobenthic order in the study stations.

Table 3. Summary of the dominant and subdominant (figures in %) macrobenthic invertebrate groups at the study station of Ogbe creek (dormant ≥ 15%; subdominant > 15% ≥ 5%; Rear > 5%, Slack *et al.,* 1973; (** indicates dominance, * indicates subdominance).

Major taxonomic group	Station 1	Station 2	Station 3
Trichlidida	7.69*	-	11.11*
Plesiopora	23.08**	30**	33.33**
Coleoptera	15.39**	10*	11.11*
Diptera	38.46**	30**	33.33**
Trichoptera	-	20**	-
Prosobranchiata	7.69*	10*	-
Pulmonata	7.69*	-	-
Lammellibranchiata	-	-	11.11*

accounted for by high amount of organic wastes, which enters the creek through run-offs. The stream was moderately oxygenated as observed in the DO values (1.0 – 5.9 mgl^{-1}). The range was similar to those reported for many other polluted Nigerian waters including that (6.9 - 8.8 mg/l) of Lagos lagoon (Ogunwenmo and

Table 4. Summary of the diversity and faunal indices of macrobenthic invertebrates at the study stations.

Indices	Station 1	Station 2	Station 3
Number of samples	12	12	12
Number of taxa	13	10	9
Number of individual	142	64	40
Margalef's taxa richness	1.91	1.78	1.64
Shannon-Weiner index of diversity (H)	1.75	1.40	1.24
Equitability	0.62	0.65	0.68

Kusemiju, 2004) and those observed (1.20 - 9.40 mg/l) for some polluted water bodies in Nigeria (Victor and Onmivbori, 1996; Edokpayi and Osimen, 2001). The low DO observed in the study area could be attributed to the high organic content, mainly human faeces, decayed plant and animal materials and domestic effluents flushed into the creek at different points. This requires large quantities of DO for aerobic decomposition.

Biochemical oxygen demand is a measure of the potential of biologically oxidisable matter for deoxygenating water, and thus provides a measure of the effect of pollution on a receiving water body (Mason, 1991). The BOD_5 values (4.3 – 9.9 mgl^{-1}) recorded in this study was higher than those (0.42 - 8.0 mg/l) reported for some Nigerian streams (Osimen, 1997; Edokpayi and Osimen, 2001; Ogbeibu, 2001; Ogunwenmo and Osuala, 2004). This is an indication of the pollution status of Ogbe creek. The high organic load was responsible for the high BOD_5 especially in the rainy months.

Macrobenthic invertebrates

The important factors that affects the abundance of macrobenthic fauna in a given community includes: the physicochemistry of the water, immediate substrate of occupation and food availability (Dance and Hynes, 1980). In this study, it was desirable to identify environmental factors that were responsible for the observed structure of the benthic communities. The high BOD_5 due to human and domestic wastes discharges appear to be responsible for the structure of the benthic macrofauna community of Ogbe creek. Chironomidae and Naididae as recorded in this study dominate the benthic macrofauna community of Ogbe creek. This observation agrees with the report of Edokpayi et al., (2004) on Kuramo Water. Chironomid larvae have been reported to dominate aquatic benthic invertebrates' communities (Hynes, 1998; Victor and Ogbeibu, 1985) as they hardly show any habitat restriction (Victor and Ogbeibu, 1991) and are known to replace other invertebrate taxa in streams perturbed by human activity. Chironomidae were represented in all the stations. The elevated levels of organic matter in Ogbe creek sediment may be responsible for the dominant status of a chironomid taxon, *Chironomus* (Edokpayi et al., 2004) at the study sites. The high abundance of the chironomids in the study area is a confirmed phenomenon in polluted water bodies in both temperate and tropical zones (Edokpayi and Nkwoji, 2007; Cardoso et al., 2010).

The naidid taxon, *Nais* also occurred in significant number at the study stations. Edokpayi et al., (2004) reported that Naidid oligochaetes have been found in polluted tropical waters and prefer soft sediment rich in organic content (Ogunwenmo and Kusemiju, 2004), as observed for the Ogbe creek. Furthermore, naidid worms have been reported to respond to organic pollution by increasing in abundance in polluted water bodies (Bishop, 1973).

The relatively lower taxa observed in station 3 could be attributed to the resultant effect of continuous dredging activities at this station and lack of vegetation cover which is the primary source of allochthonous material that may be used as food by the benthos. Anthropogenic activities such as dredging results in substratum instability and increased siltation. Suspended silt has the ability of reducing light penetration and primary productivity and can clog the gills of aquatic fauna thereby smothering them (Edokpayi and Nkwoji, 2007). The occurrence of relatively higher taxa and individuals' in station 1 may be an indication of lower degree of anthropogenic activities at this station compared to other stations.

Overall diversity has been reported to be the product of all dynamic spatial and temporal changes affecting the community (Victor and Ogbeibu, 1991). It could also be a reflection of the extent, to which the ecosystem has been perturbed by human activity. The very low diversity at the study stations is an indication of environmental perturbation.

REFERENCES

American Public Health Association (APHA) (1980). Water Pollution Method for the Examination of Water and Wastewater. 18th ed., Washington D.C. p. 1437

Barnes RSK, Calow P , Olive PJW (1988). The invertebrates: A new synthesis. Blackwell Scientific publications, Oxford, pp: 582.

Cardoso I, Granadeiro JP, Cabral H (2010). Benthic macroinvertebates vertical distribution in the Tagus estuary (Portugal): The influence of tidal cycle. J. Estuarine Coastal Shelf Sci., 86: 580 – 586.

Chukwu LO , Nwankwo DI (2003). The impact of land-based pollution on the hydrochemistry and macrocommunity of a tropical West African creek. The Ekol., 2:(1-2): 1 - 19
Dance KW , Hynes HBN (1980). Some effects of Agricultural land use on stream insect communities. Environ. Pollut. Ser., 22: 19 – 28.
Edokpayi CA, Okenyi JC, Ogbeibu AE , Osimen EC (2000). The effect of human activities on the macrobenthic invertebrates of Ibiekuma stream, Ekpoma, Nigeria. Bioscience Res. Commun. 12(1): 79 – 87.
Edokpayi CA , Osimen EC (2001). Hydrobiological studies on Ibiekuma River at Ekpoma, Southern Nigeria after Impoundment: The faunal characteristics. Afr. J. Sci. Tech. pp: 72 – 81.
Edokpayi CA, Lawal MO, Okwok NA , Ogunwenmo CA (2004). Physico-chemical and macrobenthic faunal characteristics of Kuramo water, Lagos, Southern Nigeria. Afr. J. Aquat. Sci., 29(2): 235 – 241.
Edokpayi CA (2005). Variation of chemical constituents of a brackish water prawn habitat in southern Nigeria. actaSATECH 2(1): 11 – 18.
Edokpayi CA , Ayorinde AO (2005). Physical, chemical and Macrobenthic invertebrate fauna characteristics of swampy water bodies within University of Lagos, Nigeria. West Afr. J. Appl. Ecol., 8: 129 – 139.
Edokpayi CA, Nkwoji JA (2007). Annual changes in the physico-chemical and macrobenthic invertebrate characteristics of the Lagos lagoon sewage dump site at Iddo, Southern Nigeria. Ecol. Environ. Conserv. 13(1): 13 – 17.
Egborge ABN (1993). Biodiversity for Aquatic Fauna in Nigeria. National Resources Conservation Council, Abuja. p. 173
Hynes KE (1998). Benthic macroinvertebrate diversity and biotic indices for monitoring of 5 urban and urbanizing lakes within the Halifax Regional Municipality (HRM), Nova Scotia, Canada. Soil & Water Conservation Society of Metro Halifax. 14: 114
Mason TT (1991). Biology of Freshwater Invertebrates Animals. Longman, London. p. 111
Michael Q (1977). Invertebrates of streams and Rivers. A key to identification. Edward Arnold Publishers Ltd., London. p. 84
Nigerian Environmental Study /Action Team-NEST (1991). Nigeria's Threatened Environment. A national profile. Intec. Printers Ltd. Ibadan. p. 288
Nkwoji JA, Yakub A, Ajani GE, Balogun KJ, Renner KO, Igbo JK, Ariyo AA , Bello BO (2010). Seasonal variations in the water chemistry and benthic macroinvertebrates of a south western Lagoon, Lagos, Nigeria. J. Am. Sci., 6(3): 85 – 92.
Nwankwo DI , Akinsoji A (1992). Epiphyte community on water hyacinth *Eichornia crassipes* (MART) solutions in coastal water of South Western Nigeria. Arch Hydrobio. 124(4): 501 – 511.
Nwankwo DI (1993). Cyanobacteria bloom species in coastal waters of South Western Nigeria. Arch. Hydrobiol., 4: 533 – 542.
Ogbeibu AE (2001). Distribution, density and diversity of dipterans in a temporary pond in Okomu forest reserve, Southern Nigeria. J. Aquat. Sci., 16: 43 – 52.
Ogunwenmo CA , Kusemiju K (2004). Annelids of a West African estuarine system. J. Environ. Biol., 25(2): 227 – 237.
Ogunwenmo CA , Osuala IA (2004). Physico-chemical parameters and macrobenthos of an estuarine creek and an artificial pond in Lagos southwestern Nigeria. actaSATECH 1(2): 128 – 132.
Onyema IC, Lawal-Are AO, Akinremi TA , Bassey OB (2009). Water quality parameters, chlorophyll a and zooplankton of an estuarine creek in Lagos. J. Am. Sci., 5(6): 76 - 94
Osimen EC (1997). The effects of impoundment on the physico-chemical parameters and macrobenthic invertebrate fauna of Ibiekuma River, Ekpoma, Edo State. Environ. Pollut., 64: 24 – 88.
Pidgeon RWJ , Cains SC (1987). Decomposition and colonization by invertebrates of nature and exotic leaf material in a small stream in New England (Australia). Hydrobiologia, 77: 113 – 124.
Slack KV, Nauman JW , Tilley LJ (1973). Benthic inveretebrates in a North flowing stream and a South flowing stream, Brooks range. Alaska. Water. Res. Bullet, 15: 108 – 135.
Stewart WDP, May E , Tuckwell (1975). Eutrophication and algal growth in Scottish Freshwater Lochs. In: The Ecology of resource degradation and renewal. Chadwick WJ , Goodman CT, Blackwell Scientific Oxford, 7 0-80.
Uwadiae RE, Edokpayi CA, Adegbite O, Abimbola O (2009). Impact of sediment characteristics on the Macrobenthic invertebrates community of a perturbed tropical lagoon. Ecol. Environ. Conserv. 15(3): 441 – 448.
Victor R , Ogbeibu AE (1991). Macroinvertebrate communicates in the erosional biotope of an urban stream in Nigeria. Nig. J. Sci., 4: 1 – 2.
Victor R , Onomivbori O (1996). The effects of urban perturbation on the benthic macroinvertebrates of a southern Nigeria stream. In: Schiomer F , Biland. (Eds)..SPB Academic Publishing Amsterdam, The Netherlands. pp: 223-238
Zar JH (1984). Biostatistical Analysis (2nd Ed.). Prentice Hall. New Jersey. p. 717