Journal of

Fisheries and Aquatic Science

ISSN 1816-4927

Academic Journals Inc.

www.academicjournals.com

Journal of Fisheries and Aquatic Science 3 (3): 184-194, 2008
ISSN 1816-4927

Aspects of the Ecology and Fishes of Badagry Creek (Nigeria)

[1,2]Julius I. Agboola, [1]Martins A. Anetekhai and [3]Abiodun A.B. Denloye
[1]Graduate School of Environmental Science,
Hokkaido University, Sapporo 060 0813, Japan
[2]Department of Fisheries,
[3]Department of Zoology, Faculty of Science, Lagos State University,
P.M.B. 1087, Apapa, Lagos, Nigeria

Abstract: To ascertain the ecological state of Badagry creek, Lagos, Nigeria, some physico-chemical parameters, heavy metals concentration in water and bottom sediments were analyzed and its fish composition determined. Monthly values of temperature, pH, acidity, turbidity, salinity, TDS, COD, NH_3 and NO_3 were significantly different over a period of six months ($p<0.05$). There were no significant variations in colour, alkalinity, BOD, DO and PO_4 values with the sampling periods. However, colour, temperature, alkalinity, BOD and COD values were significantly different across the sampling stations. Higher values obtained for BOD and COD at Station D (Ajido) than other stations suggests anthropogenic organic loadings on this axis of the creek. Salinity values showed highly significant correlation with TDS, BOD and COD and equally revealed Badagry creek as an estuary. N:P ratio was not statistically significant across the stations and sampling periods. Heavy metals (Hg, Ni, Cr, Cd, Ar and Se) concentrations were Not Detected (ND) in water. With the exception of Cu, there were no significant variations in other heavy metals concentration with the sampling stations, however, within the sampling periods, only Cu and Mn showed no significant variation in concentration. Bottom sediments concentrations of heavy metals (Fe, Cu, Cr, Pb, Mn and Ni) and (Cd, Pb, Fe and Ni) were statistically significant with the sampling periods and sampling stations respectively. Mercury (Hg) was not detected. Biological survey of fish species yielded 1614 samples of the fish population comprising 28 families, 34 genera and 37 species. Percentage relative abundance of species was highest for *Chrysicthys nigrodigitatus* (15.74%), *Ethmalosa fimbriata* (15.55%) and *Tilapia zilli* (8.55%).

Key words: Physico-chemical parameters, nutrients, sediments, heavy metals, creek, Lagos, fish

INTRODUCTION

Coastal environments are strongly influenced by upstream sources of pollution and freshwater inflow and are subject to an ever-growing coastal population. Sometimes, coastlines are intersected by an intricate network of creeks and rivers. Lagos State, the commercial hub of Nigeria is justifiably taunted as one of aquatic splendor, owing to her endowment with lagoons, creeks, deltaic distributaries, floodplains and mangrove swamps of which Badagry creek is a notable one (Fig. 1). The Badagry creek runs across two national boundaries. It directly connects with Nigeria's 960 km of coastline bordering the Atlantic Ocean in the Gulf of Guinea, a maritime area of 46,500 km^2 with depth of up to 50 m and

Corresponding Author: Julius I. Agboola, Graduate School of Environmental Science, Hokkaido University, Sapporo 060 0813, Japan Tel: +81 80 6090 2801

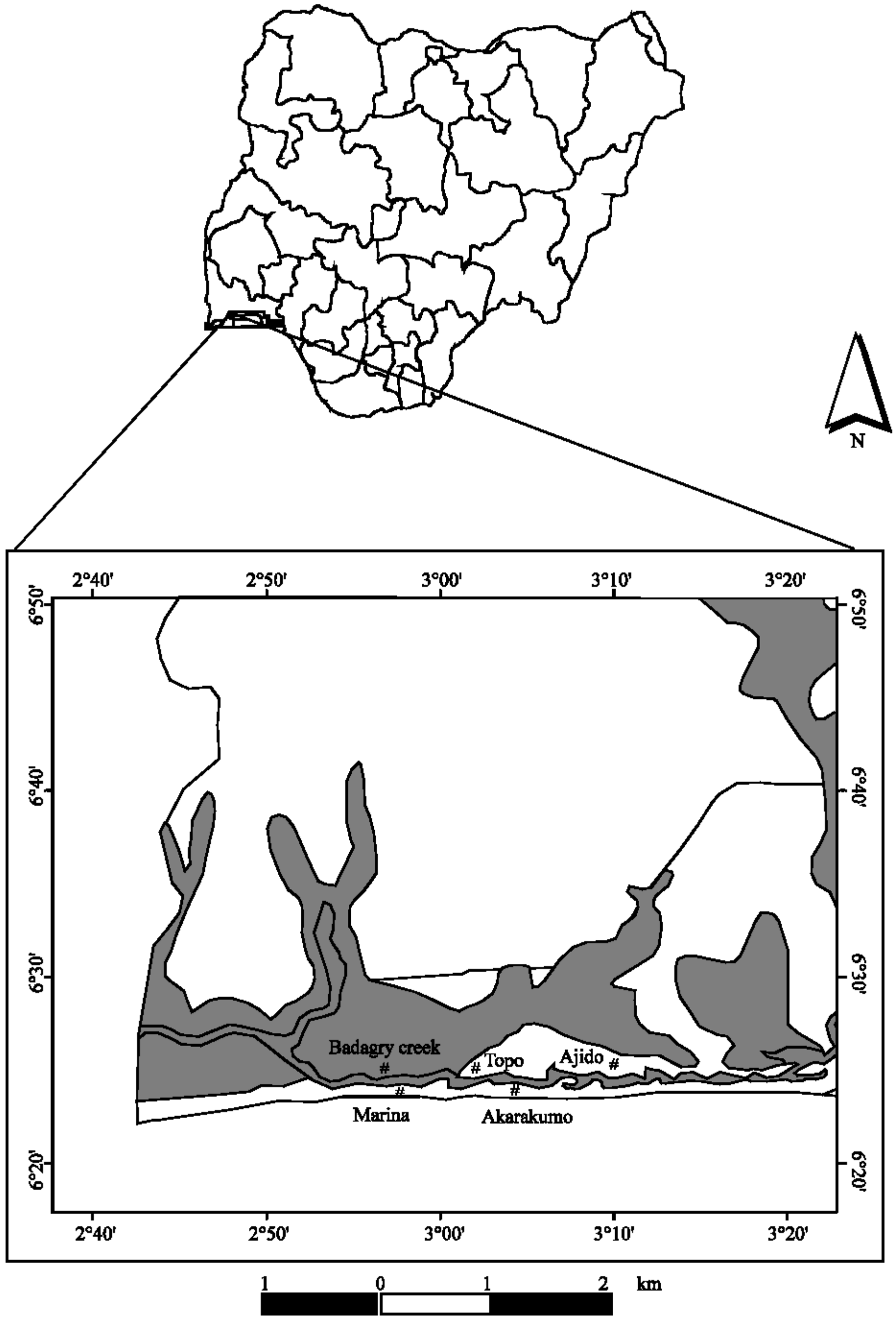

Fig. 1: Map of Nigeria showing Badagry creek and the sampling points A, B, C and D

an Exclusive Economic Zone of 210,900 km^2 (World Resources, 1990). It is important for artisanal and commercial fisheries as well as transportation, recreation and domestic purposes.

Relative to marine and inland waters, the fisheries of coastal lagoons and estuaries in developing countries like Nigeria have received little attention up to the present. Fisheries of coastal lagoons and estuaries are often based on multi-species resources, which vary widely in availability in space and time. Therefore, the need to evaluate the diverse fish species resources and monitor the water quality of coastal systems with high species diversity such as Badagry creek could enhance the conservation and management of coastal fishery resources. Moreso, as the livelihood of many villagers (fisher folks) depend on the creek, an ecological assessment as carried out in this study cannot be overemphasized.

Estuaries are formed where rivers meet the sea and are affected by variations in both terrestrial and marine conditions (Cooper, 2001). Estuaries and lagoons are interface ecosystems that couple continental and marine environments, receiving bio-geochemical active inputs from land, rivers and coastal seas (Lopes *et al*., 2005). Many toxic substances entering aquatic ecosystems accumulate in the bottom sediment, which constitutes a large reservoir of potentially bio-available contaminants (Rada *et al*., 1993).

In this context, this study provides pertinent information on the ecological state of the Badagry creek as a basis for aquatic resource management. It also serves as baseline for future studies, which may be an important platform for the management of coastal lagoon and estuarine capture fisheries in the near future.

MATERIALS AND METHODS

Study Area

This study was carried out on the Badagry creek, one of the lagoon shore locations separating the mainland sedimentary basin of South-western Nigeria from the Atlantic coastline, between June and November 2003. The creek lies within longitude 2°42'E to 3°42'E and stretches between 6°22'N to 6°42'N, sharing boundary with Republic of Benin. Based on the fishing villages along the shorelines of Badagary creek, four sampling stations: Marina (A), Topo (B), Akarakumo(C) and Ajido (D) were chosen for the study (Fig. 1).

Collection of Samples

Samples of soil sediments, water and fish species were collected from each of the sampling points and subsequently treated following the methods of Nigeria's Federal Environmental Protection Agency (FEPA, 1999) and the American Public Health Association (APHA, 1998). Ambient water temperature of the sampling stations were determined in-situ using Calibrated Mercury-in-glass thermometer, while the water transparency was determined using the Sechi disc.

Water samples were collected from the surface (0-5 m) from each sampling point once each month from June to November 2003 using acid-clean 1.5l polycarbonate bottles. From each water sample so collected, 100 mL was measured out and acidified with 0.5 mL of nitric acid to prevent microbial degradation of the metals present. Water sample was refrigerated at 4°C before laboratory analysis. Water quality parameters including dissolved oxygen, pH, salinity, temperature, turbidity, Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate (NO_3^-), Phosphate (PO_4) and Ammonia (NH_3) were determined following standard methods (APHA, 1998). Also, the concentrations of heavy metals: Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Zinc and Cobalt in each water sample were determined.

Bottom sediments, collected once a month and stored in labeled polythene bags respectively were air-dried and digested using concentrated nitric acid. The digest was placed on a hotplate for 10 min to allow the sediments to digest thoroughly and thereafter allowed to cool. This was necessary for the determination of the total concentration of the particular elements present in the sediment. The digested solution was then filtered and made up to 25 mL using distilled water and analysed for heavy metals using Atomic Absorption Spectrophotometer. Parameters of heavy metals determined in the sediment samples includes, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Zinc and Cobalt using Pyunicam SP 2900 Atomic Absorption Spectrophotometer.

Fish Sampling

Monthly arrangement for fish sample collection was made with fisher folks at the four major fish landing stations between June and November 2003. Artisanal fishermen on this creek deploy surface and bottom-set gillnets, cast-nets, ring-nets, drift-nets, beach-seines and Plank canoes for their catches. Species richness based on species diversity across the sampling periods and species types were determined with the aid of FAO species identification guide (Schneider, 1992; Leveque *et al*., 1990, 1992).

Statistical Analysis

Physico-chemical parameters were analysed using Pearson's correlation to examine intercorrelation of parameters and analysis of variance to examine differences of the water quality parameters and heavy metals concentration with respect to the sampling stations and sampling seasons. Mean separation was achieved using the Duncan multiple range post-hoc test. The relative abundance, R_i of fish species was calculated using the equation:

$$R_i = \frac{n_i}{N} \tag{1}$$

Where:

n_i = Quantity of the given fish species i

N = Total number of all fish collected

RESULTS

Water Quality Parameters in Space and Time

Variability of water quality parameters in space and time are summarized with respect to the four sampling location (Table 1), the six sampling months (Table 2) and the total samples for all stations over the sampling period (Table 3). Seven out of 14 (50%) physico-chemical parameters were not statistically different among the sampling locations. These were pH, turbidity, TDS, DO, NO_3, PO_4 and NH_3. Only 2 out of 14 (14%) variables (colour and PO_4) were not significantly different across seasons. Thus, season affected the variability of the water quality parameters more than location. The highest values of Acidity (20.1±22.6 mg L^{-1}), Alkalinity (61.9±17.5 mg L^{-1}), BOD (26.5±70 mg L^{-1}) and Salinity (1.90±2.7‰) were recorded for location D (Table 1). Ajido is characteristically different from other sampling locations in terms of its dense human settlement and intense human activities such as domestic chores, intense fishing and possible feacal discharge which could negatively impact on this location along the creek.

Water temperature is significantly different in both space and time ($p<0.05$) suggesting differences in metabolic and reproductive activities of aquatic organisms regulated by temperature. The pH are lowest in November (6.75±0.10) and highest in August (8.24±0.22).

Biological Oxygen Demand (BOD) measures the oxygen demand of biodegradable pollutants whereas the Chemical Oxygen Demand (COD) measures the oxygen demand of biogradable pollutants plus the oxygen demand of non-biodegradable oxidizable pollutants. The highest value of both parameters occurred in July (Table 2). Salinity varied from (4.01±1.95‰) in June to (0.05±0.01‰) in November.

N:P ratio was calculated as an index of limiting nutrient in water column. The values varied from 1.8 for Station B to 2.7 for Station A and were not significantly different ($p>0.05$). With respect to months, N:P ratio varies from 1.2 in July to 3.5 in August. The differences are also not significant ($p>0.05$). The grand mean and standard deviation of physico-chemical parameters are presented in Table 3. Seven out of 14 variables (50%) exhibit low variability (CV<15%), 4 variables (29%) exhibit medium variability (15% <CV<30%), whereas 3 out of 14 variables (21%) exhibit high variability S(CV>30%).

Table 1: Mean±standard deviation of water quality parameters for the sampling stations over six sampling period from June to November

	Sampling stations			
Parameters	A	B	C	D
Colour (true colour units)	20.500±3.04^{a}	22.00±2.76^{a,b}	27.50±4.76^{c}	26.10±3.76^{b,c}
Temperature (°C)	28.000±0.63^{b}	27.40±0.49^{a,b}	27.40±1.02^{a,b}	27.10±0.93^{a}
pH	7.660±0.44^{a}	7.75±0.57^{a}	7.78±0.53^{a}	7.71±0.55^{a}
Turbidity (NTU)	14.000±2.68^{a}	13.50±7.17^{a}	15.50±4.6^{a}	13.50±4.0^{a}
Acidity (mg L^{-1})	14.580±20.3^{a}	17.80±23.2^{a,b}	17.40±17.6^{a,b}	20.10±22.6^{b}
Alkalinity (mg L^{-1})	37.730±19.99^{a}	43.60±17.0^{a,b}	54.10±13.7^{a,b}	61.90±17.5^{b}
Total dissolved solids (mg L^{-1})	782.500±1108^{a}	833.60±1184.6^{a}	730.30±1013^{a}	743.50±1058^{a}
BOD (mg L^{-1})	163.000±53.37^{a}	153.30±32.8^{a}	183.60±42.3^{a}	265.80±70.0^{b}
COD (mg L^{-1})	542.500±154.8^{a}	506.10±139.2^{a}	513.50±120.9^{a}	969.70±644.2^{b}
Dissolved oxygen (mg L^{-1})	4.830±0.08^{a}	4.88±0.60^{a}	4.81±0.45^{a}	4.70±0.3^{a}
Salinity (‰)	1.312±1.89^{a}	0.52±0.64^{a,b}	1.84±2.59^{b}	1.90±2.7^{b}
Nitrate (mg L^{-1})	4.860±2.85^{a}	4.18±2.18^{a}	3.21±2.24^{a}	4.30±2.3^{a}
Phosphate (mg L^{-1})	5.080±6.01^{a}	2.82±1.45^{a}	2.15±1.95^{a}	2.70±2.3^{a}
Ammonia (mg L^{-1})	0.300±0.14^{a}	0.33±0.17^{a}	0.33±0.25^{a}	0.50±0.3^{a}

Values along the same row bearing the same superscripts are not statistically different at 5% probability level using the Duncan Multiple Range Test

Table 2: Monthly variation in water quality parameters for the four sampling stations*

Parameters	June	July	Aug.	Sept.	Oct.	Nov.
Colour (true colour units)	26.25±7.50^{a}	25.00±6.48^{a}	23.00±4.40^{a}	23.75±3.30^{a}	21.75±2.06^{a}	24.50±3.51^{a}
Temperature (°C)	27.00±0.00^{a,b}	27.63±0.25^{b,c}	27.25±0.50^{a,b}	26.63±1.11^{a}	28.00±0.00^{c,d}	28.50±0.58^{d}
pH	7.76±0.06^{b}	7.71±0.09^{b}	8.24±0.22^{d}	7.91±0.08^{b,c}	8.02±0.14^{c}	6.75±0.10^{a}
Turbidity (NTU)	12.50±2.08^{a}	14.50±2.65^{a}	10.50±0.58^{a}	12.50±3.51^{a}	12.25±1.50^{a}	22.50±4.20^{b}
Acidity (mg L^{-1})	7.53±4.51^{a}	8.35±4.90^{a}	9.73±0.92^{a}	11.55±1.83^{a}	7.85±1.93^{a}	59.93±6.65^{b}
Alkalinity (mg L^{-1})	52.83±22.25^{b}	53.60±19.05^{b}	45.43±18.3^{a,b}	54.93±19.71^{b}	62.03±11.82^{b}	27.50±2.52^{a}
Total dissolved solids (mg L^{-1})	2025.00±221.7^{b}	2323.50±78.2^{c}	52.50±26.30^{a}	79.25±16.60^{a}	77.25±9.22^{a}	77.50±5.00^{a}
BOD (mg L^{-1})	205.00±119.30^{a,b}	243.50±63.8^{b}	197.75±48.2^{a,b}	173.75±54.8^{a,b}	159.00±42.84^{a}	169.75±39.8^{a,b}
COD (mg L^{-1})	865.00±490.82^{b,c}	1032.00±600.5^{c}	523.00±198.8^{a,b}	522.75±91.99^{a,b}	368.80±36.3^{a,b}	486.50±63.48^{a,b}
Dissolved oxygen (mg L^{-1})	4.50±0.36^{a,b}	4.40±0.28^{a}	5.08±0.36^{c}	4.90±0.43^{a,b,c}	4.98±0.43^{b,c}	5.00±0.18^{b,c}
Salinity (‰)	4.01±1.95^{b}	3.86±1.81^{b}	0.23±0.10^{a}	0.25±0.11^{a}	0.04±0.01^{a}	0.05±0.01^{a}
Nitrate (mg L^{-1})	6.25±2.89^{c}	3.18±1.41^{b}	6.23±0.56^{c}	4.95±0.19^{b}	3.80±0.28^{b}	0.55±0.25^{a}
Phosphate (mg L^{-1})	4.15±2.31^{a}	3.08±1.13^{a}	5.45±6.85^{a}	4.15±3.57^{a}	2.05±0.95^{a}	0.30±0.16^{a}
Ammonia (mg L^{-1})	0.68±0.30^{c}	0.53±0.19^{b,c}	0.28±0.22^{a,b}	0.35±0.06^{a,b}	0.15±0.06^{a}	0.25±0.13^{a}

Values along the same row bearing the same superscripts are not statistically different at 5% probability level using the Duncan Multiple Range Test. *: TSS was not measured for 2 stations, therefore values were not included

Table 3: Grand mean±standard deviation of physico-chemical properties within the study period (n = 24)

Physico-chemical parameters	Values	CV (%)
Colour	24.03±3.31	14.0
Temperature (°C)	27.48±0.38	1.0
pH	7.73±0.05	0.1
Turbidity	14.13±0.95	7.0
Acidity (mg L^{-1})	17.47±2.26	13.0
Alkalinity (mg L^{-1})	49.33±10.77	22.0
TSS (mg L^{-1})	107.83±172.82	6.0
BOD (mg L^{-1})	191.43±51.17	27.0
COD (mg L^{-1})	632.95±225.05	36.0
DO (mg L^{-1})	4.81±0.08	2.0
Salinity (‰)	1.39±0.64	46.0
Nitrate (mg L^{-1})	4.14±0.69	17.0
Phosphate (mg L^{-1})	3.19±1.29	40.0
Ammonia (mg L^{-1})	0.37±0.09	24.0

Intercorrelation of Parameters

Table 4 shows that twenty-seven out of 78 correlation coefficients (35%) are significant ($p<0.05$). With the exception of PO_4, all variables here exhibited significant correlations with at least one other

Table 4: Pearson's correlation matrix of physico-chemical parameters

Parameters	pH	Temp.	Acidity	Alkalinity	Turbidity	TDS	BOD	COD	DO	Salinity	NO_3	PO_4	NH_3
pH	1.00												
Temp.	-0.517**	1.00											
Acidity	-0.898**	0.480*	1.00										
Alkalinity	0.496*	-0.466*	-0.471	1.00									
Turbidity	-0.848**	0.473*	0.825**	-0.436*	1.00								
TDS	0.006	-0.145	-0.349	0.117	-0.093	1.00							
BOD	0.050	-0.241	-0.100	0.302	0.104	0.347	1.00						
COD	0.008	-0.162	-0.152	0.409*	-0.032	0.592**	0.770**	1.00					
DO	-0.008	0.166	0.245	-0.130	0.054	-0.678**	-0.382	-0.508*	1.00				
Salinity	0.006	-0.192	-0.291	0.343	-0.032	0.841**	0.528**	0.722**	-0.510*	1.00			
NO_3	0.716**	-0.573**	-0.725**	0.169	-0.667**	0.154	0.192	0.126	-0.007	0.121	1.00		
PO_4	0.261	-0.015	-0.339	-0.040	-0.336	0.057	0.051	0.140	-0.121	0.168	0.268	1.00	
NH_3	0.037	-0.322	-0.196	0.386	-0.054	0.640**	0.549**	0.793**	-0.517**	0.759**	0.163	0.124	1.00

**: Correlation is significant at the 0.01 level (2-tailed). *: Correlation is significant at the 0.05 level (2-tailed)

Table 5: Summary of heavy metal concentration in water from the sampling stations*

	Concentration (mg L^{-1})			
	Sampling stations			
Elements	A	B	C	D
Cadmium	ND	ND	ND	ND
Chromium	ND	ND	ND	ND
Copper	0.22 ± 0.12^a	0.21 ± 0.08^a	0.40 ± 0.12^b	0.400 ± 0.04^b
Iron	0.22 ± 4.86^a	0.37 ± 0.51^a	1.01 ± 0.79^a	1.310 ± 1.96^a
Mercury	ND	ND	ND	ND
Nickel	ND	ND	ND	ND
Zinc	0.47 ± 0.15^a	0.48 ± 0.22^a	0.50 ± 0.17^a	0.417 ± 0.1941^a
Cobalt	0.03 ± 0.01^a	0.04 ± 0.02^a	0.02 ± 0.01^a	0.040 ± 0.02^a
Arsenic	ND	ND	ND	ND
Lead	ND	ND	ND	ND
Manganese	0.17 ± 0.07^a	0.23 ± 0.09^a	0.18 ± 0.06^a	0.160 ± 0.1^a

*: Not Detected. All values are Mean±SD of mean of 6 observations (n = 6)-June to November. Values with the same letter(s) are not significantly different at $p<0.05$

variable. Water temperature positively correlate with turbidity ($r = 0.47$, $p<0.05$) and acidity ($r = 0.48$, $p<0.05$) and turbidity also exhibited positive correlation with acidity ($r = 0.83$, $p<0.01$). pH however, revealed negative correlation with temperature ($r = -0.52$, $p<0.01$), acidity ($r = -0.90$, $p<0.01$) and turbidity ($r = -0.85$, $p<0.01$). Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) values showed highly significant correlation ($r = 0.770$, $p<0.01$) and both respectively exhibited strong significant correlation with salinity and NH_3 ($p<0.01$). DO showed a negative correlation with TDS ($r = -0.68$, $p<0.01$) and COD ($r = -0.51$, $p<0.05$). This corresponding inverse relationship may suggest the utilisation of DO for biological and chemical decomposition.

Heavy Metals in Water

Only Copper (Cu) content is significantly different among the sampling location ($p<0.05$). Chromium, Cadmium, Nickel, Lead, Mercury and Arsenic were not detected in water samples. While Iron (Fe) and Zinc (Zn) were significant at $p<0.05$, Copper (Cu) and Manganese (Mn) showed no significance among sampling months (Table 5).

Heavy Metals in Bottom Sediments

No significant differences were observed among locations and months for all heavy metals concentration in the bottom sediments. Sediment concentrations of Cu, Fe, Cr, Pb, Mn and Ni were significant among the sampling months, but only Pb, Fe, Zn, Cd and Ni were significantly different across the sampling stations (Fig. 2). Arsenic was not significant across the sampling stations and sampling periods. All these values are however within national and global permissible limits. Mercury (Hg) was also not detected in the bottom sediment.

Fish Species

Biological survey of Badagry creek for fish species yielded 1614 samples of the fish population comprised of 28 families, 34 genera and 37 species (Table 6). Fish species with the highest relative abundance were *Chrysichthys nigrodigitatus* (Lacepède, 1803), 15.7%; *Ethmalosa fimbriata* (Bowdich 1825), 15.5% and *Tilapia zillii* (Gervais 1848), 8.5%. The least relative specie abundance were *Hepsetus odoe* (Bloch 1794), 1.1%; *Hyperopisus bebe* (Lacepède, 1803), 1.1%; *Hemichromis fasciatus* (Peters 1857), 1.05%; *Drepane africana* (Osorio 1892), 1.05%; *Boops boops* (Linnaeus 1758), 1.0%; *Ilisha africana* (Bloch 1795), 1.0% and *Caranx hippos* (Linnaeus 1766), 0.9%.

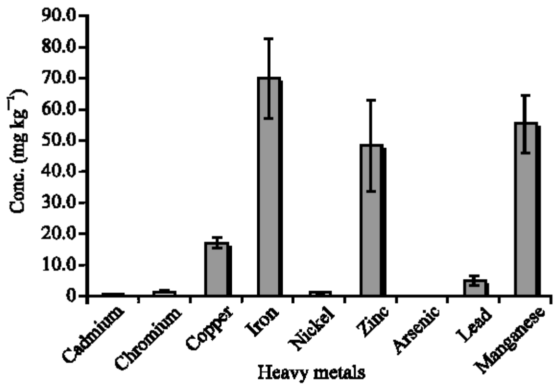

Fig. 2: Mean distribution of heavy metals concentration in bottom sediments of Badagry creek (n = 24). Error bars represent±SD and are not visible when smaller than the symbol

Table 6: Relative abundance of fish species from Badagry creek (Nigeria)

Species	n	Relative abundance (R) (%)	Rank
Polypteridae			
Polypterus senegalus	20	1.24	23
Clupeidae			
Sardinella maderensis	26	1.61	12
Pellonula leonensis	22	1.36	18
Ethmalosa fimbriata	251	15.55	2
Arapaimidae			
Heterotis niloticus	22	1.36	18
Momyridae			
Hyperopisus bebe	18	1.12	31
Hepsetidae			
Hepsetus odoe	18	1.12	31
Mugilidae			
Mugil cephalus	81	5.02	6
Citharinidae			
Distichodus engycephalus	21	1.30	21
Monodactylidae			
Monodactylus sebae	20	1.24	23
Elopidae			
Elops lacerta	20	1.24	23
Elops senegalensis	28	1.73	11
Uranoscopidae			
Uranoscopus polli	108	6.69	4
Gobiidae			
Gobioides sagitta	24	1.49	15
Bothidae			
Monolene microstoma	37	2.29	7
Sparidae			
Boops boops	16	0.99	35

Table 6: Continued

Species	n	Relative abundance (R) (%)	Rank
Belonidae			
Tylosurus crocodilus	20	1.24	23
Sphyraenidae			
Sphyraena afra	24	1.49	15
Lutjanidae			
Lutjanus agennes	30	1.86	10
Apsilus fuscus	21	1.30	21
Drepaneidae			
Drepane africana	17	1.05	33
Pristigasteridae			
Ilisha africana	16	0.99	35
Carangidae			
Caranx carangus	20	1.24	23
Caranx hippos	14	0.87	37
Cynoglossidae			
Cynoglosus senegalensis	85	5.27	5
Sciaenidae			
Pseudotolithus elongatus	36	2.23	8
Polynemidae			
Polydactylus quadrifilis	24	1.49	15
Pentanemus quinquarius	20	1.24	23
Haemulidae			
Pomadasys jubelini	26	1.61	12
Pomadasys incisus	22	1.36	18
Claroteidae			
Chrysichthys nigrodigitatus	254	15.74	1
Schilbeidae			
Schilbe intermedius	32	1.98	9
Clariidae			
Clarias gariepinus	20	1.24	23
Mochokidae			
Mochokus niloticus	20	1.24	23
Cichlidae			
Tilapia zillii	138	8.55	3
Hemichromis fasciatus	17	1.05	33
Sarotherodon melanotheron	26	1.61	12

DISCUSSION

The present study documents result of physico-chemical and fish fauna survey of Badagry creek between June and November 2003. Seasonal and locational variations in the mean values of physico-chemical parameters and heavy metal concentration were observed. Such variations in water chemistry lead to variations in the types of aquatic organisms which inhabit various waters (FAO, 1985). Metabolic rate and the reproductive activities of aquatic life are controlled by water temperature. As metabolic activity increases with an increase in temperature, fish's demand for oxygen increases. Grand mean temperature (27.5°C) recorded in this study falls within the range (20-30°C) suggested by Boyd and Lichtkoppler (1985), Erondu (1991) and the Nigeria's Federal Environmental Protection Agency (FEPA, 1999) for adequate support and propagation of tropical fishes. This indicates favourable condition for occurrence, growth and multiplication of overall aquatic resource biodiversity of Badagry creek. The mean dissolved oxygen (4.81 mg L^{-1}) recorded for the sampling stations buttressed the recommendation of Boyd and Lichtkoppler (1985) that DO level of at least 3-4 mg L^{-1} is required for fish growth. This value is however below the minimum 5.0 mg L^{-1} suggested by Erondu (1991) and the 6.8 mg L^{-1} standard suggested by FEPA for the survival of fish and other aquatic organisms. Lower oxygen dissolved in water could drastically adversely affect aquatic organisms e.g., fish kill as well as their eggs and larvae. The slight drop in DO recorded in this study may be attributed to sampling during early hours of the day. Since photosynthesis does not occur at night, available DO in water column would have been utilized for respiration at night, leaving a depleted DO in the early hours of the day.

According to Barnes *et al*. (1998), turbidity values of 10 NTU or less represent very clear waters; 50 NTU is cloudy and 100-500 or greater is very cloudy to muddy. Some fish species may become stressed at prolonged exposures of 25 NTU or greater. However, turbidity grand mean (14.13 NTU) of Badagry creek revealed variation with sampling stations and sampling periods, suggesting a not cloudy and a not very clear water body. Reduced light penetration into water column as a result of turbidity affects the aquatic environment and plant life generally, with consequent secondary effects on food chains (Hawkes, 1963). It also impairs predator-prey interaction by reducing the activity of predators.

Organisms are affected by the pH of their habitat as it regulates respiration and enzymatic activities within their body. However there is widespread disagreement between researchers on the pH to recommend for tropical aquatic ecosystems. For instance Dick (1984) and Elizabeth (1990) suggested 6.5-7.5, whereas other workers such as Huet (1972) stipulated 7.0-8.0. These ranges however agree that aquatic organisms tend to thrive well in slightly alkaline media. The mean pH of 7.7 for the sampling stations indicating slight alkalinity agrees with this assertion for aquatic life.

On the basis of salinity, aquatic ecosystem could be termed fresh water (salinity less or equal to 0.5‰), brackish (salinity range of 0.5-3.5‰) and marine (salinity range greater or equal to 35‰).

The grand mean salinity value for the sampling stations was 1.14‰, indicating that the Badagry creek is a brackish water system. However, there is marked seasonal variability (Table 2). This suggests that the creek experiences low tide (sea influx), during the months of June and July raising its salinity above the freshwater maximum of 0.5‰. The months of August to November are typified by high tide due to influx from fresh water, possibly from Lake Nokoue in Benin Republic and other adjoining fresh water bodies. Also, lower salinity recorded in stations A (1.31‰±1.89) and B (0.53‰±0.64) closest to Benin Republic further buttresses this assertion.

Nutrients such as phosphorous and nitrogen are essential for the growth of algae and other plants. Aquatic life is dependent upon these photosynthesizers, which usually occur in low levels in surface water. The N:P ratio was generally less than four (<4) and had its lowest value of 1.2 in the month of July, suggesting a near balance in the distribution of nitrate and phosphate nutrient on this creek (Fig. 3). With the mean level of ammonia concentration (0.37 mg L^{-1}), falling within the FEPA

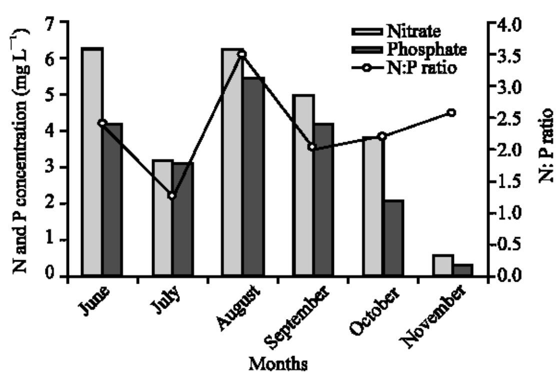

Fig. 3: Mean nutrient concentration and N:P ratio for the Badagry creek during the period June-November 2003. Nutrient concentration and N:P ratio are mean values (n = 4)

recommended standard of 2.2-1.37 mg L^{-1}, fishes within the Badagry creek may be safe from ammonia poisoning. The recommended level of alkalinity by most authors for most fish species ranged from 20-300 mg L^{-1}. The observed level of alkalinity falls within this range, suggesting that the parameter is not likely to have adverse effect on the survival of fish species of Badagry creek.

Metals can accumulate in aquatic environments and cause toxic effects on aquatic life and increase health risks of drinking water. Some of the metals of concern for human and aquatic health are cadmium, lead, copper, mercury, selenium and chromium. Cadmium is widely used in industry and is often found in solution in industrial waste discharges. Cadmium replaces zinc in the body and long-term consumption of cadmium may lead to bodily disorders. Cadmium is toxic to both humans and fish and seems to be a cumulative toxicant. Small salmon fry have been killed from concentrations of 0.03 mg L^{-1}. This study reveals that aquatic life (fishes) of the Badagry creek are quite safe from heavy metals accumulation as chromium, cadmium, nickel, lead, mercury and arsenic were not detected in water samples. The mean value of heavy metals (Cu, Fe, Mn and Zn) recorded for the sampling stations are: Cu = 0.31 mg L^{-1}; Fe = 0.73 mg L^{-1}; Mn = 0.19 mg L^{-1} and Zn = 0.54 mg L^{-1}. All these values fall within the permissible standard limits of FEPA (1999).

While Badagry creek may, as at the time of this study be devoid of heavy metals pollution, activities that could result in such discharges and resources depletion should be guided against on this creek. To achieve this, there is need to sensitize the village locals around the creek of the inherent danger of discharge of feacal and other obnoxious materials into the water body due to its fishery resource potentials.

Badagry creek exhibits relatively high species richness, which might possibly be due to succession of species temporarily using the environment for feeding, spawning and shelter. The fish population from the creek exhibits relatively high diversity, species richness and a high biological productivity than many other comparable water bodies in West Africa. Thus, the potential of Badagry creek for great fishery resources (especially for *Chrysichthys nigrodigitatus*, *Ethmalosa fimbriata* and *Tilapia zilli*) cannot be over emphasized and the need for future aquaculture on this water body may not be out of place. Success in achieving this however requires setting and enforcing Environmental standards so that these present resources are sustainably exploited without jeopardizing its future potential for socio-economic growth of the locals.

CONCLUSION

This study on the Badagry creek has revealed some seasonal variations in water quality parameters across the sampling stations that reflect a stable ecological system that could support the well-being of aquatic organisms (especially fish). However, station D (Ajido) of this study with the highest BOD value suggests organic anthropogenic loadings, which requires further studies. Heavy metals concentration in water and sediments were either not detected or below the permissible level of Nigeria's Environmental Agency (FEPA). High biological diversity of fish species on this creek shows the need for good management and conservation practices especially with locals of the Badagry creek.

ACKNOWLEDGMENTS

We appreciate the assistance of fisher folks along the Badagry creek especially the Akarakumo Village Head and Mr. Ajepe of the Fish Taxonomy Unit, Department of Fisheries, Lagos State University, Lagos, Nigeria.

REFERENCES

APHA, 1998. American Public Health Association; American Water Works Association and Water Pollution Control Federation. Standard Methods for the Examination of Water and Waste Water. 20th Edn. APHA. USA., pp: 1220.

Barnes, K.H., J.L. Meyer and B.J. Freeman, 1998. Sedimentation and Georgia's Fishes: An analysis of existing information and future research. 1997 Georgia Water Resources Conference, March 20-22, 1997, The University of Georgia, Athens Georgia.

Boyd, C.E. and F. Lichtkoppler, 1985. Water quality management in pond fish culture. International Centre for Aquaculture, Agriculture Experimental Station, Auburn University of Alabama, USA. Research Development Serial No. 22, pp: 39.

Cooper, J.A.G., 2001. Geomorphology of tide-dominated and river-dominated, barred microtidal estuaries: A contrast. J. Coastal Res. Special Issue, 34: 428-436.

Dick, M., 1984. A Fish Keeper's Guide To Community Fishes. Salamander Books Ltd., London, England.

Elizabeth, R., 1990. The Basic Book of Fish Keeping. Ballantine Books, New York, USA., pp: 91.

Erondu, E.S., 1991. Pond Management. In: Proceedings of the Fish Seed Propagation Course Conducted by ARAC, Ayinla, O.A. (Ed.). AIUU-Port Harcourt of the NIOMR, Port-Harcourt, River, Nigeria, pp: 44-49.

FAO, 1985. River fisheries. Technical Paper. No. 262. FAO, Rome, Italy, pp: 330.

FEPA, 1999. National guidelines and standard for water quality in Nigeria. FEPA, Lagos, Nigeria, pp: 114.

Hawkes, H.A., 1963. River Pollution Causes and Effects, Hawkes, H.A. (Ed.). Buttermonths Publication, London, England, pp: 31-33.

Huet, M., 1972. Textbook of Fish Culture. Fishing News Books Ltd., Farnham, Surrey, United Kingdom, pp: 436.

Leveque, C., D. Paugy and G.G. Teugels, 1990, 1992. Faune des poissons d'eaux douces et saumatres de l'Afrique de l'Ouest. O.R.S.T.O.M., Paris, pp: 910.

Lopes, J.F., J.M. Dias, A.C. Cardoso and C.I.V. Silva, 2005. The water quality of the Ria de Aveiro lagoon, Portugal: From the observations to the implementation of a numerical model. Mar. Environ. Res., 60 (5): 594-628.

Rada, R.G., J.G. Wiener and D.E. Powell, 1993. Whole-lake burdens and spatial distribution of mercury in surfacial sediments in wisconsin seepage lakes. Can. J. Fish. Aquat. Sci., 50: 865-873.

Schneider, W., 1992. FAO species identification sheets for fishery purposes. Field guide to the commercial marine resources of the Gulf of Guinea. FAO, Rome, pp: 268.

World Resources, 1990. A Report by the World Resources Institute in Collaboration with UNEP and UNDP. Oxford University Press, New York, USA., pp: 383.