Hydrochemistry and plankton dynamics of Kuramo lagoon

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Abstract

The hydrochemistry and plankton dynamics of the Kuramo lagoon was investigated between November, 2000 and August, 2001. Whereas the lagoon remained low brackish (S‰ < 4.39‰) and alkaline (pH > 7.8) all through the sampling period, the dissolved oxygen (DO) and biochemical oxygen demand (BOD_5) values (< 3.50 mg/L; > 21 mg/L) indicated stress. Although nutrient levels at the lagoon were high (NO_3-N > 1.58 mg/L; PO_4-P < 0.35 mg/L; SO_4^{2-} > 449.9 mg/L), heavy metal values were low (Fe < 1.91 mg/L, Cu < 0.32 mg/L, Pb Trace). The occurrence of *Nitzschia palea*, *Cyclotella meneghiniana*, *Gomphonema parvulum*, *Pinnularia pyrum*, *P. gibba* (diatoms), *Euglena viridis*, *Lepocinclis texta* (euglenoids), *Microcystis aeruginosa*, *M. flos-aquae* (cyanobacteria), *Brachionus angularis*, *B. calicyflous*, *B. urceolaris* (rotifers) in high numbers may highlight pollution stress in the lagoon. The proliferation of the cyanophyta and other plankton species encountered were controlled by the nutrient level. The physico-chemical characteristics, Margalef, Shannon and Wiener and *Equitability indices* indicated pollutions stress and dominance by a few species. [Life Science Journal. 2008; 5(3): 83 – 88] (ISSN: 1097 – 8135).

Keywords: closed lagoon; eutrophic; hydroclimate; plankton dynamics; tropical

1 Introduction

Habitat modification arising from need for land is one of the major ecological problems in the Nigerian coastal environment. There are 3 main types of modifications practiced. These include sand mining resulting in changes in tidal dynamics and increase in turbidity and lowering of photosynthetic depth (Nwankwo and Akinsoji, 1992; Nwankwo, 1998a), loss of suitable substrate for benthic fauna and therefore a decline in biodiversity (Oyenekan 1988; Ajao and Fagade, 1990; Brown and Oyenekan, 1998). The second type of modification involves land reclaimation through land filling leading to the cutting off of ecosystems and the creation of nutrient traps (Nwankwo, 1996a) as well as the transformation of ecosystems from lotic to lenthic environments and vice versa. The third type of modification is through pollution such as the introduction of inert solids that eventually cover original substrate, changing them for opportunistic species only (Nwankwo, 1998), introduction of volumes of biodegradable wastes and creation of organically polluted zones.

The Kuramo water has been described in literature before the sand filling of the Kuramo creek that connected it to the Five Cowrie creek (Hill and Webb, 1958; Sandison and Hill, 1966; Olaniyan, 1969; Yoloye, 1976; 1977). For instance, these authors described the Kuramo creek, as a narrow and tortuous channel which ran through mangroves and via which tidal waters entered the Kuramo water. According to them, other sources of saline water included overflow from the sea when rough weather occurred during high tide and through seepage from beach sand. Consequently, various salinity ranges were reported for Kuramo water before the transformation into a lagoon. Whereas Hill and Webb reported a salinity range of between 15‰ and 24‰, Sandison and Hill reported a range of between 7‰ and 24‰. Other reported salinity ranges included 13‰ – 25‰ (Olaniyan, 1968) and ≥ 14‰ (Yoloye, 1969).

At present, Kuramo water is the only closed lagoon along the Nigerian coast, hence the need for protection. Unfortunately, this sensitive environment serves as a sink for surrounding facilities and gradually is being transformed from a physically controlled to a biologically con-

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trolled environment. This investigation was designed to provide information on the plankton diversity of Kuramo water and to relate their population dynamics to environmental factors.

2 Materials and Methods

2.1 Description of study site

The coastal water of south-western Nigeria lies within the rainforest belt that experiences a bimodal rainfall pattern that is concentrated into one season (May – October) and a dry season that spans between November and April. The tidal regime is semi-diurnal with tidal heights that decrease inland. The Kuramo water (3º 25' 520" – 3º 26' 950" N, 6º 25' 635" – 6º 25' 940" E) was transformed into a low brackish closed lagoon after the modification of the Kuramo creek that connected it to Five Cowrie creek. The disconnection eliminated tidal influence and changed Kuramo water from a lotic to lentic environment.

2.2 Collection of samples

Biological and water samples were collected monthly for 10 months (November, 2000 to August, 2001) to cover six months of dry season and four months of wet season. All samples were collected between 10:00 and 12:00 from four stations created within the lagoon. Water samples for physico-chemical analysis were collected 0.50 m below the water surface in four litre plastic containers, properly labelled and stored in ice chests in the field. In the laboratory, the water samples were transferred into refrigerator (t = 4 ºC) and analysed within 24 h of collection. Water samples for biochemical oxygen demand (BOD_5) were collected in 200 ml light and dark bottles.

Plankton samples were collected using a 55 μm mesh size standard plankton net tied unto a motorized boat and towed horizontally at low speed (< 4 knots) for 10 min. The concentrated samples were stored in 200 ml well labelled containers with screw caps and preserved in 4% unbuffered formalin.

2.3 Physical and chemical parameters

The surface water temperature was measured with an ordinary mercury thermometer to the nearest ºC and transparency estimated with a 20 cm diameter white and black paused Secchi disc. Total suspended solids (TSS) were determined by evaporating 100 ml aliquot of the sample while total dissolved solids (TDS) were determined by evaporating 100 ml of the filtrate in preweighed evaporating dish at 100 ºC. Conductivity of the surface water was measured with a conductivity meter (model H18733) and salinity determined with a refractometer (model S100). Dissolved oxygen (DO) was measured with a Griffin oxygen meter (model 40) and the five-day BOD_5 determined according to the method described in A.P.H.A (1985). The pH was determined using a Griffin digital pH meter (model 80). Sulphate values were measured using the gravimetric method while nitrate-nitrogen and phosphate-phosphorus were determined by the phenol-disulphuric acid and molybdenum blue methods respectively. The concentration of copper, iron and lead were determined using an atomic absorption spectrophotometer (A.A.S Unicam 99 model).

2.4 Biological parameters

Plankton analysis was done using the microtransect drop count method described by Lackey (1938). For each aliquot sample, five drops were thoroughly investigated under an M II Wild binocular microscope with a calibrated eye piece. For each drop, at least five transects were investigated and the organisms identified recorded as number per ml. Three indices were used to obtain the estimate of species diversity. The species richness was estimated according to Margalef (1951), $d = (S - 1)/\ln N$. The Shannon and Wiener's (1949) diversity index ($H = -\sum P_i \ln P_i \approx -(1/\ln 2)\sum N_i/N \ln N_i/N$) and Pielon's (1966) evenness index ($J = E = H/H_{max} = H/\ln S = H \ln 2/\ln S$) were calculated.

3 Results

Data on the hydrochemistry at the Kuramo water are shown in Table 1, while the phytoplankton and zooplankton checklists and the results of their community structure are presented in Tables 2 – 5. Transparency was low (≤ 52 cm) all through the sampling period. The lowest transparency values (≤ 31 cm) were recorded in April and May. Surface water temperatures were relatively stable with a range of between 27 ºC and 30 ºC. Whereas the surface water salinity at Kuramo lagoon was of low brackish type (< 4.39‰), the pH was alkaline (> 7.8‰) and the conductivity very low ($< 5.82 \times 10^{-3}$ μS/cm). The DO values were low during the wet and dry months (≥ 3.60 mg/L) while the BOD_5 values were high all through the sampling period (≤ 22 mg/L).

TSS values were relatively higher in the dry months (> 246 mg/L) than wet months (< 251 mg/L). On the other hand, TSS values were higher (> 3110 mg/L) in the wet months than dry months. Nitrate-nitrogen values were higher in the dry months (> 1.68 mg/L). There was a de-

Table 1. The physico-chemical characteristics of surface water at Kuramo water during the period of November, 2000 – August, 2001

Parameters	Months									
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Transparency (cm)	36	57	25.9	4.4	6.2	2.4	5.1	6.8	7.0	6.2
Surface water temperature (ºC)	29.5	27.1	27.7	29.0	4.4	28.1	27.0	28.0	28.0	27.5
TSS (mg/L)	25.6	4.88	3.82	2.84	4.12	2.56	2.21	2.50	2.51	2.011
TDS (mg/L)	1444	2518	2256	2776	243.8	3210	2660	3110	3100	4100
Surface water salinity (‰)	1.96	4.39	3.51	3.52	4.22	3.69	3.36	3.02	3.00	3.59
Surface water pH	8.6	8.5	7.8	8.4	8.7	8.4	8.2	7.8	7.8	7.8
Surface water conductivity (S/cm) ($\times 10^{-3}$)	2.90	5.04	4.51	5.56	4.88	5.42	5.82	5.82	5.81	5.59
Surface water DO (mg/L)	3.80	3.60	3.30	3.50	3.30	3.80	3.43	3.45	3.40	3.58
BO_5 (mg/L)	25	32	37	25	27	26	21	26	24	42
Nitrate-nitrogen (mg/L)	2.62	2.52	2.12	2.10	1.72	1.68	1.62	1.60	1.58	1.68
Phosphate-phosphorus (mg/L)	0.32	0.35	0.28	0.30	0.26	0.20	0.21	0.19	0.16	0.19
Sulphate (mg/L)	646.04	555.86	549.72	593.30	543.0	449.9	451.2	461.0	462.2	463.0
Rainfall (mm)	-	-	46.7	14.1	74.7	216.5	105.2	250.7	200.2	170.5
Iron (mg/L)	1.61	1.60	1.63	1.58	1.40	1.70	1.60	1.96	1.91	1.89
Copper (mg/L)	6.02	0.024	0.032	0.025	0.018	0.022	0.026	0.024	0.020	0.022
Lead (mg/L)	-	-	-	-	ND	ND	ND	ND	ND	ND

ND: Not detected

cline in NO_3-N values from 2.62 mg/L in January to 1.68 mg/L in August. There was no significant difference ($P > 0.05$) in values of PO_4-P during the dry and wet seasons while sulphate values decreased from dry to wet months. Whereas iron values were high (1.40 mg/L – 1.96 mg/L) all through the sampling period, copper and lead values were low.

Fifty eight phytoplankton taxa and 14 zooplankton taxa were recorded in the lagoon. Among the phytoplankton, 26 taxa were diatoms (7-centric; 19-pennate), 19 belonged to the green algae (Chlorococcales-6, Volvocales-1, Zygnematales-4, Ulotricales-1, Euglenales-7) and the blue-green algae made up 13 taxa (Chrococcales-4, hormogonales-9). Among the zooplankton, the rotifers made up 9 taxa, Arthropoda-2, Nematode-1 and juvenile stages (2 forms). The more dominant phytoplankton taxa included *Cyclotella meneghiniana*, *Nitzschia palea*, *Gomphonema parvulum*, *Pinnularia pyrum*, *P. gibba* (diatoms), *Chlorococcum humicolum*, *Scenedesmus obliquus*, *S. quadricauda*, *Coelastrum microsporum* (green algae), *Euglena viridis*, *E. oxyuris* (euglenoid), *Microcystis aeruginosa*, *M. flos-aquae*, *M. wesenbergii* (blue-green algae). The dominant zooplankton forms included rotifers – *Branchionus callicyflorus*, *B. urceolaris* and *Monostyla bulla-styrax*, and *juvenile*

Table 2. A checklist of phytoplankton species at the Kuramo water during the period of November, 2000 – August, 2001

Phytoplankton taxa	Order	
Class Bacillariophyceae	Centrales	*Chaetoceros convolutus* Castracane
		C. lorenzianus Grunow
		Coscinodiscus eccentricus Ehrenberg
		C. lineatus Ehrenberg
		Cyclotella bodanica Eulenst
		C. comta Ehrenberg
		C. meneghiniana Kutzing
	Pennales	*Amphora veneta* kutzing
		Cymbella affinis Kutzing
		Gomphonema parvulum kutzing
		N. mutica kutzing
		N. obonga kutzing
		N. rhombrica kutzing
		N. tusula (Ehr) Van Heurck
		Nitzschia palea kutzing
		N. pungens var. *coarctacta* W. Smith
		Pinnularia aerosphaeria Breb-Kutzing

Continued

		P. gibba Ehrenberg
		P. major kutzing
		P. viridis kutzing
		Synedra acus kutzing
		S. capitata Ehrenberg
		S. ulna (Nitzsch) Ehrenberg
		Tabellaria fenestrata (byngh T. flocossa (Roth) Kutzing
Chlorophyceae	Chlorococales	*Ankistrodesmus acicularis* (A. Br.) Rorsch
		Chlorococcum humicolum Naegli
		Coelastrum microsporarum Naegli
		Scenedesmus bijuga (Turp.) Kutzing
		S. obliguus (Turp) Kutzing
		S.quadricauda (Turp) Brebison
	Volvocales	*Chlorella vulgaris* Boyer
	Zygnematales	*Closterium acerosum* (Schr) Ehrenberg
		Closterium sp
		Cosmarrium connatum Breb var. *africanum* fntsch and Rub
		C. pyramidatus Brebison
	Ulotrichales	*Microspora stagnorum* (Kutz) Lagerh
Euglenophyceae	Euglenales	*Euglena acus* Ehrenberg
		E. oxyuris Schmarda
		E. viridis
		Lepocindis ovum Herman
		L. texta Ehrenberg
		Phacus orbicularis Hubner
		Phacus pyrum
Cyanophyceae	Chrocooccales	*Gleocapsa* sp
		Microcystis aeruginosa Kutzing
		M. flos-aquae Kutzing
		M. wesenbergii komarek
	Hormogonales	*Anabaena spiroides* Klebaha
		Aphanocapsa greviller (Hass) Kirech
		Lyngbya martensiana Lemm
		Lyngbya sp
		Oscillatoria limnetica Lemm.
		O. limnosa Agardh
		O. princeps Vaucher
		Spirulina alba kolwitz
		S. platensis Geitler

Table 3. A checklist of zooplankton at the Kuramo water during the period of November, 2000 – August, 2001

Zooplankton taxa	Order	
Monogononta	Ploima	*Brachionus angularis* Ahlstrom
		Brachionus calicyflorus Ahlstrom
		Brachionus urceolaris Muller
		Platyias quadricornis Ahlstrom
		Colurella obtuse Hauer
		Trichocerca sp
		Lecane petica Hauer
		Monostyla bulla Harring & Myers
		Monostyla bulla-styrax Myers
	Flosculariaceae	*Filina longiseta* Ehrenberg
Crustacea	Cyclopioda	*Cyclops* sp. Muller
	Calanoida	*Diaptomus* sp. Westwood
Adenophorea	Rhabditida	*Panagrolaimus sub-elongatus* Cobb.
	Juvenile stages	Nauplii larvae
		Larvae veliger

stages. Both Margalef's species richness (d) and Shannon and Wiener's diversity index of phytoplankton species were higher in the dry months ($d \geq 2.70$; $Hs \geq 2.32$) than in the wet months ($d \leq 3.10$; $Hs \leq 2.69$) while equitability was higher in the wet months. Among the zooplankton, Margalef's species richness was higher in the dry months ($d \geq 0.92$) than wet months. Similarly, Hs was highest in the dry months ($H \geq 1.31$) than wet months.

4 Discussion

The modification of the areas around the Kuramo creek may have stopped the incursion of tidal sea water through the Five Cowrie creek and created the low brackish environment experienced in the lagoon. According to Nwankwo (1996a), environmental modification creates new environments and in some cases nutrient traps that may induce blooms. The alkaline environment of the Kuramo lagoon may be due to the buffering effect of the sea which has been reported by Sandison and Hill to seep into the lagoon through the coastal sand bar (Sandison and Hill, 1966). The low transparency may be connected to the high algal cell counts recorded in the lagoon as well as to biodegradable waste disposed into the lagoon.

Table 4. Phytoplankton community structure indices during the period of November, 2000 – August, 2001

Index	Months									
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Margalef's species richness (*d*)	2.70	2.70	2.72	3.85	3.82	3.21	3.10	2.56	2.72	2.94
Shannon and Wiener index (*Hs*)	2.32	2.32	2.33	3.52	3.03	3.64	2.65	2.60	2.59	2.68
Equitability (*j*)	0.26	0.26	0.27	0.37	0.32	0.15	0.30	0.42	0.48	0.47

Table 5. Zooplankton community structure indices during the period of November, 2000 – August, 2001

Index	Months									
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Margalef's species richness (*d*)	0.40	0.91	0.92	1.67	1.28	1.38	1.19	0.84	0.46	0.48
Shannon and Wiener index (*Hs*)	1.30	1.31	1.35	1.39	1.75	1.81	1.16	1.01	1.11	1.16
Equitability (*j*)	0.50	0.52	0.48	0.60	0.52	0.53	0.58	0.63	0.66	0.68

According to Nwankwo (1996b) seasonal variation in transparency in the coastal water of south-western Nigeria is linked to the rainfall pattern and associated floods from adjoining rivers. Low DO and high BOD_5 values recorded in the lagoon all through the sampling period may be due to sewage and other biodegradable waste effect on oxygen consumption during organic matter decomposition. Similar observation was reported by Saad and Antoine (1983) in the Ashar canal Iraq. The relatively lower DO values and higher BOD_5 in the dry months may be due to the elevation of water temperature. According to Thomas (1966) increased water temperature in the dry season increased the rate of bacterial decomposition of organic matter in a small man-made West African lake.

Hynes (1960) reported that BOD_5 values between 1 mg/L – 2 mg/L or less represent clean water 4 mg/L – 7 mg/L represent slightly polluted water and more than 8 mg/L represent severe pollution. Based on the above criteria, the Kuramo lagoon is severely polluted. However according to Odiete *et al* (2003), chemical measurements reflects water quality at a given time while biological assessment reflects conditions that have exited in a given environment over a long period of time.

The total phytoplankton population in the lagoon was lower in the wet months possibly due to the dilution effect of storm water which diluted ion concentration in water and modified the water chemistry. The occurrence such species as *Nitzschia palea*, *Gomphonema parvulum*, *Microcystis aeruginosa*, *M. flos-aquae*, *M. wesenbergii* (blue-green algae), *Scenedesmus obliquus*, *S. quadricanda* (green algae), and *Euglena oxyuris* (Euglenoids) may be an indication of the level of pollution of the lagoon. It is possible that wastes from surrounding areas may be a major pollution problem particularly in turning the site into a nutrient trap and in prompting the excessive algal growth experienced.

Cholnory (1968) reported that *N. palea* and *C. meneghiniana* are nitrogen heterotrophs and that *N. palea* is a very good indicator of pollution. The current change of nutrient limitation from nitrogen to phosphorus and the low heavy metal levels in the lagoon may in part have contributed to the predominance of *M. aeruginosa* and *M. flos-aquae*. According to Gerloff *et al* (1952), Microcystis has a relatively low phosphorus requirement and has the ability to utilize sulphur as an alternative to phosphorus in its metabolism. Furthermore, the prevalence of euglenoids notably *E. viridis*, *E. oxyuris*, *Lepocinclis texta* and *P. pyrum* may be a further indication of organic contamination. The frequency of rotifers alongside other organisms could be an additional pointer to the level of contamination.

From the data presented in this paper, there is no doubt that the Kuramo lagoon is under pollution stress and needs restoration.

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