The Water Chemistry and Plankton Dynamics of a Tropical High Energy Erosion Beach in Lagos

[1]Onyema, I .C., [2]Nkwoji, J. A. and Eruteya, O.J.
[1]Department of Marine Sciences, university of Lagos
[2]Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos.
[1]iconyema@gmail.com, [2]josephniomr@yahoo.com

ABSTRACT: The water chemistry characteristics and plankton dynamics of a high energy beach in Lagos was investigated from July 2008 to February 2009. The water chemistry conditions and variations reflected tropical sea water quality with turbidity and dissolved oxygen values pointing to perturbations on the shoreline linked to breaking waves. Conditions were increasingly sea-like in the dry than wet season. Whereas the phytoplankton recorded 67 species, the zooplankton was composed of 20 species and 10 juvenile stages. For the phytoplankton, the diatoms (84%), dinoflagellates (13%) and blue-green algae (3%) were the representatives. For the adult zooplankton, the copepods (70%), cladocerans (10%), mysids (5%), chaetognatha (5%), chordate (5%), and decapods (5%) were represented. Generally, plankton diversity and density were higher in the dry (December to February) than wet season (July to November). The water chemistry reflected a similar trend as the plankton spectrum. The bioindices values also followed a similar regime. Notable species in terms of frequency of occurrence and abundance were *Coscinodiscus, Odontella, Pleurosigma, Acartia, Paracalanus, Oithona*, barnacle and copepod nauplii larvae. The phytoplankton, adult zooplankton and juveniles signify suitable / favourable sea water quality characteristics at the beach during the duration of the study. [Journal of American Science 2009;5(8):13-24].

INTRODUCTION

The key and foundational role of the plankton in the aquatic environment especially with regard to trophic relationships has been reported by many authors. In this regard, the phytoplankton and zooplankton are the first and second steps respectively of the aquatic food chain (Odum, 1975; Nwankwo, 2004; Emmanuel and Onyema, 2007; Onyema *et al*., 2007). The plankton has also been reported by investigators to reflect water quality status and changes, hence acting as bio-diagnostic components that point to the health of the ecosystem (Onyema *et al*., 2003). For instance according to Onyema (2007a), phytoplankton satisfy conditions to qualify as suitable indicators in that they are simple, capable of quantifying changes in water quality, applicable over large geographic areas and can also furnish data on background conditions and natural variability.

In the adjoining creeks, Lagos lagoon and immediate sea offshore Lagos, literature on the plankton community are scanty. Whereas Akpata *et al*., (1993), Onyema *et al.,* (2003, 2007), Nwankwo *et al*., (2008) considered the plankton assemblage in the Lagos and Kuramo lagoons, Emmanuel and Onyema (2007) and Onyema and Ojo (2008) have also considered the plankton in the Abule-agege and Agboyi creeks. However, there exists ample literature on the phytoplankton diversity and dynamics of the region (Nwankwo, 1986, 1988, 1996, 1998a,b, 2004; Nwankwo *et al*., 2003; Onyema, 2008).

Around the vicinity of the Victoria beach, there exist reports by Nwankwo *et al*., (2004), Edokpayi and Nkwoji (2006), Onyema (2007 a,b) and Onyema *et al*., (2007). Presently there is only one report of a checklist of phytoplankton species offshore Lagos (Nwankwo and Onyema, 2003) and another report at the Light house beach (Nwankwo *et al*., 2004).

The Victoria beach has been reported as one of the fastest eroding beaches in the world (30m per year) (Ibe, 1988, Awosika and Ibe, 1992). According to Nwankwo *et al*., (2004), the shoreline of Lagos is exposed to high energy waves that constantly pound it. Furthermore Onyema *et al* (2007a) and Onyema (2007b) have also reported that the Light house beach is an accretion (depositional) beach, whereas the Victoria beach is an erosion beach. The Victoria beach is presently undergoing massive coastal development processes and hence, the many environmental challenges relating to human-induced impacts faced in the area are noteworthy.
The aim of this project was to investigate the water chemistry characteristics and plankton dynamics at the Bar beach in Lagos.

DESCRIPTION OF STUDY SITE

Lagos State is an African megacity and is located in south-western Nigeria on the West Coast of Africa. Lagos is located within latitudes 6° 23N and 6°41N and longitudes 2°42E and 3°42E and is undoubtedly the commercial nerve-centre of Nigeria. A significant percentage of the land in Lagos State has an elevation of less than 15m above sea level. The climate is the wet equatorial type influenced by nearness to the equator and the Gulf of Guinea. There are two main seasons in the region, namely; the rainy season (April to October) and dry season (October to March). The rainy season has two peak periods; usually in June and September or October, with rainfall being heavier in June (Fig. 2). Floods associated to rain events usually results at these periods, and dilute the ionic concentration while usually increasing the nutrient levels of coastal waters.

The Victoria beach (Fig. 1) also called the Bar beach is the south most front of Victoria Island in Lagos. The beach is located to the east of the east mole. According to Nwankwo *et al*., (2004) the construction of the east, training and west moles along the Lagos coastline (habour) was more of an economic than ecological consideration. It achieved the protection of ships from waves in the habour and created Tarkwa bay. Additionally, however, it changed the hydrodynamics and sediment regime that resulted in the accretion of sand at the light house beach and retrogation at the Victoria beach (Ibe, 1988; Nwankwo *et al*., 2004; Onyema, 2007b).

The Bar beach is about 1.75km long and located to the west of the Kuramo lagoon and beach. The station chosen for this study was located at the intertidal zone of the beach with Global Position System (G.P.S.) location of Latitude 6^o 34.900N and Longitude 3^o 24.400E.

Collection of Samples

Water samples were collected for water chemistry analysis in 75cl plastic containers with screw cap. Collection of plankton samples on the other hand was by filtering 100L of seawater through a 55µm standard plankton net and stored in 250ml plastic containers. Both water and plankton samples were collected between 4th of July, 2008 and 24th of February, 2009 at the study site. Samples were collected between 1200 and 1400hrs. At the end of each trip, the plankton samples were preserved with 4% unbuffered formalin and labeled.

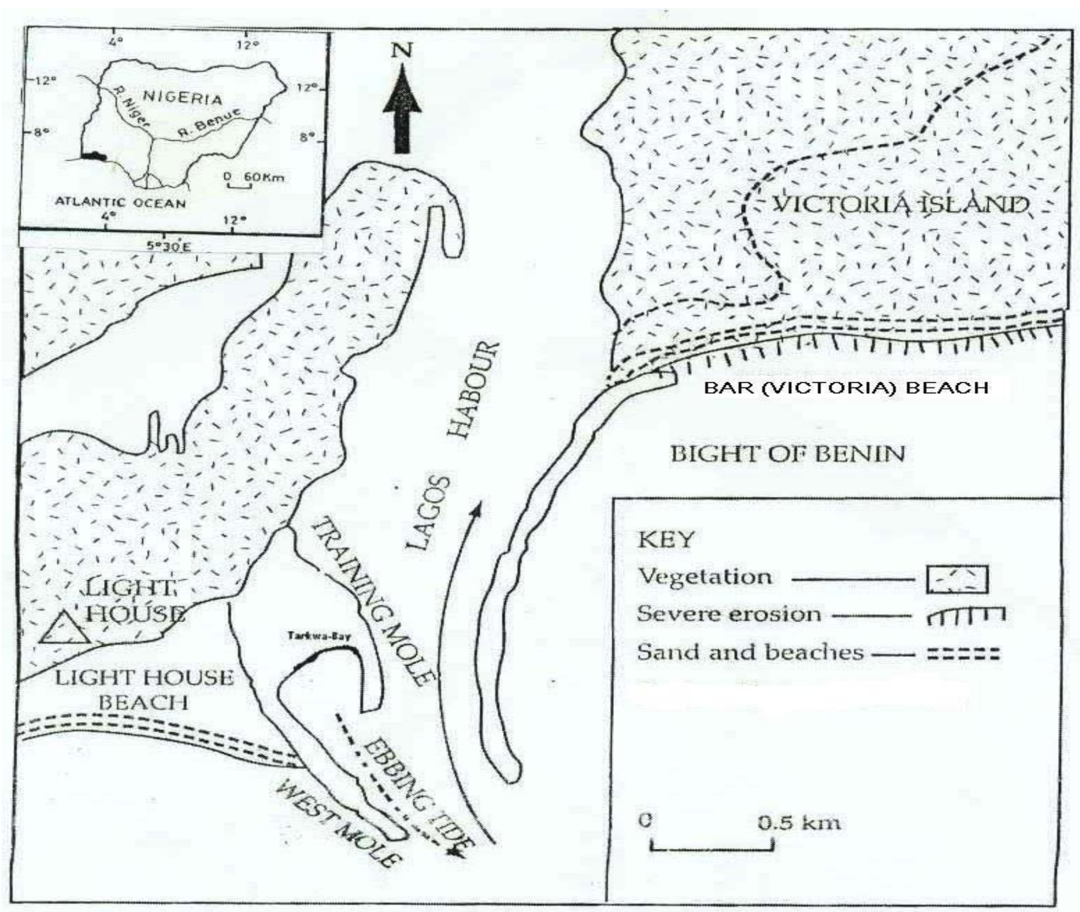

Fig. 1: The Bar (Victoria) beach, Lagos habour and Tarkwa bay in Lagos Nigeria.

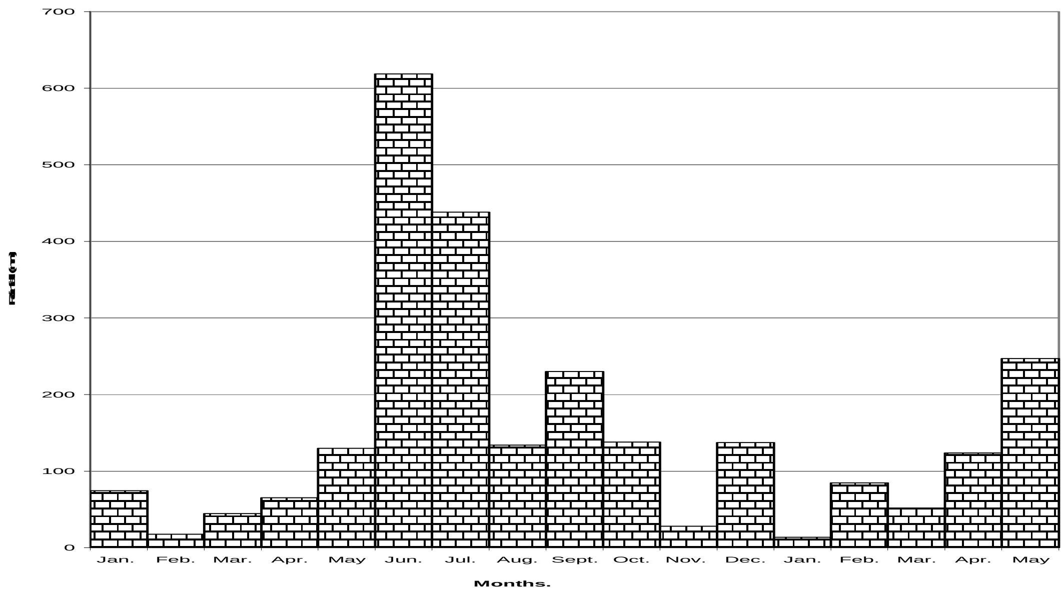

Fig. 2: Monthly distrivutive rainfall volumes from Jan., 2008 to May., 2009.

Water chemistry analysis

Air and surface water temperatures were measured *in-situ* using a mercury thermometer. Conductivity was measured using a Philip PW9505 Conductivity meter while salinity was determined by using a refractometer (BIOMARINE Aqua Fauna Model). The surface water pH was determined with a Griffin pH meter (model 80) while dissolved oxygen was determined titrimetrically using the Winkler's methods.

Plankton analysis.

In the laboratory, five drops (using a dropper) of the concentrated sample (10ml) was investigated at different magnifications (50X, 100X and 400X) using a Wild II binocular microscope with calibrated eye piece and the average recorded. The drop count microscope analysis method described by Lackey (1938) and modified by Onyema (2007) was used to estimate the plankton flora and fauna. Final data were presented as number of organisms (cells, filaments, colonies and whole organism) per ml. Appropriate texts were used to aid identification of the species. (**Phytoplankton**-Hendey 1958, 1964; Wimpenny, 1966; Patrick and Reimer, 1966, 1975; Vanlandingham, 1982; Nwankwo, 1990, 1995, 2004; Bettrons and Castrejon, 1999; Lange-Bertalot, 2001; Witkowski *et al*., 2000; Siver, 2003; Rosowski, 2003; **Zooplankton** - Newell and Newell, 1966; Olaniyan, 1975; Barnes *et al.,* 1993 and Waife and Frid, 2001).

Community structure analysis

Bio-indices applied to the biological data for this study were Species richness index (d), Menhinick's Index (D), Shannon and Wiener diversity index (Hs), Species Equitability or Evenness index (j) and Simpsons dominance index (C) (Ogbeibu, 2005). Correlation coefficient between water quality parameters and rainfall were also investigated.

RESULT

Variation in some physical and chemical characteristics of the Bar beach are presented in Table 1 and Figure 2. Air temperature ranged from 25 in September to 31 in July while water temperature ranged from 26^{o}C in Sept. to 30 ^{o}C in November and December the pH throughout the study was alkaline (8.05 – 9.10). Dissolved oxygen levels were between 6mg/L in November and 11 mg/L in August. Conductivity value on the other hand fluctuated between 40 and 52.7µS/cm. Furthermore, turbidity ranged between 13.5 (July) and 58 mg/L (August.). Alkalinity was between 16 mg/L recorded in Oct. and Nov, and 42 mg/L recorded in August while salinity varied between 25 and 34.7**‰.** Rainfall value was highest in July (438mm) and lowest in Jan. (13.7mm).

Table 1: Some physical and chemical characteristics of the Victoria Beach (July, 2007 – February, 2008).

Date	04-Jul.	17-Jul.	01-Aug.	14-Aug.	11-Sept.	26-Sept.	16-Oct.	06-Nov.	30-Nov.	30-Dec.	23-Jan.	11-Feb.	24-Feb.	Mean
Air Temperature (^{0}C)	31	28	27	26	25	27	26	29	28	29	23	27.5	28	27.27
Water Temperature (^{0}C)	29	28	28	27	26	26	28	28	30	30	26	29.5	29.5	28.08
pH	8.05	8.63	8.8	8.56	9.1	9.1	8.8	8.7	8.7	8.8	8.98	8.62	8.53	8.72
Conductivity (µS/cm)	51.4	47.7	51.8	51.8	52	48	40	48	51	47	52.7	52	51.3	49.59
Turbidity	13.5	42.5	88	58	56	16	10	26	16	26	25	28	45	34.62
Salinity (‰)	33.9	31.2	34.2	34.2	34	31	25	32	34	31	34.7	34.4	33.8	32.57
Dissolved oxygen (mg/L)	8.4	8.8	11.7	6.4	7.2	8.4	8	6	6.4	8.8	7.2	6.6	8	7.84
Alkalinity (mg/L)	19	20	18	42	38	18	16	16	20	18	24	20	22	22.38

Table 2: Pearson correlation co-efficient matrix between water quality parameters at the Bar beach (July, 2007 – February, 2008).

	Air Temperature	Water Temperature	pH	Conductivity	Turbidity	Salinity	Dissolved oxygen	Alkalinity
Air Temperature	1							
Water Temperature	0.70	1						
pH	-0.70	-0.59	1					
Conductivity	-0.10	-0.07	-0.14	1				
Turbidity	-0.23	-0.20	0.12	0.44	1			
Salinity	-0.03	0.00	-0.18	0.99	0.42	1		
Dissolved oxygen	0.13	0.03	0.23	-0.09	0.47	-0.12	1	
Alkalinity	-0.47	-0.47	0.12	0.45	0.45	0.41	-0.34	1

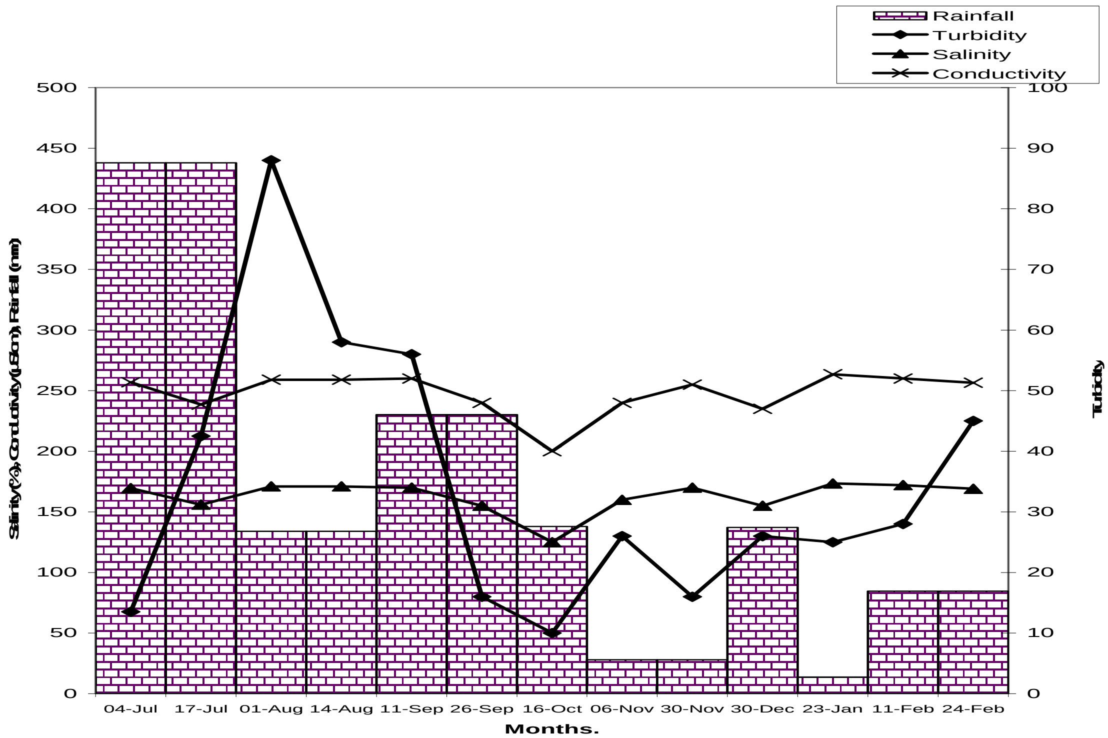

Fig. 3: Variation in some ecological factors at the Bar beach from July, 2008 - Feburary, 2009.

Plankton characteristics

The phytoplankton spectrum recorded a total of 67 species. Higher diversity and numbers per ml were recorded between November and February. The diatoms (Bacillariophyta – 56 species) (84%), Blue-green algae (Cyanophyta – 2 species) (3%) and Dinoflagellate (Prryophyta – 9 species) (13%) species were recorded.

For the diatoms, the centric forms recorded 37 species while the Pennate forms were represented by 19 species. Among these, *Coscinodiscus* – 9 species, *Odontella* – 6 species and *Melosira* – 2 species were the key genera encountered. The blue-green algae was represented by two species namely *Trichodesmium thiebautii* Gomont and *Oscillatoria limnosa* Agardh. The dinoflagellates on the other hand were represented by 9 species with the genus *Ceratium* made up of 7 species. Other species were *Peridinium africana* and *Dinophysis caudata*.

With regard to the bio-indices, generally higher values were recorded between November and February than at other times. Shannon-wiener index was highest in February (1.19) and lowest in August (0.80), while Menhinicks index fluctuated between 0.43 (August) and 0.94 (January). Margalef index was between 1.53 (July) and 2.99 (January) while equitability index values were between 0.83 (July and November) and 0.94 (February). Simpson's dominance index varied between 0.07 (February) and 0.20 (August).

For the Zooplankton, crustaceans (18 species), cladocerans (2 species), chaetognaths (1 species), chordates – (1 species), decapods (1 species), mysids (1 species), and an array of juvenile stages (10 forms) formed the Zooplankton crop. The crustaceans were represented by the calanoid and Cyclopoid copepods (70%), cladocerans (10%), mysids, chaetognath, chordate, and decapods (5% each) were represented in terms of diversity.

Acartia clausii, *Acartia discaudata*, *Paracalanus parvus* and *Temora stylifera* (calanoid copepods) were notable forms for the study in terms of frequency of occurrence. Other species included

Oithona plumifera Baird, *Oncaea venusta* (cyclopoid copepods), *Lucifer foxonii* (decapod) and *Sagitta enflata* (chaetognaths).

For zooplankton, higher bio-indices values were recorded between November and February, Shannon wiener index was highest in February. (1.01) and lowest in August. (0.51), while Menhinicks index fluctuated between 0.45 (December) and 0.99 (August). Margalef index was between 0.81 (September) and 2.14 (January) while equitability index values were between 0.73 (August) and 0.95 (September). Simpson's dominance index varied between 0.11 (February) and 0.42 (August).

Species composition and abundance in general were higher in the dry season months than the rainy months. January and February recorded the highest diversity and abundance of zooplankton species.

With regard to the juvenile stages, apart from copepod and fish egg recorded, the others were larvae of other species. The total number of forms and abundance also recorded higher values or numbers between December and February. Nauplii larvae of barnacle and copepod were more important in terms of number.

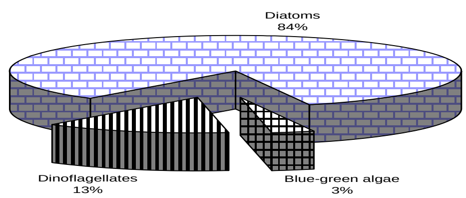

Fig. 4: Percentage abundance of phytoplankton at the Bar beach.

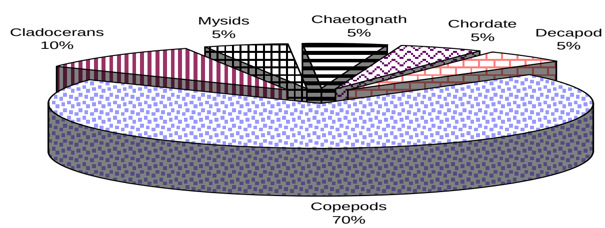

Fig. 5: Percentage diversity of adult zooplankton at the Bar beach.

Table 3: A checklist of phytoplankton species at a high energy beach in Lagos.

DIVISION – BACILLARIOPHYTA
CLASS-BACILLARIOPHYCEAE
ORDER I – CENTRALES
Actinoptychus splendens Ehrenberg
Amphiprora alata Ehrenberg
Meloseira moniliformis Agardh
Meloseira nummuloides Agardh
Campylodiscus clypeus (Ehr.) Kutzing
Chaetoceros atlanticum Cleve
Chaetoceros convolutus Castracane
Chaetoceros decipens Cleve
Odontella aurita (Lyngbe) Brebisson
Odontella biddulphiana Bayer
Odontella laevis Ehrenberg
Odontella mobilensis Bailey
Odontella regia (Schultze) Ostenfeld
Odontella sinensis Greville
Coscinodiscus centralis Ehrenberg
Coscinodiscus eccentrius Ehrenberg
Coscinodiscus jonesianus (Greville) Ostenfeld
Coscinodiscus gigas Ehrenberg
Coscinodiscus lineatus Ehrenberg
Coscinodiscus marginatus Ehrenberg
Coscinodiscus oculus-iridis Ehrenberg
Coscinodiscus radiatus Ehrenberg
Coscinodiscus sub-bulliens Jorg
Cyclotella menighiniana Kutzing
Cyclotella striata (Kutzing) Grunow
Ditylum brightwelli (T. West) Grunow
Eucampia zodiacus Ehrenberg
Hemidiscus cuneiformis Wallich
Leptocylindricus danicus Cleve
Paralia sulcata Ehrenberg
Podosira sp
Rhizosolenia alata Brightwell
Rhizosolenia styliformis Brightwell
Skeletonema coastasum Cleve
Terpsinoe musica (Ehr) Hustedt
Thalasiosira subtilis (Ostenfeld) Gran
Triceratium favus Ehrenberg

Order II – PENNALES
Achnanthes longipes Agardh
Bacillaria paxillifer (O.F. Muller) Hendey
Cymbella affinis Kutzing
Fragillaria islandica Grunner
Fragillaria oceanica Cleve
Gomphonema parvulum Grunner
Gyrosigma balticum (Ehr.) Rabenhorst
Gyrosigma scalproides (Rabh) Cleve
Hantzschia amphioxys (Ehr.) Rbenhorst
Navicula ergadensis Ralfs
Nitzschia closterium Wm. Smith
Nitzschia sigmoidea (Witesch) W. Smith
Parabelius delognei E.J. Cox
Pleurosigma angulatum (Quekett) Wm Smith
Synedra crystallina (Ag) Kutzing
Thalasiothrix fraunfeldii Cleve et Grunow
Thalasionema longissima Cleve & Grunow
Thalassionema nitzschioides Cleve &Grunow
Thalaiossira gravida Ehrenberg

DIVISION – CYANOPHYTA
CLASS – CYANOPHYCEAE
Order – HORMOGONALES
Oscillatoria limnosa Agardh
Trichodesmium thiebautii Gomont

DIVISION – DINOPHYTA
CLASS – DINOPHYCEAE
ORDER – PERIDINALES
Ceratium fusus Ehrenberg
Ceratium lineatum Ehrenberg
Ceratium macroceros (Ehr.) Cleve
Ceratium massilense Gourret
Ceratium trichoceros Ehrenberg
Ceratium tripos (O.F.M.) Nitzsch
Ceratium vultur Cleve
Dinophysis caudata Kent
Peridinium africana Kofoid

Table 4: A checklist of zooplankton species of a high energy beach in Lagos.

CLASS: CRUSTACEA
SUB-CLASS: COPEPODA
ORDER I: CALANOIDA
Acartia clausii Giesbrecht
Acartia discaudata Giesbrecht
Acartia tonsa Giesbrecht
Calanus finmarchicus (Gunn.)
Centropages furcatus Dana
Metridia longa (Lubbock)
Paracalanus parvus Claus
Paracalanus scotti Fruchtl
Temora stylifera Dana

ORDER II: CYCLOPOIDA
Corycaeus obtusus Dana
Cyclopina longicornis Claus
Cyclops sp.
Oithona plumifera Baird
Oncaea venusta Phillipi

SUB-CLASS II: BRANCHIOPODA
ORDER: CLADOCERA
Alona sp.
Penilia avirostris Dana

CLASS: MYSIDACEA
FAMILY: MYSIDAE
Mysis sp

Order II-DECAPODA
Lucifer foxonii Borrad

Phylum-CHAETOGNATHA
Order-APHRAGMORPHA
Sagitta enflata Vogt

PHYLUM: CHORDATA
CLASS: LARVACEA
Oikopleura dioica Vogt

JUVENILE STAGES
Copepod eggs
Bivalve larva
Fish eggs
Fish larvae
Gastropod larva
Lucifer zoea larva
Megalopa larva
Nauplii larva of Barnacle
Nauplii larva of copepods
Zoea larva

PHYLUM: CNIDARIA
CLASS: SCYPHOZOA
ORDER: SIPHONOPHORA
Unidentified jelly-fish

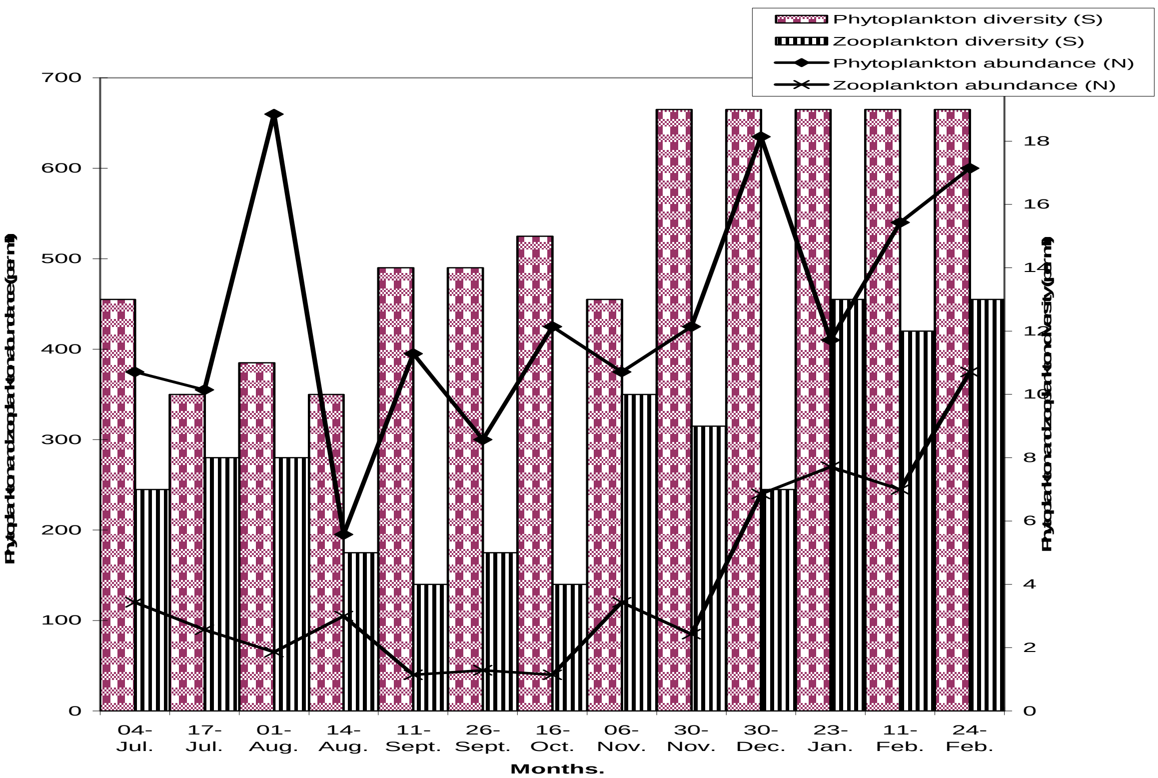

Fig. 7: Variation in phytoplankton and zooplankton dynamics at the Bar beach from July, 2008 - Feburary, 2009.

Table 5: Phytoplankton community structure indices.

Bio-index	04-Jul.	17-Jul.	01-Aug.	14-Aug.	11-Sept.	26-Sept.	16-Oct.	06-Nov.	30-Nov.	30-Dec.	23-Jan.	11-Feb.	24-Feb.
Species diversity (S)	**13**	**10**	**11**	**10**	**14**	**14**	**15**	**13**	**19**	**19**	**19**	**19**	**19**
Phytoplankton abundance (N)	375	355	660	195	395	300	425	375	425	635	410	540	600
Shannon-Wiener Index (Hs)	0.92	0.86	0.80	0.87	1.06	1.03	1.08	0.92	1.17	1.17	1.16	1.21	1.19
Menhinick Index (D)	0.67	0.53	0.43	0.72	0.70	0.81	0.73	0.67	0.92	0.75	0.94	0.82	0.78
Margalef Index (d)	2.02	1.53	1.54	1.71	2.17	2.28	2.31	2.02	2.97	2.79	2.99	2.86	2.81
Equitability Index (j)	0.83	0.86	0.76	0.87	0.93	0.90	0.92	0.83	0.92	0.91	0.90	0.94	0.93

Simpson's Dominance Index (C)	0.16	0.17	0.20	0.18	0.10	0.11	0.10	0.16	0.08	0.08	0.08	0.07	0.07

Table 6: Zooplankton community structure indices.

	04-Jul.	**17-Jul.**	**01-Aug.**	**14-Aug.**	**11-Sept.**	**26-Sept.**	**16-Oct.**	**06-Nov.**	**30-Nov.**	**30-Dec.**	**23-Jan.**	**11-Feb.**	**24-Feb.**
Species diversity (S)	**7**	**8**	**8**	5	**4**	5	**4**	**10**	**9**	7	**13**	**12**	**13**
Zoolplankton abundance (N)	120	90	65	105	40	45	40	120	85	240	270	245	375
Shannon-Wiener Index (Hs)	0.77	0.80	0.85	0.51	0.57	0.66	0.57	0.88	0.80	0.67	0.93	1.01	1.00
Menhinick Index (D)	0.64	0.84	0.99	0.49	0.63	0.75	0.63	0.91	0.97	0.45	0.79	0.77	0.67
Margalef Index (d)	1.25	1.56	1.68	0.86	0.81	1.05	0.81	1.88	1.80	1.09	2.14	2.00	2.02
Equitability Index (j)	0.91	0.89	0.94	0.73	0.95	0.95	0.95	0.88	0.84	0.80	0.83	0.94	0.90
Simpson's Dominance Index (C)	0.19	0.19	0.16	0.42	0.28	0.23	0.28	0.16	0.22	0.27	0.15	0.11	0.12

DISCUSSION

Ecological factors estimated and characterized by this study reflect a typical tropical neritic /shoreline water quality characteristics. For instance, air and water temperatures were within previously recorded limits (Longhurst 1964; Nwankwo *et al*. 2004; Onyema *et al*. 2008). In determining ecological changes in the tropics, temperature may not be as significant as rainfall (Webb 1960; Nwankwo 2004b). According to Nwankwo (2004b), rainfall distributive pattern cause four distinct ecological seasons keyed to salinity in the Lagos lagoon. Monthly rainfall volumes observed before and after this study followed known bi-modal distributive pattern as previously recorded by a number of authors (Hill and Webb 1958; Chukwu 2002; Nwankwo *et al*. 2003; Edokpayi and Nwoji 2007). The low air temperature (25^{o}C) recorded in September was probably due to imminent rain event and associated cloud cover / high humidity effects at the time of collection. Similarly the least air temperature recorded in January may be due to the presence of the harmattan season. According to Onyema *et al.* (2003) the low temperature value recorded in the same period and region may be due to the harmattan spell associated with dust haze and reduced isolation. This situation is also known to affect water temperature in lagoons and creeks of South-western Nigeria (Onyema and Nwankwo, 2009; Onyema 2008, 2009a; Onyema and Ojo 2008).

Alkaline pH values recorded throughout the study were a reflection of high amounts of Carbon (IV) oxide known to be stored as forms of carbonates in seawater. Onyema *et. al*. (2003) are of the view that the observed alkaline environment recorded for the Lagos lagoon is as a result of the buffering effect of the inflowing seawater. Similar observations have been reported by Nwankwo (1986, 1991). Dissolved oxygen levels were higher in this investigation than any other reports for the region. It is possible that the breaking of high energy plunging waves on the sand beaches on the coast-line was responsible for the increased dissolution of atmospheric oxygen in the shore waters. These agitations may also be an additional reason for higher than previously recorded pH values at the beach as more Carbon (IV) oxide is dissolved. Furthermore, perturbation form the breaking wave may also have suspended already settled particles and keeping them in suspension, hence increasing turbidity or particulate level. Turbidity values were generally higher in the wet than in the dry season. This trend has been commonly reported in the region as transparency (Nwankwo, 1998; Onyema, 2007a; Edokpayi *et al*. 2004; Emmanuel and Onyema, 2007; Onyema and Emmanuel, 2009). Turbidity and dissolved Oxygen were also positively correlated (r =0.45) with points to the perturbation of breaking waves.

Conductivity and salinity have been previously reported as associated factors (Onyema and Nwankwo 2009, Onyema 2009b). These two parameters showed a similar relationship for this study. This is evident in Table 2 (r = 0.99). Nwankwo (1996) is of the view that the dynamic interplay between freshwater inflow and tidal seawater incursion determines the Lagos lagoon environment. The least salinity (October) recorded was probably a reflection of dilution from rainfall. Salinity over the years has been singled out as a key factor in coastal waters of Nigeria in determining the absence / presence or density of endemic species (Sandison and Hill 1966, Oyenekan 1988, Brown and Oyenekan, 1998; Nwankwo 2009b, Onyema 2008).

According to Nwankwo and Onyema (2003) in a study of phytoplankton species offshore Lagos, a total of sixty three species were encountered and diatoms followed by dinoflagellates were the key groups recorded for the phytoplankton spectrum. In this study a similar order was also noted. According to Nwankwo (1988), phytoplankton production in the Lagos lagoon is high and dominated by diatoms. Furthermore Nwankwo (1998) and Onyema *et al.* (2003) are of the view that the Lagos lagoon which is linked to the Atlantic Ocean is dominated by diatoms with regard to its phytoplankton spectrum. Additionally a number of the species recorded have been reported by more recent studies in the Lagos, Kuramo, Iyagbe, Apese lagoons and adjacent creeks (Nwankwo 1988, Onyema *et al.* 2006, Nwankwo *et al.* 2008, Onyema 2007 Ijora 2009b, Onyema and Nwankwo 2009, Emmanuel and Onyema 2007).

Diatoms and dinoflagellates are important components of photosynthetic organism that form the base of the aquatic food chain (Davis, 1955; Sverdrop *et al.*, 2003). According to Onyema *et. al*. (2006) dinoflagellates are second in importance only to the diatoms as basic food producers in the plankton of marine waters. Nwankwo (1997) is of the view that with regard to the creek and lagoons around Lagos, there is an increase in the dinoflagellate cell numbers during periods of high salinity and low nutrient levels and this suggests a possible relationship. The author also suggests that the source of recruitment of the lagoonal dinoflagellates (Lagos lagoon) is the adjacent sea since most of the reported species are warm water oceanic forms. Additionally, *Trichodesmium thiebautii,* a blue-green algae encountered has been reported in blooms by Nwankwo (1993) off the Lagos coast during thermocline and low nutrient periods. Generally, changes in the standing stock of the phytoplankton follow a similar trend as that reported by Atkins and Jenkins (1953) for the western part of the English Channel as indicated by chlorophyll concentration.

In the zooplankton spectrum, the copepods particularly the calanoid forms were the more important members in terms of occurrence and frequency.

According to Onyema *et al.* (2003), in the adjoin Lagos lagoon, diatoms and copepods dominated the plankton spectrum. *Alona* sp. and *Penilia avirostris* Dana (Cladoceran) are known seawater cladocerans (Winnipenny 1966, Newell and Newell 1966: Olaniyan 1975) and these confirm the water quality situation of the Bar beach. Similarly *Lucifer foxonii*, *Sagitta enflata* and *Oikopleura dioica* fall into the same category as sea species that have been previously reported by the aforementioned authors. These marine species have also been recorded in the Lagos harbor, lagoon and the Opobo channel (Niger delta) over the year during high salinity periods in the dry season (Akpata *et. al*. 1993; Kusemiju *et. al*. 1993; Onyema *et al*. 2003, 2007).

Eggs, larvae and spores of pelagic and benthic organisms are often a conspicuous part of the plankton of neritic waters and some of the obvious seasonal changes are related to the reproductive seasons / times of the sea organisms (Tait, 1981). The diversity of forms of juvenile plankton recorded in this study is similar to that recorded by Harvey *et al*. (1935) and Harvey (1950).

REFERENCES.

1. Akpata, T. V. I., Oyenekan, J. A. and Nwankwo, D. I. (1993). Impact of Organic Pollution on the Bacterial Plankton and Benthic Populations of Lagos Lagoon, Nigeria. *International Journal of Ecology and Environmntal Sciences.* 17: 1 –10.
2. Atkins, W.R.G. and Jenkins, P.G. (1953). Seasonal changes in the phytoplankton during the year 1951 – 52 as indicated by spectrophotometric chlorophyll estimation. *J. Mar. Biol. Ass.* 31: 495 – 508.
3. Awosika, L.F.A. and Ibe, A.C. (1992). The Nigerian Continental Shelf: Geomorphology Dynamics and Response to Climate Change. In: *Global Climate Change and Coastal Resources and Installations in Nigeria: Impacts and Response Measures.* Tobor, J.G. and Ibe, A.C. (Eds.). Francis Graphix Ltd., Lagos. 39-49.
4. Barnes, R.S.K., Calow, P. and Olive, P.J.W. (1993). *The invertebrates: a new synthesis*. Blackwell Scientific Publications. London. 488pp.
5. Bettrons, D.A.S. and Castrejon, E.S. (1999). Structure of benthic diatom assemblages from a mangrove environment in a Mexican subtropical lagoon. *Biotropica.* 31(1): 48 – 70.
6. Brown, C.A. and Oyenekan, J.A. (1998). Temporal variability in the structure of benthic macrofauna communities of the Lagos lagoon and harbour, Nigeria. *Pol. Arch. Hydrobiol.* 45(1): 45 – 54.
7. Chukwu, L.O. (2002). Ecological effects of human induced stressors on coastal ecosystems in southwestern Nigeria. PIM 2002 Conference: The ocean in the New economy. Held in Cape Town, South Africa between 8–14, December, 2002. 61–70.
8. Davis, C.O. (1955). *The Marine and Freshwater Plankton*. Michigan State University press. Michigan U.S.A. 562 pp
9. Edokayi, C.A., Lawal, M.O., Okwok, N.A. and Ogunwemo, C.A. (2004). Physico-chemical and macrobenthic faunal characteristics of the Kuramo water, Lagos, southern Nigeria. *African Journal of Aquatic Sciences*. 29 (2). 235-241.
10. Edokpayi, C.A. and Nkwoji, J.A. (2007). Annual changes in the physico-chemistry and macro-benthic invertebrate characteristics of the Lagos lagoon sewage dump site at Iddo, Southern Nigeria. *Ecology, Environment* and *Conservation*. 13(1): 13 – 18.
11. Emmanuel, B.E. and Onyema, I.C. (2007). The plankton and fishes of a tropical creek in south-western Nigeria. *Turkish Journal of Fisheries and Aquatic Sciences*. 7: 105 – 114.

12. Harvey , H.W (1950). On the production of living matter in the sea off Plymouth. *J. Mar.Biol. Ass*. 29: 97.
13. Harvey , H.W., Copper, L.H.N., Lebour, M.V. and Russel, F.S. (1935). Plankton production and its control. *J. Mar. Biol. Ass.* 20: 407 (1935)
14. Hendey, N.I. (1964). *An introductory account of the smaller algae of British coastal waters.* Part 5. Bacillariophyceae (diatoms) London. N.M.S.O. 317pp.
15. Hendey, N.I. (1958). Marine diatoms from West African Ports. *Journal of Royal Microscopic Society.* 77: 28-88.
16. Hill, M.B. and Webb, J.E. (1958). The ecology of Lagos lagoon II. The topography and physical features of the Lagos harbour and Lagos lagoon. *Philosophical Transaction of Royal Society, London.* 241: 307-417.
17. Ibe, A. C. (1988). *Coastline erosion in Nigeria*. University Press, Ibadan. 217pp.
18. Kusemiju, K., D. I. Nwankwo & R. B. Bamisaye (1993). The Hydrobiology and Fishes of Opobo Channel, Rivers State, Nigeria*. Journal of Scientific Research and Development 1(1):* 74 – 79.
19. Lackey, J.B. (1938). The manipulation and counting of river plankton and changes in some organism due to formalin preservation. *U.S. Public Health Reports.* 63: 2080-2093.
20. Lange-Bertalot, H. (2001). Diatoms of Europe. Diatoms of the European Inland Waters and Comparable Habitats. Vol.2. A.R.G. Gantner Verlag K.G. 520pp.
21. Longhurst, A. R. (1964). The Coastal Oceanography of Western Nigeria. *Bulletin de I. F. A. N. TXXVI.* Ser. A. (2): 337 – 402.
22. Newell, G.E and Newell, R.C. (1966). *Marine plankton: a practical guide*. Revised Edition. Hutchinson London. 225pp.
23. Nwankwo DI (2004a). *A Practical Guide to the study of algae*. JAS Publishers, Lagos. Nigeria. 86pp.
24. Nwankwo, D. I. (1986) . Phytoplankton of a Sewage Disposal Site in Lagos Lagoon, Nigeria . 1. The Algae. *Journal of Biological Sciences 1: (2):* 89 – 96.
25. Nwankwo, D. I. (1988b). A preliminary Check-List of Planktonic Algae of Lagos Lagoon. *Nigerian Journal of Basic and Applied Sciences 2(1)*: 73 – 85.
26. Nwankwo, D. I. (1995). Euglenoids of some Polluted Storm-water Channels in Lagos, Nigeria. *Tropical Freshwater Biology.* 4: 29 – 39.
27. Nwankwo, D. I. (1996). Phytoplankton diversity and succession in Lagos Lagoon. Nigeria. *Archiv Fur Hydrobiologie 135 (4):* 529 – 542
28. Nwankwo, D. I. and Akinsoji, A. (1988). Periphyton Algae of eutrophic Creek and their possible use as Indicator. *Nigerian Journal of Botany.* 1: 96 – 105.
29. Nwankwo, D.I. (1990). Contribution to the Diatom flora of Nigeria. Diatoms of Lagos lagoon and the adjacent sea. *Nigerian Journal of Botany.* 3:53-70.
30. Nwankwo, D. I. (1997). A First list of Dinoflagellates (Pyrrophyta) From Nigerian Coastal Waters (Creeks, Estuaries,. Lagoons). *Polskie Archiwum Hydrobilogii 44: (3).* 313 - 321
31. Nwankwo, D.I. (1998). The influence of sawmill wood wastes on diatom population at Oko-baba, Lagos, Nigeria. *Nigerian journal of Botany 11*: 15 – 24.
32. Nwankwo, D.I. (2004a). The Microalgae: Our indispensable allies in aquatic monitoring and biodiversity sustainability. University of Lagos Press. Inaugural lecture seris. 44pp.
33. Nwankwo, D.I. and Onyema., I.C. (2003). A checklist of planktonic algae off Lagos coast. *Journal of Scientific Research Development.*9: 75 – 82.
34. Nwankwo, D.I., Onyema, I.C. and Adesalu, T.A. (2003). A survey of harmful algae in coastal waters of south-western Nigeria. *Journal of Nigerian Environmental Society.* 1(2). 241 – 246.
35. Nwankwo, D.I., Onyema., I.C, Labiran, C.O., Otuorumo, O.A.; Onadipe, E.I.;, Ebulu, M.O. and Emubaiye, N. (2004). Notes on the observations of brown water discolouration off the light house beach, Lagos, Nigeria. *Discovery and innovation*. 16 (3). 111 – 116.
36. Nwankwo, D.I., Owoseni, T.I., Usilo, D.A., Obinyan I., Uche, A.C. and Onyema, I.C. (2008). Hydrochemistry and plankton dynamics of Kuramo lagoon. *Life Science Journal*. 5 (3): 50 – 55.
37. Nwankwo, D.I; Onyema, I.C.; Adesalu, T.A.; Olabode, R.J.;Osiegbu, G.O. and Owoseni, T.I. (2003). Additions to a preliminary check-list of planktonic algae in Lagos lagoon, Nigeria. *Journal of Science Technology and Environmental.* 3(1). 8-12.
38. Odum, E.P. (1975). *Ecology. The link between the natural and social sciences*. Oxford & IBH Publishing Co. pvt. Ltd. New Delhi. 244pp.
39. Ogbeibu, A.E. (2005). *Biostatistics: A practical approach to research and data handling*. Mindex Publishing Company limited, Benin city, Nigeria.264pp.
40. Olaniyan, C.I.O. (1975). *An introduction to West African Ecology*. Heinemann Education Books Ltd., London. 170pp.
41. Onyema, 1.C., Okpara, C.U., Ogbebor, C.I. Otudeko, O. and Nwankwo, D.I. (2007).

Comparative studies of the water chemistry characteristics and temporal plankton variations at two polluted sites along the Lagos lagoon, Nigeria. *Ecology, Environment* and *Conservation*. 13(1):1–12

42. Onyema, I.C. (2007a). The phytoplankton composition, abundance and temporal variation of a polluted estuarine creek in Lagos, Nigeria. *Turkish Journal of Fisheries and Aquatic Sciences*. 7: 89 - 96
43. Onyema, I.C. (2007b). Mudflat microalgae of a tropical bay in Lagos, Nigeria. *Asian Journal of Microbiology, Biotechnology and Environmental Sciences*. 9 (4): 877 – 883.
44. Onyema, I.C. (2008). A checklist of phytoplankton species of the Iyagbe lagoon, Lagos. *Journal of Fisheries and Aquatic Sciences*. 3(3): 167 – 175.
45. Onyema, I.C. (2009a). Notes on the existence of an additional lagoon in South-western Nigeria: Apẹsẹ Lagoon. *Journal of American Science*. 5(4): 151 - 156.
46. Onyema, I.C. (2009b). The water chemistry, phytoplankton biomass, episammic and periphytic algae of a previously unstudied lagoon in Lagos: Apese lagoon. *Reports and Opinion*.
47. Onyema, I.C. and Emmanuel, B.E. (2009). Fishing impairment and *Spirogyra africanum* (Fruda) in a freshwater lagoon. *Estonian Journal of Ecology*. 58 (1): 1 – 7.
48. Onyema, I.C. and Nwankwo, D.I. (2006). The epipelic assemblage of a polluted estuarine creek in Lagos, Nigeria. *Pollution Research*. 25(3): 459 - 468.
49. Onyema, I.C. and Nwankwo, D.I. (2009). Chlorophyll a dynamics and environmental factors in a tropical estuarine lagoon. *Academia Arena*. 1(1) : 18 – 30.
50. Onyema, I.C. and Ojo, A.A. (2008). The zooplankton dynamics and chlorophyll a concentration of a tropical tidal creek in relation to water quality indices. *Life Science Journal*. 5 (4): 7 - 14
51. Onyema, I.C., Nwankwo, D.I. and Oduleye, T. (2006). Diatoms and dinoflagellates of an estuarine creek in Lagos. *Journal of Scientific Research Development*. 10: 73 – 82.
52. Onyema, I.C., Nwankwo, D.I., Owolabi, K.O. (2008). Temporal and spatial changes in the phytoplankton dynamics at the Tarkwa-bay jetty in relation to environmental characteristics. *Ecology, Environment* and *Conservation*. 14(4): 1 – 8.
53. Onyema, I.C., Otudeko, O.G. and Nwankwo, D.I. (2003). The distribution and composition of plankton around a sewage disposal site at Iddo, Nigeria. *Journal of Scientific Research Development*.7: 11-24.
54. Oyenekan, J.A. (1988). Benthic macrofaunal communities of Lagos Lagoon, Nigeria. *Nigerian Journal of Sciences*. 21: 45-51.
55. Patrick, R. and Reimer, C.W. (1966). The diatoms of the United States exclusive of Alaska and Hawaii (Vol. 1). *Monogr. Acad. Nat. Sci.* Philadelphia. 686pp.
56. Patrick, R. and Reimer, C.W. (1975). The diatoms of the United States exclusive of Alaska and Hawaii (Vol. 2, part 1). *Monogr. Acad. Nat. Sci.* Philadelphia. 213pp.
57. Rosowski, J.R. (2003). Photosynthetic Euglenoids. In: *Freshwater Algae of North America*. Ecology and Classification, Wehr, J.D. and Sheath, R.G. (Eds). Academic Press, New York. pp 383 – 422.
58. Sandison, E.E. and Hill, M.B. (1966). The distribution of *Balanus pallidus* Strusburi (Darwin), Gryphaea gasar (Adanson) Dautzenbergi, *Mercierella enigmatica* farvel and *Hydroides uncinata* (Philippi) in relation to salinity in Lagos Harbour and adjacent creek. *Journal of Animal Ecology*. 38: 235-258.
59. Sverdrup, K.A., Duxbury, A.C. and Duxbury, A.B. (2003). *An introduction to the worlds oceans.* Seventh Edition. McGraw Hill Publishers, New York. 521pp.
60. Siver, P.A. (2003). Synurophyte algae. In: *Freshwater Algae of North America*. Ecology and Classification. Wehr, J.D. and Sheath, R.G. (Eds). Academic Press, New York. pp 523 - 558.
61. Vanlandingham S.L. (1982). Guide to the identification and environmental requirements and pollution tolerance of freshwater blue-green algae (cyanophyta). U.S. Environmental Protection Agency, EPA – 60.
62. Waife, G. and Frid, CL.J (2001). Marine zooplankton of West Africa. Marine Biodiversity Capacity Building in the West African Sub-region. Darwin Initiative Reports 5, Ref. 162/7/45/. 120pp
63. Webb, J.E. (1960). Biology in the tropics. *Nature*. London. 188(4151): 617 - 619.
64. Whitford, L.A. and Schmacher, G.H. (1973). A
65. *manual of freshwater algae*. Sparks press Raeigh. 324pp
66. Wimpenny, R.S. (1966). *The plankton of the sea*. Faber and Faber Limited, London. 426pp.
67. Witkowski, A., Lange – Bertalot, H. and Metzeltin, D. (2000). Diatom flora of Marine Coasts 1. (219 plates). A.R.G.Gantner Verlag K.G. 925pp.

8/20/2009