Available online @ www.actasatech.com

*acta*SATECH **4**(1): 53 - 63 (2011)

Research

The Water Chemistry and Periphytic Algae at a Cage Culture Site in a Tropical Open Lagoon in Lagos

I. C. Onyema

Department of Marine Sciences, University of Lagos, Akoka, Lagos, Nigeria.

*Correspondence author <ionyema@unilag.edu.ng>

Abstract

Investigations into the water chemistry and periphytic algae attached to a cage culture system in the Lagos lagoon was investigated for 7 months (Jan. - Aug. 2010). Increased salinity conditions were recorded as sampling progressed into the dry season (from Jan. - April) whereas reducing salinities were recorded as the wet season advanced (May – Aug.). Micro-algal diversity attached to the Polyvinyl Chloride (P.V.C.). pipes were rich (33 species) and the diatoms dominated in terms of diversity (18 species) whereas the green algae (2 species), the euglenoids (4 species) and the blue- green algae (9 species) were the other algal groups represented. The effects of nutrient enrichment from fish feed were probably quite local and affected by the hydrological flow dynamics operating in the culture site area of the lagoon. Furthermore, the levels of nutrients around the cage culture site were largely controlled by the tidal and rain induced seasonal flow. The periphytic algal components were a reflection of prevailing water chemistry characteristics per time.

Keywords: Cage culture; Periphytic algae; Water Chemistry; Lagoon; Lagos

Introduction

Lagoons are key hydrological entities in South-western Nigeria (Onyema, 2009). Their hydro-climatic situations and variations are crucial to the survival of endemic aquatic organisms. The Lagos lagoon is one of the ten lagoons in South-western Nigeria and has been previously described by a number of authors over the years (Webb, 1958; Nwankwo, 1996; Onyema *et al.*, 2007; Onyema, 2007, 2009, 2010). According to these investigations, a continuum of flood waters associated with rain events and tidal sea water inflow determine the hydro-climatic conditions recordable in the lagoon at any time. The two key factors, rainfall and tidal seawater incursion are seasonal and vary from year to year. Hence the lagoon is usually increasing marine in the dry season and tends towards freshness in the wet season. Nutrient and pollutant inputs are also more discernable in the wet than dry season. Distinctly, the Lagos lagoon is under intense surge from a brew of pollutants from the metropolis of Lagos (Onyema, 2009). These inputs are largely from domestic and industrial sources. These concoctions of wastes are usually indiscriminately discharged into the lagoon at different points or eventually find their way to it.

Aquaculture is now recognized as a viable and profitable enterprise worldwide and aquaculture technology has evolved various ways of production including cages. Cage culture involves the practice of rearing fish in cages and it usually applies to existing water bodies that cannot be drained or seined and would otherwise not be suited for aquaculture (McGinty & Rakocy, 1989). The merit of cage culture include the flexibility of management, ease and low cost of harvesting, low capital investment and close observation of fish feeding response, diseases, parasites, health situations and economical treatment (McGinty & Rakocy, 1989; Ayoola, 2010).

The Lagos lagoon serves as a fertile ground for feeding, breeding and nursery ground for a number of aquatic organisms. It also serves as habitat for a number of anadromous, catadromous and estuarine species of aquatic forms notably fish (Solarin, 1998). It is also a site for fin and shellfish capture and culture. With regards to capture and culture of fish, the brush parks (Acadja) and other semi-extensive systems in the adjoining creeks and lagoons are noteworthy. Their impact on the environment are usually limited to a small area and are based on the size of the farm, stocking density, type of feed used and the hydrological regimes prevalent in the area (Ayoola, 2010). Additionally, natural food organisms are known to supply some amount of nutrients required by cage culture fish (Lovell, 1998).

Hard substrate in waters is usually colonised by an array of organisms (Onyema, 2009). Attached algal components on non-living substrate are known as periphyton and are important as foundational trophic level biota in the aquatic food chain. Specifically in coastal waters, their contributions are quite significant. Studies on attached algal components of the coastal waters of South-Western Nigeria were reported by Nwankwo and Akinsoji (1988, 1992), Nwankwo & Onitiri (1992) and Nwankwo *et al*. (1994). Other studies include Onyema & Nwankwo (2006), Onyema (2007) and Onyema & Nwankwo (2009). These authors are of the view that substrate type and water physico-chemical characteristics are the important determinants of periphytic algal assemblages. Tide and wave parameters are also key factors in this regard (Nwankwo *et al*., 2003; Onyema & Nwankwo, 2006; Onyema, 2007, 2009). Presently, there are no reports on the water chemistry fluctuations and periphytic components attached to a cage culture setup in the region. Further to this is the need to know the composition and numerical priorities of algal organism as they occur on the cage structures in the Lagos lagoon.

Materials and Methods

Description of Study Site

The cage culture site is located off the University of Lagos waterfront (Fig. 1). The setup is made up of three cages. The Polyvinyl Chloride (P.V.C.) pipes and polyethylene netting material were used in the construction of each cage. Fish production operation started from the 20th of January, 2009 when the cages were mounted in the lagoon after construction, till the 25th of August (7 months) when they were removed. This initiative was a joint effort between the Lagos state government and the department of Marine Sciences of the University of Lagos. These arrangements were placed about 50m from the shoreline of the University, before the feet of the Third-main land bridge. This setup consists of three cages with length of 5.29m and a breath of 3.86m per cage. The G.P.S. co-ordinates for the area were at about, Latitude 6^0 31.038'N and Longitude 3^0 24.261'E. The lagoon substratum in the area is about 1.5m deep. Furthermore, concrete sinkers (6) were also used to hold each floating contraption firmly at installation, to disallow drifting of the cages. The fishes were fed on artificial feed and they probably complemented with natural feed. The three cichlids species of fish stocked in the cages were *Saretherodon melanotheron, Sarethorodon galileaus* and *Tilapia guinenesis* foremost being with highest stocking density.

Bio-fouling organisms such as algae and known benthic organisms successionally and increasingly colonised the cage structures. Dorminant invertebrates in term of numbers were the Annelid – *Mecierella enigmatica*, Crustacean - *Balanus pallidus* and the bivalve - *Gryphaea gasar.* Other important species in terms of number were the hermit crab - *Clibernarius africana* inhabiting shells of *Tympanotonus fuscatus* var. *radula* and *Pachymelina aurita* and the mud skipper - *Peripthalmus* sp. The growth of the opportunistic estuarine / marine bivalve - *Perna perna* was an unusual find at the cage culture site. It developed in bloom proportion attached to the nets and even impaired harvesting operations. Other species present at the site included crabs such as *Uca tangeria, Callinectes amnicola* and *Sersama hurzadi.* All the aforementioned species recorded both juvenile and adult stages on the cages at the site.

Collection of water and attached algae (Periphytic algal samples)

Water samples were collected monthly (Jan. - Aug., 2010) within the lagoon in 75cl plastic containers with screw cap. These were then taken to the laboratory for analysis of physico-chemical parameters estimates. Periphytic algal samples were collected from the cage at harvest time (25th August). Samples horizontal intertidal P.V.C. pipes were collected according to Onyema (2007). Samples were scraped into a Petri dish, labelled and preserved with 4% unbuffered formalin before onward transfer to the laboratory.

Analysis of waters and Periphytic algal species

Water samples were analyzed using methods described by APHA (1998). The periphytic samples, was concentrated to 20ml and at least 5 drops from each sample was examined thoroughly under an Olympus binocular light microscope. The periphyton algae counts are expressed as number of species per ml as described by Onyema (2007). Five drops of each concentrated sample were investigated from each sample at different magnifications. Entire views of the mounted sample were investigated. Identification aids used included Desikachary (1959), Hendey (1958, 1964), Patrick & Reimer (1966-75), Barber & Harworth (1981), Vallandingham (1982), Whitford & Schmacher (1973) and Nwankwo (1990).

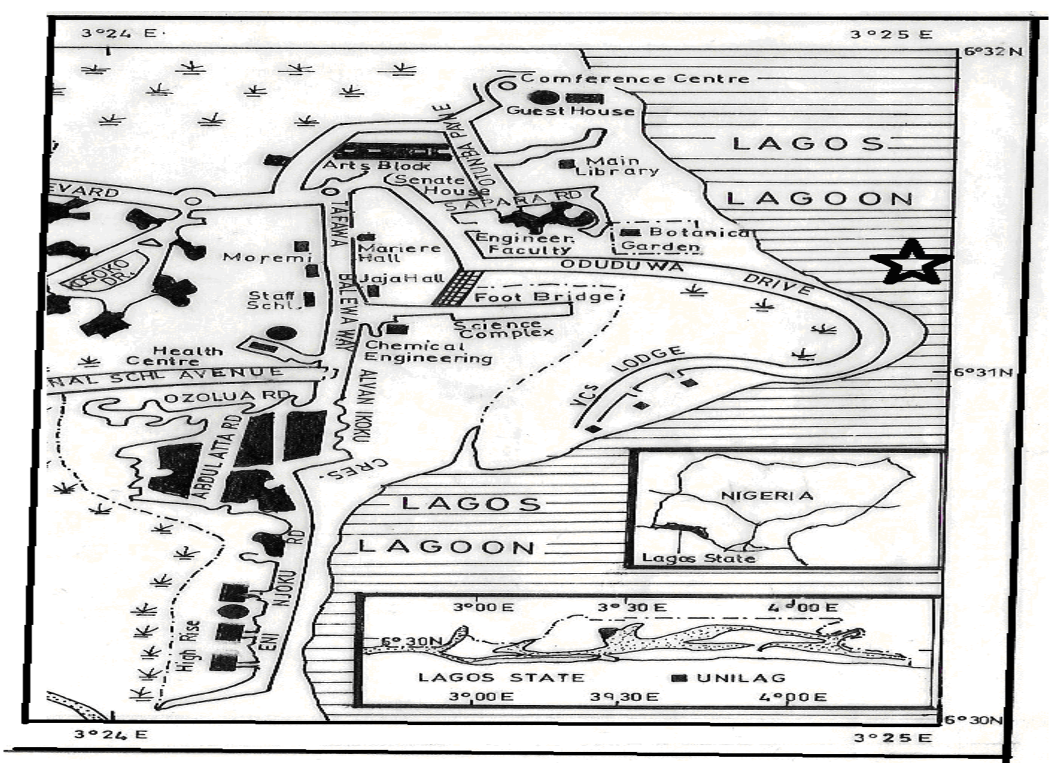

Fig. 1: University of Lagos showing the shoreline / waterfront and the cage culture site ☆.

Results

Water chemistry

The water chemistry characteristics show marked seasonal variation. Table 1 show the monthly variation in physico-chemical parameters at the site, while Fig. 2 shows graphical variations in some notable parameters at the site. For instance, salinity, conductivity, total dissolved solids and chloride among other conditions increased and were high from January to April, whereas from May, the situation generally reversed. Rainfall on the other hand increased from January to June, with the latter month recording the highest volume (444.1mm). Nutrients and heavy metal levels were also higher during the rains (May – August) than before the rains. Trends in dissolved oxygen on one hand and biological oxygen and chemical oxygen demands on the other hand were inversely related. Temperatures (air and water) were higher between January and April and lower between May and August, 2010.

Table 1: Monthly Variation in Physico-Chemical Parameters at the Cage culture site in the Lagos lagoon from 20th of Jan. to 25th of Aug., 2010

PARAMETER	January	February	March	April	May	June	July	August
Air temperature (^{0}C)	33	33	32	31	29	29	30	28
Surface water temperature (^{0}C)	31	29	30	28.8	28	28	29	28
Depth (cm)	1.43	1.54	1.45	1.50	1.52	1.50	1.54	1.55
Total Dissolved Solids (mg/L)	10386	11050	14386	16390	4690	1520	4900	865
Total Suspended Solids (mg/L)	100	60	290	233	38	26	717	220
Rainfall (mm)	50.8	40.8	45.6	171.6	233.2	444.1	149.6	161.7
pH at 25^{0}C	7.5	7.65	7.2	7.3	7.0	7.51	7.34	7.3
Acidity (mg/L)	6.2	7.0	18	8.1	9.9	10.6	8	8.6
Alkalinity (mg/L)	72.4	82.5	40.1	42	22.8	23.5	30.7	50.8
Salinity ($^o/_{oo}$)	26.26	27.25	31.50	30.33	7.86	1.85	1.08	0.35
Conductivity (uS/cm)	16320	17600	26000	26800	7260	2359	1200	1300
Dissolved Oxygen (mg/L)	4.6	4.3	4.0	3.6	3.8	3.8	3.6	3.3
Biological Oxygen Demand (mg/L)	16	18	19	20	28	29	35	18
Chemical Oxygen Demand (mg/L)	53	62	71	68	86	74	79	68
Total hardness (mg/L)	2892	4500	1682.1	1888	680	350	785.7	260.1
Chloride (mg/L)	9200	9695	3860.1	4936	2626	520	135.5	133.3
Nitrate (mg/L)	5.8	8	8	4.1	5	5	10.2	9.1
Phosphate (mg/L)	0.08	0.2	0.14	0.14	0.11	0.14	0.82	0.18
Sulphate (mg/L)	305.1	400.2	390.8	402.1	142.3	55.3	87	120
Calcium (mg/L)	105	250	180.1	118.3	80.3	60.5	50	40.1
Magnesium (mg/L)	209.2	486.1	308.5	398	120.8	48.8	78	40
Zinc (mg/L)	0.003	0.001	0.002	0.001	0.002	0.003	0.005	0.001
Iron (mg/L)	0.16	0.12	0.16	0.08	0.26	0.16	0.62	0.95
Copper (mg/L)	0.001	0.002	0.001	0.002	0.001	0.001	0.016	0.002

Table 2: Periphytic algae at the cage culture site in 1ml of concentrated sample.

CLASS-BACILLARIOPHYCEAE	
ORDER I – CENTRALES	
Aulacoseira granulata Ehrenberg (Ralfs)	*
Aulacoseira granulata var. *angstissima* Muller	*
Order II – PENNALES	
Gyrosigma balticum (Ehr.) Rabenhorst	*
Gyrosigma spenceri W. Smith	*
Gyrosigma wansbeckii (Grunow) Cleve	*
Navicula cryptocephala (Kutz) Hustedt	*
Navicula cuspidata Kutzing	*
Navicula mutica Kutzing	*
Navicula sp. I	*
Navicula sp. II	*
Navicula sp. III	*
Navicula sp. IV	*
Nitzschia sigma Grunow	*
Pleurosigma angulatum (Quekett) Wm Smith	*
Pleurosigma elongatum Wm Smith	*
Synedra ulna (Nitzsch) Ehrenberg	*
Synedra crystallina (Ag) Kutzing	**
Synedra sp.	*
CLASS – CYANOPHYCEAE	
ORDER I – CHROOCOCCALES	
Merismopedia gluca (Ehr.) Nageli	*
Order II – HORMOGONALES	
Lynbgya limnetica Lemm	***
Lynbgya martensiana Meneghini	*
Oscillatoria borneti Zukal	**
Oscillatoria chalybea Gomont	*
Oscillatoria curviceps C.A. Agardh	***
Oscillatoria formosa Bory	*
Oscillatoria limnosa Agardh	*
Spirulina platensis Geitler	*
CLASS – EUGLENOPHYCEAE	
ORDER – EUGLENALES	
Euglena acus Ehrenberg	**
Phacus curvicauda Swirenko	*
Phacus acuminatus Stokes	*
Trachelomonas hispida (Perry) Stein	*
CLASS – CHLOROPHYCEAE	
ORDER - CLADOPHORALES	
Cladophora glomerata (L) Kutzing	***
Cladophora sp.	**

Where * represents 1 – 10 cells / trichome / filament; ** represents 11 – 100 cells / trichome / filament and *** represents 101 – 4500 cells / trichome / filament.

Periphyton

Four algal classes were represented for the investigation. They were the Cyanophyceae (blue-green algae, 9 species), Chlorophyceae (green algae, 2 species), Bacillariophyceae (diatoms, 18 species) and Euglenophyceae (euglenoids, 4 species). In terms of numbers, the blue-green algae were the most important however, the diatoms were more important in terms of diversity. Following, were the green algae, diatoms and then euglenoids respectively. *Lyngbya martensiana* was the most abundant species followed by *Cladophora glomerata*, *Oscillatoria formosa* and *Cladophora* sp. in that order. Table 2 reports an inventory of periphytic algae attached to the P.V.C. pipes at the cage culture site in the Lagos lagoon. A total of 33 species were recorded. A strong negative correlation existed between salinity and rainfall values (r = - 0.64) while rainfall and nutrient in the form of nitrate showed a positive correlation (r = - 0.42) (Fig. 2).

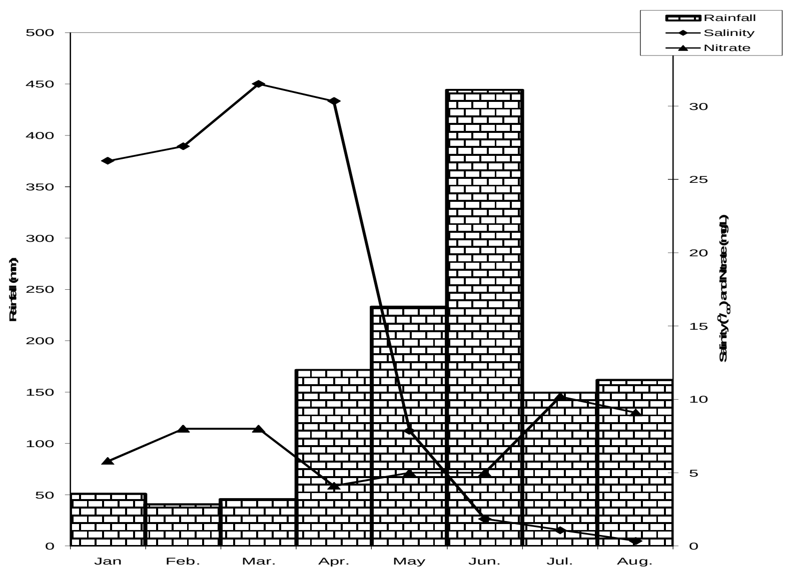

Fig. 2: Monthly variations in Nitrate, Salinity and Rainfall volume at a mariculture site in the Lagos lagoon (Jan. - Aug., 2010).

Discussion

Results from the physico-chemical analysis confirm known trends and extents from previous studies in the Lagos lagoon (Nwankwo 1996; Onyema *et al.,* 2003, 2006, 2007). For instance, higher marine conditions / salinities were recorded in the dry season (Jan. - April) whereas; reduced levels were estimated during the rains. The month of August recorded a salinity of 0.35‰ while April recorded 30‰. The cage culture system, its content and its attached communities are therefore exposed to sharp and varying salinity.

In the cages it is also possible that the fish feed introduction and consequent deterioration and disintegration of uneaten feed did not impact the water measurably as would have been expected. This is probably because the area is tidal and flow conditions change at least every 6 hours in an opposite direction (Onyema, 2009). The area is semi-diurnal (Ajao, 1996). This could have ameliorated the prospective effect of the introduction of fish feed. The nutrients and heavy metal levels were generally higher during the rains probable due to the introduction by floodwaters associated with the rains from land-based contaminated sources (Nwankwo, 2004; Onyema & Nwankwo, 2006). This trend is also reflected in the higher dissolved oxygen values during the dry season than in the wet season – the higher the amount of pollution, the lower the levels of dissolved oxygen usually estimatable (Onyema, 2009).

The abundance in occurrence of blue-green algae is noteworthy. Nwankwo *et al*. (2003) is of the view that there is a relationship between blue-green algae and nutrient enrichment in aquatic ecosystems. Most organisms recorded for this study have been previously implicated in polluted situations in the area (Nwankwo, 2004; Onyema & Nwankwo, 2006; Onyema, 2007). The supply of nutrients is known to play key roles in algal growth in natural environments (Parrish & Wangersky, 1987). Pollution inputs to the Lagos lagoon is chiefly land base and associated to anthropogenic activities. Additionally the weak and non implementation of existing environmental regulations is promoting nutrient enrichment in the lagoon and hence affecting cage culture potentials. According to McGinty & Rakocy (1989) greater risk from disease outbreak as a result of the less tolerance of fish to poor water quality act as major constraints in cage culture systems in natural water systems.

Since the periphyton are an important food component to fish especially in the wild and their abundance were clearly more in the dry season, it follows that there would be more food for fish at this time for capture in the lagoon. Additionally, the view of this study the effect of periphytic algae on the P.V.C.

pipes is negligible. Cage materials are usally durable, light weight, inexpensive, more resistant to biological fouling and more easily cleaned (McGinty & Rakocy, 1989; Ayoola, 2010).

Acknowledgement
I thank the department of Marine Sciences, University of Lagos for logistics support and use of its facilities.

References

Ajao, E.A. 1996. Review of the state of pollution of the Lagos lagoon. NIOMR Tech. Paper No. 106. 19pp.

APHA 1998. Standard Methods for the Examination of Water and Wastewater. (20th Ed.). American Public and Health Association, New York. 1270pp.

Ayoola, S. O. 2010. Morden fish farming techniques: aquaculture. Glamour books, Ibadan. 180pp.

Barber, H.G. and Harworth, E.Y. 1981. A guide to the morphology of diatom frustule. Freshwater Biol. Assoc. Publ., **44**: 9-11.

Desikachary, T.V. 1959. Cyanophyta. Indian Council of Agric. Research, New Delhi, 686pp.

Hendey, N.I. 1958. Marine diatom from West African ports. J. Royal Micros. Soc., **77**: 28-88.

Hendey, N.I. 1964. An introductory account of small-algae of British coastal water. Fishery investigation series V bacillariophyceae, London, IIMSO, 317pp.

Lovell, T. 1998. Nutrition and feeding of fish. Kluwer Academic Publishers, Massachusetts. 267pp

McGinty, A. S. and Rakocy, J. E. 1989. Cage culture of Tilapia. SRAC Publication No. 281. 4pp.

Nwankwo D. I. and Onitiri, A.O. 1992. Periphyton (Aufwuchs) Community on submerged aquatic macrophytes in Epe Lagoon, Nigeria. Journal of Agriculture Science and Technology 2(2): 135 – 141.

Nwankwo D. I. and Onitiri, A.O. 1992. Periphyton (Aufwuchs) Community on submerged aquatic macrophytes in Epe Lagoon, Nigeria. J. Agric. Sci. Technol., **2(2):** 135 – 141.

Nwankwo, D. I., Abosede A. O. and Abdulrasaq, Y. 1994. Floating Timber Log as substrate for periphyton Algae in the Lagos Lagoon, Nigeria. Polskie Archiwum Hydrobilogii., **41(4):** 419 – 430.

Nwankwo, D.I. 1996. Phytoplankton diversity and succession in Lagos lagoon, Nigeria. Arch. Fur. Hydrobiologie., **135(4):** 529-542.

Nwankwo, D.I. 2004a. A Practical Guide to the study of algae. JAS Publishers, Lagos. Nigeria. 84pp.

Nwankwo, D.I. 2004b. The Microalgae: Our indispensable allies in aquatic monitoring and biodiversity sustainability. University of Lagos Press. Inaugural lecture seris. 44pp.

Nwankwo, D.I. and Akinsoji, A. 1988. Periphyton algae of a eutrophic creek and their possible use as indicator. Nig. J. Bot., **1:** 47-54.

Nwankwo, D.I. and Akinsoji, A. 1989. The Benthic Algal Community of a Sawdust Deposition Site in Lagos Lagoon. Intl J. Ecol. Environ. Sci., **15**: 197-204.

Nwankwo, D.I. and Akinsoji, A. 1992. Epiphyte community of water hyacinth, Eichhornia crassipes (MART) Solms in coastal waters of South Western Nigeria. Arch. Fur. Hydrobiologie., **124(4)**: 501-511.

Nwankwo, D.I., Onyema, I.C. and Adesalu, T.A. 2003. A survey of harmful algae in coastal waters of south-western Nigeria. J. Nig. Environ. Soc., **1(2):** 241 – 246.

Onyema, I.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. Ecol. Environ. Conserv., **13(1):** 1 – 12.

Onyema, I.C. 2007. The phytoplankton composition, abundance and temporal variation of a polluted estuarine creek in Lagos, Nigeria. Turk. J. Fisher. Aqua. Sci., **7:** 89 – 96.

Onyema, I.C. 2009. Pollution and the ecology of coastal waters of Nigeria: Dolps and Bolps Investment Limited, Lagos, Nigeria. 216pp.

Onyema, I.C. 2010. Phytoplankton diversity and succession in the Iyagbe lagoon, Lagos. Euro. J. Scien. Res., **43 (1):** 61 – 74.

Onyema, I.C. and Nwankwo, D.I. 2006. The epipelic assemblage of a polluted estuarine creek in Lagos, Nigeria. Poll. Res., **25 (3):** 459 – 468.

Onyema, I.C., Nwankwo, D.I. and Oduleye, T. 2006. Diatoms and dinoflagellates of an estuarine creek in Lagos. J. Scient. Res. Dev., **10:** 73 – 82.

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. J. Scient. Res. Dev., **7:** 11-24.

Patrick, R. and Rumer, C.W. 1966-1975. The diatom of the United States 2 vols. Monograph of the academy of natural science. Philadephia.

Parrish, C. C. and Wangersky, P. J. 1987. Particulate and dissolved lipid classes in cultures of Phaeodactylum tricornutum frown in cage culture turbidostats with a range of nitrogen supply rates. Mar. Ecol. Prog. Ser., 35: 119 – 128.

Solarin, B.B. 1998. The hydrology, fishes and fisheries of the Lagos lagoon, Nigeria. Ph.D Thesis. University of Lagos, Akoka, Nigeria. 255pp.

Vanlandigham, S.L. 1982. Guide to the identification and environmental requirement and pollution tolerance of fresh water blue green algae (Cyanophyta). U.S. Environmental protection agency, EPA -60.

Webb, J.E. 1958. The Ecology of Lagos lagoon. 1: The lagoons of the Guinea Coast. Philosophical Transaction Royal Society London. Ser B, 241-283.

Whitford, L.A and Schmacher, G.H. 1973. A manual of fresh water algae. Sparks Press, Raeigh. 324pp.