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Nutrients to close Tropical Lagun for Primary Production

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Abstract: The primary production with regard to chlorophyll *a* concentration, nutrient (Nitrate-nitrogen, phosphate-phosphorus, sulphate, silicate), rainfall and salinity were characteristics investigated at 12 stations for two years for the Iyagbe lagoon, Lagos. The parameters reflected seasonal changes related to the inflow of nutrient rich water especially during the rains and tidal seawater incursion especially in the dry season. Whereas sulphate (20.8 - 1140mgl^{-1}), silica (0.9 - 6.0mgl^{-1}) and salinity (0.06 - 35.1%) recorded increased values in the dry than wet season, nitrate (3.3 - 59.8mgl^{-1}) and phosphate (0.01 - 1.68mg) recorded higher values in the wet than dry season. Values for chlorophyll *a* were higher in the dry than wet season. Positive spearman rank correlation coefficient was recorded between chlorophyll *a* concentrations and salinity, nitrate and sulphate. Recorded chlorophyll *a* values places the Iyagbe lagoon between the mesotrophic and eutrophic status. It is suggested that increasing tidal influence associated with reduced rain events may have encouraged elevated salinities and created conditions for the development of more algal cells, hence higher chlorophyll *a* estimates. Furthermore, the higher levels of nutrient recorded from the wet season (Nitrate-nitrogen, phosphate-phosphorus, sulphate, and silicate) were from Land-based sources.

Keywords: Physico-chemical factors, brackish, microalgae, hydroclimatic factors, Nigeria.

Introduction.

Lagoons are common features on the Guinea coast of West Africa (Webb, 1958). The Lagos lagoon complex is the largest of the four lagoon systems in this region. These lagoons usually experience seasonal changes in hydro-climatic features related to rainfall distributive pattern or / and connection to the sea. In Nigeria, there are ten lagoons found only in south-western Nigeria (Lagos). They were formed as a result of the alignment of the coastline to the dominant SW winds and the effect of the longshore current. They are the Ologe, Yewa, Badagry, Iyagbe, Kuramo, Onijedi, Lagos, Epe, Lekki and Mahin lagoons (Webb, 1958; Yoloye, 1974; Nwankwo, 2004; Onyema in press, 2012). These lagoons run parallel to the Gulf of Guinea coastline over a distance of about 237km (Ibe, 1988). Onijedi lagoon is the only closed lagoon in the region while the Kuramo lagoon is seasonally closed and flows into the sea in the wet season via the Kuramo creek (Afinowi, 1972; Yoloye, 1974; Nwankwo *et al*., 2008; Onyema *et al*, 2012). All the other eight, are open lagoons.

Until now, the primary production estimates for some of these lagoons and adjoining creeks have been measured using algal biomass in terms of numbers (Nwankwo, 1988, 1996, 1998; Onyema *et al*., 2003, 2007; Onyema and Nwankwo, 2006, Onyema, 2008a). In the estimation of primary production, the Chlorophyll *a* method is a more current, acceptable and reliable method in estimating micro-algal or phytoplankton production levels in aquatic ecosystems. For instance according to Sverdrup *et al*., (2006) chlorophyll concentration can be used to estimate the total quantity of plant material or biomass. Algal studies in the lagoons of south-western Nigeria have indicated high levels of phytoplankton production (Nwankwo, 1988, 1996) but pollution from domestic and industrial wastes are known to affect water quality and hence aquatic productivity (Chukwu, 2002; Chukwu and Nwankwo, 2004; Onyema and Nwankwo, 2006; Nwankwo, 2004) in the region.

Lagoons are affected by anthropogenic activities such as domestic, industrial, and agricultural wastes inputs (Nwankwo and Akinsoji, 1988, 1992; Ajao, 1996; Esteves, 1998; Onyema *et al*., 2007; Onyema, 2007a,b) and these activities are known to speed up the eutrophication progression. Hence nutrient pollution in coastal lagoons are usually associated with areas of high population, discharge of wastes from domestic and industrial facilities and weak or non existent enforcement of environmental standards/regulations (Chukwu, 2002, Nwankwo, 1996, 2004) .

There is a dearth of Chlorophyll *a* related literature in Nigeria especially in relation to nutrient levels. Whereas Kadiri (1993) reported on the Seasonal changes in the phytoplankton biomass of a shallow tropical reservoir, in Benin, Ogamba *et al*., (2004) reported on the Water quality and phytoplankton distribution in Elechi creek complex of the Niger delta. Both studies reflected chlorophyll *a* concentrations and trends. Take sentence from more recently, is a report by Onyema (2008 a,b) on the phytoplankton biomass and phytoplankton checklist of Iyagbe lagoon. The Iyagbe lagoon is one of the more poorly studied lagoons in the region. In the Lagos area, studies on Chlorophyll *a* estimate in relation to physic-chemical conditions include Onyema and Ojo, (2008) for Agboyi creek, Onyema *et al*., (2009) for Badagry creek, Onyema (2009) for Tomaro creek, Onyema (2009b) for the Onijedi lagoon. Additionally, there are few existing reports for the Iyagbe lagoon (Onyema, 2008 a,b) on the Phytoplankton biomass and phytoplankton checklist of Iyagbe lagoon. The Iyagbe lagoon is one of the more poorly studied lagoons in the region.

The aim of this study was to investigate the relationship between nutrient status and chlorophyll *a* concentration in the Iyagbe lagoon.

Materials And Methods

Description of study site.

The Iyagbe lagoon (Fig 1) is one of the ten lagoons in Lagos state, Nigeria. It is located between Latitude 6^0 26'N, Longitude 3^0 19' E and Latitude 6^0 23'N, Longitude 3^0 06' E (Webb, 1958; Onyema, 2008a,b). It is chiefly made up of the Porto-Novo and Badagry creeks. Salinity regime in the lagoon is seasonal with high salinities reported from around December to April and low salinities recorded between May and November. Generally points within the lagoon are more saline as proximity to the Lagos habour increases in both the wet and dry seasons. Like all parts of South-western Nigeria, the Iyagbe lagoon is exposed to two distinct seasons namely the wet (May – October) and the dry season (November – April) (Nwankwo, 2004). The harmmattan, a short season of dry, dusty North-East Trade winds are experienced sometimes between November and January in the region reducing visibility and lowering temperatures (Onyema *et al*., 2003). The lagoon area falls within the rain forest zone which experiences a well marked dry and wet seasons. The lagoon area experiences the semi-diurnal tidal regime same as the whole West African coast. Most of the Iyagbe lagoon area is colonized by a recognizable riparian mangrove swamp community. The lagoon is shallow at some point especially in the Badagry creek arm and is open all year round via the Lagos harbour to the sea. These mangrove environments are inhabited by amphipods, polychaetes, isopods, barnacles, oysters, periwinkles, nematodes, fiddler crabs, sea cucumbers, mangrove crabs, mudskippers and shrimps among others (Sandison and Hill, 1966; Onyema, 2008a). The notable macro-floral species in the area include *Rhizophora racemosa*, *R. harrisoni*, *Avicennia germinans*, *Phoenix reclinata*, *Raphia hookeri*, *Elaeis guineensis*, *Acrotiscum aureum* and *Cocos nucifera* (Akinsoji *et al*., 2002; Onyema 2008b).

Collection of samples.

Collection of water samples

12 stations were chosen for this study in other to cover the lagoon area and to reflect water salinity, nutrient characteristics and chlorophyll *a*. Twelve sampling stations (which include at least 7 confluence points) were selected to cover the lagoon area and for the collection of samples. Table 1 shows the G.P.S. location, names and number of sampling stations. Monthly surface water samples was collected for twenty-four consecutive months (October, 2004 – September, 2006) for nutrient (Nitrate-nitrogen, phosphate-phosphorus, sulphate, silicate) and salinity characteristics analysis using 500ml plastic containers with screw caps. Collection of samples from the stations was always between 10 and 15hr each time. Water samples were also collected for chlorophyll estimates just a few centimeters below the water surface at each of the twelve stations in plastic screw capped containers. All samples were then labeled appropriately and transported to the laboratory immediately for to further analysis.

Nutrient analysis.

Estimates for Nitrate-nitrogen, phosphate-phosphorus, sulphate and silicate were determined using method outlined by APHA (1998). Whereas for Nitrate-nitrogen and phosphate-phosphorus determination were by the Colorimetric method, sulphate estimate were obtained by Turbidimetric method and silicate by a Colorimeter (DR2010). Values for salinity were determined for the study using the HANNA Instrument (APHA, 1998). Rainfall values for the duration of study were supplied by the Nigerian Meteorological Agency, Lagos (NIMET).

Chlorophyll *a* analysis.

Analysis of Chlorophyll *a* levels were as described in APHA (1998).

Correlation Coefficient Values (r)

The Spearman's Rank correlation coefficient (r) (Ogbeibu, 2005) for the relationship between the salinity, rainfall nitrate-nitrogen, phosphate-phosphorus, sulphate, silicate and chlorophyll *a* parameters were obtained using the formula:

$$r = \frac{1 - 6\Sigma D^2}{N\,(n^2 - 1)}$$

Where r = correlation coefficient, $\sum D^2$ = sum of squares of difference of ranks and n = Number of months

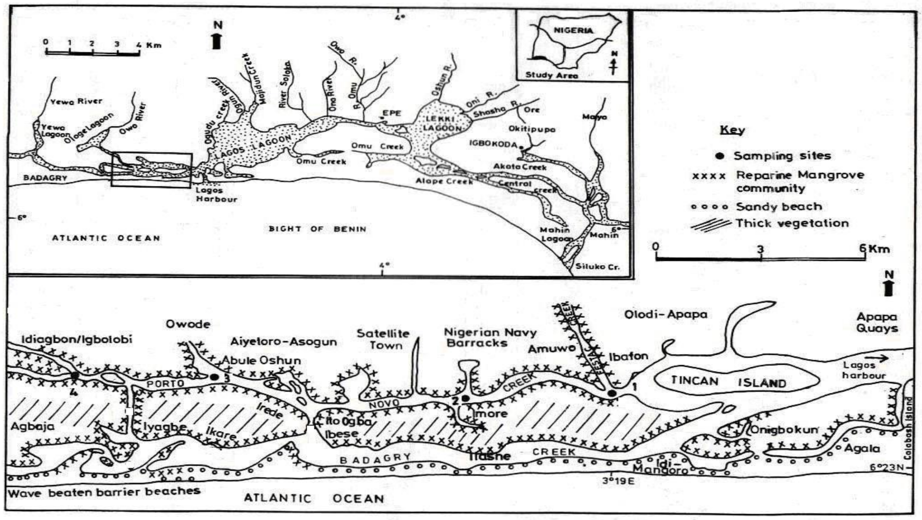

Fig. 1: Lagoons of South-western Nigeria and the Iyagbe lagoon showing the Porto-Novo creek and study stations

Table 1: G.P.S. location and station name of sampled areas in the Iyagbe lagoon.

Station No.	Station name	G.P.S. locations
Station 1	Calabash Island	Latitude 6° 25¹ .987 N, Longitude 3° 23¹.400 E
Station 2	Tin-can Island	Latitude 6° 25¹ .833 N, Longitude 3° 21¹ .532 E
Station 3	Ibafon	Latitude 6° 25¹ .964 N, Longitude 3° 19¹ .244 E
Station 4	Imore	Latitude 6° 25¹ .755 N, Longitude 3° 19¹ .915 E
Station 5	Ito-ogba	Latitude 6° 25¹ .409 N, Longitude 3° 14¹ .624 E
Station 6	Abule-oshun	Latitude 6° 26¹ .134 N, Longitude 3° 13¹ .224 E
Station 7	Idiagbon / Igbolobi	Latitude 6° 26¹.214 N, Longitude 3° 11¹ .826 E
Station 8	Iyagbe	Latitude 6° 25¹ .603 N, Longitude 3° 11¹ .990 E
Station 9	Agbaja	Latitude 6° 24¹ .473 N, Longitude 3° 12¹ .744 E
Station 10	Ikare	Latitude 6° 24¹ .632 N, Longitude 3° 13¹ .705 E
Station 11	Ilashe	Latitude 6° 24¹ .676 N, Longitude 3° 16¹ .938 E
Station 12	Idimangoro	Latitude 6° 24¹ .717 N, Longitude 3° 19¹ .307 E

Results.

Table 2 shows the recorded values for Chlorophyll *a*, Nitrate-nitrogen, phosphate-phosphorus, sulphate, silicate, salinity and rainfall values for the period.

Nitrate-nitrogen values were between 3.3 (November, 2005) and 59.8mg/L (June, 2006) whereas Phosphate-phosphorus recorded values between 0.01mg/L (January, 2006) and 1.68mg/L (August, 2005). Sulphate values ranged between 20.8 (October, 2005) and 1160mg/L
(January, 2006) throughout the sampling period. Silica values fell between 0.9 (August, 2005) and 6.0mg/L (September, 2006).

With respect to Chlorophyll *a* values, they were between 4.2 and 55 µg/L. Whereas the lowest value obtained was in June, 2005 (4.2µg/L), the highest value recorded was in November 2005 (55 µg/L). Furthermore, Chlorophyll *a* showed a positive relationship with salinity (r = 0.21), nitrate (r = 0.11), and sulphate (r = 0.20). A negative relationship existed between chlorophyll *a* and silicate (r = -0.18) and phosphates (r = -0.13) estimates.

Table 3: A summary of the minimum, maximum and mean / standard deviation estimate values Nitrate-nitrogen, phosphate-phosphorus, sulphate, silicate, salinity, rainfall and chlorophyll *a* for the Iyagbe lagoon.

	Parameter/ Unit	Minimum value	Maximum value	Mean value ± S.D.	Higher values reported in the ….

1	**Rainfall (mm)**	6	315.7	141.83 ± 116.87	Wet season
2	**Salinity (‰)**	0.06	35.1	14.43 ± 18.10	Dry season
3	**Nitrate – nitrogen (mgL^{-1})**	3.3	59.8	10.54 ± 8.37	Wet season
4	**Phosphate – phosphorus (mgL^{-1})**	0.01	1.68	0.26 ± 0.29	Wet season
5	**Sulphate (mgL^{-1})**	20.8	1140	279.71 ± 232.16	Wet season
6	**Silica (mgL^{-1})**	0.9	6.0	2.63 ± 0.91	Dry season
7	**Chlorophyll *a* (µg/L)**	4.2	55	19.63 ± 7.90	Dry season

Discussion

With regards to the salinity data within the lagoon, it is obvious that there exist a decrease in maritime influence as points on the lagoon were increasingly distant from the habour. Consequently, there existed environmental gradients from the habour to areas in the lagoon further inland. According to Sandison and Hill (1966), all the waters entering from the West of the Lagos habour flow through the Badagry creek, and the Lagos habour forms the main outlet to the sea for the brackish and freshwater flowing through the marginal lagoon system of south-western Nigeria.

The physico-chemical parameters of the Iyagbe lagoon exhibited seasonal changes that were closely related to the distributive pattern of rainfall, for the region. For instance the wet season recorded increased values for nitrate and phosphates while the dry season reported high values for Chlorophyll *a*, sulphate, silica and salinity. Primary production in terms of Chlorophyll *a* concentration was thus noticeably higher in the dry season than during the rains. This dry season period is also known to be associated with higher light energy from the sun reaching the region and this is necessary for photosynthesis. According to Brown and Kusemiju (2002), rainfall pattern in the tropics creates the dry and wet season experienced in West Africa. These seasonal differences determine salinity in coastal waters, nutrient and aquatic biota distribution (Onyema, 2009 *a*). According to Onyema *et al*., (2003) increasing tidal influence occasioned by dry and more stable conditions is known to elevate salinity and create conditions suitable for the survival of marine species in the Lagos lagoon.

Chlorophyll *a* values were lower in the wet season, which likely indicated limited phytoplankton production. This trend may be linked to the low water clarity which reduces the amount of light getting to planktonic algal components for photosynthesis to take place. Additionally is the effect of flushing of planktonic algal forms towards the sea during the rains by flood waters. This could also account for the low chlorophyll-*a* values recorded. According to Suzuki *et al*. (2002), low chlorophyll *a* values reflecting limited phytoplankton growth in an investigation of a Mexican lagoon were associated to dark water which reduced light penetration into the lagoon considerably. According to Kadiri (1993), the typical seasonal pattern of variation in chlorophyll *a*, has a single major peak usually occurring in the dry season between January and February and a minor peak occurring in the late rainy season between August and November, in the Ikpoba reservoir, Edo state Nigeria. Consequently higher chlorophyll-*a* values recorded in the dry season is probably a pointer to improved water clarity that allowed greater light penetration required for photosynthesis.

For instances, Chindah and Braide (2003) also recorded positive correlation between chlorophyll *a* values and water temperature, pH, alkalinity, sulphate and micro algal abundance ($r = 0.657 - 0.967$). Furthermore, Ogamba *et al*., (2004) reported a range of 0.15 – 37.4µg/l for the wet season and 0.10 and 40.28µg/l for chlorophyll *a* estimates. The range of chlorophyll values for the Iyagbe lagoon was between 12 and 55µg/l. Kadiri (1993) reported a range of 4.20 – 35.20 mgm^{-3} for chlorophyll *a*.

Data and trend from this study showed higher nutrients (especially nitrate and phosphates) available within the Iyagbe lagoon in the wet season. This is probably a reflection of the introduction of a large amount of allochthonous materials from the region as floodwater emptied into the lagoon and scoured the bottom of adjoining aquatic ecosystems. Similar findings have been recorded for the Lagos lagoon and habour (Olaniyan 1969, 1975; Nwankwo and Akinsoji, 1989; Onyema and Nwankwo, 2006). For instance, Suzuki *et al*., (2002) in a Mexican lagoon reported an increase in salinity values and total nutrient concentrations during a sand bar opening period, with a corresponding decrease in Chlorophyll *a* concentration. Kadiri (1993) is of the view that seasonal fluctuation in abundance of phytoplankton hence Chlorophyll *a* is influenced by changes in the physical and chemical properties of the water.

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