WET SEASON CHLOROPHYLL *a, b* AND PHAEOPHYTIN *a* LEVELS IN THE WESTERN LAGOS LAGOON AND ITS CREEKS.

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ABSTRACT

Algae are known to contain a wide array of pigments that absorb light for photosynthesis and which are useful in measuring primary production levels. In this study, the levels of these algal pigments (Chlorophyll *a, b* and phaeophytin *a*) in the Lagos lagoon and adjoining creeks were investigated in relation to water chemistry of the water bodies. Fifteen sampling stations including four of the creeks were investigated for the study. For the creeks, chlorophyll *a* ranged from 9.6 to 23.3µg/L, chlorophyll *b*, 0.4 - 1.1ug/L and phaeophytin *a*, 1.1 - 2.9µg/L. For the open lagoon areas chlorophyll *a* ranged between 8.9 and 11.8µg/L, chlorophyll *b,* between 0.6 and 1.1ug/L and phaeophytin *a* between 0.7 and 3.4µg/L. The Pearson correlation co-efficient matrix among chlorophyll *a*, *b* and phaeophytin *a* were all positive (r = 0.28 – 0.35). The positive correlation among all the three algal pigments points to their direct relationship. Chlorophyll *a* was negatively correlated with salinity. The levels of algal pigments increased as Nitrate (nutrient) and Total Suspended Solids increased, however chlorophyll *a* was negatively correlated with salinity and was higher in the creeks than the lagoon. Salinity was a limiting factor to algal production in the Lagos lagoon (especially in the wet season) chiefly because most phytoplankton forms at this time were (freshwater forms). Chlorophyll *b* levels indicated the presence of green algae and euglenoids within the study area. Phaeophytin *a* also increased with increasing floodwater inputs reflected by its correlation with Nitrate and Total Suspended Solids or detrital materials (r = 0.44, 0.60). The measurement of phytopigment content could also be a useful tool in the establishment of eutrophic levels within within aquatic ecosystems in Nigeria, particularly the Lagos lagoon complex.

Keywords: Phytoplankton, perturbation, aquatic productivity, salinity, coastal ecosystem**.**

INTRODUCTION

The algae are a very diverse group of simple mostly aquatic (both marine and freshwater) photosynthetic organisms (Castro and Huber, 2005). According to Opute and Kadiri (2013), algae are defined as chlorophyll containing photosynthetic lower plants without true roots, stems, leaves but which have primitive reproductive structures. Algae are known to contain a wide array of pigments that absorb light for photosynthesis (Kadiri, 1999). The major photosynthetic pigments are chlorophylls, carotenoids and phycobiliproteins (Nwankwo, 2004). Chlorophylls are green pigments with a porphyrin-like ring structure, a central magnesium atom and usually a long hydrophobic tail. Chlorophyll *a* is a specific form of chlorophyll used in oxygenic photosynthesis whereas chlorophyll *b* is a form of chlorophyll that helps in photosynthesis by absorbing light energy and found usually in the green algae (Lee, 2008).

Phaeophytin on the other hand is a natural degradation product of chlorophyll. Alagl phaeophytin pigment is a chlorophyll molecule lacking a central Mg^{2+} ion (Lee, 2008). Chlorophylls are capable of channeling the energy of sunlight into chemical energy through the process of photosynthesis (Bold, 1967). In photosynthesis, the energy absorbed by chlorophyll transforms carbon (IV) oxide and water into carbohydrate and oxygen hence the concentration of photosynthetic pigments is commonly used to estimate phytoplankton biomass (Onyema and Ojo, 2008). This feature makes chlorophyll *a* and other algal pigments a convenient indicator of algal biomass.

Photosynthesis in the algae and phytoplankton takes place in the chloroplast that contain photosynthetic pigments. The colour of algae is usually a result of these pigments and their concentration (Bold, 1967; Castro and Huber, 2005; Lee, 2008). It is useful to measure primary production levels especially in the phytoplankton because the process supplies food at the base of the aquatic trophic pyramid (Thurman, 2007). According to Castro and Huber (2005), the standing stock of phytoplankton is the total amount in the water columns.

Studies on the Lagos lagoon and adjoining creeks since the 1950's have largely been on biomass measured in terms of numbers or phytoplankton cell counts (Fox, 1957; Hendey, 1958; Olaniyan, 1969; Nwankwo, 1988; 1996; Onyema, 2007; Onyema *et. al*., 2003; 2007). This is also similar to studies in other parts of the country hitherto (Mills, 1932; Kadiri, 1999; 2005; Holden and Green, 1960; Chindah and Pudo, 1991; Erondu and Chindah, 1991). The measurement of algal biomass as algal pigments has received little attention and only recently in the study area (Onyema and Ojo, 2008; Onyema and Nwankwo, 2009; Nwankwo *et. al*., 2012; 2103). There is no previous study on the use of chlorophyll *a* and *b* as well as phaeophytin *a* in the measure of the standing crop of phytoplankton in the western Lagos lagoon and its connecting creeks either in the wet or dry season. This study measured these algal pigments in relation to the water chemical characteristics of the water bodies as a part of a much larger study on the production status of the Lagos lagoon.

MATERIALS AND METHODS

Description of Study Area

The Lagos lagoon is located in Lagos State, Nigeria. It is one of the ten lagoons in South-western Nigeria (Onyema and Bako, 2015). It is a large, open, shallow and tidal coastal lagoon connected to a number of creeks (Fig. 1). It covers an area of $208km^2$ (FAO, 1969) and has an average depth of less than 2m (Ajao, 1996) except for areas that are often dredged for marine traffic or from sand mining operations. The Lagos lagoon is connected to the Epe, Lekki and Mahin lagoons to the east respectively and it falls within the rainforest zone which experiences a well-marked dry and a wet season with two peaks of rainfall. The area experiences the semi-diurnal tidal regime which is a characteristic of the whole of the coast of West African. The Lagos habour is the only connection to the sea for nine of the ten lagoons in south-western Nigeria. The Onijegi lagoon is the only true closed lagoon in the area (Onyema, 2013). The lagoon environment is largely influenced by rainfall and its associated floodwaters which dilutes the lagoon water, breaks down environmental gradients and enriches the environment through floodwaters. On the other hand marine influence from tidal incursion from the Lagos harbor is experienced inland especially in the dry season.

Lagos lagoon is an estuarine lagoon which serves as a fertile ground for feeding, breeding and as a nursery area for a number of aquatic organisms (Nwankwo, 2004). It provides habitation for a number of anadromous, catadromous and estuarine fin and shell fish species (Solarin, 1998) while being a site for fin and shellfish capture and culture (Akpata *et al*., 1993). With regards to capture and culture of fish in the Lagos lagoon, the brush parks or “Acadja” and other semi-extensive systems in the lagoons of South-western Nigeria and adjoining creeks are noteworthy (Onyema, 2011; Onyema *et al*., 2011). The lagoon also serves as a waste dumping site for unmonitored and unregulated discharges at various points over the years. These points are more on the more industrialized and more impacted western parts of the lagoon area. Hence this area of the lagoon was the focus of this study.

The study area specifically, covers the western parts of the Lagos lagoon stretching from the Ikorodu area through Ajegunle and Agboyi creeks (Ogun river tributaries), Oworonsoki and Bariga areas, Abule-eledu and Abule –agege creeks, western mid lagoon points, Okobaba and Ebute-meta areas. In this region, creeks, channels, storm water drains and rivers flow into the lagoon as well as tidal seawater incursion which is semi-diurnal in nature from the Lagos habour. Nutrient rich water and pollutants are known to flow into the lagoon through these points. Furthermore, poor sewerage systems are common among the dwellers of the immediate area. Hence direct dumping of domestic wastes is rampant in the region.

According to authors, the biotic spectrum of the Lagos lagoon depends on the dynamic interplay between the volume of freshwater inflow and seawater incursion. Table 1 presents the name and approximate G.P.S. grid co-ordinates of the fifteen sampling studied (including four creeks). All samples were collected once monthly.

Table 1: G.P.S. grid Location of Sampling Stations in the Western Lagos lagoon and Adjoining Creeks.

Station name	Station No.	G.P.S. locations Latitude (N) Longitude (E)
Ajegunle creek	**St. 1**	6.6002074N, 3.4545018E
	St. 2	6.5936962N, 3.4607192E
Agboyi creek	**St. 1**	6.5948669N, 3.4423538E
	St. 2	6.5897794N, 3.4424450E
Northern Lagos lagoon	**St. 1**	6.5704175N, 3.4249952E
	St. 2	6.5597767N, 3.4330639E
Oworonsoki/ Bariga	**St. 1**	6.5151345N, 3.4033658E
	St. 2	6.5148877N, 3.4049661E
Abule-eledu creek	**St. 1**	6.5829892N, 3.4495783E
	St. 2	6.5776592N, 3.4554902E
Mid Lagos lagoon	**St. 1**	6.5215868N, 3.4106443E
	St. 2	64972841N, 3.4039982E
Abule-Agege-creek	**St. 1**	6.5286296N, 3.4127894E
	St. 2	6.5245381N, 3.4100331E
Okobaba	**St. 1**	6.4926490N, 3.3961138E

Physico-chemical Analysis

Air and water temperatures were measured using mercury – in – glass thermometer. Transparency was estimated with a Secchi disc, whereas rainfall data was supplied by NIMET, Oshodi, Lagos. Methods as described by APHA (2013) were employed in estimating Salinity, Conductivity, pH, Total Suspended Solids, Total Dissolved Solids, Dissolved oxygen, Chemical Oxygen Demand, Biological Oxygen Demand, Nitrate, Phosphate, Sulphate, Silica, Calcium, and Magnesium. Heavy metal (Copper, Lead and Iron) were measured using an Atomic Absorption Spectrophotometer (Perkin Elmer 5000 AAS and Perkin Elmer) Application methods, (2002).

Pigment Analysis

Chlorophyll concentrations in water samples were determined using a spectrophotometer with a 2 nm spectral bandwidth. It was prepared in line with the guidelines of EPA Method 446.0, Revision 1.2, 1997 and Standard Methods for the Examination of Water and Wastewater, 20th Edition, Method, 10200H. By this method, a 200 mL aliquot of the water sample was filtered, in a dark room, through a membrane or glass fibre filter paper. The pigment is extracted from the filter paper through maceration, and centrifugation in 90% acetone. The extract is then analyzed, before and after acidification, using a spectrophotometer. Addition of acid converts chlorophyll *a* to pheophytin *a*. The detection limit for this method is 5 μg/L, for a 200 mL filtered sample volume and a 20 mL extract volume.

The algal pigments were determined as follows:

1. Chlorophyll *a* [corrected; (μg/L)] = $\frac{26.7 * (A664b - A665a) * V_{extract}}{V_{filtered} * L}$

2. Pheophytin *a* (μg/L) = $\frac{26.7 * [1.7(A665a) - A664b] * V_{extract}}{V_{filtered} * L}$

3. Chlorophyll *b (μg/L)* = $\frac{[21.03(A647) - 5.43(A664) - 2.66(A630)] \times Vextract}{L \times Vfiltered}$

4. *Chlorophyll *a (μg/L)* = $\frac{[11.85(A664) - 1.54(A647) - 0.08(A630)] \times Vextract}{L \times Vfiltered}$

Where:

$V_{extract}$ = volume of extract (mL)
$V_{filtered}$ = volume of sample filtered (L)
L = light path length or width of cuvette, cm
664*b* = corrected absorbance of extract before acidification
665*a* = corrected absorbance of extract after acidification
The value 26.7 is the absorbance correction factor, and equals $A \times K$

Where:

A = absorbance coefficient for chlorophyll *a* at 664 nm = 11.0
K = ratio expressing correction for acidification = 2.43

**Un-corrected chlorophyll a*

Determination of Correlation Coefficient (r)

Pearson correlation analysis (Ogheibu, 2005) was applied to the environmental characteristics and Chlorophylls *a, b* and phaeophytin *a* levels.

$$r = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}}$$

Where r = Pearson correlation coefficient, where x and y are the sample means AVERAGE (array 1) and AVERAGE (array 2).

RESULTS

The water chemistry data of the 15 sampled stations showed variations from station to station even within the same creek or immediate area. Table 2 shows the minimum, maximum values as well as the mean and standard deviation of all the investigated parameters at the 15 stations. Table 3 shows the lowest and highest values of Chlorophyll *a*, *b* and phaeophytin *a* algal pigments as well as the mean and standard deviation values. Over all the 15 sampled stations, chlorophyll *a* ranged from 8.9 to 23.3µg/L, chlorophyll *b* ranged from 0.4 to 1.4ug/L and phaeophytin *a* was between 0.7 and 3.4µg/L.

For the four creeks stations, chlorophyll *a* ranged from 9.6 to 23.3µg/L, chlorophyll *b* ranged from 0.4 to 1.1µg/L and phaeophytin *a* was between 1.1 and 2.9µg/L, while for the open lagoon areas chlorophyll *a* ranged from 8.9 and 11.8µg/L chlorophyll *b* ranged from 0.6 to 1.1ug/L and phaeophytin *a* was between 0.7 and 3.4µg/L. The Ajegunle creek was the most productive of all the creeks studied followed by the Agboyi creek.

The pearson correlation co-efficient matrix between chlorophyll *a*, *b* and phaeophytin *a* was positive in all counts ranging from r = 0.28 – 0.35 (Table 4). The Pearson correlation co-efficient matrix between the water chemistry parameters and the three algal pigments are shown in Table 5. For instance chlorophyll *a*, *b* and phaeophytin *a* were all negatively correlated with Dissolved oxygen, Copper, Alkalinity and Chemical Oxygen demands whereas they were positively correlated with Iron, Nitrate, Phosphate and Total suspended solids. More specifically chlorophyll *a* was negatively correlated with salinity and salinity related parameters (Total dissolved solid, conductivity, Sodium, Potassium, Calcium and Magnesium).

Table 2: Water Chemistry of Western Lagos lagoon and Adjoining Creeks. (June, 2015)

Parameter	Minimum	Maximum	Mean	±STD
pH @ 25°C	6.06	7.86	7.17	0.42
Conductivity (µS/cm)	240.1	36900.2	11714.9	11702.
TSS (mg/L)	1	18	8.15	5.00
TDS (mg/L)	135	23985	7384.7	7602.1
Salinity (ppt)	0.11	22.9	6.86	7.25
Acidity (mg$CaCO_3$/L)	2.1	4.9	3.36	0.72
Alkalinity (mg$CaCO_3$/L)	39	307.2	165.45	75.27
Total Hardness (mg$CaCO_3$/L)	140	4795.2	2008.0	1677.2
DO (mg/L)	4.8	5.6	5.17	0.23
BOD_5 (mg/L)	1	3	2.04	0.72
COD (mg/L)	3	9	6.33	1.82
Chloride (mg/L)	35.1	15500	4248.8	4737.2
Nitrate (mg/L)	3.99	20.1	9.85	4.06
Sulphate (mg/L)	113.1	1900.1	755.47	603.76
Phosphate (mg/L)	0.48	3.27	1.30	0.89
Silica (mg/L)	1.1	9	2.99	2.29
Calcium (mg/L)	15.2	215.1	90.53	56.32
Magnesium (mg/L)	23.9	1014.1	416.50	362.63
Sodium (mg/L)	40.1	8928.2	2490.6	2740.5
Potassium (mg/L)	4.9	189	67.14	51.36
Zinc (mg/L)	0.004	0.019	0.01	0.00
Iron (mg/L)	0.019	0.07	0.05	0.014
Copper (mg/L)	0.00	0.01	0.01	0.00
Cadmium (mg/L)	0.00	0.00	0.00	0.00
Lead (mg/L)	0.001	0.002	0.00	0.00
Chromium (mg/L)	0.001	0.004	0.00	0.00
Manganese (mg/L)	0.014	0.061	0.033	0.01

It is important to note that the highest positive correlation values were between chlorophyll *a* and nitrate levels (r = 0.78), Chlorophyll *b* (r = 0.43), phaeophytin *a* (r = 0.44). Phaeophytin *a* was also positively correlated with total Suspended solids (r = 0.60) and negatively correlated with Chemical Oxygen demand (r = -0.71).

DISCUSSION

The chemical data obtained from this study show an estuarine zone stretching from low to high brackish water situations (0.11 – 22.9‰). Ecologists have attributed salinity gradients in the Lagos lagoon to two main factors namely influx of flood waters from rivers, creeks, surrounding wetlands and tidal sea water inflow through the Lagos harbour (Nwankwo, 1990; Onyema, 2009; Nkwoji, *et. al*., 2010). Lagoons and creeks are diluted considerably by freshwater from rainfall and river systems in the wet season, while in the dry season tidal seawater inflow becomes more prominent (Chukwu, 2002; Nwankwo, 2004). The positive correlation among all three algal pigments points to the connectedness of the pigments having a similar and related trend. So as one algal pigment increases, others similarly increase as well.

Levels of Chlorophyll *a* as reported

(8.9 -23.3 µg/L) were within the range previously reported by authors in the region. For instance, the Iyagbe lagoon, chlorophyll *a* had a range of 4.2 - 55 µg/L. Also Nwankwo *et. al*. (2012) recorded higher values for chlorophyll *a* in the Five Cowrie creek (≤0.44mg/L) than the Light house creek. According to these authors, levels were higher in the dry than in wet season. According to Onyema and Nwankwo (2009), in a study on the Iyagbe lagoon, there were positive correlation between chlorophyll *a* values, salinity, total dissolved solids, alkalinity, pH, conductivity, total hardness and chloride values. They also reported that the flushing of planktonic algal forms towards the sea during the rains by flood waters and hence dilution, could also account for the low chlorophyll *a* values (phytoplankton densities) recorded during the wet season. Chlorophyll *a* was negatively correlated with salinity in this study possibly because samples were collected only in the wet season. The positive relationship (correlation) between Iron, Nitrate, Phosphate and Total suspended solids is noteworthy. Increase in the level of nutrients led to corresponding increases in all algal pigments within the aquatic systems. Iron as a limiting factor in the marine and oceanic environments has been researched (Lee, 2008; Sverdrup *et. al*. 2003). Allochthonus (Land based) materials (Total Suspended solids) are known sources of nutrients, heavy metals and even pollutants (Ajao, 1996; Nwankwo, 2004; Onyema, 2009). Chlorophyll *a* was indirectly related with salinity, Total dissolved solids and cations levels. As reported by Onyema and Nwankwo, (2009) the range of chlorophyll *a* values for the Iyagbe lagoon in a two-year study was between 12 and 55µg/L that is between the mesotrophic and eutrophic productivity status (Suzuki *et. al*., 2002, APHA, 1998). For the wet season in the western Lagos lagoon and its creeks, levels of between 8.9 and 23.3 µg/L for chlorophyll *a*, 0.4 and 1.4 µg/L for chlorophyll *b* 0.7 and 3.4 µg/L for Phaeophytin *a* were reported. Furthermore, Ogamba *et al*., (2004) reported a chlorophyll *a* range of 0.15 – 37.4µg/L for the wet season and 0.10 - 40.28µg/l for the dry season in the Elechi creek in the Niger delta. Kadiri (1993) also reported a range of 4.20 – 35.20 mgm^{-3} for chlorophyll *a* for the Ikpoba reservoir in Benin.

It is worthy of note that salinity is acting as a limiting factor to algal production in the Lagos lagoon especially in the wet season. This may be as a results of the fact that most phytoplankton forms at this time are freshwater species and have drifted from freshwater creeks and rivers drifted downstream into the Lagos lagoon with floodwaters. This is evident in the negative correlation between salinity and algal pigments. Hence, areas with higher salinities (in the wet season) had lower algal pigments concentrations, particularly Chlorophyll *a*.

According to Onyema (2008), reduced phytoplankton densities as reflected in chlorophyll *a* values in the wet season may be linked to the low water clarity which reduces the amount of light getting to planktonic algal component for photosynthesis. Higher chlorophyll *a* values recorded in the dry season is a pointer to improved water clarity (higher transparency and lower total suspended solids) at this time which probably allowed greater light penetration. 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.

Table 2: Chlorophyll *a, b* and Phaeophytin *a* at the Western Parts and Creeks of the Lagos lagoon. (June, 2015)

Pigment	Ajegunle creek		Agboyi creek		Northern Lagos lagoon		Oworonsoki/ Bariga		Abule-eledu creek		Mid Lagos lagoon		Abule-Agege-creek		Okob aba
	St.1	St.2	St.1	St. 2	St. 1	St. 2	St. 1	St. 2	St.1	St. 2	St.1	St.2	St. 1	St. 2	
Chlorophyll *a* (µg/L)	23.3	10.1	12.6	13	9.9	8.9	9.9	11.8	11.7	9.6	11.1	10.2	9.7	13.1	10.2
Chlorophyll *b* (µg/L)	1.1	0.7	0.8	0.5	0.6	0.9	0.9	1.1	1	1	0.9	0.6	0.6	0.4	0.7
Phaeophytin *a* (µg/L)	2.9	1.6	1.1	1.9	2.1	2.2	1.3	3.4	1.6	2.6	0.7	2.2	1.1	1.8	2.2

Table 3: Statistical measures of Chlorophyll *a, b* and Phaeophytin *a* at the Western Parts anCreeks of the Lagos lagoon. (June, 2015)

Pigment	Min.	Max.	Mean	±S.T.D.
Chlorophyll *a* (µg/L)	8.9	23.3	11.4	3.5
Chlorophyll *b* (µg/L)	0.4	1.4	0.8	0.3
Phaeophytin *a* (µg/L)	0.7	3.4	2.1	0.7

Table 4: Pearson Correlation Co-efficient Matrix Water Chemistry Characteristics, Chlorophyll *a, b* and Phaeophytin *a* at the Western Parts and Creeks of the Lagos lagoon. (June, 2015).

Parameter		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
pH @ 25°C	1	1.00																														
Conductivity (µS/cm)	2	0.07	1.00																													
TSS (mg/L)	3	0.03	-0.17	1.00																												
TDS (mg/L)	4	0.06	1.00	-0.15	1.00																											
Salinity (ppt)	5	0.05	0.98	-0.19	0.97	1.00																										
Acidity (mg/L)	6	-0.16	-0.07	0.01	-0.06	-0.08	1.00																									
Alkalinity (mg/L)	7	0.42	0.40	-0.37	0.38	0.40	-0.27	1.00																								
Total Hardness (mg/L)	8	0.00	0.95	-0.23	0.95	0.93	0.06	0.45	1.00																							
DO (mg/L)	9	-0.46	0.03	-0.70	0.01	0.07	0.25	0.22	0.13	1.00																						
BOD5 (mg/L)	10	-0.13	-0.41	0.74	-0.40	-0.43	-0.04	-0.36	-0.39	-0.48	1.00																					
COD (mg/L)	11	-0.02	-0.06	-0.14	-0.08	-0.07	0.06	0.33	-0.06	0.42	0.22	1.00																				
Chloride (mg/L)	12	0.07	1.00	-0.13	1.00	0.97	-0.03	0.39	0.95	0.01	-0.37	-0.04	1.00																			
Nitrate (mg/L)	13	-0.25	-0.31	0.26	-0.30	-0.32	-0.01	-0.42	-0.43	-0.22	0.06	-0.36	-0.29	1.00																		
Sulphate (mg/L)	14	0.14	0.49	0.31	0.49	0.52	-0.36	0.27	0.50	-0.55	0.13	-0.33	0.49	-0.15	1.00																	
Phosphate (mg/L)	15	-0.25	-0.38	0.33	-0.37	-0.34	0.43	-0.36	-0.28	-0.19	0.37	-0.04	-0.35	0.10	0.01	1.00																
Silica (mg/L)	16	0.21	-0.44	0.64	-0.43	-0.44	0.47	-0.51	-0.47	-0.50	0.61	0.05	-0.39	0.22	-0.12	0.47	1.00															
Calcium (mg/L)	17	-0.13	0.82	-0.13	0.82	0.81	-0.05	0.43	0.91	0.02	-0.25	-0.18	0.83	-0.33	0.64	-0.09	-0.51	1.00														
Magnesium (mg/L)	18	0.03	0.95	-0.24	0.95	0.93	0.07	0.45	1.00	0.15	-0.39	-0.04	0.95	-0.45	0.47	-0.31	-0.45	0.88	1.00													
Sodium (mg/L)	19	0.14	0.98	-0.09	0.98	0.97	-0.11	0.45	0.92	-0.07	-0.36	-0.04	0.99	-0.28	0.58	-0.35	-0.37	0.81	0.92	1.00												
Potassium (mg/L)	20	0.17	0.95	-0.25	0.94	0.95	-0.20	0.59	0.88	0.11	-0.48	0.08	0.94	-0.34	0.45	-0.50	-0.52	0.76	0.88	0.95	1.00											
Zinc (mg/L)	21	0.02	-0.80	0.20	-0.79	-0.88	0.34	-0.33	-0.72	-0.02	0.44	0.16	-0.77	0.08	-0.59	0.36	0.52	-0.66	-0.71	-0.82	-0.83	1.00										
Iron (mg/L)	22	-0.13	-0.27	0.34	-0.24	-0.37	0.24	-0.62	-0.21	-0.40	0.44	-0.36	-0.24	0.15	-0.08	0.41	0.41	-0.16	-0.21	-0.32	-0.54	0.52	1.00									
Copper (mg/L)	23	0.35	-0.56	0.12	-0.56	-0.59	-0.04	-0.14	-0.59	-0.07	0.20	0.16	-0.57	-0.20	-0.43	0.11	0.33	-0.71	-0.55	-0.57	-0.56	0.64	0.33	1.00								
Cadmium (mg/L)	24	-0.40	-0.68	0.18	-0.67	-0.71	0.26	-0.47	-0.61	0.13	0.40	0.05	-0.68	0.19	-0.42	0.26	0.24	-0.57	-0.60	-0.74	-0.76	0.66	0.44	0.43	1.00							
Lead (mg/L)	25	-0.18	-0.38	0.09	-0.38	-0.39	-0.22	-0.01	-0.20	-0.03	0.43	0.05	-0.39	-0.33	0.23	0.07	-0.10	-0.05	-0.21	-0.38	-0.40	0.32	0.25	0.24	0.55	1.00						
Chromium (mg/L)	26	-0.11	-0.75	0.16	-0.73	-0.81	0.11	-0.22	-0.60	-0.13	0.36	-0.20	-0.74	0.20	-0.22	0.44	0.20	-0.38	-0.62	-0.76	-0.81	0.78	0.57	0.42	0.70	0.57	1.00					
Manganese (mg/L)	27	-0.15	-0.58	0.20	-0.58	-0.61	-0.04	-0.63	-0.62	-0.16	0.46	0.08	-0.57	0.33	-0.33	0.07	0.40	-0.69	-0.59	-0.60	-0.69	0.48	0.57	0.50	0.63	0.34	0.38	1.00				
Nickel (mg/L)	28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00			
Chlorophyll *a* (µg/L)	29	-0.29	-0.53	0.15	-0.52	-0.54	-0.14	-0.39	-0.56	-0.13	0.01	-0.48	-0.53	0.78	-0.14	0.07	0.01	-0.33	-0.60	-0.52	-0.50	0.25	0.09	-0.13	0.34	0.07	0.48	0.23	0.00	1.00		
Chlorophyll *b* (µg/L)	30	-0.44	0.14	0.28	0.14	0.15	0.11	-0.40	0.10	-0.09	0.06	-0.12	0.15	0.43	0.21	0.11	0.01	0.10	0.08	0.15	0.04	-0.33	0.04	-0.41	0.24	0.02	-0.16	0.26	0.00	0.28	1.00	
Pheophytin *a* (µg/L)	31	0.00	0.22	0.60	0.24	0.20	0.01	-0.38	0.12	-0.69	0.10	-0.71	0.23	0.44	0.48	0.32	0.27	0.25	0.08	0.26	0.07	-0.22	0.33	-0.26	-0.20	-0.31	-0.02	-0.15	0.00	0.32	0.35	1.00

Table 5: Pearson Correlation Co-efficient Matrix between Chlorophyll *a, b* and Phaeophytin *a* at the Western Parts and Creeks of the Lagos lagoon. (June, 2015)

	Chlorophyll *a* (µg/L)	Chlorophyll *b* (µg/L)	Pheophytin *a* (µg/L)
Chlorophyll *a* (µg/L)	1.00	0.28	0.32
Chlorophyll *b* (µg/L)		1.00	0.35
Pheophytin *a* (µg/L)			1.00

According to Sheath and Wehr (2003), Chlorophyll *b* is only found in the green algae and euglenoids with regards to algal photosynthetic pigments. Green algae and euglenoid species have been recorded almost exclusively in the wet season and in fresh or very low salinity seasons in the Lagos lagoon system and creeks (Nwankwo, 1995; Nwankwo and Akinsoji, 1992; Onyema, 2008, 2010). This may explain why Chlorophyll *b* concentration reduced with increasing salinity and vice versa. Additionally, it also indicated the presence of green algae and or euglenoids within the study area.

According to Sheath and Wehr (2003), green algae are widespread in inland habitats, but certain groups may have specific ecological requirements. The green algae and euglenoids are usually found in standing or slowly moving nutrients rich waters with light and temperature usually high. They are also common in stagnant waters, ditches, streams and ponds and the littoral zones of lakes and on soil and sub-aerial habitats. Phaeophytin *a* also increased with increasing floodwater inputs reflected by its correlation with Total Suspended Solids or detrital materials (r = 0.60). Correlation trends among the water chemistry parameters are similar to that described by Onyema and Nwankwo, (2009) for the Iyagbe lagoon. Conversely, according to Kowalewska *et al.,* (2004), a lack of correlation between chlorophylls *b, c* and chlorophyll *a* indicated that the intensive blooms of cyanobacteria occurs in the Szczecin lagoon, which is a characteristic eutrophic zones. The measurement of phytopigment content could also be a useful tool in the establishment of eutrophic levels (Kowalewska *et al.,* 2004).

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