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Water Chemistry and Chlorophyll-*a* Variations in a Perturbed Mangrove Ecosystem in Lagos

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ABSTRACT
Investigation into the water chemistry characteristics and chlorophyll-*a* concentrations at a construction site around the Abule - agege mangrove wetland was carried out for 6 months between February, 2013 and July, 2013 at two stations. Fluctuations in the water characteristics and were linked majorly with brackish water incursions from the Lagos lagoon, flood water runoff and turbidity currents from the construction site. Water (26.90 - 31.60°C) and Air temperatures (27.50 - 32.90°C) were high. The salinity in the mangrove creek ranged between 1.18 and 19.22‰ and remained alkaline. Dissolved oxygen ranged between 4 and 5.4 mg/L, Biochemical oxygen demand ranged from 1.0 to 5.0 mg/L and Chemical oxygen demand ranged between 9.0 and 26.0 mg/L at both stations. Chlorophyll *a* values were relatively higher in the dry months than the wet months. The highest value of chlorophyll *a* (12.6µg/L) was recorded in July, Station 1 and the lowest value (8.3µg/L) was recorded in June, Station 2. The mean and standard deviation values were 10.43, ±1.60 for Station 1 and 10.33, ± 1.34 for Station 2. Chlorophyll-*a* concentrations were positively correlated with Salinity r = 0.06, Iron r = 0.57, Zinc r = 0.65 for Station 1 and Air temperature r = 0.30, Water temperature r = 0.07, Total suspended solids r = 0.28, Biological oxygen demand r = 0.21, Chemical oxygen demand r = 0.01, Salinity r = 0.24 for Station 2. On the other hand, a negative correlation was recorded with Air temperature r = -0.023, Water temperature r = -0.24, Rainfall r = -0.27, Total suspended solids r = -0.19, Dissolved oxygen r = -0.04, Chemical oxygen demand r = -0.11 for Station 1 and Rainfall r = -0.42, Dissolved oxygen r = -0.43, Iron r = -0.17 for Station 2. The highest value for Chlorophyll-*a* (12.6µg/L) was recorded in July, Station 1 and the lowest value (8.3µg/L) was recorded in June, Station 2. Chlorophyll-*a* was negatively correlated with rainfall and dissolved oxygen at the two stations probably due to the ongoing construction. Chlorophyll-*a* was positively correlated with Salinity hence increasing marine conditions (lagoon water incursion) at both stations probably due to the dilution of the construction based perturbations.

Key words: Water chemistry, chlorophyll-*a*, perturbed, mangrove, coastal ecosystem, Lagos

INTRODUCTION

Creeks, swamps and lagoons are common hydrological features of Lagos (Onyema, 2009). Nwankwo and Amuda (1993) described two types of creeks in South-western Nigeria. The creeks in this region are usually connected to lagoons and find their route all year round to the sea through the Lagos harbour (Ajao *et al.*, 1996). The ecological factors prevalent in the aquatic ecosystem of Lagos, Nigeria have been documented by a number of workers (Hill and Webb, 1958; Olaniyan, 1969; Ezenwa, 1981; Nwankwo, 1996, 2004; Onyema *et al*., 2003, 2007).

Over the years, the tidal creek ecosystems, particularly in the industrialized section of the Lagos metropolis are enduring stress-induced changes owing to steadily yet increasing human activities and associated effects (Onyema and Nwankwo, 2006). Investigations of anthropogenic wastes and environmental modification in the Lagos lagoon and adjoining creeks and wetlands have revealed increased levels of pollution, stress (Akpata and Ekundayo, 1978; 1983; Nwankwo, 1993).

Creeks and mangrove ecosystems are highly productive habitats for a variety of plants and animals, serve as nurseries for prawns and shrimps and also sites for harbour, wharfs, aquaculture industries and recreation (Akpata *et al*., 1993; Onyema, 2008). Nwankwo and Adesalu (2005) reported that

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phytoplanktons are the basis of aquatic productivity and any serious alteration in their constitution may have detrimental consequence on the food chain and the entire community structure. Phytoplanktons are able to photosynthesize because of chlorophyll present in them. Hence chlorophyll concentration in an aquatic environment is an indicator of the level of phytoplankton biomass within that aqua system.

The many negative impacts of sand filling, dredging and construction in a mangrove ecosystem cannot be over emphasized. The principal reason for these changes are attributable to the imposed stressful effect which usually eliminates intolerant species (Onyema, 2007). It is known to impact water quality and the photosynthetic depth of water among other perturbations. At present there is a dearth of literature on the effect of construction perturbations on the water chemistry and Chlorophyll *a* levels in and around the Abule-agege creek. This study aims to investigate these conditions and ascertain how human induced activities affect the overall productivity dynamics in this area.

MATERIALS AND METHODS

Description of study site

The Abule-Agege creek and its adjoining mangrove swamp are located in the tropics, in Lagos, Nigeria. The creek is a part of a series of coastal creeks found along the West African coast. The Abule-Agege creek (Fig. 1) is situated west of the Lagos Lagoon at the fringe of the University of Lagos. It is around 6^{O} 30'55.07" N and 3^{O} 24' 11.96E GPS coordinates. The Abule-egg creek falls within the rain forest zone of South-western Nigeria and it is exposed to two distinct seasons; the wet (May to October) and the dry (November to April) seasons (Onyema, 2008). This creek borders the forest belt and receives freshwater from rainfall and runoff from surrounding wetland areas and the University of Lagos. The creek with an average depth of (≤1m) is prone to tidal inundation which influences its physico-chemical characteristics and qualifies it as a brackish water environment. The description of the creek wetland area is further described by Emmanuel and Onyema (2007) and Lawal-are *et al.* (2009).

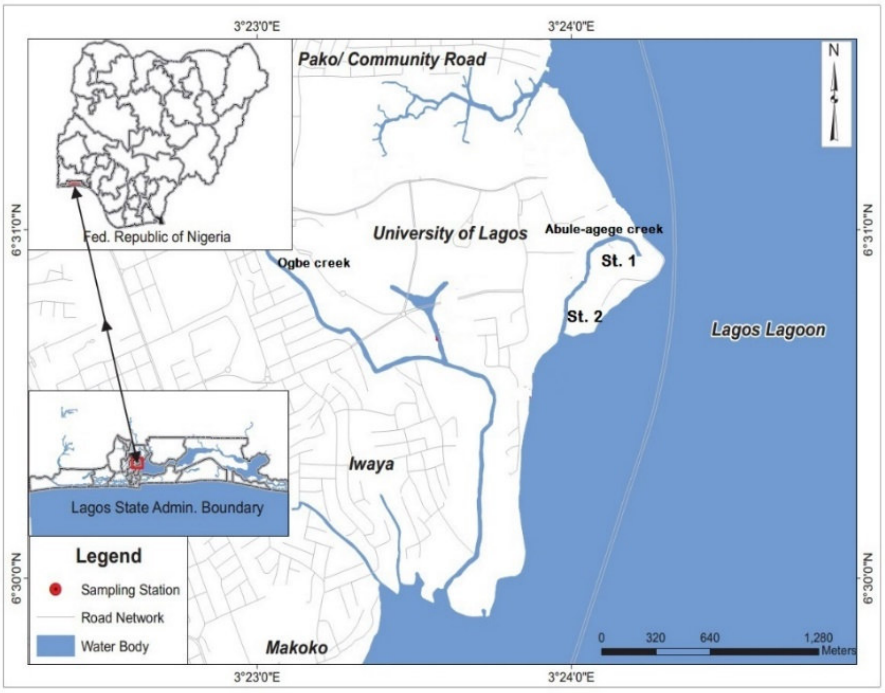

Fig. 1: Map of University of Lagos showing the construction area and sampling stations (St.1 and St. 2).

As of the time of collection, construction activities were rife in the area, including dredging, sand filling and clearing of mangrove vegetation. Samples were collected at two Stations. Whereas Station 1 was

situated further inland, Station 2 was situated closer to the mouth of the creek to the adjoining Lagos lagoon. The distance between station 1 and station 2 is about 40 meters.

Collection and sample analysis

The surface water samples were collected with a 250ml plastic container with screw caps at the site between the hours of 0900 and 1200hrs. Samples were taken to the laboratory for water chemistry analysis. Water samples were also collected for chlorophyll-*a* analysis. The plastic containers were labelled appropriately to reflect the date, name of site and contents. Air and water temperatures were recorded in situ, using a mercury-in-glass bulb thermometer. Rainfall data were obtained from Nigerian Meteorological Agency (NIMET), Oshodi Lagos. Salinity was determined in-situ using a refractometer. Heavy metal concentrations were determined using the Atomic Absorption Spectrophotometer (AAS). Other physico-chemical parameters were determined as stated in APHA (1998).

For the extraction of chlorophyll-*a,* 200ml of water sample was filtered through 0.45µm glass fibre membrane filter. The residue on the filter was transferred to a tissue blender and covered with 3ml 90% aqueous acetone and then macerated for 1minute, the sample was transferred quantitatively with 90% acetone to a centrifuge tube. It was capped and allowed to stand for 2hours in the dark at 4°C (in a refrigerator). Thereafter, it was centrifuged at 500g, for 20minutes. The supernatant was decanted, and the volume noted. The fluorometer was then calibrated with a standard chlorophyll solution (2, 5, 10 and 20µg Chlorophyll-*a*/L). The readings for each solution at ×1; ×3; ×10; ×30 sensitivity settings were noted. This is in accordance with APHA (1998).

RESULTS

The water quality parameters at the creek between February and July 2013 at the two stations exhibited seasonal variations. Table 1 shows monthly values, mean and standard deviation in some physico-chemical parameters and chlorophyll-*a* at the Abule-agege creek. The water temperature showed minimal variation ranging between 26.8 and 31.6°C. The highest temperature value (31.6°C) was recorded in March, Station 1 while the lowest temperature value (26.8°C) was recorded in June, Station 2. The highest Air temperature (32.4°C) was also recorded in March at Station 1 while the lowest (27.3°C) was recorded in June Station 2. Rainfall data recorded during the period showed distinct monthly variation with the highest rainfall (360.2mm) in June and the lowest (28mm) in February. The mean and standard deviation values for Total suspended solids were 19 mg/L, $\pm$19.64 respectively, for Station 1 and 14.67 mg/L, ± 9.11 for Station 2.

With regard to the chemical characteristics, the water pH showed minimal variation and it was alkaline all through the months and at both stations investigated. The highest value (7.86) was recorded in July (wet month) at Station 2 while the lowest pH value (7.06) was recorded in March (dry month) at Station 2. The highest Salinity and Conductivity values (19.22‰, 34701, µS/cm) were recorded in February, Station 2 and the lowest values (1.18‰, 3260, µS/cm,) were recorded in July. Dissolved oxygen showed minimal variation, ranging from 3.8 to 5.4mg/L. The lowest Dissolved oxygen level was 3.8mg/L recorded in March, Station 1, April Station 2. The highest value of 5.4mg/L was recorded in June, station 2. The Biological oxygen demand showed distinct monthly variation throughout the sampling period and ranges between 1 and 5mg/L. Chemical oxygen demand ranged between 9.0mg/L at station 2 in June and 26.0mg/L at station 1 in February and March.

Heavy metals levels also showed notable variations. The Iron concentration showed minimal monthly variations. The highest value (0.18mg/L) was recorded in March, Station 1 and the lowest value (0.05mg/L) was recorded in June, Station 2. The Zinc concentration showed a steady variation. The highest value (0.35mg/L) was recorded in July Station 2 and the lowest value (0.02mg/L) was recorded in May, Station 2.

Table 1: Monthly changes in water chemistry and chlorophyll-*a* characteristic in a perturbed mangrove ecosystem

Parameters	Station	Months							
		FEB	MAR	APR	MAY	JUN	JUL	MEAN	SD
Air Temp. (ºC)	1	31.00	32.40	31.20	32.90	28.20	27.50	30.53	2.21
	2	31.00	29.60	30.20	29.80	27.30	27.50	29.23	1.50
Water Temp.(ºC)	1	30.00	31.60	29.90	31.60	28.20	26.90	29.70	1.87
	2	30.70	29.50	28.70	29.60	27.30	26.80	28.76	1.48
Rainfall (mm)		28.00	50.10	165.30	340.80	360.00	300.00	207.51	147.34
TSS (mg/L)	1	59.00	12.00	11.00	10.00	9.00	13.00	19.00	19.65
	2	33.00	10.00	10.00	14.00	11.00	10.00	14.67	9.11
Dissolve Oxygen (mg/L)	1	4.80	3.80	4.10	4.00	5.30	5.20	4.53	0.65
	2	4.80	4.70	3.80	4.90	5.40	5.10	4.78	0.54
BOD(mg/L)	1	4.00	5.00	2.00	2.00	2.00	2.00	2.83	1.33
	2	3.00	3.00	4.00	3.00	1.00	1.00	2.50	1.22
COD (mg/L)	1	26.00	26.00	22.00	20.00	11.00	9.00	19.00	7.38
	2	19.00	16.00	15.00	22.00	9.00	10.00	15.17	5.04
Salinity (‰)	1	18.71	17.31	12.40	5.80	2.30	1.70	9.70	7.49
	2	19.22	16.90	11.83	4.20	3.12	1.18	9.41	7.65
Iron (mg/L)	1	0.10	0.18	0.04	0.11	0.16	0.18	0.13	0.06
	2	0.06	0.16	0.05	0.12	0.05	0.08	0.09	0.04
Zinc (mg/L)	1	0.03	0.04	0.03	0.02	0.03	0.03	0.03	0.01
	2	0.03	0.04	0.03	0.02	0.03	0.35	0.08	0.13
Chlorophyll *a* (µg/L)	1	9.60	12.30	10.00	9.00	9.10	12.60	10.43	1.61
	2	11.30	9.90	11.10	9.50	8.30	11.90	10.33	1.34
pH (at 25 ºC)	1	7.40	7.13	7.26	7.73	7.57	7.73	7.47	0.25
	2	7.42	7.06	7.30	7.53	7.54	7.86	7.45	0.27

Temp = Temperature, BOD = Biological Oxygen Demand COD = Chemical Oxygen Demand, DO= Dissolve Oxygen

Table 2: Pearson Correlation Co-Efficient between Chlorophyll-*a* and Physico-Chemical Characteristics of the Abule-agege creek area (February – July, 2013)

Parameters	Station 1 (r)	Station 2 (r)
Air temperature (ºC)	-0.23	0.30
Water temperature (ºC)	-0.24	0.07
Rainfall (mm)	-0.27	-0.42
Total Suspended Solids (mg/L)	-0.19	0.28
Dissolved Oxygen (mg/L)	-0.04	-0.43
Biological Oxygen demand(mg/L)	0.37	0.21
Chemical Oxygen Demand(mg/L)	-0.11	0.01
Salinity (‰)	0.06	0.24
Iron(mg/L)	0.57	-0.17
Zinc(mg/L)	0.65	0.58
pH at 25	-0.21	0.23
Chlorophyll *a* (mg/L)	1	1

Chlorophyll-*a* (µg/L) analysis

The highest value of Chlorophyll-*a* (12.6µg/L) was recorded in July, Station 1 and the lowest value (8.3µg/L) was recorded in June, Station 2. The mean and standard deviation values were 10.43 and ±1.60, respectively for Station 1 and 10.33 and ± 1.34 for Station 2.

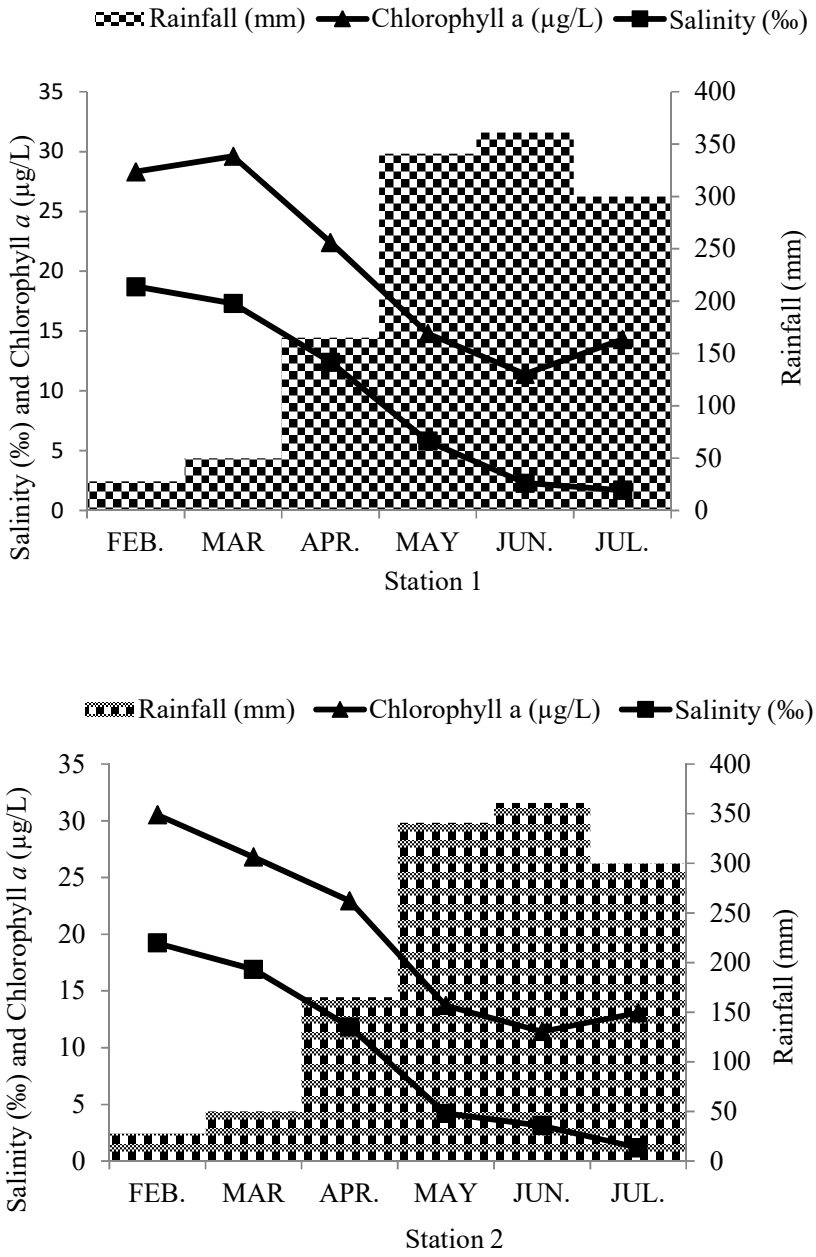

Fig. 2: Monthly Variation in Chlorophyll *a*, Salinity, and Rainfall in a Perturbed Mangrove wetland in Lagos (Stations 1 and 2).

DISCUSSION

High air and water temperatures recorded during the study are typical for the region (Nwankwo *et al*., 2003) and also could be due to habitat modification that was taken place during the sampling period. Air and water temperature values were higher in dry months for the two stations. These observations may be due to increased insolation due to lower cloud cover, and cessation of rainfall as previously reported by Nwankwo (1996), Onyema *et al.* (2007) and Nwankwo *et al.* (2008). During the study period there was a direct relationship between Total Suspended Solids (TSS), Total Dissolved Solids

(TDS), Transparency and Rainfall. In the dry months, TSS was low possibly due to low flood water inflow to the creek, but the highest value of TSS was also recorded in the dry month (59mg/L) which could be due to construction activities around the study site. Such habitat modification projects are known to lead to the re-suspension of already settled substrate materials, increasing TSS, TDS and reduced Transparency levels.

These observations confirm earlier report made by Onyema *et al.* (2007) and Nwankwo *et al.* (2008). Transparency was higher inland of the creek (Station 1) and may be due to the calmer nature of water at this part coupled with the presence of a good number of sticks in water allowing settlement of more particles.

The creek exhibited the usual alkaline properties with pH values ranging between 7.30 and 7.80. This is in agreement with Nwankwo and Akinsoji (1992) for tidal creeks in Lagos. The salinity values recorded at the sites ranged from 1.18 to 19.22‰. The increase in salinity, especially during the dry months could be due to the increased incursion of brackish water from the adjoining Lagos lagoon. The Lagos lagoon also connectedly receives inflows from the Atlantic Ocean. This tidal phenomenon is also known to regulate its salinity, especially in the dry season. The lower level of Dissolved oxygen (DO) concentration observed at the creek may be a reflection of the effect of increased temperature and increased microbial activities in the dry months. Nwankwo and Akinsoji (1988) reported that dissolved oxygen decreased in the Lagos lagoon benthos with increased temperature and bacteria activity.

Chlorophyll *a* measurement was highest in the dry months and dropped in the wet months. The subsequent rise in the phytoplankton biomass (as recorded through chlorophyll *a* measurements) in July may be due to decrease in the abundance of zooplankton species. Chlorophyll *a* was negatively correlated with rainfall and dissolved oxygen at the two stations probably due to the dilution effect of ongoing construction / associated perturbations and positively correlated with Salinity and Zinc at both stations. Iron levels were highest in the dry season and lowest in the wet season, suggesting the effect of dilution and low residence time of water within the creek.

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 harbor (Onyema, 2009). Lagoons and creeks are diluted considerably by freshwater from rain and river systems in the wet season, while in the dry season; evaporation becomes more prominent (Chukwu, 2002; Nwankwo, 2004). However, the effect of perturbations from the construction activities in the mangrove wetland cannot be dispensed with as affecting the water chemistry characteristics and chlorophyll-*a* concentrations.

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