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THE BIODIVERSITY OF PHYTOPLANKTON COMMUNITY IN SELECTED PARTS OF THE LAGOS LAGOON, NIGERIA

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ABSTRACT

The phytoplankton composition, diversity, abundance and distribution as well as surface water physic-chemical parameters of selected parts of the Lagos lagoon was investigated for seven months (March –September 2010). Phytoplankton and surface water samples were collected monthly from twelve stations and analysed at the laboratory. These were analysed air and water temperatures salinity, dissolved oxygen, pH, conductivity, turbidity and alkalinity. Phytoplankton was identified microscopically. Species diversity was calculated using standard indices. The phytoplankton was dominated by diatoms (19 species), blue –green algae (7 species), green algae (5 species) and the euglenoids (4 species). Menhinick Index (D) and Margalef (d) Index were reltively high at stations Nichem textile and at Majidun and low in other stations. Moreso, stations Nichem textile and Majidun also showed significant variation ($p < 0.05$) in occurrence of diatoms between sampling stations, while stations such as Queen's drive, Park view, Moba, Ofin, Mid lagoon, Ikate, Itedo, Oreta, Ibese and Ikorodu port showed no significant variation ($p > 0.05$) in occurrence of diatoms between stations. The rich ecological heritage of the Lagos lagoon is being threaten by the current state of environmental perturbations from municipal and industrial effluent, although some species were able to withstand these stressful situation. Changes in the biodiversity of these primary producers could make pollution management and environmental biomonitoring a little bit difficult because of the role played by these delicate organisms. However a deliberate environmental management should be recommended.

Keywords: Phytoplankton, abundance, distribution, environmental perturbations, lagoon, municipal, industrial

INTRODUCTION

The productivity of any water body is determined by the amount of plankton it contains as they are the major primary and secondary producers. Plankton communities serve as a base for the food chain that supports the commercial fisheries [1,2]. According to Wehr and Descy [3], phytoplankton communities are major producers of organic carbon in large rivers, a food source for plankton consumers and may represents the primary oxygen source in many low-gradient rivers. They are also very useful as biological indicators in pollution management. The distributions, abundance, species diversity, species composition of the phytoplankton are used to assess the biological integrity of the water [1]. Also, they reflect the nutrient status of the environment. Although they do not have control over their movements, thus, they cannot escape pollution and this makes a good indicator of pollution in the environment. Barnes [4] reports that pollution affects plankton distribution, standing crop and chlorophyll concentration. This study was conducted to assess the biodiversity of phytoplankton species and their distribution at selected parts of the Lagos lagoon. And to assess the effect of different anthropogenic activities that takes place along the Lagoon on the phytoplankton communities. More so, physico-chemical parameters of water were also analyzed.

MATERIALS AND METHOD

THE STUDY AREA

The South-western Nigeria has an assembly of lagoons which receive a number of large rivers and creeks. The seasonal distribution of rainfall, causes the Lagos lagoon to experience seasonal flooding which introduces a lot of detritus, nutrients and dilute the water considerably [1] however it is open and tidal. It has a surface area of 208km^2, with an average depth of 1.5m is a shallow micro-tidal environment [2, 3].
Phytoplankton occupies an important trophic niche in the aquatic ecosystem, as they constitute the most links in energy transfer between phytoplankton and higher aquatic fauna [4]. These organisms have been use as biological indicators to monitor environmental perturbations [5].

Investigations of anthropogenic wastes and environmental modifications in the Lagos lagoon have revealed increased levels of pollution stress [6, 7, 8, 9].

An important ecological ramification of increasing population pressure, poor sewerage system, industrialization and poor waste management in Nigerian's coastal area is that pollutants freely find their way unabated into our coastal waters through drains, canals, rivers, creeks and lagoons that act as conduits [10]. Apart from enriching the water with high amounts of biodegradable matter, these discharges introduces nutrients, toxic and other land based substances that may consequently signal epidemiological problems and an increase in human induced stressors which impairs aquatic biodiversity [11]. Information dealing with the biodiversity of Phytoplankton species as it relate to anthropogenic activities along the Lagos lagoon, is quite limited. This data will also be useful for pollution management and environmental biomonitoring due to changes in the physicochemical characteristics of the lagoon and the establishment of more industries within the city metropolis.

METHODOLOGY

THE STUDY AREA

The Lagos lagoon (Fig 1) is located in Lagos state, Nigeria and is one of the nine lagoons in South-western Nigeria [12, 13]. It is an open, shallow and tidal lagoon, with a surface area of 208km^2 [2]. The study areas were delineated into twelve sampling stations, located progressively over a salinity gradient, ranging from freshwater with less than $0.5^0/_{00}$ at the northern part of the lagoon through brackish water with about $12^0/_{00}$ (mid Lagoon) to marine environment at the southern part up to $21^0/_{00}$ (ikoyi). Monthly samples were collected from twelve stations over a period of seven months (March – September 2010).

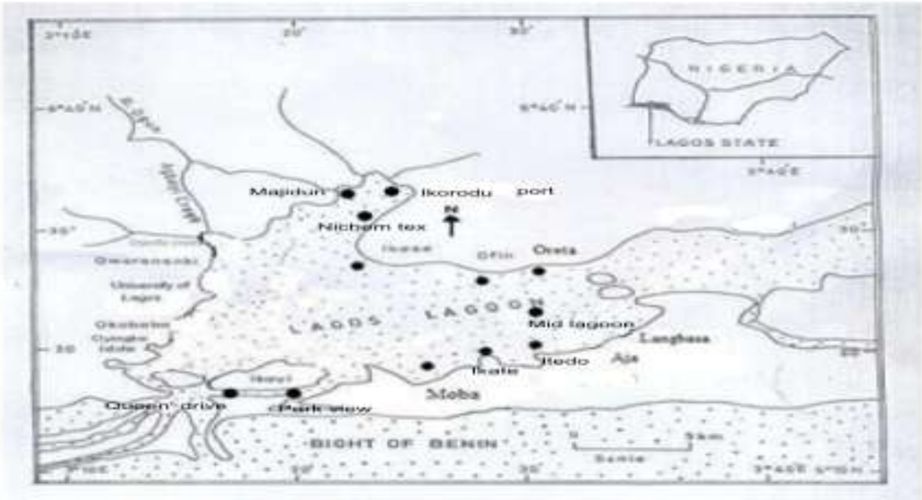

Fig. 1: Map of Lagos lagoon showing the sampling stations ●

Plankton samples were collected using towing plankton net attached to a slow moving boat and fixed with 4% formalin to preserve the organisms. Enumeration and microscopic identification were performed using a wild II binocular microscope at 50x100x 400 magnifications. A suitable plankton sample mount was then created. The drop count microscope analysis method was used to estimate the plankton fauna. Since each sample drop from the dropper accounts to 0.1ml, the results on abundance / occurrence were multiplied accordingly to give the values as numbers of organisms per ml which is the standard unit of measurement [14]. Organisms were observed for Phytoplankton species. Final data were presented as number of organisms per ml. Identification guides used were those provided by [15, 16, 17, 18, and 19].

COLLECTION AND ANALYSIS OF WATER SAMPLES

Water samples were collected with a 1dm^3 water sampler and stored in 1litre water bottles and the following physicochemical parameters were analysed in the laboratory: pH, conductivity, salinity and turbidity using a multi-meter water checker (Horiba U-12). Separate water samples were collected in 250ml dissolved oxygen bottles at each station for dissolved oxygen estimation using Winkler's method. Mercury-in-glass thermometers were used to measure air and surface water temperature *in situ*. Alkalinity of the water samples were determined by titrating dilute HCl against 50ml of the water sample using methyl orange as an indicator.

COMMUNITY STRUCTURE ANALYSIS

SPECIES RICHNESS INDEX (D)

The Species richness index (d) [20] was used to evaluate the community structure.

$$d = \frac{S - 1}{\ln N}$$

Where:

d = Species richness index
S = Number of species in a population
N = Total number of individuals in S species.

MENHINICK'S INDEX (D) [21].

The Menhinick's Index (D)

$$D = \frac{S}{\sqrt{N}}$$

S = Number of species in a population
N = Total number of individuals in S species.

SHANNON AND WIENER DIVERSITY INDEX (HS) [21]

The Shannon and Wiener diversity index (Hs)

$$Hs = \frac{N \log N - \sum P_i \log P_i}{N}$$

Where Hs = Shannon and Wiener diversity Index
i = Counts denoting the ith species ranging from 1 – n
Pi = Proportion that the ith species represents in terms of numbers of individuals with respect to the total number of individuals in the sampling space as whole.

SPECIES EQUITABILITY OR EVENNESS INDEX (J) [21].

The Species Equitability or Evenness index (j)

$$j = \frac{Hs}{\log_2 S}$$

Where

j = Equitability index
Hs = Shannon and Weiner index
S = Number of species in a population

SIMPSONS DOMINANCE INDEX (C) [21].

$$C = \sum \left(\frac{n_i}{N}\right)^2$$

Where n = the total number of organisms of a particular species
N = the total number of organisms of all species

TABLE 1: MEAN VALUE OF THE PHYSICO-CHEMICAL PARAMETERS OF THE WATER SAMPLES AT EACH STATION

	Queen's Drive	Park view	Moba	Ikate	Itedo	Mid lagoon	Oreta	Ofin	Ibese	Nichmtex	Ikorodu port	Majidun
Air Temp. (^{O}C)	28	27.2	26	28.3	30.1	30.1	30	30	30.5	30.5	30.7	31.2
H_2OTemp. (^{O}C)	29.4	29.5	28.7	28.5	28.9	29.0	29.0	29.3	29.5	28.7	28.2	28.0
Ph	9.1	8.9	9.0	9.1	8.9	8.8	9.2	8.9	9.0	9.0	8.8	9.1
Conductivity ($mScm^{-1}$)	0.84	1.0	0.64	0.67	0.61	0.12	0.19	0.3	0.24	0.54	0.18	0.61
Turbidity (NTU)	78	366	126	108	208	226	86	386	248	256	346	276
Salinity ($^{o}/_{oo}$)	0	0	0	0	0	0	0	0	0	0	0	0
D.O (mgl^{-1})	11.2	13.6	18.4	15.6	12.0	11.2	12.4	12.4	12.8	9.2	8.0	5.2
Alkalinity	8.0	8.0	6.0	8.0	10.0	8.0	8.0	8.0	8.0	8.0	12.0	8.0

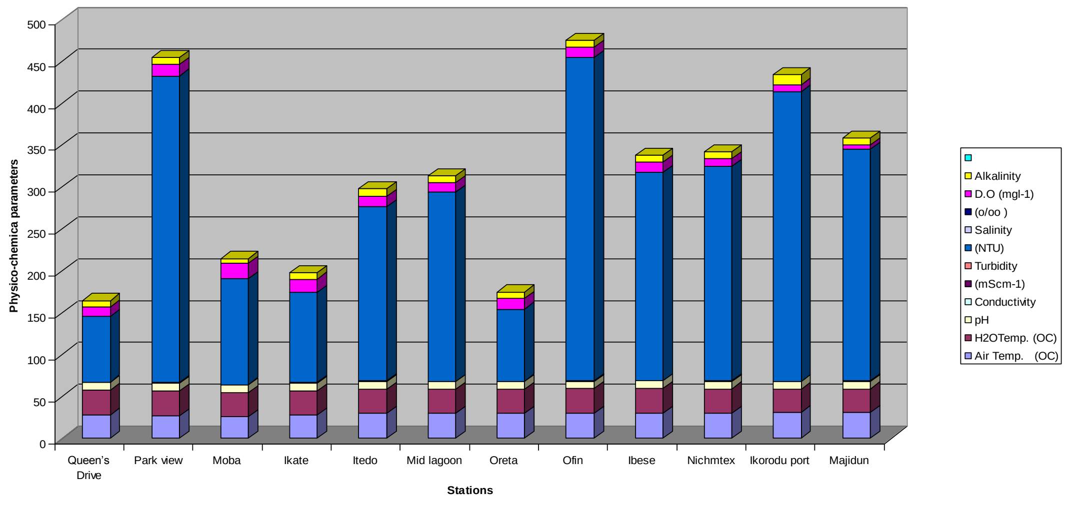

Fig. 2: Physico-chemical parameter for water sampled at each station along the lagoon

RESULTS

Mean monthly variation in surface water temperature and air temperature were relatively high in all the sampling period. The highest air temperature 30.5^0C and 30.7^0C were recorded at Nichem textile and at Ikorodu port respectively while the lowest 26^0C was recorded at Moba (Fig 2). The pH values along the stations were relatively high indicating alkaline state of the water sample. The conductivity values were relatively low in all the stations, the lowest recorded at the mid lagoon (0.12mScm^{-1}). High turbidity was recorded in all the stations. Water salinity values were very low in all the stations. The station that recorded the highest dissolved oxygen value (18.4mg^{-l}) was Moba while Ikorodu port recorded the lowest dissolved oxygen values 8.0 mg^{-l}, (Table 1).

COMMUNITY STRUCTURE

PHYTOPLANKTON COMMUNITY STRUCTURE

The Division – Bacillariophyta (diatoms) (19 species) and the Order Centrales (10 species) *Aulacoseira granulata, Aulacoseira granulata* var*. angustissima, Coscinodiscus eccentrius*, *Actinoptychus splendens*, and *Aulacoseira granulata* var. *curvata* were some occuring species (Table 2 and 3, Fig 3). Diatoms of the Order – Pennales (9 species) included *Pleurosigma angulatum, Synedra crystallina,* and *Gyrosigma balticum.* The Division – Cyanophyta (blue-green algae) (7 species) were also represented. For the Order Chroococcales (2 species) two species of the genus *Microcystis* were ecorded*.* The Order – Hormogonales (5 species) recorded four species of *Oscillatoria* (*Oscillatoria chalybea, Oscillatoria curviceps, Oscillatoria limnosa* and *Oscillatoria tenius*) and *Spirulina platensis*. For the Division – Chlorophyta (green algae) 5 species were recorded. The Order – Ulothricales (2 species) recorded *Spirogyra africana* and *Spirogyra* sp. The Order – Zygnematales (3 species) included *Closterium ehrenbergii* , *Closterium moniliferum* and *Gonatozygon.* Futhermore, the Order – Cladophorales was represented by a sole species - *Cladophora glomerata.* For the Division – Euglenophyta (euglenoids), the Order – Euglenales recorded 4 species namely *Euglena acus, Phacus acuminatus, Phacus curvicauda* and *Trachelomonas hispida.* With respect to the stations, Majidun recorded the highest number of species (26) and abundance (895 individuals per ml) whereas Park view and Oreta recorded 5 species each in term of diversity. Oueens drive, Moba, Ikate and Itedo all recording the abundance (85 individuals per ml) of all the stations.

Table 2a: Spatial variation of the phytoplankton composition and abundance in selected parts of the Lagos lagoon.

Stations	**Queen's Drive**	**Park**	**Moba**	**Ikate**	**Itedo**	**Mid**	**Oreta**	**Ofin**	**Ibese**	**Nichem**	**Ikorodu**	**Majidun**
PHYTOPLANKTON TAXA												
DIVISION – BACILLARIOPHYTA												
CLASS – BACILLARIOPHYCEAE												
ORDER I – CENTRALES												
Actinoptychus splendens Ehrenberg	20	25	-	5	-	5	-	10	5	5	15	30
Aulacoseira granulata Ehrenberg (Ralfs)	10	20	70	35	50	20	80	75	55	20	75	105
Aulacoseira granulata var. *angustissima* Muller	-	-	5	10	-	5	10	15	25	20	415	450
Aulacoseira granulata var. *curvata* Simon	-	-	-	-	-	10	5	15	5	5	5	15
Aulacoseira sp.												
Coscinodiscus eccentrius Ehrenberg	35	-	25	5	5	-	-	-	-	-	-	-
Coscinodiscus radiatus Ehrenberg	-	-	-	-	-	-	-	-	-	-	-	-
Cyclotella menighiniana Kutzing	-	-	-	-	5	-	-	-	5		36	5
Cyclotella striata (Kutzing) Grunow	-	-	-	-	-	-	-	5	-	-	-	
Terpsinoe musica (Ehr) Hustedt	-	-	-	-	-	-	-	-	-	-	-	10
Order II – PENNALES												
Gyrosigma balticum (Ehr.) Rabenhorst	15	10	25	5	-	10	-	-	-	-	-	-
Gyrosigma balticum (Ehr.) Rabenhorst												
Navicula mutica Kutzing												15
Pinnularia major (Kutzing) Rabenh	-	-	-	-	-	-	-	5	-	15	-	5
Pleurosigma angulatum (Quekett) Wm Smith	25	50	10	-	5	-	-	-	-	-	-	-
Surirella splendida Wm. Smith	-	-	-	-	-		-	-	-	5	-	5
Synedra crystallina (Ag) Kutzing	5		5	15	5	-	-	5	15	10	45	15
Synedra sp.	-	-	-	-	-	-	-	-	-	-	-	10
Synedra ulna (Nitzsch) Ehrenberg	-	-	-	-	-	10	-	-	5	-	5	15

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Table 2 contd : Spatial Variation of the Phytoplankton Composition and Abundance in Selected Parts of the Lagos lagoon.

	Queen's Drive	Park	Moba	Ikate	Itedo	Mid	Oreta	Ofin	Ibese	Nichemt	Ikd.	Majidun
DIVISION – CYANOPHYTA												
CLASS – CYANOPHYCEAE												
ORDER I – CHROOCOCCALES												
Microcystis flos-aquae Kirchner	-	-	-	-	-	5	-	15	-	-	20	45
Microcystis flos-aquae Kirchner	-	-	-	-	-	-	-	-	-	-	-	5
Order II – HORMOGONALES												
Oscillatoria chalybea Gomont	-	-	-	-	-	-	-	-	5	25	-	-
Oscillatoria curviceps C.A. Agardh	-	-	-	-	-	-	-	-	-	15	15	15
Oscillatoria limnosa Agardh	15	5	5	-	10	-	5	-	-	5	5	5
Oscillatoria tenius Agardh	-	-	-	-	-	5	-	-	15	-	5	-
Spirulina platensis Geitler	-	-	-	-	-	-	-	-	-	-	-	15
DIVISION – CHLOROPHYTA												
CLASS – CHLOROPHYCEAE												
ORDER I – ULOTHRICALES												
Spirogyra africana Fritsch Cruda	-	-	-	-	-	-	-	5	-	5	-	25
Spirogyra sp.	-	-	-	-	-	-	-	-	-	-	-	5
ORDER II – ZYGNEMATALES												
Closterium ehrenbergii Meneghini	-	-	-	-	-	-	-	-	5	35	25	30
Closterium moniliferum (Bory.) Ehrenb.	-	-	-	-	-	-	-	-		5		5
Gonatozygon sp.				25	5	55	35	50		10		25
ORDER III – CLADOPHORALES												
Cladophora glomerata (L) Kutzing	-	-	-	-	-	-	-	-	-	5	-	25
DIVISION – EUGLENOPHYTA												
CLASS – EUGLENOPHYCEAE												
ORDER – EUGLENALES												
Euglena acus Ehrenberg	-	-	-	-	-	-	-	-	-	30	-	5
Phacus acuminatus Stokes	-	-	-	-	-	-	-	5	-	-	-	5
Phacus curvicauda Swirenko	-	-	-	-	-	-	-	-	-	-	-	
Trachelomonas hispida (Perry) Stein	-	-	-	-	-	-	-	-	-	-	5	5

Total species diversity (S)	**7**	**5**	**7**	**7**	**7**	**9**	**5**	**11**	**10**	**16**	**13**	**26**
Total phytoplankton abundance (N)	**125**	**110**	**145**	**100**	**85**	**125**	**135**	**205**	**140**	**215**	**671**	**895**

Table 3: Spatial Distribution of Phytoplankton Community Along the Lagos Lagoon

Stations	**Queens**	**Park view**	**Moba**	**Ikate**	**Itedo**	**Mid**	**Oreta**	**Ofin**	**Ibese**	**Niche**	**Ikorodu**	**Majidun**
DIVISION – BACILLARIOPHYTA	110	105	140	75	70	60	95	130	115	80	596	680
DIVISION – CYANOPHYTA	15	5	5	0	1	10	5	15	20	45	45	85
DIVISION – CHLOROPHYTA	0	0	0	25	5	55	35	55	5	55	25	90
DIVISION – EUGLENOPHYTA	0	0	0	0	0	0	0	5	0	30	5	15

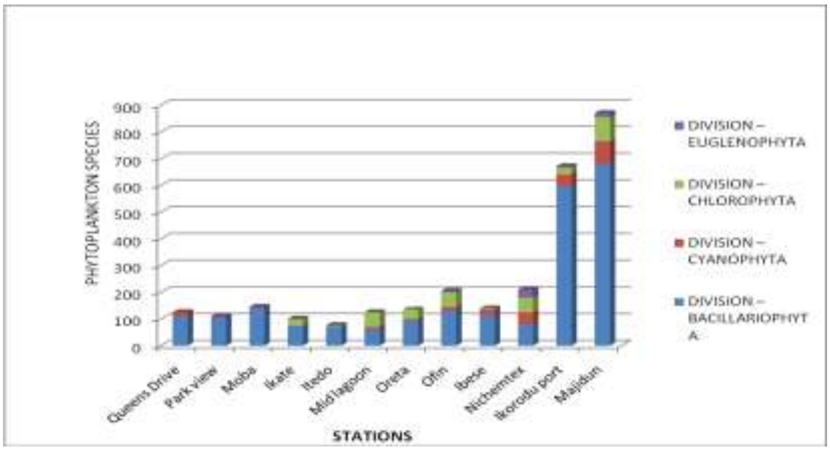

Fig.3: Phytoplankton Species Distributed along Selected Stations on the Lagoon

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Table 4 : Bio-indices Values of General Diversity, Abundance, Taxa Richness And Dominance of the Phytoplankton Species in Selected Parts of the Lagos Lagoon.

	Queens Drive	Park view	Moba	Ikate	Itedo	Mid lagoon	Oreta	Ofin	Ibese	Nichemtex	Ikorodu port	Majidun
Shannon-Wiener Index (Hs)	0.79	0.59	0.65	0.73	0.61	0.77	0.48	0.82	0.81	1.1	0.63	0.9
Menhinick Index (D)	0.63	0.48	0.58	0.7	0.76	0.8	0.43	0.77	0.85	1.09	0.5	0.87
Margalef Index (d)	1.24	0.85	1.21	1.3	1.35	1.66	0.82	1.88	1.82	2.79	1.84	3.68
Equitability Index (j)	0.93	0.85	0.77	0.86	0.72	0.81	0.68	0.79	0.81	0.91	0.57	0.64
Simpson's Dominance Index (C)	0.18	0.3	0.3	0.23	0.38	0.24	0.43	0.21	0.22	0.09	0.41	0.28

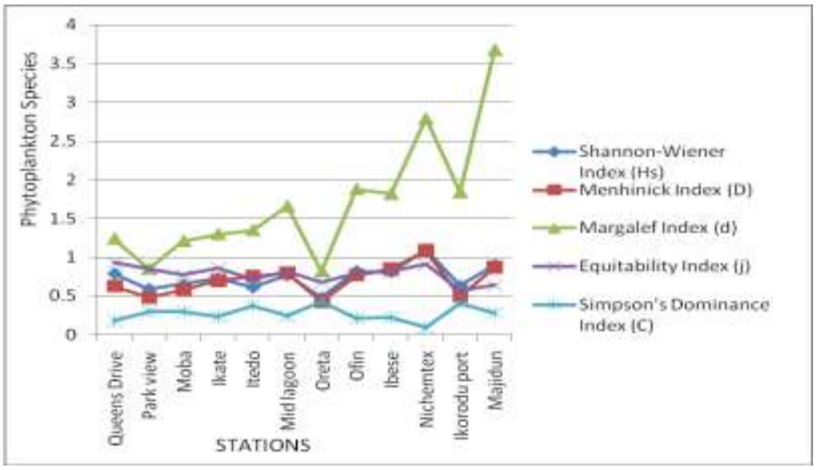

Fig.4: Biodiversity Indices of the Phytoplankton Species Distributed in Selected Stations on the Lagoon

DISCUSSION

Ibese station, had the highest air temperature (30.5^{o}C) and water temperature (29.5^{o}C) Table 1). Surface water temperatures were high (28^{o}C - 29.5^{o}C) in all the sampling stations. Majidun had the lowest dissolved oxygen values (5.2mg/l) when compared with other stations. This value is just a little above the minimum W.H.O [22] standard of 5mg/l required for water quality assessment. The water samples were very turbid in all the stations. The period of sampling was around the rainy season and particulate matters brought into the lagoon by surface run-off and flood must have caused high turbidity. Zero salinity value was recorded for all the stations and this implies a freshwater condition.

The dynamic interplay between freshwater inflow and tidal seawater incursion determine the Lagos lagoon environment from year to year [7]. The wet season creates an increased in river flow leading to a low brackish water conditions in various parts of the lagoon, however this study revealed a low salinity in all the stations. For the present study, (Table 1) there was no value for the salinity measurement at all the stations sampled. This is likely due to freshwater inflow and reduced tidal incursion [12]. In the Lagos lagoon, there is a direct relation between the seasonal bimodal rainfall pattern, the environmental and biota gradient [8].

Highest dissolved oxygen value (18.4mg^{-l}) was recorded in Moba while Ikorodu port recorded the lowest dissolved oxygen values 8.0 mg^{-l} , (Table1) this is due to less influx of human and industrial effluent at Moba while lots of human activities and industrial activities takes place at Ikorodu port. The study described a relatively low phytoplankton diversity, except Majidun where human and industrial activities do take place (Fig 4). Moreso, the current state of environmental perturbations from untreated industrial and municipal effluents could lead to a decrease in biodiversity .

The sampling period experienced an increased in rainfall, which lead to no salinity values recorded, however dilution and flushing of the lagoon water during these season depends on the amount of rainfall at the station and the attendant effects of flood waters. According to webb [23], in the tropics, rainfall is more important than temperature in determining environments. It is possible that this constant rainfall initiated floods which increased suspended and dissolve solids, diluted the water thereby reducing the salinity.
Relatively low phytoplankton production was also recorded in areas with unfavourable flood effects and low human activities as seen at Table 4 except Nichem Textile industry and Majidun.This is also similar to phytoplankton productions at Eleyele reservoir Ibadan Imevbore [25], while Adeniji [24] reported variations of phytoplankton production in Kainji Lake, Nigeria. The dominance of diatoms in all the stations conforms with the observation made by Nwadiaro [26] in the Chanomi creek system of the Niger delta, Chindah and Pudo [27] in Bonny River, while Nwankwo [28, 29] in the lagoons of south western Nigeria.

Furthermore, Majidun displayed a high diversity of phytoplankton species (Fig3.) especially the diatoms, this observed broad spectrum of diatoms at this station is suggestive of high productivity, which corroborates the report of Moses [30]. Changes in the biodiversity of these primary producers could make pollution management and environmental biomonitoring a little bit difficult because of the role played by these delicate organisms.

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