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Phytoplankton Abundance and Distribution of Fish Earthen Ponds in Lagos, Nigeria

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ABSTRACT: The study investigated phytoplankton abundance and distribution under different pond management to determine the effect of some physicochemical parameters on the community structure of three on-research fish earthen ponds of Nigerian Institute for Oceanography and Marine Research, Badore, Lagos. Samples were taken every week using standard procedure. Water quality parameters; temperature, dissolved oxygen, turbidity, salinity and pH were measured and found to be within the optimal ranges for phytoplankton productivity. Seventeen (17) phytoplankton species belonging to family Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae were identified. Densities of the phytoplankton ranged from 01.85 x 10^3 cells L^{-3} to 25.90 x 10^3 cells L^{-3} in the ponds; Chlorophyceae being the most abundant. Mean cell densities of the phytoplankton were significantly different (P<0.05). Few phytoplankton species were present in all the Ponds. The spatial distribution of Bacillariophyceae in ponds 1, 2 and 3 were 41.7%, 41.7% and 16.8%, while those of Euglenophyceae were 50%, 50% and 0% respectively. Shannon Wiener diversity index was 1.263 in Pond 1, 1.265 in pond 2 and 1.078 in Pond 3. Pond 1 had the highest phytoplankton percentage (94.11%). Correlation coefficients were calculated for abundance with pH, DO and temperature. Abundance was positively correlated with the temperature variations and levels of DO but negatively correlated with the pH. Results of phytoplankton abundance of the three ponds clearly showed the influences of the physicochemical factors on diversity, distribution and abundance of phytoplankton which indirectly affects aquaculture potentials.

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The plankton community comprises of the phytoplankton and zooplankton. Phytoplankton is important organisms which act as producers of the primary food supply in any aquatic ecosystem (Battish, 1992). They are the initial biological components from which energy is transferred to higher organisms through the food chain (Tiwari and Chauhan, 2006, Babatunde, 2014 and Saifullah, 2014). Phytoplankton significantly contributes to the dynamic and succession of zooplankton in aquatic ecosystems and without them the diversity and abundance of aquatic life would be impossible (Suzie, 2015). Dynamics and changes in phytoplankton biomass are the result of a complex interplay of physical, chemical and biological processes. The physicochemical and biological features largely control the plankton production and biology of the cultured organisms. Availability of nutrients also plays a key role in determining the phytoplankton population density (Grenz *et al*, 2002; Elliott *et al*, 2002). The term "Water quality" refers for the physical, chemical and biological parameters of water and directly or indirectly influences the survival and production of aquaculture species (Kohinoor, 2000). Environmental factors in aquatic habitats include various physical properties of water such as solubility of gases and solids, penetration of light, temperature,
and density. Chemical factors such as salinity, pH, hardness, phosphates and nitrates are also very important for growth and density of phytoplankton on which zooplankton depend (Roy, 2014). Phytoplankton species are used as indicators of water quality because their sensitivity can be a dynamic response to changes in the surrounding environment (Siddika, 2012). Qualitative and quantitative abundance of phytoplankton indicate the productive status of a water body (Chowdhury *et al*, 2008), thus a thorough knowledge of abundance of phytoplankton and its quality in time and space in relation to environmental conditions is a prerequisite for fish production. Several studies carried out in Lagos, Nigeria were concentrated on the taxonomic identification of different phytoplankton genera and were very confined to the specific regions of Lagos lagoon. There is dearth of information on the composition of phytoplankton in fish earthen ponds in Lagos, Nigeria. This study focuses on the

measurement of some physicochemical parameters such as temperature, transparency, dissolved oxygen and pH to checklist the phytoplankton abundance and distribution in fish earthen ponds in the Nigerian Institute for Oceanography and Marine Research, Badore, Lagos.

MATERIALS AND METHODS

Study Area: Three on-farm research fish ponds in the Nigeria Institute for Oceanography and Marine Research Badore, Lagos, were selected. The station is located off Ado – Badore road and lies between 719917.527mN 566343.226mE and 719187.784mN 566933.382mE off the coast of Lagos (Figure 1). The sampling ponds were 50 m apart and underground water was the main source of water for the ponds. The ponds were free from any shading and had adequate sunlight throughout the day. The size of the ponds, their respective capacities and culture system were shown in Table 1.

Fig 1: Map of Lagos State showing location of study area by Lagos Lagoon.

Table 1: Morphometric Characteristics of the Ponds

PONDS	Dimensions(m)	Sizes(Acres)	Depth(m)	Capacity(m^3)	Culture System
Pond 1	38.0×32.0	1.2	1.8	2188.8	Semi-intensive
Pond 2	34.8×30.5	1.06	2.2	2547.4	Semi-intensive
Pond 3	64.4×51.0	3.6	3.2	11823.8	Extensive

Ponds 1 and 3 were stocked with Tilapia (*Oreochromis niloticus*) while Pond 2 was stocked with Tilapia (*Oreochromis niloticus*) and Africa mud cat fish (*Clarias gariepinus*).

Sampling techniques: Physicochemical and biological water quality variables were measured from the sample ponds' water. Samples were taken from each pond once a week, between 09.00 a.m. and 10.00 a.m. in duplicate for a period of eight weeks; from September to October, 2016. The pH, salinity, dissolved oxygen, temperature and water transparency was measured in-*situ.* A mercury in glass thermometer was used to measure the temperature (^{o} C), while transparency (m) was measured with Secchi disc, 20 cm diameters (LaMotte-0171). Digital electronic meter (JPB-607A) was used to measure the dissolved oxygen (DO) (mgL^{-1}). The pH of samples was measured using hand held electronic probe (pH-98108) and salinity with RHW-25Brix (ATC).

Phytoplankton sampling and analysis: Samples for phytoplankton analysis were collected from four sampling points using a cone shaped, silk bolting cloth plankton net with a 50 ml concentrate bottles. The concentrates were transferred to separately labeled 100 ml glass jars and fixed immediately with 5% formalin, which served as a fixative. Fixed samples were allowed to settle in the Laboratory for 24 hours and the supernatant carefully discarded until concentration of 40 ml was obtained. Phytoplankton species were examined, identified and counted using Trinocular Olympus microscope quipped with digital scope photo (×9) and computer system window 2000. Drop count method as described by (Ramachandra and Malvikaa, 2007) was modified for the counting while identification of phytoplankton up to generic level was made according to (Apha, 1998).

Utilize Index and Statistical Analysis: Shannon Wiener diversity index was used to determine the plankton species composition and their diversity across the different ponds sampled. Physicochemical parameters and phytoplankton parameters were analyzed using one-way ANOVA and Post-hoc comparisons using Duncan test (P>0.05) while Pearson's Correlation coefficient was used to determine the association between abundance and physicochemical parameters.

RESULTS AND DISCUSSION

Most physicochemical parameters of the sampled ponds fell within the standard range and thus were favorable for the growth of phytoplankton and fish culture. The only shift from this trend is in the turbidity and pH of the ponds' water which were variable (Table 2 and Fig.2). Pond 3 water with high transparency of 0.89m and slightly low pH (4.81 ± 0.51) would be harmful to the non-tolerant phytoplankton, hence low phytoplankton abundance in the pond.

There is no significant difference in the average water air temperature and dissolved oxygen (DO)

values between the ponds. Significant difference was however found in the pH values.

Table 2: Water quality parameters (Means ± SEM) of the ponds

PARAMETERS	POND 1	POND 2	POND 3
Water temperature (^{0}C)	27.06 ± 0.03	27.18 ± 0.01	27.25 ± 0.02
Air Temperature (^{0}C)	28.50 ±1.84	28.50±01.84	28.50±1.84
Dissolved Oxygen (mgL^{-1})	7.4 ± 0.10	7.52 ± 0.14	6.40 ± 0.24
Transparency (m)	0.48± 0.05	0.49 ± 0.04	0.89 ± 0.09
pH	7.09 ± 0.25	7.16 ± 0.27	4.81 ± 0.51

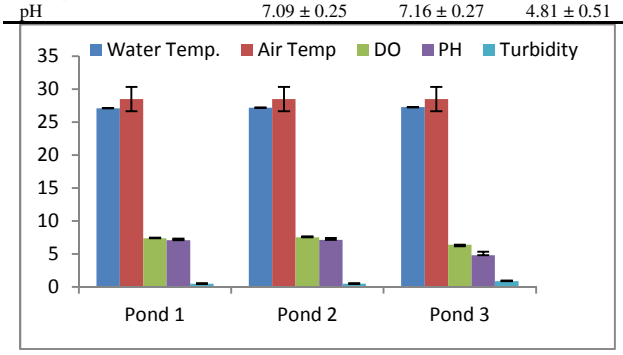

Fig 2: Physico-chemical parameters in the ponds. Values shown = Mean ± SEM

Phytoplankton composition of the four families; Cyanophyceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae identified were shown in Table 3. The Chlorophyceae was the most abundant, followed by Bacillariophyceae, Cyanophyceae and Euglenophyceae in ponds 1 and 2. The total number of genera per pond varied from 13 to 16. Pond 1 had the highest number of genera (16), while the least number of genera (13) was recorded in pond 3. It was obvious that pond 1 had more phytoplankton (94.11%) than pond 2 (88.23%) and pond 3 (41.17%). Six phytoplankton genera were constant (frequency of occurrence 1) in all the Ponds. Phytoplankton abundance was in the order

Bacillariophyceae>Chlorophyceae>Cyanophyceae>Euglenophyceae. Shanon-Wiener's index (H') was 1.263 in Pond 1, 1.265 in pond 2 and 1.078 in Pond 3. The order of diversity is thus: P2>P1>P3 (Table 3). This is in agreement with the findings of Adeogun *et al*, 2005 that blue algae, green algae and diatoms dominate the tropical lakes.

Table 3: Percentage distribution, species richness and diversity of phytoplankton in the ponds

Parameters	Phytoplankton family	Genera	Pond 1	Pond 2	Pond 3	Frequency of Occurrence
	Bacillariophyceae	*Taballaria*	×××	××	×	1
		Asterionella	××	××	A	0.67
		Cyclotella	××	××	××	1
		Surrirella	××	×	A	0.67
		Navicula	×××	××	A	0.67
	Cyanophyceae	*Microcystis*	××	××	×	1
		Gomphospaeria	×	××	A	0.67
		Anabaena	×××	×××	××	1
		Oscillatoria	××	××	A	6.67
		Aphanocapsa	×	a	A	0.33
	Chlorophyceae	*Ulothrix*	××	××	A	0.67
		Oocystis	×××	×××	A	0.67
		Pediastrum	a	×	××	0.67
		Scenedesmus	×××	×××	××	1
		Chlorella	×××	×××	×	1
		Actinastrum	×	a	A	0.33
		6	5	5	3	
	Euglenophyceae	*Euglena*	××	××	A	0.67
Number of genera/pond		17	16	15	7	
Percentage distribution of species (%)	Bacillariophyceae		100	100	40	
	Cyanophyceae		100	80	40	
	Chlorophyceae		83.33	83.33	50	
	Euglenophyceae		100	100	0	
Spatial distribution of species (%)	Bacillariophyceae		41.7	41.7	16.8	
	Cyanophyceae		45.5	36.3	18.2	
	Chlorophyceae		38.4	38.4	23.1	
	Euglenophyceae		50	50	0	
Species composition (%)	Bacillariophyceae		31.25	33.33	28.57	
	Cyanophyceae		31.25	26.67	28.57	
	Chlorophyceae		31.25	33.33	42.85	
	Euglenophyceae		6.25	6.67	0	
Percentage composition (%)			94.11	88.23	41.17	
Shannon-Wiener's index (H')			1.263	1.265	1.078	

hytoplankton enumeration and relative abundance rankings: x =1-15 cells/ml^{-1}(sparsely abundant), xx =16-63 cells/ml^{-1}(fairly abundant) xxx = 64-255 cells/ml^{-1}(very abundant), a = species absent, not encountered in entire enumeration.

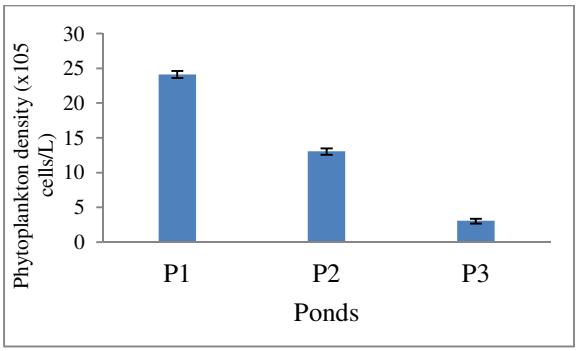

Fig 3: Cell densities of phytoplankton in the ponds. Values shown = Mean ± SE

Phytoplankton density was variable among the ponds investigated. The highest total density of phytoplankton was observed in pond 1. The lowest phytoplankton density in pond 3 was due to the treatment of ponds 1 and 2 with manure which influenced their pH and nutrient availability thus increasing the phytoplankton communities. Shannon –Weaver species diversity index was relatively high in ponds 2 and 1 and low in pond 3 (Table 3). This portrayed more species diversity in ponds 1 and 2 compared to pond 3; order of diversity being P2>P1>P3 (Table 4). There was a significant difference in the mean phytoplankton density of the three ponds ($P < 0.05$). Similar observations were made by (Elliott *et al*, 2002) in various pond habitats.

Table 4: Variations in mean abundance of total phytoplankton (x 10^3 cells l^{-3}) during the study period

Week	Pond 1	Pond 2	Pond 3
1	23.05±0.95^c	12.00±0.35^b	3.07±0.17^a
2	25.90±1.30^c	14.00±0.20^b	3.16±0.14^a
3	22.70±0.40^c	11.90±0.40^b	2.30±0.10^a
4	22.39±0.01^c	11.39±0.01^b	1.89±0.01^a
5	22.60±0.10^c	12.60±0.10^b	1.50±0.40^a
6	25.72±0.10^c	14.10±0.20^b	3.40±0.20^a
7	25.30±0.70^c	14.60±0.45^b	4.24±0.06^a
8	25.32±0.78^c	14.57±0.52^b	4.50±0.15^a
Total mean density	24.12±0.42^c	13.26±0.36^b	3.01±0.26^a

The effect of the negative correlation between phytoplankton abundance and pH range in the ponds characterized with acidic water resulted in low phytoplankton density and diversification (Table 5). This is in agreement with the findings of (Asha, 2015) that water resources with strong acidic water may sustain only acidic species. The spatial distribution (%) varied for the family of Cyanophyceae (Fig 4a-c). The spatial distribution for Bacillariophyceae in ponds 1, 2 and 3 were 41.7%, 41.7% and 16.8% respectively while those for the Euglenophyceae were 50%, 50% and 0% in ponds 1, 2 and 3 respectively (Fig.4a-c). Pearson's correlation coefficients showed that water transparency is inversely proportional to the abundance of phytoplankton; hence an increase in plankton will reduce transparency of water and increase avail ample food availability to fishes for high productivity

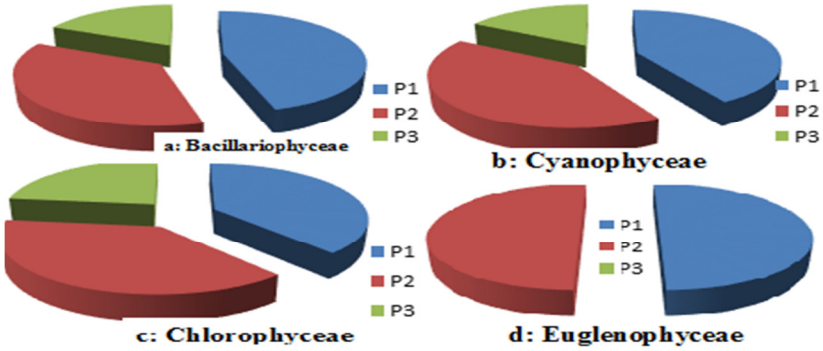

Fig 4a-d: Spatial distribution of phytoplankton in Pond 1 (P1), Pond 2 (P2) and Pond 3 (P3)

Table 5: Pearson Correlation Matrix between Physicochemical Parameters and Phytoplankton Densities of the three Earthen Fish Ponds **KEYS:** Pond (P1, P2, P3), Temperature (T), Dissolved Oxygen (DO), pH

	P1	P2	P3	T1	T2	T3	DO1	DO2	DO3	pH1	pH2	pH3
P1	1			0.528			0.870			-0.726		
P2		1			0.647			0.690			-1.081	
P3			1			0.942			0.875			-0.168
T1	0.528			1			0.716			-0.1866		
T2		0.647			1			0.942			-0.018	
T3			0.942			1			0.479			-0.706
D01	0.870			0.716			1			-0.692		
DO2		0.690			0.942			1			-0.443	
DO3			0.875			0.479			1			-0.249
pH1	-0.726			-0.186			-0.702			1		
pH2		-1.081			-0.436			-0.443			1	
pH3			-0.168			-0.706			-0.249			1

Conclusion: It is evident that the occurrence and abundance of phytoplankton species in these ponds were closely related to their physicochemical characteristics. The physicochemical parameters influenced the distribution and abundance of the phytoplankton and zooplankton. In view of the quantity, quality and the phytoplankton abundance and distribution in the ponds; there is a need to employ a measure to improve the quality of the ponds' water for sustainability of the cultured fishes.

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