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Effect of Physico-chemical Factors and Plankton Abundance in Selected Tropical Fish Earthen Ponds' Water

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Abstract

The study investigated the plankton diversity and abundance of three selected on-farm research fish ponds in Nigerian Institute for Oceanography and Marine Research, Lagos. Samples were taken from three ponds using standard procedure and physico- chemical features of the water bodies were measured. Plankton of class (*Bacillariophyceae, Chlorophyceae, Cyanophyceae* and *Euglenophyceae*I) and Zooplanktons of (*Cladocera, Rotifera* and *Copepoda*) family were found. There were varying results for the phytoplaktons and zooplaktons respectively during the study. The highest percentage composition for phytoplankton was recorded in Pond 1 (94.11%), and the highest Shannon-Weaner diversity (1.265%) in pond 2. The highest percentage of zooplankton was recorded in pond 2 (91.67%). Utilizing the parameter of Shannon index value, the abundance value for zooplaktons was not remarkable. Statistical association between parameters and abundance reflected that abundance was positively correlated with temperature, and negatively correlated with pH while the levels of dissolved oxygen (DO) were positively correlated. The low densities and plankton diversity in pond 3 was an indication of low pH and high transparency as a result of nutrient depletion.

Keywords: Abundance; physico-chemical factors; phytoplankton; zooplankton; fish ponds

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Introduction

The richness of planktons and its interaction with the environment as essential for fish production. Wetzel (1989) showed that fresh water production which influences the growth of fish, is also influenced by its physical, chemical, and biological contents. According to Sikoki and Veen, (2004), plankton productivity is a function of ecological, chemical and physical factors respectively. Wetzel (1989) further showed that fresh water production which influences the growth of fish is also influenced by its physical, chemical, and biological contents.

Abowei (2010) reported that the population density of plankton production and its distribution is a greatly influenced by physical, chemical and environmental factors. Furthermore, Santhosh and Singh (2007) established that the relationship between the physico-chemical parameters of water quality and plankton production in fish ponds is of great importance to fish culture. Reasonable fish production is greatly influenced by biological and physo-chemical qualities of water (Ugwumba and Ugwumba, 1993; Santhosh and Singh, 2007). Sharmin et. al. (2015) showed that phytoplankton composition and abundance were variable in freshwater fish ponds. Several studies on the physical and chemical parameters on some indigenous habitats had been undertaken (APHA, 1991; Boyd, 1998).

Allen, (1991) found that in fish production, understanding the hydrological conditions and the planktons of given water were not only enough, as they also throw more light on the life cycle and population of any fish community. This study thus aimed at evaluating plankton taxonomic composition, biomass and community structure under different pond management to determine the effect and interdependence of physico-chemical parameters on their community structure.

Materials and Methods

Study Area

The study area was the Nigerian Institute for Oceanography and Marine Research (NIOMR) Lagos, Badore out station (Plate 1), located off Ado Badore road. The land lies between 06° 30' 47.8" N 06° 30' 24.01" N and 03° 36' 00.13" E 03° 36' 19.31" E off the coast of Lagos, Nigeria with total land area of 29.455 hectares (Okoro, 2014). Three on-farm research fish ponds located within the same station, 50 m apart and 1.5 km off Lagos lagoon were used for the study. The source of water supply for the fish ponds was drilled borehole. Sampling ponds 1 and 3 were stocked with *Oreochromis niloticus* while pond 2 was stocked with *Oreochromis niloticus* and *Clarias gariepinus*.

Sampling techniques

Physico-chemical parameters and total plankton abundance were measured from the sample ponds. Sampling took place between September, 2017 and November, 2017. Samples were collected from the ponds between 09.00 a.m. and 10.00 a.m. once a week. The pH, salinity, dissolved oxygen, temperature and water transparency measurements were taken *in-situ*. Transparency and temperature were measured with Secchi disc of diameter 20 cm and mercury in glass thermometer respectively. Digital electronic meter (JPB-607A) was used to measure the dissolved oxygen (DO). The pH was measured with electronic probe (pH-98108) and salinity with (RHW-25 Brix (ATC)).

Phytoplankton sampling and analysis

Samples for plankton analysis were collected using a cone shaped, silk bolting cloth 53 µm plankton net with a 50 ml concentration bottle. The 50 ml concentrates were transferred to separately labeled 100 mL glass jars and fixed immediately with 5% formalin from four sampling points. The fixed samples were allowed to settle in the laboratory for 24 hours and the supernatant carefully discarded until concentration of about 40ml was obtained. Phytoplankton species were examined, identified and counted using Trinocular Olympus microscope equipped with digital scope photo (×9) and computer system window 2000 at 10× and 40× objectives using drop count method as described by (Santhosh and Singh, 2007).

Statistical analysis

One way analysis of variance was utilized in data analysis (ANOVA) at 5% level of significance. Density of the plankton species and their diversity were determined with Shannon-Weaver diversity index while Karl Pearson correlation coefficient was used to determine the correlation between the physico-chemical parameters.

Results and discussion

Water quality parameters

The physico-chemical parameters of the sampled ponds fell within the standard range except pond 3 with slight deviation from the trend where the pH of the pond water was slightly low. This may be harmful to non-acid tolerant phytoplankton, thus the low phytoplankton abundance in the pond (Fig. 1). Mean transparency values were similar to those documented by (Abowei, 2010)

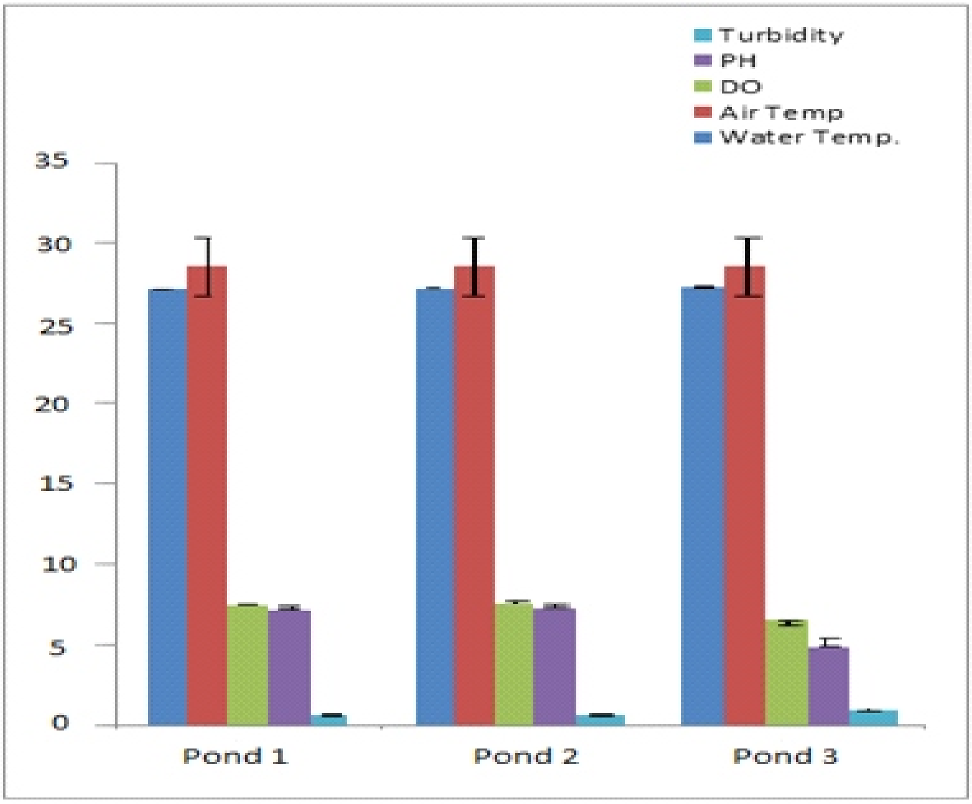

Figure 1 Physico-chemical parameters in the ponds.
Values shown = mean ± SEM

The high turbidity of Ponds 1 and 2 showed that the various nutrients in both ponds' waters were adequate. Same was concord by Abowei (2010). The water temperatures fall within acceptable range (24°C to 34.0°C) for the tropics. The dissolved oxygen was within the optimum range; 5.0 to15.0 mg L^{-1} (Fig.1) which facilitates plankton abundance and distribution. This is in agreement with the findings of **(**Ekubo and Abowei, 2011; Santhosh and Singh, 2007)**.**

Distribution pattern, abundance and community structure of plankton

The phytoplankton community consisted of 17 genera belonging to four families; Chlorophyceae (6), Cyanophyceae (5), Bacillariophyceae (5) and Euglenophyceae (1). The Chlorophyceae was the most abundant, followed by Bacillariophyceae, Cyanophyceae and Euglenophyceae. The impact of massive phosphatase draining in a rich agricultural land and sun light probably contributed to the dominance and abundance of chlorophyceae and bacillariphyceae in a pond. This is in line with the findings of Udo (2007) and also Ogbeibu and Victor, (1995).

There is variation of the range of species in each pond (13-16). Pond 1 had the highest number of species (16) while the least number of species (13) was recorded from the pond 3. The high phytoplankton abundance in pond 1 with light bloom could be attributed to the ponds' water management. Same was concord by Abowei (2010).

Twelve zooplankton species belonging to three families were recorded; Cladocera (4), Rotifera (6) and Copepoda (2) (Table: 1). Copepoda species were common to all the ponds. Species **r**ichness was highest in Pond 2 and least in pond 3 while richness index for zooplankton was low in all the ponds. Phytoplankton species were significantly higher than zooplankton species ($P > 0.05$).

Table 1 : Richness and frequency of occurrence of plankton species in the Ponds

PARAMETERS	MAJOR GROUPS	GENERA	POND1	POND2	POND3	FREQUENCY OF OCCURRENCE
Phytoplankton Species	Bacillariophyceae	Taballaria	×××	××	×	1
		Asterionella	××	××	A	0.67
		Cyclotella	××	××	××	1
		Surrirella	××	×	A	0.67
		Navicula	×××	××	A	0.67
	TOTAL	5	5	5	2	
	Cyanophyceae	Microcysti	××	××	×	1
		Gomphospaeria	×	××	A	0.67
		Anabaena	×××	×××	××	1
		Oscillatoria	××	××	A	6.67
		Aphanocapsa	×	A	A	0.33
	TOTAL	5	5	4	2	
	Chlorophyceae	Ulothrix	××	××	A	0.67
		Oocystis	×××	×××	A	0.67
		Pediastrum	A	×	××	0.67
		Scenedesmus	×××	×××	××	1
		Chlorella	×××	×××	×	1
		Actinastrum	×	A	A	0.33
	TOTAL	6	5	5	3	
	Euglenophyceae	Euglena	××	××	A	0.67
	TOTAL	1	1	1	0	
Zooplankton species	Cladocera	Daphnia	×××	×××	A	0.67
		Ceriodaphnia	×××	××	××	1
		Moina	×××	×××	A	0.67
		Diaphanosoma	×××	×××	×	1
	TOTAL	4	4	4	2	
	Copepoda	Diaptomus	×××	×××	×	1
		Cyclops	×××	×××	×	1
	TOTAL	2	2	2	2	
	Rotifa	Brachionus	×××	×××	×	1
		Keratella	×××	×××	A	0.67
		Filinia	A	×	A	0.33
		Keratella	×××	a	A	0.33
		Polyarthra	×××	×××	A	0.67
		Hexarthra	A	××	×	0.67
	TOTAL	6	4	5	2	

Plankton 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)
xxxx = 256-1024 cells/ml^{-1}'(most abundant)
a = absence of not encountered in entire enumeration.
O = rare species occurrence encountered in the entire enumeration.

Table 2 : Percentage Distribution and Diversity of Planktons

Parameters	Abundance	Species	P1	P2	P3
Phytoplankton	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	26.67	28.57
		Chlorophyceae	38.4	38.4	23.1
		Euglenophyceae	50	50	0
	Percentage composition (%)		94.11	88.23	41.17
	Shannon Weaver diversity index(H)		1.263	1.265	1.078
Zooplankton	Percentage distribution of species (%)	Cladocera	100	100	50
		Copepoda	100	100	100
		Rotifa	66.67	83.33	33.33
	Spatial distribution of species (%)	Cladocera	40	40	20
		Copepoda	33.33	33.33	33.33
		Rotifa	36.36	45.46	18.18
	Percentage composition (%)		83.33	91.67	50
	Shannon Weaver diversity index (H)		1.054	1.036	1.097

The densities of phytoplankton ranged from 1.85 x 10^3 cells L^{-3} to 25.70 x 10^3 cells L^{-3} in all the ponds. There were significant differences in the cell densities of the phytoplankton in the ponds ($P < 0.05$; Fig. 2). Phytoplankton abundance was in the order, pond 1 > pond 2 >pond 3 (Figure 1) probably due to reduction of light bloom in the specified order.

High Shannon Weaver species diversity index in ponds 1 and 2 was an indication of greater species diversity in the two ponds. The high abundance of phytoplankton and zooplankton in ponds 1 and 2 was probably due to the suitable ecological conditions of the ponds. The differences in plankton composition, distribution pattern, abundance and community structure between the ponds showed that plankton distribution and abundance are affected by season, physical and chemical parameters, water movement, soil and biological factors. This is in agreement with the findings of Davies et al (2009).

The densities of the zooplankton ranged from 6.70 $\times 10^3$ cells L^{-1} to 80.10 $\times 10^3$ cells L^{-1} in all the ponds (Table 2). Zooplankton abundance was in the other, pond 1 > pond 2 >pond 3 (Figure 3) probably due to reduced light quality in that order.

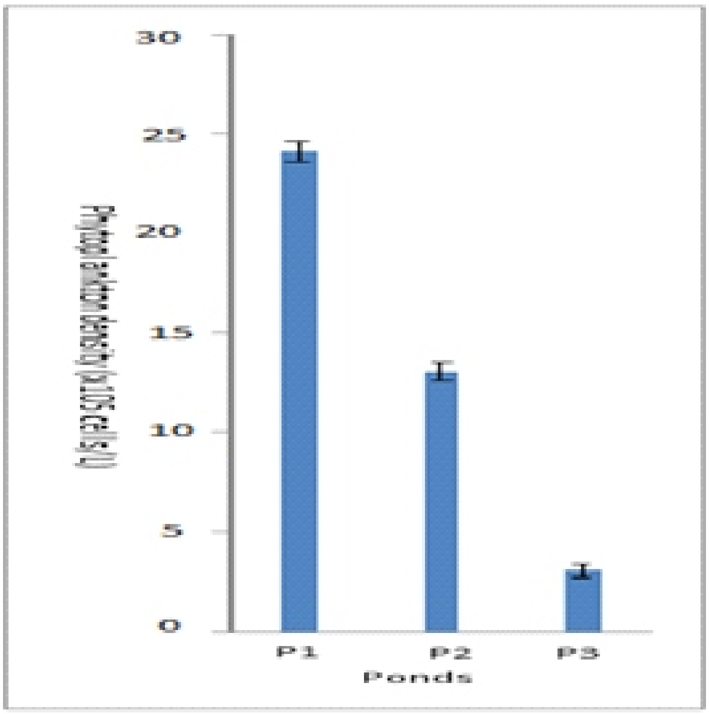

Figure 2: Cell densities of total phytoplankton in the ponds. Values shown = mean ± SEM

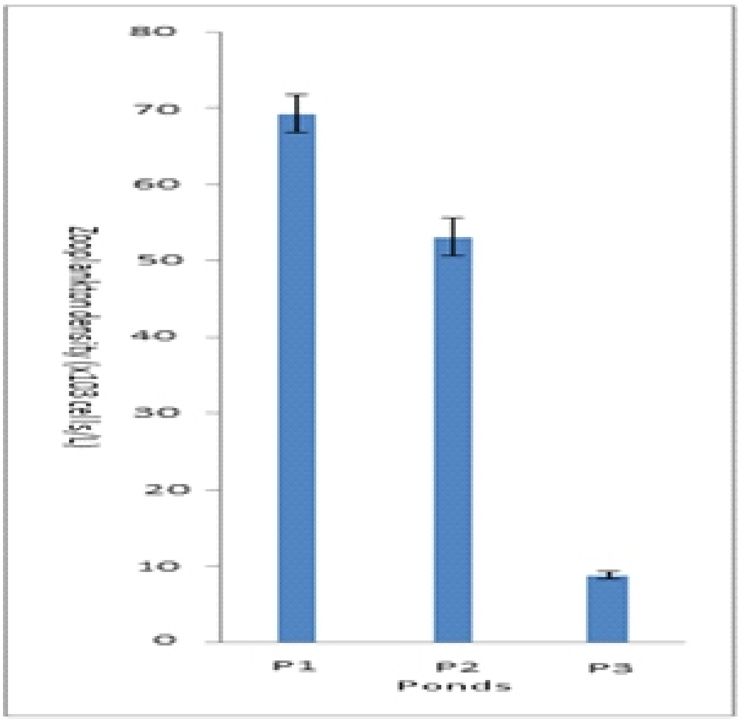

Figure 3 Cell densities of total zooplankton in the ponds. Values shown = mean ± SEM.

Statistical association between parameters and abundance are shown in Table 3

Table 3: Correlation of Temperature, DO, pH and Plankton Abundance

	P1	P2	P3	T1	T2	T3	DO1	DO2	DO3	pH1	pH2	pH3
P1	1	0	0	0.528			0.870			-0.726		
P2	0	1	0		0.647			0.690			-1.081	
P3	0	0	1			0.942			0.0.875			-0.168
T1	0.528	0	0	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			0.0.875			0.479			1			-0.249
pH1	-0.726			-0.1866			-0.702			1		
pH2		-1.081			-0.436			-0.443			1	
pH3			-0.168			-0.706			-0.249			1

KEYS: Pond (P1, P2, P3), Temperature (T), Dissolved Oxygen (DO), pH.

Plankton abundance was positively correlated with temperature (Table 3) and with the levels of DO, but negatively correlated with pH; (r= -0.72619), (r= -1.081) and (r=-0.1681) in ponds 1, 2 and 3 respectively. Low DO concentration during the sampling periods was probably because the samples were collected early in the morning, when the level of Carbon (IV) oxide was high due to respiration. The negative correlation between plankton abundance and pH was an indication that the higher the pH of the ponds' water the lower the phytoplankton abundance. This is in line with the findings of Davies et. al. (2009). The variations in transparency agreed with the findings of (Ogbeibu and Victor, 1995) that the phytoplankton biomass increase with increase in transparency, frequently associated with dry season.

Conclusion

The presence and distribution of phytoplaktons and zooplaktons were influenced by the physical and chemical changes in the water ponds. Phytoplankton and zooplankton respond rapidly to any change in water bodies which may adversely affect the aquatic life leading a reduction in biotic diversity. The quantity and quality of planktons showed that the ponds' water had reached threshold levels. There is thus a need for some corrective measures to maintain water chemistry of the ponds and enhance sustainability of cultured organism (fish).

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