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International Journal of Fisheries and Aquaculture

Full Length Research Paper

Physical, chemical parameters and plankton in a tropical earthen pond catfish farm in Badagry, Nigeria

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The physico-chemical parameters and plankton abundance of four artificial fish ponds in Omageyu Farms, Ijotun, Badagry, Nigeria was studied and analysed using standard methods monthly from June to December 2015. Water temperature, pH and dissolved oxygen ranged from 27.80 to 32.00°C, 6.90 to 7.40 and 6.80 to 10.00 mg/l, respectively in the four ponds. Water temperature, pH, and dissolved oxygen in Pond A were significantly different from ponds B, C and D. Forty-five planktonic organisms, including 40 phytoplankton and 5 zooplankton species, were identified. Shannon Weiner index was highest for pond A = 2.824 and decreased in the order: pond C = 2.81, pond B = 2.797 and pond D = 2.767. Margalef's index of species richness was greatest for pond D = 2.313 and least for pond A. Berger-Parker Dominance Index (BPDI) for the ponds decreased in order of ponds A = 0.2422, C = 0.2328, B = 0.192 and D = 0.1858. Total plankton in the four ponds showed positive correlation with dissolved oxygen. The class Chlorophyta was the prevalent group in the four ponds. The results showed that physico-chemical parameters have an influence on the distribution and diversity of plankton in earthen fish ponds*.*

Key words: *Clarias gariepinus*, earthen ponds, physicochemical parameters, phytoplankton, zooplankton.

INTRODUCTION

Fish appears as a cheap source of protein and an important international trade commodity in many regions and across the global market. It has contributed to the economic growth of various countries around the world. In Nigeria, aquaculture has produced an output of 15,489 tonnes per annum (Ozigbo et al*.,* 2014), which contributed 1% to the Fisheries subsector (FDF, 2005); this, however, seem to contribute to the fulfillment of protein demand across the country. The curtailing of food insecurity encourages employment opportunities,

promoting income generation for individuals and employees across the sub-Saharan African Country. It implies that fisheries have contributed immensely to increasing the output of agriculture which further contributes 34% (Ozigbo et al*.,* 2014) to the country's Gross Domestic Product (GDP). The high cost of feed is related to fish-meal, whereas zooplanktons and other herbivorous aquatic organisms are seen as cheaper alternatives or supplements.

Water is the physical support in which aquatic

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organisms carry out their life functions such as feeding, breeding, digestion and excretion (Bronmark and Hansson, 2005). The monitoring of physico-chemical characteristics of a water body is vital for both short and long-term analysis, because the quality, distribution and productivity level of organisms in a water body are largely governed by its physico-chemical and biological factors (Ashton and Schoeman, 1983; Adakole et al., 2003). Water quality in fish ponds is often due to the interactions of several physico-chemical components and can have profound effects on pond productivity, the level of health and fish health.

Phytoplankton is important in fish farming because it is a primary producer (Yisa, 2006; Bwala et al., 2009). In the aquatic environment, all life forms depend on phytoplankton species, as they are at the base of the food chain, serving as food to zooplanktons and other herbivorous aquatic organisms (Verlencar and Desai, 2004). Phytoplankton occurs naturally in water bodies, but often it may be introduced from cultures to serve as food supplement for fish. Phytoplankton has also been reported to cause fish poisoning in many parts of the world, due to the ability of some species to form toxins during blooms (Cook et al., 2004). Phytoplankton plays an important role as bioindicator of water quality (Tiseer et al., 2008). Zooplankton also plays an important role in the food chain, being in the second trophic level as primary consumer and also as contributors to the next trophic level (Rahman and Hassain, 2008). The zooplankton community is a dynamic system that responds quickly to environmental changes. The relationship between the physico-chemical parameters of water quality and plankton production in fish ponds is of great importance and essential for fish culture (Islam, 2007).

This study is designed to investigate the physico-chemical parameters, phytoplankton and zooplankton composition in earthen ponds. Results of this study will be of immense value to the local aquaculture industry in Nigeria.

MATERIALS AND METHODS

Study area

The four fish ponds studied are located in the Omageyu Farms, Ijotun, Badagry, Nigeria. The earthen ponds were constructed for fish production and holds water all year round, except for occasional changing of the water. The ponds were designated as: POND A- Culture pond for *Clarias gariepinus* fries to fingerlings (3-6 weeks), POND B- *C. gariepinus* Broodstock pond (4-5 years), POND C- *C. gariepinus* Table-size pond (5-9 months), POND D- *Heterotis niloticus* pond (2-3years). *C. gariepinus* fries to fingerlings (25,000) were stocked in 60 m wide × 80 m long × 1.5 m depth while *C. gariepinus* Broodstock (100), *C. gariepinus* Table-size (500), and *H. niloticus* (500) were stocked in the pond 30 m wide × 40 m long × 1.5 m depth respectively.

Water analysis

Water samples were collected monthly for seven months between June and December, 2015. Samples for physico-chemical analysis were collected in 1-L plastic jars from the middle of each pond. Dissolved Oxygen (DO), temperature (°C) and pH was determined using a Horiba U-10 water quality checker. Alkalinity and hardness were determined using methods described by APHA (1998).

Collection of plankton samples

A modified standard phytoplankton net, 55 μm mesh size was dragged for three minutes in each pond just below the water surface to collect plankton monthly for seven months (June to December, 2015), including small-celled phytoplankton, which was collected in a detachable bucket (glass jar) at the rear end of the equipment. After dragging, the water collected in the detachable bucket jar was transferred into plastic bottles enclosed in polystyrene to prevent the water from pouring out.

Qualitative plankton analysis

Identification of the phytoplankton species was done using a phase contrast light microscope (Olympus Tokyo) at 10×40 magnification (Model No: 602980). The magnification for all organisms viewed was x400. Quantitative analysis of phytoplankton was done on Sedgewick-Rafter counting chamber (S-R cell). Analysis involved transfer of 1 ml sub-sample from each of the samples to the Sedgewick-Rafter counter and counting of cells within 5 squares of the cells, chosen randomly. Plankton quality analysis and identification was done using internationally accepted taxonomic keys of Edmonton (1959), Prescott (1970) and Sharma (1986).
The number of organisms per mm was calculated using the following formula (GEMS/WATER, 1977):
:

$$\text{Number of plankters per ml} = \frac{(T)\ 1{,}000}{AN} \times \frac{\text{Volume of concentrate (ml)}}{\text{Volume of Sample (ml)}}$$

Where,
T= total number of plankters counted
A= area of grids in mm^2
N= number of girds employed
1,000= area of counting chamber in mm^2

Data analysis

Descriptive statistics of data for water quality analyses and plankton was done using Microsoft Excel, while the paleontological statistics software package for education and data analysis was used to calculate the; Number of Species, Individuals, Shannon Weiner Index (H), Simpson Diversity index (1-D), Evenness (e^H/S), Menhinicks Index, Margalef's Richness index, Equitability_J, Fisher_Alpha and Berger-Parker dominance index. Analysis of variance (ANOVA) was used to test for statistical differences between the means of the physical and chemical parameters of the fish ponds. The strength and pattern of association between the water quality parameters and Plankton abundance in each pond within the sampling period was established using Pearsons Correlation Analysis in the SPSS version 20.0 software.

RESULTS AND DISCUSSION

Physico-chemical parameters

The results obtained from the monthly variation in

Table 1. Mean values of the physico-chemical parameters for each pond recorded within the sampling period (June - December, 2015).

Parameter	Pond A	Pond B	Pond C	Pond D
Ph	7.25±0.13[a]	7.32±0.13[bd]	6.98±0.05[cd]	7.06±0.08[d]
Dissolved oxygen (mg/l)	8.56±0.89[a]	7.50±0.40[b]	7.30±0.34[b]	7.39±0.45[b]
Alkalinity (mg/l)	30.14±6.6[a]	27.14±5.6[a]	27.43±4.20[a]	27.00±4.80[a]
Total hardness (mg/l)	67.27±3.36[a]	66.03±3.4[ab]	64.34±1.85[ab]	63.49±3.57[b]
Temperature(^{0}C)	29.31±1.32[a]	29.50±1.16[a]	29.19±1.16[a]	29.14±1.01[a]

Values in the same rows with the same superscript are not significantly different (ANOVA, $p > 0.05$).

physico-chemical parameters assessed between the months of June to December, 2015 are presented in Table 1. Temperature ranged between 27.80 to 32.00°C; Broodstock pond (B) had the highest mean temperature (29.50±1.16, range = 28 - 31.5°C) and Heterotis pond (D) the lowest (29.14±1.01, range = 28.2 – 30.9°C). Dissolved oxygen ranged from 6.80 to 10.00 mg/l with Catfish fries to fingerlings pond (A) having the highest mean DO (8.56±0.89, range = 8.2 - 10.0 mg/l) and Catfish Table-sized pond (C) the lowest (7.30±0.34, range = 6.8 - 7.9 mg/l). pH ranged from 6.90 to 7.40, Catfish Broodstock pond (B) had the highest mean pH (7.32±0.13, range = 6.90 - 7.32) and Catfish Table-sized pond (C) the lowest (6.98±0.05, range = 6.90 - 7.02). Alkalinity ranged from 21.00 to 40.00 mg/l with Catfish fries to fingerlings pond (A) having the highest mean alkalinity (30.14±6.6, range = 23 - 40 mg/l) and Heterotis pond (D) the least (27.00±4.80, range = 21 - 36 mg/l). Total hardness had a range of 61.00 - 72.06 mg/l with Catfish fries to fingerlings pond (A) having the highest mean hardness (67.27±3.36, range = 62 - 71.45 mg/l) and Heterotis pond (D) the least (63.49±3.57, range = 61 - 71.09 mg/l).

The physico-chemical parameters examined for the four ponds were in a suitable range of water quality for fish survival according to Erondu (1991), Akinwole and Faturoti (2007) and Hoff et al. (2001). According to Roberts et al. (1997), maximum temperature range for aquatic life is considered to be 20-33°C, and the temperature range recorded for the duration of the experiment was 27.8 - 32.0°C, which suggested that the range was suitable for fish growth and plankton proliferation.

Erondi (1991) reported that dissolved oxygen > 5 mg/l is necessary for the survival of fish and any aquatic organisms. The dissolved oxygen for the four ponds ranged between 6.8 - 10 mg/l, which was within the appropriate range (3.0 - 5.0 mg/L) recommended by the Federal Environmental Protection Agency (FEPA) (2003). Dissolved oxygen was relatively low during the peak of the rainy season (July) and high during the peak of the dry season (November). This may be due to an increase in turbidity during the rainy season and reduction during the dry season.

According to Hoff and Snell (2001), the optimum pH range for plankton production is between 6.5 and 9.5. The pH recorded within the sampling period ranged between 6.90 and 7.40, which is within the optimum range for plankton production and fish growth. Alkalinity normally reflects carbonate content of rocks and soils of water sheds and bottom mud (Jobbágy and Jackson, 2001). The relatively lower values of alkalinity recorded during the July may be attributed to the dilution effect of the rain during this period.

Relative abundance of plankton in the four ponds

Forty-five planktonic organisms were identified in the four ponds. They include 40 phytoplankton species like Green algae (21 species), Blue- green algae (4 species), Diatoms (5 species), Red algae (2 species), Golden-brown algae (2 species), dinoflagellates (2 species) and Euglenophytes (4 species). There were five zooplankton species including three (3) protozoans, one (1) crustacean and one (1) rotifer.

Figure 1 shows the relative abundance of plankters per ml in each pond observed within the period of study. Catfish fries to fingerlings Pond A had the highest number of plankters (231,200) followed by Catfish Broodstock Pond B with 229,200 individuals, Heterotis pond D with 180,800 individuals and Catfish Table-size Pond C with 163,200 individuals. Class Chlorophyta was the most abundant amongst the four ponds (100,000 individuals in Pond A; 126,000 individuals in Pond B; 92,800 individuals in Pond C and 86,400 individuals in Pond D). Pond D was found to be the richest in Class Chrysophyta, protozoa and rhodophyta. Class Crustacean was absent in ponds B and C throughout the period of sampling.

The composition of phytoplankton community of the ponds agreed with reports that blue-green algae and green algae dominate most tropical water bodies (Adebisi, 1981; Ayodele and Ajani, 1999). It has been reported that increase in primary production (phytoplankton) is accompanied by increase in zooplankton abundance (Rocha et al., 1999). Zooplankton forms about 5% of the total plankton
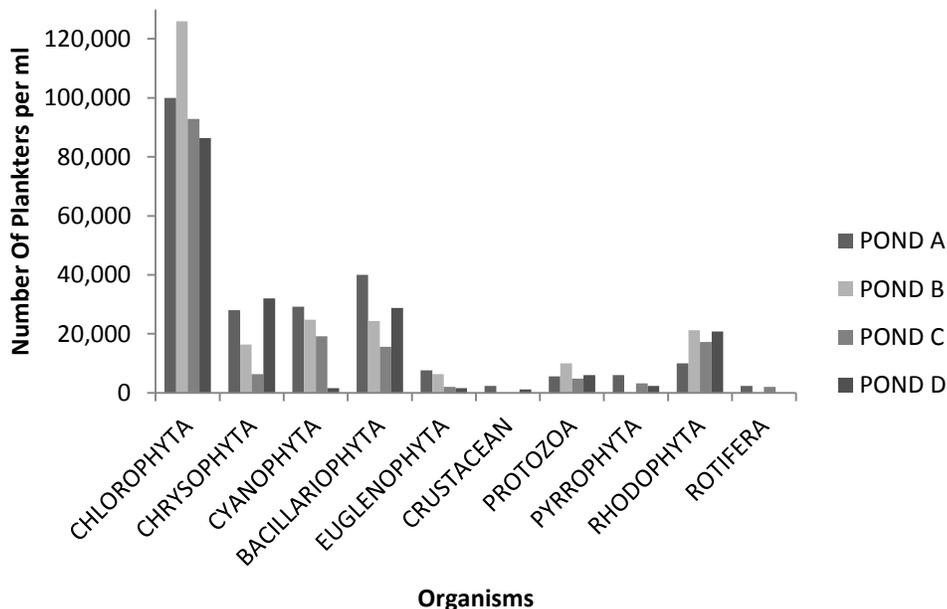
Figure 1. Relative abundance of plankters per mililiter in each pond within the period of study (June - December, 2015).

population in Catfish fries to fingerlings pond (A) and lesser in the other ponds.

Protozoa was the dominant zooplankton class in the four ponds. An increase in the zooplankton abundance in Catfish fries to fingerlings pond (A) resulted in a reduction in phytoplanktonic abundance as the zooplankton feed on phytoplankton. Within the sampling period, it was observed that Catfish fries to fingerlings pond had a green colouration which is an indication of its high Chlorophyte density.

Total abundance of plankters in each pond per month

Number of plankters per ml observed in each pond per month within the sampling period (June - December, 2015) is illustrated in Figure 2 where Pond A had the highest number of plankters in month of December.

Percentage abundance of plankters in specific ponds

In the Catfish fries to fingerlings Pond A, the chlorophytes had the highest percentage abundance (43.25%), followed by the Bacilliariophyte (17.30%), Cyanophyte group (12.63%), Chrysophyte (12.11%), Rhodophyte (4.33%), Euglenophyte (3.29%), Protozoa (2.42%), Pyrrophyte (2.60%), and then Rotifer and Crustacean (1.04%) the least abundant.

In the Catfish Broodstock Pond "B", the Chlorophytes was the prevalent specie; it had the highest percentage abundance (54.97%), followed by the Cyanophyte group

(10.82%), Diatom (10.65%), Rhodophyte (9.25%), Chrysophyte (7.16%), Protozoa (4.36%), and the least abundant Euglenophyte (2.79%).

In Catfish Table-Size Pond C Chlorophytes species prevailed (56.86%), followed by the Cyanophyte group (11.76%), Rhodophyte (10.54%), Diatom (9.56%), Chrysophyte (3.92%), Protozoa (2.94%), Pyrrophyte (1.96%) and the least abundant Euglenophyte and Rotifer (1.23% respectively).

In the Heterotis Pond "D" the Chlorophytes had the highest percentage abundance (47.79%) followed by the Chrysophyta group (17.70%), Diatom group (15.93%), Rhodophyte (11.50%), Protozoa (3.32%), Pyrrophyte (1.33%), Cyanophyte (0.88%), Euglenophyte (0.88%) and Crustacean (0.66%).

Correlation between total plankton and physico-chemical parameters

Correlation between total plankton in the four ponds and the physico-chemical parameters within the period of study was calculated. The total plankton in the four ponds had positive correlation with dissolved oxygen concentration (Pond A r = 0.441, Pond B r = 0.815, Pond C r = 0.463, Pond D r = 0.637). The correlation between total plankton in Catfish fries to fingerlings pond (A) and the physico-chemical parameters showed positive significant correlation with alkalinity (r = 0.809) and low positive correlation with pH (r = 0.353). Plankton showed negative correlation with temperature (r=-0.172) and 0.045 correlation value with water hardness meaning that
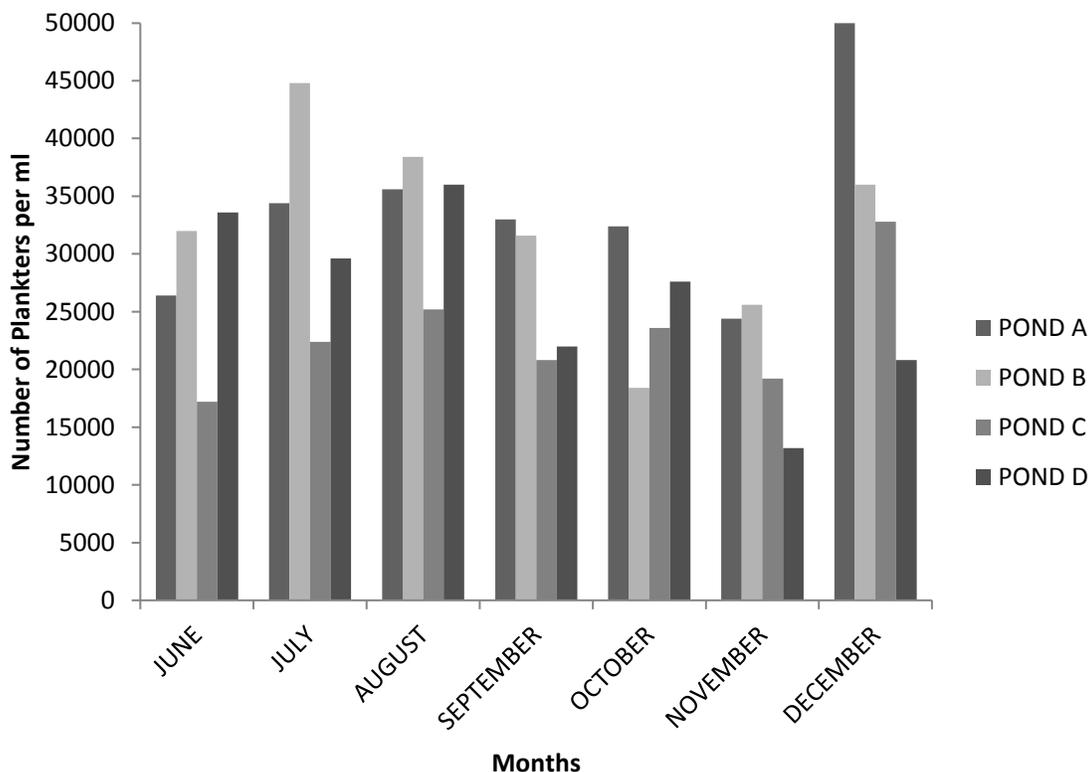
Figure 2. Number of plankters per ml observed in each pond per month within the sampling period (June - December, 2015).

Table 2. Correlation values of physico-chemical parameters and total plankton in each pond recorded within the sampling period (June - December, 2015).

Parameter	Pond A	Pond B	Pond C	Pond D
Total plankton/dissolved oxygen	0.441	0.815	0.463	0.637
Total plankton/temperature	-0.172	0.115	-0.241	-0.769
Total plankton/water hardness	0.045	0.007	-0.331	-0.037
Total plankton/alkalinity	0.809	0.485	-0.205	0.584
Total plankton/pH	0.353	-0.118	0.807	0.719

an increase in temperature and water hardness levels led to a decrease in plankton abundance.

In Catfish Broodstock Pond (B), total plankton revealed high positive correlation with alkalinity (r = 0.485) and low positive correlation with temperature (r = 0.115) and water hardness (r = 0.007). The correlation between total plankton and pH was negative, r = -0.118.

Total plankton in Table sized pond (C) showed negative correlation values with temperature (r = -0.241), water hardness (r = -0.331) and alkalinity (r = -0.205) and a high positive correlation value with pH (r = 0.807).

Total plankton in the Heterotis pond (D) showed positive correlation with alkalinity (r = 0.584) and pH (r = 0.719) and negative correlation with temperature (r = -

0.769) and water hardness (r = -0.037) (Table 2).

Diversity Indices

Shannon Weiner index was highest for Catfish fries to fingerlings pond (A) = 2.824 and decreased in the order Catfish Table-sized pond (C) = 2.81 to Catfish Broodstock pond (B) = 2.797 and Heterotis pond (D) = 2.767. Evenness of distribution was highest for Catfish fries to fingerlings pond (A) = 0.624 and lowest for Heterotis pond (D) = 0.5489. Margalef's index of species richness was greatest for Heterotis pond (D) = 2.313, and least for Catfish Fries to fingerlings pond A. Berger-

Table 3. Diversity indices for each pond measured within the sampling period.

Diversity index	Pond A	Pond B	Pond C	Pond D
No. of Species	27	29	27	29
Individuals	231200*	229200	163200**	180800
Shannon Weiner Index (H)	2.824*	2.797	2.81	2.767**
Simpson Diversity index (1-D)	0.9064	0.9131*	0.907	0.9061**
Evenness (e^H/S)	0.62*	0.5655	0.6151	0.5489**
Menhinicks Index	0.05615**	0.06057	0.06683	0.0682*
Margalef's Richness index	2.105**	2.269	2.166	2.313*
Equitability_J	0.8569*	0.8307	0.8526	0.8219**
Fisher_Alpha	2.348**	2.542	2.429	2.601*
Berger-Parker	0.2422*	0.192	0.2328	0.1858**

* Highest values for the indices; ** Lowest values.

Parker Dominance Index (BPDI) for the ponds decreased in order of pond A = 0.2422, pond C = 0.2328, pond B = 0.192 and pond D = 0.1858 (Table 3).

Conclusion

The results showed that phytoplankton composition and their abundance are variable in freshwater fish ponds even within the same farm environment. Temperature, dissolved oxygen, photo-period, insolation, water pH, wind, seasonal variations, water characteristics, nutrient enrichment and predator-prey relationship may be related to variable changes in the phytoplankton distribution and their abundance in ponds' water.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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