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Phytoplankton abundance and species diversity in selected catfish ponds in monai cluster fish farm, southern basin of Kainji lake, Nigeria

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Abstract
This study was done with the aim of determining the specie composition and abundance of microalgae/Phytoplankton species in water samples from Catfish ponds in Monai Cluster fish farm. It was also conducted to determine the most adapted algae specie/species in Catfish environment amidst the high nutrient concentrations in earthen Catfish ponds in Monai cluster fish farm. Information from this study will be important in deciding the algae species to be isolated and used for laboratory batch cultures utilizing recycled nutrients from these catfish ponds. Water and Plankton samples were collected once per month during the dry season and the duration of the sampling period was three months, from March, 2021 to May, 2021.This study revealed an excellent diversity of phytoplankton community in earthen fish ponds in Monai cluster fish farm. Nineteen (19) Phytoplankton genera belonging to seven (7) families. These include; seven (7) species of phytoplankton belonging to Chlorophyceae, three (3) species belonging to Bacillariophyceae/diatom, four (4) species belonging to Cyanophyceae/Cyanobacteria and one specie each belonging to Xanthophyceae, Euglenophyceae, Trebouxiophyceae and Fragilariophyceae respectively. Temperature and pH ranged from 29◦C to 31◦C and 8.6 to 10.4 respectively while nitrate and phosphate concentrations across the months ranged from 1.20mg/l to 3.53mg/l to 0.64mg/l to 4.02mg/l respectively. The list of algae species isolated was dominated by Chlorophyceae, Bacillariophyceae and Cyanophyceae. This array of specie dominance amongst these dominant groups shows that Phytoplankton samples from these ponds can be used for single specie isolation to produce unialgal cultures utilizing recycled nutrients form these ponds.

Keywords: Microalgae, phytoplankton, monai, cluster, species, ponds, abundance, composition

Introduction

Phytoplankton are tiny microscopic organisms which form the foundation of the food chain in aquatic ecosystems [1]. They are photosynthetic organisms that have been reported be responsible for over half of the photosynthetic activity on earth [2]. They are also responsible for carbon dioxide sequestration, where they are able to reduce carbon dioxide levels in the atmosphere. Phytoplankton also play a vital role in global nutrient cycles as well primary productivity in aquatic ecosystems [3]. The abundance and specie distribution of the phytoplankton populations are largely controlled by inorganic nutrients such as phosphorus as orthophosphate, nitrogen as nitrate, nitrite and ammonia as well as silica [4]. In the fish pond environment, nutrient availability and concentration are dictated by respective management practices on individual fish ponds such as feeding, feed type, frequency of feeding and water quality management. According to Brenttum and Anderson, 2005[5], Phytoplankton communities are sensitive to changes in their environment and therefore phytoplankton total biomass and phytoplankton species distributing can be used as indicators of water quality and general well-being of the pond ecological system. Microalgae / Phytoplankton have been widely reported as viable and cheaper sources of proteins, lipids, vitamins and amino acids [17; 18]. However, the conventional culture of algae involve the use of synthetic media which comprise of various additions of nutrient sources and vitamins in form of micro (trace metals and vitamins) and macro nutrients (nitrogen and phosphorus). These chemicals are not only expensive but also difficult to procure since most of them are imported. The use of recycled nutrients and animal wastes in growing microalgae is gradually gaining more attention in algae biotechnology particularly in developing countries. Information from this study will be important in deciding the algae species to be isolated and used for laboratory batch cultures, utilizing recycled nutrients from Catfish ponds in Monai cluster fish farm.

This will give more insight about the most adapted algae specie/species in these Catfish ponds amidst their high nutrient concentrations.

Materials and Methods
The Study Area
Location and description of the study area
Monai village is one of the fishing communities located in the Southern basin of Kainji Lake with cluster fish farms that are individually owned by villagers and non- villagers. It lies between latitude 9°53.313'N and longitude 4°32.89'E. Aside from its use for fishing and aquaculture, the Southern basin of the lake provides a source of portable water to the villagers for domestic and irrigation purposes.

Description of production system, water and feed management
Production is either intensive or semi intensive, where catfish (hybrid and Dutch Clarias) are the most cultured fish species. Water management system in the cluster farm is mainly flow-through system in earthen ponds that are connected in series. Water is usually pumped from the lake upstream to feed the ponds downstream with the use of water pumping generating sets. Wastewater from the adjoining ponds that link to the water way is channelled to the lake as no wastewater settling or treatment ponds exist. Feeding is mostly done twice a day (Morning and evening) or three times a day (rarely). Most farmers feed their fingerlings with crushed clupeids to a stage where they can consume at least 2mm of foreign feed (floating) containing 40 – 45% crude protein.

At juvenile stage, farmers swiftly switch to locally compounded feed (un-extruded) using local ingredients to minimise expenses. Fish is being fed with local feed till it gets to the harvest period, usually 4 – 7 months or more depending on the financial capability of the farmer.

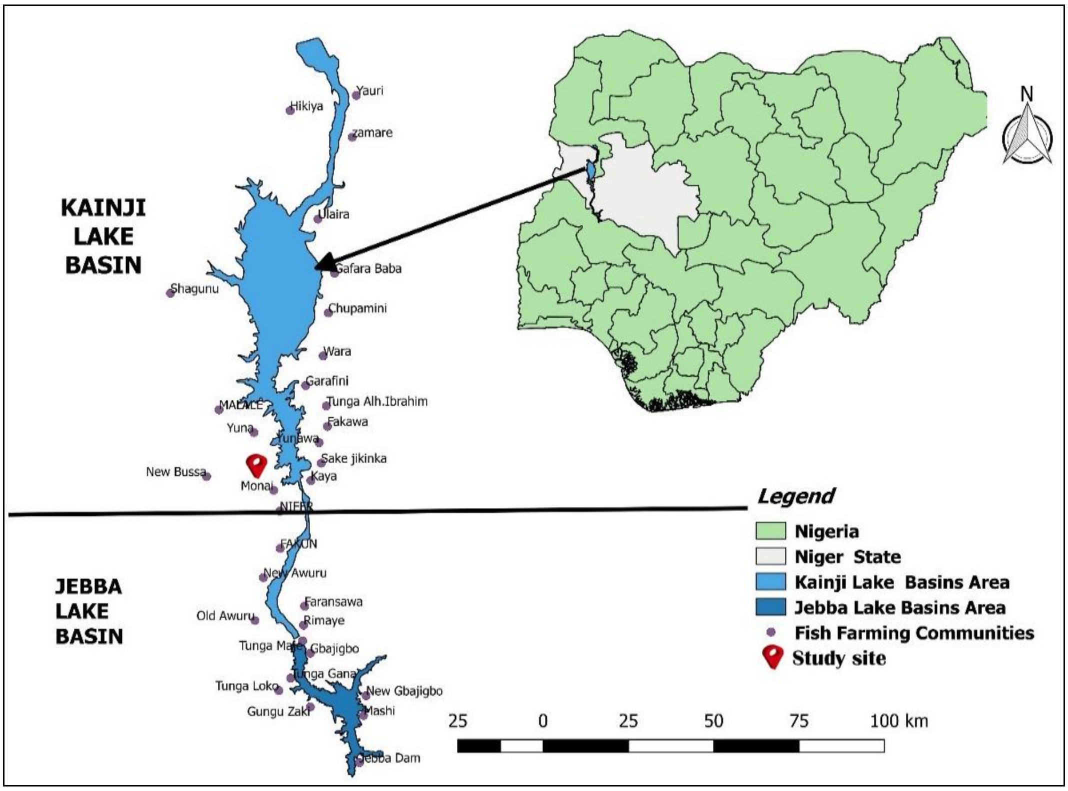

Fig 1: Map and location of the study area

Measurement of Physicochemical Parameters
Water samples were collected once per month during the dry season and the duration of the sampling period was from March, 2021 to May, 2021. Random sampling technique was used to collect water samples from the ponds with the aid of an automated water sampler (Van dom water sampler). Water samples for physicochemical parameters were collected once a month in the morning (8:00hr). The pH, surface temperature, total dissolved solids (TDS) and turbidity were all determined in situ. Other physicochemical variables measured were conductivity, nitrate (NO_3^-), nitrite (NO_2^-) and orthophosphate (PO_4^{3-}). Water temperature and was measured with the aid of a mercury-in glass thermometer while pH was determined with the aid of a hand-held digital pH meter (pHep®, HANNA, USA). Total dissolved solids (TDS) was also determined with a digital TDS/temperature meter (AP-1, HM, USA) and turbidity was measured with the help of a secchi disk.

Collection of Water Samples for Plankton Analysis
Samples for plankton study were collected from the fish ponds once per month from July, 2019 to December, 2019 in clean sterile 250ml sample bottles using a phytoplankton net (55µm mesh size). Samples were collected from twenty (20) randomly selected fish ponds in the cluster fish farm using standard procedure. All samples collected were concentrated and preserved with Lugol's solution and 1ml of 10% formalin respectively. This was allowed to stay overnight for sedimentation to take place prior to analysis. Identification and counting of phytoplankton was done the following day using an inverted microscope using plankton determination keys by Prescott (1970) [6] and Sharma (1986) [7] as well as Belcher and Swale (1976) [8].

Statistical Analysis

Statistical analysis was done using SPSS, version 16. Analysis of variance (ANOVA) was used to make a comparison of the means of monthly variation in microalgae specie composition and relative abundance as well as physicochemical parameters. Phytoplankton abundance was computed as percentages and diversity index which include Shannon-Wiener diversity index and species richness as well as Simpson's diversity index were used to determine the plankton species composition and their diversity across the various sampling periods.

Results

This study revealed an excellent diversity of phytoplankton community in earthen fish ponds in Monai cluster fish farm. Nineteen (19) Phytoplankton genera belonging to seven (7) families were identified in this study from March, 2021 to May, 2021. These include; seven (7) species of phytoplankton belonging to Chlorophyceae, three (3) species belonging to Bacillariophyceae/diatom, four (4) species belonging to Cyanophyceae/Cyanobacteria and one specie each belonging to Xanthophyceae, Euglenophyceae, Trebouxiophyceae and Fragilariophyceae respectively (Table 3). Result of water chemistry variables showed mean pH values ranging from (9.2 to 10.4), conductivity values ranging from (600 µS/cm to 860 µS/cm) and total dissolved solids (TDS) values ranging from (317 mg/l to 582 mg/l) respectively across all months sampled. Similarly, nutrient analyses recorded mean total nitrogen values ranging from (4.58 mg/l to 5.95 mg/l) and mean phosphate (PO_4^{3-}) values ranging from (4.02 mg/l to 5.64 mg/l) respectively (Table 1).

Table 1: Water Quality and Nutrient Analysis

Parameters	Months		
	March	**April**	**May**
Surface temperature (◦C)	29.0±0.3	30.8±0.1	31.0±0.1
pH	10.4±0.1	9.2±0.5	8.6±0.2
Conductivity (µS/cm)	600±49	720±54	860±36
TDS (mg/l)	582±26	439±62	317±50
Turbidity (NTU)	0.03±0.1	0.20±0.5	0.09±0.1
Nitrates (mg/l)	4.64±0.5	2.42±0.5	1.32±0.2
Nitrite (mg/l)	1.20±0.1	3.53±0.3	3.26±0.0
Total Nitrogen (mg/l)	5.84±1.7	5.95±0.6	4.58±1.0
Phosphate (mg/l) (Orthophosphate)	4.02±0.5	4.82±0.3	5.64±0.1

Table 2: Relative Abundance of Phytoplankton families from Catfish Ponds in Monai Cluster Fish Farm

March		
Algae Class	**R.A**	**Cells/ml**
Chlorophyceae	85.15	1714950
Bacillariophyceae	1.22	23550
Cyanophyceae	13.35	266950
Xanthophyceae	0.10	1600
Trebouxiophyceae	0.02	500
Euglenophyceae	0.10	2300
Fragillariophyceae	0.10	1200
April		
Algae Class	**R.A**	**Cells/ml**
Chlorophyceae	92.1	2314020
Bacillariophyceae	1.22	23550
Cyanophyceae	15.0	425250
Xanthophyceae	0.52	2180
Trebouxiophyceae	0.05	800
Euglenophyceae	0.20	2800
Fragillariophyceae	0.18	2200
May		
Algae Class	**R.A**	**Cells/ml**
Chlorophyceae	72.8	238765
Bacillariophyceae	0.82	18753
Cyanophyceae	14.2	208532
Xanthophyceae	0.56	2200
Trebouxiophyceae	0.05	300
Euglenophyceae	0.13	2512
Fragillariophyceae	0.12	3211

Table 3: Checklist of Phytoplankton Specie Composition from Catfish Ponds in Monai Cluster Fish Farm

	Phytoplankton Class	**Species**
1.	Chlorophyceae	*Closterium sp.* *Microspora sp.* *Pediastrum sp.* *Scenedesmus incrassatulus* *Chlorella sp.* *Scenedesmus quadricauda* *Navicula sp.*
2.	Bacillariophyceae	*Synedra sp.* *Nitzchia sp.* *Melosira sp.* *Diatomella sp.*
3.	Cyanophyceae/Cyanobacteria	*Anabaena sp.*

		Oscillatoria sp. *Spirullina sp.* *Anacystis sp.*
4.	Xanthophyceae	*Arthrospira sp.*
5.	Trebouxiophyceae	*Hormidium sp.*
6.	Euglenophyceae	*Euglena sp.*
7.	Fragillariophyceae	*Synedra sp.*

Table 4: Changes in diversity indices of Phytoplankton groups `

Shanon-Wiener				Simpson's index (D_{simp})
Months	**Index**	**Species Evenness**	**% Evenness**	**Index**
March	0.5	0.3	30%	0.3
April	0.5	0.3	30%	0.3
May	0.9	0.5	50%	0.5

Relative abundances (R.A) of phytoplankton families showed that Chlorophyceae were the most dominant algae class with R.A percentages of 85%, 92.1% and 72.8% recorded in the moths of March, April and May respectively (Table 2). There was no statistical significant difference between the phytoplankton specie composition and abundance within months of sampling ($p>0.05$). This can further be buttressed with results of other statistical tests conducted because both Shanon-Wiener and Simpson indices showed close similarity between the phytoplankton counts of all three months (March-May) as shown on table 4. Specie evenness was quite low due to the dissimilar abundances between algae groups. This means that some algae groups such as Chlorophyceae, Bacillariophyceae and Cyanophyceae dominated other groups. Similar trend was recorded by [9], on a similar study carried out in Ikere-Gorge dam, Oyo state, Nigeria.

Discussion

Physicochemical parameters of water in an aquatic habitat are key to the distribution and abundance of aquatic organisms in such ecosystems. These parameters are affected by rainfall particularly in tropical climates where the seasonal variation of water quality are mainly influenced by precipitation [10]. The rich diversity of microalgae/phytoplankton species observed in Catfish ponds in the cluster can be attributed to the fact that the study was conducted during the middle of the dry season period (March to April). Characteristic features of Catfish ponds during this period of the year include; low water levels, high nutrient loads as seen in table 1 and high surface temperatures. This is in agreement with the work of Yusuf (2020) [11], who stated that the overall phytoplankton density in a tropical water reservoir in Nigeria was higher in the dry season than the wet season. During this period of no rainfall, most of the Catfish ponds are under off season production period. The alkaline pH values recorded across the months (March-May) may likely be due to the higher photosynthetic rates carried out by microalgae and higher plants, thus shifting the equilibrium to the alkaline side as suggested by Trivedi (1989) [12]. This will in turn have a positive effect on the abundance and distribution of microalgae, thus favoring their abundance. The high abundance of the Chlorophyceae, Bacillariophyceae and Cyanophyceae algae groups recorded in the month of April compared to other months in this study could be high nutrient availability due to nutrient enrichment between the epilimnion and the hypolimnium brought about by strong winds at a time when the water levels in the ponds were shallow because most ponds had been harvested prior to this time and also de-mudded to remove accumulated sediments out of the ponds. This agrees with the statement by Naselli-Flores (2003) [13] that mixing of the thermocline results in nutrient enrichment during periods with high temperature and light, thus leading to major phytoplankton bloom. Nitrate and Phosphate concentrations across the months ranged from 1.20mg/l to 3.53mg/l to 0.64mg/l to 4.02mg/l respectively. High Phosphorus values recorded can be attributed to the impact of de-mudded sediments from newly harvested fish ponds which might have entered adjacent ponds via draining or diffusion of the sediment-pore water [14; 15]. This also agrees with the statement of Carpenter *et al*. (1998) [16] that nutrients can build up in sediments over time and create a potential of both internal and external loading that can be recycled under different environmental conditions.

Conclusion

Microalgae/Phytoplankton are very important players in the aquatic system because of their significance as primary producers. Their composition and abundance is influenced by nutrient availability, seasonality and availability of light. This study revealed Nineteen (19) Phytoplankton genera belonging to seven (7) families in Catfish ponds in Monai cluster fish farm in Southern basin of Kainji lake, Nigeria. The list is dominated by Chlorophyceae, Bacillariophyceae and Cyanophyceae. It can be concluded that these algae families are the most dominant and well adapted species amidst the high nutrient concentrations in Catfish ponds in Monai cluster fish farm. Information from this study will be important in isolating algae species to be used for laboratory batch cultures utilizing recycled nutrients from these catfish ponds.

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