

## Comparative Study on the Phytoplankton Community in Two Newly Inundated Ponds, Using Organic and Inorganic Fertilizer.

### Abstract

A comparative study on the communities of phytoplankton in two newly inundated ponds was carried out from September 2023 to October 2023. The study was conducted in a completely random design experimental setup with two treatments and replicated twice using organic and inorganic fertilizer (chicken manure and diammonium phosphate fertilizer (20:10:10) (2.5kg for each). Out of 1114 individuals of phytoplankton identified, 611 belong to the organic fertilized tank while 503 individuals were accounted for the inorganic fertilized tank. The highest and the lowest phytoplankton species identified were *Dactylococlopsis irregularis* (79) > *Phormidium tenue* (53) > *Ankistrodesmus falcatus* (39) for the organic fertilized tank while the dominant species for the inorganic tank were *Dactylococlopsis irregularis* (45) > *Ankistrodesmus falcatus* (36) > *Dinobryon barbaricum* (31). The least dominant species found in this current study for organic fertilizer were *Closterium macilentum* (7) > *Amoeba polyopodia* (7) > *Volvox aureus* (3) > *Raphidiopsis curvata* (2) while the trend for inorganic fertilizer were *Aphanizomenon flosaquae* (7) > *Spirulina subtilissima* (4) > *Nitzschia linearis* (2). Physicochemical factors like Temperature, pH, Potassium, and Total nitrogen, were found to be the important factors influencing the growth and distribution of phytoplankton and they exhibited a significant positive correlation with phytoplankton in the PCA and CCA biplot. This present study revealed inter-tank differences in some of the physico-chemical parameters investigated. Potassium, phosphorus, nitrogen, and dissolved oxygen were significantly different across the two treatments while temperature and pH were non-significant, statistically ( $P < 0.05$ ). The result from the analysis of all community parameters (Shannon-Wiener diversity, Evenness, Simpson, and Margalef indices) showed that parameters varied slightly. The highest in Shannon-Wiener diversity, Evenness, the Simpson and Margalef indices were found in the inorganic tank with their respective values (3.216, 0.8901, 0.956, and 4.34), while the lowest in Shannon-Wiener diversity, Evenness, the Simpson and Margalef indices were found in the organic fertilized tank with their respective values (3.141, 0.8256, 0.9481 and 4.209). This result indicates that the abundance and structure of phytoplankton communities were affected by the different fertilizer used and also the physicochemical condition of the tank.

**Keywords:** Organic Fertilizer, Inorganic Fertilizer, Inundated Ponds, Phytoplankton, Community

### 1.0 Introduction

In the realm of the aquatic ecosystem, phytoplankton serves as a fundamental component, playing a pivotal role in nutrient cycling and primary productivity (Ni *et al.*, 2018) and the structure of phytoplankton community is a good indicator of water quality due to its alertness to environmental stresses (George and Atakpa, 2015; George and Opeh, 2016; George *et al.*, 2021). The introduction of fertilizers, whether organic or inorganic into aquatic ecosystem can significantly influence phytoplankton composition and abundance, thereby impacting overall ecosystem dynamics (Sipaúba-Tavares *et al.*, 2011; Akpan *et al.*, 2022; Asuquo *et al.*, 2022).

The abundance and structure of the populations of phytoplankton are majorly regulated by inorganic nutrients which include but not limited to nitrogen, phosphorus, and silica (Akunga *et al.*, 2018). The major available nitrogen occurs as nitrate, nitrite, and ammonia. Phosphorus occurs as soluble orthophosphate while silicone exists in form of silicates (USEPA, 2008). Phytoplankton communities are sensitive to alterations in their habitats, and thereby, phytoplankton total biomass and many phytoplankton species are utilized as indicators of aquatic habitat qualifications (Chellappa *et al.*, 2009). Phytoplankton demonstrates water quality through changes in its community composition, and distribution, and proportion of sensitive species (Gharibet *et al.*, 2011). Phytoplankton are largely governed by light, nutrients, temperature, community structure, life-cycle history, stratification or vertical mixing, and tides (Yusuf, 2020).

Environmental conditions can directly or indirectly affect the community structure of phytoplankton (Whitton, 2012). Previous studies have proved that the change characteristics of phytoplankton structure are closely related to hydrological conditions, and nitrate concentration (Negro *et al.*, 2000), and also have a good coupling relationship with chemical oxygen demand (COD) and particulate organic matter (POM) (Lee and Kang, 2010). When environmental factors change, it can still control the phytoplankton community structure to a great extent. It is becoming more and more essential to study the changes in phytoplankton community structure to improve water quality assessment (Huang *et al.*, 2022). Therefore, monitoring phytoplankton community structure and diversity has become an essential water ecosystem health and water quality evaluation (Nunes *et al.*, 2018). Thus, understanding the changes in

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in phytoplankton communities in ponds contaminated by agriculture may contribute to determining the directions of protection of these ecosystems and provide reference cases for wider research (Huang *et al.*, 2022).

Fertilization of ponds to enhance phytoplankton production and zooplankton suitable for larval fish is a common practice in Nigeria (Sipaúba-Tavares *et al.*, 2011). Fertilizer sources maybe inorganic or organic (matter) as the case may be, which include agricultural by-products and animal manures. Chemical fertilizer typically is composed of nitrogen, phosphorus, and potassium compounds that dissolve readily to provide nutrients to phytoplankton (Green, 2015). Organic fertilizer includes agricultural by-products, for example, rice bran, cottonseed meal, and animal manures, for example, poultry litter, and cow manure, which first must undergo decomposition to release nutrients for phytoplankton growth. The combined use of organic and inorganic fertilizer is known to have a direct impact on the plankton community structure (Sipaúba-Tavares *et al.*, 2011) by promoting both the autotrophic and heterotrophic organisms in the ponds. Organic fertilization is also known to promote the growth of ~~smaller-smaller-sized~~ zooplankton, especially the rotifers (Okojin and Obi, 1999) as well as other micro-zooplankton such as protozoans and copepod nauplii (Pinto-Coelho *et al.*, 2005) which usually dominate eutrophic water.

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This comparative study aims to investigate the effects of organic and inorganic fertilizers on phytoplankton communities in two newly inundated ponds. The choice of fertilizers-organic and inorganic is motivated by their contrasting compositions and potential ecological implications. Organic fertilizers, derived from natural sources, typically contain complex organic compounds and micronutrients, while inorganic fertilizers are composed of synthetic compounds with readily available nutrients.

The inundation of ponds provides a unique opportunity to observe the establishment and development of phytoplankton communities in relatively undisturbed environments. By comparing the responses of phytoplankton to different types of fertilizers, this study seeks to elucidate how nutrient availability influences community structure, species diversity, and biomass production. Furthermore, understanding the ecological implications of fertilizer type on phytoplankton communities can inform sustainable management practices for freshwater ecosystems. Insights gained from this study may contribute to the development of strategies aimed at mitigating eutrophication and maintaining the ecological integrity of aquatic habitats.

## 2.0 Materials and Methods

### 2.1 Study Area

The study was conducted from September 2023 to October 2023 at the hatchery research unit of the Department of Fisheries and Aquatic Environmental Management University of Uyo,

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### 2.2 Pond Preparation and Experimental Design

~~Few~~ A few days prior to the trial, ponds were prepared, drained, and washed, water supply and draining systems were checked, and vegetation was removed from the bottom and sides of the ponds. One week before the trial, ponds were filled, and subsequently, water loss due to evaporation was compensated to maintain the same level throughout the study. The study lasted for only 31 days. The study was conducted in a completely random design with two treatments and two replicates using organic and inorganic fertilizers (plate 1). Two types of fertilizers viz: chicken manure and di-ammonium phosphate fertilizer) were used in this experiment. Fresh manure from layers kept in the cages ~~were was~~ collected from the poultry unit belonging to the Department of Animal Science University of Uyo. N (2.55%) and P (0.95%) in chicken manure ~~was were~~ determined using proximate analysis at the Animal Science laboratory according to the Association of Official Analytical Chemists (AOAC, 2002). Four concrete tanks having an area of approximately 7.62m<sup>2</sup> each were used and then filled with water of a depth of 2.5ft. Two treatments: 2.5kg of chicken manure, 2.5kg of di-ammonium phosphate fertilizer, and no fertilizer (control) were randomly assigned to the tanks. Each treatment was replicated once.

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Plate 1: Experimental setup

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### 2.3 Phytoplankton Collection and Identification

One week after fertilization, water samples were collected. On-farm phytoplankton samples were taken at 15 cm below the water surface. Phytoplankton specimens were collected by filtration of 25 L water using a 20-micrometer plankton net (Plate 2). The phytoplankton samples were collected and fixed in 4% formalin for further analysis in the laboratory. Samples were taken at approximately 8 a.m. at 2 or 3-day intervals. Phytoplankton was concentrated by filtration through sand and counted in a counting chamber under a microscope fitted with an ocular micrometer (APHA, 2005). Identification of phytoplankton was done by observing through the microscope and for enumeration under the light microscope (objective x 40) and by using standard keys for plankton identification according to Needham and Needham (1975); as well as guides provided by Newell and Newell (1975); APHA (1985); and Egborge (1973).

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Plate 2: Plankton net

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### 2.4 Species Indices

Species composition and abundance of phytoplankton were described using the method of Hoppenrath *et al.* (2009). The phytoplankton community structure was analyzed using the Shannon-Wiener Index ( $H'$ ), species richness ( $d$ ), and the Evenness index ( $J'$ ) using Partversion 3.25 (Hammer *et al.*, 2001). Correlation analysis and principal component analysis (PCA) were used to determine the relationships between the phytoplankton and environmental factors using the XLSTAT BASIC+ (Addinsoft, US).

#### 2.4.1. Phytoplankton species indices

The phytoplankton community structure was estimated using the Shannon diversity index ( $H'$ ) of biodiversity, the species equality index ( $E$ ), and the Simpson dominance index ( $D$ ). The diversity index was calculated with the Krebs's equation (Krebs, 2014).

#### 2.4.2 The Species Evenness (or Equitability)

The calculation of the uniformity index is based on the equation of Krebs (2014):

$$E = H' / H_{maks}$$

Where:

$e'$  - uniformity index;

$H'$  - diversity index;

$H_{max}$  -  $\ln S$ ;

$S$  - number of types.

The ratio of the observed diversity ( $H$ ) to the maximum diversity ( $H_{max}$ ) was taken as a measure of the evenness ( $E$ ). According to Krebs (2014), it measures the distribution of individuals.

#### 2.4.3 Margalef's species richness index

According to Pielou(1966), this is presented as:

$$d' = \frac{s - 1}{\ln(N)}$$

Where:

$s$  = Total number of species in the sample

$\ln$  = natural or Naperian logarithm, and

$N$  = total number of individuals in the sample

#### 2.4.4. Shannon-wiener diversity index ( $H$ )

The index used to determine the level of species diversity in a community is the Shanon-Wiener index (Krebs 2014):

$$H = - \sum_{i=1}^n P_i \ln P_i$$

Where:

$H$  - index of species diversity

$P_i$  - probability function for each part as a whole ( $n_i/N$ );  $n_i$  - number of individuals of type- $i$ ;

$N$  - total number of individuals.

#### 2.4.5 Simpson index

The dominance index is used to determine the extent to which a species dominates another group. The dominance index was obtained using the Simpson index (Krebs 2014):

Where:

$$D = \sum_{i=1}^s \left( \frac{n_i}{N} \right)^2$$

$D$  - Simpson dominance index;

$n_i$  - number of individuals of type  $i$ ;

$N$  - total number of individuals;

$S$  - number of types (species).

#### 2.5 Collection of Water Sample

Three plastic and dissolved oxygen bottles measuring 50 cl each were used to collect water samples. The bottles were immersed to about 60 cm below the water surface and filled to capacity. Then brought out of the water and properly closed. Each bottle was flushed severally and confirmed that no air bubble ~~sexistsexist~~. Then transport to the fisheries laboratory in the Department of Fisheries and Aquatic Environmental Management for further analysis.

#### 2.6 Water quality

Water temperature, dissolved oxygen (DO), and pH were determined at in-situ in the morning by 8:00am using a mercury-in-glass thermometer, portable pH meter model HI98107 Hanna instrument, and portable dissolved oxygen meter model HI 98303 Hanna instrument (APHA, 1998; APHA, 2005). Other water quality parameters

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(phosphate, nitrates, and potassium) were determined in the laboratory based on standard laboratory procedure according to (APHA, 2005; APHA, 1998).

## 2.7 Statistical Analysis

Data on the physico-chemical parameters and phytoplankton composition were analyzed. Analysis of variance (ANOVA) was used to test for statistical differences between the means of the physical and chemical parameters of the fish ponds. Descriptive statistics of data for water quality analyses and phytoplankton ~~was~~ were done using Microsoft Excel. Principal Components Analysis (PCA) was used to determine the relationship between physico-chemical parameters and phytoplankton using the PAST software.

## 3.0 Results

### 3.1 Mean Variations in Physicochemical parameters in the two Tanks

Dissolved oxygen in this present study was  $4.13 \pm 0.16^b$  for the inorganic tank and  $4.71 \pm 0.18^a$  for the organic tank. This parameter exhibited a significance difference at  $P < 0.05$  in the study. The highest mean DO value ( $4.71 \pm 0.18^a$ ) was observed in the inorganic fertilized tank while the least value ( $4.13 \pm 0.16^b$ ) was recorded in the organic fertilized tank (Table 1).

Temperature values for inorganic and organic treated tanks were ( $6.20 \pm 0.19^a$ ) ( $5.96 \pm 0.23^b$ ) respectively. The highest mean temperature ( $6.20 \pm 0.19^a$ ) was observed in the organic treated tank while the least value ( $5.96 \pm 0.23^b$ ) was recorded in the inorganic treated pond. For the two treatments, there was no significant ~~different difference~~ observed in temperature (Table 1).

The pH values were  $5.96 \pm 0.23^a$  and  $6.20 \pm 0.19^a$  for inorganic and organic fertilized tanks respectively. The highest value ( $6.20 \pm 0.19^a$ ) was recorded in the organic fertilized tank while the least value ( $5.96 \pm 0.23^a$ ) was obtained in the inorganic treated tank. Statistically, a significant different was not observed for this parameter at  $P < 0.05$  between the two treatment tanks (Table 1).

Potassium level in this present study was  $51.29 \pm 2.88^a$  for the inorganic fertilized tank and  $16.52 \pm 1.19^b$  for the organic fertilized tank. The study revealed a significant difference across the two fertilizers used (Table 1).

Phosphorus level were found to be  $27.97 \pm 1.08^a$  for the inorganic tank and  $12.30 \pm 0.43^b$  for the organic tank. This parameter was highly significant at  $P < 0.05$  in the study (Table 1).

Total nitrogen levels were found to be  $33.39 \pm 0.66^a$  for the inorganic tank and  $11.85 \pm 0.58^b$  for the organic tank. This parameter showed a marked significant difference ( $P < 0.05$ ) in the study (Table 1).

**Table 1: Mean ( $\pm$ SE) of Physico-chemical parameters in the two Fertilized Tanks**

Variables	INORGANIC	ORGANIC
DO	$4.71 \pm 0.18^a$	$4.13 \pm 0.16^b$
TEMP	$6.20 \pm 0.14^a$	$5.97 \pm 0.14^a$
PH	$5.96 \pm 0.23^a$	$6.20 \pm 0.19^a$
POTASSIUM [MG/L]	$51.29 \pm 2.88^a$	$16.52 \pm 1.19^b$
PHOSPHORUS [MG/L]	$27.97 \pm 1.08^a$	$12.30 \pm 0.43^b$
TOTAL NITROGEN [MG/L]	$33.39 \pm 0.66^a$	$11.85 \pm 0.58^b$

Means with different superscripts along the same row are significantly different (Duncan's test)  $p < 0.05$

### 3.2 Pearson Correlation Matrix for The Physio-Chemical Parameters

Pearson's correlation analysis was conducted to reveal the relationships between the environmental parameters in the two tanks. Based on the Pearson analysis, potassium and total nitrogen have a significantly positive correlation (0.90), potassium and phosphorus (0.90). Significant positive correlation was observed for phosphorous and total nitrogen (0.85). DO has a relatively weak correlation with pH (0.34), with phosphorus (0.23). pH has a weak correlation with phosphorus (0.04). High negative correlations occur between pH and total nitrogen (-0.18), pH and potassium (-0.14) (Table 2).

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**Table 2: Pearson correlation matrix for the physico-chemical parameters**

Variables	DO	TEMP	PH	POTASSIUM	PHOSPHORUS	TOTAL NITROGEN
DO	<b>1.00</b>					
TEMP	0.09	<b>1.00</b>				
PH	<b>0.34</b>	0.10	<b>1.00</b>			
POTASSIUM	0.07	0.00	-0.14	<b>1.00</b>		
PHOSPHORUS	<b>0.23</b>	0.07	0.04	<b>0.90</b>	<b>1.00</b>	
TOTAL N	0.09	0.00	<b>-0.18</b>	<b>0.90</b>	<b>0.85</b>	<b>1.00</b>

Values in bold are different from 0 with a significance level  $\alpha=0.05$

### 3.3 Phytoplankton Abundance

The phytoplankton species recorded during the study are presented in Table 3. A total of 1,114 individuals were recorded in both fertilized tanks. The phytoplankton composition was dominated by *Dactyloclopsis irregularis* (79) > *Phormidium tenue* (53) > *Ankistrodesmus falcatus* (39) in the organic fertilized tank while the dominant species for the inorganic tank were *Dactyloclopsis irregularis* (45) > *Ankistrodesmus falcatus* (36) > *Dinobryon bararicum* (31). The least dominant species found in this current study for organic fertilizer were *Closterium macilentum* (7) > *Amoeba polyppodia* (7) > *Volvox aureus* (3) > *Raphidiopsis curvata* (2) while the trend for inorganic fertilizer were *Aphanizomenon flos-aquae* (7) > *Spirulina subtilissima* (4) > *Nitzschia linearis* (2).

**Table 3: Phytoplankton Abundance in the two Fertilized Tanks**

Phytoplankton Species	Organic (No. of individuals)	Inorganic (No. of individuals)
<i>Dactyloclopsis irregularis</i>	79	45
<i>Dinobryon cylindricum</i>	27	22
<i>Dinobryon bararicum</i>	19	31
<i>Phormidium tenue</i>	53	18
<i>Euglena tripteris</i>	15	17
<i>Euglena sanguine</i>	23	24
<i>Closteriopsis longissima</i>	20	12
<i>Synedra ulna</i>	10	18
<i>Gonatozygon aculeatum</i>	19	17
<i>Nitzschia paradoxa</i>	19	12
<i>Aphanizomenon flos-aquae</i>	26	7
<i>Ankistrodesmus falcatus</i>	39	36
<i>Melosira granulata</i>	27	26
<i>Synedra acus</i>	17	19
<i>Closterium gracile</i>	27	19
<i>Spirulina subtilissima</i>	26	4
<i>Tabellaria floccosa</i>	17	12
<i>Tabellaria fenestrata</i>	23	21
<i>Phormidium valderiae</i>	33	19
<i>Lyngbya limnetica</i>	23	13
<i>Volvox aureus</i>	3	8
<i>Amoeba polyppodia</i>	7	16
<i>Rivularia planctonica</i>	11	29
<i>Raphidiopsis curvata</i>	2	27
<i>Nitzschia linearis</i>	8	2
<i>Onychonema filiforme</i>	16	10
<i>Closterium macilentum</i>	7	8

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**3.4 Phytoplankton Diversity Indices**

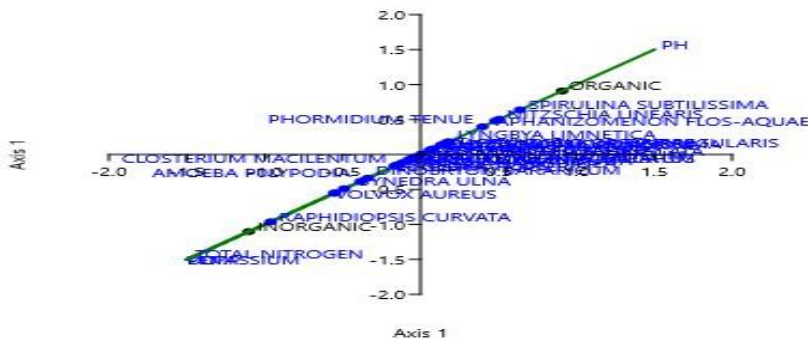
The existence of phytoplankton in each treatment investigated were recorded and used for numerical analysis in all community parameters (Shannon-Wiener diversity, Evenness, Simpson, and Margalef indices. These parameters varied slightly as shown in (Table 4). The highest in Shannon-Wiener diversity, Evenness, the Simpson and Margalef indices were found in the inorganic tank with their respective values thus: (3.216, 0.8901, 0.956, and 4.34), while the lowest in Shannon-Wiener diversity, Evenness, the Simpson and Margalef indices were found in the organic fertilized tank with their respective value thus (3.141, 0.8256, 0.9481 and 4.209).

**Table 4: Phytoplankton Diversity Indices in the two Fertilized Tanks**

Indices	ORGANIC	INORGANIC
Taxa_S	28	28
Individuals	611	503
Dominance_D	0.05188	0.044
Simpson_1-D	0.9481	0.956
Shannon_H	3.141	3.216
Evenness_e^H/S	0.8256	0.8901
Brillouin	3.018	3.07
Menhinick	1.133	1.248
Margalef	4.209	4.34
Equitability_J	0.9425	0.9651

**3.5 Canonical Correspondence Analysis of Environmental Variables with Phytoplankton**

Six environmental factors affected phytoplankton presence with different degrees. Temperature, pH, DO, Potassium, Phosphorus, and total nitrogen had a great influence on phytoplankton as indicated by their high correlation with the two significant canonical roots. The phytoplankton in the first quadrant of biplot were strongly correlated to pH, Temp, and DO, and negatively correlated to total nitrogen and potassium. Only one species of phytoplankton was found in the second quadrant. *Amoeba polyopdia*, *Closterium macilentum*, *Volvox aureus*, *Raphidiopsis curvata*, *Synedra ulna* were the dominant species distributed in the third quadrant (Fig. 1).



**Figure 1: Canonical correspondence analysis of environmental variables with phytoplankton**

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**3.6 Principal Component Analysis (PCA) Plot of The First Two Components of All Variables Measured During the Study Period**

The study revealed a total of 1114 individuals of 28 species of phytoplankton consisting of 611 individuals in the tank fertilized with organic fertilizer and 503 individuals from the inorganic treated tank and 6 environmental factors (Temperature, DO, pH, Potassium, Phosphorus, and Total nitrogen) screened for PCA analysis based on the

abundance of phytoplankton. PCA biplot showed the eigenvalues of the two axes were 18.49% (Fig. 3-Figure 2). The PCA between the first environmental factors axis and species axis was 10.19%, while that for the second axes was 8.30%, indicating a close relationship between phytoplankton and environmental variables analyzed. The most important environmental variables were Phosphorus and total nitrogen (mg/l), potassium, and dissolved oxygen.

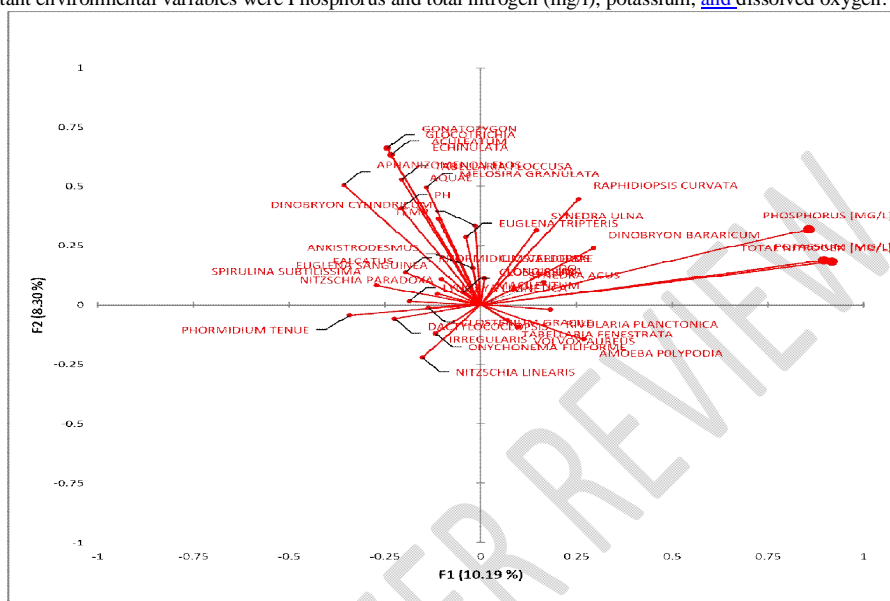


Figure 2: Principal component analysis (PCA) plot of the first two components of all variables measured.

#### 4.0 Discussion, Conclusion and Recommendations

##### 4.1 Discussion

This present study revealed inter-tank differences in some of the physico-chemical parameters investigated. Potassium, phosphorus, nitrogen, and dissolved oxygen were significantly different. But, temperature, and pH was non-significant, statistically. Dissolved oxygen is the most significant ecological factor of the fish pond ecosystem (Prabhat, 2019). Mahboob (1992) recorded the maximum average dissolved oxygen when there was the abundance of phytoplankton. Similar trend was observed in these present investigations as the values obtained were within the permissible level of  $4\text{mg l}^{-1}$  for aquaculture. The water remained close to the saturation values with regard to oxygen showing the presence of a healthy environment in the study period. ( $4.13 \pm 0.16^b$  ( $4.71 \pm 0.18^a$ )).

A mean of  $7.03 \pm 0.49$  dissolved oxygen has been recorded in studies on physicochemical characteristics and phytoplankton diversity in fish ponds (El Nemaikiet *et al.*, 2008). A range of  $7.69 \pm 0.15$  -  $7.74 \pm 0.20$  DO was reported by Prabhat (2019) for two fertilized fish ponds; Akunga *et al.* (2018) reported the values of  $7.0 \pm 0.2$ ,  $6.7 \pm 0.2$  and  $6.0 \pm 0.3$  for concrete, earthen and liner pond respectively which are all higher than the values recorded in this present study. The reason for this dissimilarity in DO with the present study could be due to the high mean temperature observed in this study. This is because the dissolved oxygen of water declines with an increase in the temperature of the water and vice versa. Yet other studies have shown a dissolved oxygen concentration of  $2.53\text{ mg l}^{-1}$  for drainage water and  $5.68\text{ mg l}^{-1}$  for irrigation water (Fafioyee *et al.*, 2005) which are conformable to the values recorded in this present study.

Temperature is an important independent factor which can affect phytoplankton (Saeiamet *et al.*, 2020). Temperature affects fish growth by influencing the physicochemical conditions of water. It also affects the speed of chemical changes in soil, water, and the contents of dissolved gases (Prabhat, 2019). Studies on the effects of urea along with a constant supply of quality of poultry manure on phytoplankton production in earthen fish ponds, reveals that pond water temperature varied from  $26.3\text{ }^\circ\text{C}$  to  $33\text{ }^\circ\text{C}$  (Davies *et al.*, 2009) which is in line with the values obtained in this present study. Temperatures values recorded in this present study are within the optimal ranges for plankton growth ( $18.3$ - $37.8\text{ }^\circ\text{C}$ ) (Bagchi and Jha, 2011) and are recommended for fish culture ( $26.06$ - $31.97\text{ }^\circ\text{C}$ ) (Boyd, 1982) in tropical ponds. Inter-tanks differences for water temperature in this current study were non-significant as the values

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26.00±0.14<sup>a</sup>, 25.97±0.14<sup>a</sup> were observed for inorganic and organic fertilized tanks respectively. This result corroborates the submission of Prabhat (2019) who also reported not a significant difference in the temperature of the fertilized ponds investigated. The values of temperature obtained in this present study is in line with the range 24.2±0.4 - 24.1±0.4 - 26.0±0.4 reported by Akunga *et al.* (2018) for concrete pond, earthen and liner pond respectively.

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Qiu *et al.* (2018) stated that fertilizer application significantly affects the pH of a medium. However, no significant difference was found in this current study. The pH values were 5.96±0.23<sup>a</sup> and 6.20±0.19<sup>a</sup> for inorganic and organic fertilized tanks respectively. This result corroborates the findings of Prabhat (2019) who also reported that there was no significant difference in the pH values from their investigation. The authors reported pH values of both fertilized ponds in the range between 7.30 to 9.40 (T1) and 7.60 to 9.10 (T2) in their respective ponds. Hassan (1989) observed that the production was more in experimental ponds whose pH ranged from 6.9 to 9.5 which is also in tandem with the values observed in this present study.

Phytoplankton require nutrients such as nitrate, and phosphate for growth. However, some phytoplankton can fix nitrogen and can grow in areas where nitrate concentrations are low (Kumar *et al.* 2014). Potassium level in this present study was 51.29±2.88<sup>a</sup> for the inorganic fertilized tank and 16.52±1.19<sup>b</sup> for the organic fertilized tank. Tank with the inorganic fertilizer recorded a higher amount of potassium level as compared with tank fertilized with organic fertilizer. This could be attributed to the high potassium released by the inorganic fertilizer.

The mean phosphorus level in this present study was higher in the inorganic tank than the organic which was contrary to the submissions of Hossain *et al.* (2006) who suggested that the capacity of phosphorus released from poultry manure might be more efficient than other organic fertilizers and inorganic fertilizers used in their study. The mean phosphorus levels (27.97±1.08<sup>a</sup>) (12.30±0.43<sup>b</sup>) in this present study is lower than 610–1010 µg l<sup>-1</sup> reported from studies on phytoplankton diversity and its relationship to physicochemical parameters reported by Hossain *et al.* (2006). More so, it is also lower than the mean total phosphorus levels (458.7±50.8) reported in liner ponds by Akunga *et al.* (2018). The variations could be attributed to the water holding facilities used in the previous findings and also could be attributed to the effects of pH in the pond since pH had a positive correlation with phosphorus level in the earthen pond. However, the mean phosphorus level in this current study is significantly higher than the values reported by George and Atakpa (2015) in their investigations who recorded the range of 0.14–0.67, 0.05–0.64 for phosphorus in Pond A and Pond C respectively.

The mean total nitrogen concentrations (33.39±0.66<sup>a</sup>) (11.85±0.58<sup>b</sup>) in this present study was higher in the inorganic treated tank than the organic. Tank treated with inorganic fertilizer recorded a relatively high amount of total nitrogen due to a low number of nitrifying bacteria and the absence of soil medium in the bottom of the tank as compared to the one treated with organic fertilizer. Total nitrogen concentration in this present study is far lower when compared to the ranged 272.81 µg l<sup>-1</sup> in liner ponds to 2887.6 µg l<sup>-1</sup> in concrete ponds with a mean of 728.2±68.1 µg l<sup>-1</sup> as reported by Akunga *et al.* (2018) and 200 - 300 µg l<sup>-1</sup> reported by (Saeed and Mohammed, 2012). This variation can be ascribed to the low number of nitrifying bacteria present in their pond and the nature of the pond bottom in their study.

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Based on the result from the Pearson correlation matrix of the physico-chemical parameters, the difference of phytoplankton composition is obtained from a combination of physical conditions and water chemistry. The study revealed that some parameters say, potassium, phosphorus, and total nitrogen have a significantly positive correlation with phytoplankton abundance.

Phytoplankton has an important role in aquatic ecosystem due to their fast response to changes (Soeprawat *et al.* 2021). In this present study, a total of 1114 individuals of phytoplankton were identified of which the trend of species dominated in composition were *Dactyloclopsis irregularis*(79)>*Phormidium tenue* (53)>*Ankistrodesmus falcatus*(39) in the organic fertilized tank while the dominant species for the inorganic tank were *Dactyloclopsis irregularis*(45)>*Ankistrodesmus falcatus*(36)>*Dinobryon bararicum* (31). The least dominant species found in this current study for organic fertilizer were *Closterium macilentum*(7)>*Amoeba polyopodia* (7)>*Volvox aureus* (3)>*Raphidiopsis curvata*(2) while the trend for inorganic fertilizer were *Aphanizomenon flos-aquae* (7) >*Spirulina subtilissima* (4) >*Nitzschia linearis*.

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The species diversity expressed with the Shannon index was on a higher level within the range 3.141–3.216 in this current study. The higher values of Shannon's index (H) in the inorganic fertilized tank of 3.216 indicated greater species diversity as compared to 3.141 in the organic fertilized tank. This slight difference may be due to the fact that the inorganic treated tank could not lose out fertility easily and due to the tank physicochemical parameters. In addition, the high Shannon index in inorganic tank over the organic could be attributed to the suitable atmospheric conditions of the inorganic tank. Differences in phytoplankton diversity could also be an indication that phytoplankton diversity is affected by the tank type and physicochemical parameters.

The combined range 3.141 – 3.216 of Shannon index for organic and inorganic treated tanks found in this present study is slightly higher than the reported range 0.108–2.584 by Saeiam *et al.* (2020). Evenness Index (E) of 0.8256 – 0.8901 showed all the species were slightly-equally abundant in the various treatments investigated. The combined range 0.8256 – 0.8901 of Evenness (J) for organic and inorganic treated tanks found in this present study is

in agreement with the reported range 0.086 —0.530 by Saeiamet *al.* (2020). The combined range 0.9481—0.956 for Simpson in organic and inorganic treated tanks found in this present study agrees totally with the reported range of 0.031 —0.900 by Saeiamet.*al.* (2020).

The Index of individual abundance was highest in [the](#) tank treated with organic fertilizer with (611) individuals followed by [the](#) inorganic fertilized tank with (503) individuals. The highest individual phytoplankton abundance observed in the organic fertilized tank in this present study might be due to the fact that the tank was not severely polluted and so favored the abundance of species. Margalef Indices (a measure of species Richness or Taxa Richness 'd') was highest (4.34) in tank treated with inorganic fertilizer reflecting that the fertilizer – treated tank was still rich in biodiversity.

In [the](#) CCA biplot, it was noticed in the study that most of the dominant species were distributed in the first and fourth quadrants, which might be related to the heavy pollution of fertilized treated tanks. There were many environmental factors affecting the growth and distribution of phytoplankton. However, the main impacted factors varied among the different CCA biplot. The main factors impacting [the](#) phytoplankton community in this current study were, pH, DO, and total nitrogen and potassium. Thus, it is inferred that the condition of water quality in the two treated tanks had [a](#) great impact on [the](#) phytoplankton community.

The projections of the entire sets of variables in PCA plots show the role of pH, total nitrogen and potassium in [the](#) structuring of the phytoplankton system, with high amounts of the phytoplankton *Dinobryonbararicum*, *Euglena tripteris*, *Synedra ulna*, *Raphidiopsiscurvata*, *Spirulina subtilissima* strongly correlated to Do, total nitrogen and potassium in the first quadrant and *Ankistrodesmusfalcatius*, *Spirulina subtilissima*, *Dinobryoncylicindricum*, *Euglena sanguine*, *Nitzschiaparadoxa* had a strong affinity for temperature, and pH as shown in [figure \(2\)](#).

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#### 4.2 Conclusion

From results obtained in this study, it can be concluded that the abundance and composition of phytoplankton was affected by the tank treatment type and physicochemical condition of the tank. A high abundance and species composition of phytoplankton was found in tanks treated with organic fertilizer as compared to the one treated with inorganic fertilizer. The current study found that [a](#) higher diversity of phytoplankton might reflect the water quality and the environmental condition in the different tank's treatment. The results in this study revealed that the addition of fertilizers to the tank influenced some of the physicochemical properties of the water. It is assumed that Water bodies with a higher diversity of phytoplankton generally affect water quality, which could be observed through the fluctuation in its biotic and abiotic variables. The result of this present study indicated that the addition of fertilizers to the fish tanks also increased the level of nitrogenous compounds which is considered as a good source for phytoplankton growth. Canonical Correspondence Analysis (CCA) and Principal Component Analysis (PCA) showed that DO, pH, Total nitrogen, Potassium, and Phosphorus were important environmental factors influencing the distribution of [the](#) phytoplankton community. The study also revealed that different species demanded different environment. CCA biplot results indicate that the relationship between [the](#) phytoplankton community and water quality [are](#) strongly affected by the treatment of the fertilizers used.

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