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 – 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 di-a1mmonium phosphate fertilizer (20:10:10) (2.5kg for each). Out of 1114 individuals of phytoplankton identified, 611 belong to the organic fertilized treated tank while 503 individuals were accounted for the inorganic fertilized tank. The highest and the lowest phytoplankton species identified were *Dactylococlopsisirregularis*(79)>*Phormidium tenue* (53)>*Ankistrodesmusfalcatus*(39) for the organic fertilized tank while the dominant species for the inorganic tank were *Dactylococlopsisirregularis* (45)>*Ankistrodesmusfalcatus* (36), >*Dinobryonbararicum* (31). The least dominant species found in this current study for organic fertilizer were *Closterium macilentum*(7)>*Amoeba polypodia* (7)>*Volvox aureus* (3)>*Raphidiopsiscurvata*(2) while the trend for inorganic fertilizer were *Aphanizomenonflosaquae*(7) >*Spirulina subtilissima* (4) >*Nitzschia linearis* (2). Physicochemical factors like Temperature, pH, Potassium, Total nitrogen, were found to be the important factors influencing the growth and distribution of phytoplankton and they exhibited 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 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 was 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 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 (Gharib*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 of 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 of 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, 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 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 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.

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 hatchery research unit of the Department of Fisheries and Aquatic Environmental Management University of Uyo.

2.2 Pond Preparation and Experimental Design

Few days prior to the trial, ponds were prepared, drained, washed, water supply and draining systems checked, vegetation 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 fertilizer (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 collected from poultry unit belonging to Department of Animal Science University of Uyo. N (2.55%) and P (0.95%) in chicken manure was determined using proximate analysis at Animal Science laboratory according to Association of Official Analytical Chemists (AOAC, 2002). Four concrete tanks having an area of approximately 7.62m^2 each were used and then filled with water of 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.


Plate 1: Experimental setup

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).


Plate 2: Plankton net

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 principalcomponent 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;
Hmax - ln S;
S - number of types.

The ratio of the observed diversity (H) to the maximum diversity (Hmax) 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:

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

Where:
s = Total number of species in the sample
In = 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):

$$H = \sum_{i=1}^{n} Pi\, In\, Pi$$

Where:
H - index of species diversity
Pi - probability function for each part as a whole (ni/N); ni - 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:

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

D - Simpson dominance index;
ni - 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 exists. 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 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 (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 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 ± 0.16^{b} for the inorganic tank and 4.71 ± 0.18^{a} for the organic tank. This parameter exhibited significance difference at $P<0.05$ in the study. The highest mean DO value (4.71 ± 0.18^{a}) was observed in the inorganic fertilized tank while the least value (4.13 ± 0.16^{b}) was recorded in the organic fertilized tank (Table 1).

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

The pH values were 5.96 ± 0.23^{a} and 6.20 ± 0.19^{a} for inorganic and organic fertilized tanks respectively. The highest value (6.20 ± 0.19^{a}) was recorded in the organic fertilized tank while the least value (5.96 ± 0.23^{a}) was obtained in the inorganic treated tank. Statistically, 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 ± 2.88^{a} for the inorganic fertilized tank and 16.52 ± 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 ± 1.08^{a} for the inorganic tank and 12.30 ± 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 ± 0.66^{a} for the inorganic tank and 11.85 ± 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 (±SE) of Physico-chemical parameters in the two Fertilized Tanks

Variables	INORGANIC	ORGANIC
DO	4.71 ± 0.18^{a}	4.13 ± 0.16^{b}
TEMP	26.00 ± 0.14^{a}	25.97 ± 0.14^{a}
PH	5.96 ± 0.23^{a}	6.20 ± 0.19^{a}
POTASSIUM [MG/L]	51.29 ± 2.88^{a}	16.52 ± 1.19^{b}
PHOSPHORUS [MG/L]	27.97 ± 1.08^{a}	12.30 ± 0.43^{b}
TOTAL NITROGEN [MG/L]	33.39 ± 0.66^{a}	11.85 ± 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 relative 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).

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

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

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

3.3Phytoplankton 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 *Dactylococlopsisirregularis*(79)>*Phormidium tenue* (53)>*Ankistrodesmusfalcatus*(39) in the organic fertilized tank while the dominant specie for the inorganic tank were *Dactylococlopsisirregularis (45)>Ankistrodesmusfalcatus (36),* >*Dinobryonbararicum* (31). The least dominant species found in this current study for organic fertilizer were *Closterium macilentum*(7)>*Amoeba polypodia* (7)>*Volvox aureus* (3)>*Raphidiopsiscurvata*(2) while the trend for inorganic fertilizer were *Aphanizomenonflos-aquae* (7) >*Spirulina subtilissima* (4) >*Nitzschia linearis* (2).

Table 3: Phytoplankton Abundance in the two Fertilized Tanks

Phytoplankton Species	ORGANIC (INDIVIDUALS)	INORGANIC (INDIVIDIUALS)
Dactylococlopsisirregularis	79	45
Dinobryoncylindricum	27	22
Dinobryonbararicum	19	31
Phormidium tenue	53	18
Euglena tripteris	15	17
Euglena sanguine	23	24
Closteriopsislongissima	20	12
Synedra ulna	10	18
Gonatozygonaculeatum	19	17
Nitzschiaparadoxa	19	12
Aphanizomenonflos-aquae	26	7
Ankistrodesmusfalcatus	39	36
Melosiragranulata	27	26
Synedra acus	17	19
Closterium gracile	27	19
Spirulina subtilissima	26	4
Tabellariafloccusa	17	12
Tabellariafenestrata	23	21
Phormidiumvalderiae	33	19
Lyngbyalimnetica	23	13
Volvox aureus	3	8
Amoeba polypodia	7	16
Rivulariaplanctonica	11	29
Raphidiopsiscurvata	2	27
Nitzschia linearis	8	2
Onychonemafiliforme	16	10
Closterium macilentum	7	8
Glocotrichiaechinulata	15	11

3.4 Phytoplankton Diversity Indices

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

3.5Canonical 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 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 polypodia, Closteriummacilentum, Volvox aureus, Raphidiopsiscurvata, Synedra ulna* were the dominant species distributed in the third quadrant (Fig, 1)

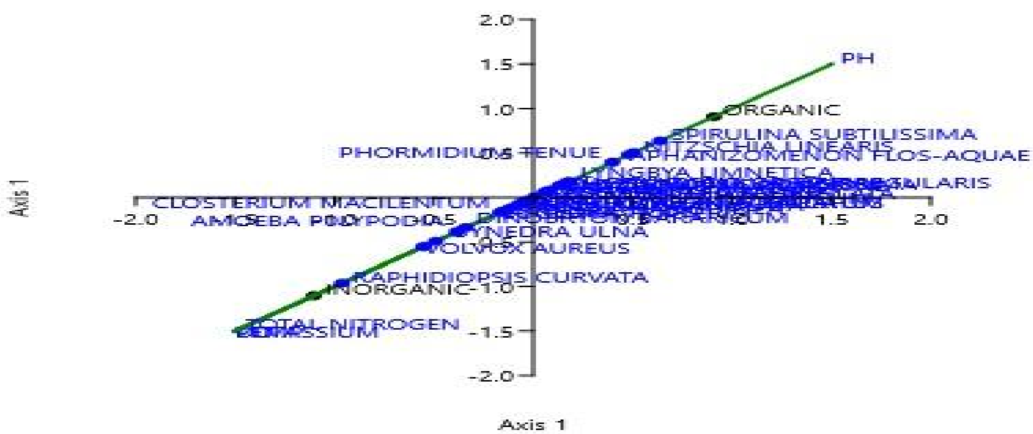

Figure 1: Canonical correspondence analysis of environmental variables with phytoplankton

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 abundance of phytoplankton. PCA biplot showed the eigenvalues of the two axes were 18.49% (Fig. 3.). 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, dissolved oxygen.

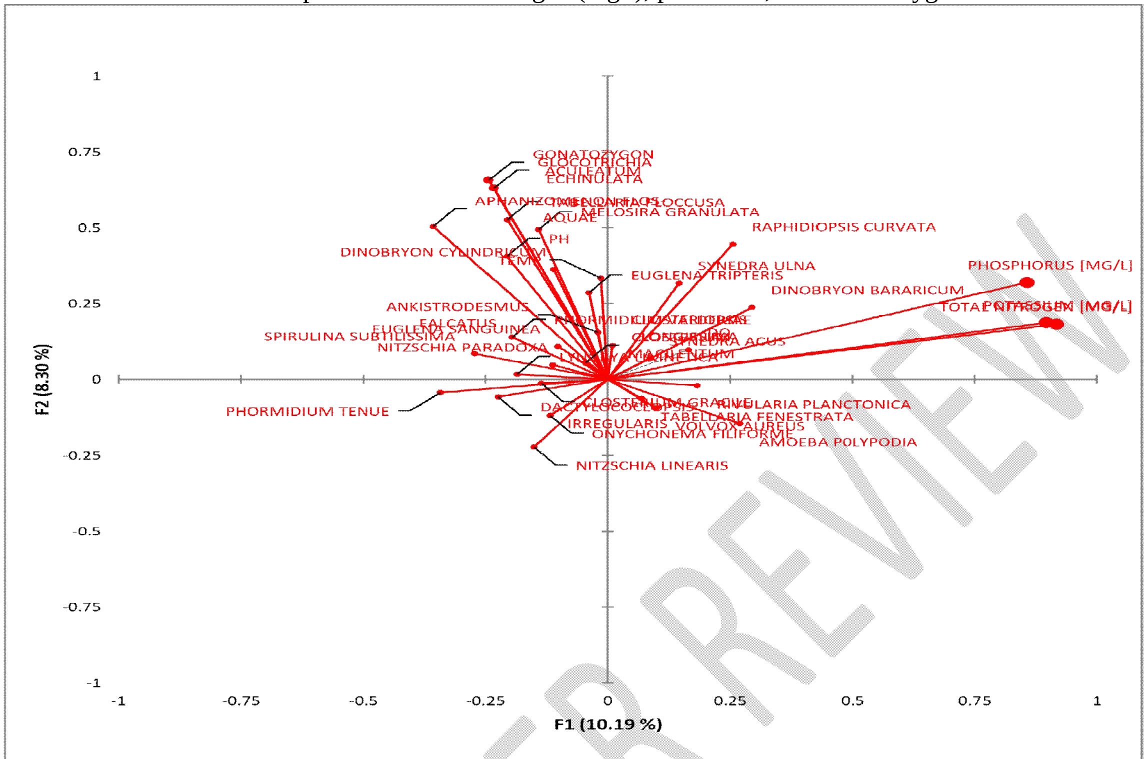

Figure 2: Principal component analysis (PCA) plot of the first two components of all variables measured.

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, 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 abundance of phytoplankton. Similar trend was observed in these present investigations as the values obtained where within the permissible level of 4mgl^{-1} for aquaculture. The water remained close to the saturation values with regard to oxygen showing the presence of healthy environment in the study period. (4.13±0.16^{b} (4.71±0.18^{a})

A mean of 7.03±0.49 dissolved oxygen has been recorded in studies on physicochemical characteristics and phytoplankton diversity in fish ponds (El Nemaki*et al.*, 2008). A range of 7.69±00.15 - 7.74±00.20 DO was reported by Prabhat (2019) for two fertilized fish pond; Akunga*et al.* (2018) reported the values of 7.0±0.2, 6.7±0.2 and 6.0±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 high mean temperature observed in this study. This is because dissolved oxygen of water declines with increase in temperature of the water and vice versa. Yet other studies have shown a dissolved oxygen concentration of 2.53 mgl^{-1} for drainage water and 5.68 mgl^{-1} for irrigation water (Fafioye*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 *al*, 2020). Temperature affects fish growth by influencing 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 ^{o}C to 33 ^{o}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°C) (Bagchi and Jha, 2011) and are recommended for fish culture (26.06-31.97°C) (Boyd, 1982) in tropical ponds. Inter-tanks differences for water temperature in this current study were non-significant as the values 26.00±0.14^{a}, 25.97±0.14^{a}were observed for inorganic and organic fertilized tanks respectively. This result corroborates the submission of Prabhat (2019) who also reported non – significance 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.

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^{a} and 6.20 ± 0.19^{a} 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 (Tl) 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, 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^{a} for the inorganic fertilized tank and 16.52 ± 1.19^{b} for the organic fertilized tank. Tank with the inorganic fertilizer recorded higher amount of potassium level as compared with tank fertilized with organic fertilizer. This could be attributed to 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^{a}) (12.30 ± 0.43^{b}) in this present study is lower than 610-1010 $\mu g\ l^{-1}$ 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 phosphorous 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 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^{a}) (11.85 ± 0.58^{b}) in this present study was higher in the inorganic treated tank than the organic. Tank treated with inorganic fertilizer recorded relatively high amount of total nitrogen due to 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 μgl^{-1}in liner ponds to 2887.6 μgl^{-1} in concrete ponds with a mean of 728.2±68.1 μgl^{-1}as reportedby Akunga***et al.*** (2018) and 200 - 300 μgl^{-1} 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.

Based on the result from 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, phosphorous 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 (Soeprobowati*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 *Dactylococlopsisirregularis*(79)>*Phormidium tenue* (53)>*Ankistrodesmusfalcatus*(39) in the organic fertilized tank while the dominant species for the inorganic tank were Dactylococlopsis*irregularis (45)>Ankistrodesmusfalcatus (36), >Dinobryonbararicum* (31). The least dominant species found in this current study for organic fertilizer were *Closterium macilentum*(7)>*Amoeba polypodia* (7)>*Volvox aureus* (3)>*Raphidiopsiscurvata*(2) while the trend for inorganic fertilizer were *Aphanizomenonflos-aquae* (7) >*Spirulina subtilissima* (4) >*Nitzschia linearis.*

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, high Shannon index in inorganic tank over the organic could be attributed to 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 Saeiam*et 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 Saeiam*et.al.* (2020).

The Index of individual abundance was highest in tank treated with organic fertilizer with (611) individuals followed by 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 CCA bioplot, 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 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 great impact on phytoplankton community.

The projections of the entire sets of variables in PCA plots show the role of pH, total nitrogen and potassium in 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, phosphorus in the first quadrant and *Ankistrodesmusfalcatus, Spirulina subtilissima, Dinobryoncylindricum, Euglena sanguine, Nitzschiaparadoxa* had a strong affinity for temperature, and pH as shown in figure (2)

4.2Conclusion

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 tank treated with organic fertilizer as compared to the one treated with inorganic fertilizer. The current study found that 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 importantly environmental factors influencing the distribution of phytoplankton community. The study also revealed that different species demanded different environment. CCA biplot results indicate that the relationship between phytoplankton community and water quality are strongly affected by the treatment of the fertilizers used.

5.0 References

Akpan, I. I., Ukekpe, U. S., **George, U. U**. and Okon, J. E. **(2022).** The Relationship of Plankton Abundance to Physicochemical Parameters in a Segment of Lower Imo River Estuary. *International Journal of Fauna and Biological Studies*; 9(2): 30 – 37.

Akunga, G., Getabu, A. and Njiru, J. (2018). Effect of pond type on physicochemical parameters, phytoplankton diversity and primary production in, Kisii, Kenya *International Journal of Fisheries and Aquatic Studies*; 6(6): 125-130

American Public Health Association (APHA) (1985). Standard Methods for Examination of Water and Wastewater. 16th Edition APHA, AWWA, WPCF, Washington D.C.;1268Pp.

American Public Health Association (APHA), (2005): Standard methods for examination of water and wastewater. 21st Edn. APHA, AWWA, WPCF, Washington DC, USA (2005).

American Public Health Association (APHA). (1998). Standard methods for the examination of water and wastewater. 20th edition. Washington, D.C.: American Public Health Association Inc.

Association of Official Analytical Chemists, (2002). *Official Methods of Analysis,* Association of Official Analytical Chemists (AOAC). JRC-European Commission, Washington D.C, USA

Asuquo, G. 1., Akpan, I. I., **George, U. U**., Asuquo, I. E. Ukpatu, J. E., and. Ejiogu, I. N. (2022). Phytoplankton Composition and Abundance in Mbiakong River, Cross River Estuary, Niger Delta, Nigeria. *Asian Journal of Environment & Ecology,* 19(4):135-141.

Bagchi, A. and Jha, P. (2011). Fish and fisheries in Indian heritage and development of pisciculture in India. Reviews in Fisheries Science, 19:85-118.

Chellappa, N.T., Câmara, F.R.A. and Rocha, O. (2009). Phytoplankton community: indicator of water quality in the Armando Ribeiro Gonçalves Reservoir and Pataxó Channel, Rio Grande do Norte, Brazil. *Brazilian Journal of Biology*; 69(2), 241-251.

Davies, O. A, Abowei, J. F. N. Otene, B.B. (2009). Seasonal abundance and distribution of plankton of Minichinda stream. Niger Delta, Nigeria*Americal of Journal Science Research*; 2(2):20-30.

Egborge, A. B. M. (1973). A Preliminary Checklist of the Phytoplankton of River Oshun. Freshwater Biology. 3:569-572.

El Nemaki, F., Ali, N., Zeinhom, M. and Radwan, O. (2008). Impacts of different water resources on the ecological parameters and the quality of Tilapia production at El Abbassa, Fish farm in Egypt. 8th International symposium on tilapia in Aquaculture, 191 – 512

Fafioye, O. O., Olurin, K. B. Sowunmi A. A. (2005). Studies on the physicochemical parameter of Omi water body of Ago-Iwoye, Nigeria. *African Journal of Biotechnology;* 4(9): 1022-1024.

George, U. U. and Atakpa, E. O. (2015). Diversity and Species Composition of Periphyton in a Tropical Earthern Pond in South Eastern Nigeria. *World Rural Observations,* 7(4): 65-70.

George, U. U. andOpeh, P. B.(2016**).** Spatial distribution and abundance of bacteria and phytoplankton in Calabar River, Cross River State, Nigeria, *International Journal of Fauna and Biological Studies*, 3(3): 45-51.

George, U. U., Mbong, E. O., Ita, R. E. (2021). Spatio-Temporal variation in Phytoplankton Distribution and Abundance in a Tropical Freshwater Body in Niger Delta, Nigeria. *Nature and Science*; 19(4):18-26.

Gharib, S.M., EL-Sherif, A.Z.M., Abdel-Halim, M. and Radwan, A.A. (2011). Phytoplankton and environmental variables as a water quality indicator for the beaches at Matrouh, south-eastern Mediterranean Sea, Egypt: an assessment. *Oceanologia*, 53(3), 819-836.

Green, B (2015) "Fertilizers in aquaculture" (2015). Publications from USDA-ARS / UNL Faculty. 2422.

Hammer, O., Harper, D. A. T. and Ryan, P. D. (2001). PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica*, 4(1):1-9.

Hassan M. (1989). Effect of cowdunglurea-fedi manure fertilization of fish pond on the growth performance of three maior carps. viz., *Caffa catla*, *Labeorohita*and *Cirrfiinamrigafa*. M.Phil. Thesis. Univ. Agric. Faisalabad. Pakistan, 91.

Hoppenrath, M., Elbrachter M. and Drebes, M. (2009). Marine phytoplankton, Stuttgart, E Schweizerbart'sche Verlagsbuchhandlung, 49:1-264.

Hossain, M. Y., Jasmine, S., Ibrahim, A., Ahmed, Z., Ohtomi, J., Fulanda, B., Begum, M., Mamun, A., El-kady, M. and Wahab, M. (2007). A Preliminary observation on water quality and plankton of an earthen fish pond in Bangladesh: Recommendations for future studies. *Pakistan Journal of Biological Sciences*, 10:868-873.

Huang Y, Shen Y, Zhang S, Li Y, Sun Z, Feng M, Li R, Zhang J, Tian X and Zhang W (2022). Characteristics of Phytoplankton Community Structure and Indication to Water Quality in the Lake in Agricultural Areas. *Frontiers in Environmental Science;* 10:833409

Krebs C. J. (2014). Ecological methodology. 3rd edition. Harper Collins Publisher, New York, 680 p.

Kumar, S. D., Kumar, S. P., Kumar, V. U. and Anbuganapathi, G. (2014). Efficacy of Biofertilizer Enriched Flower Waste Vermicompost on Production and Growth of Primary Producers and Freshwater Aquarium Fishes. *Global Veterinaria*, 56 (2): 215-220.

Mahboob S. (1992). Influence of fertilizer and artificial feed on the growth performance in composite culture of major, common and some Chinese carps. Ph.D. Thesis, Deptt. *Zool. Fisheries, Univ. Agri*c., Faisalabad, Pakistan, 261.

Needham, J. G., Needham, P. R. (1975). A guide to the study of fresh water biology. San Francisco:Holding-Day Inc.1-108.

Negro, A. I., De Hoyos, C., and Vega, J. C. (2000). Phytoplankton Structure and Dynamics in Lake Sanabria and Valparaíso Reservoir (NW Spain). *Hydrobiologia*, 424 (1-3), 25–37.

Newell, G. B., Newell, R. C. (1977). Marine plankton: A practical Guide. Hutchinson and Company Publishers Ltd. London;229Pp.

Ni, M., Yuan, J. L., Liu, M. and Gu, Z. M. (2018). Assessment of water quality and phytoplankton community of *Limpenaeusvannamei*pond in intertidal zone of Hangzhou Bay, China. *AquacultureReports*, 11:53-58.

Nunes, M., Adams, J. B., and Rishworth, G. M. (2018). Shifts in Phytoplankton Community Structure in Response to Hydrological Changes in the Shallow St Lucia Estuary. *Mar. Pollut. Bull;* 128:275–286.

Okojin, V.A, Obi, A.W. (1999). Effects of three fertilizer treatments on zooplankton productivity in plastictanks. *Indian Journal of Animal Science*, 69(5): 360-363.

Pielou, E. C., (1966). The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology*, 131-144.

Pinto-coelho RM, Giani A, Morais Junior CA, Carvalho Junior ER, Bezerra-neto, JF. (2005). The nutritional status of zooplankton in a tropical reservoir: effects of food quality and community structure. *Brazilian Journal of Biology*, 65(2): 313-324.

Prabhat, R. (2019). Study of fish pond fertilization: Comparison of ecological conditions. *International Journal of Fisheries and Aquatic Studies*; 7(4):310-313

Qiu, Y.; Lin, Y.; Tang, L.; Guan, T.; Chen, Q.; Chen, K. and Wang, L. (2018). The biodiversity assessment of phytoplankton community in summer within main stream and tributary of Huaihe River. *J. Environ. Sci.-China*, 38: 1665–1672.

Saeed, M.S. and Mohammed, M.A.(2012). Influence of physicochemical characteristics of water on metals accumulation in water and Tilapia Zillii inhabiting different habitats in Egypt.*Journal of the Arabia Aquaculture Society*; 7(1):29-50.

Saeiam, Y. Pichitkul, P. Nedtharnn, U. and Wudtisin, I. (2020). Phytoplankton community dynamics and its impacts on the quality of water and sediments in the recirculated-water earthen pond system for hybrid red tilapia (*Oreochromisniloticus*x*mossambicus*) farming. I*nternational Journal of Agricultural Technology*; 16(3): 695-710.

Sipauba-Tavare, L. H., Donadon, A. R. V. and Millan, R. N. (2011). Water Quality and Plankton Populations in an Earthen Polyculture Pond. *Brazilian Journal of Biology*, 71(4): 1-11.

Soeprobowati, T. R., Addadiyah, N. L., Hariyati, R.,and Jumari, J. (2021). Physico-chemical and biological water quality of Warna and Pengilon Lakes, Dieng, Central Java. *Journal of Water and Land Management* 51(10-12):38-49

Whitton, B. A. (2012). Changing Approaches to Monitoring during the Period of the 'Use of Algae for Monitoring Rivers' Symposia. *Hydrobiologia* 695 (1): 7–16

Yusuf, Z. H. (2020). Phytoplankton as bioindicators of water quality in Nasarawa Reservoir, Katsina State Nigeria. *Acta LimnologicaBrasiliensia*, 32(4):1-11.