Comparative Analysis of Phytoplankton Communities in Newly Inundated Ponds Using Organic and Inorganic Fertilizers

Abstract

A comparative study on the communities of phytoplankton in two newly inundated ponds was carried out from September 2023to October 2023.The study was conducted in a completely random design experimental setup with two treatments,eachreplicated twice using organic (chicken manure) and inorganic fertilizer(di-a1mmonium phosphate fertilizer, (20:10:10) (2.5kg for each)fertilizers. Out of 1114 individuals of phytoplankton identified, 611 were fromthe organic fertilizer-treated tank, while 503 individuals were from the inorganic fertilizer- treated 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 (DO) were significantly different across the two treatments while temperature and pH were not statistically significant ($P<0.05$). The result fromthe analysis of all community parameters (Shannon-Wiener diversity, Evenness, Simpson and Margalef indices) showed slight variation. The highest in Shannon-Wiener diversity, Evenness, Simpson and Margalef indices were found in the inorganicfertilizer- treated tank (3.216, 0.8901, 0.956 and 4.34, respectively), while the lowest were found in the organic fertilize treated tank (3.141, 0.825, 0.948 and 4.209, respectively). This result indicates that the abundance and structure of phytoplanktoncommunities were affected by the different fertilizer used and thetanks physicochemical conditions.

Keywords: Phytoplankton Community, Organic Fertilizer, Inorganic Fertilizer, Physico-chemical factors, Species diversity indices

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). The structure of phytoplankton community is a good indicator of water quality due to its sensitivity 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 phytoplankton populations are primarily regulated by inorganic nutrients, which include,but are not limited to nitrogen, phosphorus, and silica (Akunga*et al.*, 2018). The major forms ofavailable nitrogen exist in the form of nitrate, nitrite and ammonia. Phosphorus occurs as soluble orthophosphate while silica exists in theform of silicates (USEPA, 2008). Phytoplankton communities are sensitive to alterations in their habitats, and therefore, phytoplankton total biomass and many phytoplankton species are utilized as indicators of aquatic habitat quality (Chellappa*et al.*, 2009). Phytoplankton demonstrate water quality through changes in their community composition, 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 shown that the characteristics of phytoplankton structurechanges are closely related to hydrological conditions, and nitrate concentration (Negro *et al*., 2000). Additionally, these changes have a strongcoupling relationship with chemical oxygen demand (COD) and particulate organic matter (POM) (Lee and Kang, 2010). When environmental factors change, they can still greatlycontrol the phytoplankton community structure. It is becoming increasingly essential to study the changes inphytoplankton community structure to improve water quality assessment (Huang *et al.*, 2022). Therefore, monitoring phytoplankton community structure and diversity has become essential for assessingwater ecosystem health and water quality(Nunes*et al.*, 2018). Understanding the changes of phytoplankton communities in ponds contaminated by agriculture may contribute to determining the best approaches forprotectingthese ecosystems and provide reference cases for broaderresearch (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 organicwhich include agricultural by-products and animal manures. Chemical fertilizer typically consistsof 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, such as, 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 Description of Study Area / Pond Preparation and Experimental Design

The study was conducted from September 2023 to October 2023 at thehatchery research unit of the Department of Fisheries and Aquatic Environmental Management University of Uyo. AFew days prior to the trial, ponds were preparedby draining, washing and checking water supply and draining systems.Vegetation was removed from the bottom and sides of the ponds. One week before the trial, theponds were filled, and subsequently, water loss due to evaporation was compensated to maintain the same level throughout the study. The study lasted for 31 days and was conducted in a completely random design with two treatments and two replicates using organic and inorganic fertilizers (see 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 was collected from poultry unit belonging to theDepartment of Animal Science University of Uyo. The nitrogen (N 2.55%) and phosphorous (P 0.95%) in chicken manure were determined using proximate analysis at theAnimal Science laboratory according to theAssociation of Official Analytical Chemists (AOAC, 2002). Four concrete tanks, each withan area of approximately 7.62m^2 were used and filled with water to depth of 2.5ft. Two treatments: 2.5kg of chicken manure, 2.5kg of di-ammonium phosphate fertilizer and acontrol (no fertiler) were randomly assigned to the tanks, witheach treatment replicated once.

Plate 1: Experimental Setup

2.2Phytoplankton 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 Lof water using a 20-micrometer plankton net (Plate 2). The collectedphytoplankton samples were 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 were concentrated by filtration through sand and counted in a counting chamber under a microscope fitted with an ocular micrometer (APHA, 2005). Identification of phytoplankton specieswas conductedby observing through the microscope andenumerating under a light microscope (objective x 40) 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

2.3Species 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).

2.3.1. Phytoplankton species indices

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

2.3.2 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.

2.3.3Margalef'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

2.3.4. 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.

2.3.5 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).

2.4**Collection of Water Sample**

Three plastic bottles for water samples and DOeach measuring 50 cl were used. The bottles were immersed to about 60 cm below the water surface and filled to capacity. After removal from the water, each bottle was carefully sealed ensuring no air bubbles were present.They were then transported to the fisheries laboratory in the Department of Fisheries and Aquatic Environmental Management for further analysis.

2.5**Water quality**

Water temperature, DO and pH were measuredin-situ in the morning by 8:00am using mercury – in – glass thermometer, portable pH meter model – (HI98107 Hanna instrument), and portable DO meter model-(HI 98303 Hanna instrument) (APHA, 1998, APHA, 2005). Other water quality parameters (phosphate, nitrates and potassium) were determined in the laboratory following standard proceduresaccording to (APHA, 2005), and (APHA 1998).

2.6 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 were done using Microsoft Excel. Principal Components Analysis (PCA) was used to determine the relationship between physico-chemical parameters and phytoplankton utilizing the PAST software.

3.0 Results

3.1 Mean Variations in Physicochemical parameters in the two Tanks

The DO in the present study was 4.13 ± 0.16^{b}in the inorganic tank and 4.71 ± 0.18^{a}inthe organic tank. This parameter exhibited significant difference at P<0.05. The highest mean DO value (4.71 ± 0.18^{a}) was observed in the inorganic fertilized tank while the lowest 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} and 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 differenceobserved 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 lowest 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 levels in the present study were 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 levels 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 (MG/L)	4.71 ± 0.18^{a}	4.13 ± 0.16^{b}
TEMPERATURE (^{0}C)	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).A significant positive correlation was observed for phosphorous and total nitrogen (0.85). DO has a relativelyweak correlation with pH (0.34), andwith phosphorus (0.23). pH has a weak correlation with phosphorus (0.04). High negative correlations occur between pH and total nitrogen (-0.18),and between 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**					
TEMPERATURE	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

The existence of phytoplankton in each treatment investigated was 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, Simpson, and Margalef indices were found in the inorganic tank with respective values of 3.216, 0.8901, 0.956 and 4.34. The lowest in Shannon-Wiener diversity, Evenness, Simpson, and Margalef indices were found in the organic fertilized tank with respective value of 3.141, 0.8256, 0.948 and 4.21.

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	0.948	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	4.21	4.34
Equitability_J	0.9425	0.9651

3.5Canonical Correspondence Analysis of Environmental Variables with Phytoplankton

Six environmental factors affected phytoplankton presence to varying degrees. Temperature, pH, DO, potassium, phosphorus and total nitrogen had a significantinfluence on phytoplankton, as indicated by their high correlation with the two significant canonical roots. The phytoplankton in the first quadrant of thebiplot were strongly correlated with pH, temperature and DO, and negatively correlated with 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)

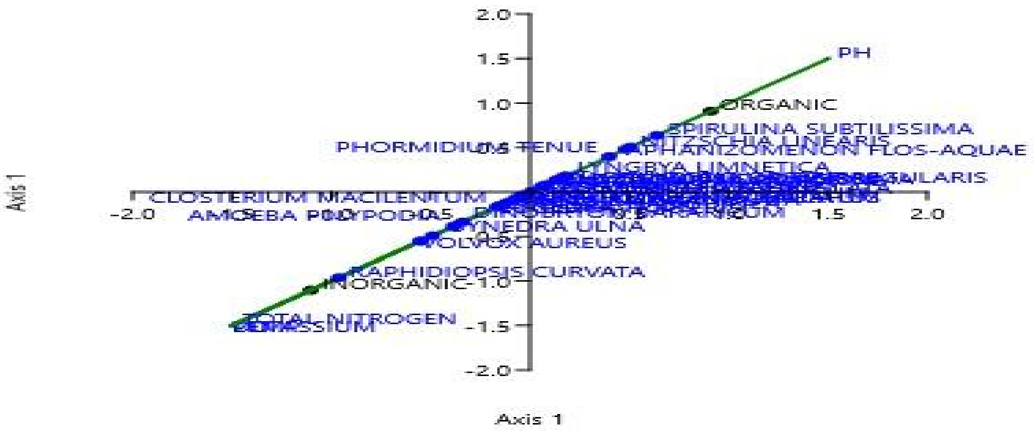

Figure 1: Canonical Correspondence Analysis of Environmental Variables with Phytoplankton

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 inthe inorganic treated tank.Six environmental factors (temperature, DO, pH, potassium, phosphorus and total nitrogen) werescreened for PCA analysis based on theabundance of phytoplankton. PCA biplot showed that the eigenvalues of the two axes were 18.49% (Fig. 3.). The variance explained by 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 andthe environmental variables analyzed. The most important environmental variables were phosphorus, total nitrogen, potassium and DO.

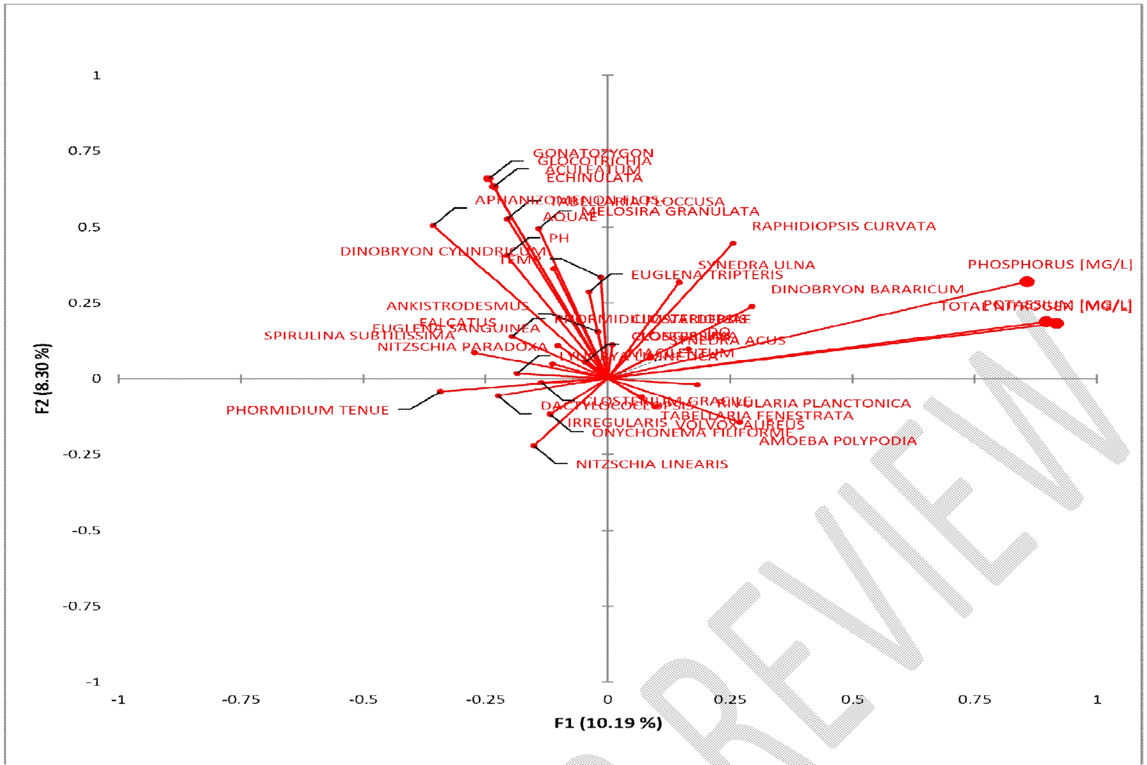

Figure 2: Principal component analysis (PCA) plot of the first two components of all variables measured.

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 DO were significantly different buttemperatureandpH was not statistically significant.DO is the most significant ecological factor of the fish pond ecosystem (Prabhat, 2019). Mahboob (1992) recorded the maximum average DO when phytoplankton was abundance. A similar trend was observed in these present investigations as the values obtained were 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 duringthe study period. (4.13±0.16^{b} (4.71±0.18^{a})

A mean of 7.03±0.49 DO 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 to7.74±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. DOin water declines withan increase in temperature and vice versa. Other studies have shown DO concentration of 2.53 mgl^{-1} for drainage water and 5.68 mgl^{-1} for irrigation water (Fafioye*et al.*, 2005) which are comparable to the values recorded in this present study.

Temperature is an important independent factor thatcan affect phytoplankton (Saeiamet *al*, 2020). Temperature influencesfish growth by affecting the physicochemical conditions of water. It also impactsthe 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 poultry manure on phytoplankton production in earthen fish ponds, revealed 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. The temperatures values recorded in this 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-tank differences inwater temperature in this study were non-significant with values 26.00±0.14^{a}for the inorganic fertilized tankand 25.97±0.14^{a}for organic fertilized tanks. This result corroborates the findingsof Prabhat (2019) who also reported no significant difference in the temperature of the fertilized ponds investigated. The temperature values obtained in this study arein line with the range 24.2±0.4 - 24.1±0.4 - 26.0±0.4 reported by Akunga*et al.* (2018) for concrete, 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 no significant difference in the pH values from their investigation. The authors reported pH values of both fertilized ponds in the range of 7.30 to 9.40 (Tl) and 7.60 to 9.10 (T2) in their respective ponds**.** Hassan (1989) observed that the production was higher in experimental ponds with pH values ranged from 6.9 to 9.5 which is also consistent with the values observed in this study.

Phytoplankton require nutrients such as nitrateand phosphate for growth. However, some phytoplankton can fix nitrogen and grow in areas where nitrate concentrations are low (Kumar *et al* 2014). The potassium level in this study was 51.29±2.88^{a} for the inorganic fertilized tank and 16.52±1.19^{b} for the organic fertilized tank. The tank with the inorganic fertilizer recorded ahigher amount of potassium compared to thetank fertilized with organic fertilizer. This could be attributed tothe high potassium released by the inorganic fertilizer.

The mean phosphorus level in this study was higher in the inorganic tank than in the organic tank, which was contrary to the findings of Hossain *et al.* (2006) who suggested that the capacity of phosphorus released from poultry manure might be more efficient than other organic and inorganic fertilizers used in their study. The mean phosphorus levels (27.97±1.08^{a})in the inorganic tank and (12.30±0.43^{b}) in the organic tank in this study arelower than 610-1010 µg l^{-1} reported in studies on phytoplankton diversity and its relationship to physicochemical parameters by Hossain *et al.* (2006).Additionally, these levels are 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 differentwater-holding facilities used in previous studiesand could be influence bythe effects of pH in the pond since pH had a positive correlation with phosphorus levels 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) who recorded the range of 0.14-0.67 and 0.05-0.64 for phosphorus in Pond A and Pond C respectively

The mean total nitrogen concentrations (33.39±0.66^{a})in the inorganic treated tank and (11.85±0.58^{b})in the organic treated tank in this studywere higher in the inorganic treated tank. The tank treated with inorganic fertilizer recorded arelatively high amount of total nitrogen due to thelow number of nitrifying bacteria and the absence of soil medium at the bottom of the tank compared to the one treated with organic fertilizer. Total nitrogen concentration in this study is much lower when compared to the ranged of272.81 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) andthe200 - 300 µgl^{-1} reported by Saeed and Mohammed, (2012). This variation can be attributed to the low number of nitrifying bacteria present in their pond and the nature of the pond bottom in their study.

Based on the results from thePearson correlation matrix of the physico-chemical parameters, the difference in phytoplankton composition is influence by a combination of physical conditions and water chemistry. The study revealed that certainparameters, potassium, phosphorous and total nitrogen, have a significantly positive correlation with phytoplankton abundance.

Phytoplankton play an important role in aquatic ecosystems due to their fast response to changes (Soeprobowati*et al* 2021). In this 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 ranged from 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 compared to 3.141 in the organic fertilized tank. This slight difference may be due to the fact that the inorganic treated tank retainsfertility more effectively, influence byits physicochemical parameters. Additionally, the higher Shannon index in inorganic tank over the organictankcould be attributed to more favorable atmospheric conditions in the inorganic tank. Differences in phytoplankton diversity may also be an indicator that phytoplankton diversity is influence by the tank type and physicochemical parameters.

The combined range of Shannon index (H`) from3.141to 3.216 for organic and inorganic treated tanks found in this study is slightly higher than the reported range of 0.108 to2.584 by Saeiam*et al.* (2020). Evenness Index (J) of 0.8256 to 0.8901 indicate thatallthe species were relatively evenly abundant across the various treatments investigated. The combined range of Evenness for organic and inorganic treated tanks in this study aligns with the reported range of 0.086 to0.530 by Saeiam*et al.* (2020). Similarly, the combined range of Simpson index (1-D) from 0.9481to 0.956 for organic and inorganic treated tanks in this study also fall within the reported range of 0.031 to 0.900 by Saeiam*et.al.* (2020).

The Index of individual abundance was highest in thetank treated with organic fertilizer, with 611 individuals, followed by theinorganic fertilized tank with 503 individuals. The high individual phytoplankton abundance observed in the organic fertilized tank in this study might be due to the fact that the tank was less severelyimpactedby pollution, thereby favoringspeciesabundance. TheMargalefIndex (a measure of species richness or taxa richness 'd') was higher (4.34) in tank treated with inorganic fertilizer, reflecting that this fertilizer-treated tank maintained a high level of biodiversity.

Inthe CCA bioplotof the study, it was observed that most of the dominant species were distributed in the first and fourth quadrants, possibly indicating higher pollution levelsin the fertilized treated tanks. Various environmental factors were found to significantly impact the growth and distribution of phytoplankton. However, the specific factors varied across different CCA biplots.The key factors influencing the phytoplankton communitywere identified as pH, DO, total nitrogen, and potassium. Therefore, it can be inferred that water quality condition in the two treated tanks had a significant impact on phytoplankton community.

The PCA plots illustrate the role of pH, total nitrogen, and potassium in structuring the phytoplankton system.High concentrations of phytoplanktonspecies such as*Dinobryonbararicum, Euglena tripteris, Synedra ulna, Raphidiopsiscurvata,*and *Spirulina subtilissima*werestrongly correlated with DO, total nitrogen, potassium,and phosphorus in the first quadrant.Species like*Ankistrodesmusfalcatus, Spirulina subtilissima, Dinobryoncylindricum, Euglena sanguine,*and*Nitzschiaparadoxa*showed a strong affinity for temperature and pH, as shown in Figure 2.

4.2 Conclusion

The results of this study indicate that the abundance and composition of phytoplankton were significantly influencedby the type of fertilizer treatment and thephysico-chemical condition of the tanks. The tank treated with organic fertilizer exhibitedhigher abundance and species composition of phytoplankton compared to the tank treated with inorganic fertilizer. Furthermore, higher phytoplankton diversity observed in organic fertilizer-treated tank may reflect better water quality and the environmental conditionscompared to the inorganic fertilizer-treated tank. The study also found that the addition of fertilizers altered severalphysico-chemical properties of the water. Water bodies with a higher diversity of phytoplankton generally indicate better water quality, as evidenced by fluctuation in both biotic and abiotic variables. The resultssuggest that the addition of fertilizers increased nitrogenous compounds, which are beneficial for phytoplankton growth. Canonical Correspondence Analysis (CCA) and Principal Component Analysis (PCA) highlighted DO, pH, total nitrogen, potassium, and phosphorus as critical environmental factors influencing the distribution of phytoplankton communities. The study further revealed that different phytoplankton species exhibit preferences for specific environmental conditions. The CCA biplot results underscored the relationship between phytoplankton community structure and water quality influenced fertilizer treatments.

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Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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Details of the AI usage are given below:

1.

2.

3.

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. and Opeh, 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.

Lee, Y. S., and Kang, C. K. (2010). Causes of COD Increases in Gwangyang Bay, South Korea. *J. Environ. Monit.* 12 (8), 1537–1546.

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. Agric*., 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. *Aquaculture Reports*, 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

United States Environmental Protection Agency (USEPA) (2008). Water Quality Monitoring and Assessment Guidelines. The Volunteer, 54: 138-145. Handbook Turtle Press pty Ltd, Tas Australia, 30-51.

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.