

Effect of Two Organic Fertilizers on Phytoplankton Abundance Cultured Under Laboratory Condition

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ABSTRACT

The comparative effects of two animal manures (chicken and cow manures) on phytoplankton abundance and water quality were investigated under laboratory condition. Two concentrations of each manure were used to produce four treatments plus the control treatment resulting to five treatments (T1 10g of chicken manure, T2 20 g of chicken manure, T3 10 g of cow manure, T4 20 g of cow manure, and T5 is the control with zero manure). The treatments were replicated thrice and were kept and monitored in the laboratory for twenty-one days. Data collection was done every three days. The identified phytoplankton groups in this study were Cyanophyta, Euglenophyta, Cyanophyta, and Bacillanophyta. The phytoplankton biomass results revealed that T1 and T2 (chicken manure) treatments were higher than the other treatments and were significantly different ($P=0.012$) in the following order $T2>T1>T4>T3>T5$, 2.19, 1.87, 1.04, 0.93, and 0.04. Statistical analysis on the water quality parameters revealed that the treatments were not significantly different ($P>0.05$) in Temperature ($P=0.619$), pH ($P=0.465$), Dissolved Oxygen ($P=0.129$), Alkalinity ($P=0.252$), but were significantly different in Nitrate ($P=0.0001$), Ammonia ($P=0.004$) and Transparency ($P=0.0001$). Analysis of correlation on phytoplankton abundance and water quality parameters indicated that Temperature, pH, Alkalinity, Nitrate and Ammonia were positively correlated (0.636, 0.862, 0.884, 0.806 and 0.837) with phytoplankton abundance except for Dissolved Oxygen and Transparency which were negatively correlated (-0.716 and -0.418). The study results revealed that chicken manure is the preferred media for phytoplankton culture under laboratory condition but with caution as excessive used of it can lead to low Dissolved Oxygen and Transparency.

Keywords: Fish Food, Physiochemical Parameters, Chicken Manure, Cow Manure, and Live Microscopic Organisms.

INTRODUCTION

Fish contribute more than 60 percent of the world protein supply. The cost incurred for fish feed remains a major issue, especially among small-scale fish farmers in the aquaculture industry (Rashid et al., 2018). This is because feed accounts for over 70% cost of producing a table-size fish (Omeje et al., 2020). A common approach to increasing fish production and reducing feed cost in ponds is the direct production of plankton via application of fertilizer which enhances the natural food item for fish. Phytoplankton assemblages are characterized by their high ability to provide many valuable phytonutrients and biologically active ingredients, e.g. fatty acids, amino acids, sterols, organic minerals, enzymes, carotenoids, chlorophyll, trace elements, vitamins, antioxidants (Kovač et al., 2018). Pond fertilization practices using animal wastes are widely used in many countries to sustain productivity at low cost (Nair et al., 2014). Ćirković et al. (2012) reported that organic fertilization with livestock manure is a very cheap and effective method of increasing practically all nutrient components in fish pond ecosystems. Adewumi et al. (2011) and Orihabor and Ansa, (2006) in separate studies of organic manure observed that nitrogenous wastes from farm yard manure efficiently influence the pond water productivity as it supplies the plankton with essential nutrients.

Livestock wastes including livestock manure and poultry by-products are menace to the environment but are

also sources of wealth creation in fish farming (Adewumi et al., 2011). The livestock wastes; cow-dung, poultry and pig excreta, goat and sheep pellets, are useful in enhancing the production of fish food organisms thereby cutting down the expenditure on feeds and inorganic fertilizers. However, phytoplankton growth and productivity are often limited by the availability of nutrients, especially nitrogen and phosphorus, in the water. Therefore, fertilization is a common practice to enhance phytoplankton abundance and diversity in aquaculture ponds and lakes. The different types of fertilizers may have different effects on the water quality, phytoplankton community composition and dynamics. Cow dung and poultry manure are widely available and cheap sources of organic fertilizers, but their effects on phytoplankton growth and quality under laboratory conditions have not gained much study. Away from the laboratory environment, some studies have reported positive effects of cow dung and poultry manure on phytoplankton biomass, chlorophyll-a concentration, and cell count (Chibugwu, 2021), while others have reported negative effects such as eutrophication, algal blooms, or toxicity (Ahlberg-Eliasson et al., 2021). Therefore, it is important to investigate the effect of different organic fertilizers and dosages on the development of phytoplankton under laboratory conditions where the factors affecting phytoplankton growth can be controlled and monitored.

Materials and Method

Study Area

The study was conducted at the Biotechnology Laboratory of University of Africa, Toru-Orua, Sagbama, Bayelsa state. The University lies at Latitude 5° 6' 1" and Longitude 6° 3' 58", a highly humid terrain (85%-90%) according to Time and Date Forecast. The study was carried out in three weeks between the months of October and November (twenty-one days study period).

Experimental Treatments and Procedure

The experiment was conducted using ten (15) plastic troughs of four litres (4L). Two different organic fertilizers (chicken droppings and cow dung manures) were used for the study. There were four treatments (two concentrations of 10g and 20g for each fertilizer). The fifth treatment was the control troughs which served as the reference trough, they were not subjected to any organic fertilizer treatment. The treatments were T1, T2, T3, T4 and T5. T1 and T2 were treatments with chicken manure of different concentrations of 10 g (T1) and 20 g (T2). T3 and T4 were treatments with cow manure of different concentrations of 10 g (T3) and 20 g (T4). T5 was the control treatment with no organic fertilizers (just water). All treatments had three replicates each.

All trough were filled with 2cm layer of river sand and 1.5L of water, with a pH of 8.1. The troughs were allowed to be naturally inoculated for three days before adding treatments manures. The treatments manure dosages were prepared with 0.5L of water and added to the respective trough at weekly interval for the period of twenty-one days. The treatments remained and were monitored in the laboratory all through the culture period. The composition of the Organic manure is as shown in Table 1 and 2. The water level of the troughs were maintained throughout the culture period, water was replenished when required.

Table 1: Proximate Compositions of Organic manures

Parameters %	Chicken manure	Cow manure
Moisture	7.74	8.37
Crude Protein	17.32	9.68
Crude Fat	4.81	0.99
Crude Fibre	8.37	5.85
Ash	17.15	21.19
NFE	45.29	54.08

Table 2: Chemical Composition of Nutrients in Organic Manure

Parameters (Mg/L)	Chicken manure	Cow manure
Nitrogen	1.74	0.43
Phosphorus	0.78	0.19
Silica	0.04	0.02

Data Collection

Water samples for physiochemical parameters, phytoplankton organisms were collected every three days with 0.5L plastic containers. Phytoplankton samples were collected from two spots at the bottom of the troughs with a 6cm² cone shaped scope net. The scope net was used to scrape up the substratum. Physical and chemical characteristics were analyzed with methods described in APHA (1985). The detailed analytical methods are as follows:

Water Quality Parameters: Temperature was measured in the laboratory using Celsius mercury thermometer. pH was measured using conductivity meter. Dissolved oxygen was measured using DO meter. Transparency was measured using Secchi disc of 4cm diameter constructed for this study. Ammonia and nitrate were determined using kits.

Primary Productivity: Phytoplankton species were analyzed quantitatively and qualitatively as recommended by APHA (1995). Phytoplankton density was determined by using Lackey drop (micro-transient) method. Phytoplankton diversity was determined using the diversity index of Boyd (1990).

Statistical Analysis

The experimental design was complete randomized design (CRD). Data were subjected to ANOVA to determine statistical differences, least significant difference (LSD) was used to differentiate treatment means. Correlation analysis was used to determine the relationship between physiochemical parameters and phytoplankton abundance. All statistical analysis was done using SPSS 23 at P<0.05 level of significance.

RESULTS AND DISCUSSION

Results

The results on the study of two organic fertilizers (each with two concentrations) effects on Phytoplankton development under laboratory conditions are as shown in Table 3. The overall means of the Phytoplankton growth and physiochemical parameters of the different treatments of chicken and cow manures are shown in Table 3.

Table 3: Means ($\pm$ SE) Of Physiochemical Parameters and Phytoplankton Abundance of Five Different Organic Manure Treatments

Parameters/ Plankton	P Value	T ₁ Mean $\pm$ SD	T ₂ Mean $\pm$ SD	T ₃ Mean $\pm$ SD	T ₄ Mean $\pm$ SD	T ₅ Mean $\pm$ SD
Phytoplankton	0.012**	1.87 ^{ab} $\pm$ 1.04	2.19 ^{ab} $\pm$ 1.63	0.93 ^{ac} $\pm$ 0.62	1.04 ^{ac} $\pm$ 0.75	0.40 ^c $\pm$ 0.34
Temperature	0.691*	27.29 ^a $\pm$ 1.11	27.86 ^a $\pm$ 1.35	27.14 ^b $\pm$ 1.07	27.57 ^b $\pm$ 0.98	27.14 ^b $\pm$ 0.90
pH	0.465*	6.73 ^a $\pm$ 0.36	6.9 ^a $\pm$ 0.44	6.59 ^a $\pm$ 0.24	6.69 ^a $\pm$ 0.31	6.64 $\pm$ 0.25

Dissolved Oxygen	0.129*	2.28 ^{ab} ± 0.70	1.76 ^{ab} ± 0.39	2.89 ^a ± 1.36	2.95 ^a ± 1.30	2.99 ^a ± 1.02
Alkalinity	0.252*	95.29 ^a ± 39.94	108.186 ^{ab} ± 45.10	85.14 ^a ± 30.95	86.86 ^a ± 34.90	64.71 ^{ac} ± 24.74
Nitrate	0.0001**	1.17 ^a ± 0.40	1.44 ^a ± 0.34	0.72 ^b ± 0.24	0.83 ^b ± 0.17	0.39 ^c ± 0.24
Ammonia	0.004**	0.30 ^a ± 0.16	0.35 ^a ± 0.20	0.24 ^a ± 0.06	0.30 ^a ± 0.09	0.08 ^b ± 0.04
Transparency	0.0001**	3.27 ^a ± 0.68	2.87 ^a ± 0.69	4.09 ^b ± 0.23	3.37 ^a ± 0.51	4.14 ^b ± 0.44

** Highly Significant, * Not Significant. Means of Treatments with same superscript alphabets are not significantly different while those with different alphabets are significantly different

Phytoplankton

Total mean phytoplankton production increased with time (three days interval). T2 revealed a major fluctuation between day 9, 15 and 18 while the others had very slight fluctuation (Fig.2). Fig 1 revealed the percentage phytoplankton abundance of each treatment. Mean phytoplankton abundance for all the treatments was 1.2857 g/L, with a range of 0.10 - 4.70 g/L (Table 5). Statistically, there was a significant difference in the treatments' phytoplankton abundance (P=0.012), Table 3. Mean comparison indicated that T1 and T2 are different from T5 (Table 3). Mean percentage phytoplankton abundance in Fig.3, showed the dominant phytoplankton in the following order of Cyanophyta > Euglenophyta > Chlorophyta > Bacillariophyta.

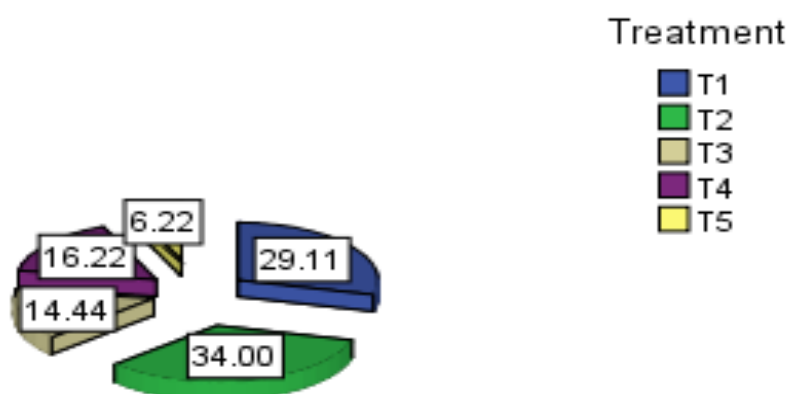


Fig. 1: Percentage Dominance of Phytoplankton in Treatments

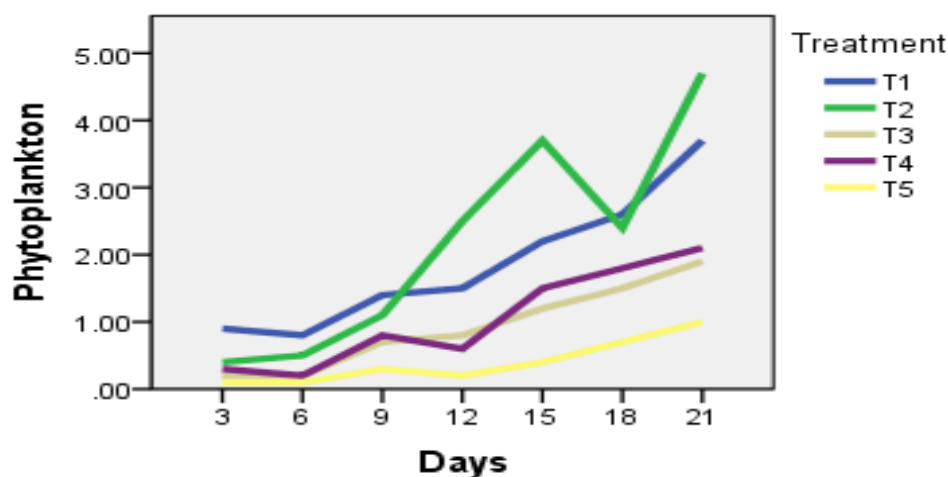


Fig. 2: Mean variation in days of phytoplankton for five treatments of different organic manure

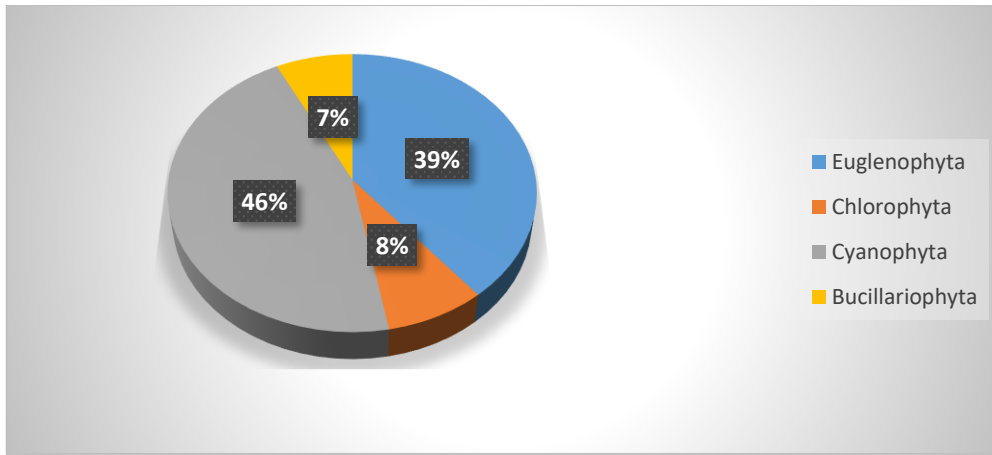


Fig. 3: Percentage Overall Dominant Structure of Phytoplankton

Water Parameters

Temperature: The average water temperature for all the treatments was 27.4 °C and ranged from 26-30 °C (Table 5) and were not significantly different ($P=0.691$), Table 3. The highest temperature was recorded for T2 (27.86°C) and the lowest were T3 (27.14°C) and T5 (27.14°C) which are cow manure with concentration of 10g and the control treatments.

pH: The mean pH during sampling period of the study was 6.71, (Table 5). The mean range is between 6.30-7.6. The lowest pH was recorded for T3 and the highest was recorded for T2. There was no significant difference in the treatments ($P=0.465$), Table 3.

Dissolved Oxygen: Mean DO for the treatments was 2.571 mg/L with mean range of 1.40 -5.01 mg/L (Table 5). Statistically, the treatments revealed no significant difference ($P=0.129$), Table 3. However, T2 was significantly different from T3, T4 and T5. The result showed that T5 had the highest value 2.99mg/L in DO while T2 had the lowest value, 1.76mg/L.

Alkalinity: The mean Alkalinity value for all the treatments was 88.17 mg/L with a mean range of 38.00-169.00 mg/L (Table 5). Statistically, there were no significant differences in treatments ($P=0.252$). T2 showed a significant difference with T3 only (Table 3). The control treatment had the lowest value (64.71mg/L), and T2 had the highest value (108.18mg/L).

Nitrate: The mean Nitrate value for all the treatments was 0.9106 mg/L. A mean range of 0.15 mg/L - 1.90 mg/L was observed in the study (Table 5). There was no significant difference in the treatments ($P=0.0001$), (Table 3). However, the study revealed that T1 was not different from T2, T3 was not different from T4. T4 had the highest (0.83mg/L) while T1 had the lowest (1.17mg/L).

Ammonia: The mean Ammonia value for all the treatments was 0.2534 mg/L having a mean range of 0.03 - 0.63 mg/L (Table 5). Statistically, the treatments were significantly different ($P=0.004$), (Table 3). Multiple comparison revealed that T1 - T4 were not significantly different from one another but all were significantly different from T5. T5 had the lowest (0.08mg/L) and T2 had the highest (0.35mg/L).

Transparency: The mean transparency value for all the treatments was 3.5486 cm with a range of 2.10 – 4.80 cm (Table 5). Statistically, there was significant difference in the treatments ($P=0.0001$). However, multiple comparison revealed that treatment T1, T2 and T4 were not significantly different. Likewise, T3 and T5 were not significantly different, but both groups were significantly different (T1, T2 and T4 significantly different from T3 and T5), Table 3. T5 had the highest value (4.14cm) and T2 had the lowest (2.87cm).

Relationship between phytoplankton and water quality parameters

Results from Pearson correlation analysis revealed that total phytoplankton abundance and the different water quality parameters had positive correlation (a positive linear relationship) except for Dissolved Oxygen and

Transparency which had negative correlations (a negative linear relationship) for phytoplankton (-0.716 for DO and -0.884 for Transparency). Despite the negative correlations, the relationships were significantly different ($P=0.0001$), which indicate a significant association between the water quality parameter and phytoplankton abundance, (Table 4). Fig. 4, showed the rate of phytoplankton development and percentage abundance at three days interval.

Table 4: Phytoplankton Correlations with Water Quality Parameter and Level of Significance

Phytoplankton	TP	PH	DO	Alkalinity	Nitrate	Ammonia	Transparency
Euglenophyta	0.180 (0.500)	0.349 (0.040)	- 0.477 (0.004)	0.456 (0.006)	0.501 (0.002)	0.501 (0.0001)	- 0.548 (0.001)
Chlorophyta	- 0.114 (0.516)	- 0.135 (0.441)	0.017 (0.924)	- 0.122 (0.486)	0.312 (0.68)	0.024 (0.892)	0.006 (0.972)
Cyanophyta	0.619 (0.0001)	0.797 (0.0001)	- 0.532 (0.001)	0.792 (0.0001)	0.621 (0.0001)	0.673 (0.0001)	- 0.696 (0.0001)
Bacillariophyta	0.048 (0.786)	0.031 (0.858)	0.048 (0.785)	- 0.153 (0.379)	- 0.316 (0.064)	- 0.420 (0.012)	0.228 (0.188)
Total Phytoplankton	0.636 (0.0001)	0.862 (0.0001)	- 0.716 (0.0001)	0.884 (0.0001)	0.806 (0.0001)	0.837 (0.0001)	- 0.868 (0.0001)

Table
5:

Means, SD, and Ranges of Physiochemical Parameters and Phytoplankton Abundance

Parameters	N	Mean $\pm$ SD	Range	
			Minimum	Maximum
Temperature	35	27.40 $\pm$ 1.0627	26	30
pH	35	6.7086 $\pm$ 0.3275	6.3	7.6
DO	35	2.571 $\pm$ 0.94	1.4	5.01
Alkalinity	35	88.1714 $\pm$ 36.6939	38	169
Nitrate	35	0.9106 $\pm$ 0.4597	0.15	1.9
Ammonia	35	0.2534 $\pm$ 0.1489	0.03	0.63
Transparency	35	3.5486 $\pm$ 0.7102	2.1	480
Phytoplankton	35	1.2857 $\pm$ 1.1356	0.1	4.7

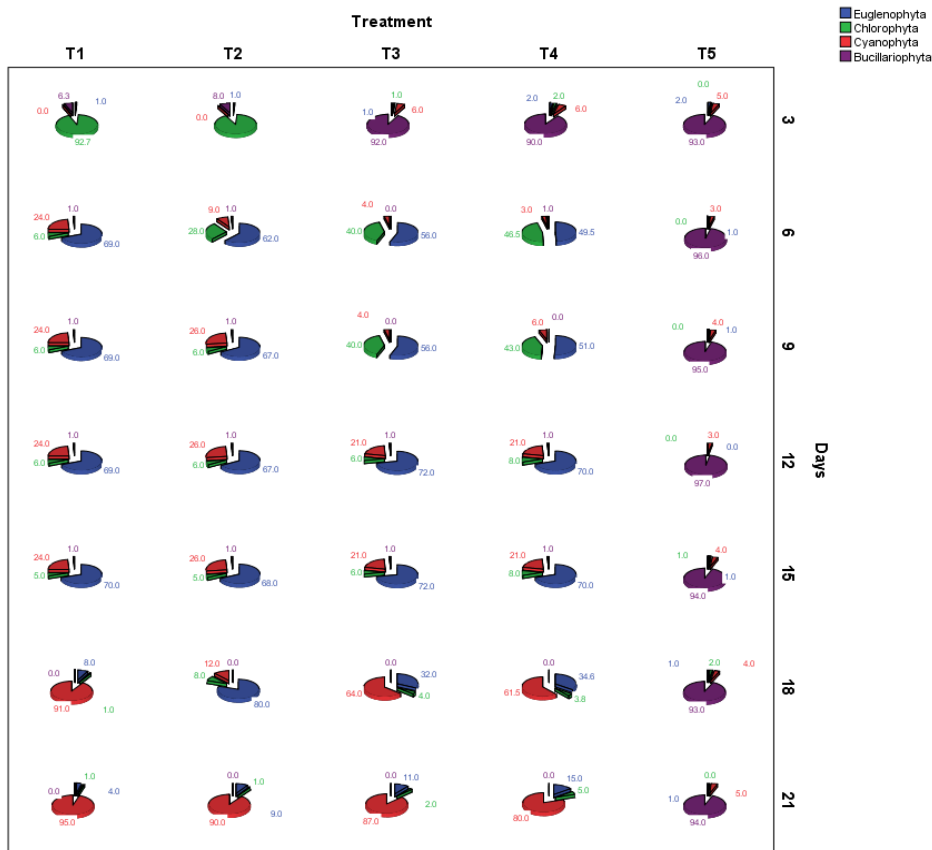


Fig. 4: Mean Phytoplankton abundance every three days for the five different Treatments

DISCUSSION

In the study of phytoplankton development under laboratory condition using two organic fertilizers, T2 (chicken manure with 20 g concentration) had the highest phytoplankton abundance (2.19g), next was T1 (chicken manure with 10 g concentrate), 1.87g, followed by T4 (cow manure with 20 g concentration), 1.04g, and T3 (cow manure with 10 g concentration), 0.93g, T5 (control treatment) had the least biomass, 0.40g. This agrees with the findings of Rajanna and Shivananda (2021) and Safi et al. (2016) who stated that phytoplankton biomass was influenced by different organic fertilizer but was higher in chicken manure. This is also in accordance with the findings of Rapatsa and Moyo (2013) who indicated that chicken manure treatment has the optimum nutrient conditions for phytoplankton growth. The manures chemical composition analyses are consistent with Adewunmi et al. (2011), whose study reported that nutrients (Nitrogen, Phosphorus and Potassium) for phytoplankton growth are highest in chicken manure. According to FAO (1985), chickens and pigs are monogastric animals and the food in their stomach are digested once, retaining most of the nutrient contents. But that of ruminant animals like cow digest their food more than once with most of the nutrient assimilated into the body leaving very little in their excreta (FAO, 1985; Edwards et al., 2000). Amongst the existing phytoplankton, the species identified in this study were Euglenophyta, Chlorophyta, Cyanophyta and Bacillariophyta, this agreed with report of Akter et al. (2018) and Raju et al. (2018) who reported similar species composition in their study. During the period of this study, there were fluctuation in phytoplankton abundance in the different treatments, the total number of phytoplankton was dominated by Cyanophyta (46 %), followed by Euglenophyta and Bacillariophyta was the least (7 %).

Effect of water quality parameters on the different treatments during the culture period varied. The mean values of the physiochemical parameters measured every three days for the twenty-one days culture period are within the acceptable range required for plankton growth. The mean total temperature recorded for the study period was 27.40 °C which is within the required rate according to Bocek and Gray (2002). Mean total pH for all the treatments and study period was 6.71 which according to Reginal and Donald (2004) and Wurtz (2009) report falls within the recommended pH range for freshwater organism. The mean total value of DO was 2.57 mg/L which is below the recommended range of Wurtz (2009) of 5.0 mg/L for freshwater organisms' culture. The

mean of Nitrate value for this study was 0.911 mg/L which is within the range reported by Muh et al. (2025), 0.9-3.5 mg/L. Their study reported that the optimum growth of phytoplankton requires nitrate levels in the range of 0.9-3.5 mg/L. Total phytoplankton correlations analysis with the physiochemical parameters were similar to the findings of Fayyaz et al. (2022), Dissolved oxygen and Transparency had negative correlations with total phytoplankton abundance but with significant relationships. The negative correlations indicated that as plankton production increased, dissolved Oxygen and transparency decreased. This could be detrimental to fish production if DO is less than 0.3 mg/L for a long time. The minimum value for fish to be kept alive for a long time is 1.0 mg/L, 5.0 mg/L is the optimum value for a fish pond as recommended by Ekubo and Abowei (2011).

CONCLUSION

Based on the study conducted, it can be concluded that the composition and abundance of phytoplankton are Cyanophyta > Euglenophyta > Chlorophyta > Bacillariophyta (in order of abundance). The presence of these phytoplankton indicated that the different organic fertilizer treatments of poultry and cow manures were able to release nutrients required for the different phytoplankton production in a laboratory environment, which are important for aquatic ecosystems, especially in relation to fish production in shaded farm space or indoors fish farming. Chicken manure favoured the growth of phytoplankton more than cow manure. However, there are limitations to the positive effect of organic fertilizers, its excessive application might be detrimental through the decrease of Dissolved Oxygen and Transparency in culture system. For future research, similar studies be conducted with a focus on other types of plankton, such as zooplankton. This is significant for the development of eco-friendly and sustainable aquaculture management strategies.

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