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RESEARCH PAPER

# Plankton Composition and Abundance in Semi Intensive Aquaculture Pond and their Preference by Nile tilapia

**Teklay Gebru Tikue[1], Kassaye Balkew Workagegn[2,3,*]**

[1]Kabridahar University, Department of Biology, Collage of Natural & Computational Sciences, P. O. Box 250, Kabridahar, Ethiopia
[2]Centre for Aquaculture Research & Education (CARE), and [3]Department of Aquatic Sciences, Fisheries & Aquaculture, Faculty of Biological Sciences, Collage of Natural & Computational Sciences, Hawassa University, P. O. Box 05, Hawassa, Ethiopia

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**Corresponding Author**
Tel.: +251936211992
E-mail: kassayebalkew@gmail.com

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## Abstract

Plankton is major food item for Nile tilapia and their availability is one of the most important factors affecting its growth performance in an extensive and semi-intensive pond-based culture systems. Thus, this study aimed to examine plankton composition, abundance, and feeding preference by Nile tilapia reared under a semi-intensive pond-based production system. The experiment was carried out using ponds (10mx15mx1.7m size) fertilized with chicken manure at the rate of 100g/m$^2$/week. Nile tilapia with 7.8g average body weight was stocked at a density of 2 fish/m$^2$. Examination of plankton from both pond water and stomach samples of fish was done using qualitative assessment methods. The results showed that a total of 20 phytoplankton groups were identified following standard identification key. These include four types of Blue-green algae (Cyanophyceae), seven types of Green algae (Chlorophyceae), six Diatoms (Bacillariophyceae), one type of Dinophyceae, and two types of Euglenophyceae. Among the phytoplankton groups, Chlorophyceae was the dominant group with 56% followed by Bacillariophyceae (23%), Cyanophyceae (17%), and Euglenophyceae (3%) while the least was Dinophyceae (1%). The most frequently observed algal genus was Scenedesmus. In addition, three Zooplankton groups namely Copepods (43%), Rotifers (31%) and Cladocerans (26%) were also identified. The result indicated that, the most preferred planktonic groups used by Nile tilapia was green algae, particularly Chlorophyceae followed by Copepoda and Rotifers. The level of chlorophyll "a" was 62.3±2.0 µg/l concentration. The different water quality parameters together with the availability of different plankton were optimal for the growth of Nile tilapia which resulted in a 0.45 specific growth rate. In conclusion, Nile tilapia exhibit preference for green algae, blue-green algae from phytoplankton, and Copepods from zooplankton groups than other groups of plankton.

## Introduction

Tilapia is the second most cultured aquaculture species next to carp. It provides a major source of protein and income particularly in money tropical and subtropical developing countries. Its production is primarily in a semi-intensive pond-based culture system with supplementary feed. The success of such system depends on natural food availability such as plankton which can determine by the nutrient level presented in a pond that influences the optimum growth of the fish and productivity of the system (Ikpi *et al.,* 2013). Plankton biomass serves as a sustainable fish food and food product (Sorrachat *et al.,* 2012). They are the most diverse groups of organisms playing key roles in the aquatic ecosystem as primary producers (Loram *et al.,*

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2007; Ikpi *et al.,* 2013). They sequester carbon dioxide by photosynthesis thereby they are important for climate mitigation in addition to food and oxygen supply to consumers of aquatic environments (Mario *et al.,* 2005). They are also affected by the nature of both biotic and abiotic factors and thus, they are the main indicators of the condition of aquatic ecosystems and the quality of water bodies (Loram *et al.,* 2007). Plankton composition and abundance in semi-intensive pond-based culture system depend on nutrients that intern depends on inputs such as manure/fertilization, and types of supplementary feed (Shoko *et al.,* 2014).

The application of manure enhances plankton productivity however; after a certain limit, they cause deterioration of water quality, plankton, and fish growth (Mlelwa, 2016). It has been reported that an increase in plankton biomass is often associated with nutrient enrichment (Smith 2003). Plankton is sensitive to increase or decrease in nutrients (Mlelwa, 2016). The absence of large filter-feeding Cladocerans such as *Daphnia* could increase phytoplankton species in a pond (Sarma *et al.,* 2005).

In a fish pond, algal biomass should be maximized by the application of both artificial and natural fertilizers. The maximum amount of dry chicken manure application to earthen ponds is recommended as 250-500kg/hac (Flores-Nava, 2007). It is a cheap natural fertilizer that enhances the development of natural food organisms, especially phytoplankton and zooplankton. Poultry manure leads to increased biological productivity of ponds through various autotrophic (algae production) and heterotrophic (bacterial production) pathways, which results in increased fish production (Oribhabor & Ansa, 2006). Although Nile tilapia is a filter feeder several studies showed that the fish can select different plankton species (Rumisha & Nehemia, 2013), in which composition and abundance of plankton are important (Ansa & Jiya, 2002). Thus this study aimed to investigate the composition and abundance of plankton in ponds fertilized by chicken manure and the stomachs of Nile tilapia.

## Material and Methods

### Description of the Study Area

The experiment was conducted at the experimental site of the Centre for Aquaculture Research and Education (CARE) Hawassa University which is found 275 km South of Addis Ababa, the capital city of Ethiopia. It is located at 7 °3’7” N latitude and 38 °3’17” E longitude and situated at 1714masl. The experiment was conducted from January to April 2021. For this experiment, a pond with a size of 10mx15mx1.7m was fertilized with 100g/m$^2$/week of chicken manure (Flores-Nava, 2007; Kour *et al.,* 2016) having 5.8 pH, 6.8% organic carbon, 2.5% Nitrogen, 2.2% potassium and 2.7% phosphorus of dry weight basis. Nile tilapia having an average body weight of 7.8g from the center was stocked at a stocking density of 2fish/m$^2$. In addition, the fish were given a supplementary feed for four months. The water exchange rate was 25% of the pond volume per week. The source of water was groundwater.

### Identification and Abundance of Phytoplankton

Water samples from three points of the pond were monthly collected using a water column sampler (La Motte Water Sampler). The samples were then pooled and preserved using 0.7% Lugol’s solution for plankton identification and chlorophyll-*a* analyses (Boyd & Tucker 1992). In the laboratory, for plankton identification (Boyd & Tucker 1992), samples were examined under a microscope (KRUSS OPTRONIC, GERMANY) at 10x, 40x and 100x magnification. Identification of plankton groups was done using available keys and manuals (John *et al.,* 2002). The abundance of each taxon was estimated using the following formula.

$$C(cells/ml) = \frac{\mathrm{N} * 1000\mathrm{mm3}}{\mathrm{A} * \mathrm{D} * \mathrm{F} * \text{concentration factor}}$$

Where N= number of individuals, A= area of the field, D= depth of the field and F= number of fields counted.

### Chlorophyll Analysis

One hundred milliliters of water samples for chlorophyll-*a* analysis were filtered through a filter paper (Whatman GF/F with a pore size of 0.7µm), using a water jet vacuum pump to get a filtrate. Filter papers containing algal samples were cut into small pieces, and 5ml of 90% cold acetone was added in to test tubes that contain samples and kept for 24 hours in the refrigerator. Then after filter papers were crushed and centrifuged at 3000rpm for 10 minutes. 5ml of cold acetone was added and absorbance was recorded at 665nm and 750nm before and after acidification using a spectrophotometer (JENWAY 6305 visible spectrophotometer). From the spectrophotometer chlorophyll-*a* (µg/l) was calculated using the following formula (Shoko *et al.,* 2011).

$$\text{Chlorophyll-}a\ (\mu g/l) = \frac{(Eo\ 665 - Eo\ 750) - (Ea\ 665 - Ea\ 750) * 2.43 * 11.49 * v}{V * L}$$

Where,

Eo665 = Absorption at 665 nm before acidification,

Eo750= Absorption at 750 nm before acidification;

Ea665= Absorption at 665 nm after acidification;

Ea750=Absorption at 750 nm after acidification;

2.43=factor to associate the reduction in absorbance to the initial concentration of chlorophyll;

11.49=absorption coefficient of chlorophyll *a*,

V = volume of the sample filtered (l),

L = length of the cuvette (cm) and v= volume of the extract in ml

**Algal Diet Composition of Nile Tilapia**

In the present study, the stomach algal composition of Nile tilapia was examined at the end of the experimental period. Out of a total of 40 fish examined, 37(92.5%) fish had food items in their stomach and the remaining 3(7.5%) had empty stomachs. The size of the fish used for this study ranged between 12 and 17 cm in total length and their weight was between 38 and 113 g. In addition to the supplementary feed given to the fish, these stomachs contained a total of six different plankton groups, and unidentified food items were found.

**Water Quality Measurement**

The main water quality parameters such as water temperature, dissolved oxygen (DO), ammonia, nitrate, nitrate, pH, and Secchi depth visibility were measured once in a week. Samples for temperature and dissolved oxygen (DO) measurements were taken by using (HI 9145, dissolved oxygen meter) while, ammonia, nitrate, nitrate, and pH were measured using the ECO-CHECK water quality parameter kit. Secchi depth visibility of the pond was measured by Secchi-disc once a week. The main body measurement parameters of fish such as body weight and length were recorded twice a month. Fish body weight and body length were recorded to the nearest 0.1g with a weighing balance (SF 400A, Electronic Compact Scale) and the nearest 0.1cm with a graduated ruler.

## Results

**Plankton Composition**

The plankton communities observed in the water samples are presented in Table 1. The table showed that a total of 20 phytoplankton and three zooplankton groups were identified. The phytoplankton groups include four blue-green algae (Cyanophyceae), seven green algae (Chlorophyceae), six diatoms (Bacillariophyceae), one Dinophyceae, and two Euglenophyceae, while the zooplankton groups include Copepod, Rotifers and Cladocerans. The most frequently observed phytoplankton was genus Scenedesmus. The phytoplankton abundance indicated by cells density is presented in Figure 1. The abundance of phytoplankton was different for different groups in which Scenedesmus was the highest followed by Navicula and Pediastrum, while Microcystis, Surirella and Zygnema were the lowest (Figure 1). In addition, presentation of three zooplankton groups were also identified, namely Copepod, Rotifers and Cladocerans (Figure 2). The concentration chlorophyll *a* level in the present study was 62.3±2.0 µg/l.

**Algal Diet Composition of Nile Tilapia**

In the present study, the algal diet composition of Nile tilapia was examined at the end of the experimental period and presented in Table 2. A total of 40 fish examined, 37(92.5%) fish had food items in their

**Table 1.** Plankton groups identified during the study period (1-5 indicates frequency of occurrence of species: 1=rare, 2 = sporadic, 3 = common, 4 = abundant, 5 = very abundant)

| Group | Genus | Relative abundance |
|---|---|---|
| Cyanophyceae (Blue green algae) | *Aphanizomenon* | 4 |
| | *Anabaena* | 3 |
| | *Cylindrospermopsis* | 1 |
| | *Microcystis* | 1 |
| Chlorophyceae (Green algae) | *Scenedesmus* | 5 |
| | *Pediastrum* | 4 |
| | *Cosmarium* | 3 |
| | *Coelastrum* | 2 |
| | *Ankyra* | 2 |
| | *Zygnema* | 1 |
| | *Actinastrum* | 1 |
| Bacillariophyceae (Diatoms) | *Cymbella* | 3 |
| | *Navicula* | 4 |
| | *Nitzschia* | 3 |
| | *Cyclotella* | 2 |
| | *Syndra* | 2 |
| | *Surirella* | 1 |
| Dinophyceae | *Peridinium* | 2 |
| Euglenophyceae | *Euglena* | 2 |
| | *Phacus* | 1 |
| Zooplankton | *Cladocerans* | 3 |
| | *Rotifers* | 2 |
| | *Copepods* | 2 |

stomach and the remaining 3 (7.5%) had emptied stomachs. A total of six different plankton groups and several unidentified food items were found in the stomachs of fish. The first three dominant groups were green algae, diatom and blue-green algae consisted of 7, 6 and 3 genera, respectively, while the other two groups namely and Euglenophyceae and Dinophyceae were represented by 2 and 1 genera, respectively. Based on the frequency of occurrence the dominant phytoplankton food items of Nile tilapia in the pond were green algae and diatoms (Table 2). The significant quantities of these contributions were mainly due to genera Scenedesmus (100%) and Pediastrum (73.0%) from green algae and Navicula (86.5%) and Cymbella (64.9%) from diatoms respectively.

Green algae had the highest value of frequency of occurrence which was found in 100% of the examined fish guts, in which genus Scenedesmus was the most dominant green algae (100% of the examined fish guts). Diatoms were the second in terms of frequency of occurrence (89.2%). This is mainly due to genera Navicula (86.5%) and Cymbella (64.9%). Blue-green algae were found to be the next most important dietary food item in the frequency of occurrence (81.08%), which was mostly represented by genera Anabaena (75.7%) and Aphanizomenon (43.2%). Euglenophyceae were found to be the fourth most important food items found in the examined guts of fish in terms of the frequency of occurrence (43.3%), which was represented by genera Euglena (37.8%) and Phacus (13.5%). Dinophyceae had the least values of frequency of occurrence (16.2%) which was represented only by genus Peridinium (16.2%). From the other groups of algae, Cylindrospermopsis was not seen in the gut of

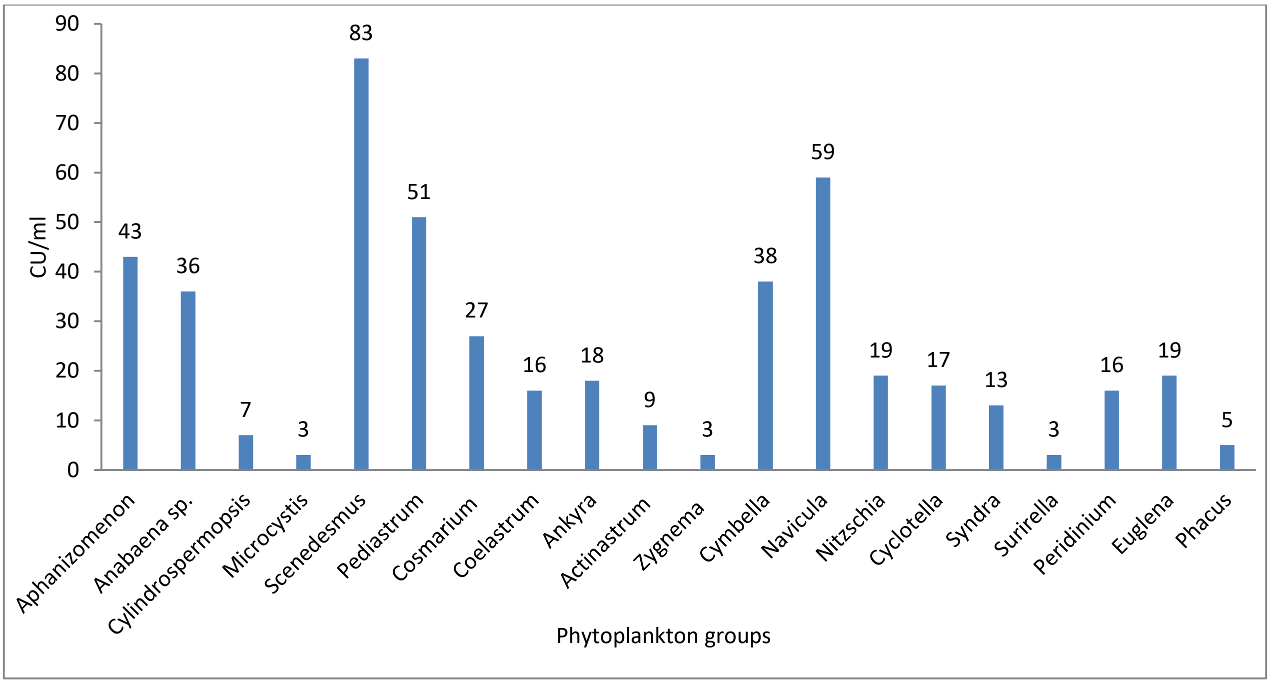


**Figure 1.** Phytoplankton abundance found in semi-intensive pond based fish production system.

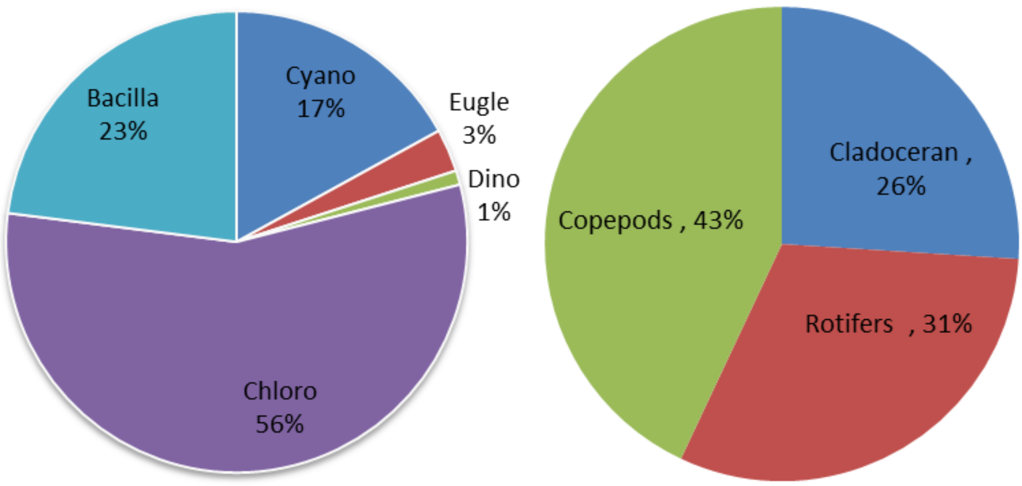


**Figure 2. Percentage contribution of plankton** (Cyano=Cyanophyceae, Eugle=Euglenophyceae, Chloro=Chlorophyceae, Bacilla=Bacillariophyceae, Dino=Dinophyceae, Copepods, Rotifers and Cladoceran) **groups to the total counts of each group**

Nile tilapia, and was rarely found in the fish pond. Therefore, green algae, diatoms and blue-green algae were found to be the most frequent available food items. Zooplankton groups were represented by the three subclass namely: Cladocerans (91.9%) Copepods (64.9%) and Rotifers (43.3%) (Table 2).

The water quality parameters measured during the study period were temperature, pH, DO (dissolved oxygen), ammonia, nitrate, nitrite, and Secchi depth visibility and are presented in Table 3. Most of the water quality parameters were optimal for Nile tilapia growth in which the average growth performance of the fish in terms of average final weight was 61.8g after three months of rearing. The average temperature, pH and, DO were 24.6±0.4°C, 8.3±0.2 and, 4.1±0.1mg/l respectively. While for ammonia ($NH_3$), nitrate and nitrite were 0.05±0.001mg/l, 0.12±0.01mg/l, and 0.15±0.03mg/l respectively. The different water quality parameters together with the availability of diverse plankton were optimal for the growth of Nile tilapia which resulted in 0.45 specific growth rate.

**Table 2**. Frequency of occurrence of the various food items found in the stomach content of 37 individuals of Nile tilapia sampled from the pond

| Food items | | Frequency of occurrence | |
|---|---|---|---|
| | | Number of fish that fed a specific algal group | Percentage |
| Phytoplankton | Blue green algae | 30 | 81.08 |
| | *Anabaena* | 28 | 75.67 |
| | *Aphanizomenon* | 16 | 43.24 |
| | *Microcystis* | 5 | 13.51 |
| | Green algae | 37 | 100 |
| | *Scenedesmus* | 37 | 100 |
| | *Pediastrum* | 27 | 72.97 |
| | *Cosmarium species* | 19 | 51.35 |
| | *Ankyra* | 17 | 45.94 |
| | *Actinostrum* | 14 | 37.83 |
| | *Zygnema* | 12 | 32.43 |
| | *Coelastrum* | 7 | 18.91 |
| | Diatoms | 33 | 89.18 |
| | *Navicula* | 22 | 86.48 |
| | *Cymbella* | 24 | 64.86 |
| | *Cyclotella* | 24 | 64.86 |
| | *Nitzschia* | 18 | 48.64 |
| | *Syndra* | 13 | 35.13 |
| | *Surirella* | 3 | 8.10 |
| | Dinophyceae | 6 | 16.21 |
| | *Peridium* | 6 | 16.21 |
| | Euglenophyceae | 16 | 43.24 |
| | *Euglena* | 14 | 37.83 |
| | *Phacus* | 5 | 13.51 |
| Zooplankton | | 37 | 100 |
| | Cladocerans | 34 | 91.89 |
| | Copepods | 24 | 64.86 |
| | Rotifers | 16 | 43.24 |

**Table 3.** Physicochemical values of the pond used for the experiment (Mean ±Standard error)

| Water quality parameters | Values |
|---|---|
| Temperature (°C) | 25.9±0.4 |
| PH | 8.3±0.2 |
| Dissolved oxygen (mg/l) | 4.1±0.1 |
| $NH_3$ (mg/l) | 0.05±0.001 |
| Nitrate (mg/l) | 0.12±0.01 |
| Nitrite (mg/l) | 0.15±0.03 |
| Secchi depth visibility (cm) | 34±2.0 |

## Discussion

The plankton community is a group of organisms that include phytoplankton and zooplankton. They are the most important food supply for extensive and semi-intensive pond based production systems and play a key role in pond productivity when the environmental conditions are suitable for their development (García *et al.,* 2012) particularly when the pond is well fertilized. In the present study, where the pond was fertilized with chicken manure, six different group of plankton group were identified, in which five of them were phytoplankton that consist high level of 20 genera, while the remaining one group was zooplankton that consist three subclasses. Among the phytoplankton genera, Scenedesmus was dominant due to its high efficiency of utilizing nutrients from chicken manure as also stated by Han *et al.* (2017). As the authors stated that nutrients extracted from chicken manure accelerate the growth of Scenedesmus as the algae has efficient utilization capacity of the available nitrogen and phosphorus in the manure for its high growth and biomass production. The reason for the occurrence of diverse phytoplankton groups could be due to the absence of large filter-feeding such as Daphnia (Sarma *et al.,* 2005; Abelneh Yimer *et al.,* 2015). On the other hand, the absence of large Daphnia could favor the diversity of rotifers. This is inconsistent with the work of Abelneh Yimer *et al.* (2015) who reported the percentage contribution of rotifers in pond waters was more than 70% of the total zooplankton groups. Furthermore, the high level of chlorophyll *a* (62.3±2.0 µg/l) found in pond fertilized with chicken manure, favored good growth of phytoplankton in fish ponds. The current chlorophyll *a* value is greater than the value reported by Abelneh Yimer *et al.* (2015) in which the values of chlorophyll *a* ranged from 18.2±2 to 23.4±3.9 µg/l. The reason for the difference in chlorophyll *a* may be due to the difference in phytoplankton population is pond systems, water quality parameters and/or seasonal variation. On the other hand, the chlorophyll *a* value recorded in the present experiment is in agreement with the works of Shoko *et al.* (2011) who reported that the level of chlorophyll *a* found in pond fertilized with animal manure is 59.2±9.54 µg/l. Furthermore, the chlorophyll *a* concentration found in the present study is within the recommended range by Boyd (1998), who reported that productive aquaculture ponds often have chlorophyll *a* concentration of 50-200 µg/l.

The frequency of occurrence revealed that the dominant food items eaten by fish were green algae (100%) followed by diatoms (89.2%) and blue-green algae (81.1%). The reason for the highest contribution of phytoplankton may be due to the presence of diverse phytoplankton groups available in the fish pond. However, the frequency of occurrence of Dinophyceae and Euglenophyceae was very low. This may be due to their rare occurrence in this fish pond. The dominant food items could be dependent on the abundance of the phytoplankton genera present in the pond. Similarly, from the zooplankton group, Cladocerans were dominant in the frequency of occurrence followed by copepods and rotifers. The reason for the higher volumetric contribution of Cladocerans may be due to their abundance in the fish pond. Similar results were reported by Garcia *et al.* (2012).

The mean values of some water quality parameters measured in a weekly basis remained within the acceptable range required for normal growth of aquatic organisms including fish. The results of the current study agree with the findings of Santhosh and Singh (2007) and Workagegn (2012) who reported a better growth rate of tilapia in a temperature ranging from 24°C to 32°C. The pH value of the present study was also in agreement with the desired range of pH (6.5-9.5) for pond production system reported by FAO (2011) and Megersa Endebu *et al.* (2016). The mean dissolved oxygen value of the present study also corresponds with the results reported by Shoko *et al.* (2011), who reported a dissolved oxygen value in a range of 3.9-7.0mg/l. The reason for the lower dissolved oxygen value in this study (4.1mg/l) may be due to the decomposition of chicken manure used and feed remains, which leads to the depletion of dissolved oxygen within the fish pond. The amount of total nitrogen (ammonia, nitrite and nitrate) is dependent on the amount of manure used, the protein content of the feed, and the rate of feeding. According to Santhosh and Singh (2007), a Secchi depth visibility of 15 to 80 cm is good for fish health in aquaculture in which the value reported in the present study was with in this rang. The average Secchi depth value (34cm) recorded is lower than the average Secchi depth values reported by Oben *et al.* (2015) who reported that Secchi depth values from 46cm to 50.2cm is good for pond based fish production. The reason for the difference in Secchi depth may be due to the difference in plankton abundances.

## Conclusion

In the current study green algae, diatoms, and blue-green algae were the dominant food items of the fish in the integrated aquaculture system. Similarly, these algae were the dominant algal groups found in the pond. Particularly, Scenedesmus was the most abundant phytoplankton found both in the pond and in the stomach content of the fish. On the other hand, Dinophyceae and Euglenophyceae were found in a limited amount of the pond water. In general blue-green algae, green algae, and diatoms from phytoplankton and Copepods from zooplankton groups were the dominant and potential live food for the fish.

## Ethical Statement

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## Funding Information

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## Author Contribution

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## Conflict of Interest

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