JIMMA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
DEPARTMENT OF BIOLOGY

MSc Program in Aquaculture and Fisheries Management

Effect of Cow Dung and Poultry Manure on Pond Productivity, Water Quality, and Growth Performance of Nile Tilapia (*Oreochromis Niloticus* L.1758) in Earthen Ponds 0930573685

By: Efe Abebe Sori (BSc)
Advisor: Tokuma Negisho (Ph.D.)
Co-advisor: Mulugeta Wakjira (Ph.D.)

A Thesis Submitted to Department of Biology, College of Natural Sciences, Jimma University, in Partial Fulfillment of the Requirements for the Degree of Master of Science in Biology (Aquaculture & Fisheries Management).

August 2022
Jimma, Ethiopia

Approval Sheet

I hereby certify that I have read and evaluated this Thesis entitled "**Effect of Cattle Dung and Poultry Manure on Pond Productivity, Water Quality, and Growth Performance of Nile Tilapia (*Oreochromis Nniloticus*, L.1758) in Earthen Ponds"** prepared under my guidance by Efe Abebe Sori. I recommend that it can be submitted as fulfilling the thesis requirement.

Major Advisor	Signature	Date
Co-Advisor	Signature	Date

As a member of the board of examiners of the MSc open Thesis defense examination, I certify that I have read and evaluated the Thesis prepared by *Efe Abebe Sori* and examined the candidate. I recommend that the thesis be accepted as fulfilling the Thesis requirement for the degree of Masters of Science in Aquaculture and Fisheries Management.

Chairperson	Signature	Date
Internal Examiner	Signature	Date
External Examiner	Signature	Date

Final approval and acceptance of the thesis is contingent upon the submission of its final copy to the Council of Graduate Studies through the candidate's department or school graduate committee

Acknowledgments

Primarily, Glory is to the Sovereign, the Almighty God, who is the source of all Wisdom, Knowledge, Understanding, and Power. I thank the Almighty, God every day for giving me the strength to pursue and complete this degree.

I would like to express my deepest gratitude to Jimma University, College of Natural Sciences, Department of Biology, for financial sponsorship and for allowing me to enroll in the postgraduate study program.

I would like to convey my heartfelt thanks, appreciation, and acknowledgment to my advisors Dr. Tokuma Negisho and Dr. Mulugeta Wakjira for their guidance, consistent advice, invaluable constructive comments, and timely feedback in the course of this thesis preparation, starting from proposal development up to the completion of thesis write-up. Their critical and constructive comments in designing the research, feedback on proposal development, and close supervision in the write-up of the final thesis enormously facilitated the smooth completion of this study. My respect and admiration for them cannot be adequately expressed in words. My deepest gratitude also goes to Mr. Sagni Gobana for his support spatially during data analysis.

Also I thank my classmate students Abate Meleku and Omod Ochalla for their support especially during poultry manure collection, drying, and fish data collection.

My unique personal appreciation and heartfelt thanks go to my brother Seboke Abebe, My husband Birahanu Negesh and all my family for their moral support, love, and encouragement during my study.

Finally, I wish to thank all my friends, those who helped me in one way or another throughout the study period. Many persons have guided, encouraged, supported, and inspired me in this endeavor. I am truly wishing you all the best in your life. Thank you!

Table of Contents

List of Tables

List of Figures

Abbreviations and Acronyms

ANOVA	Analysis of Variance
CD	Cow Dung
DGR	Daily Growth Rates
DO	Dissolved Oxygen
EC	Electrical Conductivity
FAO	Food and Agriculture Organization
PM	Poultry Manure
RGR	Relative Growth Rate
SGR	Specific Growth Rate
SR	Survival Rate
TDS	Total Dissolved Solid
TL	Total Length
WG	Weight Gain

Abstract

Aquaculture is the fastest-growing food-producing sector and is perceived to have the greatest potential to meet the growing demand for aquatic food. The major bottlenecks of aquaculture are fish feeds, fish seeds, environmental pollution, and competition of land with other farming activities. This study was conducted for 120 days to evaluate the effect of cow dung and poultry manure on the growth performance of Nile tilapia (*O. Niloticus)*, pond productivity, and water quality. The experiment was carried out in six ponds grouped into two treatments, cow dung (T1) poultry manure (T2), and controls each in duplicates. Fish weighing 7.31 ± 0.145 g and length 6.4± 0.12 cm were stocked into six pond of $20m^2$ surface area each at 2 fish m^2 (40 fish per ponds). Nile tilapia in the poultry manure treatment showed significantly higher weight gain than those in the cow dung and control. Also the highest final mean weight (40.35±7.58 g), length (14.63±0.89), weight gain (WG) (33.15±7.9 g) and relative growth rate (RGR) (487.127±177. 08 g) were recorded in the treatment T2 while the least growth values were recorded in the control. One-way ANOVA was used to test the differences in mean body weight, length, weight gain, absolute growth rate, and relative growth rate of fish in pond experiments. The survival rates were not significantly different across the treatments. Generally, T2 (PM) showed significantly higher fish growth performance in case of FMW, WG, DGR and RGR than T1 (CD) in the control group ($P < 0.05$). Additionally, there was a significant difference in Electric conductivity (EC), Total dissolved solids (TDS), and Salinity between T1, T2, and control ($P < 0.05$), while DO and pH was a significant difference only between the treatment group and control, but not significant between T1 & T2. Moreover, there was no significant variation in ammonia and nitrite concentrations within the treatment and control. A higher number of phytoplankton and zooplankton were recorded in poultry manure followed by cow dung while less number of plankton was recorded in control. However, the variation was not statistically significant among the treatment. It can be concluded that locally available organic manure like cow dung and poultry manure is suitable for fish growth and pond productivity. Especially, poultry manure was preferable to cow dung as understood from the present finding.

Keywords: Pond fertilization, cow dung, poultry manure, Nile tilapia, water quality.

1. INTRODUCTION

1.1. Background

Aquaculture is the fastest-growing food-producing sector and is perceived to have the greatest potential to meet the growing demand for aquatic food (Kumari *et al.*, 2017). According to the FAO (2013) aquaculture is understood to mean the farming of aquatic organisms including fish, mollusks, crustaceans, and aquatic plants. Aquaculture can be conducted in completely artificial facilities built on lands such as in the case of fish tanks, ponds, aquaponics, or raceways, where the living conditions rely on human control such as water quality (oxygen), feed, and temperature.

Aquaculture is developing, expanding, and intensifying in almost all regions of the world (FAO, 2009). However, Aquaculture development in most African countries is primarily focused on socio-economic objectives such as nutrition improvement in rural areas, income generation, diversification of integrated farming, and creation of employment, especially in rural communities (Gabriel *et al.*, 2007). Fish appears as a cheap source of protein and an important international trade commodity in many regions and across the global market. It has contributed to the economic growth of various countries around the world (Anetekhai *et al.*, 2018). For centuries fish farmers have increased fish products by fertilizing their fishponds using inorganic fertilizers. However, because the cost of inorganic fertilizers is high, particularly in developing countries there has been a shift to utilize organic fertilizers (Das & Jana, 1996).

Organic fertilizer is also called organic manure. Mostly, it refers to compost made from animal waste and plant residues that are rich in natural by-products. It is less expensive than chemical fertilizers. Animal manure has a long history of use as a source of soluble phosphorus, nitrogen, and carbon for algal growth and natural food production. Animal manure is often used in earthen ponds to improve primary production and fish growth (Kang'ombe *et al.*, 2006; Terziyski *et al.*, 2007). Organic fertilizer has been used to stimulate the development of heterotrophs (bacteria), autotrophs (algae), and other food organisms to increase fish production in ponds (Qin *et al.*, 1995). It can also increase bacterial and algal production by providing a source of organic and inorganic nutrients.

The application of organic manure in nurseries and rearing ponds can play a vital role to ensure the production of planktonic feed for fingerlings. Organic manure has been widely used in tilapia ponds, especially in Asia, Central America, and Africa (Abdelghany & Ahmad, 2002). Production of cultivated fish can be increased by introducing organic fertilizers of different origins in fish ponds to increase primary productivity (Javed *et al.*, 1992; Knud-Hansen *et al.*, 1991). As the organic fertilizer decomposes it provides forage for bacteria and fungi, which are directly utilized by zooplanktons. In water with low alkalinities, manure decomposition may also provide algae with an important source of dissolved inorganic carbon (DIC) through decomposition and release of carbon dioxide (Knud-Hansen *et al.*, 1993).

A wide variety of organic manures, including poultry manure, cattle dung, Rumen liquor, pig dung, Goat, Sheep, Horses, and composted agricultural byproducts, are currently in use in fish pond fertilization (Endebu *et al.*, 2016). Among these cow dung and poultry manures are the most commonly used organic manures in pond culture due to high content of phosphorus and nitrogen concentrations which plays a vital role in primary production and promotion of fish growth (Pratapn *et al.*, 2005; Reyes *et al.*, 2019). The various types of manure have been found to influence the natural productivity of the pond differently in terms of abundance and prevalence of phytoplankton and zooplankton as well as the benthic materials found in ponds. As reported by Kang'ombe *et al.* (2006) poultry manure triggers more production of phytoplankton in ponds than any organic fertilizers including chemical fertilizers.

However, there is no enough knowledge and information about the impact of animal manure as a fertilizer or direct or indirect fish feed in our country. Therefore, the current study was carried out to evaluate the effect of organic animal manures (poultry manure & cow dung) on pond productivity, the performance of Nile Tilapia, and water quality parameters.

1.2. Statement of the Problem

Fish nutrition is one of the major inputs in effective aquaculture production (Kumar *et al.*, 2005). It is the fundamental challenge facing the development and growth of aquaculture in developing countries. Aquaculture development in Ethiopia has been among the less attended sector of the economy for a longer time mainly with a deficiency of ample fish feed resources. Even though few farmers are starting an aquaculture farm in Ethiopia, their fish feeding is a bottleneck.

Commercially formulated fish feeds are very costly. Therefore, it is necessary to look for appropriate fish feeds which are least cost, among the locally available waste sources for better fish production. The recycling of animal manure/ wastes in fish ponds for natural fish production is important for sustainable aquaculture and to reduce expenditure on costly feeds and fertilizers which form more than 50% of the total input cost (Deka *et al.*, 2018). The use of animal manure as a source of proteins and other essential mineral supplements solves the problem of feedstuff since it is affordable to smallholder farmers.

However, the main problems associated with manures have been found to influence the natural productivity differently in terms of abundance and prevalence of plankton as well as the benthic organisms in ponds (Kang'ombe *et al.*, 2006). Phytoplankton and other aquatic plants are limited to most commonly by inadequate nitrogen and phosphorus supply (Gangadhar *et al.*, 2017). The different nutrient concentrations of animal manure significantly affect some water quality parameters (Rapatsa & Moyo, 2013). A fish pond with good water quality and low nutrient content results in low fish yields, while a pond with high nutrient content but poor water quality may result in the production of contaminated fish (Rapatsa & Moyo, 2013). The fish growth rate is a function of the summation of parameters either separately or in the collection being affected by fertilizers, Physico-chemical, and phytoplankton conditions in water (Garg & Bhatnagar, 1996). Cow dung and poultry manures are the most commonly used organic manures in pond culture due to the high content of phosphorus and nitrogen concentrations (Pratapn *et al.*, 2005; Reyes *et al.*, 2019) . Moreover, Mischke (2012) reported that fertilizer recommendations varies widely depending on the region and species cultured. However, there is a limited literature and scientific information in Ethiopia on pond productivity, Nile tilapia growth performance and water quality of pond fertilized by organic manures. This study was, therefore, intended to evaluate the effect of animal manures (cow dung & poultry manure) on pond productivity water quality, and growth performance of Nile tilapia (*Oreochromis Niloticus*) in earthen pond.

1.3. Objectives of the Study

1.3.1. General Objective

- To evaluate the effect of animal manures on pond productivity, water quality and growth performance of Nile Tilapia (*Oreochromis niloticus).*

1.3.2. Specific Objectives

- To assess plankton diversity and abundance in ponds fertilized with organic manure (Poultry manure and cow dung).
- To evaluate the dynamics of basic water quality parameters like temperature, pH, dissolved oxygen, electrical conductivity, NH3 concentration, and Salinity in the experimental ponds.
- To evaluate growth performance, survival, and of Nile tilapia in the ponds fertilized with Poultry manure and cow dung.

1.4. Significance of the Study

The finding of the proposed study will contribute to the knowledge of the local community on the use of animal manures to increase Nile tilapia production in aquaculture. Certainly, this study outcome will provide information about the effect of animal manure on pond productivity, performance, and survival rate of Nile tilapia, considered a fish of great promise for fish farming in Ethiopia because of its resistance to disease, poor water quality, and easily reproduce in ponds. Furthermore, the result of this study will play a vital role in providing baseline scientific information on the use of organic manures as a fish pond fertilizer and as direct or indirect fish feed.

2. LITERATURE REVIEW

2.1. Overall History of Aquaculture

An aquaculture is a form of agriculture that involves the propagation, cultivation, and marketing of aquatic animals and plants in a controlled environment. Aquaculture contributed 43 percent of aquatic animal food for human consumption in 2007 excluding mammals, reptiles, and aquatic plants, and is expected to grow further to meet the future demand (Bostock *et al.*, 2010). Aquaculture has been started as primarily an Asian freshwater food production system and has now spread to all continents, encompassing all aquatic environments and using a range of aquatic species (Subasinghe *et al.*, 2009)**.**

World aquaculture has grown dramatically in the last 50 years. From the production of fewer than 1 million tons in early 1950, production in 2006 was reported to have risen to 51.7 million tons, with a value of US $78.8 billion. This show that aquaculture continues to grow more rapidly than other animal food-producing sectors (FAO, 2009). As stated by Subasinghe (2017), still Aquaculture is the fastest-growing food-producing sector in the world and it is expected to bridge the future global supply-demand gap for aquatic food.

World aquaculture is heavily dominated by the Asia–Pacific region, which accounts for 89 percent of production in terms of quantity and 77 percent in terms of value. This dominance is mainly due to China’s enormous production, which accounts for 67 percent of global production in terms of quantity and 49 percent of global value (FAO, 2009). Although aquaculture seems to be increasing at a high rate, it is still unable to supply the needed quantity. As suggested by Sadiku and Jauncey (1995) proper planning, development and management could be the solution to increasing primary, intermediate and terminal productivity capacities of our natural aquatic ecosystem and creation of productive artificial aquatic ecosystems.

2.2. Aquaculture in Africa

The modern concept of aquaculture was introduced from Europe into Africa during the colonial periods. Aquaculture in Africa has come a long way since it was first introduced. However, in comparison to the rest of the world, aquaculture production in Africa is still an infant at the global level and accounts for about 0.9 percent (404 571 t) of the total global aquaculture production in 2000 (FAO 2003). For total world aquaculture in 2003 amounted to some 54 786 000 tones, Africa as a whole contributed 531 000 tones (0.97 percent). The sub-Saharan Africa contribution of 72 334 tones to the African total in 2003 was a mere 13.6 percent or 0.13 percent of the world total (Hecht, 2006)

Aquaculture production in Africa over the period 1970–2008 has been steadily increasing at an annual average growth rate of 12.6% each year. Between 2006 and 2010, the African aquaculture production growth rate jumped to 18.6 per annum. In 2010 Africa produces 1,301,432 tons representing 2.3% of total global aquaculture production while Asia produces 50,793,600 tons representing 88.8% of total global aquaculture production (FAO, 2011). Egypt, which produces 64% of total farmed fish in Africa, leads the continent in aquaculture production followed by Nigeria (15.4%) and Uganda (7.2%) FAO (2011).

2.3. Aquaculture in Ethiopia

The history of aquaculture development in Ethiopia dates back to 1955 when ponds were constructed around Bishoftu and Akaki, both located closer to the Capital Addis Ababa, for growth observation (Wakjira *et al.*, 2013). Aquaculture practice officially started in Ethiopia after the establishment of the former Sebeta Fish Culture Station (the current National Fishery and Aquatic Life Research Center) in 1977 by the Ministry of Agriculture through financial support obtained from the Government of Japan.

There are so many challenges faced by aquaculture development in Ethiopia which include mainly; a lack of cheap and efficient locally available fish feeds, and a lack of locally selected and certified fish seeds. Likewise, the problem of land ownership policies in the country, over-reliance on capture fisheries, not successful integration of aquaculture with other farming activities, shortage of small-scale low-cost aquaculture support for rural development, lack of licensed fish seed multiplication centers, and lack of institutional capacity in the area of training, research, and technology transfer also challenging conditions for aquaculture development in Ethiopia (Kebede *et al.*, 2017; Natea *et al.*, 2017; Tilahun *et al.*, 2016)

Most of the Ethiopian freshwater capture fisheries come from the lakes, and its aquaculture sector is virtually undeveloped (Gindaba *et al.*, 2017). Among Candidate species for aquaculture development in Ethiopia include Nile tilapia *(Oreochromis niloticus*) and the African catfish (*Clarias gariepinus*) (Gindaba *et al.*, 2017; Wakjira *et al.*, 2013). They are relatively resistant to poor water quality and disease and easily reproduce in ponds.

2.4. Nile Tilapia (*Oreochromis Niloticus*)

Nile tilapia (*Oreochromis niloticus*) is cultured worldwide, mostly in semi-intensive culture systems. Tilapia is the common name applied to three genera of fish in the family Cichlidae: Oreochromis, Sarotherodon, and Tilapia. The species that are most important for aquaculture are in the genus Oreochromis Since the commercially cultured Oreochromis species attain better growth rates and bigger sizes than their counterpart Tilapia species (Al-Amoudi, 1987). Tilapias possess an impressive range of attributes that make them ideal for aquaculture. They have good-tasting flesh with a mild flavor, are widely accepted as food fish, are used in many cuisines, and their consumption is not restricted by religious observances. Several color variants meet the preferences of different consumers. From the standpoint of reproduction, they breed freely in captivity without the need for hormonal induction of spawning.

Tilapias used in aquaculture are mouth brooders and provide a high level of parental care; eggs are large, producing large fry at hatching that is hardy and omnivorous at first feeding. All of these factors result in a simple hatchery technology. They reach sexual maturity in less than 6 months, which is advantageous for selective breeding. Nile tilapia are tolerant of a wide range of environmental conditions including low dissolved oxygen levels (1 ppm); high ammonia levels (2.4 to 3.4 mg/L unionized), and will grow in water ranging from acidic (pH 5) to alkaline (pH 11) (Chervinski, 1982a).

A fundamental advantage of tilapia for aquaculture is that they feed on a low trophic level. Members of the genus *Oreochromis* are all omnivores, feeding on algae, aquatic plants, small invertebrates, detritus, and associated bacterial films, as well as a variety of feeds of animal origin. This makes them relatively inexpensive to feed and suitable for rearing under extensive or semi-intensive conditions that depend on the natural productivity of a water body, with minimal inputs of feed or fertilizer, or under intensive conditions that can be operated with lower-cost feeds. As omnivores, tilapia can grow rapidly on lower protein levels and tolerate higher carbohydrates than many carnivorous species cultured (Watanabe *et al.*, 2002).

Importance of Culturing Nile tilapia in ponds including easy breeding, fast growth, tolerability to adverse environmental conditions, good taste, and market price (Gustafsson *et al.*, 2013). High tolerance to low water quality, efficient food conversion, disease resistance, and good consumer acceptance make tilapia a suitable fish for culture (El-Saidy & Gaber, 2005; Peña-Mendoza *et al.*, 2005).

2.5. Food and Feeding Habits of Nile Tilapia in Pond Culture

Nile tilapia has a versatile feeding behavior, characterized by generalist and opportunistic omnivorous feeding behavior. Its diet composition may vary within a wide range of seasonal and spatial conditions of the environments (Tesfahun & Temesgen, 2018). The culture of this species is advantageous for the reason that it feeds on low tropic levels. However, their feeding rates depend on factors such as natural food availability, size, species, digestible energy/protein (DE/P), and water quality and are inversely related to the size of the fish (Sargent *et al.*, 2002). Its Juvenile preferentially feeds on zooplankton, but as they grow larger they increasingly filter feed or suction-feed mainly on phytoplankton.

Nile tilapia ingests a wide variety of natural food organisms including plankton, some aquatic macrophytes, planktonic and benthic aquatic invertebrates, larval fish, detritus, bacterial films, and decomposing organic matter (Beveridge & Baird, 2000; Engdaw *et al.*, 2013; Wakjira *et al.*, 2013). Feed intake in Nile tilapias through filter feeders or surface grazing, because they can efficiently harvest plankton from the water.

2.6. Plankton

The word “plankton” comes from the Greek for “drifter” or “wanderer.” An organism is considered plankton if it is carried by tides and currents, and cannot swim well enough to move against these forces. Some plankton drifts this way for their entire life cycle. Others are only classified as plankton when they are young, but they eventually grow large enough to swim against the currents. Planktons are usually microscopic, often less than one inch in length, but they also include larger species like some crustaceans and jellyfish. Plankton community is a heterogeneous group of tiny drifting plants (phytoplankton) and animals (zooplankton) adapted to suspension in the sea and fresh water.

2.6.1. Phytoplankton

Phytoplankton represents the microscopic algal communities of water bodies and the pioneer of the aquatic food chain. The predominant forms of phytoplankton are diatoms, golden-brown algae, green algae, blue-green algae, and dinoflagellates. The productivity of an aquatic system is directly related to the diversity of phytoplankton. Phytoplanktons are important microorganisms that serve as primary producers in aquatic ecosystems (Anetekhai *et al.*, 2018; Cunha *et al.*, 2019). They are a source of food for zooplankton, fishes, and other aquatic organisms. The diversity of phytoplankton responds rapidly to changes in the aquatic environment, particularly in relation to silica and other nutrients (Ansari *et al.*, 2015). The diversity and density of phytoplankton indicate the richness of an aquatic ecosystem (Najmus & Bari, 2019). In fertilized ponds phytoplankton increase is due to the intensity and type, as productivity increases with careful management, with continuous and controlled addition of organic fertilizers to produce autotrophic organisms (Ponce *et al.*, 2010).

An increase in nutrient content provides favorable conditions for phytoplankton production. Phytoplankton productivity, biomass, and species composition seasonally change in response to variations in the light environment and nutrient availability (Asiyo, 2003). Phytoplankton as well as microorganisms responsible for the mineralization of organic matter serves as a food source for zooplankton. Moreover, it increases the biomass of zooplankton and benthic organisms which are important as natural fish food. In organically manured ponds, the organic matter is degraded by aerobic bacteria into carbon dioxide and ammonia. Algae will utilize carbon dioxide. During photosynthesis, the algae will produce oxygen which will sustain fish, zooplankton, and phytoplankton. Algae represent a major food source for fish in ponds (Rapatsa & Moyo, 2013).

Phytoplanktons, an integral component of aquatic food webs are grazed by zooplankton and constitute an important link in energy flow**.** Variation in phytoplankton community composition depends on the availability of nutrients, temperature, light intensity, and other limnological factors and it forms the basic link in the food chain of an aquatic ecosystem and virtually all the dynamic features of lakes such as color, clarity, trophic state, zooplankton, and fish production depend to a large extent on the phytoplankton. Phytoplankton is an important indicator of the ecological status of a water body and their composition and dynamics play an important role in biodiversity and energy flow in Lake Ecosystem. The quality and quantity of phytoplankton and their seasonal successional patterns have been successfully utilized to assess the quality of water (Mili *et al.*, 2017).

2.6.2. Zooplankton

The term zooplankton is derived from the Greek words zoo, meaning animals, and plankton, meaning wanderers. The members of zooplankton include the marine and freshwater planktonic community that drifts according to the water currents. It plays an important and probably the most significant role in aquatic productivity, determining the future commercial fishery of an area. They form a vital link in any aquatic food web as primary consumers or secondary producers (Deivanai *et al.*, 2004). Zooplankton occupies an intermediate position in the food web and they mediate the transfer of energy from lower to a freshwater ecosystem (Manickam *et al.*, 2015).

Freshwater zooplankton is dominated by protozoans, rotifers, and three subclasses of Crustacean, i.e. Cladocera, Copepoda, and Ostracoda. The planktonic Protozoa have limited locomotion, but the rotifers, Cladocera, and Copepoda micro crustaceans and certain immature insect larvae often move extensively in quiescent water. Much of the wild zooplanktons are an important source of live food organisms and they can play a vital role in the hatchery production of seeds. The live food provides highly essential nutrition to achieve good growth and survival rates of commercially important finfish, particularly for Nile tilapia (Bhavan *et al.*, 2015). The Zooplankton community is cosmopolitan in nature and they inhabit all freshwater habitats of the world. Zooplankton diversity is one of the most important ecological parameters in water quality and biodiversity assessment because they are strongly affected by environmental conditions and respond quickly to changes in water quality. Zooplankton is the intermediate link between phytoplankton and fish. The qualitative and quantitative study of zooplankton is very important in plankton diversity (Najmus & Bari, 2019; Sala *et al.*, 2000).

2.7. Pond Fertilization

Artificial culture media or ponds are small bodies of freshwater either natural or artificially made and have a depth range of 0.5-10 m) (Adigun, 2005). It is highly productive because of its characteristic slow movement; which enhances the stability of water nutrients. Pond fertilization is a common practice in aquaculture aimed at increasing the production of natural food for farmed fishes, while Fertilizers are substances that help to accelerate the productivity of a medium (Adigun, 2005). It provides nutrients to microscopic plants (algae) which in turn enhance the accelerated growth of zooplankton. Pond fertilization practices using animal wastes are widely used in many countries to sustain productivity at low costs since soluble organic matter supplied to ponds by using manure stimulates phytoplankton growth (Hassanien *et al.*, 2010).

Fertilization of aquaculture ponds increases the productivity of phytoplankton which is the food base of zooplankton and benthic animals. As observed from various experiments, a fertilized pond can have fish yields three or four times of unfertilized ponds (Adedeji *et al.*, 2011). Plankton remains of plankton (detritus) benthos are food for fish and crustaceans (Mischke, 2012). Fertilization of aquaculture ponds is analogous to fertilization of pastures to increase forage for livestock since Fertilizers used in aquaculture are the same ones used in traditional agriculture. The application of livestock manures to increase crop production began in western Asia and spread to Europe in the 6th millennium BC (Bogaard *et al.*, 2013). Early Roman and Grecian writers mentioned livestock manures, wood ashes, mud, and legumes as fertilizers Boyd (2018).

Fertilization of ponds using either inorganic fertilizers, organic fertilizers or both is a management practice that enhances biological productivity. It enables fish farmers to increase fish yield by ensuring natural food in the pond ecosystem. However, because the cost of inorganic fertilizers is high, particularly in developing countries there has been a shift to utilize organic manure (Das & Jana, 1996). However, organic manures become the best choice of fertilizer if they are managed properly in pond fertilization. Among organic fertilizers, poultry manure is considered the best fertilizer in pond fertilization because its content is a combination of both urine and feces which releases a high amount of nitrogen (Knud-Hansen *et al.*, 1993). It is also considered a complete fertilizer because it has both the qualities of organic and inorganic fertilizers (Kusi, 2017). The purpose of pond fertilization is to augment(increase) fish production through autotrophic and heterotrophic pathways (Reyes *et al.*, 2019).

2.7.1. Poultry Manure

Chicken manure is the feces of chickens used as an organic fertilizer, especially for soil low in nitrogen. The utilization of poultry manure as an organic fertilizer is essential in improving soil productivity. It adds organic matter and increases the water holding capacity and beneficial biota in soil. Organic wastes contain different amounts of water, mineral nutrients, and organic matter (Dikinya & Mufwanzala, 2010). Among manure used, poultry manure is preferred because of its high concentration of macro-nutrients, ready solubility, and high level of phosphorus and nitrogen concentrations which play a vital role in primary production and promoting fish growth with high profit (Khan *et al.*, 2001; Okwor *et al.*, 2012; Reyes *et al.*, 2019). Chicken manure has always been used in phytoplankton and zooplankton production. According to (Oparaku, 2013) reported that Fertilizing the pond with raw poultry manure will enhance the production of natural food organisms such as microbes, Phytoplankton, and zooplanktons which would serve as food for the fingerlings. These natural foods contain an excess of protein, which is a limiting and costly nutrient in supplementary feeding.

2.7.2. Cattle Manure

Cattle manure can be defined as the undigested residue of consumed food material being excreted by herbivorous bovine animal species. It is commonly used as a fertilizer for fish ponds. C**a**ttle manure is a valuable source of key nutrients including nitrogen (N), phosphorus (P), potassium (K) sulfur (S) magnesium (Mg), and calcium (Ca) as well as certain micronutrients. Fertilizing the ponds with cow dung is so far the most useful technique to make up or provide the essential needed nutrients to enhance the natural productivity through the production of aquatic biota, which serves either directly or indirectly as the food of fishes (Knud-Hansen *et al.*, 1998).

2.8. Water Quality Monitoring in Nile Tilapia Pond

Water is the physical support in which aquatic organisms carry out their life functions such as feeding, breeding, digestion, and excretion. The monitoring of physicochemical characteristics of a water body is vital for both short and long-term analysis, because the quality, distribution, and productivity level of organisms in a water body are largely governed by its physicochemical and biological factors (Ashton & Schoeman, 1983). Water quality in fish ponds is often due to the interactions of several physicochemical components and can have profound effects on pond productivity, the level of health, and fish health (Anetekhai *et al.*, 2018). As said by (Krishnan *et al.*, 1999), the maintenance of a healthy aquatic ecosystem depends on the physicochemical and biological diversity of the ecosystem.

Physico-chemical parameters affect plankton distribution, occurrence, and species diversity (Raymond, 1983). So it is necessary to understand the major water quality parameters and their interrelationships, which affect fish growth, and health, and determine the failure or success of overall cultural practices. Therefore, successful management of fish ponds requires an understanding of water quality, which is determined by biotic factors such as temperature, dissolved oxygen (DO), transparency, turbidity, water color, carbon dioxide, pH, alkalinity, Water hardness, unionized ammonia, nitrite, nitrate (Bhatnagar & Devi, 2013; El-Sayed, 2006). Many of these elements have a direct impact on nutrient concentration in the pond environment during initial production. These factors are required to be optimized to increase animal stock density where phytoplankton quality and quantity play a vital role (Saeiam *et al.*, 2020). Good water quality is characterized by adequate oxygen, proper temperature, transparency, limited levels of metabolites, and other environmental factors affecting fish culture.

2.8.1. Salinity

The term salinity refers to the total concentration of all dissolved ions in natural water expressed in milligrams per liter. The osmotic pressure of solutions increases with increasing salinity. Fish species differ in their osmotic pressure requirements, so the optimum salinity for fish culture differs to some extent with species. Salinity is a major driving factor that affects the density and growth of the aquatic organism population (Bhatnagar & Devi, 2013). The first candidate for aquaculture in brackish water is tilapia. Salinity tolerance (‰) of Nile tilapia (*O. niloticus*) is Upper limit of 36 ‰ and lower limit of 5 ‰ and an optimal 5–10, 15 ‰) (Al-Amoudi, 1987).

2.8.3. Dissolved Oxygen

Dissolved Oxygen is the amount of gaseous oxygen (O2) dissolved in the water. It is probably the most critical water quality variable in fish culture, so the fish farmer should be familiar with the dynamics of dissolved oxygen concentrations in ponds (C. E. Boyd, 1982). The ambient DO range produces the best fish performance, while low DO levels limit the respiration, growth, and other metabolic activities of fish (Tsadik & Kutty, 1987). Dissolved Oxygen fluctuation is affected by photosynthesis, respiration, and diel fluctuation. When water contains a dissolved oxygen concentration equal to the solubility of oxygen in water at the existing temperature, the water is said to be saturated with dissolved oxygen while water contains more dissolved oxygen than it should for the particular temperature, it is supersaturated.

Water may also contain less dissolved oxygen than saturation. Nile tilapias are known to withstand very low levels of DO. Most tilapias can tolerate DO levels as low as 0.1–0.5 mg/l for varying periods of time (Tsadik & Kutty, 1987). They can even survive at zero DO concentration; if they are allowed access to surface air, but tilapia usually suffer from high mortality if they fail to reach surface air. On the other hand, tilapia can tolerate conditions of high oxygen super-saturation (up to 400%), which usually occurs because of high photosynthesis resulting from phytoplankton and macrophytes blooming (Morgan, 1972).

2.8.4. PH

The pH is a measure of the hydrogen ion concentration and indicates whether the water is acidic or basic in reaction. The pH level in freshwater species rearing ponds ranges between pH 6.5 -pH 8.5. Nile tilapia can tolerate a wide range of pH from 3.7 to 11, but Nile tilapia show the best growth in water that is close to neutral or slightly alkaline water (Webster & Lim, 2006).

2.8.5. Ammonia

Ammonia is an inorganic compound composed of a single nitrogen atom covalently bonded to three hydrogen atoms and is an amidase inhibitor and neurotoxin. Most of the nitrogenous wastes of fish are excreted via gills in the form of ammonia. Excreted ammonia exists in un-ionized NH_3form (UIA-N), which is toxic to fish, and ionized NH^{4+}, which is nontoxic (Chervinski, 1982b). The toxicity of ammonia depends on DO, CO2, and pH. The toxicity increases with decreasing DO and decreases with increasing carbon.

2.8.6. Electric Conductivity

Electrical conductivity (EC) is a measure of how well a solution conducts electricity and is correlated with salt content. Freshwater fish generally thrive over a wide range of electrical conductivity. Some minimum salt content is desirable to help fish maintain their osmotic balance. The upper range varies with fish species. Seawater has a conductivity of around 50,000 to 60,000 µS/cm. Electrical conductivity (EC) also can be used to give a rough estimate of the total amount of dissolved solids (TDS) in water.

3. MATERIALS AND METHODS

3.1. Description of Study Area

The pond experiment was conducted at Aquaculture experiment site, Department of Biology College of Natural Sciences, Jimma University, which is located in the southwestern part of Ethiopia at about 345 km away from Addis Ababa. The locality is found at an elevation of 1753 meters above sea level and at a latitude of 7°40´N and longitude 36°50´E. Jimma town receives an average annual rainfall of 1,559 mm with maximum and minimum temperatures of 26.8 and 13.6 0C, respectively according to 2017 report from Jimma metrological station (Lemma *et al.*, 2020).

3.2. Experimental Design

A total of six experimental earth ponds each with an area of 20 m^2 were used to carry out the experiments. The experiment was conducted for a period of 120 days with one control (without any manure) and two treatments in duplicates as in (Table 1)

Table 1: Different organic manure used in experimental pond

Treatments	Type of organic fertilizer	Replica
T1	Cow dung (CD)	Two times
T2	Poultry manure (PM)	Two times
Control	No manure applied (C)	Two times

Before stocking the ponds with the experimental fingerlings, all ponds were cleaned and dried. Initially, all ponds were fertilized with an equal amount of cow dung by hanging a sack at the inlet of the pond and leaving it for two weeks to allow the natural plankton growth (Figure 1). All ponds were then filled with water to an average depth of 0.5 m using tap water.

Figure1: Pond cleaning, drying, and pond fertilization before fish stock

3.3. Preparation of Manure

Locally available organic manure such as fresh cow dung was collected from the dairy farm found in Jimma University Agricultural Campus and dried to sunlight, grinded, and processed for experiment while fresh poultry manure was collected from poultry farm of individual person found in Jimma town Dipo Kebele and processed through drying to sunlight and grinding as seen in (Figure 2).

Figure 2: Preparation of locally available organic manure for experiment

3.4. Source of Experimental Fish and fish stocking

The source of brooder of Nile tilapia for this experiment was from Chamo strain and cultured in earth pond found in Jimma University aquaculture site. Fingerlings of those brooders were used for present experiment. All fingerling of Nile tilapia used were the same batch. Then fish fingerlings with average weight (7.31±0.145 g) and length (6.4±0.122 cm) were selected and stocked randomly into each pond. A total of 40 fish (2 fish /m^2) were stocked in each pond.

3.5. Manure Application and Frequency

For the treatments, manure applications were done directly above the surface of pond water every week. The first treatment (T1), Cow dung, was applied at a rate of 100g/m^2 per week while the second treatment (T2), Poultry manure, was applied at a rate of 50g/m^2 per week based on a previous study (Kang'ombe *et al.*, 2006). During the experimental period, no supplementary feed was given to the fish.

3.6. Identification and Quantification of Plankton

Plankton sampling was conducted by taking water sample from pond using plankton net and transferred to falcultube every two weeks for identification and quantification following standard procedures. One drop (1ml) of water sample was taken from falcultube to glass slide and the plankton samples were examined under the compound microscope with magnification power of 40X and 100X. Identification was made to genus or species level using identification key Hlilarv and Erica (1976) and Fernando (2002) . Following identification, the numerical abundance of major taxa was quantified from 1ml of water sample (Figure 3).

(A) (B)

Figure 3: Plankton collection (A) and identification (B).

3.7. Measuring Water Quality

Water temperature (T) was measured for monitoring while the dissolved oxygen (DO), electrical conductivity, salinity, and Total dissolved solids (TDS) were measured as responsive variables once every two weeks three times a day in the morning, mid-day, and evening using Palintest Micro 800 multi-parameter. The pH was measured using an Aawa AD8000 meter.

a b c

Figure 4: Mmeasurements of water quality taken during the experiment in the lab and ponds.

3.8. Collection of fish Performance data

Total length (TL) and total weight (TW) of 20 random fish samples of fish were measured from each pond every two weeks throughout the study period. Dead fish were removed, and differences between the number of fish stocked and the number of fish at harvest were used to calculate the percentage of fish surviving in each treatment. At the end of the experiment, water was reduced and all fish were harvested. Then& Survival rate were calculated after the final harvest (Figure 5).

(a) (b)

Figure 5: Measuring Total weight (a) and total length of fish (b) during the experiment

3.8. Computations and Statistical Analysis

Fish Growth was determined in terms of weight gain (WG) (g), daily growth rates (DGR), specific growth rate (SGR), and Fulton's condition factor (FCF). Survival rate (SR) was also determined as presented below:-

- Weight gain, WG (g) = Final weight (g) – Initial weight (g) (Bahnasawy *et al.*, 2003).
- Daily growth rate, DGR (g/day) = Final weight (g) – Initial weight (g)/culture period (Bahnasawy *et al.*, 2003)
- Relative growth rate (RGR) = wf-wi/ wi x100 while wt and wi represent the final weight and initial weight respectively.
- Fulton's condition factor, K = $W/L^3 \times 100$, where W and L are individual weight (g) and length (cm) of Nile tilapia respectively (Nash *et al.*, 2006)
- Survival rate (%) = No. of harvested fishes at the end of the Experiment /Initial no. of fishes stocked x100 (Limbu & Jumanne, 2014).

The mean value of fish growth, water quality parameters, phytoplankton abundance, and zooplankton abundance were analyzed using one-way analysis of variance (ANOVA) at a significance level (P, < 0.05) SPSS (version 24).

4. RESULTS

4.1. Plankton Abundance

4.1.1. Phytoplankton

A total of 26 species, representing four classes Phytoplanktons (Chlorophyceae,Euglenophyceae, Bacillariophyceae, and Cyanophyceae) were identified over the study period. (Table 2).

Table 2: List of phytoplankton species identified during the study period.

Chlorophyceae		Euglenophyceae	Bacillariophyceae	Cyanophyceae
Chlorella spp	Eudorina	Euglena	Surirella,	Ocillatoria
Spirogyra spp	Oedogonium	Phacus	Navicula,	Anabaena
Ankistrodesmus	Pandorina		Synedra	Nostoc
Scenedesmus	Zynema		Melosira	
Gonium, Coelastrum	Volvox		Gomphonema	Trichodesmium
Pediastrum	Mougeotia		Fragilaria	
Closterium	Tetraedron			

Generally, the most commonly observed genera were Chlorella, Spirogyra, Ankistrodesmus, Gonium, Eudorina, Oedogonium, Pandorina, Scenedesmus, Zygnema, Volvox, Pediastrum, Mougeotia, Closterium, Coelastrum and Tetraedron belong to Chlorophyta group. Euglena and Phocus belong to Euglenophyta goup while Surirella, Navicula, Synedra, Melosira, Fragilaria and Gomphonema belong to Bacillariophyta group and Ocillatoria, Anabaena , Nostoc and Trichodesmium belongs to Cyanophyta group. The observed most common phytoplankton groups are also shown in Annex 5.

To understand which groups contributed more to total abundance, individual phytoplankton classes were analyzed. The result of phytoplankton was summarized in (Table 3). The total abundance of phytoplankton counted during the study period was found with a mean value of 5.6714286 x 10^3 cell/L^{-1}in control, 17.6428572 x 10^3 cells /L^{-1} in pond fertilized with CD (T1), and 23.8285714 x 10^3 cells L^{-1} in pond fertilized with PM (T2) as shown (Table3).

Table 3: Mean abundance of phytoplankton (X 10^3 cell/L) in pond water under different treatments.

	Control	T1	T2
Chlorophyta	1.3857143 x 10^3	7.4285714 x 10^3	10.3285714 x 10^3
Euglenophyta	1.5714286 x 10^3	4.3571429 x 10^3	5.7142857 x 10^3
Bacilariophyta	2 x 10^3	3.5714286 x 10^3	4.7142857 x 10^3
Cyanophyta	0.7142857 x 10^3	2.2857143 x 10^3	3.0714286 x 10^3
Total phytoplankton	5.6714286 x 10^3	17.6428572 x 10^3	23.8285714 x 10^3

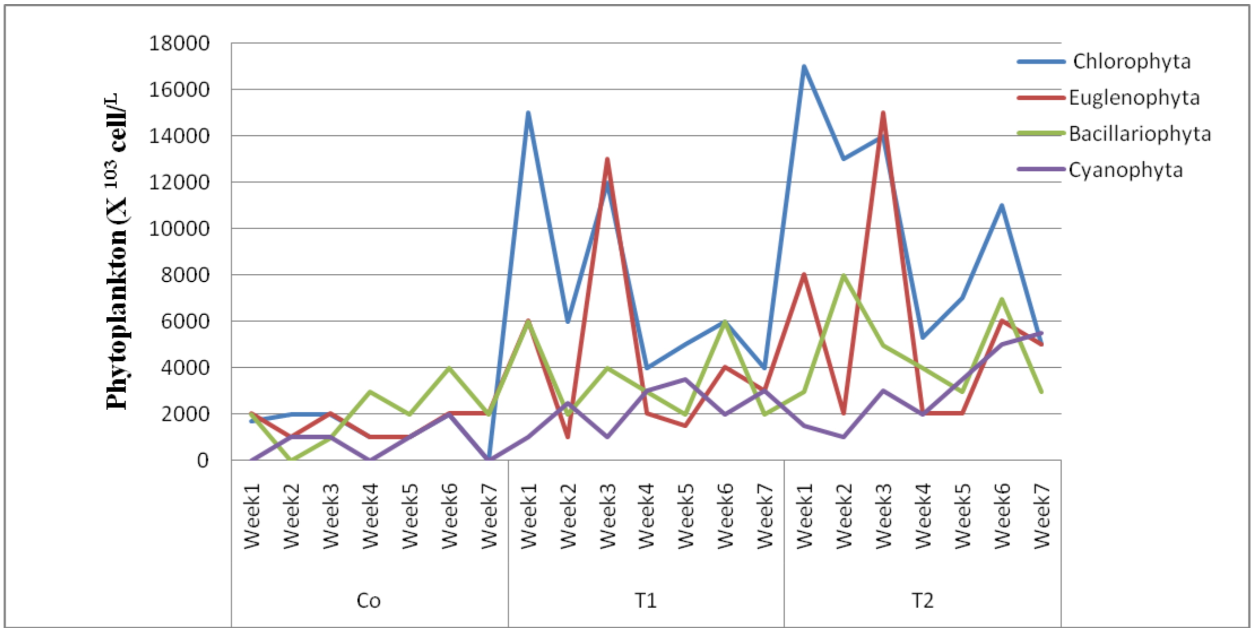


Figure 4: Weekly variations in abundance of phytoplankton in Nile tilapia pond water receiving different organic manure throughout the sampling period.

Chlorophyceae was the most abundant group in all experimental treatments followed by Euglenophyceae except in a control. In control chlorophyceae and Cyanophyceae were less abundance (Figure 6).

Except for the Chlorophyceae classes in Control &T1 (P=0.018) and control &T2 (P=0.001) and the Cyanophyceae group in control & T2 (P=0.006) the abundance of phytoplankton groups identified was not significantly different between the ponds under fertilized with CD and PM (p > 0.05). However, a relatively higher abundance was recorded in ponds fertilized with PM compared to those fertilized with CD and unfertilized ones. The weekly variations in the abundance of phytoplankton in Nile tilapia pond water receiving different organic manure treatments throughout the sampling period were taken (Figure 6).

4.1.2. Zooplankton

During the study period 13 zooplankton species, representing copepod, rotifers, and Cladocera groups were identified (Table 4). The most common observed picture of zooplanktons were shown in Annex 5

Table 4: List of zooplankton species identified during the study period.

Copepoda	**Rotifera**	**Cladocera**
Cyclop spp	Filinia terminals	Daphnia spp
Calanoid spp	Cephalodella Gibb	Moina
Nauplius larvae spp	Filinia longiseta	
Paracyclops fimbriatus	Euchlanis dilatata	
	Trichocerica elongate	
	Trichocerca pusilla	
	Brachionus calyciflorus	

The total abundance of Zooplankton recorded during the study period was found with a mean value of 2.5714281 x 10^3 cell/l^{-1} counted in control, 9.5142857 x 10^3cell/l^{-1} was observed in CD (T1) and 15.3857143 x 10^3 cells L^{-1} were observed in (T2) (Table 5).

Table 5: Mean abundance of zooplankton (X 10^3 cell/1) in pond water under different organic manure treatments.

Zooplankton	Treatments		
	Control	T1	T2
Copepod	1.428571 x 10^3	4.0428571 x 10^3	7.3857143 x 10^3
Rotifers	1.1428571 x 10^3	3.6142857 x 10^3	6.4285714 x 10^3
Cladocera	Not appeared	1.8571429 x 10^3	1.5714286 x 10^3
Total zooplankton	2.5714281 x 10^3	9.5142857 x 10^3	15.3857143 x 10^3

The highest abundance of zooplankton during this study period was recorded in Nile tilapia ponds fertilized with PM followed by Nile tilapia ponds fertilized with CD while less abundant in unfertilized (control) ponds (Table 5). Also the variotian of zooplankton among the fertilized and unfertilized pond was statistically different ($p<0.05$).

The weekly variations of zooplankton abundance in Nile tilapia pond water under different treatment also identified (Figure 7).

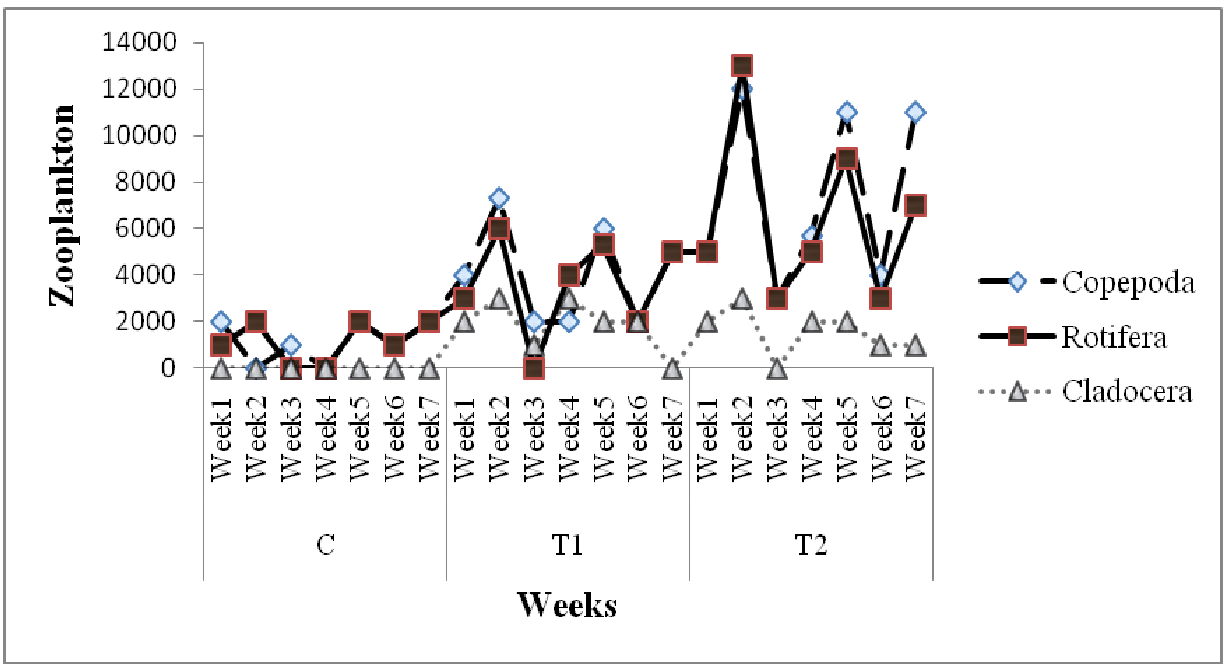


Figure 5: Weekly variations of zooplankton X 10^3 cell/L abundance in Nile tilapia pond water under different organic manure treatments throughout the sampling period.

In the present finding, Copepod contributes the maximum number to the total abundance followed by Rotifers while the Cladocera groups contribute the least to the total abundance in all treatment groups through sampling periods (Figure 7).

4.2. Water Quality Analysis

The different manure applications affected the quality of the water in several ways during this experiment. Physicochemical parameters of the water in each pond were recorded and presented in (Table 6). The highest mean water temperature was recorded in Control (22.9±1.238^{o}C) and followed by T1 (22.32±0.73^{o}C), while the lowest was recorded in T2 (21.67±0.856^{o}C). During experimental periods, no statistically significant difference was observed between each treatment and control in terms of water temperature.

Dissolved oxygen in each experimental group was recorded as 7.93±0.609 mg/l, 4.88±2.178 mg/l, and 3.376±1.377 mg/l in control, T1 and T2 respectively. The highest DO was recorded in Control and followed by T1 while the lowest DO was recorded in T2. The variation in DO is statistically significant only between control and T1 and control and T2 (P=0.04) and (P=0.000) respectively (Table 6). However, there is no significant difference between T1 and T2 (p>0.05).

Salinity in each group was recorded as 0.04±0.00 ppt, 0.45±0.0046 pp 0.53±0.0066 ppt, in control, T1, and T2 respectively. The highest salinity was recorded in T2 and followed by T1, while the lowest was recorded in control. Statistically significant variation was observed between all treatments and control group (P= 0.008, P=0.000 & P=0.003) control & T1, control & T2 and T1& T2 in respectively (Table 6). Electric conductivity (EC) in each pond was recorded as 125.9±3.095µs/cm in control, 143.38 ±9.96T3 µs/cm in T1, and 160.76±11.86 µs/cm in T2 respectively. The highest value of EC was recorded in T2 while the lowest value was recorded in control. Statistically, significant variation was observed between all treatments and the control group.

Total dissolved solid (TDS) in each treatment was 81±1.74mg/L, 92.57±6.17mg/L 106.0476±11.538 recorded in control, T1, and T2 respectively. The highest value of TDS was recorded in T2 while the lowest was recorded in Control. Statistically, significant variation was observed between all treatments and the control group, (P=0.0028. P=0.000, and P=0.01) between control & T1, control & T2, and T1 & T2 respectively (Table 6).

Moreover, pH , ammonia, and nitrite were also recorded in each pond during the study period presented in (Table 6) However, there is no significant variation between treatment groups and control for PH, ammonia, and nitrites.

Table 6: Water quality parameters measured in ponds fertilized with different organic manure and stocked with Nile Tilapia for 120 days.

Parameters	Control	Treatment	
		T1	T2
Temp (^oC)	22.9±1.238	22.32±0.73	21.67±0.856
DO (mgL^{-1})	7.93±0.609[a]	4.88±2.178[b]	3.376±1.377[c]
Salinity	0.04±0.00[a]	0.45±0.0046[b]	0.53±0.0066[c]
EC	125.9±3.095[a]	143.38±9.96[b]	160.76±11.86[c]
TDS	81±1.74[a]	92.57±6.17[a]	106.0476±11.538[a]
pH	8.057±0.249[a]	7.6179±0.31[b]	7.489±0.356[c]
NH_3-N(mgL^{-1})	0.079±0.029	0.166±0.062	0.311±0.179
NO_2-N (mgL^{-1})	0.065±0.025	0.14±0.05	0.26±0.15

Different letter superscripts in the same row indicate groups with statistically significant variation (P<0.05)

T=Treatment; Temp= Water temperature; DO= Dissolved oxygen; EC= Electric conductivity TDS= Total dissolved solid; pH= Hydrogen ion concentration

4.3. Fish Growth Performance

The growth parameters of fish fertilized with CD, PM & Control in each pond in terms of mean initial weight MIW (g), mean initial MIL length (cm), Final weight FW (g), weight gain (g), RGR g, DGR (% day^{-1}), FCF and survival rate (%) with standard deviation were presented (Table 7). The mean initial weight (MIW) and total length (MTL) ranged from 7.05±0.99 g, 7.15±1.598 g, 7.2±1.54 g while 6.385±0.98 cm, and 6.32±1.4 cm respectively. Statistically, there was no significant difference in the mean initial fish size among each group of treatment ($p > 0.05$).

The final mean fish weight, in each treatment, was 16.3g, 29.6 g, and 40.35 g for C, T1 & T2 respectively. During the study period, the highest fish growth performance, both in weight and length was recorded in T2. In contrast, the least growth values were observed in the control while T1 was intermediate between control and T2. The variation in the final mean weight between the control and the treatment groups was statistically significant (P=0.000). The mean weight gain of fish in each treatment was 9.25 g on Control, 22.45 g on T1, and 33.15 g on T2. The variation in the final mean total length between the control and treatment groups was also statistically significant (P=0.000). The result of the Post Hoc test using Tukey HSD showed that the variation in Mean FW, WG, and DGR among all treatment were highly significant (P = 0.000). The RGR for all treatments were also significantly different ($P < 0.05$).

Table 7: Initial weight g, weight gain g, Daily growth rate g per day, and specific growth rate of Nile Tilapia reared in ponds fertilized with different types of organic manure.

Growth parameters	Control	Treatments		P-value
		CD (T)	PM (T2	
M IW	7.05±0.998[a]	7.15±1.598[a]	7.2±1.54[a]	0.993
M IL	6.385±0.98[a]	6.385±0.98[a]	6.32±1.4[a]	0.980
FMW	16.3±4.3	29.6±6.3	40.35±7.58	0.000
FML	11.03±0.88	13.225±0.85	14.63±0.89	0.000
WG	9.25±4.178	22.45±6.18	33.15±7.9	0.000
DGR	0.08	0.195	0.288	0.000
RGR	133	329.49	487.127	0.001
FCF	1.188±0.055	1.26±0.092	1.27±0.054	0.017
SR	97	95	94	

Keys *MIW- Mean Weight gain | * RGR- Relative growth rate

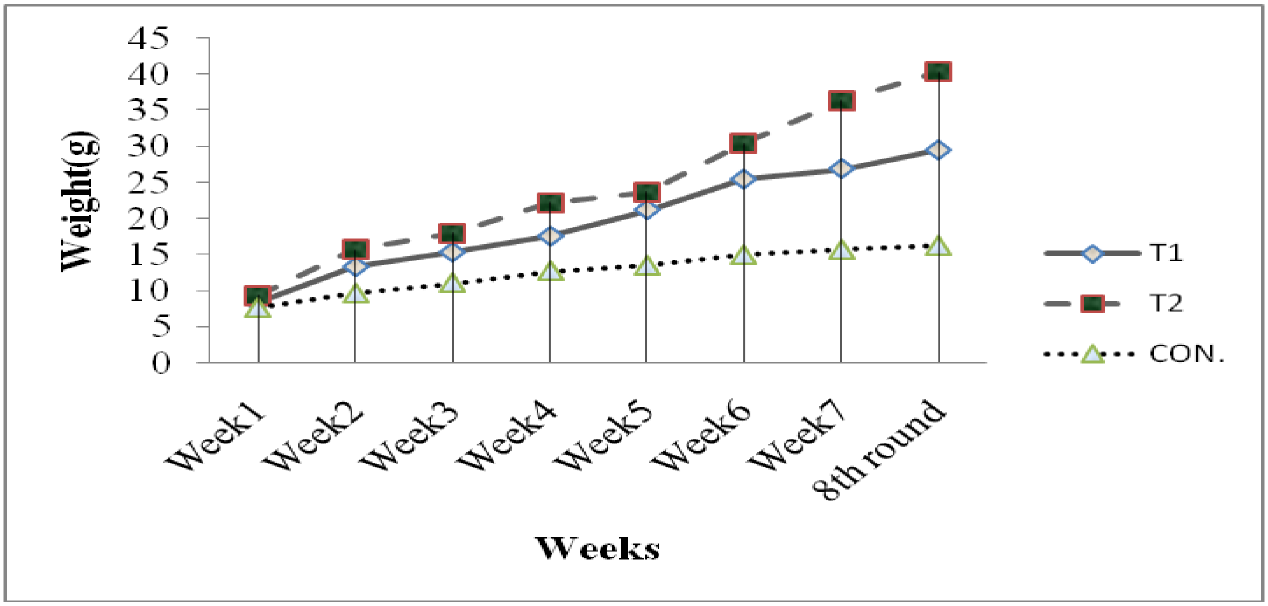
* MIL- Mean length gain | * SR- Survival rate

* FMW- Mean final weight | * FCF- Fulton condition factor

* FML- Mean final length | * DGR- Daily growth rate

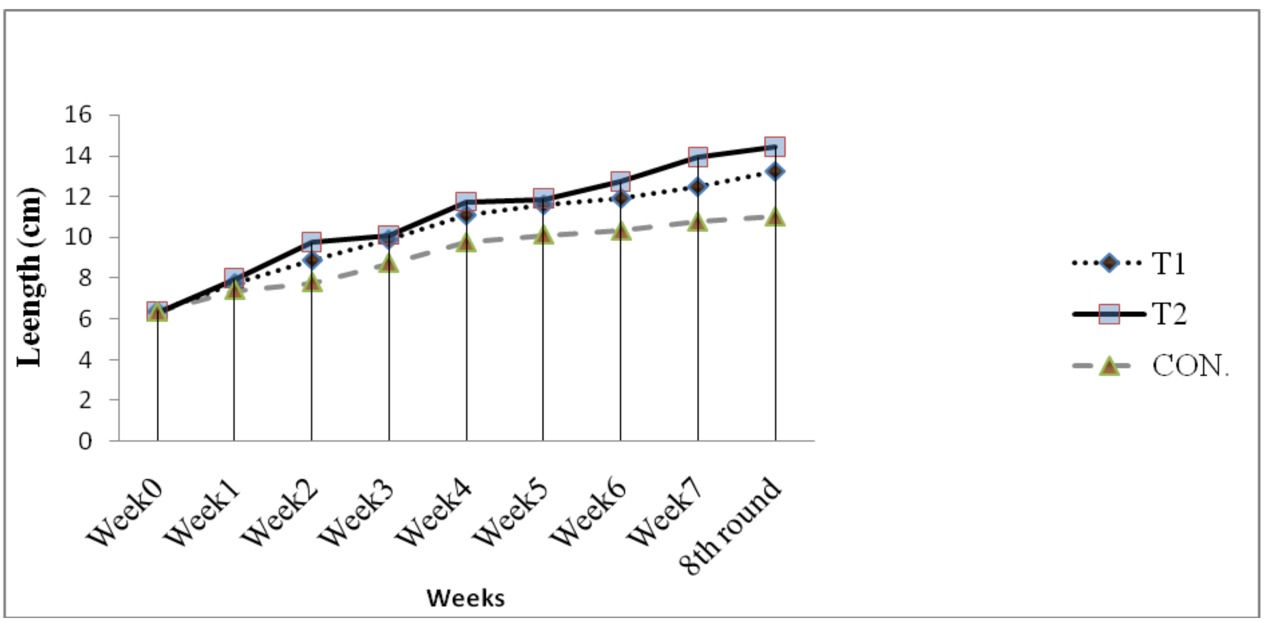
The similar latter of supperscribt shows no significany variation.

The weekly mean growth and mean length variation of Nile tilapia fertilized pond with different



organic manure was shown in the Figure 8.

(a)



(b)

Key: - Week1- Represent the 1st two week of 1st month,…, Week8 represent 2nd two week of 4rth month.

Figure 6: Mean weight (a) and Mean length (b) over time of Nile Tilapia grown in ponds fertilized with different organic manure.

As seen from figure 8, during first week there is no variation of weight and length among the treatment and controls. But gradually the fish pond fertilized with poultry manure shows best growth performance followed by cow dung fertilized ponds.

5. DISCUSSION

The present study assessed the effect of organic animal manure for pond fertilization to produce primary productivity used for fish feeds. The study revealed that, poultry manure had preferable to fertilize fish pond than cow dung incase of primary productivity and fish performance. Several scientific reports (Kang'ombe *et al.*, 2006; Knud-Hansen *et al.*, 1993; Kumara *et al.*, 2003) indicated that chicken manure promotes plankton growth and fish production than cow dung partly due to superior nutrient content.

5.1. Plankton Abundance

The dominance of phytoplankton observed in CD and PM treatment manures was Chlorophyceae followed by Euglenophyceae, Bacillariophyceae, and Cyanophyceae (Figure 4). Chlorophyceae were the most dominant in almost all studying periods in all different treatment ponds when compared with other group of phytoplankton. This result is agreement with finding of (Ansari *et al.*, 2015; Rajagopal *et al.*, 2010) who suggested that, Chlorophyceae was the most significant group of phytoplankton during the study. Hoek *et al.* (1995) also reported that, higher Chlorophyceae are a large and important group of freshwater algae. Moreover Philipose (1960), also reported that, Chlorophyceae group dominate the water that is rich in nutrients such as nitrate and phosphate. The Cyanophyceae groups were less dominant at the beginning of experiment when compared with others and increased gradually specially in fertilized ponds after 4rth weeks. This may be due to slow growth of Cyanophyceae. Cromar and Fallowfield (1997) reported that, Cyanobacteria have slower growth rate than the green algae.

The present finding showed that the total mean phytoplankton production was higher in pond water fertilized with poultry manure followed by pond receiving cattle dung than in control throughout the experimental period. This was similar to the report of (Kumara *et al.*, 2003) who suggested, ponds with chicken manure had significantly higher phytoplankton than those with cow dung due to high levels of nutrients released from poultry wastes can support the extensive growth of phytoplankton and lead to high levels of secondary productivity.

During this study, three groups of zooplankton namely copepods, rotifer and cladocerans were identified. Present result zooplankton group was dominated by copepod found in all treatments followed by rotifers and less number of cladocerans in treatment and not detected in control.

This result was dissimilar to the dominance rotifer followed by Cladocera reported by (Nana Towa *et al.*, 2018). The highest zooplankton population was recorded in poultry manure (15385.7) followed by cow dung (9514.29) and the control (2571.43) (Table 5). This agrees with the research findings of (Ipinmoroti & Iyiola, 2011; Rapatsa & Moyo, 2013), poultry dropping is the best for the culture of fresh water zooplankton due to its high nutrient composition promoting pond production in relation to other forms of manures. Ekelemu and Nwabueze (2010) also reported that, poultry droppings as a better source of organic manure compared to cow dung other organic manure. In the present finding cladocerans group was better in the cow dung ponds and this was consistent with work reported by (Kang'ombe *et al.*, 2006), while rotifers were more abundant in chicken manure ponds.

5.2. Physico-chemical water Parameters

Mean water temperature recorded during the experiment was 22.9 ±1.24, 22.32 ±0.73, and 21.67 ±0.86 in control, T1, and T2 respectively, and not significant among treatment and controls (Table 6). The temperature range for the normal development, reproduction, and growth of Nile tilapia is about 20 to 35°C, depending on fish species, with an optimum range of about 25–30° (Philippart & Ruwet, 1982). Kumara *et al.* (2003) also reported that natural feeds are adequately produced from manure when the water temperature is above 18°C.

Dissolved oxygen is the most critical water quality parameter for aquaculture (Ebeling & Timmons, 2010). DO recorded was significantly higher in control and a lower value was found in pond fertilized with poultry manure. The variation of DO was highly significant between the control and treatment groups, but not among the treatment (Table 6). The results of the present study were in agreement with the findings of (Kaur *et al.*, 2015) who reported that a lower concentration of DO in organic manure treatment attributes to the deposition of organic manure and the use of DO by bacteria. Moreover, Das *et al.* (2005) reported that the change in water parameters after the application of different doses of cow dung, poultry manure, feed mixture, and organic and inorganic fertilization caused a significant reduction in dissolved oxygen and an increase in free CO_2, low level of CO_2 in control may be due to absence or low level of organic load.

The pH value recorded during the experiment was significant between the control group and treatment group but not significant among the treatment. 8.05±0.25, 7.62 ±0.3, and 7.49 ±0.36 were recorded in control, T1, and T2 respectively (Table 6). According to Boyd. (1998) optimum pH for growth and health of most fresh water fish is in the range of 6.5 to 9 while suboptimal pH can cause stress, increased susceptibility to disease, and poor fish growth. Nile tilapia show the best growth in water that is close to neutral or slightly alkaline water (Webster & Lim, 2006). Therefore, the pH values recorded in the present finding from different ponds (7.47 to 8.05) indicated good productivity of the pond water.

In the present study salinity, Electrical conductivity, and total dissolved solid showed higher values in the poultry manure fertilized pond followed by cow dung and minimum in control. Ammonia is another water quality parameter that determines the condition of cultured fish in the culture system. According to El-Sherif and El-Feky (2008), ammonia is toxic to tilapia at concentrations of 2.5 mg/l and unionized ammonia becomes toxic to fish at 7.1 mg/l. However, the concentration of ammonia recorded in the present study was 0.079 ± 0.03, 0.166 ± 0.06, and 0.31 ± 0.18 in controls, T1 and T2 respectively (Table 6). This indicates that ammonia concentration recorded in the present study was on the side of the acceptable range of Nile tilapia production. Nitrite recorded during the study period was not significant among the treatment and controls (Table 6). According to (El-Sayed, 2006) the tolerance range of Nile tilapia to Nitrite is (0.1-0.2 mg/l. the present result is also on the side of this range.

5.3. Fish Growth Performance

Organic manure used in this study showed notable variations in the growth performance of fish among the treatment and control groups. This was in-line with the report of Ekelemu and Nwabueze (2010), fish production in ponds that were fertilized using organic manure such as cow dung and poultry droppings showed almost double production over unfertilized ponds. In the current study, the highest growth performance in terms of final weight, weight gain, specific growth rate, relative growth rate, and Daily growth rate was observed on the fish ponds fertilized with PM followed by the fish ponds fertilized with CD for final weight, weight gain, specific growth rate, relative growth rate and daily growth rate while fish of unfertilized pond (control) was shows less final weight, weight gain, specific growth rate, relative growth rate and daily growth rate. This was in line with the finding of (Kang'ombe *et al.*, 2006) who reported that the highest fish growth performance in poultry manure, followed by cow dung and low growth performance in the control. Moreover, the differences in growth performances expressed in the present finding in terms of mean FW, DGR, and WG among all experiments were significantly different ($P = 0.000$). Also, the RGR and SGR among the treatment group and control group were statistically significant ($p < 0.05$).

Generally Fish in ponds fertilized with poultry manure grew significantly better than fish in ponds fertilized with cow dung and control. This could be due to the high nutrient content of poultry manure than cow dung and high zooplankton and phytoplankton diversity observed in ponds applied with poultry manure than cow dung and control-treated ponds. This result was consistent with the report by (Rapatsa & Moyo, 2013) Chicken manure had the highest nitrogen, phosphorus, potassium, crude protein, and ash content while Cow manure exhibited the lowest nutrient concentrations (Hassanien *et al.*, 2010) Growth of fish was significantly increased by the increases in the level of natural food. Hossain *et al.* (2006) also suggested the capacity of phosphorus released from poultry manure might be more efficient than other organic fertilizers and inorganic fertilizers. However, still fish in ponds fertilized with cattle dung shows higher growth than in control ponds.

The condition factor also known as length - weight factor shows the degree of the well-being of the fish in their habitat and is expressed by the coefficient of condition. Condition factor is useful in assessing the general well-being and health of fish in their habitat (Onimisi & Ogbe, 2015).

In the present study, fish fertilized pond showed better conditions than that of control during 120 days of experimental (table 7) by recording 1.27±0.054 in PM, 1.26±0.092 in CD, and 1.188±0.055 in control among the different treatments and control groups. The variation has statistically significant ($p < 0.05$). According to a report by (Avşar, 2005; Bolger & Connolly, 1989), the FCF value greater than or equal to 1 was indicative of good fish condition. Therefore, the FCF values, greater than 1, recorded during the present experiment were indicative of good and healthy fish conditions under the different organic manure treatments.

The highest survival rate was recorded in control when compared with CD and PM ponds during the experimental period. This variation was occurred due to dried tap water for three days consequently and causes fish mortality in CD and PM ponds. Treatments did not affect the survival rate of *O. niloticus* differently as the values are close to each other.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

From the results of the present investigation, it could be concluded that the use of organic animal manure (cow dung and poultry manure) in earthen ponds is produce a high growth performance of fish. Moreover, the effects of organic fertilizers (poultry manure and cattle dung) increase significantly the productivity of phytoplankton and zooplankton in fish ponds. Organic manuring is normally considered more beneficial for the farmer because it is economical and reduces the cost of inorganic fertilizer and supplementary feed. The present study showed that poultry manure treated ponds had maximum production compared to cow dung manure application due to higher level of nitrate and phosphate content in poultry manure than cattle dung helps in natural food production in the fish ponds.

Therefore, it is suggested that the use of poultry manure deserved priority in fish production and pond productivity followed by cow dung which is important to sustainable aquaculture and to reduce expenditure on the cost of feeds and fertilizers.

6.2. Recommendations

Based on the result of the study, the following recommendations were needed.

- Poultry manure fertilized pond enhances the natural food production and showed better growth performance of Nile tilapia in aquaculture practice. However, further research could be conducted to determine effect of different fertilization rate of poultry manure and cow dung on fish reared in earth ponds.
- During this experiment only growth performance of Nile tilapia were evaluated. So for the future study, it is better to evaluate the chemical composition of Nile tilapia reared by the manures.
- For the future study it is better to fertilize ponds every two weeks.

7. REFERENCES

Abdelghany, A. E., & Ahmad, M. H. (2002). Effects of feeding rates on growth and production of Nile tilapia, common carp and silver carp polycultured in fertilized ponds. *Aquaculture Research, 33*(6), 415-423.

Adedeji, A., Aduwo, A., Aluko, O., & Awotokun, F. (2011). Effect of chicken droppings as organic fertilizer on water quality and planktonic production in an artificial culture media. *Ife journal of science, 13*(2), 239-249.

Adigun, B. (2005). Water quality management in aquaculture and freshwater zooplankton production for use in fish hatcheries. *New Bussa, Niger State, Nigeria*, 12-13.

Al-Amoudi, M. (1987). Acclimation of commercially cultured Oreochromis species to sea water—an experimental study. *Aquaculture, 65*(3-4), 333-342.

Anetekhai, M. A., Clarke, E. O., Osodein, O. A., & Dairo, M. T. (2018). Physical, chemical parameters and plankton in a tropical earthen pond catfish farm in Badagry, Nigeria. *International Journal of Fisheries and Aquaculture, 10*(6), 71-76.

Ansari, E., Gadhia, M., & N.C., U. (2015). Phytoplankton Diversity and Water Quality Assessment of ONGC Pond, Hazira. *International Journal of Research in Environmental Science (IJRES), 1*(1).

Ashton, P., & Schoeman, F. (1983). Limnological studies on the Pretoria Salt Pan, a hypersaline maar lake. *Hydrobiologia, 99*(1), 61-73.

Asiyo, S. G. (2003). *The phytoplankton primary productivity, biomass and species composition in the Finger Ponds Uganda.* M. Sc. Thesis, UNESCO-IHE Delft, The Netherlands.

Avşar, D. (2005). Fisheries biology and population dynamics, 332 pp: Nobel Press, Adana.

Bahnasawy, M. H., Abdel-Baky, T. E., & Abd-Allah, G. A. (2003). Growth performance of Nile tilapia (Oreochromis niloticus) fingerlings raised in an earthen pond. *Fisheries & Aquatic Life, 11*(2), 277-285.

Beveridge, M., & Baird, D. (2000). Diet, feeding and digestive physiology *Tilapias: Biology and exploitation* (pp. 59-87): Springer.

Bhatnagar, A., & Devi, P. (2013). Water quality guidelines for the management of pond fish culture. *International journal of environmental sciences, 3*(6), 1980-2009.

Bhavan, P., Selvi, A., Manickam, D. N., Srinivasan, V., Santhanam, P., & Vijayan, P. (2015). Diversity of zooplankton in a Perennial Lake at Sulur, Coimbatore, India. *International Journal of Extensive Research, 5*, 31-44.

Bogaard, A., Fraser, R., Heaton, T. H., Wallace, M., Vaiglova, P., Charles, M., . . . Andersen, N. H. (2013). Crop manuring and intensive land management by Europe's first farmers. *Proceedings of the National Academy of Sciences*, *110*(31), 12589-12594.

Bolger, T., & Connolly, P. (1989). The selection of suitable indices for the measurement and analysis of fish condition. *Journal of Fish Biology*, *34*(2), 171-182.

Bostock, J., McAndrew, B., Richards, R., Jauncey, K., Telfer, T., Lorenzen, K., . . . Gatward, I. (2010). Aquaculture: global status and trends. *Philosophical Transactions of the Royal Society B: Biological Sciences, 365*(1554), 2897-2912. doi:doi: 10.1098/rstb.2010.0170

Boyd. (2018). Aquaculture pond fertilization. *CAB Reviews, 13*(002), 1-12. doi:doi: 10.1079/PAVSNNR201813002

Boyd, C. E. (1982). *Water quality management for pond fish culture*: Elsevier Scientific Publishing Co.

Boyd., C. E. (1998). Water quality for fish pond. *Aquaculture research and development series*(43), 37.

Chervinski, J. (1982a). *Environmental physiology of tilapias.* Paper presented at the The Biology and Culture of Tilapia. Proceedings ofthe 7th ICLARM Conference, Manila, Philippines: International Center for Livin.

Chervinski, J. (1982b). *Environmental physiology of Tilapias [in Africa and Israel]*. Paper presented at the International Conference on the Biology and Culture of Tilapias, Bellagio (Italy), 2-5 Sep 1980.

Cromar, N. J., & Fallowfield, H. J. (1997). Effect of nutrient loading and retention time on performance of high rate algal ponds. *Journal of Applied Phycology, 9*(4), 301-309.

Cunha, M., Quental-Ferreira, H., Parejo, A., Gamito, S., Ribeiro, L., Moreira, M., . . . Pousão-Ferreira, P. (2019). Understanding the individual role of fish, oyster, phytoplankton and macroalgae in the ecology of integrated production in earthen ponds. *Aquaculture, 512*, 734297. doi:DOI: 10.1016/

Das, Chandra, P., Ayyappan, S., & Jena, J. (2005). Comparative changes in water quality and role of pond soil after application of different levels of organic and inorganic inputs. *Aquaculture Research, 36*(8), 785-798.

Das, & Jana, B. (1996). Pond fertilization through inorganic sources: an overview. *Indian Journal of Fish, 43*(2), 137-155.

Deivanai, K., Arunprasath, S., Rajan, M., & Baskaran, S. (2004). *Biodiversity of phyto and zooplankton in relation to water quality parameters in a sewage polluted pond at Ellayirampannai, Virudhunagar District.* Paper presented at the The proceedings of National Symposium on biodiversity resources management and sustainable use, organized by the center for biodiversity and Forest studies, Madurai Kamaraj University. Madurai.

Deka, P. M., Tamuli, K. K., Dutta, M. P., Phukan, B., & Baishya, S. (2018). Effects of different doses of pig dung on the growth performance of Catla, Catlacatla (Hamilton, 1822). *Journal of Applied and Natural Science, 10*(1), 425-429.

Dikinya, O., & Mufwanzala, N. (2010). Chicken manure-enhanced soil fertility and productivity: Effects of application rates. *Journal of Soil Science and Environmental Management, 1*(3), 46-54.

Ebeling, J. M., & Timmons, M. B. (2010). *Recirculating aquaculture*: Cayuga Aqua Ventures Freeville, NY, USA.

Ekelemu, J. K., & Nwabueze, A. A. (2010). COMPARATIVE STUDIES ON ZOOPLANKTON PRODUCTION USING DIFFERENT TYPES OF ORGANIC MANURE. *PROCEEDINGS OF FISHERIES SOCIETY OF NIGERIA (FISON*.

El-Sayed, A.-F. M. (2006). Tilapia culture in salt water: environmental requirements, nutritional implications and economic potentials. *Avances en Nutricion Acuicola*.

El-Sherif, M., & El-Feky, A. M. (2008). *Effect of ammonia on Nile tilapia (O. niloticus) performance and some hematological and histological measures.* Paper presented at the Eighth International Symposium on Tilapia in Aquaculture. Cairo, Egypt.

El-Saidy, D. M., & Gaber, M. M. (2005). Effect of dietary protein levels and feeding rates on growth performance, production traits and body composition of Nile tilapia, Oreochromis niloticus (L.) cultured in concrete tanks. *Aquaculture Research, 36*(2), 163-171.

Endebu, M., Tugie, D., & Negisho, T. (2016). Fish growth performance in ponds integrated with poultry farm and fertilized with goat manure: a case in Ethiopian Rift Valley. *Int J Fishery Sci Aquac, 3*, 040-045.

Engdaw, F., Dadebo, E., & Nagappan, R. (2013). Morphometric relationships and feeding habits of Nile tilapia Oreochromis niloticus (L.)(Pisces: Cichlidae) from Lake Koka, Ethiopia. *International Journal of Fisheries and Aquatic Sciences*, *2*(4), 56-71.

FAO. (2009). Aquaculture Department Food and Agriculture Organization of the United Nations, The state of world fisheries and aquaculture 2008: Electronic Publishing Policy and Support Branch Communication Division FAO, Rome.

FAO. (2011). *World aquaculture 2010*: Food and Agriculture Organization of the United Nations.

Fernando, C. H. (2002). *A guide to tropical freshwater zooplankton: identification, ecology and impact on fisheries*: Backhuys Publishers.

Gabriel, U., Akinrotimi, O., Bekibele, D., Onunkwo, D., & Anyanwu, P. (2007). Locally produced fish feed: potentials for aquaculture development in subsaharan Africa. *African Journal of Agricultural Research, 2*(7), 287-295.

Gangadhar, B., Umalatha, H., Hegde, G., Vasundhara, R., & Sridhar, N. (2017). Influence of commonly used manures on the growth and nutrient composition of periphyton. *Insights in Aquaculture and Biotechnology, 1*, 1-6.

Garg, S., & Bhatnagar, A. (1996). Effect of varying closes of organic and inorganic fertilizers on plankton production and fish biomass in brackish water fish ponds. *Aquaculture Research, 27*(3), 157-166.

Gindaba, A., Getahun, A., & Wakjira, M. (2017). Growth Performance and Yield of Nile Tilapia (Oreochromis niloticus (Linnaeus, 1758)) under Different Stocking Densities and Fertilization Scenarios in Earthen Pond Culture. *International Journal of Sciences: Basic and Applied Research (IJSBAR), 32*, 80-94.

Gustafsson, J., Cederberg, C., Sonesson, U., & Emanuelsson, A. (2013). The methodology of the FAO study: Global Food Losses and Food Waste-extent, causes and prevention"-FAO, 2011: SIK Institutet för livsmedel och bioteknik.

Hassanien, H., Abdallah Hassanien, H., Salem, M., Samir, H., Marian, H., & Algal, S. (2010). Algal Abundances and Growth Performances of Nile Tilapia (Oreochromis niloticus) as

Affected by Different Fertilizer Sources. *Journal of American Science Journal of American Science, 66*, 584-393.

Hecht, T. (2006). Regional review on aquaculture development for Sub-Saharan Africa-2005.

Hlilarv , B., & Erica, S. (1976). *A beginner's guide to freshwater algae*: HMSO.

Hoek, C., Mann, D., Jahns, H. M., & Jahns, M. (1995). *Algae: an introduction to phycology*: Cambridge university press.

Hossain, M. Y., Begum, M., Ahmed, Z. F., Hoque, M. A., Karim, M. A., & Wahab, M. A. (2006). A study on the effects of iso-phosphorus fertilizers on plankton production in fish ponds. *South Pacific Studies, 26*(2), 101-110.

Ipinmoroti, M., & Iyiola, A. (2011). *Organic production of zooplankton from locally sourced cassava peels using no supplemental nutrients.* Paper presented at the A. Leu, H. Lee, H, Z. Zhou, P. Villegas and L. Zuck (Eds). Procedings (precomference) of the 17th IFOAM Organic World Congress held at Gyeonggi Paldang, Republic of South Korea.

Javed, M., Hassan, M., & Sial, M. (1992). FISH POND FERTILIZATION. IV. EFFECT OF COW-DUNG ON THE GROWTH PERFORMANCE OF MAJOR CARPS. *Pakistan: jurnal of Agricaltural Science, 29*(2).

Kang'ombe, J., Brown, J. A., & Halfyard, L. C. (2006). Effect of using different types of organic animal manure on plankton abundance, and on growth and survival of Tilapia rendalli (Boulenger) in ponds. *Aquaculture Research, 37*(13), 1360-1371.

Kaur, S., Masud, S., & Khan, A. (2015). Effect of fertilization and organic manure on water quality dynamics a proximate composition of Cyprinus carpio. *Journal of Fisheries & Livestock Production, 2015*.

Kebede, A., Meko, T., Hussein, A., & Tamiru, Y. (2017). Review on opportunities and constraints of fishery in Ethiopia. *International Journal of Poultry and Fisheries Sciences, 1*(1), 1-4.

Khan, S., Ahmed, G., & Ahmed, S. (2001). Effects of organic manuring (chicken droppings) on growth of Labeo rohita Ham. spawn. *Bangladesh Journal of Fisheries Research, 5*(1), 23-28.

Knud-Hansen, F, C., Batterson, T. R., McNabb, C. D., Harahat, I. S., Sumantadinata, K., & Eidman, H. M. (1991). Nitrogen input, primary productivity and fish yield in fertilized freshwater ponds in Indonesia. *Aquaculture, 94*(1), 49-63.

Knud-Hansen, Fulton, C., & Clair, D. (1998). *Pond fertilization: ecological approach and practical application*: Pond Dynamics/Aquaculture Collaborative Research Support Program, Oregon ….

Knud-Hansen, C., Batterson, T., & McNabb, C. (1993). The role of chicken manure in the production of Nile tilapia, Oreochromis niloticus (L.). *Aquaculture Research, 24*(4), 483-493.

Krishnan, K., Thomas, S., George, S., Murugan, R. P., Mundayoor, S., & Das, M. (1999). A study on the distribution and ecology of phytoplankton in the Kuttanad wetland ecosystem, Kerala. *Pollution Research, 18*(3), 261-269.

Kumar, M. S., Nguyet, N. T., Johnson, J., & Luu, L. T. (2005). The impact of nutrient concentration (N: P) and manure type on fish polyculture. *Journal of applied aquaculture, 16*(3-4), 61-78.

Kumara, A., Edirisinghe, U., & Dematawewa, C. (2003). Effect of chicken manure and cow dung on water quality, pond productivity and growth and survival of goldfish (Carassius auratus) fry.

Kumari, R., Ojha, M., Saini, V., & Sharma, S. (2017). Effect of Azolla supplementation on growth of rohu (Labeo rohita) fingerlings. *J. Entomol. Zool. Stud, 5*, 1116-1119.

Kusi, I. O. (2017). *Effect of Fertilization Frequency on the Productivity of Earthen Ponds Cultured with All-Male Oreochromis Niloticus (Nile Tilapia).*

Lemma, D. T., Megersa, H. G., & Banjaw, D. T. (2020). ASSESSMENT of PAPAYA POSTHARVEST LOSS at WHOLESALER and RETAILER LEVELS in JIMMA TOWN, SOUTH WESTERN ETHIOPIA. *International Journal of Plant Breeding and Crop Science, 7(3)*.

Limbu, S. M., & Jumanne, K. (2014). Effect of restricted and re-feeding regime on feeding cost, growth performance, feed utilization and survival rate of mixed sex Nile tilapia Oreochromis niloticus cultured in tanks. *Int J Fish Aquat Stud, 2*(1), 118-123.

Manickam, N., Bhavan, P. S., Santhanam, P., Muralisankar, T., Srinivasan, V., Vijayadevan, K., & Bhuvaneswari, R. (2015). Biodiversity of freshwater zooplankton and physico-chemical parameters of Barur Lake, Krishnagiri District, Tamil Nadu, India. *Malaya Journal Bioscience, 2*, 1-12.

Mili, K., Rout, S. K., Jana, D., Annupama, R., & Chakraborty, S. (2017). Assessing the Phytoplankton Population of Hard Water Ponds in Eastern Kolkata, India. *Environment & Ecology, 35*(4B), 3087-3092.

Mischke, C. C. (2012). *Impacts of nutrient input on production:Aquaculture pond fertilization*: John Wiley & Sons.

Morgan, P. R. (1972). Causes of mortality in the endemic tilapia of Lake Chilwa (Malawi). *Hydrobiologia, 40*(1), 101-119.

Najmus , S. K., & Bari, J. B. A. (2019). The effects of Physico-chemical parameters on plankton distribution in poultry manure and artificial formulated feed treated fish ponds, Noakhali, Bangladesh. *International Journal of Fisheries and Aquatic Studies,* 1-7.

Nana Towa, A., Algrient, Algrient, E., Thomas, Z., Togouet, S., Hubert, T., & Joseph. (2018). Effects of doses of chicken manure on the biodiversity of zooplankton populations in ponds.

Nash, R. D., Valencia, A. H., & Geffen, A. J. (2006). The origin of Fulton's condition factor—setting the record straight. *Fisheries, 31*(5), 236-238.

Natea, G., Wakjira, M., Negisho, T., & Endebu, M. (2017). Spawning response of African catfish (Clarias gariepinus (Burchell 1822), Claridae: Teleost) exposed to different piscine pituitary and synthetic hormone. *International Journal of Fisheries and Aquatic Studies, 5*(2), 264-269.

Okwor, C., Ofojekwu, P., Ajima, M., & Nasir, A. (2012). Effects of chicken manure to fingerlings of Nile tilapia (Oreochromis niloticus).

Onimisi, M., & Ogbe, F. (2015). Length-weight relationship and condition factor for fish species of River Okura, Kogi State, Central Nigeria. *International Journal of Scientific Research and Engineering Studies, 2*(7), 1-3.

Oparaku, N. F. (2013). Evaluation of different biological waste for use in plankton productions. *Agriculture and biology journal of North America, 4*(5), 527-531.

Peña-Mendoza, B., Gómez-Márquez, J. L., Salgado-Ugarte, I., & Ramírez-Noguera, D. (2005). Reproductive biology of Oreochromis niloticus (Perciformes: Cichlidae) at Emiliano Zapata dam, Morelos, Mexico. *Revista de biologia tropical, 53*(3-4), 515-522.

Philipose, M. (1960). *Freshwater phytoplankton of inland fisheries.* Paper presented at the Proceeding of the symposium on Algology.

Philippart, J.-C., & Ruwet, J.-C. (1982). *Ecology and distribution of tilapias.* Paper presented at the The Biology and Culture of Tilapias. ICLARM Conference Proceedings 7, 432 pages.

Ponce , J. T., Arredondo Figueroa, J. L., Castillo Vargasmachuca, S. G., Rodriguez Chavez, G., Benitez Valle, A., Regalado De Dios, M. A., . . . Lopez Lugo, P. (2010). The effect of chemical and organic fertilization on phytoplankton and fish production in carp (Cyprinidae) polyculture system. *CONACYT, 1*.

Pratapn, C. D., Ayyappan, S., & Joykrushna, J. (2005). Comparative changes in water quality and role of pond soil after application of different levels of organic and inorganic inputs. *Aquaculture Research, 36*(8), 785-798.

Qin, J., Culver, D., & Yu, N. (1995). Effect of organic fertilizer on heterotrophs and autotrophs: implications for water quality management. *Aquaculture Research, 26*(12), 911-920.

Rajagopal, A., T., & G., A. (2010). Comparison of physico-chemical parameters and phytoplankton species diversity of two perennial ponds in Sattur area, Tamil Nadu. *Journal of Environmental Biology, 31*(5), 787-794

Rapatsa, M. M., & Moyo, N. A. G. (2013). Performance evaluation of chicken, cow and pig manure in the production of natural fish food in aquadams stocked with Oreochromis mossambicus. *Physics and Chemistry of the Earth, Parts A/B/C, 66*, 68-74. doi:10.1016/j.pce.2013.08.009

Raymond, J. (1983). Plankton and productivity in the oceans. Volume 2-Zooplankton: Pergamon Press, Oxford: 824pp.

Reyes, A., Ramos, A., & Saturno, J. (2019). Phytoplankton abundance, diversity, evenness and composition in tilapia ponds fertilized with chicken manure and organic fertilizer. *International Journal of Botany Studies, 4*, 72-76.

Sadiku, S., & Jauncey, K. (1995). Soybean flour-poultry meat meal blend as dietary protein source in practical diets of Oreochromis niloticus and Clarias gariepinus. *Asian Fisheries Science, 8*, 159-168.

Saeiam, Y., Pichitkul, P., Nedtharnn, U., & 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 (Oreochromis niloticus x mossambicus) farming. *International Journal of Agricultural Technology, 16*(3), 695-710.

Sala, O. E., Chapin, F. S., Armesto, J. J., Berlow, E., Bloomfield, J., Dirzo, R., . . . Kinzig, A. (2000). Global biodiversity scenarios for the year 2100. *science, 287*(5459), 1770-1774.

Sargent, J., Tocher, D., Bell, J., Halver, J., & Hardy, R. (2002). Fish nutrition. *Academic press*, 182-257.

Subasinghe, R. (2017). World aquaculture 2015: a brief overview. *FAO Fisheries and Aquaculture Report*(1140).

Subasinghe, R., Soto, D., & Jia, J. (2009). Global aquaculture and its role in sustainable development. *Reviews in Aquaculture, 1*(1), 2-9.

Terziyski, D., Grozev, G., Kalchev, R., & Stoeva, A. (2007). Effect of organic fertilizer on plankton primary productivity in fish ponds. *Aquaculture international, 15*(3-4), 181-190.

Tesfahun, A., & Temesgen, M. (2018). Food and feeding habits of Nile tilapia Oreochromis niloticus (L.) in Ethiopian water bodies: A review. *International Journal of Fisheries and Aquatic Studies, 6*(1), 43-47.

Tilahun, A., Alambo, A., & Getachew, A. (2016). Fish production constraints in Ethiopia: A review. *World Journal of Fish and Marine Sciences, 8*(3), 158-163.

Tsadik, G., & Kutty, M. (1987). Influence of ambient oxygen on feeding and growth of the tilapia Oreochromis niloticus (Linnaeus). *FAO document AC168E*.

Wakjira, Tolemariam, T., Kim, J., & Kim, K. (2013). Aquaculture development in Ethiopia: Review on potential and strategy. *J of Agricultural, Life and Environmental Sciences, 25*(3), 20-25.

Watanabe, W. O., Losordo, T. M., Fitzsimmons, K., & Hanley, F. (2002). Tilapia production systems in the Americas: technological advances, trends, and challenges. *Reviews in fisheries science, 10*(3-4), 465-498.

Webster, C. D., & Lim, C. (2006). *Tilapia: biology, culture, and nutrition*: CRC Press.

8. APPENDICES

Annex 1: One-way ANOVA output for growth performance significance difference test within each treatment.

Dependent Variable	(I) Control, T1 & T2	(J) Control, T1 & T2	Mean Difference (I-J)	Std. Error	Sig.
IW	Control	T1	-.100000	.444656	.973
		T2	-.150000	.444656	.939
	T1	Control	.100000	.444656	.973
		T2	-.050000	.444656	.993
	T2	Control	.150000	.444656	.939
		T1	.050000	.444656	.993
IL	Control	T1	.000000	.362600	1.000
		T2	.065000	.362600	.982
	T1	Control	.000000	.362600	1.000
		T2	.065000	.362600	.982
	T2	Control	-.065000	.362600	.982
		T1	-.065000	.362600	.982
FW	Control	T1	-13.300000*	1.967744	.000
		T2	-24.050000*	1.967744	.000
	T1	Control	13.300000*	1.967744	.000
		T2	-10.750000*	1.967744	.000
	T2	Control	24.050000*	1.967744	.000
		T1	10.750000*	1.967744	.000
FL	Control	T1	-2.195000*	.278235	.000
		T2	-3.600000*	.278235	.000
	T1	Control	2.195000*	.278235	.000
		T2	-1.405000*	.278235	.000
	T2	Control	3.600000*	.278235	.000
		T1	1.405000*	.278235	.000
WG	Control	T1	-13.200000*	1.986247	.000

		T2	-23.900000*	1.986247	.000
	T1	Control	13.200000*	1.986247	.000
		T2	-10.700000*	1.986247	.000
	T2	Control	23.900000*	1.986247	.000
		T1	10.700000*	1.986247	.000
DGR	Control	T1	-.114783*	.017272	.000
		T2	-.207826*	.017272	.000
	T1	Control	.114783*	.017272	.000
		T2	-.093043*	.017272	.000
	T2	Control	.207826*	.017272	.000
		T1	.093043*	.017272	.000
RGR	Control	T1	-196.179564*	40.693285	.000
		T2	-353.818452*	40.693285	.000
	T1	Control	196.179564*	40.693285	.000
		T2	-157.638889*	40.693285	.001
	T2	Control	353.818452*	40.693285	.000
		T1	157.638889*	40.693285	.001
SGR	Control	T1	-.526393*	.076707	.000
		T2	-.792557*	.076707	.000
	T1	Control	.526393*	.076707	.000
		T2	-.266164*	.076707	.003
	T2	Control	.792557*	.076707	.000
		T1	.266164*	.076707	.003
FCF	Control	T1	-.073877*	.021973	.004
		T2	-.086459*	.021973	.001
	T1	Control	.073877*	.021973	.004
		T2	-.012582	.021973	.835
	T2	Control	.086459*	.021973	.001
		T1	.012582	.021973	.835

* The mean difference is significant at the 0.05 level

Annex 2: One-way ANOVA output of water quality parameters in control and treatment groups.

Dependent Variable	(I) Control, T1 & T2	(J) Control, T1 & T2	Mean Difference (I-J)	Std. Error	Sig.
Temperature	Control	T1	.58095	.51669	.512
		T2	1.23333	.51669	.069
	T1	Control	-.58095	.51669	.512
		T2	.65238	.51669	.433
	T2	Control	-1.23333	.51669	.069
		T1	-.65238	.51669	.433
DO	Control	T1	3.04405*	.81725	.004
		T2	4.55214*	.81725	.000
	T1	Control	-3.04405*	.81725	.004
		T2	1.50810	.81725	.184
	T2	Control	-4.55214*	.81725	.000
		T1	-1.50810	.81725	.184
Salinity	Control	T1	-.00619*	.00181	.008
		T2	-.01310*	.00181	.000
	T1	Control	.00619*	.00181	.008
		T2	-.00690*	.00181	.003
	T2	Control	.01310*	.00181	.000
		T1	.00690*	.00181	.003
Electric conductivity	Control	T1	-17.47619*	4.87520	.006
		T2	-34.85714*	4.87520	.000
	T1	Control	17.47619*	4.87520	.006
		T2	-17.38095*	4.87520	.006
	T2	Control	34.85714*	4.87520	.000
		T1	17.38095*	4.87520	.006
Total Dissolved	Control	T1	-11.57143*	4.07379	.028
		T2	-25.04762*	4.07379	.000

Solid	T1	Control	11.57143*	4.07379	.028
		T2	-13.47619*	4.07379	.010
	T2	Control	25.04762*	4.07379	.000
		T1	13.47619*	4.07379	.010
PH	Control	T1	.43929*	.16463	.040
		T2	.56810*	.16463	.008
	T1	Control	-.43929*	.16463	.040
		T2	.12881	.16463	.718
	T2	Control	-.56810*	.16463	.008
		T1	-.12881	.16463	.718

Annex 3: One-way ANOVA output for zooplankton

		Sum of square	df	Mean square	F	Sig
Cope pod	Between group	136635238.100	2	68317619.05 0	10.301	.001
	Within group	119382857.100	18	6632380.952		
	Total	256018095.200	20			
Rotifera	Between group	97922857.140	2	48961428.57 0	8.069	.003
	Within group	109220000.000	18	6067777.778		
	Total	207142857.100	20			
Cladocera	Between group	14000000.000	2	7000000.000	10.023	.001
	Within group	12571428.570	18	698412.698		
	Total	26571428.570	20			

Annex 4: One-way ANOVA output for phytoplankton

		Sum of square	df	Mean square	F	Sig
Chlorophyta	Between group	291435238.100	2	145717619.000	10.684	.001
	Within group	245497142.900	18	13638730.160		
	Total	536932381.000	20			

Euglenophyta	Between group	62452380.950	2	31226190.480	2.347	.0124
	Within group	239500000.000	18	13305555.560		
	Total	301952381.000	20			
Bacillariophyta	Between group	26000000.000	2	13000000.000	4.244	.031
	Within group	55142857.140	18	3063492.063		
	Total	81142857.140	20			
Cyanophyta	Between group	20166666.670	2	10083333.330	6.704	.007
	Within group	27071428.570	18	1503968.254		
	Total	47238095.240	20			

Annex 5: Plankton sample identified during the study period

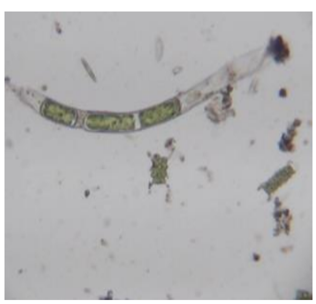
Phytoplankton

Chlorophyta group

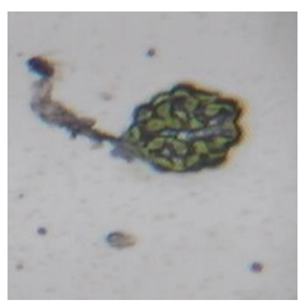
Zynema

X

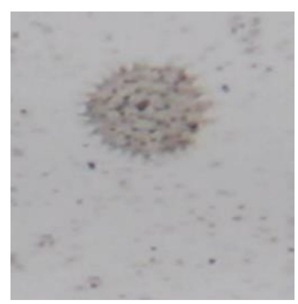
Closterium

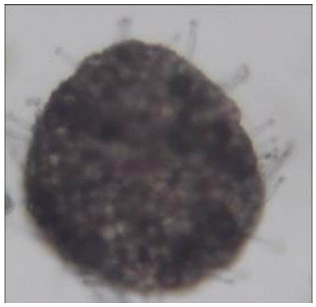
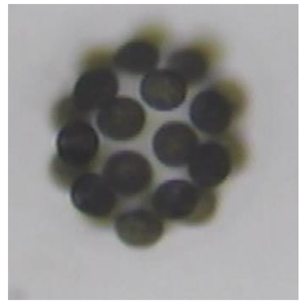
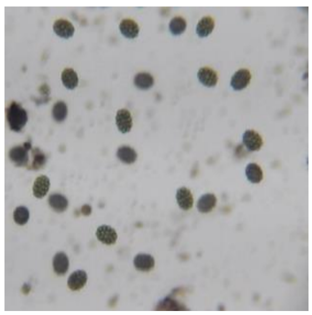
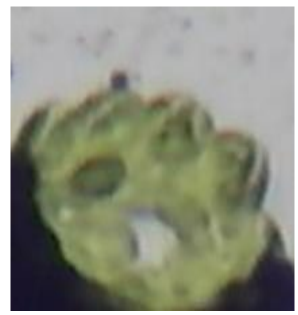
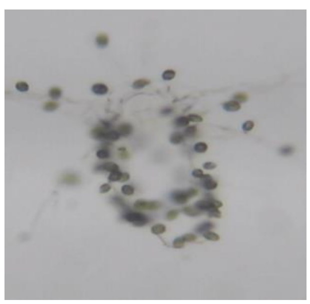
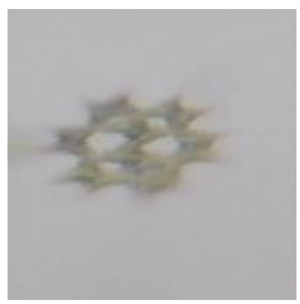


Mougeotia

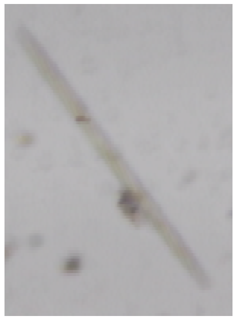


Coelastrum



			
	Pediastrum	Gonium	Ankistrodesmus
			
	Oedogonium	Pandorina	Spirogyra
			
	Chlorella	Tetraedron	Scenedesmus
Euglinophyta group			
	Euglena	Phocus	

Bacillariophyceae



Synedra

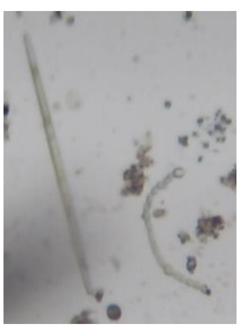
x

Gomphonema

Navicula

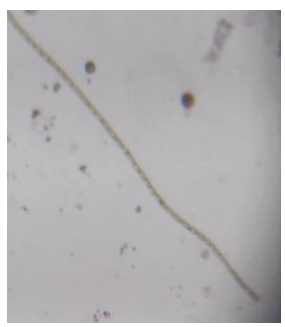
Fragilaria

Cyanoph

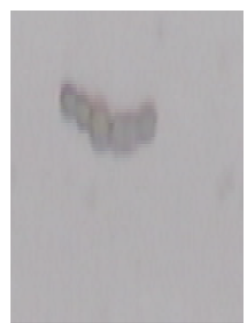


Nostoc

Trichodesmium



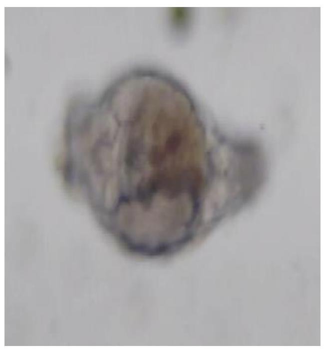
Anabaena

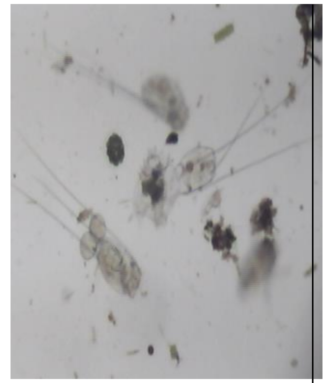


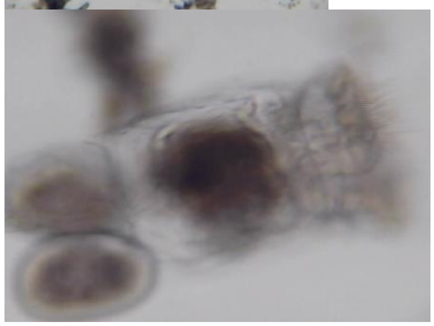
Zooplankton

Copepods group









Rotifer group

Cladocera group

Daphnia

Moina