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Research Article

EFFECTS OF STOCKING DENSITY OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*) (L. 1758) AND TYPES OF FERTILIZER ON WATER QUALITY IN EARTHEN PONDS IN TIGRAY, NORTHERN ETHIOPIA

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ABSTRACT

This research was conducted to assess effects of stocking density of Nile tilapia and fertilizer types on water quality in earthen ponds, in Tigray. The study was conducted in eight ponds of the same size of 10 m^2. Nile tilapia fingerlings were stocked excluding the two controls with stocking density of 5 individuals /m^2 and 10 individuals /m^2. Chemical fertilizers at the rate of 200 kg/ ha/2 weeks (0.2kg/10 m^2/pond /2 weeks) and Organic fertilizer (chicken manure) 1000 kg /ha /2 weeks (1kg/10 m^2 pond /2 weeks) were used. Data were collected bi-monthly sampling rate for a total of five months from December 2011-April 2012. Chi-square test was used to test any statistical significance effect of stocking density and fertilizer type on water quality parameters. Both stocking density and fertilizer type have significant effect on the water quality variables in earthen pond ($p<0.01$). On the other hand stocking density has no significant effect on transparency and total phosphorus ($P=0.2066$, $P=0.3391$), respectively. Inorganic fertilizer was strongly coorelated with total phytoplankton, chalorophyll a ($p<0.001$), but negatively coorelated with water transparency. Stocking density was inversly coorelated with total zooplankton. Dinophyceae group and Moina species were the dominant species in earthen pond respectively.

Keywords: Earthen pond, Fertilizer, Nile tilapia, Stocking density, Water quality

INTRODUCTION

Water quality is the assessment of physical, chemical and biological characteristics of water in general. It is a measure of the condition of water relative to the requirements of one or more biotic species and/or to any human need or purpose (APHA, 1998). Consequently, water quality can be defined by a range of different variables or parameters which limit water use for specific purpose (Boyd and Tucker, 1998). A good water condition is a prerequisite for the survival and growth of fish because most of the entire life process of the fish is wholly dependent in water quality (Hewitt *et al.*, 2006).

Nowadays worldwide view is increasing of demands on sustainable usage of primary resources, such as water. In addition to this there is an urgent need to improve semi-intensive fish farming systems especially in developing countries (Dulic *et al*., 2010). As the world population increases, the demand for high-protein foods will gradually rise from time to time especially in developing countries (FAO, 2004).

Fish growth depends on water quality in order to enhance its production, but physicochemical parameters of water are known to affect the biotic components of an aquatic environment in various ways (Ugwurnba and Ugwurnba, 1993). However, the secret of success in any fish farming operation depends to a large extent on the ability of the fish farmer to closely manage the pond water quality by monitoring its physical, chemical as well as the biological properties of water. Furthermore, it is argued that water supply and its quality is one of the limiting factors for fish culture in earthen pond and

for improvement of pond fisheries production by increasing the available natural food (phytoplankton and zooplankton) for larval fish it is necessary to fertilize the pond water with different organic and chemical fertilizers at different rate (Jasmine *et al*., 2011). Different types of organic fertilizer such as pig, cow, chicken and green manure are the most commonly used in earthen pond to enhance natural primary productivity for fish growth in many countries (El-Dahhar *et al*., 2006). Among those chicken manure is preferred because contain high level of phosphorus concentrations need by phytoplankton (Sathiadhas *et al.,* 2006). Organic manure provides economic benefit to the farmer and also locally accessible and at the same time it reduce 50 % cost from chemical fertilizer and supplementary feed (Hossain et *al*., 2006).

Earthen ponds are established to be the best medium, providing the best optimum conditions of effective fish growth as compared to the concrete ponds because of high natural productivity (Hussain *et al.,* 2011). To keep the earthen pond favourable for existence of fish, physical and chemical factors like temperature, turbidity, pH, dissolved oxygen, nutrients, etc must be controlled regularly and individually (Aslam and Afzal, 2002).

In earthen pond, the physico-chemical parameters of water like pH, temperature, dissolved oxygen, transparency, total phosphorus, total nitrogen, turbidity, amount of suspended matter, chlorophyll a and others are affected by excessive application of fertilizer, fish feed and other wastes materials that are toxic to fish and eventually could cause the fish farmer economic loss (Bhakta *et al.,* 2004). The physco-chemical component of water in general play great role in earthen pond for high production of fish. So the aim of the study is to assess the impact of fertilizer type and stocking density of *O. niloticus* on water quality parameters.

MATERIALS AND METHODS

Description of study area

This study is conducted in Aynalem, Mekelle zone of Tigray, Northern Ethiopia. The pond site was selected at downstream of Gereb Beati reservoir which is located at 13^0 26'57'' longitude and 39^0 25' 31'' latitude, and lies at latitude of 1251m.a.s.l. The study area is 6 km far from Mekelle the capital city of Tigray regional state.

Site selection

Inside Kalamino campus suitable site compatible to tilapia culture were selected to construct 8 ponds based on different. After appropriate sites were selected, a total of 8 ponds were constructed: each with an area of 10 m^2 (4 m in length x 2.5 m wide). Pipes of 10 cm diameters were fit to each pond in the water inlet. A screen of mesh wire (2 mm) was fixed to each of the water inlet and outlet to prevent the entrance of other small species, escape of experimental fish from the pond. Layers of fertile soil (top soil) were spread over the surface of the bottom of the pond to promote pond soil fertility. Following the standard procedures outlined in Sophea (2010), lime at rate of 200 gm/m^2 was added before stocking the fish to kill parasite and pathogenic organisms. Then a total of 450 O. *niloticus* fingerlings were collected from Midmar dam (Adwa) in Central Zone of Tigray, Seine net (with 25 m length x 2.5 m width stretched mesh size of 20 mm) was used collected fingerlings. Fishes were transported in plastic bag with oxygen to Kalamino special high school campus immediately after collection the fingerlings inside the plastic bags were gradually familiarized to water of the pond by floating the sealed bags in the pond water for 15 minutes to allow the water in the bag to attain the same temperature as the water outside the bag. Fingerlings with 2.77±0.39 g weight and 4.81± 0.11 cm length were stocked at a stocking density of 5 individuals /m^2 (50 individuals/10 m^2) and 10individuals /m^2 (100 individuals/10 m^2) then 2 of the ponds were provided with inorganic fertilizer and the other two were provided with organic fertilizer.

Firstly two ponds were conduct in a factorial design with two factors: Fertilizer (organic and in organic) and stoking density (50 and 100) with two levels each. This was designed to see the comparative effect of stocking densities of Nile tilapia and chemical fertilizer on water quality parameters. Fingerlings were stocked at a stocking density of 50 and 100 in each of the two ponds respectively. Chemical fertilizers at the rate of 200 kg/ ha/2 weeks (0.2kg/10 m2/pond /2 weeks) following the standard procedures outlined in (Yaro *et al*., 2005) were added in each ponds on bimonthly after water quality parameter samples were taken.

Secondly two ponds were conduct to investigate the effect of organic fertilizer (chicken manure in this case) and stocking density on Nile tilapia on water quality parameters. Organic fertilizer were added at rate of 1000 kg /ha /2 weeks (1 kg/10 m2 pond /2 weeks) following the standard procedures outlined in Yaro *et al*., (2005). Thirdly two ponds were designed to analysis the impact of stocking density of Nile tilapia on water quality parameters in earthen pond. In this case there were no additions of both organic and chemical fertilizer. But, stocking density of Nile tilapia was similar with the first and second one. The last two ponds were taken as control group. Those were design

without addition of fish, organic and chemical fertilizer used to compare and analysis the impact of fertilizer type and stocking density on water quality variables.

Data collection

During the study period Physical, chemical and biological water quality parameters were sampled every two weeks at 10:30 A.M from December 2011-April 2012. The physical water quality parameters measured were: temperature, dissolved oxygen, transparency and turbidity. Furthermore, chemical water quality parameter such as pH was measured in situ. Water transparency was measured using cylindrical Snell's tube in the field. Both dissolved oxygen (mg/l) and water temperature (°C) were sampled in all ponds using oxygen meter. pH was recorded using a portable pH meter (model 06020543). Turbidity and chlorophyll-a were measured by Fluorometer (model No: 8000-001) from the pooled sample taken by Tube sampler. Total nitrogen and total phosphorus sample was taken from the pooled sample and then transported to Mekelle University analytical chemistry laboratory for further analysis. Phytoplankton sampling was carried out on biweekly basis by using tube sampler then Phytoplankton sub sample was taken from the pooled sample and preserved in iodine solution. After that the sample were counted and identified using inverted microscope with magnification power 20x in the laboratory to genus level using identification keys of Toini and Torbjorn, (1992) then, Phytoplankton biomasses was estimated using bio mass software converter. Zooplankton sample were taken with a Schindler-Patalastrap sampler. Then samples were fixed in sucrose saturated formalin solution (4%) and transported to Mekelle University, Biology department aquatic laboratory centre. Zooplankton were counted and identified to a genus level using identification keys of Fernando (2002) in the laboratory under Stereomicroscope magnification power 35×

Data analysis

All the collected data were subjected to statistical analysis appropriate for each data. Chi-square without replicate is used to analyze the effect of fertilizer type (organic and inorganic using the no fertilizer treatment as a control) and stocking density (50 and 100 individuals/10 m^2 pond) on water quality parameters. Besides, t-test is used to see the effect of stocking density on water quality parameters (α=0.05). All statistical analyses were conducted using SPSS (Version 16). Sigma plot Ver.11.0 and Canoco Ver.4.5 were used to plot the graph.

RESULTS

PCA **analysis of water quality parameters, fertilizer type and stocking density in earthen pond**. The PCA (Fig.2) indicated that the varation and relationship of water quality variables in eight different earthen ponds. The eigenvalues of axis 1 was (38.4%) that of axis 2 (16.4%) (54.8 %). Phytoplankton increase turbidity also increase but, water transparency was highly decrease. Both stocking density and fertilizer type affected transparency of water. As compare inorganic fertilizer and organic fertilizer in organic fertilizer were highly affected or strong coorlation with turbidity, chlorophyll a, total phosphours, dissolved oxygen, pH and phytoplankton. Stocking density were highly affected than fertilizer type on zooplankton density. This, indicated as stocking density increase zooplankton density was dicrease. Total nitrogen was strong coorelation with stocking density. Ponds with no fertilizer and stocking density were higher water transparency and zooplankton density but, lower total phospours, phytoplankton and turbidity.

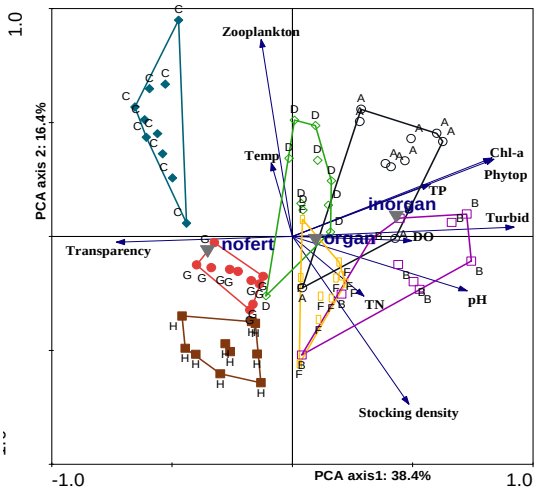


Figure 1 Figure 2 PCA (Principal Component Analysis) indicated water quality variables in earthen ponds.

Effect of fertilizer type on Chlorophyll a

The highest value of Chlorophyll a was recorded in pond (inorganic fertilizer with 50 and 100 stocking density). However lower value of chlorophyll a was recorded in the control group (absence of fertilizer but in the presence of fish) and this was inverse relation with time (see Fig. 3B and 3C). The highest value of chlorophyll a was record in ponds that contain in organic fertilizer. When compare the effect of inorganic fertilizer with organic fertilizer on Chlorophyll a inorganic fertilizer was highly significant (see Fig. 3A).

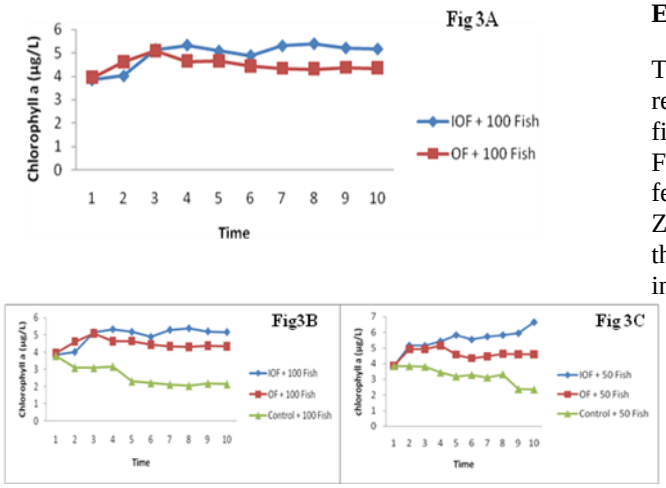


Figure 2: Effect of fertilizer type on Chlorophyll a (µg/L)

Key: IOF-Inorganic fertilizer; OF-Organic fertilizer

Effect of fertilizer type on transparency

As (Fig. 4B and 4C) indicated that highest value of transparency was recorded in the control group (absence of fertilizer but in the presence of fish). Inorganic fertilizer was highly affected water transparency compare with organic fertilizer; this showed the lower value of water transparency was recorded in ponds which contain inorganic fertilizer. Generally water transparency was positive correlation with time in the control group, while inverse correlation with fertilizer type. Inorganic fertilizer was significant effect than organic fertilizer on water transparency (see Fig. 4A). Both type of fertilizer were negative correlation with time.

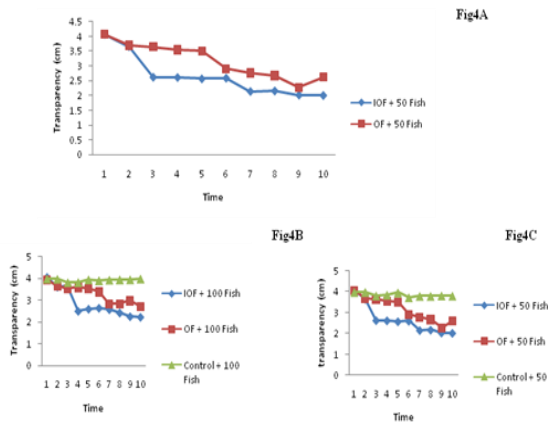


Figure 3 Effect of fertilizer type on transparency (cm)

Effect of fertilizer type on Zooplankton density

The highest values of Zooplankton density were records in ponds contain inorganic fertilizer with fish compare with organic fertilizer with fish (see Fig. 5A). However in the control group (absence of fertilizer but in the presence of fish) lower value of Zooplankton density were records. This indicated that zooplankton density were decrease as time increase in the control group (Fig. 5B and 5C).

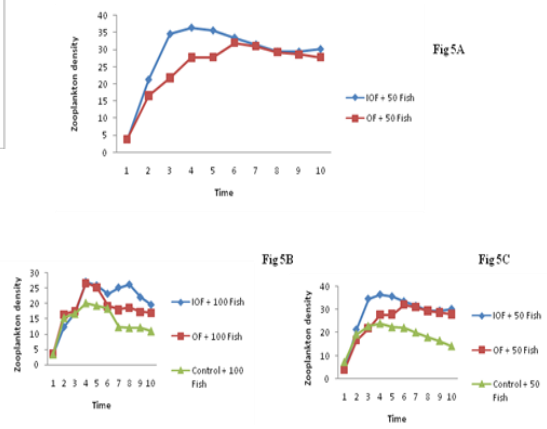
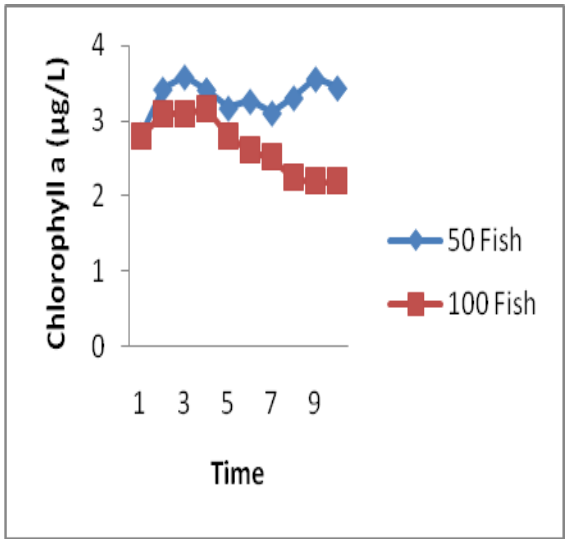


Figure 4 Effect of fertilizer type on Zooplankton density (individual/L)

Effect of stocking density on chlorophyll a

Highest chlorophyll a value was record in ponds with low rate of stocking density (50 fish/10m^2). In the control group (absence of fish) was record high value of chlorophyll a compared with the experimental group. As the experimental time increase density of zooplankton also increase in the control group, but it is reverse in the experimental group (see Fig 6).



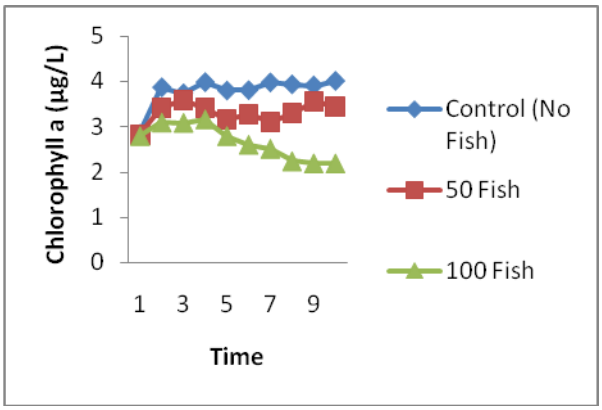
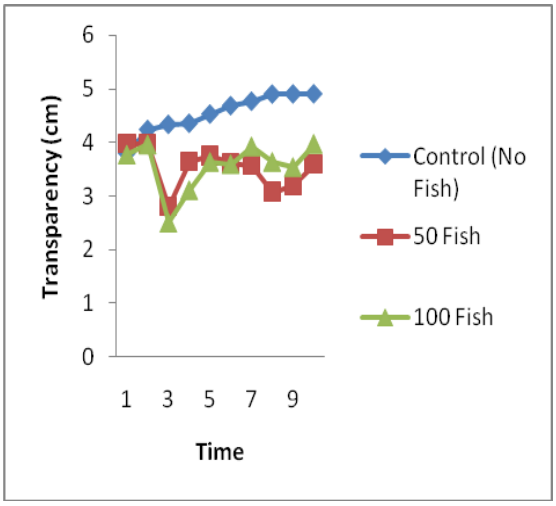


Figure 5: Effect of stocking density on chlorophyll a

Effect of stocking density on transparency

The highest water transparency were records in the control group (with absence of fish), but the lower value was recorded in ponds with the highest stocking density at the begging of the experiment, however this was reverse from the middle time to the end of the experiment. In the control group Zooplankton density was positive correlation with time (Fig 7).



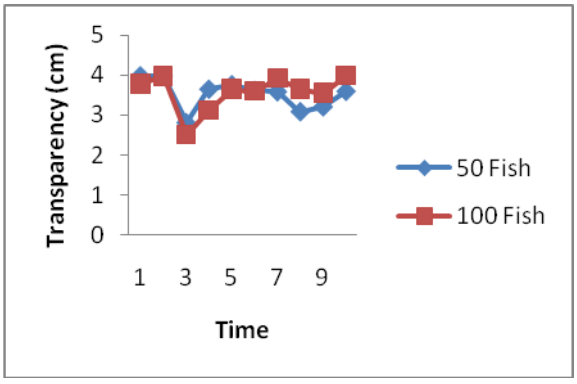
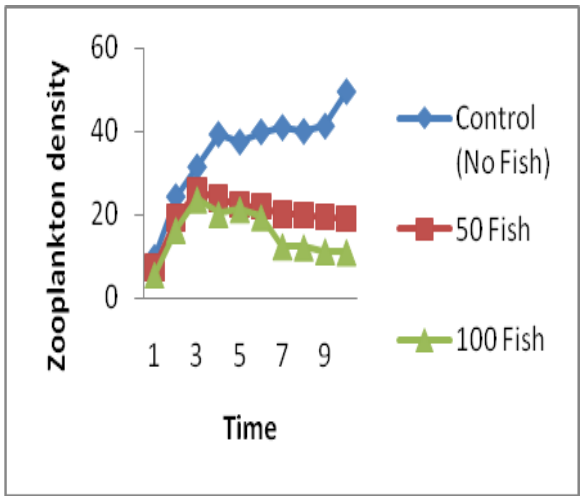


Figure 6 Impact of stocking density on transparency (cm)

Effect of stocking density on zooplankton density

Highest value of zooplankton density were record in the control group (no fish) compared with ponds contain high stocking density. However the lower values of zooplankton density were record in ponds with high rate of stocking density (100 fish/10m^2). (Fig 8) showed that as stocking density increase the density of zooplankton was decrease, but in the control group it is positive correlation with time.



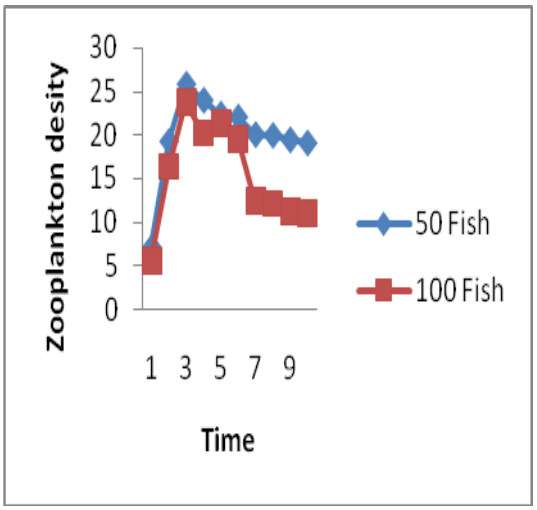


Figure 7 Effect of stocking density on zooplankton density

Diversity of zooplankton

In pond C higher abundance zooplankton were observed compered with the other ponds however, the lower average value of zooplankton species were recorded in pond H. *Moina* were the dominant genera in all ponds except in pond B. similar average value of *D.cf.simillis* and *Diaphnosoma* were recorded in pond C

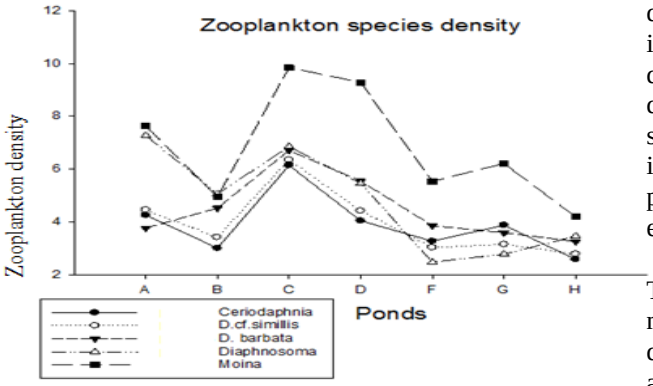


Figure 8: Diversity of zooplankton in earthen ponds

DISCUSSION

Previous studies by El naggar *et al.* (2008) indicated that fertilizer type was effective than stocking density on water quality parameters except for TN and chlorophyll "a" which were more affected by stocking density than fertilizer type. The present finding was in line with the previous result. The only exception here was chlorophyll a which was highly effect by fertilizer type and stocking density. In the case of the impact of chlorophyll a by fertilizer type was argue with (Nguenga *et al*., 1997, Jana *et al*., 2001) chlorophyll a was positive correlation with fertilizer type. This might be due to the addition of different contents of phosphorus and nitrogen that stimulate the production of planktonic organisms.

The present finding indicated that both stocking density and fertilizer type was posetively significant affect on pH, however types of fertilizer were highly significant impact on pH in earthen pond. This finding is inagreement with previous study by (Qin *et al* ., 1995). According to Elnady *et al*., (2010) higher values of pH were detected in the organic fertilizer treatments compared to those of chemical fertilizer treatments while the present finding the present finding indicated the higher pH value were recorded in ponds with presence of chemical fertilizer. This might be due to the higher algae production in the chemical fertilizer ponds and the accomulation of waste materials from fish, the presence of TN and TP in fertilizer type, high water solubility of chemical fertilizer than organic fertilizer and pH of water increases when plants are rapidly removing carbon dioxide from water for use in photosynthesis.

The present finding indicated that the highest mean value of dissolved oxygen recorded in ponds with the presence of inorganic fertilizer. This is in line with previous study by Qin *et al.* (1995). This is due to the high abundance of phytoplankton to increase in photosynthetic activity leading to dissolved oxygen production in earthen pond. Low dissolved oxygen can be lethal to aquaculture species. Some effects of low dissolved oxygen include stress, increased susceptibility to disease; poor feed conversion efficiency, poor growth and even death (Kramer, 1987).

The outcome of this finding argue that adding manure or fertilizer will have positive impact on dissolved oxygen, phytoplankton abundance and also inverse relationship with temperature and water transparency (Vromant *et al*., 2002). For tilapia species culture, the ideal water temperature is between 25°C and 30°C. The greater the requirement for oxygen and food and the faster the growth rate (Natividad, 1984), but the mean average value of temperature in the present outcome was much lower than the standard.

Water transparency showed an inverse correlation with plankton abundance and turbidity (Padmavathi and Prasad, 2007) this is in line with the present study in the case of fertilizer type. This could be fertilizer was highly stimulated the growth of phytoplankton because the presence of TN and TP and the movement of fish when compared with no fish ponds. The current finding indicated that both stocking density and fertilizer type increase turbidity of ponds. This might be due to increased suspended organic matter, fish movement in pond and the abundance of phytoplankton biomass (Boyd, 1984). Fertilization can be increased to a certain limit and deteriorate water quality (Dhawan and Kaur, 2002). The recent results are in line with the previous finding Abdel-Tawwab *et al*., (2005). Higher turbidity of water can decrease fish productivity as it reduce light radiation into the water and thus oxygen production by the water plants block filters and injure fish gills (Eer *et al*., 2004).

Concentrations of total phosphorus in water were higher in ponds with the greatest fertilizer inputs (Tabinda and Ayub, 2010). This finding agrees with the current finding. Stocking density were also a factor which influences the physico-chemical factors of earthen ponds water (Qin *et al* ., 1995). However the present study indicated that fertilizer type showed effect on most of water quality paramtres in earthen pond rather than stocking density.

The present finding was in line with Kamal *et al*., (2008), which demonstrated that total phytoplankton dominance in the presence of chemical fertilizer in earthen pond. This is due to the highest water solubility of chemical fertilizer compared with organic fertilizer so, enhance the

growth and abundance of phytoplankton. Eer *et al*., (2004) reported that average pH 6.5 favours good zooplankton abundance. Stocking density and fertilizer type on the density of zooplankton which was higher density recorded in the control group. This might be due to there was no Zooplanktivorous fish, no any fertilizer to flourished phytoplankton species but the current finding is disagree with the previous study by El-Dahhar *et al*., (2006). The increase in planktonic biomass was significant due to the addition of different levels of phosphorus and nitrogen fertilizers. However, response was poor in temperature without any addition of fertilizer. These results were in line with (Uddin *et al*., 1987 and Jana *et al*., 2001), who achieved better production of planktonic organisms with the addition of nitrogen and phosphorous fertilizers at various levels. This is due to fertilizer was highly stimulated the growth and abundance of phytoplankton in earthen pond. In this finding the readings of Secchi disc was dramatically decreased from at the beginning of the experiment to the end. This is in line with previous study by El-Dahhar *et al*., (2006) and this might be due to increase the level of chlorophyll a concentration and the disturbance of water sediment because of fish movement.

The out come of this finding argue with (Salama *et al* ., 2006), total nitrogen is positive relationship with stocking density of O. *niloticus*. This might be due to the addition of waste materials like fish faces and the disturbance of the water sediment in the case of fish movement. Moina is the dominant genera in this outcome similar with prvious finding by Abdel-Tawwab *et al*., (2005). This might be there were no fish in the control group (no fish, no fertilizer) to feed zooplankton species.

To conclude this present study water quality in fish pond is affected by the interaction of fertilizer type and stocking density in earthen pond. Fertilizer type has mostly affectes chlorophyl a, turbidity, total phytoplankton, pH and dssloved oxygen. Inorganic fertilizer has high effect on the water quality parameters in earthen pond when compering with or organic fertilizer and stocking density of O.*niloticus* affected zooplankton abundance in earthen pond.

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