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Vermicompost using WH substrate improves the productivity of tilapia fingerlings in Batu aquaculture ponds (Ethiopia)

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Abstract
A study was conducted to investigate the effects of different pond fertilization and physicochemical parameters on the growth performance of *Oreochromis niloticus* under pond aquaculture. Twelve concrete partitioned fish ponds, each measuring six m^2, were constructed and each pond was stocked with 18 *Oreochromis niloticus* fingerlings weighing seven grams, sourced randomly from the Batu Fish and Other Aquatic Life Research Center. The growth performance of *Oreochromis niloticus* was measured every 30 days for 90 days in water-filled ponds receiving Mixed Fertilizer (Triple superphosphate and Urea in 1:1 ratio), Triple Super Phosphate (TSP) alone, and Vermicompost (VC) as direct application fertilizer. The results showed that the highest fish production was obtained in ponds treated with VC (69.00±.78964 g) followed by MF (66.1917±.57309 g), TSP (63.144±.51088 g), and the lowest in control (CO) (51.00±.82446 g) ponds. The study concludes that different pond fertilizations affect the growth performance (SGR, DGR, FCR, and weight gain) of *Oreochromis niloticus* in various culture systems. The vermicompost has no effect on water quality in this study.

Keywords: Aquaculture, *Oreochromis niloticus,* Plankton, Pond fertilization, Vermicompost

Introduction

Aquaculture is the fastest-growing sector in global food production, serving not only as a vital source of dietary protein but also as a means of economic empowerment, particularly in developing countries where it contributes significantly to poverty alleviation and nutrition (FAO, 2016) [1]. However, despite its potential, aquaculture faces challenges, notably in productivity and environmental sustainability. Small-scale aquaculture is especially important for meeting the world's growing demand for fish. As fish require a smaller environmental footprint than other animal source food, aquaculture is a more environmentally sustainable option for meeting the world's food needs than other animal source foods (FAO, 2018) [2].

Overreliance on inorganic fertilizers has long been the norm in aquaculture, yet this practice has led to diminishing yields and declining product quality over time. In light of rapid industrialization and modernization, there's a growing recognition of the need to explore alternative fertilization methods that prioritize sustainability and environmental health. So to make aquaculture more economical, especially for small farmers and the rural community, there is a need to find alternative cheap sources of fertilizers. With advancements in science and technology, the concept of waste resource recycling has come up and newer technologies continually developed to cater to the needs of the various industries in this regard. Therefore, rather than using inorganic fertilizer; using organic fertilizer prepared from different materials is more appropriate, and using such fertilizers should ensure a hygienic condition, should be ecologically feasible and economically viable, and should ensure maximum production in the shortest period (Bhakta *et al*., 2004) [3].

Amidst these challenges, Water hyacinth (*Pontederia crassipes*), typically regarded as a harmful weed, has received much attention in recent years for its potential benefits as animal fodder, aqua feed, water purification, fertilizer, and biogas production, even food for humans and other products. Of particular significance is its role in agriculture as an organic fertilizer, where decomposed water hyacinth can be used as green manure or as compost that enriches soil fertility and crop yield, especially in regions where mineral fertilizers are prohibitively expensive (Ndimele, 2012) [4]. The indiscriminate use of chemical fertilizers has led to the deterioration of water and food, soil health, and contamination of air and attention has to be given to the organically managed system of aquaculture for the achievement of harmful chemicals-free and safe food for human consumption (Chakraborty *et al*., 2009) [5]. Hence, the potential of organic manures to enhance soil health and reduce reliance on chemical fertilizers is increasingly recognized as essential for sustainable aquaculture, ensuring the production of safe and nutritious food while minimizing environmental impact.

One promising avenue in organic fertilization is vermicomposting, a natural process facilitated by earthworms that transforms organic waste into vermicast, a nutrient-rich organic fertilizer. Research into the utilization of vermicompost in aquaculture holds promise for addressing the challenges of productivity and water quality. Studies have shown that vermicompost enriches pond ecosystems, promoting the growth of beneficial microorganisms and enhancing phytoplankton production. Improved water quality resulting from organic fertilization translates to higher fish yields, offering a sustainable solution to enhance aquaculture productivity. The advantage of the use of vermicompost as organic fertilizer is the quick availability of nutrients in 'ready-to-uptake' forms (Nath and Lannan, 1992) [6]. Therefore, vermicompost has been reported to result in higher survival and growth of aquatic organisms including fish and prawns (Kumar *et al*., 2007) [7] without adversely affecting the water quality.

Many fish farmers have continued to raise fish in different culture systems utilizing various inputs; commercial fish pellets, Diammonium phosphate, and lime whose information on their effects on fish production in different culture systems is limited. Therefore, since water hyacinth is locally available, plentiful free of cost, and very simple to compost; it's effective use as organic manure for fish production would be an interesting intervention to address related environmental issues. Limited work has been done (Sahu *et al*., 2002; Chakrabarty *et al*., 2009) [8, 5] to evaluate the utilization of water hyacinth compost as manure for fish rearing and on the growth and survival of tilapia. Despite its impact, Water hyacinth provides economic importance of compost making and rich source of different nutrients in Ethiopia which are used as a management tool (Bogale Ayana, 2021) [9].

In light of these considerations, this study aims to investigate the effect of water hyacinth-based vermicompost pond fertilization on the productivity and water quality of aquaculture ponds. Specifically, the study assesses the growth performance of *Oreochromis niloticus* in ponds receiving two inorganic fertilizers and one organic manure, namely; MF, TSP, and VC. Such knowledge is currently limited in the Ethiopian context. Therefore, this research seeks to contribute valuable insights into sustainable aquaculture practices and resource management.

2. Materials and Methods

2.1 Experimental Design

This research was carried out in 12 outdoor cement ponds that are part of the Batu Fish and Other Aquatic Life Research Center, Oromia Regional Agricultural Research Institute. The experiment involved the allocation of four treatment groups, each randomized in a triplicate pond. The first group served as control and was kept without fertilization. At the same time, other groups were given water hyacinth-based vermicompost, mixed with triple super phosphate (MF), and TSP. The treatment included Triple super phosphate (TSP) with a concentration of 0.225 kg / m^2/ 90 days, mixed fertilizer (Urea + TSP) at 0.205 kg/ m^2/ 90 days and water hyacinth vermicompost with concentrations of 1 kg/ m^2/ 90 days. For the purpose of achieving good natural food production, manure fertilizer was applied at regular intervals of 15 days to all treatment series, with the first application done 15 days before fish introduction.

2.2 Preparation of vermicompost

Vermicomposting pits were employed as the next step in this study. After being collected in a large sac from Ziway Lake, the water hyacinth samples were taken for distribution to recombinate at Batu Fish and Other Aquatic Life Research Center. Vermicompost preparation was carried out in the manner described by Gezahegn Degefe *et al*. 2012) [10]. Crushed and dried water hyacinth was used in vermicomposting, which involved the use of chopped and *Esenia fetida* species of worms from the Batu Fish and Other Aquatic Life Research Center.

2.3 Stocking of fish fingerlings

Average weight and length measurements of fish fingerlings of mixed sex were recorded before releasing the seeds into the pond for growth studies. After completing all pre-management practices, fish fingerlings were stocked in ponds to continue the experiments. Nile tilapia, *Oreochromis niloticus* of 7gm average weight was stocked at a stocking density of 3 fish/ m^2 which is recommended by Diana *et al*. (1995) [11]. The use of supplementary feeds composed of either Triple ingredient or formulated diets was observed in the growth and development of juvenile tilapia in ponds and cages (Zenebe Tadesse *et al*., 2012) [12]. The composition of the feeds was (35%, protein, fat %, fiber 4%, Ca, 2%, and moisture, 9%). Nile tilapia has a feeding pattern and dietary preferences that are dependent on their age and developmental stage (El-Sayed, 2006) [13]. As a result, in this experiment, the feed was given at three percent of the fish's body weight per day.

2.4 Water quality parameters

The pond site's water quality parameters, including temperature, dissolved oxygen, conductivity, and pH, was assessed twice a week using the HI 9829 multiparameter. Turbidity was measured monthly at noon using the Secchi disc. Visibility was calculated as the average depth at which the Secchi disc disappeared when lowered, and the depth at which it reappeared when raised (Boyd, 1990) [14]. Total alkalinity in terms of concentration of hydroxide (OH-), carbonate, and bicarbonate ions was estimated by titration with acid using phenolphthalein and methyl orange as indicators according to APHA (1985) [15] and finally read under spectrophotometer. Using an analytical spectrophotometer with seal at 530nm, the nitrate solution was read against a blank using the method of sodium salicylate. Phosphate (Ascorbic acid method), nitrite, and sulfate concentrations were analyzed biweekly using a spectrophotometer (AQ400) following the procedure by APHA (1999) [16]. Sodium, Calcium, and potassium were analyzed by flame photometer. Samples for water quality analysis were collected from the experimental ponds and it was collected and Analyses Of Variance (ANOVA) were performed to analyze the data collected.

2.5 Phytoplankton and Zooplankton identification

To estimate phytoplankton and zooplankton abundance in the experimental pond, water was collected from the surface of the water starting from December to February 2021/22. Zooplankton samples were collected by using plankton nets of different sizes. Similarly, phytoplankton samples were collected using plankton nets of different sizes. All samples collected were preserved in 5% formalin and stored in plastic containers in the laboratory. The plankton samples were examined with an inverted ZEISS Axiocam 202 digital microscope and identified using appropriate references and identification keys (Whit Ford & Schumacher, 1973) [17].

2.6 Growth Performance Parameters

At the end of the experiment, all fish had been collected, counted and length-weight data measured. Based on the data collected during the experimental period, Growth performance and feed utilization were calculated in terms of change in Weight Gain, Daily Growth Rate, Specific Growth Rate, Feed Conversion Ratio, and Survival Rate. Growth parameters were calculated following standard equations used by different investigators (Michael *et al.*, 1994, Gashaw Tesfaye and Zenebe Tadesse, 2008) [19, 20, 12]. The initial weight, length, and number of stocked fish were recorded on 15 November 2021 for each treatment. 1/3rd of the fish were sampled randomly from an earthen pond partitioned with concrete using a seine net every 15 days till 15 February 2022. The average body weight (ABW) and Average body length (ABL) of each sample of fish were measured by portable balance (Model: SKX2201) and measuring board. At the end of the experiment, the fish were harvested and counted, and the weight and length of all the fish were measured and calculated using the following formula.

Mean Weight Gain = Mean final weight (g) – Mean initial weight (g)

$$\text{Mean Daily Growth Rate (DGR, g/day)} = \frac{\text{Mean final weight} - \text{Mean initial weight}}{\text{Cultured days}}$$

$$\text{Specific Growth Rate (SGR, \%/day)} = \frac{\ln(\text{Mean final weight}) - \ln(\text{Mean initial weight}) \times 100}{\text{Culturing periods}}$$

$$\text{Food conversion ratio (FCR)} = \frac{\text{Feed fed (dry weight (kg) x 100}}{\text{Weight gained (kg)}}$$

$$\text{Survival rate (SR, \%)} = \frac{\text{Number of fish harvested x100}}{\text{Number of fish stocked}}$$

Statistical analysis of each experiment was done by using SAS 8.2 (SAS Institute, 2001) [18] statistical package. Data was analyzed by using One Way Analysis of Variance (ANOVA).

3. Results

3.1 Water quality: The results of the water quality parameters such as temperature, pH, dissolved oxygen, and Conductivity which were measured at the pond site with HI 9829 multiparameter and transparency during the experimental period, and other chemical parameters done in the laboratory were presented in Table 1.

Table 1: Mean of some physicochemical of pond water during the experimental period from 15th of November to 15th of February (2021/22) (Mean ± SE)

Parameters	Treatments			
	Vermicompost	**TSP**	**MF(Urea +TSP)**	**Control (CO)**
Temperature (C°)	20.39 ± 1.26^{a}	20.83 ± 1.49^{a}	20.46 ± 1.75^{a}	20.18 ± 1.54^{a}
DO (mg/l)	8.35 ± 2.07^{a}	8.75 ± 0.7^{a}	8.57 ± 1.62^{a}	8.06 ± 1.09^{a}
PH	9.77± 0.77^{b}	9 ± 0.00^{a}	9.65 ± 0.46 ^{b}	9.34± 0.23^{ab}
Conduct. (mS/cm)	2718.5 ± 328.83^{ab}	2769.83 ± 305.91^{ab}	2570.16 ± 162.48^{a}	2909.83 ±45.4^{b}
Alkalinity (mg/l)	34.70±.2876	36.70±.1034	39.51±.04601	39.83±.0572
Secchi depth (cm)	31.33 ± 1.21^{a}	34.67 ± 0.81^{b}	32 ± 0.89^{a}	36.67 ± 0.81^{c}
Nitrites (mg/l)	4.26 ± 0.26^{b}	4.46 ± 0.15^{c}	3.62 ± 0.04^{a}	4.62 ± 0.6^{c}
Nitrate (NO_3 mg/l)	8.61 ± 0.01^{d}	7.8 ± 0.02^{a}	8.14 ± 0.02^{b}	8.51 ± 0.14^{c}
Phosphate(mg/l)	0.5 ± 0.01^{c}	0.3 ± 0.07^{b}	0.16 ± 0.07^{a}	0.15 ± 0.01^{a}
Sulfate(SO_4, mg/l)	207.17 ± 7.17^{b}	273.22 ± 0.15^{d}	215.73 ± 0.67^{c}	148.5± 0.01^{a}
Sodium (Na, mg/l)	850.5 ± 7.17^{b}	993.99 ± 3.52^{c}	994.78 ± 3.07^{c}	640.16 ± 7.08^{a}
Calcium(Ca, mg/l)	42.30 ± 0.00^{b}	47.01 ± 0.7^{c}	48.74 ± 0.18^{d}	37.43 ± 0.12^{a}
Potassium(K mg/l)	48.45 ± 1.23^{b}	56.21 ± 0.15^{c}	60.47 ± 0.12^{d}	38.86 ± 0.08^{a}

Values in the same row having the same letters are not significantly different at p<0.05

3.2 Composition of Phytoplankton and Zooplankton Analysis in Experimental Ponds

The composition and relative abundance of phytoplankton and zooplankton in experimental ponds are presented in Table 2. Plankton composition was absent or very rare for the first week of pond fertilization in every experimental pond. Phytoplankton started appearing on its week and Zooplankton appeared after a week in each pond.

The results showed that the experimental pond developed green color which is an indication of the development of phytoplankton. Microscopic examination of pond water showed the presence of different species of phytoplankton. The Phytoplankton taxa are represented by the blue greens algae the *Cynophyceae*, the green algae the *Chlorophyceae*, *Euglenophyceae*, and the diatoms, the *Bacillariophyceae*. The blue-greens are represented by two genera namely *Microcystis* and *Chroococcus* spp; the green algae are represented by four genera such as *Chlorella*, *Ankistrodesmus*, *Sphaerocystis*, and *Chlamydomonas*; *Euglenophyceae* is represented by one genus the Euglena; and the diatoms by *Tabellaria*, *Fraglaria*, *Pinnularia*, and *Navicula*. Among the four phytoplankton groups, *Bacillariophyceae* showed the highest abundance composition in all four treatments on various sampling days, whereas *Cyanophyceae* showed the lowest trend in all the treatments. The phytoplankton abundances were found in increasing order in vats treated with VC followed by MF and then by TSP. Zooplankton is represented by four taxa; *Brachionus*, *Copepods (Cyclopoids)*, *Rotifers*, and *Keratella*.

3.2. Composition of Phytoplankton and Zooplankton Analysis in Experimental Ponds

The composition and relative abundance of phytoplankton and zooplankton in experimental ponds are presented in Table 2. On its week, phytoplankton made their first appearance, and then Zooplankton appeared after a week. Green algae were detected in the experimental pond, suggesting that phytoplankton have evolved over time. The Phytoplankton taxa consist of *Cynophyceae*, *Chlorophyceae*, *Euglenophyceae* and *Bacillariophyceae*, which are blue green algae. The abundance composition of phytoplankton groups was highest among *Bacillariophyceae* on different sampling days in all four treatments, but lowest among *Cynophyceae* in each of the other two. Vats treated with VC, then MF, finally TSP showed an increasing pattern of phytoplankton abundance.

Table 2: Phytoplankton and zooplankton identified in the treatment ponds

Phytoplankton Group	Treatments			
	Vermicompost	TSP	MF(Urea +TSP)	Control
Cyanophyceae (Blue green algae)	*Microcyst*$^{+++}$	*Microcyst*$^{+}$	*Microcyst*$^{+}$	*Microcyst*$^{+}$
	Chroococcussp. $^{++}$	*Chroococcussp.*$^{+}$	*Chroococcussp.* $^{+}$	*Chroococcussp.* $^{+}$
Chlorophyceae (Green algae)	*Chlorella*$^{++}$	*Chlorella*$^{++}$	*Chlorella*$^{++}$	*Chlorella*$^{++}$
	Ankistrodesmus^{+}	*Ankistrodesmus*$^{+}$	*Ankistrodesmus*$^{+}$	*Ankistrodesmus*$^{+}$
	Sphaerocystis^{+}	*Sphaerocystis*$^{+}$	*Sphaerocystis*$^{+}$	*Sphaerocystis*$^{+}$
	Chlamydomonus^{++}	*Chlamydomonus*$^{++}$	*Chlamydomonus*$^{++}$	*Chlamydomonus*$^{++}$
Euglenophyceae	*Euglena*$^{++}$	*Euglena*$^{++}$	*Euglena*$^{++}$	*Euglena*$^{++}$
Bacillariophyceae (Diatoms)	*Tabellaria*$^{++}$	*Tabellaria*$^{++}$	*Tabellaria*$^{++}$	*Tabellaria*$^{++}$
	Fraglaria^{+++}	*Fraglaria*$^{+}$	*Fraglaria*$^{+}$	*Fraglaria*$^{+}$
	Navicula^{+++}	*Navicula*$^{++}$	*Navicula*$^{+++}$	*Navicula*$^{++}$
	Pinnularia^{++}	*Pinnularia*$^{+}$	*Pinnularia*$^{++}$	*Pinnularia*$^{+}$
Zooplankton Group	*Cop.(Cylopoids)*$^{+++}$	*Cylopoids*$^{++}$	*Cylopoids*$^{++}$	*Cylopoids*$^{++}$
	Rotifera^{++}	*Rotifera*$^{++}$	*Rotifera*$^{++}$	*Rotifera*$^{++}$
	Brachionus^{+++}	*Brachionus*$^{++}$	*Brachionus*$^{++}$	*Brachionus*$^{+}$
	Keratella^{+}	*Keratella*$^{+}$	*Keratella*$^{+}$	*Keratella*$^{+}$
Note: - $^{+++}$ Most abundant, $^{++}$ Abundant, $^{+}$ Rare				

3.3 Growth performance of fish

The growth performance of fish in different treatments in terms of initial weight gain, specific growth rate (SGR% per day), food conversion ratio (FCR), and survival rate (%) is presented in Table 3. There was no significant difference in mean initial length and mean initial weight between treatment and control groups (Table 3). However, there was a regular increase in the weight of fish in all the treatments; however, the growth was much greater in the treated with ponds vermicompost than in other treatments. Among the various treatments, maximum growth increment, and total gains were recorded with VC followed by MF and TSP. A minimum growth rate was recorded in the Control groups. This indicates that tilapia production can be increased in ponds treated with vermicompost at a dose of 1 kg/ m^2/ 90 days or 10,000 kg/ha which was nearly similar to the study done by Abhed and Parveen (2020) [21].

Table 3: Growth parameters of tilapia observed in different treatments

Parameters	Treatments			
	VC	TSP	MF	CO
Fertilizer added (kg)	6	1.35	1.215	0
Mean initial weight (g)	7.00 ±.78964^{a}	7.144±.51088^{a}	7.1917±.57309^{a}	7.00 ±.82446^{a}
Mean final weight (g)	69.00±.78964^{a}	63.144±.5108^{c}	66.1917±.57309^{b}	51.00±.8244^{d}
Mean initial length(cm)	8.433 ±.4633 ^{a}	8.3944±.1379^{a}	8.4120±.3490 ^{a}	8.400 ±.4232^{a}
Mean final length (cm)	13.900 ±.5652^{a}	13.944±.1464^{a}	13.914±.1115^{a}	12.833±.057^{b}
SGR (% per day)	2.54	2.49	2.44	2.20
Daily growth rate (g/d)	0.688	0.655	0.622	0.488
Weight gained (g)	62	56	59	44
Feed given in (g)	86.40	86.40	86.40	86.40
Food Conversion Ratio	1.39	1.54	1.46	1.96
Survival rate (%)	94	94	94	100
Stocking den.(3fish/m^2)	18	18	18	18

Results in the same row having the same letters are not significantly different at $p<0.05$

Average Body Weight (ABW)
The averages of the initial body weight of fish at the beginning of the experiment were found to be 7.00+.78964, 7.144+.51088, 7.1917+.57309, and 7.00+.82446 g and for fingerlings groups of VC, TSP, MF, and CO respectively. During the three-month experimental period, the fish in the three groups showed variations in growth rate. In the 1st, 2nd, and 3rd months after the experiment started, differences in body weights among the fingerlings were different within fingerling groups. The fish fingerlings of the VC showed higher growth (mean = 69.00+.78964 g), as compared with either the MF (mean weight = 66.1917+.57309 g), the TSP group (mean weight = 63.144+.51088 g) and (mean weight = 51.00+.82446 g) for control sets after three months. The growth trend of the fish recorded at two-week intervals over three months between November and March 2021/22 is shown in Figure 1.

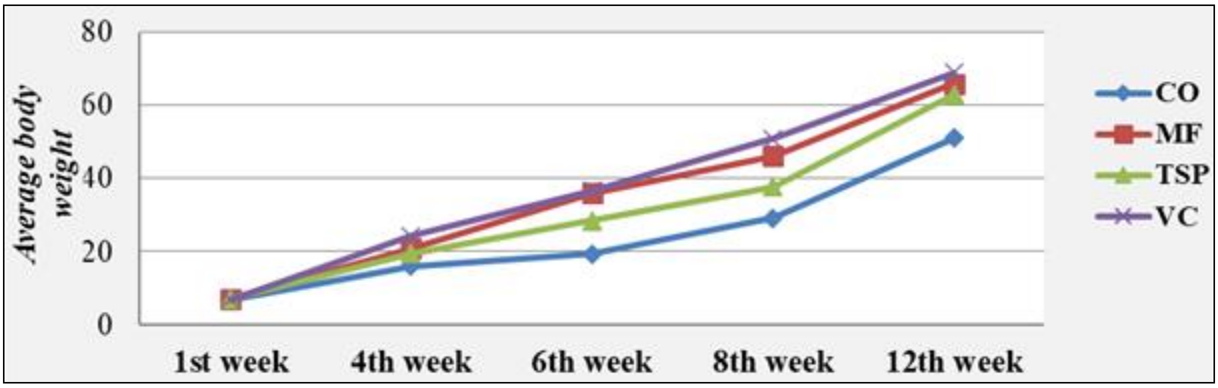

Fig 1: Fortnightly and monthly growth trend of *Oreochromis niloticus* in average body weight

Average Body Length (ABL)
The averages of the initial body length of fish at the beginning of the experiment were found to be 8.433+.4633, 8.3944+.1379, 8.4120+.3490, and 8.400 +.4232 cm for fingerlings groups (VC, MF, TSP, and CO) respectively. During the three-month experimental period, the fish in the four groups showed variations in total length. During the period's 1st, 2nd, and 3rd months after the experimental start, differences in body length among the fingerlings were different within fingerling groups. The fish fingerling of the VC group showed higher total length (mean length = 13.900+.5652 cm), as compared with CO (mean length = 12.833+.0574) and nearly similar with either MF (mean length = 13.944+.1464 cm) or the TSP group (mean length = 13.914+.1115 cm) after 3 months.

4. Discussion
4.1 Water quality parameters
Research on the physico-chemical parameters of an aquatic ecosystem is basic for understanding its biological productivity. Although each factor plays its role, it is the synergistic effect of various parameters that determines the composition and productivity of the flora and fauna. A conducive range of these factors is essential for obtaining optimum fish production. Among physicochemical factors influencing aquatic productivity; temperature, pH, total alkalinity, dissolved oxygen (DO), Secchi disc, and dissolved inorganic nutrients like nitrate and phosphorus are considered to be important. However, the water quality parameters tested in the pond water revealed that all the parameters are within the acceptable levels required for the normal growth and physiological activities of the Nile tilapia *Oreochromis niloticus* (Anand *et al*., 2013) [22].
Analyzing physico-chemical features of an aquatic ecosystem is essential for comprehending its biological activity. Although each factor plays its role, it's the synergistic effect of various parameters that determines the composition and productivity of the flora and fauna.

A. Temperature
Water temperature is one of the most influencing environmental factors affecting pond dynamics and both the metabolism and growth of fish (Boyd, 1990) [14] and it is the basic environmental factor that affects the chemical and biological reaction in water (Boyd, 1982) [23]. According to Anita Bhatnagar and Pooja Devi (1993) [24], acceptable range, desirable range, and stress for pond water fishery are 15 - 35, 20 - 30, and <12, >35 ○C) respectively. As depicted in Table 1, the water temperature during this study was typically between 20.18 C and 20.83 °C on average. Water temperature was favorable for fish culture as mentioned by Boyd (1990) [14]. Tilapia can tolerate water temperatures as low as 12 °C and cannot survive in water temperatures below 10 °C for prolonged periods (Carbolla *et al*., 2008) [25].

B. Dissolved oxygen (DO)
Boyd (1982) [23] and Banerjea (1967) [26] recommended that pond waters should have an acceptable concentration of DO of 6 to 9 mg/L for optimal production. The DO content in the study was found to be between 8.06 and 8.7583 mg/l, which was suitable for fish culture (Boyd, 1990) [14] and similar to the results of Abdel-Tawwab *et al*. (2007) [27]. In the pond waters treated with vermicompost, DO was found to be at maximal level as compared to control. This might be due to the abundance of phytoplankton that increases photosynthetic activity leading to the production of large amounts of DO.

C. pH
Factors such as the pH of source water, acidity of bottom soils, and biological activity determine the PH of fish in a fish pond. In cases where CO2 concentrations are different, and carbon dioxide levels are high, the pH of water samples may be altered (Boyd & Lichtoppler 1979) [28]. According to Santhosh and Singh (2007) [29], the suitable pH range for fish culture is between 6.7 and 9.5 and the ideal pH level is between 7.5 and 8.5, and above and below this is stressful to

the fish. This study's pH values were between 9.00 and 9.76, suggesting that the current state of this particular pond is nearly appropriate for its fish consumption. According to Popma and Masser (1999) [30], Tilapia can survive in a pH ranging from 5 to 10, but they do best in a pH range from 6 to 9.

D. Turbidity of the water (Secchi depth)
The turbidity of water in SD visibility tests is typically caused by suspended soil particles and/or plankton abundance (Boyd, 1990) [14]. Boyd and Lichtkoppler (1979) [28] suggested that the presence of clay turbidity in water with depths of 30 cm or less may prevent plankton blooms. They also noted that 30 to 60 cm is generally enough for fish production, and values above 60c can lead to an increase in dissolved oxygen problems. According to Bhatnagar *et al*. (2004) [31] turbidity range from 30-80 cm is good for fish health; 15-40 cm is good for an intensive culture system and < 12 cm causes stress. According to the current study, pond water is suitable for fish growth as the readings between 31.33 and 36.67 cm were found for Secchi disks.

E. Alkalinity
The strength of the water's alkalinity, which is a gauge of its ability to endure changes in pH, is used to determine the total number of bases present in pond water, including carbonates, bicarbonates and hydroxides, as well as dissolved calcium, magnesium, and other compounds. A small amount of acid can cause a significant change in pH when the alkalinity is low. Moyle (1946) [32] gave the range of total alkalinity from 0.0 - 20.0 ppm for low production, 20.0 - 40.0 ppm- low to medium, 40.0 - 90.0 ppm- medium to high production, and above 90.0 ppm- productive. In the current investigation, the pond's productivity was measured in the range of 34 to 39 mg/l depending on the total alkalinity. Vermicompost ponds can enhance the control of alkalinity in a thriving ecosystem, as indicated by these results.

F. Nitrate concentration (NO^3-)
Where ammonia and nitrite are toxic to the fish, nitrate is harmless and is produced by the autotrophic Nitrobacter bacteria combining oxygen and nitrite. According to Stone and Thomforde (2004) [33], nitrate is relatively nontoxic to fish and does not cause any health hazard except at exceedingly high levels (above 90 mg/l). Santhosh and Singh (2007) [29] described the favorable range of 0.1 mg/l to 4.0 mg/l in fish culture ponds. In the present study, nitrate concentration in the fish pond averaged between 7.8083 and 8.6133 mg/l and this level has no negative factor for the fish cultured. The results were similar to the study by Kiran (2010) [34], who recorded 4.5 mg/l to 8.0 mg/l in fish ponds of the Bhadra project in Karnataka.

G. Available phosphate
The majority of phosphorus found in water is in the form of PO4 and surface water usually contains bound particles attached to living or dead particulate matter, while insoluble Ca3 (PO4)2 and adsorbed phosphates are present in soil and colloids, except under highly acidic conditions. In Abowei (2010) [35], the acceptable range, desirable range and stress condition are defined as 0.03 –2, 0.01 -3 and above 3 mg/l respectively. In the present study, the total phosphate concentration was between 0.1510 and 0.507 mg/l in the ponds. The phosphorus content in this study was considered to be reasonably high. It is also in agreement with Bhatnagar and Devi (2014) [36], who stated that aquaculture ponds are required to have an optimum range of 0.01-3 mg/l.

4.2 Plankton community in the pond
Water-dwelling organisms that are not capable of swimming but instead move through the motions of the water are known as planktons. The green algae and diatoms were found to be abundant in the pond water (Smith & Swingle, 1938) [37]. Therefore, the high levels of phytoplankton and zooplankton is also served as an important food source for fish. Considering the significance of plankton, it was discovered that Nile Tilapia could meet more than 50% of its nutritional needs by feeding on algae and zooplankton, particularly during its early stage of development (Karisa, 2008) [38]. The phytoplankton growth in the treatment pond was evident in its light greenish water. Pond water samples from various algal species were also observed at a microscopic level (Table 2). This resulted in flagellates (mainly the Euglena and diatoms) dominating the more green-colored water of the pond. The addition of Organic matter to the experimental pond from the accumulation of feeds may have resulted in Euglenophytes dominating the treatment area.

4.2.1 Composition of phytoplankton populations
These findings suggest that the addition of organic fertilizers to fish ponds can increase the amount of nitrogenous compounds and minerals found in these areas, which are crucial for phytoplankton growth. Manures and fertilizers are said to enhance the phytoplankton's productivity in fish ponds by increasing their growth, as reported by Lin *et al*. (1998) [39], Dang and Dalsgaard, (2012) [40], and Saad *et al*. (2014) [41]. Therefore, in this study in all the treatments, green algae (*Chlorophyceae*) and diatoms (*Bacillariophyceae*) dominated abundantly and commonly the phytoplankton population and flagellates (*Euglenophyceae*) constituted rare compared with the former. Among the different phytoplankton groups, blue-green algae (*Cyanophyceae)* were the least found. Even though, among different phytoplankton groups, an abundantly higher *Cyanophyceae* population was seen in the Vermicompost-treated pond; while differences concerning the phytoplankton population were different among treatments. All the treatments had a predominance of various phytoplankton groups, with *Bacillariophyceae>Chlorophyceae>Euglenophyceae >Cyanophyceae*. Increased water hyacinth compost levels could be linked to the lower *Cyanophyceae* population, which may have impeded the growth of other phytoplankton species as noted by Paerl and Tucker (1995) [42]. Better planktonic growth was recorded by the application of organic manure i.e., water hyacinth compost in ponds, agreeing with the reports published (Saha *et al*., 1974) [43]. The water hyacinth compost might have enriched the water, leading to an increased plankton population. This was supported by Silva and Anderson (1995) [44] who reported that phytoplankton and zooplankton are rich sources of protein often containing 40-60% protein on a dry matter basis and is sufficient to support excellent fish growth. Saad *et al*. (2014) [41] found that nitrogenous and phosphorus compound fertilizers improve the growth of phytoplankton

and zooplankton which in turn improves the growth performance of the fish.

4.2.2 Composition of zooplankton populations

Compared to inorganic fertilizer (MF and TSP) in this study, the water hyacinth compost (vermicompost) has been found to have a positive impact on the Zooplankton population. The current study suggests that the water hyacinth compost has contributed to an increase in *copepoda* population by dominating all zooplankton populations in VC, MF, TSP, and CO, respectively. In all treatments, the population of *Rotifera* has been higher than that in other treatments by abandoning VC-treated ponds. The *Brachionus* population was significantly higher in VC than in MF and TSP, as well as the Control treatment. Of the zooplankton population, *Keratella* were the least abundant group of Zooplankton species. *Copepod (Cyclopoids)* > *Rotifera* > *Brachionus* > *Keratella* were the zooplankton groups that predominated. The findings indicate that the inclusion of water hyacinth compost has no impact on the dominance order of different zooplankton groups in any of the treatments. Improved planktonic growth and increased productivity were observed in ponds with the use of water hyacinth fertilizer, as reported in Sahu *et al*. (2002) [8]. The presence of *Rotifera* and *Copepoda (Cyclopoids)* was observed in ponds with water hyacinth fertilized, suggesting an increase in planktonic plant species.

4.3 Growth performance of cultured Nile tilapia

The growth of tilapia (*Oreochromis niloticus*) depends on the pond fertilization, stocking density, food quality and energy content of the diet, its physiological status, reproductive state, and environmental factors such as temperature, pH, etc. (Lovell, 1989) [45]. There was a regular increase in the weight of fish in all the treatments; however, the growth was much greater in the treated ponds than in the control. Among the various treatments, maximum growth increment, and total gains were recorded with VC followed by MF and SP. A minimum growth rate was recorded in CO. For the evaluation of proper growth performance of tilapia fingerling in different treatments during the experimental period, initial weight, final weight, weight gain, Daily growth rate (DGR %/day), SGR (%/day), Survival rate (%) and Food conversion ratio (FCR) were calculated.

Fish final weight: As presented in Table 3 the average initial body weight of fingerlings was 7g during the stocking and the final body weight was found to be 69.00+.78964 g, 66.1917+.57309 g, 63.144+.51088 g, and 51.00+.82446 g for fingerlings groups (VC, MF, TSP, and CO) respectively. There was no significant (P>0.05) difference in the initial weight of fish in different treatments (Table 3) but there was a significant difference in the final weight of fish in different treatments. Over the three-month experimental period, the differences in body weights among the fingerlings were significant between groups. The fingerlings stocked under a vermicompost-treated pond showed significant (p<0.05) higher total mean weights which were 69.00+.78964 g and minimum final weight was observed in Control 51.00+.82446 g treatment where only supplementary feed was applied in 3 months. These results are to the findings of Chakrabarty *et al*. (2008) [46] who reported that the growth performance of Nile tilapia cultured in earthen ponds recorded significantly higher plankton production that ultimately enhances the fish growth in vermicompost-treated ponds as compared to traditionally used organic and inorganic fertilizers.

Fish weight gain (g): The weight gain of fish was 62.5±2.55, 59±2.05, 56.6±1.06 and 44.0±2.47 g in (VC, MF, TSP and CO) treatments respectively. The highly significant (P<0.01) weight gain (62.5 g) was found in treatment VC, where manuring with vermicompost was applied at the dose of 1 kg/ m^2/90 days or 10,000 kg/ha with 3% feed of body weight, and the lowest weight gain (44.0 g) was found in CO where only supplementary feed was applied. The average weight and total fish yield achieved in any treatment charged with VC were essentially higher than that of the MF, TSP, and Control treatments, VC might be a cost-effective fertilizer in tilapia culture, replacing the expensive chemical fertilizer MF and TSP. This is particularly significant in our country Ethiopia where the purchasing power of fish farmers for chemical fertilizer is very low, and VC forms an abundant alternative natural resource for inexpensive P fertilizer. The lowest and the highest production of fish in CO and VC (set) were related to the lowest and the highest ratio of the treatments.

Daily growth rate (g/day): The average values of the daily growth rate of tilapia were 0.688, 0.655, 0.622, and 0.488 g in treatments (VC, MF, TSP, and CO) respectively. However, the daily growth rate acquired on this observation is much decreased than the outcomes mentioned for O. niloticus. According to Liti *et al*. (2005) [47], *O. niloticus* fed with and without premix attained a daily growth rate ranging between 1.3 and 1.5 g/day. Workagegn and Gjoen (2012) [48] additionally pronounced daily growth rates ranging from 0.68 and 0.86 g/day for distinct *O. niloticus* strains. However, the result in this study was higher than the result reported by Ogunji *et al*. (2008) [49] which were stated as a lower daily growth rate (0.16-0.23 g/day). El-Shebly (1998) [50] had higher DGR values (1.56-3.47 g/d) in tilapia offering supplemental food (25% crude protein) twice daily in addition to fertilization. Yi *et al*. (2002b) [51] obtained a higher DG R (2.11 g/d) for tilapia-consumed food containing 30% protein in addition to fertilization.

Specific growth rate (%/day): Vermicompost application showed a significant increase in SGR for tilapia in comparison to the control, which had risen to 2.54%/day in the VC group. This outcome is similar to Silva's (2020) [52] analysis of 2.58%/day, while Rafiee *et al*. (2019) [53] the feeding protocol used for all three treatments resulted in a lower SGR of 1.84-0.13%/day. In this study, among the treatments used (VC, MF, TSP and CO), the specific growth rate of tilapia was averaged at 2.54, 2.49, 2.44 and 2.22, respectively for these species. Specific Growth Rates of *O.niloticus* in this study as compared to the reports of Abdel-Tawwab (2004) [54] that ranged between 0.97-1.23% per day and Ashagrie Gibtan *et al*. (2008) [55] from 0.79-1.03% per day were higher. But it is closely similar as Workagegn and Gjoen (2012) [48] reported that *O. niloticus* levels were between 2.59-2.73% of daily values.

Survival rate (%): The survival rate recorded was fairly high ranging from 94 to 100%. Tilapia fingerling's growth with vermicompost indicates its amenability to intensive culture practice. However, this may additionally be attributed to favorable environmental situations at some stage in the experiment. This agrees with El Sherif *et al*. (2011) [56] who found out that survival of up to 100% could be linked to good environmental conditions.

Food conversion ratio: FCR is an important indicator of the quality of fish feed and a lower FCR indicates better utilization of the fish feed (Mugo *et al*., 2013) [57]. FCR recorded in this study were 1.39, 1.54, 1.46, and 1.96 in VC, TSP, MF, and CO respectively. Therefore, food conversion ratio values obtained in the (VC) were better than those obtained in other treatments (Table 3). The low FCR of 1.39 exhibited in the VC-treated pond indicates that the fish utilized the feed well. The current FCR values also coincided nearly with ranges reported for O. niloticus ranging from 1.43 to 2.30 (Al-Hafedh, 1999) [58]. Still, they were lower than the FCR of 2.6 to 3.0 in tilapia fed on on-farm formulated diets in fertilized ponds (Liti *et al*., 2005) [47]. The result of the FCR that ranged between 1.39 and 1.96 in the present study is also nearly between the recommended values of 1.5 for aquaculture (Stickney, 1979) [59]. This enhancement in the food conversion ratio suggests efficient food utilization by extracting more nutrients from the food & converting it into flesh (Bhijkajee & Gobin, 1997) [60]. Also, the variation might probably be due to, different culture environments and feed quality as has been reported by Guimaraes *et al*. (2008) [61]. It could also be the digestibility of the feed given since there is no information on the digestibility of the locally formulated feed.

The quality of fish feed is closely linked to the FCR, with a lower FCR being indicative of better feeding behavior (Mugo *et al.,* 2013) [57]. Accordingly, the (VC) yielded higher food conversion ratio values than those obtained with other treatments. VC-treated ponds showed fish using the feed well, with an FCR of. FCR values were almost at the same ranges reported for O. In the current study, the FCR between 1.39 and 1.96 is almost at or near to the 1.5 values that are generally considered suitable for aquaculture (Stickney, 1979) [68].

Generally, the overall growth rate of *Oreochromis niloticus* during the whole experimental period was higher than 0.488 grams a day. The TSP group and the MF group did not show any variation, leading them to suggest that the vermicompost-treated pond would be more productive as the natural food needed by tilapia was highly produced. The current experiment's high fish yield and growth rates are largely due to the availability of natural food with high nutritional value in both treatments. The primary productivity of water and the absolute growth of fish in all treatments were highly predictive of each other, just as was found in the current experiment. Boyd (1982) [23] recommended that tilapia should be kept in water for aquaculture to achieve the maximum growth and development potential, while also meeting all the necessary physical and chemical water properties.

5. Conclusion and recommendations

5.1 Conclusion

Also, vermicomposting can convert refuse and aquatic plants into useful products that are environmentally friendly and help to improve the nutrient balance of soils. The biochemical composition and bacterial population of water hyacinth are particularly noteworthy, with the resultant vermicompost being more abundant than most other plants, and there are fewer antibiotic-resistant bacteria. When compared to inorganic Mixed Fertilizers or Triple Super Phosphate fertilizers, vermicompost provides higher levels of nutrients, increased plankton and nutritional value, and optimal water quality conditions for fish growth. Additionally, vermicompost consumption can be reduced in feed expenses, making it a cost-effective and environmentally beneficial option for farmers that should be promoted for regular pond fertilization. The use of red worms in the production of vermicompost makes it an easy and inexpensive natural source for manure and fish feed, respectively, with better results for fish.

In the vermicompost-treated pond, the best weight gain per fish and the highest success rate in all growth parameters (food conversion ratio to nutrients/weights), as well as specific growth rate and total weight gained. A significant effect on growth, feed conversion, and weight gain can be observed when treated ponds with organic (vermicompost) and inorganic fertilizer (TSP), but not survival.

5.2 Recommendation

Based on the above conclusions the subsequent recommendations are forwarded:

- Based on a study, it is suggested that vermicompost should be used in earthen ponds for better productivity, but this may vary depending on the desired output and available resources for managing carrying capacity.
- To improve production, vermicompost made from water hyacinth weed can be used to fertilize the ponds and prepare natural feed for Nile tilapia.
- To create the necessary fish food organisms for a low-cost Nile tilapia cultivation in the water, it is recommended that fertilization at 1kg/m^2/90 days or 10,000 kg/ha of water hyacinth vermicompost with an additional feed of 3% body weight of fish.
- Manuring ponds with tilapia, which are commonly raised for fish, was suggested by the study to avoid any negative impact on water quality parameters.

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