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Water Quality in Floating Raft Aquaponic Systems With Different Types of Plants in Cultivation of Tilapia (*Oreochromis niloticus*)

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A B S T R A C T

This research aims to determine the effect of the floating raft aquaponic system with different types of plants on water quality in cultivation of tilapia (*Oreochromis niloticus*) and to obtain plants that are very good for maintaining water stability. This study used a Completely Randomized Design (CRD) with 4 treatments and 3 replications. The parameters tested in this research were phosphate, pH, temperature and DO, with treatments K (control), A (water spinach plants), B (pakchoi plants) and C (lettuce plants). The difference in aquaponic system plants in tilapia (*O. niloticus*) cultivation had a significant effect on pH and DO. Water spinach plants (*Ipomoea reptans poir*) were the best plants in maintaining water quality with phosphate values in H56 of 1.41 mg/L, pH 8.51, temperature 25.7°C and DO 8.23 mg/L.

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INTRODUCTION

Aquaponics is a combination of plants and fish in a cultivation that utilizes waste from fish farming as fertilizer for plants. In principle, aquaponics applies a recirculation system where water from the fish farming container is returned to the container after going through a filtration process (Shobibah *et al.*, 2022). The advantage of the aquaponic system is that it utilizes high nitrogen for horticultural growth.

One type of freshwater fish that has high economic value is tilapia (*O. niloticus*). Where this fish is the main commodity in the national program. The development and cultivation of tilapia is given more attention in this program, in order to achieve export demand and the local market (Siantara *et al.*, 2017). The reason farmers increase fish production through intensive cultivation is so that the potential for the fish market also increases. The results of fish physiological activities will increase waste in the cultured water which is in line with intensive cultivation, where this waste will become a hazardous substance in the water. Poor water quality will affect fish growth, therefore, in the maintenance process, good cultivation media are also needed (Setijaningsih and Suryaningrum, 2015).

The recirculation system can be applied to the cultivation media as water management, where plants can be used as filtration (Haspari, 2020). The filtration process by plants can be said to be aquaponics (Setijaningsih and Chairulwan, 2015). FAO (2014) states that the plants selected in aquaponics are related to the extent to which the plants are able to absorb wastewater from cultivation. This ability is the basis for considering the use of plants as biofilters. Aquaponic plants are divided into two, namely green leafy plants and vegetable plants. The choice of plants is categorized based on the duration of the application of the aquaponic system to be carried out. This is related to the extent to which each plant is effective in managing waste.

Research on the use of green plants in aquaponics has been conducted by Nazlia and Suraiya (2018). The study utilized catfish with an initial weight of 0.35 g which was cultivated for 42 days, and used water spinach and green mustard greens. The results showed that the growth rate value in the aquaponic system was relatively high, at 13.40±0.17%/day. Thus, tilapia was chosen as a cultivation commodity that could be considered by maintaining a fairly promising market potential. Using different plants in the aquaponic system can ensure that all the nutrients needed by the aquaponic system can be met properly.

LITERATURE REVIEW

Tilapia has a wide body morphology, which is one third of its slender body length, relatively large scales, large and prominent eyes. There are five fins, namely the dorsal, ventral, pectoral, anal and caudal fins. It has 9-11 weak rays and three hard rays, two weak rays are located on the caudal fin and 6-18 weak fin rays. The dorsal fin has 17 hard rays and 13 weak fin rays. Then the pectoral fins have five weak fin rays and one hard fin ray, on the ventral fin there is one hard fin ray and five weak fin rays as well as scales that cover the entire body (Amri and Khairuman, 2007).

The classification of tilapia (*O. niloticus*) according to Lukman *et al*. (2014) is:

Kingdom : Animalia
Phylum : Chordata
Sub Phylum : Vertebrata
Class : Pisces
Sub Class : Achanthopterygii
Ordo : Perciformes
Family : Cichlidae
Genus : Oreochromis
Species : *Oreochromis niloticus*

The aquaponic system is a simple integrated system between hydroponics and aquaculture where the results of metabolic waste and feed waste can be used as plant fertilizer (Stathopoulou *et al*., 2018 *in* Shobihah *et al*., 2022). According to Hasan *et al*. (2017) stated that the aquaponic system can make fish and plants mutually beneficial, because fish feces that dissolve in water will produce nutrients for plant growth, while plant roots can be used as biological filters that can produce good water quality for fish survival. Using an aquaponic system can be a profitable cultivation option, because with an aquaponic system, we can save land (narrow land), save water, easy to install and maintain and environmentally friendly.

METHODOLOGY

Time and Place

This research was conducted in June - August 2024 at the Dryland Fisheries Laboratory, Nusa Cendana University. Water quality testing in the form of phosphate was carried out at the UPTD Environmental Laboratory, Environmental and Forestry Service, while pH, temperature and DO measurements were directly at the research site.

Tools and Materials

The tools used in this study were thermometers, pH meters, DO meters, scales, rulers, soldering irons, pens, notebooks, cameras and trays, while the materials used were tilapia, F-1 feed, kale plants, pak choi, lettuce, tarpaulins, plastic cups, styrofoam and charcoal.

Test Animals

The test animals used in this study were tilapia (*O. niloticus*) with a size of ± 13 cm, which came from the Dryland Fisheries Laboratory of Nusa Cendana University with a total of 180 fish with an average weight of 27.621 g and a stocking density in each tarpaulin pond of 15 fish. This fish will be acclimatized or adjusted to the environment for one week.

Aquaponic System Preparation

Preparation of plant seeds, done by sowing kale, pak choi mustard and lettuce seeds in a bucket that has been filled with rice husks. Then it will be covered again using rice husks so that the plant seeds are not lifted. The growth period of these three types of plants is one week with 2 or 3 leaves. Then prepare the charcoal that will be used as a plant support in a plastic cup container. Before using charcoal, it should be washed first. After that, the plastic cup is placed on a Styrofoam that has been perforated with a size of 40 × 40 cm, where the holes in the Styrofoam are 12 holes. Styrofoam is used for plastic cups containing plants to remain afloat.

The feed given to the fish during the study was in the form of commercial pellet feed F-1 which has 38% protein, with a feeding rate of 3% and a frequency of feeding twice a day, namely in the morning at 09:30 WITA and in the afternoon at 16:30 WITA, with a maintenance period of 60 days.

The maintenance container uses a tarpaulin pool measuring 100 × 50 × 50 cm. The tarpaulin pool is placed on a wooden frame. One wooden frame is used by four treatments. Then the tarpaulin pool is filled with water with a water height of 30 cm (150 L).

Experimental design

The experimental design used was a Completely Randomized Design (CRD) with 4 treatments and 3 repetitions, the composition of the four treatments, namely*:*

K : control without using plants
A : Aquaponic system using water spinach plants
B : Aquaponic system using pakchoi plants
C : Aquaponic system using lettuce plants

Test Parameters

Test parameters include Phosphate, pH, temperature and DO. Phosphate was tested at the UPTD Environmental Laboratory, Department of Environment and Forestry. Water samples were tested at the beginning of maintenance (H0) and the end of maintenance (H56). The phosphate tested was orthophosphate, while temperature, pH and DO were measured directly at the research location. Where temperature was measured using a thermometer, pH was measured using a pH meter and DO was measured using a DO meter. Measurements of temperature, pH and DO were carried out once a week, namely in the morning at 08:00 WITA, noon at 12:00 WITA and evening at 16:00 WITA

Data Analysis

The data obtained from the research results were analyzed statistically using analysis of variance (ANOVA) in SPSS. If the analysis of variance data shows that the treatment shows a real or very real effect, then to compare the values between treatments, the Tukey test can be continued.

RESEARCH RESULT

Phosphate

The average phosphate value during the study on tilapia aquaponics can be seen in the following graph*:*

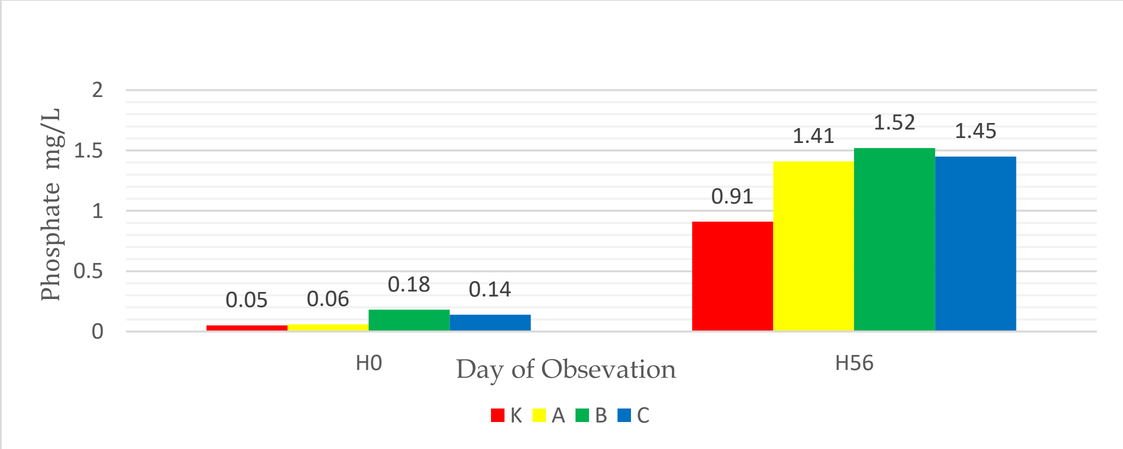

Figure 1. Average Phosphate in Tilapia Aquaponics Cultivation

Based on the results of the ANOVA test on H0, it shows that the difference in plants does not have a very significant effect on phosphate. Meanwhile, based on the results of the ANOVA test on H56, it shows that the difference in plants also does not have a very significant effect on the phosphate content in tilapia aquaponics (*O. niloticus*).

Temperature

The average morning temperature value of the aquaponic system in tilapia cultivation can be seen in the graph in Figure 2 below:

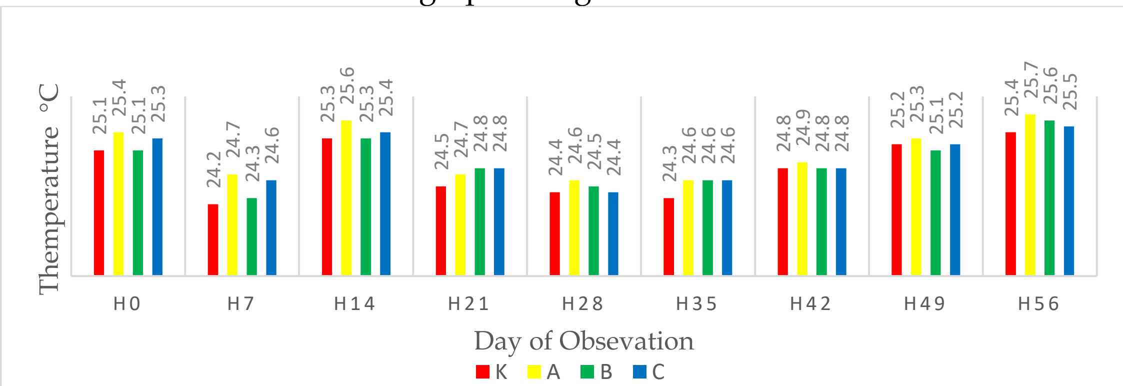

Figure 2. Average Morning Temperature of Tilapia Aquaponics Cultivation

The results of the ANOVA test on H56 showed that the difference in plants in the aquaponics system did not have a very significant effect on the morning temperature of the tilapia *(O. niloticus*) aquaponics system. Based on the results of the study, the average highest temperature value was in treatment A which ranged from 24.6°C-25.7°C, and the lowest temperature was in treatment K which ranged from 24.2°C-25.4°C. The morning temperature in the tilapia aquaponics study was measured at 08:00 WITA, and measurements were taken once a week for eight weeks.

The average daytime temperature of aquaponics in tilapia (*O. niloticus*) cultivation can be seen in the graph in Figure 3 below:

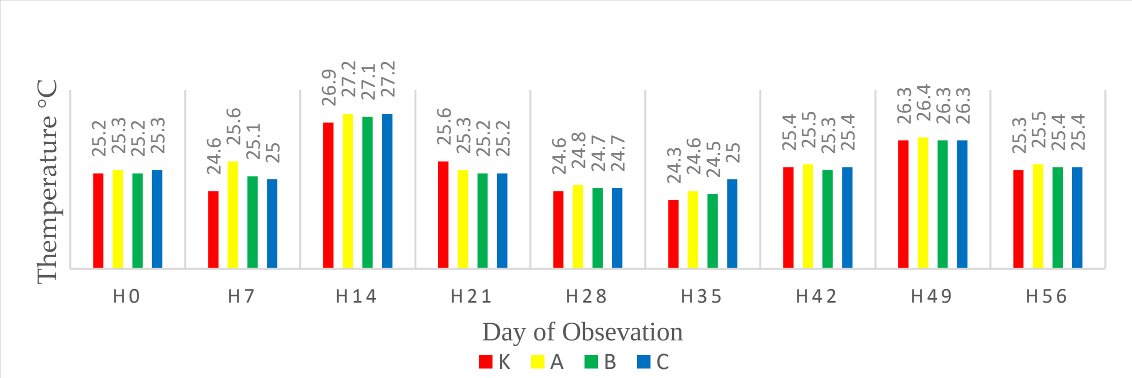

Figure 3. Average Afternoon Temperature of Tilapia Aquaponics Cultivation

The results of the ANOVA test at H56 showed that the difference in plants in the tilapia aquaponics system did not have a very significant effect on afternoon temperatures. Based on the results of the study, the average value of the highest afternoon temperature was in treatment A with a range of 24.9°C-27.4°C, while the lowest afternoon temperature was in treatment K with a range of 25.3°C-27.3°C. Afternoon temperatures were measured once a week, namely at exactly 16:00 WITA, which was carried out for eight weeks.

The average afternoon temperature value in the tilapia (*O. niloticus*) aquaponics cultivation system can be seen in the graph in Figure 4 below:

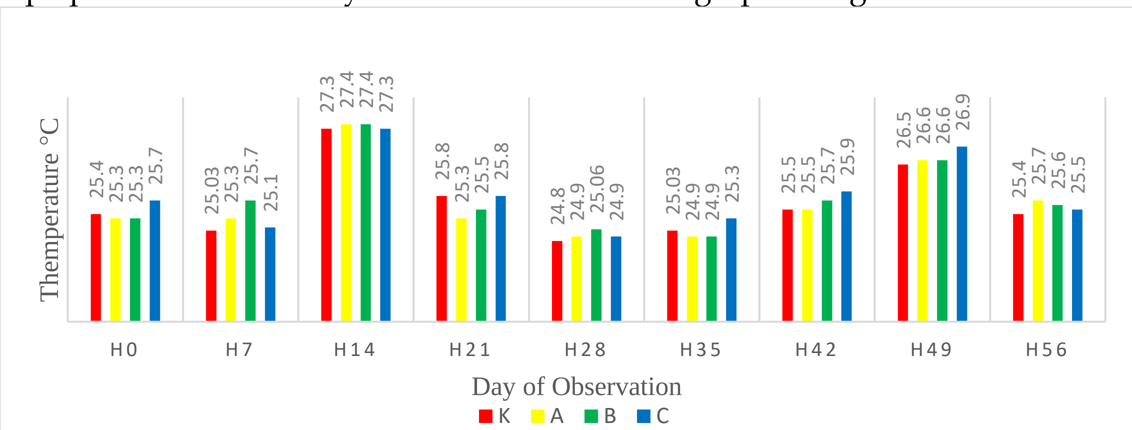

Figure 4. Average Afternoon Temperature of Tilapia Aquaponics Cultivation

The results of the ANOVA test at H56 showed that the difference in plants in the tilapia aquaponics system did not have a very significant effect on afternoon temperatures. Based on the results of the study, the average value of the highest afternoon temperature was in treatment A with a range of 24.9°C-27.4°C, while the lowest afternoon temperature was in treatment K with a range of 25.3°C-27.3°C. Afternoon temperatures were measured once a week at exactly 16:00 WITA for eight weeks.

Acidity Degree (pH)

The average morning pH value during the study can be seen in the following graph:

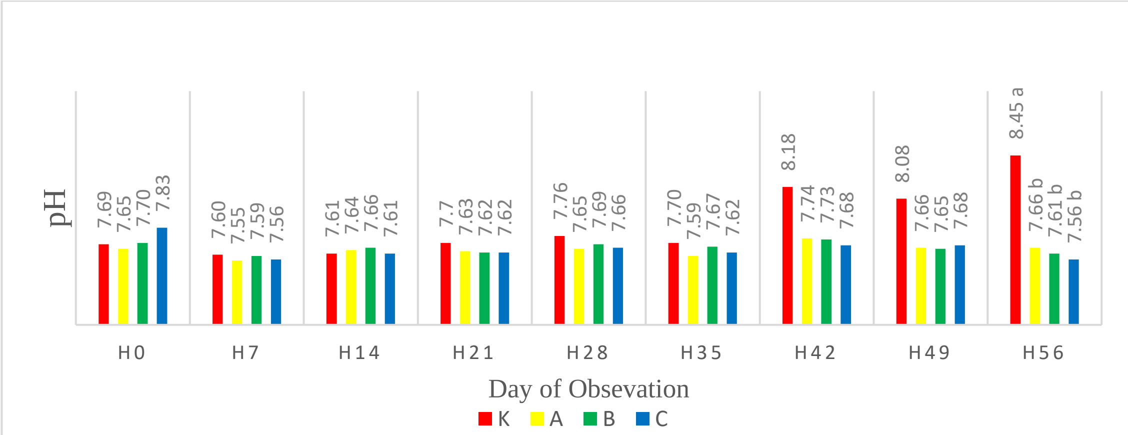

Figure 5. Average Morning pH of Aquaponics in Tilapia Cultivation

The results of the ANOVA test at H56, showed that the difference in plants in the tilapia aquaponic system had a very significant effect on the morning pH, so a further Tukay test was carried out which showed that the K treatment was significantly different from A, B and C. Based on the results of the study, the highest morning pH was in the K treatment with a range of 7.69-8.45, while the lowest morning pH was in the A treatment with a range of 7.55-7.66.

The average value of the afternoon pH in the tilapia aquaponic system can be seen in Figure 6 below:

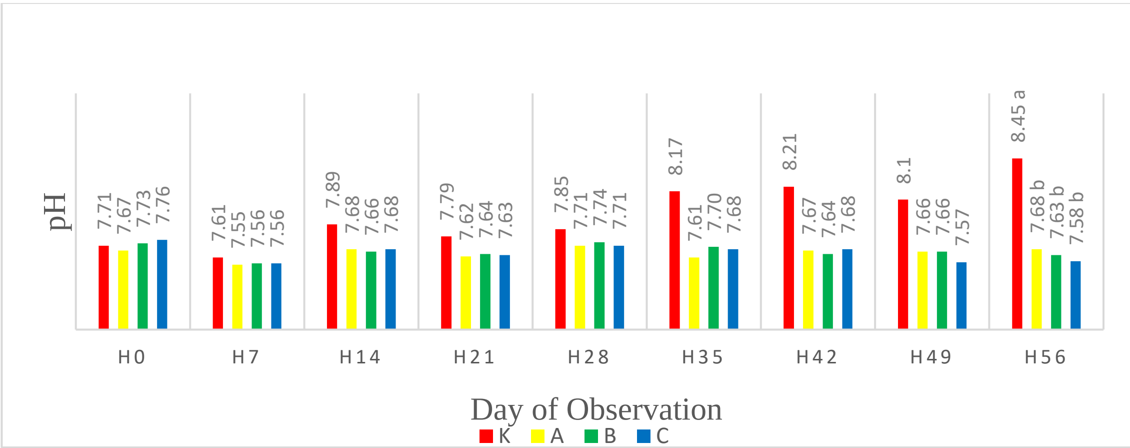

Figure 6. Average Afternoon pH of Aquaponics in Tilapia Cultivation

The results of the ANOVA test at H 56 showed that the difference in plants in the tilapia aquaponic system had a very significant effect on the afternoon pH, then a further test (tukay) was carried out which showed that the K treatment was significantly different from treatments A, B and C, namely the highest afternoon pH value was in the K treatment, which ranged from 7.61-8.45, while the lowest afternoon pH was in treatment A, which ranged from 7.55-7.71.

The average afternoon pH value in the tilapia aquaponic system can be seen in Figure 7 below:

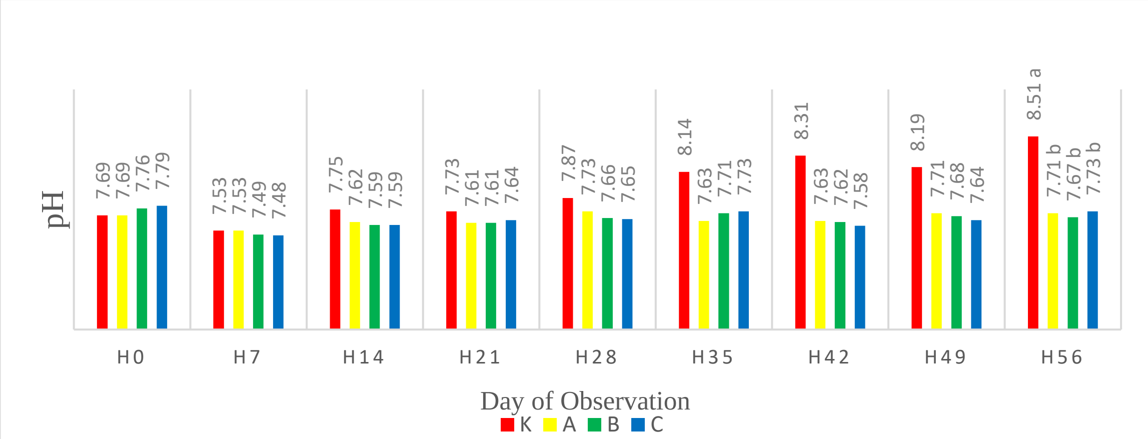

Figure 7. Average Afternoon pH of Aquaponic System in Tilapia Cultivation

The results of the ANOVA test at H56 showed that the difference in plants in the aquaponic system had a very significant effect on afternoon pH, then a further test (tukay) was carried out which showed that the K treatment was significantly different from treatments A, B and C, namely with the highest afternoon pH in the K treatment with a range of 7.53-8.51, while the lowest afternoon pH was in treatment A with a range of 7.53-7.69.

Dissolved Oxygen (DO)

The average morning DO value of the aquaponic system in tilapia cultivation can be seen in the following Figure 8 graph:

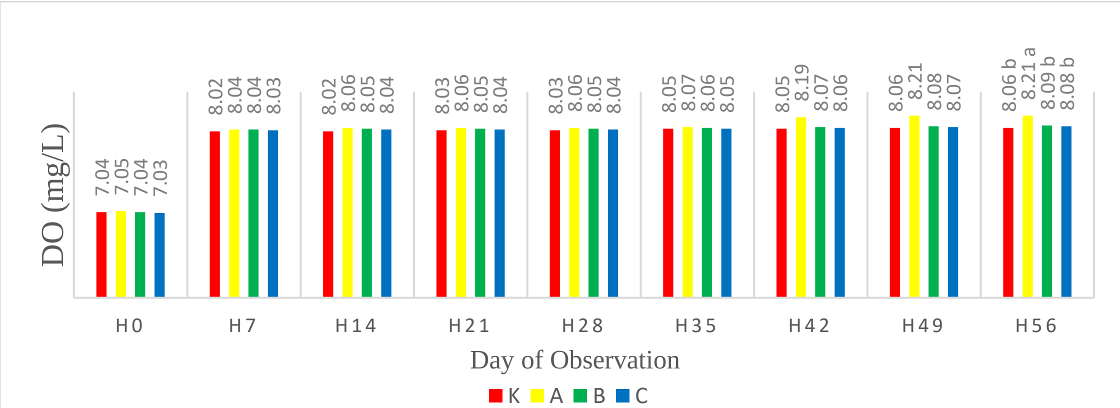

Figure 8. Average Morning DO of Aquaponic System in Tilapia Cultivation

The results of the ANOVA test at H56 showed that the difference in plants in the tilapia cultivation aquaponic system had a very significant effect on the afternoon DO. Because it had an effect, a further test (tukay) was carried out which stated that treatment A was significantly different from treatments K, B and C. The highest morning DO value was found in treatment A with a range of 8.06-8.22 mg/L, and the lowest was found in treatment K with a range of 7.05-8.06 mg/L.

The average afternoon DO value in the tilapia cultivation aquaponic system can be seen in the graph in Figure 9 below.

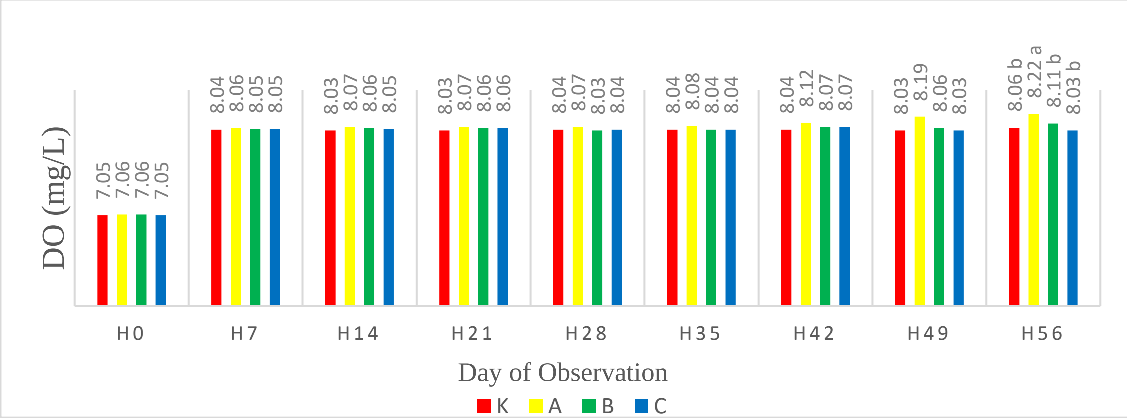

Figure 9. Average Afternoon DO of Tilapia Aquaponics Cultivation

The results of the ANOVA test at H56 showed that the difference in plants in the tilapia aquaponics cultivation system had a very significant effect on afternoon DO, so a further test (tukay) was carried out which stated that treatment A was significantly different from treatments K, B and C. The highest afternoon DO value was found in treatment A with a range of 7.08-8.23 mg/L, and the lowest was found in treatment K with a range of 7.05-8.07 mg/L.

The average afternoon DO value of the aquaponics system in tilapia cultivation can be seen in the graph in Figure 10 below:

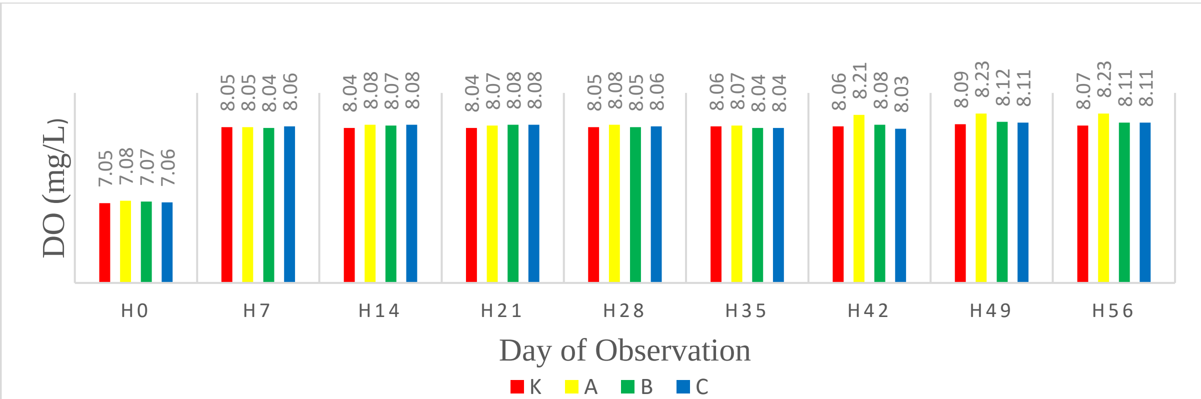

Figure 10. Average DO Afternoon Aquaponics Tilapia Cultivation

Based on the results of the research that has been carried out, the difference in plants in the aquaponics fish cultivation system has a very real effect on DO in the morning, afternoon and evening, where the oxygen concentration in the morning, afternoon and evening has different values, with the highest DO value in the afternoon being higher than DO in the morning and afternoon.

DISCUSSION

The low phosphate levels (Figure 1) in H0 are due to the low availability of phosphate and no feces or feed residues settling at the bottom of the water. The concentration of phosphate levels in each treatment in H0 is still very good, while in H56 the K treatment is still good, but treatments A, B and C have exceeded the optimal phosphate limit in fish farming.

Because based on the water quality standards in PP No. 82 of 2001, the minimum limit for phosphate levels for fish farming activities is 1 mg/L, and according to Suraya *et al*., (2001), states that the phosphate concentration for fish farming is 0.2-1 mg/L. high phosphate values in waters can cause water pollution (Thaib *et al*., 2023). Excessive phosphate levels in waters can cause an explosion of algae growth in waters which can cause the use of large amounts of oxygen, resulting in a decrease in dissolved oxygen levels in waters. Plants can utilize orthophosphate directly from waters. Meanwhile, phosphate levels that are too low will inhibit the growth of roots, stems, leaf stalks and leaves. One factor in increasing phosphate concentration is decreasing temperature and pH (Effendi, 2015).

Based on the results of the research that has been done, the temperature varies between morning, afternoon and evening. This difference is influenced by weather and wind conditions that occur during the research process, as explained by Cahyantil (2022) that temperature can be influenced by environmental conditions, weather and wind. The average temperature value in the afternoon is higher than the morning and afternoon temperatures.

The high temperature in the afternoon in this study occurred because plants that carried out photosynthesis during the day experienced increased respiration which released heat into the water and also the maintenance container used was a plastic tarpaulin, which is a material that easily absorbs heat from the sun which then the temperature in the aquaponic system increases due to the absorption results, as explained by Putra *et al.* (2018) that controlled environments such as tarpaulin containers can absorb and retain heat

The water temperature in this study was still very good because based on the Indonesian National Standardization issued by the National Standardization Agency (BSN), the optimal temperature for black tilapia cultivation is 24°C-35°C.

The pH value in the morning, afternoon and evening in treatment K was higher than treatments A, B and C. The Indonesian National Standardization issued by the National Standardization Agency (BSN) states that the optimal pH standard for tilapia cultivation is 6.5-8.5. The pH value for the growth and development of tilapia is 7-8 (Yunus *et al*., 2018).

The high pH value in treatment K occurred because this treatment did not have plants that were used as biofilters, so that there was an accumulation of feces and also leftover feed at the bottom of the pond which caused the pH to become wet and unstable. While in treatments A, B and C the pH value remained stable, because they had plants that were used as biofilters, so that there was absorption of dirt in the waters.

Dissolved oxygen in the morning, afternoon and evening has different values. This difference occurs because in the morning before the sun fully rises, and high-intensity light dissolved oxygen is still limited, during the day the DO level is higher because there is a lot of light and oxygen production begins to increase, while in the afternoon the water temperature is lower and it is easier to dissolve oxygen (Alfatihah *et al*., 2024).

However, based on research that has been conducted, the dissolved oxygen level in the tilapia aquaponic fish farming system, in the afternoon the oxygen is higher compared to the morning and afternoon. The high dissolved oxygen in the afternoon occurs because the oxygen circulation in the water in the afternoon is more balanced and around the pond begins to cool which can allow dissolved oxygen to increase.

CONCLUSIONS AND RECOMMENDATIONS

Treatment using different types of plants in the aquaponic system using a floating raft system has a very significant effect on water quality parameters, namely pH and DO and the best plant in maintaining water quality in this study was water spinach, namely with a phosphate value in H56 of 1.41 mg/L, pH 8.51, temperature 25.7°C and DO 8.23 mg/L.

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