Asian Journal of Aquatic Sciences, April 2025. Vol 8, Issue (1) 20-32
e-issn: 2716-4608
p-issn: 2655-366X

EFFECT OF REVERSE BIOFLOC SYSTEM WATER QUALITY ON GROWTH AND SURVIVAL OF RED TILAPIA (*Oreochromis niloticus*) IN CIANJUR, WEST JAVA

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ABSTRACT

This study aims to determine the effect of a reverse biofloc system on the water quality, growth, and survival of red tilapia (*Oreochromis niloticus*). The research method is experimental with a completely randomized design (CRD). The containers used were 13 buckets with a capacity of 100 L, with one control and three treatments, each repeated four times. Each container was filled with 10 red tilapia fish. Treatments included probiotics with doses of 5 mL, 10 mL, and 15 mL. The results showed that the treatment with 15 mL probiotics produced the highest fish weight growth, with an average of 558.75 g and an average length growth of 9.1 cm. Analysis of variance (ANOVA) showed significant differences in fish weight and length growth, indicating that probiotic concentration influenced fish growth. All treatments' survival rates (SR) reached 100%, indicating that the inverted biofloc system can maintain optimal environmental conditions. Water quality in the reverse biofloc system did not significantly affect fish growth, so other factors, such as microorganism density and nutrient availability, played a role. This study concludes that the reverse biofloc system with the addition of 15 mL probiotics provides the best results in increasing the growth of red tilapia without affecting its survival.

Keywords: Reverse Biofloc, Probiotics, Water Quality, Survival, Red Tilapia.

1. INTRODUCTION

Red tilapia (*Oreochromis niloticus*) farming is one of the major aquaculture commodities in Indonesia. Red tilapia is known for its fast growth rate and resistance to variations in water quality and diseases, making it a superior choice in freshwater aquaculture in the country[1]. Due to its high economic potential, red tilapia is very popular among aquaculture farmers in West Java, one of the main production centers. However, despite its resilience to several environmental conditions, the productivity of red tilapia farming has declined in recent years. Based on data from KKP[2], red tilapia production in West Java decreased from 270,925.025 tons in 2021 to 262,916.765 tons in 2022 in the enlargement phase. This decline is often attributed to water quality degradation, the environment's decreasing carrying capacity, and the increased stocking density of fish in aquaculture ponds[3].

Although red tilapia has a relatively high tolerance to variations in water quality, non-optimal environmental conditions can adversely affect its growth rate and survival. According to BSN[4], water quality parameters affecting fish health include temperature, pH, dissolved oxygen, and ammonia levels. If these parameters are outside the optimal range, such as temperatures that are too high or excessive ammonia levels, fish can experience stress that leads to decreased growth and increased

Received: 8 February 2025
Accepted: 30 March 2025

mortality rates[5]. In addition, the high stocking densities commonly applied to increase productivity can also lead to increased waste production, reduced oxygen levels, and ammonia accumulation that are harmful to fish[6-7].

One of the emerging solutions in aquaculture is the biofloc system, which can improve water quality and productivity of fish farming. This system converts feed waste and fish excretions into microbial flocs, useful for additional nutrients and can reduce ammonia levels in the water[8]. However, conventional biofloc systems take about seven days for floc formation and require many resources, such as feed, electricity, and intensive labor, an obstacle to efficient and sustainable fish farming practices[9].

Alternatively, the reverse biofloc system offers a more efficient solution by performing floc formation after the fish have been in the pond for one week. This delay aims to create an initial environment free of pathogens, such as harmful fungi and bacteria, that may have been carried over from the previous culture cycle. By allowing a week without flocs, the fish can acclimate to the new, more sterile environment, reducing the risk of infection that often affects fry in the early phase. This system is expected to accelerate floc formation, increase resource use efficiency, and reduce fish mortality[10].

In addition to bioflocs, probiotics in aquaculture are also receiving increasing attention. Probiotics can improve water quality by reducing the number of pathogenic bacteria and supporting microbial balance in the biofloc system[11]. Probiotics have also improved fish's nutrient absorption and digestion, leading to better growth and a lower feed conversion ratio[12]. When applied in conjunction with a biofloc system, probiotics can accelerate the decomposition of organic matter, improve water quality, and reduce ammonia and nitrate levels that are harmful to fish[13].

Although biofloc technology and probiotics have been widely applied in shrimp and catfish farming, the reverse biofloc system combined with probiotics in red tilapia farming still needs to be explored more. Some previous studies have focused more on other species, while studies examining the potential of the reverse biofloc system to improve water quality, growth, and survival of red tilapia are still limited. Therefore, this study aims to analyze the impact of the inverted biofloc system experiment on water quality, growth and survival of red tilapia and explore the potential of this system as an efficient solution to improve aquaculture productivity in West Java. Thus, it is hoped that this research can positively contribute to developing environmentally friendly aquaculture technology and enhance the welfare of fish farmers in Indonesia.

2. RESEARCH METHOD

This research was conducted at Rumah Belajar Pranasiswa, Karangtengah, Cianjur, West Java, from September to December 2024. The method was experimental with a completely randomized design (CRD) consisting of three probiotic concentration treatments, namely 10%, 15%, and 20%, with four replicates each. The 15% concentration was chosen as the best dose.

Biofloc culture media used plastic drums with a capacity of 100 L equipped with an aeration system in the form of diffuser aerators with as many as four units per container and a blower with a capacity of 45 L per minute. The containers were thoroughly washed and dried in the sun to remove unwanted microorganisms before use. Biofloc formation was conducted after red tilapia were stocked for the first seven days by inoculating probiotics (Airake3) in 10%, 15%, and 20%. In addition, molasses and dolomite were added as a carbon source to stabilize pH. Aeration was continuously performed to ensure even distribution and prevent biofloc settling.

Biofloc culture management is carried out with regular water quality monitoring, including parameters such as pH (7-8), temperature (28-30°C), dissolved oxygen

(DO), and ammonia, nitrite and nitrate concentrations measured using Seachem and Sera test-kits. Floc density was monitored using Imhoff cones, where if the flocs were too high, dilution up to 50% was done, while if the flocs were too low, the dose of molasses and probiotics was increased. Feeding is done two to three times a day, with the amount adjusted based on the biomass of the fish, using floating pellet-shaped feed[14].

Data Collection Procedure

This research procedure begins with preparing and cleaning the container and equipment one day before the research. Cleaning is done to ensure the condition of the container is sterile and free from unwanted microorganisms. The container used is a plastic drum with a capacity of 100 L, which has been washed and dried in the sun before use. After the container was ready, the experimental biota was prepared by spreading 8-10 cm red tilapia as many as 10 fish per container. To establish and maintain the stability of the biofloc system, probiotics (Airake3) were given in three different doses, namely 10 mL, 15 mL, and 20 mL, each of which had four replicates. In addition, molasses as a carbon source and dolomite to stabilize pH were also added to the biofloc media. Aeration was carried out continuously using a diffuser aerator of four units per container and a blower with a capacity of 45 L per minute to ensure even oxygen distribution and prevent biofloc settling.

Water quality measurements were conducted daily to monitor the environmental conditions of red tilapia aquaculture. Parameters measured included pH using a pH meter, temperature using a temperature thermometer, and dissolved oxygen (DO) using a DO meter. In addition, ammonia, nitrite, and nitrate contents were analyzed using Seachem and Sera test kits, while biofloc density was monitored using Imhoff cones. Measurements were taken twice daily, in the morning at 07.00-07.30 WIT and the afternoon at 16.00-16.30 WIT. The measurement results were recorded in the observation table for further analysis. If the biofloc density was too high, dilution up to 50% was done, while if it was too low, the dose of molasses and probiotics was increased to stimulate biofloc formation.

Before feeding, the overall fish weight (biomass) was weighed to determine the amount of feed to be given. The feed dose used was 5% of the total fish biomass. Probiotics were mixed into the feed before they were given to the fish. Feeding was done two to three times daily, at 08.00-08.30 am and 4.30-5.00 pm, adjusted based on fish growth. During the study, the data collected were analyzed using the Analysis of Variance (ANOVA) method to determine the effect of treatment on the development and survival of red tilapia.

Data Analysis Technique

The data analysis used in this research is a completely randomized design (CRD), an experimental method suitable for relatively homogeneous environmental conditions. RAL is used because it does not require local control and is suitable for research conducted in a controlled environment, such as the reverse biofloc system in red tilapia rearing. In this study, the experimental design consisted of three treatments with three replications for each treatment, so there were nine experimental units. The treatments given include:

- Treatment A: Red tilapia rearing with the addition of probiotics at 10 mL of the total feed used.
- Treatment B: Red tilapia rearing with the addition of probiotics as much as 15 mL of the feed used.
- Treatment C: Maintenance of red tilapia with probiotics as much as 20 mL of the feed.

Absolute Weight Growth

According to Effendi[15], absolute weight growth is an important indicator in evaluating fish growth performance in aquaculture systems, especially regarding environmental factors, feed, and maintenance management. Formula:

$$W = Wt - Wo$$

Description: where W is the absolute weight growth (g), Wt is the final weight of the fish (g), and Wo is the initial weight of the fish (g).

Specific Growth Rate (SGR)

According to Ricker[16], specific growth rates are commonly used in fisheries studies to compare fish growth rates under various environmental conditions. This is also supported by Hepher & Pruginin[17], who state that SGR can indicate feed efficiency and optimal aquaculture management. Formula:

$$SGR \frac{\ln Wt - \ln Wo}{t} x\ 100\%$$

Description: with SGR as the specific growth rate (%), Wt is the average weight of fish at time t (g), Wo is the average weight of fish at the beginning of the study (g), and t is the study time (days).

Feed Conversion Efficiency (FCR)

Feed Conversion Ratio (FCR) is a parameter used in aquaculture to measure feed efficiency in producing fish growth. FCR indicates the feed required to increase fish weight by one kilogram. The lower the FCR value, the more efficient the use of feed in fish farming. According to Tacon & Metian[18], FCR is one of the main factors in determining the success of fish farming because feed is the most significant cost component in aquaculture operations. Effendi[15] also stated that a low FCR value indicates high feed efficiency, which means that fish can convert feed into biomass better.

Factors influencing the FCR value include feed quality, feeding frequency, water quality, and fish health conditions[19]. With good feed management and an optimized culture system, the FCR value can be lowered, thereby increasing economic returns for farmers. Formula:

$$FCR \frac{Pa}{Wt - Wo}$$

Description: where FCR is the feed conversion ratio, Pa is the amount of feed consumed (kg), Wt is the final biomass of the fish (kg), and Wo is the initial biomass of the fish (kg).

Survival Rate (SR)

Survival rate (SR) is a parameter in aquaculture used to measure the percentage of fish that survive during the rearing period compared to the initial number of fish stocked. The SR value is very important in assessing the success of an aquaculture system because it shows good environmental conditions, feed quality, and the effectiveness of maintenance management in supporting fish survival. According to Stickney[20], survival rate is a key indicator in evaluating the success of an aquaculture system. Factors that affect SR values include water quality, stocking density, feed quality, stress levels, and diseases that can attack fish during rearing.

In addition, Boyd[21] stated that a high SR indicates favourable environmental conditions and good aquaculture management. To increase SR, fish farmers must maintain optimal water quality, provide quality feed appropriately, and control diseases with proper biosecurity measures. Formula:

$$SR \frac{Nt}{No} x\ 100\%$$

Where SR is the percentage of survival (%), Nt is the total fish population at the end of the study (fish), and No is the total fish population at the beginning of the study (fish).

3. RESULT AND DISCUSSION

Growth

This study aims to determine the effect of probiotic concentration in an inverted biofloc system on the growth and survival of red tilapia. The biofloc system is a fish farming method that relies on the balance of microorganisms in the water to improve environmental quality and feed efficiency[22]. The parameters observed in this study included fish weight growth, survival rate (SR), and feed conversion ratio (FCR) based on three probiotic concentration treatments, namely 10 mL, 15 mL, and 20 mL.

Probiotics used in biofloc systems increase the availability of nutrients, accelerate the degradation of organic waste, and maintain the stability of the microbial ecosystem in the water[23]. Thus, it is expected that increasing the concentration of probiotics in this system can have a positive impact on fish growth. The data processing results showed significant differences in fish growth based on the number and average weight produced. The following summarises the results based on the red tilapia growth Table 1.

Table 1. Growth rate of red tilapia

Probiotic Concentration (mL)	Replicate				Total (g)	Average (g)
	1	2	3	4		
10	462	461	462	459	1.844	461
15	560	558	562	555	2.235	558.75
20	512	508	510	502	2.032	508
Total	1.534	1.527	1.534	1.516	6.111	1.527.92

Based on the calculation results, the standard deviation (SD) and standard error of the mean (SEM) show the variation in the growth of red tilapia (Oreochromis niloticus) in each probiotic treatment. SD illustrates how much the data spread to the mean value, while SEM shows how accurately the sample mean represents the population[24].

The 15 mL concentration treatment had an SD of 4.32 and SEM of 2.16, which was the highest value compared to the other treatments. This indicates that although fish growth at the 15 mL dose was higher on average, there was greater variation in fish weight between replicates. The high variation could be due to factors such as feed competition, individual metabolic differences, or the effectiveness of probiotics within each replicate unit[25].

Meanwhile, treatments with probiotic concentrations of 10 mL and 20 mL had lower SEM, 0.71 and 0.91, respectively. The smaller SEM values indicate that the data in these groups are more consistent and less variable, so the average fish growth in these treatments is more reliable than the 15 mL treatment[26]. This diversity of fish responses to probiotic concentrations suggests that the optimal effect may occur at a certain dose, while increasing or decreasing the dose may cause greater variation in growth. Previous studies have also found that excessive probiotic doses do not necessarily provide greater positive effects, as they may cause microbial competition that reduces the metabolic efficiency of the fish[27].

Length Growth

The length growth of red tilapia is an important parameter in evaluating aquaculture systems' effectiveness, including using inverted biofloc systems. Length growth reflects the response of fish to environmental conditions, especially water quality and nutrient availability in the pond[22]. Factors such as dissolved oxygen levels, ammonia concentration, and the density of microorganisms in biofloc can affect the growth rate of fish[28].

In this study, the length growth of red tilapia was observed at various concentrations of probiotics applied in an inverted biofloc system. Probiotics play a role in improving water quality and increasing feed efficiency through improving microbial balance in the biofloc ecosystem[29]. The results showed variations in length growth between treatments, reflecting how each dose of probiotics can support optimal fish growth.

Previous studies have also shown that the use of probiotics in biofloc systems can increase nutrient utilization and improve water quality parameters, which in turn has an impact on increasing fish length growth[14]. Therefore, the analysis of the results of this study will describe the pattern of fish length growth in each treatment and identify factors that may have contributed to the differences in observed results.

Table 2. Length growth rate of red tilapia

Probiotic concentration (mL)	Replicate 1	2	3	4	Total length (cm)	Average length (cm)
10	7.5	7.4	7.6	7.3	29.8	7.45
15	9.2	9.0	9.3	8.9	36.4	9.1
20	8.0	7.8	7.9	7.7	31.4	7.85
Total	24.7	24.2	24.8	23.9	97.6	8.13

Survival Rate (SR)

Survival Rate (SR) is the percentage of fish that remain alive until the end of the study compared to the number of fish at the beginning of maintenance. The calculation of SR in this study refers to the method proposed by Baktiar[30]. SR is an important parameter in fish farming because it reflects the effectiveness of maintenance management, environmental quality, and fish health conditions[21].

The results showed that the survival rate of red tilapia reached 100%, which means there were no fish deaths during the rearing period. This success is inseparable from several supporting factors, such as optimal container preparation, feeding with adequate nutritional content, and routine monitoring of water quality[22].

Feed containing balanced nutrients is required to ensure optimal fish survival and growth. The main factors affecting fish survival rates include stocking density, feed quality, the presence of disease, and water quality parameters, such as temperature, ammonia levels, nitrite levels, dissolved oxygen, and water pH[28]. The biofloc system increases fish survival rates by optimizing water quality and growing nutrient utilization efficiency[14]. Meanwhile, based on research by Akhmad[31], the survival rate of swamp sepat fish was 68.89% to 75.56%. The results of this study indicate that the reverse biofloc system can create environmental conditions that support the optimal survival of red tilapia.

Feed Conversion Ratio (FCR)

Feed conversion ratio (FCR) and feed efficiency are key parameters in assessing the effectiveness of a given feed. FCR refers to the ability of fish to convert feed into body mass, while feed efficiency measures the amount of fish meat produced from each unit weight of dry feed consumed[32]. The smaller the FCR value, the more efficient the feed utilization by the fish. Factors such as oxygen availability also play a role in determining feed conversion efficiency[33]. The results of the research on FCR from various treatments can be seen in Figure 1.

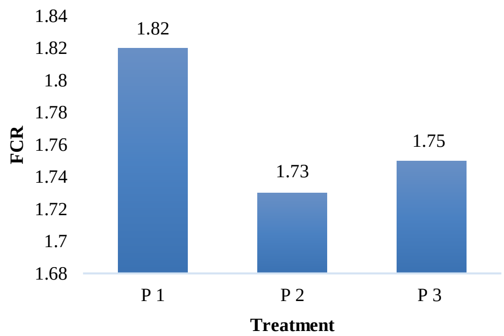

Figure 1. FCR value

Based on the study's results, the administration of 10 mL probiotics in treatment I resulted in an FCR value of 1.82. In Treatment II, with a probiotic dose of 15 mL, the FCR value obtained was 1.73, the best value compared to other treatments. Meanwhile, in Treatment III with a 20 mL probiotic dose, the FCR value was 1.75. This data shows that providing probiotics as much as 15 mL provides optimal results, where every 1.73 kg of feed can produce 1 kg of tilapia weight.

According to Merrifield et al.[34], feeding 15 mL of probiotics per kg of feed can increase the daily growth rate of freshwater fish and improve feed conversion efficiency, with a lower FCR than the treatment without probiotics. This confirms that the smaller the FCR, the less feed is needed to increase fish weight[18], following the theory proposed by Tacon & Metian. In general, the FCR value of fish ranges from 1.5 to 2.5, and this study shows that the administration of 15 mL probiotics can optimize feed efficiency in the reverse biofloc system.

In addition, according to El-Sayed & Kamel[35], probiotics in fish farming can reduce FCR on commercial feed by up to 0.8 kg to produce 1 kg of fish weight. In addition to improving feed efficiency, probiotics can also speed up rearing time, making it an effective strategy in tilapia aquaculture. In addition to improving feed efficiency, probiotics can also speed up rearing time, making it an effective strategy in red tilapia farming in Cianjur, West Java.

Feeding Efficiency

Feeding efficiency in red tilapia aquaculture significantly affects its growth and productivity. Feed efficiency is calculated based on the ratio between the wet weight of the fish produced and the amount of dry feed given[18]. The higher the feed efficiency value, the better the feed conversion into fish growth, which can reduce aquaculture production costs[36]. In this study, providing probiotics with different doses significantly affected feed efficiency. In the treatment with a 10 mL probiotic dose, the feed efficiency value (EPP) was recorded at 57%. Meanwhile, the 15 mL dose gave the highest EPP value of 60%, indicating optimal feed conversion. While at the 20 mL dose, the EPP value decreased slightly to 58%.

These results indicate that the 15 mL probiotic dose improves feed efficiency in red tilapia. Every 1 kg of feed consumed at this dose can be converted into 0.60 kg of fish weight. Thus, using probiotics in feed at the optimal dose can increase fish growth efficiency while supporting tilapia aquaculture's sustainability Thus, the use of probiotics in feed at optimal doses can improve fish growth efficiency while supporting the sustainability of more economical and productive red tilapia farming[14,22].

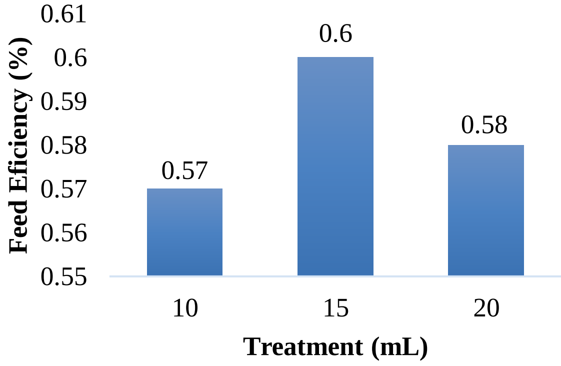

Figure 2. Feeding efficiency

Water Quality Management

Temperature is an environmental factor that plays an important role in the growth and survival of red tilapia in a reverse biofloc system. Water temperature affects fish's metabolic rate, dissolved oxygen availability, and various chemical reactions in the aquatic ecosystem. An increase in temperature can accelerate the metabolic rate, but if it is too high, it can cause stress and reduce the survival rate of fish[33].

According to Effendi[15], temperature also plays a role in controlling the level of oxygen solubility in water, where the higher the temperature, the lower the level of oxygen that can dissolve in water. This affects the respiratory activity of the fish and can affect growth efficiency in the reverse biofloc system. In this study, the water temperatures obtained from the various treatments are shown in Figure 3 and Figure 4, which illustrate the temperature variation during the rearing period of red tilapia in the inverted biofloc system.

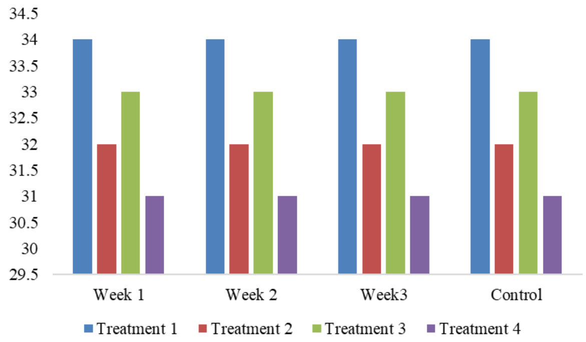

Figure 3. Temperature measurement values in the morning

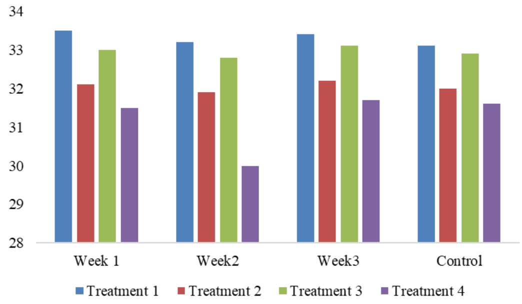

Figure 4. Graph of temperature values in the afternoon

Figure 3 and Figure 4 show that the temperature during this study ranged from 26.90-34^{0}c. The highest average temperature was obtained in week 1. The temperature difference obtained often changes due to weather differences at the research site. The degree of acidity (pH) is an important parameter in aquatic ecosystems that reflects the balance between hydrogen ions (H^+) and hydroxide ions (OH^-). The pH value plays a role in determining the suitability of the aquatic environment for the life of aquatic organisms, including red tilapia. According to Effendi[15], water pH can be influenced by factors such as carbon dioxide (CO_2) content, acidic and basic compounds, and biological activity in aquatic ecosystems.

Waters with a pH of less than 7 are acidic, while waters with more than 7 are alkaline or alkaline. Optimal water conditions for the growth of red tilapia are generally in the pH range of 6.5-8.5, where the balance between ions in water can support optimal fish physiological processes[33,37]. In this study, the pH value is obtained in Figure 5.

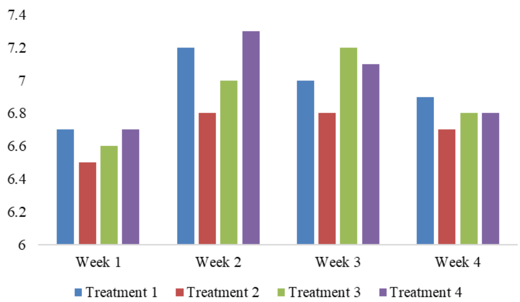

Figure 5. Graph of water pH value

From Figure 5, the measurement results during the study showed that the pH value ranged from 6.7 to 7.2. The highest pH value was recorded in the second week of the first treatment, at 7.2. Based on the measurement results, the pH value is still within the optimal range for red tilapia cultivation.

According to Boyd[33], water pH that is too low or too high can interfere with the physiological processes of fish, especially in the mechanism of osmoregulation and ion exchange in the body. In addition, Kusmini et al.[38] stated that a stable pH within the optimal range can increase the efficiency of fish metabolism and support their growth and survival rate. Therefore, the measurement results in this study indicate that the inverted biofloc system can maintain pH within a range suitable for the growth of red tilapia.

Dissolved Oxygen (DO) is an important water quality parameter affecting fish growth and survival. DO refers to the amount of oxygen dissolved in water and required by aquatic organisms for respiration. DO levels in aquatic systems are influenced by temperature, microorganism activity, and phytoplankton photosynthesis[33].

In this study, DO values were measured periodically to assess the effectiveness of the inverted biofloc system on water quality in red tilapia aquaculture. The optimal DO value for tilapia growth ranges from 3-7 mg/L, with levels below 3 mg/L causing stress and fish death. The

e-issn: 2716-4608
p-issn: 2655-366X

graph of DO measurement results during the study is shown in Figure 6.

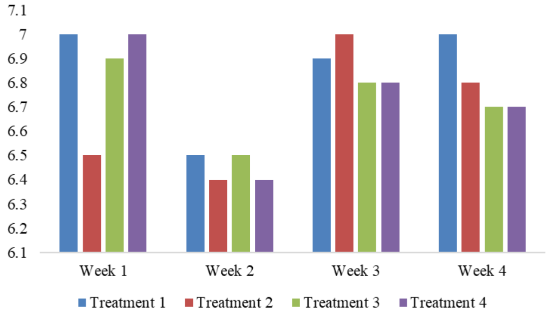

Figure 6. Graph of DO values

Figure 6 shows that the results of DO measurements during the study ranged from 6.4 to 7.0 ppm. The lowest DO value occurred in the second week, with an average dissolved oxygen level of 6.4 ppm in each treatment. Meanwhile, DO levels tended to stabilize around 6.8-7.0 ppm in the first, third, and fourth weeks.

Changes in DO values during the study could be caused by increasing turbidity due to residual feed and fish waste and technical disturbances, such as power outages that caused the aerators not to function optimally. However, the variation in DO changes in this study was relatively small, so it did not significantly impact the survival of red tilapia. According to Effendi[15], the effect of DO levels on fish survival can be described as follows: 1) < 0.3 ppm: Only a few fish survive; 2) 0.3-1.0 ppm: May cause fish mortality if prolonged; 3) 1-5 ppm: Fish can survive, but growth is inhibited, 4) 5 ppm: The optimal range for almost all aquatic biota. Based on the study's results, the DO levels obtained were within the optimal range (> 5 ppm), thus supporting the growth and survival of red tilapia during the maintenance period.

Ammonia is a water quality parameter that greatly affects fish's survival and growth. In an inverted biofloc system, ammonia is produced from fish excretion and the decomposition of leftover feed and other organic matter in the water. Ammonia that accumulates in high amounts can be toxic to fish, inhibit growth, and cause physiological stress. According to Boyd[33], safe ammonia levels for cultured fish are generally below 0.05 ppm, while concentrations above 0.1 ppm can inhibit growth, and if they exceed 0.5 ppm, it can cause death. Therefore, monitoring ammonia levels in this study is an important aspect of assessing the effectiveness of the reverse biofloc system in maintaining optimal water quality for red tilapia.

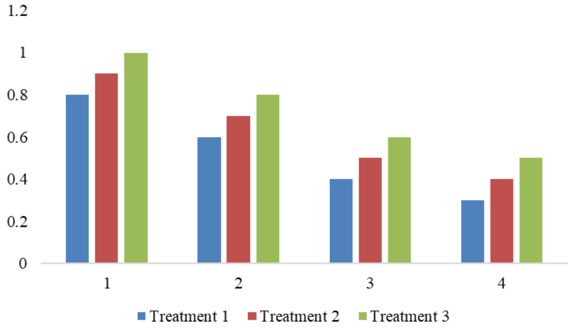

Figure 7. Ammonia graph

Based on the graph above, the measurement results of ammonia levels during the study showed a downward trend from the first week to the fourth week. At the beginning of the study (week 1), the highest ammonia levels were detected in Treatment 3 with a value of 1.0 ppm, followed by Treatment 2 at 0.9 ppm and Treatment 1 at 0.8 ppm.

Over time, ammonia levels decreased. In week 2, ammonia levels decreased to 0.8 ppm in Treatment 3, 0.7 ppm in Treatment 2, and 0.6 ppm in Treatment 1. This downward trend continued until week 4, when ammonia levels reached 0.5 ppm in Treatment 3, 0.4 ppm in Treatment 2, and 0.3 ppm in Treatment 1. This decrease in ammonia levels indicates the effectiveness of the reverse biofloc system in controlling nitrogen waste in the water. The main mechanism in ammonia reduction is the microbial activity in the biofloc system that converts ammonia into nitrite and then nitrate through the nitrification process[22]. The presence of these microorganisms helps maintain optimal water quality for fish growth.

Ecologically, ammonia levels declined to ≤ 0.5 ppm by week 4, indicating more stable and safe environmental conditions for red tilapia. This is important because high ammonia levels (>1 ppm) can be toxic to fish and inhibit their growth and survival[21]. Thus, the reverse biofloc system is proven to significantly improve water quality, support optimal development, and increase the survival rate of red tilapia in aquaculture environments.

Nitrate (NO_3-) is one of the nitrogen compounds produced from the nitrification process, which is the oxidation of ammonia (NH_3) to nitrite (NO_2-) and then to nitrate by nitrifying bacteria such as Nitrosomonas and Nitrobacter[22]. In the reverse biofloc system, the role of microorganisms is crucial in converting toxic nitrogen compounds such as ammonia into a more stable and less harmful form for fish.

The presence of nitrate in aquaculture is generally non-toxic in low to moderate concentrations, but accumulation in high amounts can negatively affect fish growth and health. Nitrate concentrations that are too high can cause physiological stress in fish and reduce feed efficiency[21]. Therefore, monitoring nitrate levels in inverted biofloc systems is essential to ensure the culture environment remains optimal for the growth and survival of red tilapia.

In this study, nitrate levels were measured periodically to evaluate the effectiveness of the reverse biofloc system in controlling nitrogen effluent in the waters. Changes in nitrate concentration during the study will be analyzed to understand water quality dynamics and its impact on cultured fish.

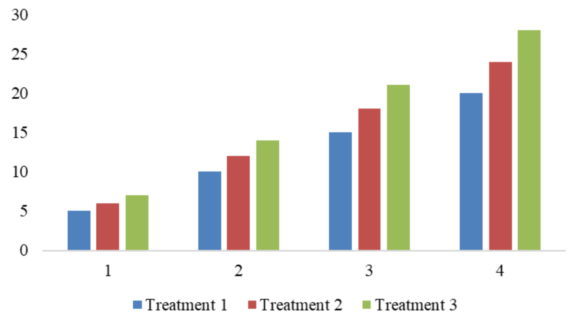

Figure 8. Nitrate graph

The graph shows the increase in nitrate levels in the reverse biofloc system over the four weeks of the study. Treatment 3 experienced the highest growth, reaching more than 25 ppm, while Treatments 2 and 1 were around 20 ppm and 15 ppm, respectively. This increase reflects nitrate accumulation due to nitrification, which converts ammonia into nitrate as the final form. High nitrate levels can affect water quality and cause stress to fish, so proper management is required to maintain the balance. Differences between treatments indicate variations in the effectiveness of the biofloc system in treating nitrogen effluent, which affects the growth and survival of red tilapia in Cianjur, West Java.

Nitrite (NO_2-) is an intermediate compound in the nitrogen cycle formed from ammonia oxidation by nitrifying bacteria, such as Nitrosomonas. In aquaculture systems, nitrite accumulation in water can negatively impact the quality of the aquatic environment and fish health, mainly due to its toxicity at certain levels[21]. The reverse biofloc system plays a role in managing nitrite levels by increasing the activity of heterotrophic microbes that can convert nitrite into gaseous nitrogen, which is safer for aquatic ecosystems[22]. Therefore, this study aims to analyze the dynamics of nitrite levels in the reverse biofloc system and its impact on water quality, growth, and survival of red tilapia in Cianjur, West Java.

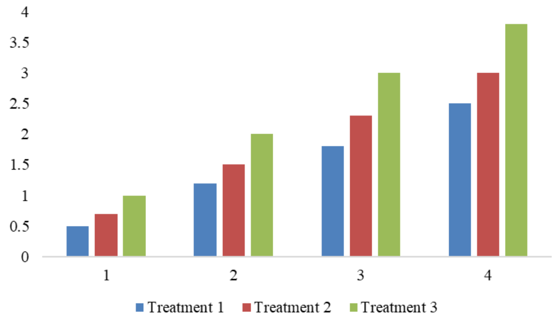

Figure 10. Nitrite graph

The graph shows the changes in nitrite (NO_2-) levels in the inverted biofloc system over four weeks across the three treatments. In general, nitrate levels increased over time, with differences between treatments indicating variations in the effectiveness of nitrogen management in the reverse biofloc system. Treatment 1 (blue line) had the lowest nitrite levels, followed by Treatment 2 (green line), while Treatment 3 (red line) showed the highest nitrite levels.

This increase in nitrite levels indicates the nitrification process, where ammonia (NH_3) is converted into nitrite by nitrifying bacteria such as Nitrosomonas. However, excessive nitrite accumulation can negatively affect water quality and fish health, as nitrite can interfere with oxygen transport in the blood (methemoglobinemia or brown blood disease)[21]. Therefore, the effectiveness of biofloc systems in controlling nitrite levels is an important factor in the sustainability of red tilapia aquaculture

4. CONCLUSION

The effect of the reverse biofloc system on water quality, growth and survival of red tilapia showed positive results for fish farming. The addition of probiotics to the inverted biofloc system affects the growth of weight and length of red tilapia. A probiotic concentration of 15 mL produced the highest fish weight of 558.75 grams and the highest average fish length of 9.1 cm. Probiotic concentration significantly influenced the growth of fish weight and length.

The inverted biofloc system can create a stable culture environment and support optimal conditions for the survival rate of red tilapia. In addition, water quality in the inverted biofloc system did not directly affect fish growth, indicating that other factors, such as microorganism density and nutrient availability in bioflocs, also play a role in fish growth.

Thus, the inverted biofloc system with 15 mL probiotics was shown not to interfere with their survival. This system has the potential to be a sustainable aquaculture method with optimal water quality management.

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