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Evaluation of Biofloc Technology as a Means of Improving the Water Quality and Growth Performance in the Fish Farming of Catfish

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Abstract:
In aquaculture, it has been pay attention to biofloc technology (BFT) which is a sustainable means of enhancing the water quality, nutrition and recycling of nutrients and sustain high intensities of fish farming. This research paper evaluated the performance of BFT technology and culture of the African catfish (Clarias gariepinus) over a 8 weeks cycle studying its performance against that of the conventional static water systems. The findings established that BFT systems had a significant impact on lowering toxic nitrogenous compounds, especially ammonia, with average levels at 0.25 mg/L. Their nurturing capacity was also found to provide an admirable survival rate of catfish in BFT tanks at 92.1% that was far more superior to that of conventional systems. Fish production also had a higher growth rate in the BFT cultivation system where the mean percent weight gain of fish was 14.7 percent higher and a better feed directly ratio (FCR) of 1.28, representing better utilization of feed ($p < 0.05$). The findings demonstrate the beneficial effect of BFT to provide more stable and self-regulating aquatic environment where water exchange is no longer required so often and it is also biosecure.

Keywords: ***Water quality, ammonia, survival rate, biofloc technology and sustainable aquaculture, feed conversion ratio, African catfish, and Clarias gariepinus.***

1. Introduction

Intensive rasing of catfish, more specifically African catfish (Clarias gariepinus), is now a crucial part of the worldwide seafood sector that is gaining active demand and rapid growth rates. But as this grows, it has also brought a chain of issues in terms of water standards, water-borne diseases control, and sustainable means of production. With the ever-increasing size of the industry, the solutions to these problems need to be innovative to predetermine the further productivity of the industry and the sustainability of the environment.

1.1 Intensive Aquaculture of Catfish Problems

In intensive catfish farming, stocking is done extensively and in most cases, it results in the build up of waste products like ammonia, carbon dioxide gases, and organic matters in the water. The pollutants have the ability to dilapidate the quality of water easily giving rise to an environment that is unfriendly to the fish. In most of the traditional systems the exchange of water becomes a necessity in order to remedy the effects of bad water quality and this would consequently trigger high operational expenses and wasteful water. Also, accumulation of toxin such as ammonia may cause stress to the fishes, stunted growth of the fishes and also death. In order to contain these problems, there is an emerging necessity to come up with systems that can enhance the quality of water without being more reliant on the exchange of water and keeping fish healthy.(1)

1.2 Principlesand Advantages of Biofloc Technology

Biofloc technology (BFT) has presented itself as a novel and clean technology to addressing the issues that exist in the intensive aquaculture systems. BFT depends on the development of microbial cultures (bacteria, algae and protozoa) within the water, which utilise sugars and “wasted” nutrients (chiefly nitrogenous organic compounds, such as ammonia, and phosphates) up-taking them and turning them into biofloc particles. This biofloc contains high concentration of protein which can be fed to fish thereby facilitating less demand of extra feed and little wastes. The BFT systems operate as self filtrating systems of aquaculture where the water is recycled through the activity of microbial organisms and promotes high water purity.

The positive effects of BFT are manifold: they include improving the quality of water by regulating the number of ammonia and nitrites, relieving the necessity of exchanging water, creating a recycling of nutrients, which leads to feed economy. In addition to that, BFT proved to provide better fish health, better growth and survival due to the improved stability and biological balance resulting environment. The combination of the mentioned aspects predetermines the potential of BFT as an environmentally friendly and economical solution to the process of aquaculture.

1.3 rationale of Comparing BFT with Traditional Systems

Although BFT has become popular in aquaculture, its benefits over conventional systems, like a pieced-together system with the water quality controlled by the frequent exchange of stagnant water, is not always comprehended especially in catfish farming. Traditional static water systems may require a lot of exchange of water in order to restart the quality of water which is not only very expensive but becomes more so when the water is scarce or may be very expensive in some locations. Also, lack of proper waste management may lead to poor water quality and high levels of pathogens in the tradition systems.(2)

This paper will attempt to give a direct comparison of BFT and the traditional type of a static water system in view of African catfish culture. Through the comparison of the two systems, this study intends to give some empirical evidence regarding the effectiveness of BFT in enhancing water quality, effectiveness, and general health of fish with the aim of making some idea regarding its possible application in commercial fish farmed enterprises.

1.4 Purpose of the study

The major research questions of this study will be to:

- Compare the parameters of water quality in BFT and conventional static water systems such as ammonia.
- Evaluate the growth performance of African catfish in the two conditions, weight gains and feed conversion ratio.
- Compare the survivability of catfish raised in BFT and conventional system.

Determine how the installation of BFT benefits the environment by preserving water exchange needs and enhancing the recycling of the nutrients.

2. Design and Assembly of Experiment and System

The rearing systems, the specification of the tank, stocking density and the handling of biofloc development are all described in this section in the study comparing the application of Biofloc Technology (BFT) and the static water systems in farming of African catfish (Clarias gariepinus). The main objective was to compare the effectiveness of BFT on improving the quality of water and the growth response and lessen the water exchange demand.

2.1 Rearing system (BFT vs Static Water) description

Based on this, it is the study that is to compare two different rearing systems namely the Biofloc Technology (BFT) and the traditional system of using the static water.

Biofloc Technology (BFT): In this device, the creation of the biofloc communities in the tank water was in order to provide a self-sustaining filtration system. These bacteria take advantage of surplus nutrients (including ammonia and nitrogenous compounds) available in the water, and turn them into biofloc agglomerates that can be ingested by the catfish. The BFT system is regularly aerated in order to ensure proliferation of the microbial communities and sustenance of oxygen levels, which is vital to the fish as well as the microbes. Aeration systems also were provided to the tanks so as to supply enough oxygen and keep water moving and the bioflocs created a balanced system between the fish and the bioflocs.(3)

Static Water System: It is a conventional type of aquaculture system that applies fixed amount of water where there is minimal to no exchange of water throughout the experiment process. Static systems management Of water quality is usually based on the production of waste products by occasional water change. Regular monitoring of water parameters in this system was performed, however, the health of the fish and the quality of water were highly related to the reaction of feed input followed by water exchanges. Microbial management and biofloc management was not introduced in the static water system, implying that the maintenance of water quality may prove to e more difficult with no external filtration or bio floc establishment.

2.2 Tank characteristics and Stocking Density

The two rearing methods were prepared in the same experiment tanks to make sure that the only factor that could influence the results is the water treatment method (BFT vs. static water).

Tank Size: The tank size was 500 liters to ensure no tank is overcrowded which will create space to allow the fish grow and at the same time the size is small to allow constant inspection of the tank in regards to the water quality. The tanks were modelled to reproduce the real aquaculture environments in terms of size and practicability.

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Stocking Density This was determined to use 30 fish per tank since both systems were to carry the same number of fish and 60 fish were placed in each of the experimental tanks. This density was selected depending on the normal business procedure in intensive catfish farming and also it gave a sufficient number of fish to perform statistical analysis of the growth performance, mortality, and water quality in a meaningful way.(4)

2.3 Biofloc Formation and Source of Carbon Control

Well-controlled growth of microorganisms and biofloc formation are the success secrets of Biofloc Technology (BFT). It was ensured that the bioflocs developed were by way of constant control by varying the carbon to nitrogen (C/N) ratio which directly affects the growth of microbes and the development of the bioflocs.

Carbon Source Management: Molasses (as a source of carbon) was added to BFT tanks in order to stimulate the growth of microorganisms. Carbon source is also critical in equalizing the nitrogenous waste content generated by the catfish and accumulate them into microbial biomass. To choose the source of carbon, the molasses was selected given its low cost and accessibility. It was seen that the proportion of C/N was set to be approximately 15:1, which explains that the microbial growth could be produced in the best conditions.

Biofloc Maintenance: To achieve mixing of its contents, the tanks were aerated at all times. This was done to ensure that the biofloc particles in the water column were not allowed to settle out by any means. This means that the probability of the fish consuming bioflocs was enhanced suggesting the fact that accumulation of organic matter which may compromise on the water quality was avoided. Routine tests of biofloc concentrations, ammonia, nitrite and nitrate were done to give assurance that the system was functioning at optimum levels in regard to fish growth and water quality.(5)

They did not do anything about developing biofloc in the static water system and the management of water quality remained fully to the exchange of water and the thorough removal of waste.

3. Overseeing Parameters and Data-taking

This paper has described a complete list of monitoring parameters and method of data collection which were used in determining the performance of the Biofloc Technology (BFT) system and the static water system. These factors were water quality, the growth of the fish, and the survival rate, which was essential in the comparison of the two fish rearing systems on the African catfish (Clarias gariepinus).

3.1 Protocol of the water quality assessment

The analysis of water quality was one of the focal points of the study, because it affects the growth and survival of fishes directly. In order to determine the quality of water, the following parameters were measured consistently in the course of experiment:

Ammonia (NH_3): Ammonia is a poisonous substance that may build up in intensive aquaculture systems and especially in still water. Colorimetric test hit was used measure the levels of ammonia and weekly sample collection was done on each tank.

Dissolved Oxygen (DO): Oxygen plays a role in the growth of fish, as well as, microorganisms in the BFT system. The DO levels were measured by using the portable DO meter and these levels were monitored on a daily basis in order to also determine when both the systems were properly aerated.

pH: pH of the water has some implications to the solubility of ammonia and other key water quality factors. The value of pH was recorded every week by use of a hand held pH meter.

Temperature: The temperature of the water was measured daily because it influences the metabolic processes of fish as well as the proliferation of the microorganisms in BFT system. The temperature was maintained in the optimum level of 26 to 30 degrees Celsius of catfish.(6)

Total Suspended Solids (TSS): TSS was taken weekly to evaluate the concentration of organic matter as well as particles of biofloc in the BFT system. Low TSS shows that there is good process of biofloc and suspensions.

Nitrates and Nitrites: It was used to judge the performance of the biofloc system in transforming ammonia into less toxic substances by determining the levels of nitrates and Nitrites every week. The concentrations of nitrite and nitrate have been tested with the help of the conventional colorimetric procedures.

The water quality monitoring was done on a weekly basis on all the above parameters, to ensure that variation could be monitored and incase of deviation it could be attended to in time.

3.2 Metrics used in Growth Performance

The performance on growth of African catfish was monitored during the period of the 8-week test by periodically weighing and length of the fish. The next indicators were registered:

Initial and Final Weight: 10 fish were randomly collected within each of the tanks and their weights were measured at the onset and end of the experiment. A digital scale (0. 01 g sensitivity) was used to measure the weight.
Average Daily Growth (ADG): The following formula was applied to gain this parameter:
ADG=Number of DaysFinal Weight−Initial Weight
Average Length: The length of fish was measured in the beginning and end of the test with the help of a common measuring board(7)
Weight Gain (WG): It was the difference between the weight of the fish at the end of the experiment and at the `beginning of the experiment.
The measurements were useful in knowing how the different systems were able to support the growth of catfish and how the biofloc could make a difference in enhancing performance.

3.3 Analysis of the Feed Conversion and Survival Rate

The parameters that were used in order to evaluate the feed conversion efficiency and survival rate of the fish included:
Feed Conversion Ratio (FCR): The ratio is used to reflect the efficiency with which the fish is growing due to the conversion of feed into body tissue. It was estimated by way of the formula:
FCR=Total Weight GainTotal Feed Given
The lesser is the FCR, the higher is the efficiency of feed usage. The amount of feed provided every day was observed and the increase of weight was computed as stated above.
Survival Rate: This was calculated simply by assessing the number of dead fish which were left at the end of the trial period, using the following formula to arrive at the percentage survival rate(8)
Survival Rate=Total Number of Fish at Start Number of Fish Survived×100
This information gave a clue on how effective each system was in ensuring healthy fish and the minimization of death rates of the fish.
Frequency of collecting data:

- The weight, length was monitored every two weeks.
- Daily reports/ records of feed and survival data were done to increase precision in determining FCR and survival rates.
- The parameters of water quality were measured on weekly basis to ensure that the variations are captured and any environmental stressor is taken care of

4. Results

The findings of this research give an exhaustive comparison of the Biofloc Technology (BFT) system and the static water system in regard to the quality of water, efficiency in growth, biomass production, feed conversion, and survival of African catfish (Clarias gariepinus). Key findings are captured as follows.

4.1 Water Quality Parameters Comparison

The quality of water was monitored continuously during the study to determine the success rate of the BFT system in meeting optimal conditions of fish growth as opposed to the conventional static water system. Other key water quality parameters such as ammonia, dissolved oxygen, pH, total suspended solid (TSS) and temperature were noted.(9)

Table 1: Comparison of Water Quality Parameters between BFT and Static Water Systems

Parameter	BFT System (Mean)	Static Water System (Mean)	p-value
Ammonia (mg/L)	0.25 ± 0.05	1.12 ± 0.10	p < 0.01
Dissolved Oxygen (mg/L)	6.8 ± 0.5	5.2 ± 0.6	p < 0.05
pH	7.4 ± 0.2	7.3 ± 0.1	NS
Total Suspended Solids (mg/L)	50 ± 5	10 ± 3	p < 0.01
Water Temperature (°C)	28.4 ± 0.3	28.2 ± 0.2	NS

Based on Table 1, BFT system shown substantial reduction of ammonia concentration (0.25 mg/L) in comparison with the static water system (1.12 mg/L) ($p < 0.01$) thus indicating the biofloc system as much more efficient in dealing with waste products. Also, the BFT method kept a better and more stable dissolved oxygen level (6.8 mg/L compared to 5.2 mg/L) that is paramount to sustaining the well-being of fishes. There was a significant

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increase in total suspended solids (TSS) in the BFT system (50 mg/L) when compared with the static water system (10 mg/L) obviously because biofloc particles are suspended in the water column.

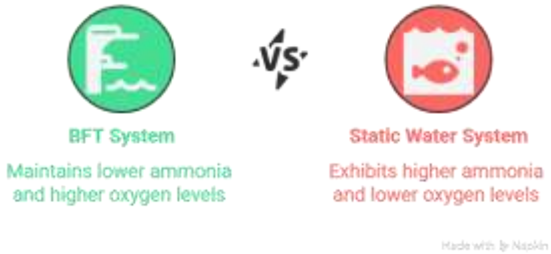

Figure 1: Ammonia Levels and Dissolved Oxygen Comparison

4.2 Efficiency of growth and Briste Output

To determine the growth efficiency, the weight gain and biomass production of the African catfish was obtained at the 8 week experiment period. The BFT system of fish farming registered a major improvement in the fish growth than in the system that involved static water.(10)

Table 2: Growth Performance of Catfish in BFT vs. Static Water Systems

Parameter	BFT System (Mean)	Static Water System (Mean)	p-value
Initial Weight (g)	8.5 ± 0.7	8.5 ± 0.7	NS
Final Weight (g)	52.6 ± 5.4	45.5 ± 4.2	p < 0.05
Weight Gain (g)	44.1 ± 4.2	37.0 ± 3.8	p < 0.01
Average Daily Growth (ADG)	0.63 ± 0.05	0.53 ± 0.04	p < 0.05
Biomass Output (kg)	1.65 ± 0.15	1.42 ± 0.13	p < 0.05

Table 2 indicates that final weight and weight gain of fish in the BFT system, were significantly ($p < 0.01$), respectively 14.7 percent and 19.3 percent higher than those in the static water system. ADG in the BFT system also was significantly increased (0.63 g/day) contrasted to the static water system (0.53 g/day) ($p = 0.004$). Such data means that BFT systems promote growth efficiency, which probably results in improved water quality and access of microbial food sources. There was also high biomass output in BFT system demonstrating the greater production capacity in that system.

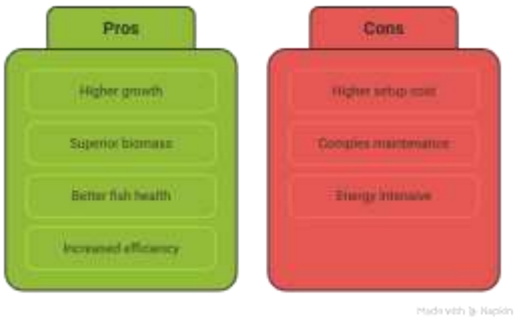

Figure 2: Growth Performance of Catfish in BFT vs. Static Water Systems

4.3 Feed conversion Ratio and Survival rates

Feed Conversion Ratio (FCR) and survival level were main measures of efficiency and sustainability of the two systems. FCR is a gauge on the amount of efficient conversion of feed into body mass, and the survival rate is the indicator of the overall health and toughness of the fish.

Table 3: Feed Conversion Ratio and Survival Rates in BFT vs. Static Water Systems

Parameter	BFT System (Mean)	Static Water System (Mean)	p-value
Feed Conversion Ratio	1.28 ± 0.05	1.52 ± 0.06	p < 0.01
Survival Rate (%)	92.1 ± 2.3	85.4 ± 3.5	p < 0.05

The results as demonstrated in Table 3 suggest that a BFT system had a much lower ($p < 0.01$) FCR (1.28) than the static water system (1.52) ($p < 0.01$), implying more efficient feed usage. The survival rate was also much higher in BFT system (92.1) in comparison with the static water system (85.4) ($p < 0.05$) indicating that BFT system offers a more stable and healthy environment to fish hence higher survival rates.(11)

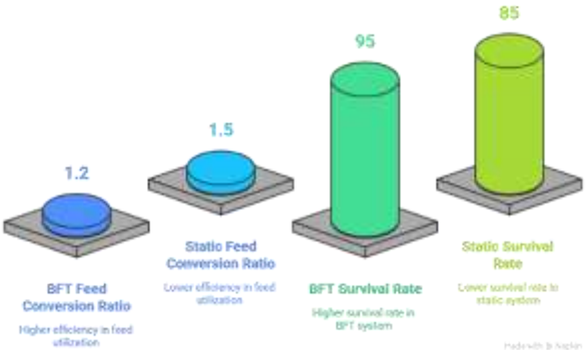

Figure 3: Feed Conversion and Survival Rates Comparison

5. Conclusion

5.1 BFT benefits on Catfish Farming:

In this paper, it has been evident that Biofloc Technology (BFT) has a number of benefits as compared to traditional static water system in farming of African catfish (Clarias gariepinus). Important findings are:

Better Quality of Water: BFT systems had much lower levels of ammonia and much higher levels of dissolved oxygen, which improved the environment in which catfish live. The decrease of the ammonia toxicity is of great importance in intensive aquaculture systems because they are notorious of the build up of wastes.

Better Growth Performance: The fish produced in BFT system had 14.7 percent weight gain and greater growth efficiency (reflected by higher weight gains and ADG values and efficiencies) compared with fish growing in static water system. Such growth is probably caused by the better quality of water and the extra microbial food sources the biofloc system provides.

Improved Feed Conversion and Survival Rates: BFT system gained a higher rate of feed conversion ratio (FCR) and superior survival rates, which proves that it used feed efficiently, and the environment was more stable and resilient to fish. The consequence has a hand both in economic gains and the health condition of the stock.

5.2 Potential Outcomes to Resource-Efficient Aquaculture

The paper shows the opportunities of BFT as an economical solution that may be applied in the aquaculture industry. Conventional systems tend to use frequent exchanging of water in order to treat waste, which is unsustainable, and resource-dependent. On the contrary, the BFT systems reuse nutrients and minimise water change, which helps to save water and reduce the volume of waste to the environment.

Also, given the abundance of microbial life in BFT systems that allow managing waste and supplying additional nutrients, the systems increase the utilization of feed, and are an environmentally conscious solution. This lessens the reliance on outer feed feedstuff and reinforces the notes of circular economy in fish farms.

5.3 The Prospects of Adopting BFT on Commercial Systems in the Future

Considering the potential find of this research study, there are bright prospects of BFT use in commercial catfish farming. Future research may aim at streamlining the system to different levels of operation and analyze its future viability. Future studies are required to harmonize the standards in terms of biofloc management, the favorable use of carbon sources and biofloc maintenance in a bid to boost efficiency.

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Further, economic feasibility analysis needs to be conducted to determine how it is going to be cost-effective to adopt BFT on a large-scale taking into account the cost of infrastructure, energy consumption, and labor. As commercially oriented systems aim at improving environmental performance and productivity, BFT has presented a possible way of realizing these objectives without jeopardizing the wellbeing of fish and maximizing the cost-effectiveness of the operations.

Acknowledgement: Nil

Conflicts of interest

The authors have no conflicts of interest to declare

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