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# Comparative Study of Biofloc Systems with Varying Management Approaches for Indoor Culture of Clarias Batrachus

**Ankit Kumar[1], Dr. Nageshwar Wast[2]**

[1]Research Scholar, Jai Prakash University, Chapra, Bihar, India
[2]Assistant Professor, Ram Jaipal College, Chapra, Bihar, India

**Abstract:**
Biofloc technology (BFT) is an environmentally sustainable approach in aquaculture that improves water quality and natural food availability through microbial flocs in the water column; however, there is insufficient data regarding its comparative efficacy with other management strategies for Clarias batrachus in intensive indoor culture systems. To compare the static systems, aerated systems, and probiotics-aided biofloc systems on the basis of quality and quantity of water, growth, feed utilization, and survival of Clarias batrachus in an indoor culture environment. This research involved three 500 L tanks replicated three times to take 90 days of experimentation. There were three treatments as follows: (T1) static biofloc, (T2) aerated biofloc and (T3) probiotic-assisted biofloc. Parameters of water quality (temperature, dissolved oxygen, pH, TAN, nitrite) and indicators of fish performance priority (weight gain, specific growth rate, feed conversion ratio, and survival) were also measured every week. Mean values and graphical trends were done with Microsoft excel. The dissolved oxygen was maintained at a higher level ($6.2 \pm 0.2$ mg/ml) and the TAN and nitrite were also lower ($0.52 \pm 0.02$ mg/ml; $0.15 \pm 0.02$ mg/ml) in probiotic-assisted biofloc (T3) than aerated (T2) and non-aerated (T1) system. Fish cultured in T3 had the highest final weight (84.2g), weight gain (72g), specific growth rate, improved feed conversion ratio and survival rate as compared to T2 that was ranked second and T1 had the lowest values. The research concludes that probiotic aided biofloc systems have the best effect in improving the water quality, improving growth, and survival of the Clarias batrachus in an indoor and intensive fish culture, and its applicability as an eco-friendly strategy of fish farming.

**Keywords:** Biofloc-technology, Clarias batrachus, Indoor culture, Probiotics, Water quality

## 1. INTRODUCTION

Aquaculture has become one of the most rapidly developed spheres of food production on the global level, and the intensive practices employed in it tend to result in the deterioration of water quality, the spreading of diseases and the possible environmental effects. Biofloc Technology (BFT) has in the recent years become a promising, ecological, and sustainable solution to these challenges [1]. BFT entails positive microbial grouping (bioflocs) that utilizes nitrogenous waste, enhance water quality and act as a supplementary natural feed of cultured species that contains protein enriched natural food. This system limits the exchange of water thus minimizing pollution and maximizing the use of the feed; a system that is very suitable for intensive aquaculture systems [2].

Although there have been considerable studies on BFT with significant applications in the growth of shrimps and tilapias, the applicability of the BFT in air-breathing freshwater fish like Clarias batrachus walking catfish has been less discussed. The fast growth, hardiness and consumer demand make this species extremely important economically and indoor intensive farming is most suited to this species. In serious cases, however, keeping C. batrachus indoors by highly intensive culture can cause an excessive build-up of organic matter, ammonia toxicity and low oxygen, compromising the growth and survival of the organism. These problems could be alleviated by using effective biofloc management programmes [3]. Various management techniques in biofloc systems, i.e., static, aerated and probiotics-assisted bioflocs are reported to have effects on microbial activities and water quality but without direct comparison in C. batrachus culture present. Addition of probiotics in biofloc system would help increase the microbial diversity and decrease the pathogenic bacteria and increase the reuse of nutrients and aeration would enable the mixing and provision of oxygen both to the fish and microbes [4].

The research was driven by the rising demand for sustainable indoor culture systems and sought to compare the effects of three biofloc system types—static, aerated, and probiotics—on water quality, growth performance, feed efficiency, and survival rates of Clarias batrachus in an intensive indoor culture setting.

### 1.2 Objectives

- To make a comparison of the scope of effects of static, aerated and probiotic-aided biofloc systems on every limitation of water quality when conducting intensive indoor culture of the Clarias batrachus.
- To determine the influence of different techniques of biofloc management on the performance of growth, feed utilization efficiency and survival of Clarias batrachus reared.
- To compare the development of biofloc (floc volume and microbial quality) with biofloc systems performance (the three biofloc systems).

## 2. LITERATURE REVIEW

**Chen et al., (2025)** determined the effects of glucose (soluble) and PHBV (slow release) carbon sources on chemoautotrophic nitrification of biofloc systems. This study observed that although, in all groups, nitrification preceded, presence of glucose introduced delays in nitrate peaks and resulted in reductions in abundances of amoA and nxrB genes and in microbial communities. The difference between the HBV and the control was less than the HBV effect. Microbial communities exhibited three community member clusters that were related to the environmental factors, and deterministic processes overrode the randomness and were evident as the communities were influenced by addition of carbon sources. These pieces of information can be used to optimize BFT in the treatment of aquaculture wastewater [5].

**Jamal et al., (2025)** compared Nile tilapia cultured in super-intensive biofloc technology (BFT) and "conventional pond culture systems (CPCS)". BFT fish obtained very high results in growth performance, SGR, productivity, and a better FCR, as well as hematological parameters (WBC, RBC, Hb, HCT, MCV, MCH, and MCHC) and PLT. Yet, the proximate composition (crude protein, fat, and ash) in CPCS was superior to that in BFT and moisture was higher in BFT. There was almost a hundred percent survival in both systems which depicted the superiority of BFT in terms of growth and health performance [6].

**Solanki S et al., (2023)** carried out a twenty-day factorial experiment in 100 L HDPE experimental tanks, to determine the impacts of the C/N ratio and stocking density on Gibelion catla spawn nursery

rearing within the indoor biofloc system. The carbon source of manipulating C/N ratios was rice bran. Water parameters indicated that an increment of C/N ratio of 10 to 20 changed greatly ($P < 0.05$) in TAN and nitrite nitrogen (NO2-N) and nitrate nitrogen (NO 3-N) in the water [7].

**Augustiawan et al., (2023)** analyzed the profitability of the catfish business in Turikale District and Mandai District, Maros Regency using conventional and biofloc methods. This research method uses the quantitative analysis method with the location chosen deliberately, namely Turikale and Mandai Districts. Sampling was carried out using snowball sampling. Data analysis was done by using qualitative and quantitative analysis. The results of the research are the total profits obtained by catfish farming with conventional techniques in the Mandai and Turikale Districts of IDR 10,493 and 854.71/harvest profits for conventional techniques of IDR 4,669,332.40 and for the Biofloc technique. IDR 5,824,522.31 which means the advantage of the biofloc technique is greater than conventional [8].

**Zabidi et al., (2021)** determined the impact of various probiotics strains within a biofloc system on the growth of red hybrid tilapia and its disease resistance. An MP comprising of three strains demonstrated the most significant inhibition of Streptococcus spp., recorded the highest specific growth rate (3.73, 0.23% day-1), and FCR (0.76, 0.04). Survival of the MP in an experiment, after pathogen challenge was also highest at 83, 1.43%. Probiotic groups lowered the nitrite levels and ammonia levels in all the probiotic biofloc groups when compared to the control, which means that probiotics increase growth, survival and water quality with biofloc systems [9].

**Hisano et al., (2021)** compared Nile tilapia fingerlings that were cultured 60 days in biofloc technology (BFT) and recirculating aquaculture systems (RAS). Compared to RAS, fish in BFT had a significantly high weight gain, feed conversion and protein efficiency even though the water quality and hematological parameters were comparable between the systems. The composition of the biofloc changed over time and supplied extra nutrients. The learning shows the importance of the value of bioflocs as natural supplementary food of improved growth performance [10].

**Azim et al., (2019)** studied the effects of different feeding rates and frequencies on the growth and survival of Clarias batrachus fingerlings in indoor culture. After more than 90 days, weight gain, specific growth rate and protein efficiency ratio were highest after receiving a 20 percent feeding rate (FR2). In another 60-day feeding trial, it was found that once-daily feeding (FF1) had the least amount of water weight gain and did not make a significant difference to water quality. This study drew the conclusion that in indoor rearing of C. batrachus fingerling, the commonly accepted feeding regimen is 20 per cent of body weight fed once a day [11].

**Bapary et al., (2017)** compared the nutrition and biochemical characteristics of Koi, Shing, and Tilapia farmed in biofloc systems and Traditional practice farming and harvesting systems. At the protein, lipid, and ash levels, there was a significant increase in the BFT fish. All of the fish contained some nutritional deterioration during a 60-day frozen storage with BFT fish having a better quality with reduced TVB-N and TBARS values. The research highlights the utility the use of BFT has in the creation of nutritionally better and even more viable aquaculture products [12].

### 2.1 Research gap

Although there is increasing use of biofloc technology in fish farming, little research has been conducted on other fish species like tilapia and shrimp in outdoor and semi-intensive systems where a significant gap has to be filled on the utilisation of the biofloc system on air-breathing fish like the Clarias batrachus which is kept under indoor and intensive culture. There is little comparative data on the various management processes employed in biofloc systems, namely, static, aerated and probiotic-assisted, and

their impact on water quality, microbial dynamics, nutrient recycling, growth performance, feed and no growth and survival. Also, there are no species-specific practices for maximizing the stocking density, C:N ratios, and the use of probiotics under moderated indoor conditions and hence, warrants the use of systematic assessments on these strategies.

## 3. METHODOLOGY

### 3.1 Preparation of biofloc system

The study was carried out in 500 L fiberglass tanks in triplicates three times with three treatments, static, aerated, and probiotics-aided biofloc systems. Clarias batrachus fingerlings (10 -15 g) were allowed to adapt to the surrounding conditions of the tank for 7 days and stocked at 150-200 pieces per tank. The organic carbon source was used with a C: N ratio of 15:1. The degree of aeration was minimal in the static tanks and was continuous in the aerated tanks and continuous addition of probiotic weekly in the probiotic -assisted tanks. Commercial diet was provided to all groups adjusted on biomass and the biofloc volume and water quality was monitored weekly.

**Table 1: Preparation of Biofloc system**

| Step/Component | Static Biofloc System | Aerated Biofloc System | Probiotic-Assisted Biofloc System |
|---|---|---|---|
| **Tank Setup** | 500 L circular fiberglass tanks (triplicate) | Same as static | Same as static |
| **Stocking Density** | 150–200 fingerlings/tank (10–15 g) | Same as static | Same as static |
| **Acclimatization** | 7 days prior to experiment | 7 days | 7 days |
| **C:N Ratio Adjustment** | Addition of organic carbon to maintain 15:1 C:N | Same as static | Same as static |
| **Aeration** | Minimal / intermittent aeration | Continuous aeration | Continuous aeration |
| **Probiotic Application** | Not applied | Not applied | Commercial probiotic added weekly |
| **Feeding** | 30–32% protein diet at 4–5% body weight per day; adjusted every 15 days | Same as static | Same as static |
| **Biofloc Formation** | Naturally develops with limited aeration | Enhanced by continuous aeration | Enhanced by aeration + probiotics |
| **Water Monitoring** | Routine monitoring of water quality and biofloc volume | Same as static | Same as static |
| **Biofloc Volume Measurement** | Imhoff cone weekly | Imhoff cone weekly | Imhoff cone weekly |

### 3.2 Research design

The current experimental research entails carrying out the experiments in an indoor aquaculture unit to examine results concerning the use of three types of biofloc systems namely, static, aerated, and

probiotic assisted. There were nine experimental (circular fiberglass) tanks made of fiberglass, of a 500 L capacity, placed in triplicates within each treatment. A stocking density of 150-200 fingerlings of Clarias batrachus (Linn) of an average initial weight of 10-15 g was measured after 7 days acclimatization. Addition of organic carbon sources were carried out to develop a C: N ratio of 15:1 and based on the specific treatment requirements, the tanks were maintained under minimal aeration and under static biofloc, continuous aeration and under continuous aeration with weekly addition of commercial probiotics under probiotic assisted biofloc. All fish have fed a commercial diet with a 30-32% protein content at 4-5% of their body weight per day and feeding frequencies were altered after a period of 15 days according to the biomass.

**3.3 Evaluation parameters**

The evaluation involved maintain a ratio of 15:1 C:N and aeration specificity in each of the following treatments: intermittent (static oxygenation), continuum (aerial treatment) and continuum with addition of weekly probiotics (probiotic-aided). Fish received 4-5% body weight per day as 30-32 % protein diet which was changed after every 15 days. The volume of biofloc was registered every week and the growth and feed parameters were registered at the end of the experiment.

Evaluated parameters

- Specific growth rate (SGR)
- Feed conversion ratio (FCR)
- Biomass yield
- Biofloc volume (Imhoff cone method)

**3.4 Data collection and analysis**

All recorded values pertaining to water quality parameters (temperature, dissolved oxygen, pH, total ammonia nitrogen, nitrite) and developmental indicators (weekly weight, final weight, weight gain, specific growth rate, feed conversion ratio, and survival rate) were systematically entered into Microsoft Excel for data analysis purposes. The data has been organised, and calculations such as the mean and percentage were performed directly in Excel. Excel tools were utilised to create graphical representations, including bar charts, and pie charts, to illustrate the trends of the three treatment modalities (static, aerated, and probiotic-assisted biofloc systems).

**3.5 Ethical considerations**

- The research protocol received approval from the Institutional Animal Ethics Committee (IAEC) in compliance with CPCSEA/ICAR requirements prior to the commencement of the investigation.
- Fish were meticulously managed during stocking and sampling to reduce stress, employing anaesthetics (clove oil/MS-222) as required; humane endpoints were adhered to for any moribund fish.
- The quality of water was preserved during the experiment, and effluents were processed prior to disposal to prevent environmental pollution.
- All operations conformed to ethical standards, biosafety protocols, and principles of scientific integrity for precise data collecting and reporting.

## 4. RESULTS

The three biofloc systems exhibited significant disparities in the study. T3 or probiotic-assisted biofloc resulted in optimal water quality, characterised by elevated dissolved oxygen levels and diminished TAN and nitrite concentrations, alongside superior growth, survival rates, and feed efficiency. T2,

representing aerated biofloc, outperformed T1, which denotes static biofloc. Nonetheless, it is less effective than T3. Overall, growth trends, specific growth rate (SGR), and biomass were maximized in T3, showing the impact of simultaneous aeration and probiotics on the indoor cultivation of Clarias batrachus.

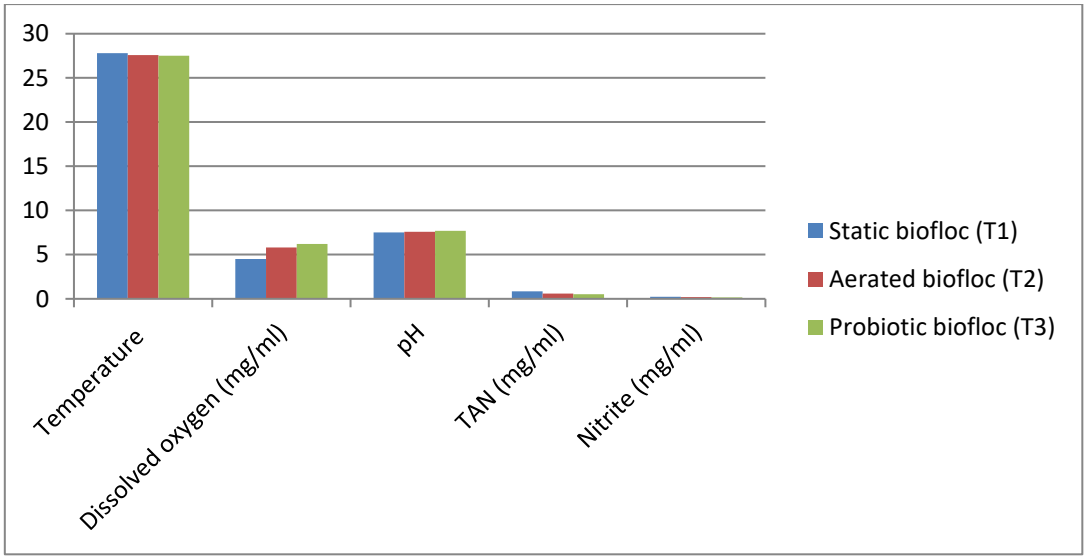
### 4.1 Water quality parameters

The values of parameters of water were maintained at an optimum level during the 90 days test of the culture of Clarias batrachus. The dissolved oxygen level and ammonia levels were well maintained in aerated and probiotics assisted systems than in the case of the static biofloc system.

**Table 2. Mean ± SE water quality parameters recorded in different biofloc systems during the experiment**

| Parameter | Static biofloc (T1) | Aerated biofloc (T2) | Probiotic biofloc (T3) |
|---|---|---|---|
| Temperature (°C) | 27.8 ± 0.3 | 27.6 ± 0.2 | 27.5 ± 0.2 |
| Dissolved oxygen (mg/ml) | 4.5 ± 0.2 | 5.8 ± 0.3 | 6.2 ± 0.2 |
| pH | 7.5 ± 0.1 | 7.6 ± 0.1 | 7.7 ± 0.1 |
| TAN (mg/ml) | 0.85 ± 0.05 | 0.60 ± 0.03 | 0.52 ± 0.02 |
| Nitrite (mg/ml) | 0.25 ± 0.03 | 0.18 ± 0.02 | 0.15 ± 0.02 |

**Interpretation:** As shown in the table, the water quality was maintained optimally in probiotic biofloc system (T3). Although the temperature (27.8 ± 0.3, 27.6 ± 0.2, and 27.5 ± 0.2°C in treatments T1, T2, and T3, respectively) exhibited no significant variation among treatments, dissolved oxygen levels (4.5 ± 2.0 mg/ml in T1, 5.8 ± 0.3 mg/ml in T2, and 6.2 ± 2.0 mg/ml in T3) increased by 13% subsequent to the addition. The level of total ammonia nitrogen went down to 0.85± 0.05 (T1) to 0.60 ±0.03 (T2) and 0.52 ± 0.02 (T3), whereas the level of nitrite went down to 0.25 ± 0.03 (T1) to 0.18± 0.02 (T2) and 0.15 ± 0.02 (T3). This indicates the fact that probiotics and aeration enhanced airflow and dropped nitrogenous waste.



**Interpretation:** In the bar chart, it was observed that the temperature and pH level barely varied in all the three biofloc systems. The highest value of dissolved oxygen is found in probiotic biofloc (T3) while no oxygen was found in static biofloc (T1). Concentrations of total ammonia nitrogen (TAN) and nitrite levels are observed to be the lowest in T3, moderate in T2 and highest in T1, thus showing that water quality is enhanced with the supplementation of probiotics and aeration.

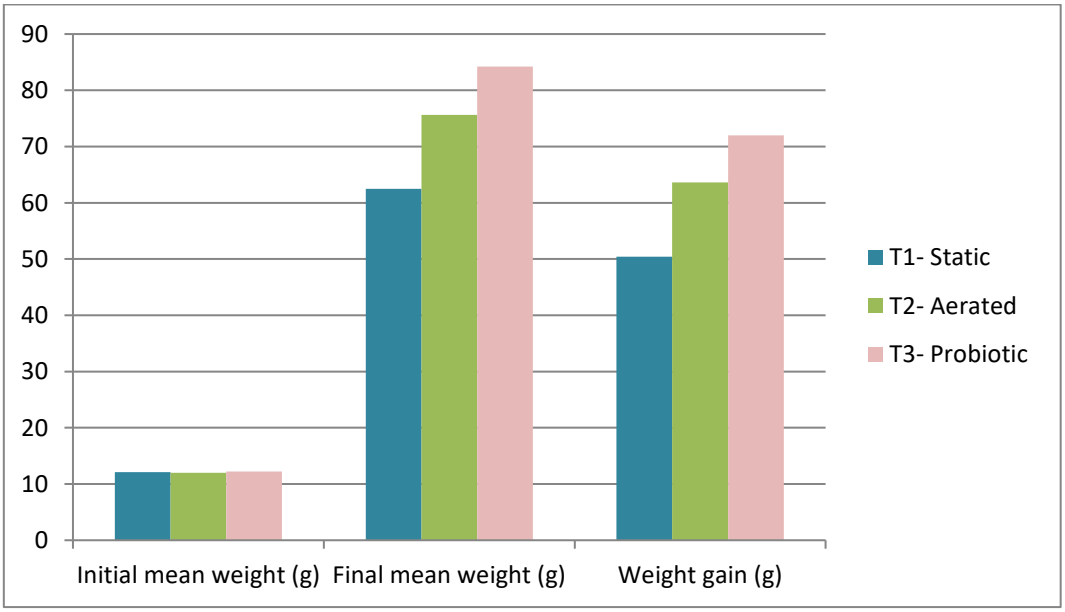
### 4.2 Growth performance

There were significant results ($p < 0.05$) in the parameters of growth across the treatments. The maximum weight gain, SGR and survival rate were observed with probiotic-assisted biofloc (T3), and the minimum performance was obtained with the static biofloc (T1).

#### 4.2.1 Weight gain

| Parameters | T1- Static | T2- Aerated | T3- Probiotic |
|---|---|---|---|
| Initial mean weight (g) | 12.1± 0.3 | 12.0 ± 0.4 | 12.2 ± 0.3 |
| Final mean weight (g) | 62.5 ± 1.8 | 75.6 ± 2.1 | 84.2 ± 1.9 |
| Weight gain (g) | 50.4 | 63.6 | 72.0 |

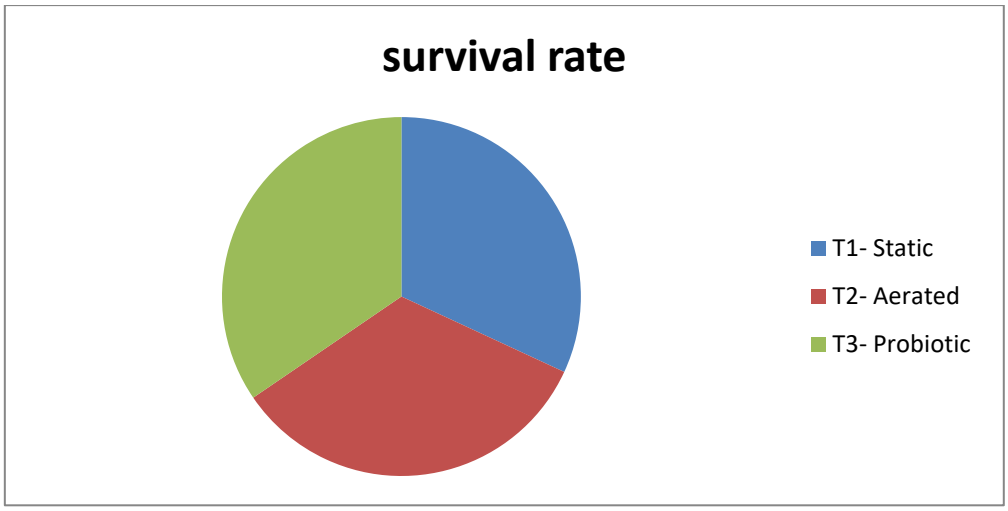
**Interpretation:** In table 4.3, data indicate that all three biofloc systems facilitated the growth of Clarias batrachus, however with varying degrees of success. The probiotic treated biofloc (T3) recorded the best final weight (84.2 ± 1.9 g) and weight gain (72.0g), construed by the 75.6 ± 2.1g and 63.6 g final weight and gain by the aerated biofloc (T2). The final weight and gain during this experiment were lowest in the static biofloc (T1) group, 62.5 ± 1.8 g and 50.4 g gain respectively. These findings show that aeration and more, so probe supplementation have a great impact on growth compared to the static systems.




**Interpretation:** The average weight of fish at baseline is almost the same in all treatments as displayed with the bar graph. But the mean weight and gain after weight was highest at the probiotic biofloc system (T3), then followed by the aerated biofloc (T2) and the lowest was on the static biofloc (T1). This shows that probiotic supplementation and aeration have very high growth performance as compared to static conditions.

### 4.2.2 Survival rate

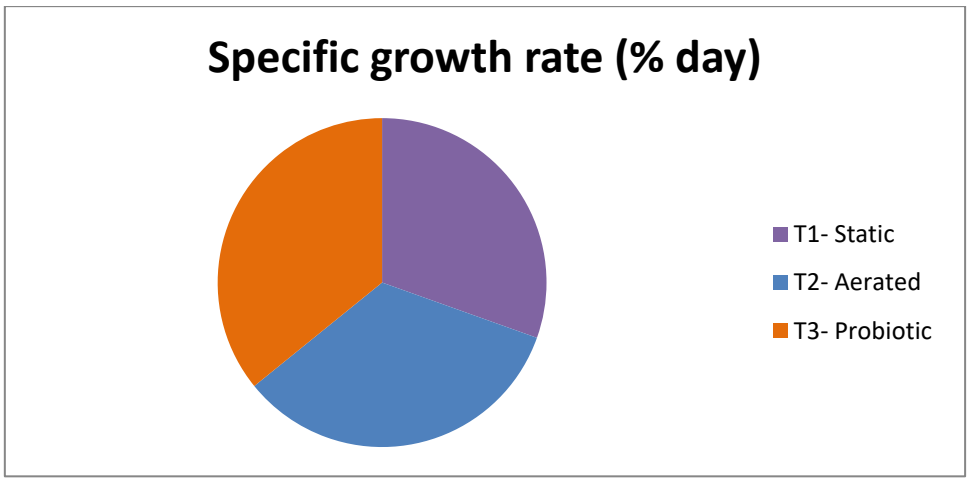
Survival rate is defined as the percentage of Clarias batrachus fingerling which were alive at the end of culture period in various biofloc management systems. The living was found to depend on the kind of biofloc system that was being used. The highest survival rate was observed in the probiotic-assisted biofloc system (T3) that is followed by the aerated biofloc (T2), and the lowest survival was recorded in biofloc (T1). This successful survival rate in T2 and T3 would also be due to the quality of water, increased oxygen content in the water, and the positive aspect of probioticcs in promoting a healthy microbe area that minimizes stress and incidence of the disease in the fish.




**Interpretation:** As depicted in the pie survival chart, the highest survival rate was in the probiotic biofloc (T3, approximately 35 percent), followed by the aerated biofloc (T2, approximately 34 percent) and a slightly lower survival rate in the static biofloc (T1 approximately 31 percent). This shows that the use of aeration and probiotic supplement led to the increased survival of fish as compared to the static system.

### 4.2.3 Specific growth rate (SGR)

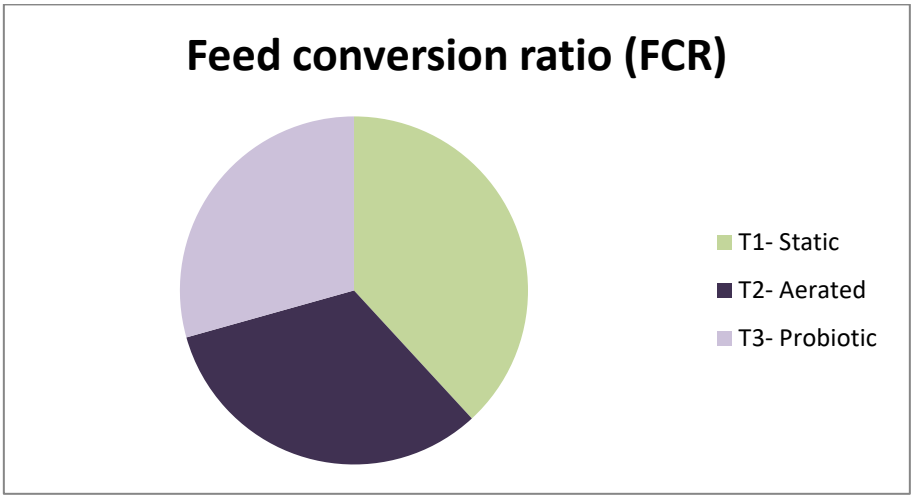
The probiotic-assisted biofloc system exhibited the highest SGR, followed by the aerated system and last, the static system was at the lowest rate. Better SGR at T3 and T2 is achieved by improved water quality, nutrient availability that stimulates feed utilization and growth.



**Interpretation:** The pie chart of specific growth rate ( % per day ) indicates that with probiotic biofloc system ( T3 ) the maximum proportion (approximately 36 %) was contributed the same, the aerated bio floc ( T2 ), the proportion was approximately 34% and the static bio floc ( T1 ), proportion was around 30%. This shows that probiotic feed supplements and aeration have great effect on specific growth rate over that achieved on the static conditions.

**4.2.4 Feed conversion ratio (FCR)**

The least amount of FCR is seen with the probiotic-assisted biofloc system, followed by the aerated and lastly by the static system. Reduction of FCR at T3 means more effective use of feed since enhancement of water quality and probiotics enhanced digestion and minimized feed waste as compared to stationery.



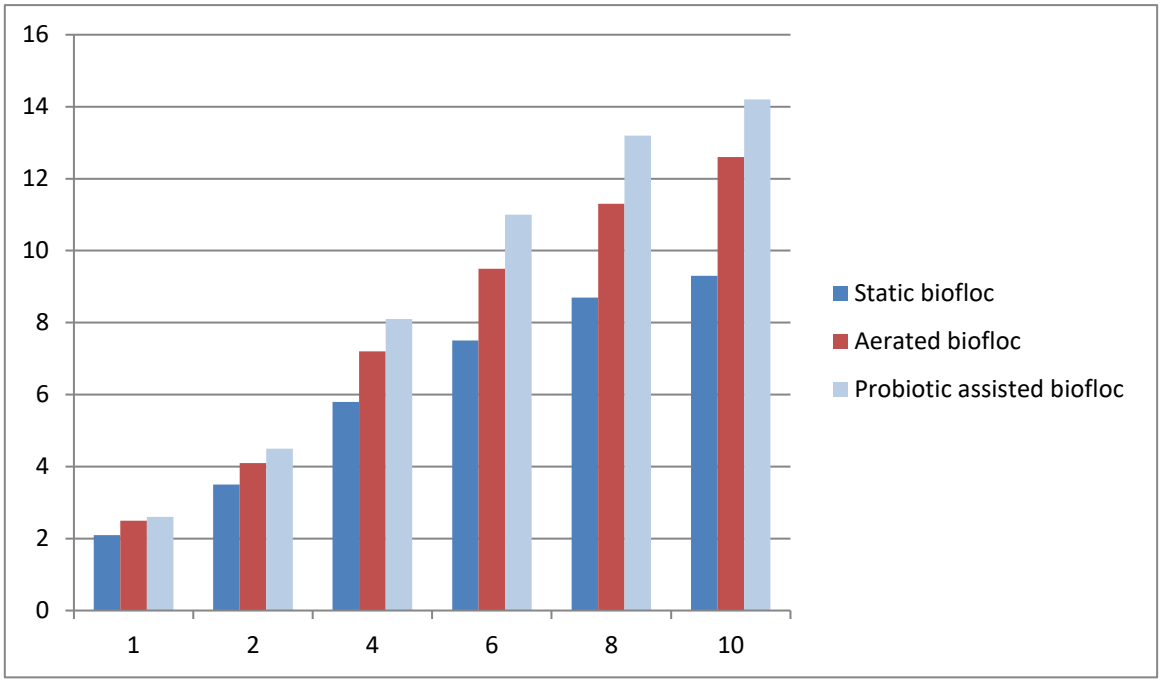

**Interpretation:** The pie chart depicts the feed conversion ratio (FCR) reveals that the static biofloc system (T1) has the biggest share (approximately 38%), which means that there is less conversion of feed. Aerated biofloc (T2) has the largest fraction of approximately 33%, whereas the probiotic biofloc (T3) shows the most excellent feed efficiency with the least fraction of about 29%. Aeration and more probiotics enhance a better feed conversion efficiency than in the case of static systems.

**4.3 Weekly biofloc volume (ML/L) measured usinf Imhoff cone**

| Week | Static biofloc | Aerated biofloc | Probiotic assisted biofloc |
|---|---|---|---|
| 1 | 2.1 ± 0.2 | 2.5 ± 0.2 | 2.6 ± 0.2 |
| 2 | 3.5 ± 0.3 | 4.1 ± 0.3 | 4.5 ± 0.3 |
| 4 | 5.8 ± 0.4 | 7.2 ± 0.5 | 8.1 ± 0.5 |
| 6 | 7.5 ± 0.5 | 9.5 ± 0.6 | 11.0 ± 0.7 |
| 8 | 8.7 ± 0.5 | 11.3 ± 0.6 | 13.2 ± 0.7 |
| 10 | 9.3 ±0.5 | 12.6 ± 0.7 | 14.2 ± 0.8 |

**Interpretation:** In table 4.4, data presented in the weekly growth indicates a definite trend of better growth in the probiotic assisted biofloc systems than in the aerated and the static ones. During the 1st and 10th week, the heaviest fish is in the probiotic system (which increased between 2.6 ± 0.2 g to 14.2 ± 0.8 g), followed by the fish in biofloc with aeration (between 2.5 ± 0.2 g to 12.6 ± 0.7 g) and less growth is depicted by the fish in static biofloc (between 2.1 ± 0.2 g to 9.3 ± 0.5 g). This reveals that

probiotic supplementation and aeration promotes a substantial increase in the growth rate and total biomass according to the comparison to stagnant conditions.




**Interpretation:** The bar chart indicates the continuous improvement in the growth overtime in all of the systems, however, the probiotic-assisted biofloc system recorded the most growth at each point. At week 10, fish in probiotic system had attained approximately 14.2 g whereas in aerated biofloc, fish had attained 12.6 g with lowest growth of fish being recorded in the static biofloc which attained only 9.3 g. This proves that the application of probiotic supplementation and aeration is very instrumental to the weekly growth rates in comparison to the static biofloc.

## 5. DISCUSSION

The research proved the best water quality, growth, feed conversion efficiency and survival of Clarias batrachus when probiotic assisted biofloc systems (T3) are compared to aerated (T2) and static (T1) systems. These results are well correlated with the study by Kumar et al., (2020) that stated that Clarias gariepinus showed growth and feed conversion when maintained in probiotic-enriched bioflocs. On the same note, Hussain et al., (2021) noted that biofloc technology improved the immune response and survival of C. batrachus because the microbial environment remained stable. Better waste management of nitrogen and the increased dissolved oxygen in this case conform to the findings of Chen et al., (2025), under controlled aeration and biofloc conditions, ammonia and nitrite are minimized. Besides, the higher survival rates in T3 can be combined with the evidence of Bapary et al., (2017) that biofloc-based systems can offer extra nutrients and decrease stress. On the whole, the research contributes more viable evidence that probiotic-assisted biofloc in intensive indoor catfish farming is a viable and environment-friendly practice.

## 6. CONCLUSION

The analysis ends by revealing that probiotic-aided biofloc systems and aerated systems have the best management response when it comes to the indoor raising of Clarias batrachus and the least performance

is associated with the static biofloc systems. Greater growth, specific growth rate, feed efficiency and survival were achieved by the combined effect of aeration and probiotic supplementation by improving dissolved oxygen level and decreasing the level of ammonia and nitrite to give a better water quality. These results affirm that probiotics can be placed into biofloc technology as a sustainable and beneficial activity toward improvement of productivity and fish health in intensive indoor aquaculture.

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