

A regional assessment of water quality and fish health via Biofloc Technology for rohu culture in Chapra District

Randhir Kumar Singh¹, Dr. Mohammad Waseem²

¹PhD Scholar, Jai Prakash University, Chhapra, Bihar, India

²Assistant Professor, Jai Prakash University, Chhapra, Bihar, India

Abstract - There are several problems in aquaculture of chapra district like water management, fish health, and production efficiency. Biofloc technology (BFT) emerged as an efficient and economical viable option for improving water quality and promoting fish development via recycling nutrients within the culture environment. To assess the water quality and fish health via Biofloc technology. The study conducted in two groups : the biofloc system and the traditional system. Various evaluating parameters were used i.e, specific growth rate (SGR), feed conversion ratio (FCR) and survival rate. The hematological parameters (WBC count, RBC count, hemoglobin and hematocrit) were also examined. The biofloc system produced superior outcomes, significantly exceeding the old method in weight increase (133.1g), specific growth rate (SGR) at 1.82% per day, and survival rate (92.5%), while demonstrating a lower feed conversion ratio (FCR) of 1.30. Enhanced physiological profiles were seen in the hematological parameters of aqua-cultured fish in biofloc, with elevated levels of WBC, hemoglobin, RBC, and hematocrit. Throughout the cultivation period in the Biofloc system, the water quality remained within ideal parameters. The authors assert that Biofloc Technology significantly improves water quality, fish growth, feed conversion efficiency, and overall health in rohu aquaculture. The implementation of first-generation aquaculture in Chapra area would serve as an effective and ecologically friendly alternative to conventional fish farming practices.

I. INTRODUCTION

To accommodate the swiftly increasing human population, food producing sectors, including aquaculture, require both horizontal and vertical development [1]. The fast expansion of the worldwide aquaculture sector cannot be overstated, as environmental and economic constraints may impede

its progress [2]. The intensification of aquaculture activities produces a substantial quantity of surplus organic pollutants, which may result in acute harmful effects and long-term environmental hazards [3].

Recently Biofloc technology (BFT) has gathered popularity as long-term and environmentally friendly aquaculture system that controls water quality while producing value-added microbial protein feed for aquatic species. There has been much research on the use of BFT systems for aquaculture of marine shrimp. This method encourages good aquaculture operations while being commercially feasible and ecologically sustainable [4].

1.1 Biofloc technology

BFT relies on sustaining elevated concentrations of microbiological bacterial floc in suspension by continuous aeration and the incorporation of carbohydrates to facilitate oxygen breakdown of organic matter [5]. The addition of carbohydrates stimulates heterotrophic bacterial growth and ease the conception of microbial proteins via nitrogen assimilation [6]. Water quality may be advanced by the generation of good quality single-cell microbial protein by controlling the C-N ratio in the aquaculture environment. This can be achieved via the addition of carbon sources or by increasing the carbon content in feed externally.

Under these conditions, dense bacteria proliferate, serving as a bioreactor that regulates water grade while also providing a protein food supply for fish and shrimp [7]. Due to heterotrophic organisms' tenfold higher growth rate and microbial biomass output per unit substrate compared to autotrophic nitrifying bacteria, the attenuation of toxic nitrogen variety occurs much more immediately in bioflocs [8]. The

method operates on the fundamental concept of flocculation, involving the co-culture of heterotrophic bacteria and algae within the environment. BFT has been effectively utilized in aquaculture, particularly in shrimp farming, owing to its lucrative, environmental, and marketing assets compared to traditional culture systems [9]. In comparison to traditional aquaculture methods, biofloc technology offers a more cost-effective and sustainable approach, characterized by less water exchange and decreased feed input, rendering it a low-cost solution for the advancement of sustainable aquaculture [10].

1.2 Use of BFT in aquaculture

a) Hatchery

Fish seeds and feeds are in high demand due to the expanding aquaculture industry in tropical nations. Rotifers, copepods, and *Artemia nauplii* are essential starting foods in hatcheries for successful larviculture, which is the development of fish seeds [11]. The tiny size, great digestion, palatability, and nutritional adequacy of live food make it the preferred choice in fry and fingerling production [12]. The conventional method of cultivating living food involves using expensive, fragile, and stressful high-density microalgal pastes. So, new ways for producing live food resources in large quantities using BFT have been developed. In BFT systems, certain strains of rotifers, specifically "Proales similis" and "Brachionus rotundiformis" were cultured at high densities (> 1200 individuals' ml⁻¹) [13]. Extensive study has shown that BFT may be used in outdoor settings to create high densities of varied zooplankton species, including rotifers, copepods, and cladocerans. As a result, BFT appears to be a huge step forward in aquaculture operations, allowing for the pre-planning of fish seedling development all year round [14].

b) Nutritional supplements

Due to their outstanding nutritional qualities, bioflocs can serve as nutritional supplements and also increase the fast population density of living food resources [15]. The presence of essential "polyunsaturated fatty acids (PUFAs)" in biofloc paste has been verified by research. This means that it may be used as an enrichment emulsion for live food sources (such as cladocerans, rotifers, copepods, and *Artemia*) and larval fish, reducing or eliminating the need for

expensive commercial enrichment emulsions. Asian and European hatcheries currently use expensive commercial emulsions to enhance live food supplies (such as *artemia*, algae, and rotifers) [16]. Traditional homemade emulsions prepared with yolk sac and fish oil have a short shelf life, limiting their use in aquaculture. However, the bio-friendly emulsion has the potential to outlast these alternatives. Biofloc polyunsaturated fatty acids (PUFAs) provide farmed fish with a wide range of natural nutrients that are essential for their health and have improved antioxidant defenses [17].

c) Biofloc meal

A premium and scarce protein source in the aquaculture feed industry, fish meal has a viable substitute in bioflocs. In local hatcheries, the biofloc paste may be collected and used to make compounded feed. This may facilitate a significant advancement in the formulation of economical fish feed inside cottage companies in impoverished nations [18]. Initiatives aimed at formulating feeding techniques like bioflocs and periphyton, which optimize the use of natural and supplementary foods in aquaculture facilities, would enhance productivity in the sector. In this context, it is essential to prioritize the presence of easily digested bacteria that provide energy enriched compounds to enhance BFT in the aquaculture system. Nevertheless, the concept of biofloc meal requires comprehensive scientific investigation [19].

d) Proteins and lipids for grow-out and forerunners

The possible impact of BFT on the breeding of fish remains largely uncharted. Research has demonstrated the enhanced efficacy of biofloc feeding in the initial phases of broodstock gonad formation and ovarian development, hence improving spawning performance [20]. The continuous provision of biofloc nutrients enhances sexual tissue development and reproductive activity in brooders. BFT has been effectively utilized in the nursery period for many shrimp species, including *Penaeus monodon*, *Farfantepenaeus* sp and *Litopenaeus vannamei*. When comparing bioflocs to a conventional clear-water system, researchers found that during the early postlarval stage of *F. paulensis*, the weight increased by 50% and the ultimate biomass increased by 80% [21]. At 56%-100%, the *L. vannamei* survival rate was achieved. *Oreochromis niloticus* is the fish species used for tilapia farming. Fish fed 35% CP in non-BFT systems grew at a slower

pace than those in BFT tanks that used 24% CP. The increased rate of growth might be linked to the nutritional bioactive compounds found in BFT [22].

1.3 Objectives of the study

1. To evaluate the impact of BFT on the water quality metrics (dissolved oxygen, ammonia, nitrite, nitrate, pH, and total suspended particles) in rohu (*Labeo rohita*) cultivation ponds located in the Chapra district.
2. The objective is to assess the influence of BFT on the health condition of rohu fish, focusing on growth performance and survival rate through measures including body feed conversion ratio (FCR), weight increase, specific growth rate (SGR), and the incidence of fish illnesses in rohu fish.

II. LITERATURE REVIEW

Alkhamis et al., (2023) performed assessed the influence of BFT on critical water quality parameters in aquaculture systems. Various parameters were evaluated pH, dissolved oxygen, nitrate, ammonia, nitrite, total ammonia nitrogen, total suspended solids, and alkalinity. The outcomes of the research showed that BFT reduced nitrite levels and favourably affected TSS whereas the remaining parameters showed no significant alterations. The observations demonstrated the beneficial effect of BFT on the management of nitrogenous compounds, and enhanced water quality. Hence BFT supports sustainable aquaculture production [23].

Deswati et al., (2023) assessed BFT in catfish culture by the application of carbonation and bioballs to improve the nitrogen – carbon ratio and microbial biofloc deposition. The study evaluated COD, BOD, TDS, floc volume, BOD/COD ratio, orthophosphate and sulfate via following total randomized design including five treatments and four replications. This study shown significant improvement in water quality and fish performance having recorded volume of floc 7699ml-l and feed efficiency of 98.79% [24].

Pimentel et al., (2023) aimed to develop a cost-effective method for evaluating coloration of biofloc bacteria to determine water quality in dense marine shrimp farms. The study proposed the “microbial community colour index (MCCI)” using RGB (red ,

green , blue) image analysis of biofloc samples from 17 tanks. MCCI demonstrated positive correlations with carbon, phosphorus and nitrogen levels in bioflocs, total suspended solids, but shown negative association with water clarity and values of green colour. The colour shifts from green to brown and correlates with the progression of the culture’s autotrophic to heterotrophic microbial communities. The study confirmed that RGB averages in fake pictures accurately estimate water quality. MCCI might serve as a foundation for future practical ways such as colour scale or a mobile app to quickly verify shrimp BFT infrastructure water quality [25].

Dhar et al. (2023) compared the macro-mineral and hazardous metal concentrations in BFT and conventional fish farms. The researchers aimed to assess the contribution and relative health risk of dietary minerals for adults and children inside the USEPA deterministic model. Fish cultivated in biofloc exhibited elevated macro-mineral levels and reduced harmful metal concentrations ($p < 0.05$) compared to market samples. The target hazard quotients (THQs) for all metals were below 1.0, indicating a low non-carcinogenic risk. The hazard index (HI) of certain market samples of *Tilapia* exceeded acceptable levels, raising concerns about long-term use. The TCR values of lead (Pb) in all samples were below the permissible range (10^{-6} to 10^{-4}), although market fish exhibited greater TCR values than biofloc fish. The study revealed that biofloc fish are safer and healthier for human consumption than conventionally farmed fish [26].

Deb et al., (2020) investigated the efficiency of BFT for culturing Indian major carps (IMC) in tanks at stock densities of 4.28, 8.57 and 12.85 fish. This study showed that BFT improved water quality and reduced nitrogenous compounds (nitrate, ammonia, nitrite) at minimal stocking rate. Flocculation and water quality were optimal at 4.28 fish m⁻¹, with catla and rohu exhibiting specific growth rates of 1.1% and 0.98% respectively. The growth rate reduced with increased density, nevertheless the water quality remained acceptable. BFT improved water quality and growth performance, emerged as a potential and sustainable option for improving the production of aquaculture [27].

Despite significant advancements in BFT within aquaculture, certain research gaps remain

unaddressed. The predominant literature endorses tank-based research with a restricted number of species, which are not realistically applicable in regions, especially in rural areas like Chapra district. There is a deficiency of integrated studies connecting many water quality factors to fish health, growth performance, immunological response, and disease resistance in natural pond environments. Although the recycling of color-based water quality measurement tools has demonstrated efficacy in marine shrimp culture, a similarly low-cost, fast, and consistent method has yet to be developed for Indian major carp cultivation in freshwater environments. Moreover, there is a paucity of evidence about the nutritional safety and toxicological characteristics of fish raised in bio-floc systems, especially concerning the human consumption of freshwater fish species. Research is required to optimize various carbon sources to modify the microbial community structure and nutrient cycling inside a freshwater bio-floc system. Furthermore, there is a lack of evidence about the economic viability, farmer knowledge, and adoption potential of BFT in rural aquaculture contexts, indicating the necessity for more comprehensive, regionally focused studies.

III. RESEARCH DESIGN

Study design: comparative experimental field study design

Study area and duration: conducted in Chapra district, Bihar, India. This study took 4 months

Sample size: Approximately 100 rohu fingerlings will be stocked each pond or tank. To determine fish health, 10 fish will be randomly chosen from each pond monthly, while 30 fish per group will be collected monthly for physiological and water quality evaluations.

Sampling techniques: a random sampling technique was applied to avoid biasness in result

3.1 Sample selection criteria

3.1.1 Inclusion criteria

- Rohu fingerlings have uniform size within 10-15g
- Ponds have similar water and environmental conditions

- Farms strictly using either traditional or bio-floc culture system

3.1.2 Exclusion criteria

- Ponds have poor management history
- Fish showing signs of any disease or stress
- Farm using mixed culture system

3.2 Data collection

All procedures are conducted under ethical guidelines and ensure minimal harm or stress during sampling. All samples underwent a detailed evaluation procedure.

3.2.1 Water quality indicators

- pH
- Temp
- Dissolved oxygen
- Total ammonia nitrogen
- Total suspended solids
- Nitrite and Nitrate

3.2.2 Fish health parameters

- Growth performance, FCR, and weight gain
- Hematological indicators : WBC count, hemoglobin, RBC count

3.3 Data management and statistical analysis

The data acquired throughout the research will be categorized and entered into Microsoft Excel, where it will initially be verified and sanitized. The data will be examined using SPSS (version 25.0). Water quality and fish health data will be summarized descriptively using statistical measures such as mean and standard deviation. A one-way ANOVA will be utilized to evaluate the performance of Biofloc and conventional systems, followed by "Tukey's test" as a post hoc multiple comparison analysis. Correlation analysis employing Pearson's method will be conducted to ascertain relationships between water quality factors and fish health indicators. The significance test will be conducted at $p < 0.05$, and the findings will be presented in tables and graphs for effective interpretation.

Ethical permission was secure from institutional animal ethics committee prior to the beginning of the study and ensuring adherence to ethical standards.

IV. RESULTS

4.1 water quality parameters in biofloc and traditional culture system

Water quality parameter	Biofloc system (Mean \pm SD)	Traditional system (Mean \pm SD)
Temperature ($^{\circ}$ C)	28.5 \pm 1.3	28.2 \pm 1.1
pH	7.6 \pm 0.4	7.2 \pm 0.4
Dissolved oxygen (DO)	5.8 \pm 0.5	4.6 \pm 0.6
Ammonia	0.25 \pm 0.05	0.60 \pm 0.10
Nitrite	0.10 \pm 0.03	0.26 \pm 0.05
Nitrate	1.8 \pm 0.3	3.2 \pm 0.4
Total ammonia nitrogen (TAN)	0.30 \pm 0.05	0.65 \pm 0.08
Total suspended solids (TSS)	450 \pm 31	150 \pm 21
Biological oxygen demand (BOD)	3.2 \pm 0.4	4.5 \pm 0.6

Table 1: Comparative Water Quality Parameters between Biofloc and Traditional Culture Systems (Mean \pm SD)

Interpretation - Comparing water quality data between the Biofloc system and conventional culture technique shows various factors that affect rohu (*Labeo rohita*) growth and health. The two systems kept water temps between 26-30 $^{\circ}$ C for rohu growing. The Biofloc system had a slightly higher average temperature (28.5 \pm 1.2 $^{\circ}$ C) than the traditional system (28.2 \pm 1.0 $^{\circ}$ C), perhaps due to enhanced microbial activity and aeration in the tanks. The biofloc system produced a steady, slightly alkaline pH of 7.6 \pm 0.3, ideal for rohu growth. Due to reduced biological activity and nutrient recycling, the conventional system had a lower pH (7.2 \pm 0.4). The DO levels in the Biofloc system (5.80 \pm 0.5 mg/L) were substantially higher than those in the traditional system (4.60 \pm 0.6 mg/L). Biofloc's high dissolved oxygen is likely due to constant aeration and a supportive microbial ecosystem, which boosts fish metabolism and minimizes hypoxia risk. The Biofloc system (0.25 \pm 0.05 mg/L) had lower and more regulated ammonia (NH₃-N) and Total

Ammonia Nitrogen (TAN) concentrations than the traditional system (0.60 \pm 0.10 mg/L). Biofloc also reduced TAN (0.30 \pm 0.05 mg/L). This shows that heterotrophic bacteria in the biofloc system consumes nitrogen well, reducing ammonia levels. Fish nitrite toxicity was insignificant since the Biofloc system had substantially lower nitrite concentrations (0.10 \pm 0.02 mg/L) than the previous system (0.25 \pm 0.05 mg/L). Biofloc had lower nitrate contents (1.8 \pm 0.3 mg/L), indicating better nitrogen utilization and microbial conversion. The biofloc system had higher total suspended solids (TSS) (450 \pm 30 mg/L) than the normal system (150 \pm 20 mg/L). This increase is expected because biofloc systems accumulate microbial floc, which supplies fish with an extra natural nutrition supply. The Biofloc system has lower BOD (3.2 \pm 0.4 mg/L) than the traditional system. This shows increased biofloc ecosystem microbial control and organic material decomposition.

4.2 Comparative growth performance of Rohu in traditional vs biofloc system

Table 2: Growth performance of Rohu in biofloc and traditional culture system (Mean \pm SD)

Parameter	Biofloc system (Mean)	Traditional system (mean)
Weight gain (g)	133.1	97.9
SGR (%/day)	1.82	1.52
FCR	1.30	1.70
Survival rate (%)	92.5	85.6

Interpretation: A comparison of growth performance metrics between the Biofloc system and the Traditional system clearly indicates that the enhancement of rohu culture via the implementation of BFT is more successful. The Biofloc system exhibited significantly greater weight increase (133.1g) compared to the old method (97.9g), demonstrating superior growth potential. The SGR in Biofloc rose to 1.82% per day, surpassing the 1.52%

per day observed in the conventional setup, indicating accelerated daily growth. The FCR was lower in the Biofloc group (1.30) compared to the old method (1.70), indicating more effective feed utilization with less waste. The survival rate of Rohu was much higher in the Biofloc system (92.5%) compared to the conventional system (85.6%), indicating enhanced fish health and water quality conditions.

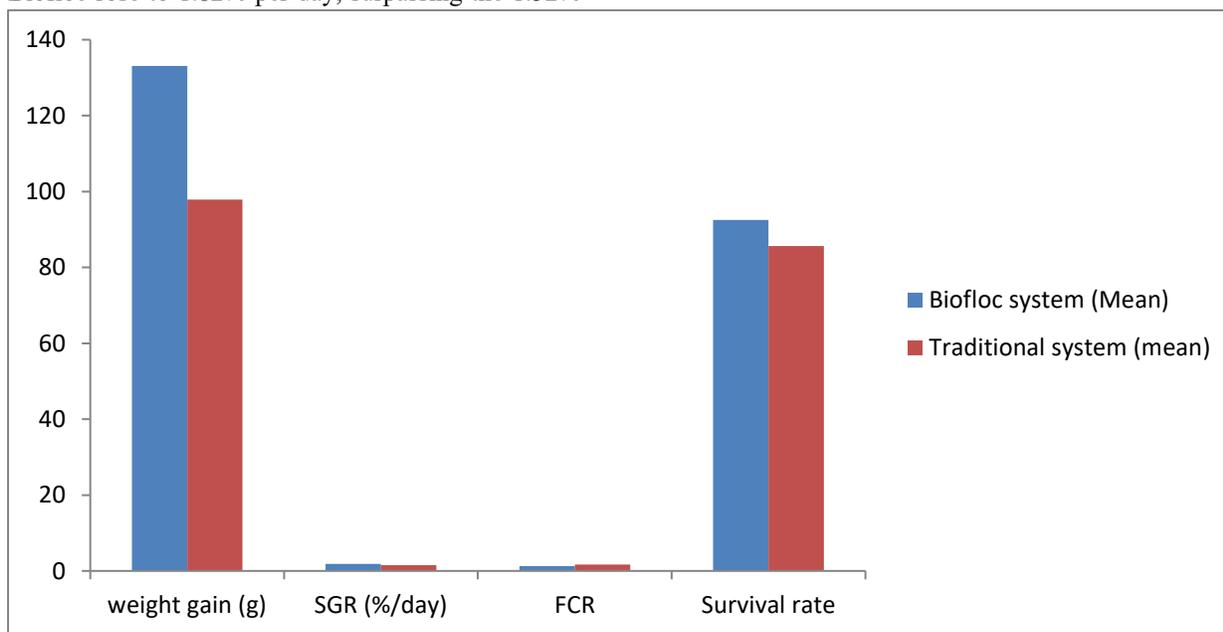


Figure 1: Comparative growth performance of Rohu

Interpretation: The bar graph clearly indicates that rohu cultivated in the Biofloc system had superior results compared to those grown in the traditional method regarding growth and vital factors. The Biofloc group exhibited a significantly greater rise in weight and SGR, indicating enhanced growth velocity and nutrient utilization efficiency. Furthermore, the

FCR in the Biofloc system was reduced, signifying a superior degree of feed efficiency. Biofloc exhibited superior survival rates, indicating enhanced fish health and reduced mortality. The graph clearly demonstrates the advantageous impact of biofloc technology on the development and survival of rohu compared to traditional pond culture methods.

Parameter	Biofloc system	Traditional system
RBC Count ($\times 10^6/\text{mm}^3$)	2.85 ± 0.14	2.31 ± 0.13

WBC Count ($\times 10^3/\text{mm}^3$)	9.8 ± 0.5	7.1 ± 0.5
Hemoglobin (g/dl)	9.5 ± 0.3	7.8 ± 0.2
Hematocrit (%)	34.6 ± 1.7	28.7 ± 1.6

Table 3: hematological parameters of Rohu in traditional and biofloc culture system

Interpretation : In the comparison of hematological parameters, rohu cultured in the Biofloc system exhibited significant differences in RBC count ($2.85 \times 10^6 /\text{mm}^3$), hemoglobin level (9.5 g/dl), WBC count ($9.8 \times 10^3 /\text{mm}^3$), and hematocrit percentage (34.5%) compared to those cultured in the traditional

system, which recorded an RBC count ($2.30 \times 10^6 /\text{mm}^3$) and WBC count ($7.2 \times 10^3 /\text{mm}^3$). These values indicate that the Biofloc environment positively influenced the oxygen-carrying capacity, immune response, and overall health of rohu.

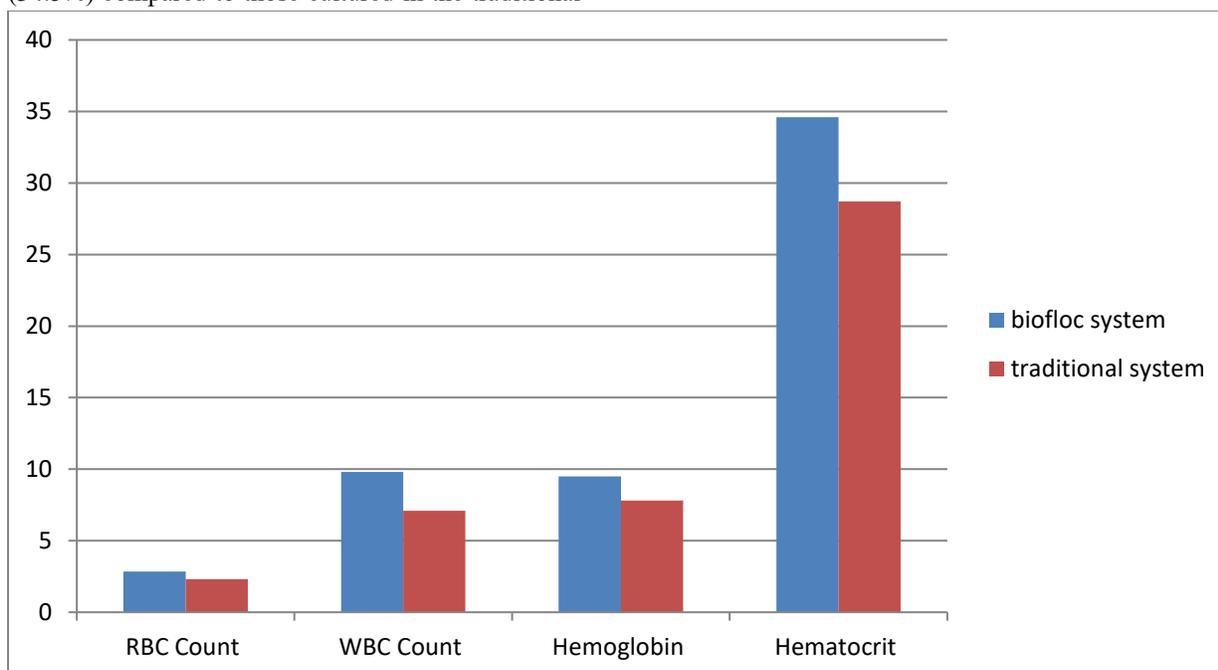


Figure : 2 Comparative hematological profile of Rohu.

Interpretation: The bar graph presents a comparison analysis of the primary hematological parameters (WBC count, Hemoglobin, RBC count, and Hematocrit) between Biofloc and Traditional aquaculture systems for the rohu species. Overall, all metrics in the Biofloc system (blue bars) exceed those in the standard system (red bars). Specifically, the rise in RBC within Biofloc indicates enhanced oxygen transport. The elevated WBC count indicates improved immune function. Correspondingly, the hemoglobin concentration is increased in the Biofloc group, signifying enhanced oxygen-carrying ability. Finally, there exists a substantial discrepancy in hematocrit percentages, with fish raised on Biofloc exhibiting considerably elevated levels, indicating

superior blood condition and general physiological health.

V. DISCUSSION

Currently, BFT has significant potential for improving the water quality, growth, and health of rohu (*Labeo rohita*) cultivated in the Chapra region. This study revealed that fish cultivated utilizing the biofloc methodology exhibited superior weight increase (133.1g), enhanced Specific Growth Rate (1.82), and a reduced Feed Conversion Ratio of 1.30 in comparison to the conventional method. The Biofloc group had a markedly enhanced survival rate of 92.5%, compared to 72.5% in the control group,

indicating superior health and resilience to environmental stress in the fish. The water quality metrics were consistently maintained at optimal levels during the experiment, indicating that BFT effectively managed nitrogenous waste and created circumstances favorable for fish development.

The findings align with previous research, including Deb et al. (2020) and Alkhamis et al. (2023), which demonstrated comparable growth performance and improvements in water quality for Indian main carps and other aquaculture species inside biofloc systems. Hematological assessments validated these findings, indicating that biofloc-cultivated fish exhibited a significant elevation in red blood cell count ($2.85 \times 10^6/\text{mm}^3$), white blood cell count ($9.8 \times 10^3/\text{mm}^3$), hemoglobin concentration (9.5 g/dL), and hematocrit percentage (34.5%). The results concurred with the observations of Deswati et al. (2023) and Dhar et al. (2023), which noted improved blood profiles and immune responses in fish and catfish cultivated in biofloc systems. The study demonstrates improved feed efficiency and elevated nitrogenous waste levels, alongside increased survival rates, for the BFT population. Pimentel et al. (2023) substantiate this through the modeling of the microbial community color index and the assessment of water quality in a biofloc-based shrimp production.

This study demonstrated that BFT is a more sustainable and superior method for cultivating rohu in Chapra area, leading to enhanced growth, feed conversion efficiency, health status, and water quality, so providing a viable alternative to traditional fish farming practices.

VI. CONCLUSION

Recent studies demonstrated that BFT is an exceptionally efficient and sustainable aquaculture approach, particularly for the development of rohu (Labeo rohita) in the Chapra region. The use of BFT significantly improved water quality metrics, creating a more stable and nutrient-rich aquatic habitat conducive to fish growth.

During the benchmarking process, Rohu cultivated in the biofloc system demonstrated superior growth performance, evidenced by enhanced weight gain, advantageous SGR, optimal FCR, and elevated

survival rates in comparison to Rohu raised in the conventional farming system.

Furthermore, hematological assessments indicated that biofloc fish exhibited superior physiological and immunological fitness, as demonstrated by elevated levels of RBCs, WBCs, hemoglobin, and hematocrit, signifying less stress and an overall advantageous condition.

The results indicate that Biofloc Technology is an eco-friendly, economical, and nutritionally beneficial approach to enhancing fish health and productivity in freshwater aquaculture. The study aligns with the growing use of BFT, particularly in the Chapra region, to foster sustainable and productive aquaculture techniques.

REFERENCES

- [1] Gephart JA, Golden CD, Asche F, Belton B, Brugere C, Froehlich HE, Fry JP, Halpern BS, Hicks CC, Jones RC, Klinger DH. Scenarios for global aquaculture and its role in human nutrition. *Reviews in Fisheries Science & Aquaculture*. 2020 Aug 3;29(1):122-38.
- [2] Young N, Brattland C, Digiovanni C, Hersoug B, Johnsen JP, Karlsen KM, Kvalvik I, Olofsson E, Simonsen K, Solås AM, Thorarensen H. Limitations to growth: Social-ecological challenges to aquaculture development in five wealthy nations. *Marine Policy*. 2019 Jun 1;104:216-24.
- [3] Mavraganis T, Constantina C, Kolygas M, Vidalis K, Nathanailides C. Environmental issues of Aquaculture development. *Egyptian Journal of Aquatic Biology and Fisheries*. 2020 Mar 1;24(2):441-50.
- [4] Yu YB, Lee JH, Choi JH, Choi YJ, Jo AH, Choi CY, Kang JC, Kim JH. The application and future of biofloc technology (BFT) in aquaculture industry: A review. *Journal of Environmental Management*. 2023 Sep 15;342:118237.
- [5] Dauda AB. Biofloc technology: a review on the microbial interactions, operational parameters and implications to disease and health management of cultured aquatic animals.

- Reviews in Aquaculture. 2020 May;12(2):1193-210.
- [6] Khanjani MH, Sharifinia M. Biofloc technology with addition molasses as carbon sources applied to *Litopenaeus vannamei* juvenile production under the effects of different C/N ratios. *Aquaculture International*. 2022 Feb;30(1):383-97.
- [7] Akpoilih BU. Microbial-Based Systems and Single-Cell Ingredients: Exploring Their Role in Sustainable Aquaculture Production. In *Emerging Sustainable Aquaculture Innovations in Africa 2023* May 12 (p. 209-249). Singapore: Springer Nature Singapore.
- [8] Robles-Porchas GR, Gollas-Galván T, Martínez-Porchas M, Martínez-Cordova LR, Miranda-Baeza A, Vargas-Albores F. The nitrification process for nitrogen removal in biofloc system aquaculture. *Reviews in Aquaculture*. 2020 Nov;12(4):2228-49.
- [9] Faizullah MM, Rajagopalsamy C, Ahilan B, Daniel N. Application of biofloc technology (BFT) in the aquaculture system. *J Entomol Zool Stud*. 2019;7:204-12.
- [10] Nisar U, Peng D, Mu Y, Sun Y. A solution for sustainable utilization of aquaculture waste: a comprehensive review of biofloc technology and aquamimicry. *Frontiers in Nutrition*. 2022 Jan 12;8:791738.
- [11] Lal J, Mogalekar HS. *Culture and utilization of live food organisms for aquahatcheries*. CRC Press; 2024 Aug 16.
- [12] Pailan GH, Biswas G. Feed and Feeding Strategies in Freshwater Aquaculture. In *Transforming Coastal Zone for Sustainable Food and Income Security: Proceedings of the International Symposium of ISCAR on Coastal Agriculture*, March 16–19, 2021 2022 Aug 10 (pp. 455-475). Cham: Springer International Publishing.
- [13] Hosain ME, Amin SN, Kamarudin MS, Arshad A, Karim M, Naser MN, Fotedar R. Effects of Different Carbon Sources on the Growth and Production of Rotifer (*Brachionus plicatilis*) in a Zero-Water Exchange Biofloc Culture System. *Aquaculture Research*. 2024;2024(1):8837330.
- [14] Silva DA, de Lima PC, da Silva AE, de Oliveira Filho PR, da Silva SM, Olivera Galvez A, Brito LO. Effects of adding rotifers on the water quality, plankton composition and growth of Pacific white shrimp, *Litopenaeus vannamei* juvenile, when cultured with biofloc technology. *Aquaculture Research*. 2021 Sep;52(9):4380-93.
- [15] Khanjani MH, Mozanzadeh MT, Sharifinia M, Emerenciano MG. Biofloc: A sustainable dietary supplement, nutritional value and functional properties. *Aquaculture*. 2023 Jan 15;562:738757.
- [16] Santhosh B, Ambarish GP, Anuraj A, Krishna S, Anzeer FM, Aneesh KS. Live feeds in aquaculture.
- [17] Meligrana MC. A scientific contribution towards sustainable aquaculture.
- [18] Ogello EO, Outa NO, Obiero KO, Kyule DN, Munguti JM. *Scientific African*.
- [19] Nisar U, Peng D, Mu Y, Sun Y. A solution for sustainable utilization of aquaculture waste: a comprehensive review of biofloc technology and aquamimicry. *Frontiers in Nutrition*. 2022 Jan 12;8:791738.
- [20] Sallam GR, Shehata AI, Basuini MF, Habib YJ, Henish S, Rahman AN, Hassan YM, Fayed WM, El-Sayed AF, Aly HA. Integrated biofloc technology in red tilapia aquaculture: Salinity-dependent effects on water quality, parental stock physiology, reproduction, and immune responses. *Aquaculture International*. 2024 Dec;32(7):8731-61.
- [21] Mugwanya M, Dawood MA, Kimera F, Sewilam H. Biofloc systems for sustainable production of economically important aquatic species: A review. *Sustainability*. 2021 Jun 29;13(13):7255.
- [22] Ariadi H, Fadjar M, Mahmudi M. The relationships between water quality parameters and the growth rate of white shrimp (*Litopenaeus vannamei*) in intensive ponds. *Aquaculture, Aquarium, Conservation & Legislation*. 2019 Dec 1;12(6):2103-16.
- [23] Ahmed Alkhamis Y, Sultana A, Tareq Arafat S, Abdur Rouf M, Mustafizur Rahman S, Thomas Mathew R, Ganesan N, Sultana A, Saleh Alngada R, Abdul Whed R, Abdulaziz Aljaafari N. The Impact of Biofloc Technology on Water Quality

in Aquaculture: A Systematic Meta-Analysis. *Aquaculture Nutrition*. 2023;2023(1):9915874.

- [24] Deswati D, Zein R, Suparno S, Pardi H. Modified biofloc technology and its effects on water quality and growth of catfish. *Separation Science and Technology*. 2023 Mar 24;58(5):944-60.
- [25] Pimentel OA, Amado AM, They NH. Biofloc colors as an assessment tool for water quality in shrimp farming with BFT systems. *Aquacultural Engineering*. 2023 May 1;101:102321.
- [26] Dhar PK, Tonu NT, Dey SK, Chakrabarty S, Uddin MN, Haque MR. Health risk assessment and comparative studies on some fish species cultured in traditional and biofloc fish farms. *Biological Trace Element Research*. 2023 Jun;201(6):3017-30.
- [27] Deb S, Noori MT, Rao PS. Application of biofloc technology for Indian major carp culture (polyculture) along with water quality management. *Aquacultural Engineering*. 2020 Nov 1;91:102106.