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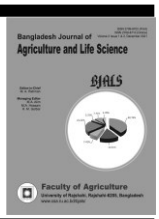

Present Status and Potentiality of Biofloc Technology in Bangladesh

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ABSTRACT

Biofloc technology stands as the blue revolution in aquaculture, presenting a new technique for improving water quality and utilizing feed wastes in the aquaculture system. The research aimed to assess the current status and potentiality of Biofloc fish farming in Bangladesh. Data were collected during July 2021 to December 2022 across various districts in Bangladesh. Data from a total of ten farmers were included used in the study who were involved in Biofloc fish farming technology (BFT). The majority of the farmers were within the age category of 30 to 40 years. From the survey, 100% educated individuals were interested in BFT. Additionally, majority of farmers received training directly or indirectly via YouTube. Farmers faced challenges such as diseases *i.e.,* fungal disease, fin and tail rot disease, and dropsy. the survey also revealed the other problems like lack of proper knowledge about technology, inappropriate species selection, and elevated operational costs. This small-scale fish farming was not be a profitable venture. However, the proper designing and management of the Biofloc unit should increase the fish productivity and also established a platform for knowledge sharing and experience exchange among farmers who have successfully implemented Biofloc systems to minimize the loss in this sector.

Introduction

The rising demand for aquatic food, pressured by the global population of nearly eight billion people and hence, expansion and intensification of aquaculture production are highly required. Bangladesh, with its extensive inland waters and a complex riverine system, holds considerable promise for both capture fisheries and aquaculture. There are 845399 ha of inland closed waters and 3860772 ha inland open waters in Bangladesh which are highly potential for fisheries sector (DoF, 2023). The majority of these water bodies are conducive to freshwater fish culture. In the 2021-22 period, Bangladesh secured the 5th position in global aquaculture production and the total fishery production for the country reached 4,758,731 metric tons where aquaculture contributes 57.39% (DoF, 2023). The fisheries

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sector holds an essential role in the national economy of Bangladesh, making a significant contribution of 2.83% to the Gross Domestic Product (GDP) and a substantial 22.14% to the agricultural GDP (DoF, 2023). Aquaculture has the potential to play a crucial role in attaining self-sufficiency in the food sector and reduce poverty in Bangladesh (Das et al. 2018).

In the age of modern aquaculture, researchers and collaborators worldwide are consistently investigating environment friendly and sustainable culture systems to address the increasing demand for protein-rich food. Among various alternatives, including the Biofloc system, recirculatory aquaculture system (RAS), raceway system, integrated aquaponics system, and integrated aquaculture system, the Biofloc system stands out as the most recognized for its sustainability and cost-effectiveness (Rashid and Ashab, 2022). Additionally, Biofloc technology (BFT) is recognized as an innovative, sustainable, and reliable system that facilitates the continuous recycling and reuse of nutrients (Kamruzzaman et al. 2023). In the context of Bangladesh, Biofloc technology represents a new and developing approach in commercial fish farming systems. It was first established at Ifremer-COP (the French Research Institute for Exploitation of the Sea, Oceanic Center of the Pacific) in the early 1970s using a variety of penaeid species, including *Litopenaeus stylirostris*, *Fenneropenaeus merguiensis*, *Penaeus monodon*, and *Litopenaeus vannamei* (Emerenciano, 2013). Countries around the world have included the Biofloc technology to optimize resource utilization, especially in sectors like shrimp farming, small-scale aquaculture, and research. Both developed and developing nations have effectively enhanced fish culture practices and achieved economic stability through the adoption of this technique. In developing countries like Bangladesh, where challenges such as nutrient shortages, disparities between nutrient demand and supply, and competition for water and land resources exist, Biofloc fish farming emerges as a vital solution to address these issues. As the fish culture in Bangladesh is very well regarded and considered with the Biofloc technique, offering a valuable tool to enhance fish production, supply, and maintain equilibrium between the demand and supply of natural food resources. Through the Biofloc technique, it becomes feasible to achieve significant fish yields in aquaculture with minimal water discharge and reduced environmental degradation. Despite the country's dependance on traditional pond-based aquaculture, the adoption of innovative and sustainable methods such as Biofloc presents an opportunity for Bangladesh to further optimize its fish farming practices.

Biofloc technology (BFT) functions by recycling nutrients and nitrogenous wastes, emphasizing the maintenance of a high carbon: nitrogen ratio.

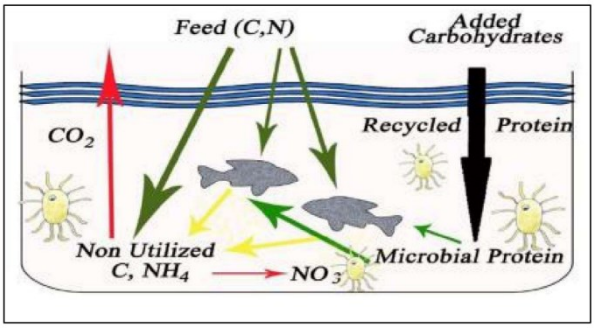

Fig. 1. Biological processes in Biofloc fish culture (Kamruzzaman et al. 2023)

Carbon sources, including molasses, wheat bran, and cellulose, play a pivotal role in development bacterial growth and regulating the C:N ratio within the culture system. The introduction of carbohydrates into the pond serves to stimulate heterotrophic bacterial growth and enhance nitrogen uptake through the production of microbial proteins (Avnimelech, 1999). Due to bacterial growth, the reduction in ammonium concentration occurs more rapidly than nitrification in Biofloc technology and attributed to the fact that the growth rate and microbial biomass yield per unit substrate of heterotrophic bacteria are approximately 10 times higher than that of nitrifying bacteria (Neupane et al. 2020). Biofloc technology not only helps to maintain water quality but also offers essential and higher-quality nutrition to shrimps and fish, leading to accelerated growth, lower Feed Conversion Ratios (FCR), and the potential to prevent diseases (Suneetha et al. 2018). The implementation of Biofloc technology in larvae culture offers a readily available food source for larvae outside regular feeding moments, mitigating potential negative social interactions during feeding (Ekasari et al. 2015). According to Ju et al. (2008), Biofloc also comprise a variety of bioactive compounds, including free amino acids, chlorophylls, essential fatty acids, and carotenoids.

Table 1. Available literature of Biofloc technology in world wide.

Aspects	Country	References
Biofloc Aquaculture	Noakhali, Bangladesh	Islam et al. (2022)
Present Status, Problems & Prospect	Chapainawabganj, Bangladesh	Ali et al. (2022)
Principle of Biofloc	-	Walker et al. (2019)
Prospects & Challenges	Nepal	Neupane et al. (2020)
Prospects of Biofloc technology	-	Ogello et al. (2021)
Review of Biofloc technology	-	Halim et al. (2019)
Socio-demographic status	Sylhet, Bangladesh	Rashid and Ashab (2022)

Despite being highly profitable and popular worldwide, BFT is facing challenges in Bangladesh, with a declining interest in this technology among the people day by day, primarily due to a lack of proper technical knowledge and limited availability of fish seeds (Rashid et al. 2015). The existing Biofloc system in Bangladesh is predominantly manual, time-consuming, and occasionally susceptible to errors. However, with technological advancements and widespread dissemination through various social media platforms, a growing number of farmers, both educated and non-educated, have shown interest in Biofloc technology. Despite this flow, the outcomes of these newly developed Biofloc fish farms in Bangladesh have not been thoroughly assessed.

There are a few studies of BFT including present status, problems & prospects of northwestern district- Chapainawabganj (Ali et al., 2022) and Socio-demographic status of eastern district- Sylhet (Rashid and Ashab, 2022) have been conducted in Bangladesh. Whereas BFT is an appropriate cultural technique to enhance the fish production and promote viable economic growth for the aquaculture sector, more study is required to minimize the loss of BFT. Therefore, the goal of this research was to highlight the current status and potentiality of BFT throughout Bangladesh.

Materials and methods

Study area

The present study was conducted at Ghatail, Tangail (24°29'15.38"N, 89°58'24.23"E); Beanibazar, Sylhet (24°49'18.77"N, 92°93'08.1"E); Mokam Bazar, Moulvibazar (23°27'54.65"N, 90°23'26.98"E); Barachowna, Sakhipur, Tangail (24°23'55.91"N, 90°11'32.47"E); Brahmanbaria (23°59'49.03"N, 91°63'32.9"E); Karimganj, Kishoreganj (24°28'28.5"N, 90°52'20.96"E); Sreemongal, Moulvibazar (24°18'27.68"N, 91°43'55.46"E); Rupjang, Narayanganj (23°48'55.42"N, 90°32'25.9"E); Narosingdhi (23°56'59.5"N, 90°43'24.07"E) and Tangail Sadar, Tangail (24°15'38.8"N, 89°54'58.11"E) in Bangladesh.

Data Collection

In the present study both the primary and secondary data were collected from the selected sites. Primary data were obtained through the methods such as focus group discussions (FGD), interviews, and distribution of questionnaires. A set of preplanned questionnaires was designed to address various aspects of Biofloc fish farms, including fish culture, farmers' socioeconomic conditions, and challenges related to Biofloc fish culture The study also explored correlations between different independent variables, such as farmer's age, income, profession, information sources, and experience. Secondary data were gathered from available literature, internet sources, and relevant departments, including the Department of Fisheries (DoF).

Data analysis

All collected information were evaluated, and analyzed by Microsoft Excel. The results were then presented in both graphical and tabular formats for enhanced comprehension. The methodological approach is outlined in Fig. 3.

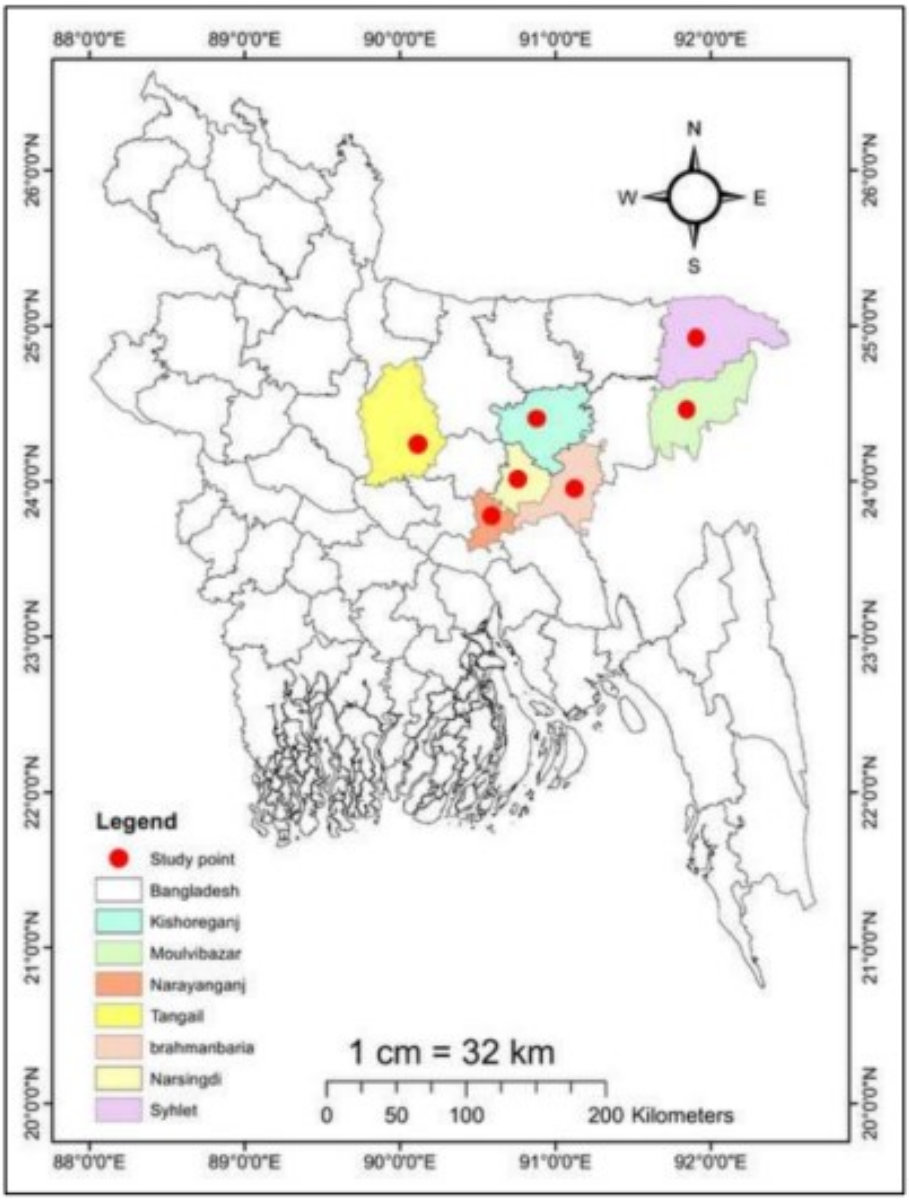

Fig. 2. The study area of Biofloc fish farming Ten Biofloc fish farms were selected and monitored. The entire process of data collection was conducted from July 2020 to December 2022.

Results

Demographic profile of Biofloc fish farmers in the study area

In the current study, various socio-economic indicators of the farmers have been examined. Among the farmers surveyed, all participants (100%) were male, and no female Biofloc fish farmers were observed. Farmers were classified into three age groups, and the analysis revealed that approximately 60% of Biofloc fish farmers were within the 30 - 40 age group while 30% were categorized in the age group < 30, and only 10%

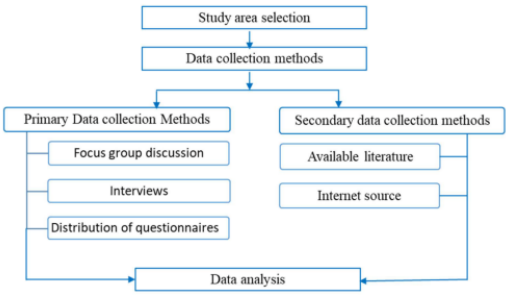

Fig. 3. Outline of the methodological approach

belonged to the age group > 40. Individuals in the 30 - 40 age group exhibited a higher level of interest in Biofloc technology. Interestingly, in the studied population, there were no illiterate farmers. Instead, 10% possessed a secondary level of education, another 10% had completed higher secondary education, and the majority, comprising 80%, held a graduation-level education. All of the farmers (100%) in our survey had selected Biofloc fish farming as their secondary occupation. The majority of participants were either students or had recently graduated. Concurrently, they were involved in business activities along with their education, aiming to achieve self-employment and independence. Nevertheless, in the current study, all farmers had secondary job engagements, with 80% involved in business and 20% in service. The study revealed that all farmers (100%) invested their own funds in Biofloc fish culture.

Table 2. Socio-economic indicators of Biofloc fish farmers in the study area (*n* = 10)

Characteristics	Level	Frequency	Percentage (%)
Sex	Male	10	100
	Female	None	0
Age	< 30	3	30
	30 - 40	6	60
	> 40	1	10
Family type	Nuclear	None	0
	Joint	10	100
Family member	< 5	1	10
	≥ 5	9	90
Education	Illiterate	None	0
	Primary	None	0
	Secondary	1	10
	Higher secondary	1	10
	Graduation	8	80
Ownership	Leased	None	0
	Own	10	10
Occupation	Business	8	80
	Service	2	20
Investment (Own)	< 5	7	70
	≥ 5	3	30
Training	Training and YouTube	3	30
	YouTube and Project Visit	4	40
	Literature and YouTube	1	10
	Training from Indonesia	1	10
	YouTube	1	10

Training on Biofloc fish culture

During this study, it was observed that the majority of farmers (40%) obtained training from sources such as YouTube, different trainers who trained before YouTube and suggestion from old farmer. Some farmers (30%, 10%, 10%, and 10%, respectively) received information via visiting a Biofloc fish farming project, reading literature, receiving training from Indonesia, and watching YouTube videos, respectively.

Disease of Biofloc fish farm

In the study area, farmers reported the occurrence of diseases such as fungal disease, tail & fin rot disease, and dropsy & gill rot disease during the culture period. Fungal diseases, accounting for 50%, were the most commonly reported diseases in that area. Fin & tail rot disease were observed among 10% of the respondents, while dropsy disease & gill rot disease were found to affect 40% during the culture period.

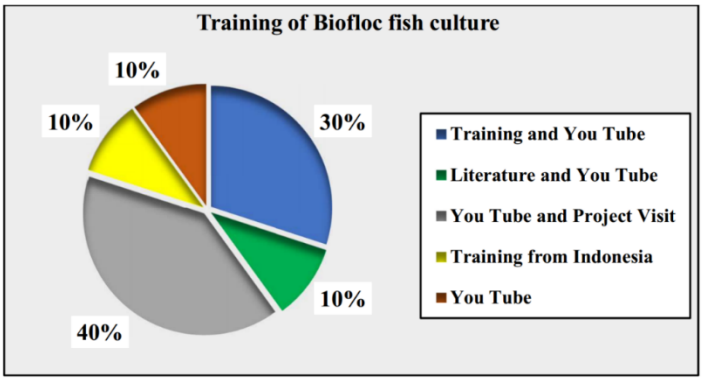

Fig. 4. Training on Biofloc fish culture in the study area.

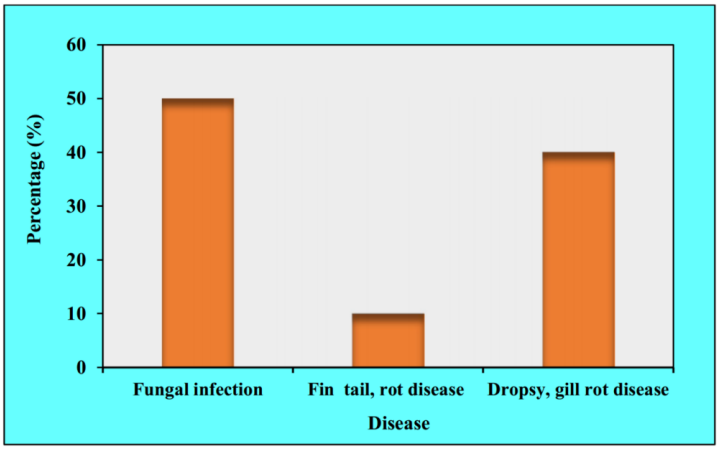

Fig. 5. Different disease occurrence in the Biofloc fish farms of study area in Bangladesh.

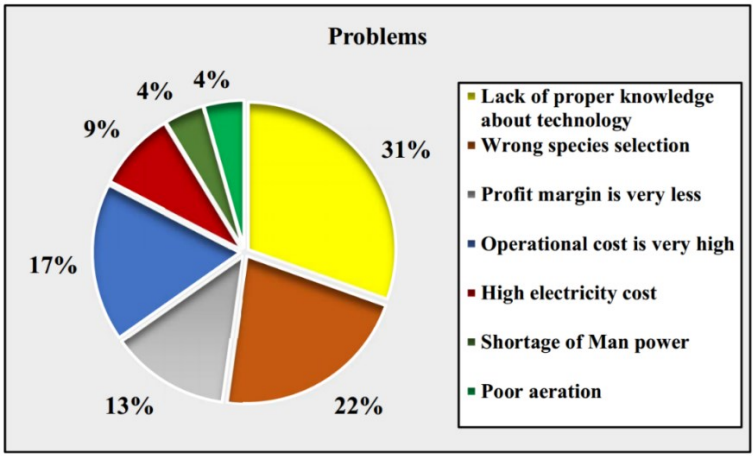

Fig. 6. Problems associated with Biofloc fish farming in the study area.

Problems on Biofloc fish culture in Bangladesh

Despite the many advantages of Biofloc culture, there are still many problems that need to be addressed before it can be widely adopted in Bangladesh. Biofloc fish farmers in the study area faced major problems, including a lack of proper knowledge about Biofloc technology, wrong species selection, a very low profit margin, very high operational costs, high electricity costs, a shortage of manpower, and a poor aeration system.

Discussion

Though there is only one available literature on present status in Biofloc fish culture at Chapainawabganj District, Bangladesh. However, a comprehensive study of present scenario *i.e.*, problems, challenge and potentiality for Biofloc fish culture unexplored all over the country in Bangladesh. Nevertheless, the current study, focuses on the present status, problems, challenge, potentiality and recommendation of Biofloc fish culture all over the country of Bangladesh.

In the current study, various socio-economic indicators of the ten Biofloc fish farmers have been observed. Here all of the participants (100%) were male. Biofloc fish farmers were observed in the study area due to variations in technologies and training. In this study, most of the Biofloc fish farmers (60%) fell within the 30 - 40 age group. The observed values closely almost similar with the results reported by Rashid and Ashab (2022), who identified 65% of farmers in the 30-40 age range in their study on fish farming. Similarly, Ali et al. (2022) found that 53.3% of young respondents and 40% of middle-aged respondents expressed interest in this form of fish farming. In current study, there were no illiterate farmers. This pattern may be attributed to the technology-intensive and skill-demanding nature of Biofloc fish farming. According to Ali et al. (2022), there were also found no illiterate farmers. All of the farmers in our survey had selected Biofloc fish farming as their secondary occupation. On the other hand, Ali et al. (2022) reported that 40% of the farmers had chosen Biofloc fish farming as their primary occupation. According to the survey, every farmer (100%) funded the Biofloc fish culture with their own money. In contrast, Ali et al. (2022) found that 93.3% of farmers invested their own funds.

In this study, 40% farmer obtained training from sources such as YouTube, different trainers who trained before YouTube and suggestion from old farmer. According to Ali et al. (2022), their study revealed that 53.3% of respondents did not receive any form of Biofloc fish culture training; additionally, 13.3% received training from professional trainers, another 13.3% gained knowledge through on-site visits to different farms, and only 20% visited established farms to acquire information and experience about Biofloc before initiating their own ventures. Fungal diseases, fin & tail rot disease and dropsy disease & gill rot disease were observed 50%, 10% and 40% Biofloc fish farm to affect during the culture period. On the other hand, Ali et al. (2022), both fungal and bacterial disease were observed equally (20%).

In the study area, Biofloc fish farmers met the major problems, including a lack of proper knowledge about Biofloc technology, wrong species selection, a very low profit margin, very high operational costs, high electricity costs, a shortage of manpower, and a poor aeration system. For these reasons, farmers couldn't succeed or fail in Biofloc fish culture in Bangladesh. On the other hand, Ali et al. (2022) identified obstacles in Biofloc fish culture, including the absence of nearby hatcheries, insufficient availability of high-quality fingerlings, high costs associated with fingerlings, a lack of proper training, and low market prices for fish, which constitute significant barriers to the advancement of Biofloc fish farming in Bangladesh.

Biofloc technology has demonstrated its effectiveness as an environmentally friendly approach that enhances the productivity of cultivated species. Many farmers in Bangladesh do not have the technical knowledge to successfully implement Biofloc culture. This is a major barrier to the adoption of this technology. Although research has increased significantly, this has not been reflected equally at the commercial level. Further research, both governmental and non-governmental, is needed to determine the suitable species and assess the profitability of BFT in Bangladesh. The government of Bangladesh has not yet provided much support for the development of Biofloc culture. In this context, knowledge and skills remain constrained and need to be addressed to support for the technology. Often, scientific investigations are confined to small-scale studies conducted under controlled laboratory conditions, which are often distant from real-world commercial conditions. The diverse

array of interacting factors poses a challenge, obstructing the technology transfer process and implementation on a larger scale (Walker et al. 2019). In this regard, there is a compelling need to transition from experimental setups to commercial conditions. The scale-up process has demonstrated increased profitability compared to conventional fish farming, ensuring higher production with minimal feed input and this technique is particularly well-suited for urban areas facing challenges of limited land and water resources but equipped with advanced technology (Neupane et al. 2020). This fish farming on a very small scale might not be a profitable venture but the proper designing and management of the Biofloc unit should increase the production of fish.

Biofloc technology operates on a zero-water exchange principle, meaning that water exchange is not necessary in the culture ponds. This characteristic leads to reduced water input, providing economic benefits to farmers. Additionally, the approach minimizes the risk of pathogenic entry of organisms through water, enhancing biosecurity in fish culture. Biofloc technology improvements fish survival by promoting the dominance of beneficial microorganisms that act antagonistically against pathogenic bacteria, thereby preventing disease outbreaks and increasing the percentage of survival during harvest (Halim et al. 2019). The presence of beneficial bacteria in the Biofloc prevents the colonization of harmful bacteria, ensuring the highest survival rate of fish in the farms (Perez-Fuentes et al. 2013). The feed requirement is significantly reduced, as the Biofloc itself serves as a feed for the cultivable animals, leading to a lower Feed Conversion Ratio (FCR) (Krummenauer et al. 2011).

Recommendation

According to the study the following recommendation are made -

- Develop and promote training programs for farmers, extension workers, and aquaculture professionals to enhance their understanding of Biofloc technology.
- Spread the technical knowledge and skills required for successful implementation and identify technical challenges faced by farmers in terms of system design, water quality management, and disease control.
- Support research initiatives to address specific challenges faced by farmers in Bangladesh.
- Promote collaboration between research institutions, government agencies, and the private sector.
- Explore options for providing financial support or incentives to encourage farmers to adopt Biofloc technology.
- Establish platforms for knowledge sharing and experience exchange among farmers who have successfully implemented Biofloc systems.
- Advocate for supportive policies at the government level to facilitate the adoption of sustainable aquaculture practices, including Biofloc technology.

Conclusion

Biofloc technology facilitates the progression of aquaculture towards an environment friendly approach while enhancing biosecurity. From the survey, we can see that since last two decades the Biofloc technology are not profitable for Bangladesh even though this technology successfully operated in other country as India, Thailand etc. The current study indicates that Biofloc fish farming on a very small scale may not be a profitable venture. However, effective design and management of the Biofloc unit have the potential to enhance fish production. Hence, both government and nongovernment initiatives are essential to address the existing problems, thereby ensuring increased fish production and higher profitability.

Authors contribution

Conceptualization, MYH, MMR and K; Methodology, MYH, K and MSK; Data collection and analysis, K, MSK, TAL, MMR, MAI, OR, MSS, MH and MAI; Drast preparation, K, MSK, TAL, MMR, MAI, OR, MSS. MH and MAI; Review and editing, MYH and MMR. All authors have read and agreed to the published version of the manuscript.

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