International Journal of Frontiers in
Science and Technology Research
Journal homepage: https://frontiersrj.com/journals/ijfstr/
ISSN: 2783-0446 (Online)

(Review Article)

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Biofloc technology (BFT) for indoor rearing of *Clarias batrachus* (Linn)

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International Journal of Frontiers in Science and Technology Research, 2024, 06(01), 007–012

Publication history: Received on 09 November 2023; revised on 03 January 2024; accepted on 06 January 2024

Article DOI: https://doi.org/10.53294/ijfstr.2024.6.1.0079

Abstract

Increasing human population trends from 1.5 to 6.4 billion, with a projected growth to 9 billion by 2050, necessitates production diversification, which has been estimated at 840 million, in order to prevent malnutrition. The natural resources, particularly the fish reserves in lakes, rivers, and oceans, are negatively impacted by the population's exponential development. In order to encourage sustainable farming, aquaculture production must be increased without significantly utilizing the necessary natural resources. Sustainable fish farming is a method of managing suitable benthic conditions and water quality in a culture system while having a low environmental impact. In order to provide a nutrient-balanced diet, particularly one high in protein, animal husbandry and fishing are the two sources of animal protein. Fish products are the safest group of muscle protein, which contains all needed amino acids, essential fatty acids. Since very few literatures is available in the Biofloc technology (BFT), the present dissertation encompasses the research work from a very grass-root level i.e. from water analysis of BioFloc system to study of different rearing techniques and their effects on the growth of *Clarias batrachus*. The Biofloc aquaculture system is an eco-friendly one that produces using organic debris and recycled nutrients including phytoplankton, bacteria, dead organic matter by manipulating the C/N ratio to transform harmful nitrogenous wastes into beneficial microbial protein. which aids in water quality improvement in a zero-water exchange system. It may serve as a comprehensive supply of nourishment for aquatic species, as well as some bioactive substances that will improve growth, survival, and defense mechanisms, and it may serve as a unique way to aquaculture health management by boosting animals' innate immune systems.

Keywords: BioFloc; *Clarias batrachus*; Fish; Immunity; Nutrition; Population

1. Introduction

Increasing human population trends from 1.5 to 6.4 billion, with a projected growth to 9billion by 2050, necessitates production diversification, which has been estimated at 840 million, in order to prevent malnutrition [1].The natural resources, particularly the fish reserves in lakes, rivers, and oceans, are negatively impacted by the population's exponential development. In order to encourage sustainable farming, aquaculture production must be increased without significantly utilising the necessary natural resources. Sustainable fish farming is a method of managing suitable benthic conditions and water quality in a culture system while having a low environmental impact [1]. In order to provide a nutrient-balanced diet, particularly one high in protein, animal husbandry and fishing are the two sources of animal protein.Fish and fish-related products. The safest group of animal proteins is muscle protein, which contains all needed amino acids as well as essential fatty acids from the n-3 and n-6 series.

For the development of aquaculture products, three major goals must be considered. The primary goal is to consider improving aquaculture productivity without considerably increasing the usage of natural resources e.g. water and land [2]. More than 41% of the world's population today lives in drought-stricken areas near rivers due to a paucity of freshwater supplies. By 2050, 70% of the world's population will confront water scarcity [3], as a result, many aquaculture professionals are looking for water-saving practices that can help them minimize their aquaculture water

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usage. The creation of sustainable systems without having a negative influence on the environment is the second primary objective [4].It is essential that we pay close attention to creating farming methods that are environmentally friendly because the aquaculture business has seen tremendous increases in environmental degradation in recent years. Land limits and a heavy reliance on fish oil and meal as feed ingredients are further obstacles to commercial aquaculture [5]. The third objective is to develop systems that give fish production a good cost-benefit ratio [3].

However, some difficulties have been identified as barriers to sustainable fish farming, such as complex site acquisition processes, limitations in good food and water quality, restrictions on water discharge and environmental impacts, and so on. To escape such constraints, Indian big carps are typically grown in ponds, cages, pens, tanks, or various types of nets. These practices are environmentally unsustainable due to the large amount of freshwater used and the random dumping of aquaculture wastewater into freshwater basins without prior treatment.

According to (Crab et al., 2014, [2]), the Biofloc aquaculture system is an eco-friendly aquaculture system that produces using organic debris and recycled nutrients. Biofloc is a microbiological community that includes phytoplankton, bacteria, and live and dead particle organic matter. Biofloc technique includes manipulating the C/N ratio to transform harmful nitrogenous wastes into beneficial microbial protein, which aids in water quality improvement in a zero-water exchange system. It may serve as a comprehensive supply of nourishment for aquatic species, as well as some bioactive substances that will improve growth, survival, and defence mechanisms, and it may serve as a unique way to aquaculture health management by boosting animals' innate immune systems.

In the aquatic environment, the carbon-nitrogen ratio (C/N) plays a significant role in the immobilization of hazardous inorganic nitrogen molecules into beneficial bacterial cells (single-cell protein), which may operate as a direct source of food for cultured organisms [3].The growth of heterotrophic microorganisms requires a C/N ratio of 10 or more in the feed because bacterial cells have a C/N ratio of 5:1 [7] and have a conversion rate of 40–60%. The bacterial process known as nitrification converts the harmful forms of nitrogen (ammonia and nitrite) into one that is poisonous only at high concentrations (nitrate).The addition of various inexpensive local carbon sources (agricultural byproducts) and the reduction of the protein level in the feed can both raise the C/N ratio in an aquaculture system [3,7] by altering the C/N ratio in shrimp culture, different organic carbon sources (glucose, cassava, molasses, wheat, corn, sugar bagasse, sorghum meal, etc.) are used to increase production and improve the nutrient dynamics [3]. C/N ratio is also frequently used as a guide for analysing the decomposition of organic matter [7].

One more aspect of biofloc technology is the microbial community that plays a very important role in the maintenance water quality. According to studies by Hargreaves and Goodson (2006) [7], heterotrophic ammonia-assimilating and chemoautotrophic nitrifying bacteria, as well as bacterial populations in these two functional categories, are principally in charge of maintaining water quality in minimum or zero water exchange systems (intense systems).As the culture develops, the colour changes from green to brown as the system shifts from being dominated by algae to being dominated by bacteria. Biofloc ponds are a biotechnological enterprise since they can contain between 106 and 109 bacteria/ml of floc plug, which comprises between 10 and 30 mg of dry matter [8] Phytoplankton, bacteria, and collections of both live and dead organic particle matter make up the established microbial communities [7]. In terms of quality, biofloc contains 38% protein, 3% lipid, 6% fiber, 12% ash, and 19 kJ/g energy (on dry matter basis [8].

The nutritional value of the floc biomass is complete, and it also contains a number of bioactive substances that can help the aquatic species' welfare indices in general. A natural probiotic and immune-stimulant, beneficial microbiological bacterial floc and its derivatives, including organic acids, polyhydroxy acetate, and polyhydroxy butyrate, can inhibit the growth of other infections. The method aids in preserving the ideal water quality parameters in a system with zero water exchange, preventing eutrophication and effluent discharge into the environment. The method will also be helpful to maintain biosecurity because there is no water exchange other than sludge treatment. The technology is socially and economically feasible as well as environmentally sustainable.

The importance of fisheries and aquaculture is increasing as a result of our concern for sustainability, environmentally friendly solutions, conservation, and food security. Therefore, thorough research on the physiology, genetics, and general biology of a fish species is crucial for developing conservation strategies and newer, better methods of aquaculture. *Clarias batrachus* has been cultivated in freshwater and is a popular species of fish among customers, making it a good candidate for detailed assessments of numerous aspects. *Clarias batrachus* is a freshwater fish from the Clariidae family that is native to Southeast Asia. It gets its name from its ability to 'walk' and wiggle across dry land in search of food or suitable habitats.

According to estimations from the FAO, there is a rising global demand for catfish, and *Clarias batrachus*, with its many advantages, continues to be popular, especially among Asians. Government agencies and fish geneticists should collaborate to protect this species' genetic resources against unintended hybridization, to which they are particularly sensitive. Today, there is a need to maintain habitat and promote sustainable fish consumption.

Crab et al. (2014) [2], the Biofloc system is an aquaculture system that uses recycled nutrients and organic materials for production.According to studies (Ebeling et al., 2006) [9]. microbial community in biofloc), heterotrophic ammonia-assimilating and chemo-autotrophic nitrifying bacteria, as well as bacterial populations in these two functional categories, are principally in charge of maintaining water quality in minimum or zero water exchange systems (intense systems).According to (Avnimelech 1999) [3], The carbon-nitrogen ratio (C/N) in the aquatic environment is crucial for the immobilisation of hazardous inorganic nitrogen molecules into helpful bacterial cells (single-cell protein), which may serve as a direct food source for cultured organisms. The goal of this chapter is to review the use of Biofloc Technology (BFT) in the aquaculture system and describe the use of biofloc biomass as an ingredient in compounded diets [10]. Researchers reported the proximate composition, mineral content, energy content, and C: N ratio of bio floe made from wheat flour as a carbohydrate source. Biofloc contains 30% crude protein as well as other important minerals. Bio floc contains an important fatty acid that is suitable for the nutritional requirements of common carp. As a result, it indicates that the created bio floc can be utilized successfully as fish feed, especially for herbivorous and omnivorous species.Microbes, algae, protozoa, and other creatures coexist with detritus, or dead organic particles, to form bioflocs. The biofloc is a one-of-a-kind ecosystem of rich and potent particles suspended in low water. The fundamental principle of biofloc technology (BFT) is waste retention and conversion to biofloc, a natural food within the culture system. Biofloc technology is now widely used in the aquaculture industry. The idea of floc generation in activated sludge systems can be applied to biofloc technology.

According to Avnimelech, 1999 [3], Aquaculture water quality can be improved using the biofloc technology, which balances the system's nitrogen and carbon levels. With the extra benefit of manufacturing proteinaceous feed on-site, the concept has recently attracted attention as a sustainable way to maintain water quality. If the ratio of carbon to nitrogen in the solution is optimal, bacterial biomass will also be produced from organic nitrogenous waste and ammonium [11]. The pond's heterotrophic bacterial growth is boosted by the addition of carbohydrates, and nitrogen uptake occurs as a result of the creation of microbial proteins. Biofloc technology is a method of improving water quality by adding extra carbon to the aquaculture system, either from an external carbon supply or by increasing the carbon content of the feed. Biofloc technology allows aquaculture systems to minimise water exchange and water usage by maintaining adequate water quality within the culture unit while producing low-cost bio floc rich in protein, which can then be fed to aquatic organisms [12-14]. When compared to traditional aquaculture water treatment methods, biofloc technology offers a more cost-effective alternative (a 30% reduction in water treatment expenses) as well as a potential savings on feed costs (protein efficiency).

The main expense in the aquaculture system is feed, which accounts for around 50% of the overall cost. Aquaculture animals only consume 20 to 30 percent of the feed used, with the remainder building up as waste. In a closed system, the culture animals are poisoned by $NH^{4+}N$ and/or $NO^{2-}N$, which are present in the collected waste. Utilizing biofloc technology, it is possible to produce microorganisms by modifying the carbon-to-nitrogen ratio (C/N) and turning these harmful wastes into beneficial nutrients. According to Be (De Schryver et al., 2008), photoautotrophic microbes, such as algae, and heterotrophic microbes, including bacteria, rotifers, ciliates, protozoan, and nematodes, are frequently found in association with flocs. The microbial community is critical to the biofloc system. Microbes are crucial because they provide a rich natural source of protein-lipid "in situ" that is available all day. They contribute primarily in three ways: (i) Improving water quality (ii) pathogen control and (iii) nutrition Water quality is maintained, mostly by the management of the bacterial community over autotrophic microorganisms, by utilizing a high carbon-to-nitrogen (C: N) ratio [15]. Microbes connected with floc after consumption is helpful in digestion. FCR lowers dietary protein levels and heterotrophic bacteria, which coupled with probiotic bacteria prevent the growth of potential pathogen bacteria.Additionally, the application of biofloc technology enhances a variety of elements of cultures, including growth rates, survival rates, water quality, water usage, and disease incidence. Microorganisms play a crucial part in the biofloc system.

According to (Arumugam et al., 2023) [16] It is a potentially sustainable aquaculture production system with a wide range of advantages, including an increase in production, improved disease resistance in cultured organisms, and higher farmer profitability. However, the efficiency of this system depends on how well the operating principles are understood, how the microbial interactions in the system interact with one another, and how well the key parameters can be adjusted to meet the requirements of the target organism that will be produced in the system. It has been determined that the carbon sources and ratio are crucial MT factors. [17, 18].

Objective of This Study

Methodological approach to the problem:

Since very little literature is available in the Biofloc technology (BFT), present dissertation encompasses the research work from a very grass-root level. Hence, the present research work has been designed with following objectives which are appended below in a tabular/nut-shell format.

- To analysis the water from Biofloc system.
- To develop the Biofloc system using different carbon sources.
- To study probiotic /microbial analysis of Biofloc by using the standard methods.
- To study biofloc fish disease, immunological and others parameter.
- To study application of Biofloc system for the growth and enhancement of *Clarias batrachus*.
- To study of different rearing techniques and their effects on the growth of fish.

2. Research Methodology

In this study, *Clarias batrachus*will be used as a model organism.

- Collection of samples from fish seed production centre.
  - Samples will be collected from different fish seed production centre and then acclimatised in rearing production site.
- Monitoring of collected samples in the tank by using different carbon sources.
  - Further, It will be investigated the appropriate carbon sources combined with molasses in a biofloc system for C. batrachus culture.
- Water analysis by using standard methods such as DO (Dissolved Oxygen), pH, alkalinity, TSS (Total Suspended Solid),TAN (Total Ammonia Nitrogen), BUN (Blood Urea Nitrogen).
- Sampling for fish growth and biomass monitoring will be performed in every week.
- The calculation for fish growth parameters.
- Biofloc proximate analysis.
  - Analysis of protein, lipid, minerals and water content in fish muscle.
- Identification of probiotics and microbes from the biofloc system.
- Estimation of the total nutrients from Immunological probiotics.
- Calculation and Statistical Analyses of the data.

2.1 Significance of the present study

The Biofloc culture system has several advantages, including being eco-friendly and having a lower environmental effect.

- Enhances water and land use effectiveness

Improve water and land use effectiveness through sustainable practices, efficient irrigation, and conservation measures, leading to optimized resource utilization and reduced environmental impact.

- Minimal or non-existent water exchange

Minimal or non-existent water exchange refers to a situation where there is very little or no movement of water in and out of a particular system or environment. This can lead to stagnant or isolated conditions, potentially impacting the ecosystem and its inhabitants.

- Greater productivity (It improves fish culture systems' feed conversion, growth performance, and survival rate).

Increasing productivity in fish culture systems leads to improved feed conversion, enhanced growth performance, and higher survival rates of the fish.

- Increased biosecurity

Increased biosecurity refers to the implementation of heightened measures and protocols to prevent and control the spread of infectious diseases and biological threats.

- Decreases disease introduction and dissemination risk and water pollution

Implementing proper waste management and sanitation practices decreases disease introduction and dissemination risk while also reducing water pollution.

- Affordable feed production.

To achieve affordable feed production, focus on optimizing ingredient sourcing, minimizing waste, and implementing efficient production processes.

- It lowers the expense of conventional feed and the utilisation of protein-rich feed.

It reduces the cost of traditional feed and minimizes the need for protein-rich feed, leading to more cost-effective livestock or poultry farming.

- It reduces the burden on capture fisheries, i.e., the use of less expensive food fish and trash fish in the preparation of fish feed.

Using less expensive food fish and trash fish in the preparation of fish feed helps reduce the burden on capture fisheries.

3. Conclusion

The Biofloc culture system has several advantages, including being eco-friendly and having a lower environmental effect. It may serve as a comprehensive supply of nourishment for aquatic species, as well as some bioactive substances that will improve growth, survival, and defense mechanisms, and it may serve as a unique way to aquaculture health management by boosting animals' innate immune systems.

Compliance with ethical standard

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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