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Biofloc Systems: A Game-Changer for Small-Scale Fish Farmers

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Introduction

Aquaculture, the farming of aquatic organisms, has witnessed significant advancements in recent years to address challenges in sustainability, cost-effectiveness, and productivity. One notable development that has gained attention is Biofloc Technology (BFT), a revolutionary approach aiming for economical and sustainable aquaculture with zero water exchange. In response to the need for a more efficient and environmentally friendly system, BFT has emerged as a promising method, harnessing the power of microorganisms to enhance the growth performance of aquatic animals. This technology not only offers economic benefits but also contributes to sustainable aquaculture practices. In this context, it becomes crucial to delve into the intricate roles of microorganisms within the Biofloc system and understand the specific advantages it brings to the aquaculture industry.

Fig: 1. Biofloc Tanks

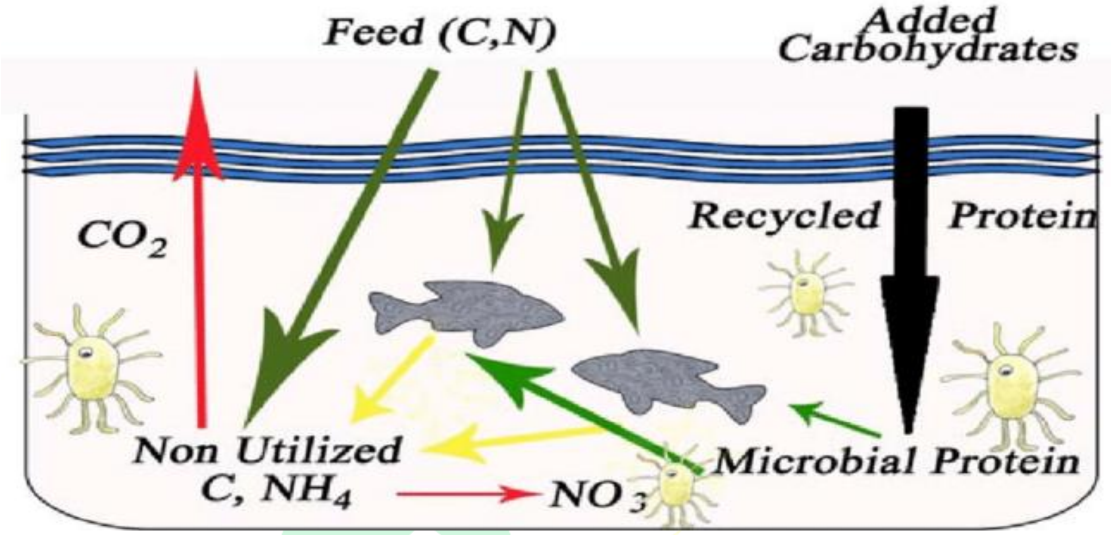

Fig 2. Biofloc Diagram

Recirculatory Aquaculture System (RAS)

RAS systems have been developed as a technology for intensive fish farming, mostly utilised in regions where water availability is limited. By utilizing a variety of components, it allows for the recycling of up to 90–99% of the water. The ideal conditions for fish production are made possible by these systems, which give the operator more control over environmental and water quality parameters (Heinen *et al.*, 1996). RAS has a requirement for some water exchange mainly due to the accumulation of nitrate (Suzuki *et al.*, 2003; Dauda 2019). There is a possibility of using denitrification columns that can convert nitrate to nitrogen gas under anaerobic conditions (van Rijin *et al.*, 2006; Dauda 2019), but that will cost proper management and maintenance. The high cost of installation, operation (high electricity uses in recirculation process), and maintenance are the major drawbacks that have limited the mass adaptation of this technology in developing countries (Schneider *et al.*, 2006; Dauda 2019). Another technological limitation which was highlighted by Badiola *et al.*, (2012) that the technique is highly reliant on the stage of life of the cultured animal; for example, managing newly hatched or small animals differs; afterwards, on-growing and hatchery are treated independently.

The Rise of Biofloc Technology

The need for a more economical and zero water exchange aquaculture system led to the development of current biofloc technology (BFT). The growth performance of aquatic animals is enhanced by Biofloc, which when combined with formulated feeds, offers a complete food chain (Khanjani *et al.,* 2020). According to Ekasari (2014), when compared to non-biofloc systems like traditional and recirculating aquaculture systems, biofloc systems can increase net productivity by 8–43%. Biofloc is a microbial-based aquaculture system that relies on maintaining optimal conditions for stable growth and maintenance of heterotropic bacteria populations, for this, it is needed to keep a high C/N ratio. In this technology, manipulation of bacteria is done, normally there are enough nitrogenous compounds in the pond for the growth and multiplication of bacteria, but externally low protein and high carbon compounds are added like flour, molasses, rice bran, cassawa, etc., then there will be an excess need for nitrogen for producing protein for the growth of microorganisms which will be fulfilled by absorbing ammonia nitrogen from the water which will lead to a reduction in its concentration. BFT is having a self-generated bioremediation process (Panigrahi *et al.,* 2018). Bacteria are microscopic but when their density is high in the culture system, they show a tendency to form bioflocs containing bacteria, other organisms, and organic particles. ICAR-CIBA, Chennai, India, has developed a ready-made inoculum for the development and maintenance of biofloc, which is available commercially.

Suitable species for BFT in India

Species like *Catla catla, Labio rohita, Cirrhinus mrigala* (Indian Major Carps) are suitable for landlocked states, and species like *Mugil cephalus, Chanos chanos, Penaeus indicus,* and *Penaeus vannamei* are suitable for coastal states where seawater is readily available for this technology.

Microorganisms in BFT

The following are the three different types of microorganisms having specific roles in the BFT (Dauda *et al.,* 2019)

1. **Heterotrophic bacteria** – It assimilates ammonia-nitrogen to its biomass, which can be consumed by the aquatic animals in the culture system. They require the highest amount of oxygen as compared to other bacteria in the system, high C/N ratio must be maintained for their growth. They are observed to be active in limited light. Bio-augmentation of *Virgibacillus* and a consortium of other heterotrophic bacteria has been proven to have improved growth, immunity, and survival in Indian white shrimp (Panigrahi *et al.,* 2020).
2. **Photoautotropic algae and phytoplanktons** – It convert ammonia-nitrogen to its biomass. They are found to be dominant in low dissolved oxygen. The high C/N ratio is unfavorable for it. It shows higher activity during the day because of a higher rate of photosynthesis.

3. **Chemoautotropic bacteria** – It oxidises ammonia-nitrogen to a lesser toxic form of nitrogen which is nitrate. Its requirement for the amount of dissolved oxygen is higher as compared to photoautotrophs. Utilising inorganic salts (sodium nitrite and ammonium chloride) in BFT systems can accelerate the nitrifying bacteria's growth and activity, preventing systemic peaks in ammonia and nitrite (Sesuk *et al.*, 2009; Otoshi and Moss, 2011).

Pathogenic Bacteria in BFT

Apart from these microorganisms, various pathogenic bacteria are also found in BFT e.g. *Aeromonas hydrophila, A. salmonicida, A. sobria, A. veronii, Eenterobacter sakasakii, Vibrio fluvialis, Pasteurella neumotropica, Brucella spp*., *Moraxella spp., Citrobacter freundii*, and *Erwinia spp.* (Gutierrez *et al.*, 2016).

Table 1: Advantages and limitations of BFT

Advantages	Limitations
Zero water exchange culture system	High energy input requirements for aeration
Very good biosecurity (from water born pathogens)	Chances of culture collapse in case of power failure
Production is better than the normal aquaculture system	Proper training is required to operate efficiently
Low FCR (feed conversion ratio), as less feed is given	High startup period, i.e., biofloc development needs time
Lower production cost than the normal aquaculture system	

Hands-on Training on BFT

Authentic training for BFT is being provided by various government institutes, colleges, and state fisheries departments. One such institution providing training is the Indian Council of Agricultural Research - Central Institute of Brackishwater Aquaculture (ICAR-CIBA), Chennai, India. The last training was conducted from 1st - 4th May 2023 by ICAR - CIBA.

Requirements of shrimp *(P. vennami)* BFT

- High stocking density - over 130 – 150 PL10/m2

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- High aeration – 28 to 32 HP/haPWAs
- Paddlewheel position in ponds (control biofloc and sludge by siphoning)
- Biofloc control at <15ml/L
- HDPE / concrete-lined ponds
- Grain(pellet)
- Carbohydrate
- C&N ratio >15
- Expected production 20–25 MT/ha/crop with 18-20 gms shrimp.

Economics perspectives of BFT

The expected expenditure per annum of shrimp BFT farming having 6 production cycles is Rs. 443425, having a net profit of Rs. 186575. Further details about the economics aspects can be found on the website https://course.cutm.ac.in/wp-content/uploads/2020/06/Economics-of-Bio-Floc-Based-Farming.pdf.

Conclusion

The advantages of this technology are less area requirements, relatively lesser cost of production (low feed requirement), and high yield per unit area, which makes BFT a suitable fit for small-scale farmers. BFT is not just a cost-effective technology, but it has been shown to have good yield and meet the commitments of sustainable aquaculture. There is much research going on in different parts of the world to understand the complex interaction of microorganisms and the standardization of protocols for obtaining maximum production and eliminating the chances of failure of this technology. Using biofloc technology enhances several elements of culture, including increased survivability, better water quality, higher growth rates, reduced water use, and an overall reduction in disease (Wasave *et al.*, 2019). Since microorganisms play a significant role in BFT, further research into the identification of more microbes that may be present in these systems is required.

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