Biofloc Culture System

Madhu. K., Rema Madhu, Mridula Mohan, Abhilash, K.S. and Jinu Joseph

ICAR-Central Marine Fisheries Research Institute, Kochi

Email: kmadhu30@rediffmail.com

Introduction

The global population is projected to reach 9.6 billion by 2050, and with the growing demand for animal protein each year, it is challenging to provide high-quality protein while conserving natural resources for future generations. In this scenario, aquaculture is crucial for promoting health by supplying animal protein and fostering employment and economic growth. Biofloc Technology (BFT) is considered the new "blue revolution" because it allows continuous recycling and reuse of nutrients in the culture medium, benefiting from minimal or zero water exchange. BFT is an eco-friendly aquaculture technique based on the in-situ production of microorganisms. Biofloc consists of suspended growth in ponds or tanks, comprising aggregates of living and dead particulate organic matter, phytoplankton, bacteria, and grazers of the bacteria. This method uses microbial processes within the pond or tank to provide food for the cultured organisms while simultaneously acting as a water treatment solution. Hence, this system is also known as active suspension ponds, heterotrophic ponds, or even green soup ponds.

History

Historically, Biofloc Technology (BFT) was first developed at the French Research Institute for the Exploitation of the Sea, Oceanic Centre of the Pacific. It has become a popular technology in the cultivation of various aquatic species, including Tilapia, *Penaeus monodon*, Pacific white shrimp (*Litopenaeus vannamei*), giant freshwater prawn (*Macrobrachium rosenbergii*), *Fenneropenaeus merguiensis*, and *Litopenaeus stylirostris*. To further study BFT, Ifremer initiated a research program called "Ecotron" in 1980. Around the same time, Israel and the USA (Waddel Mariculture Centre) began research and development on BFT with Tilapia and white shrimp. Commercial applications of BFT started in 1988, with the Belize Aquaculture Farm in Central America producing approximately 26 tons/ha/cycle using 1.6 ha grow-out ponds. Greenhouse BFT farms are successfully operating in Maryland, USA. Nowadays, successful implementation of BFT has expanded in Latin and Central America, with smaller scale operations in the USA, South Korea, Brazil, China, Italy, Indonesia (P.T Central Prtiwi Bahari), Australia, and India. Research institutes in many countries are focusing on further applications of BFT, including energy kinetics, bacterial identification, economics, and low-cost processing. In Belize, achieving 13.5 metric tons of shrimp per hectare was a significant milestone, and this model has been successfully applied in Indonesia. The technology, combined with partial harvest, was repeated in Medan, Indonesia, with better results during 2008 and 2009. Now, BFT is common in Bali and Java, Indonesia, where shrimp aquaculture intensification is being done in HDPE-lined and plastic-covered ponds using this technology. Malaysia is currently initiating a 1000-hectare integrated shrimp farming project at Seitiu, Terengganu by Blue Archipelago. In India, this technology is not yet widespread. It has been proven that BFT can be applied in the larval culture of *Macrobrachium rosenbergii*. Nursery rearing of this species using BFT has improved larval stocking density and animal health compared to conventional systems. Sensitivity of floc at different hydrogen ion concentrations was studied, and it was found that a pH of 7.5 is optimal for good flocculation in shrimp aquaculture. It was stated that the C/N ratio in aquaculture sludge is high, and to reach the optimal range of 10-15, an additional carbon source is necessary. BFT is an in-situ production system that increases nitrogen retention as body mass in cultured organisms. Since the introduction of BFT, numerous research groups have expanded on this technology, and ongoing research continues to explore more applications of this innovative waste management technique.

Principle of BFT

Biofloc Technology (BFT) is a wastewater treatment method that has become increasingly vital in aquaculture. It involves maintaining a high carbon-to-nitrogen (CN) ratio by adding a carbohydrate source, which improves water quality by producing high-quality single-cell microbial protein. This setting fosters the growth of heterotrophic microbes that absorb nitrogenous waste. The cultured species can feed on this microbial growth, and the system acts as a bioreactor to manage water quality. In biofloc systems, toxic nitrogen species are immobilized more rapidly because heterotrophic microbes have a growth rate and microbial production per unit substrate that are ten times greater than those of autotrophic nitrifying bacteria. The technology is based on the principle of flocculation within the system.

Nutritional Value

Biofloc consists of a heterogeneous mix of suspended particles and various microorganisms associated with extracellular polymeric substances. This mixture includes bacteria, algae, fungi, invertebrates, detritus, and more. Biofloc forms a protein-rich live feed by converting unused feed and excreta into natural food within a culture system exposed to sunlight and vigorous aeration. Each floc is held together in a loose matrix of mucus secreted by bacteria and bound by filamentous microorganisms or electrostatic attraction. While larger flocs can be seen with the naked eye, most are microscopic, ranging from 50 to 200 microns. It is therefore, biofloc has high nutritional value, with a dry weight protein content ranging from 25% to 50% and fat content from 0.5% to 15%. It is a rich source of vitamins and minerals, particularly phosphorus, and has pro-biotic like effects. Dried biofloc is being considered as an ingredient to replace fishmeal or soybean in feed.

Advantages of BFT: Eco-friendly culture system- reduces environmental impact, judicial use of land and water, limited or zero water exchange system. Higher productivity- enhances survival rate, growth performance, and feed conversion in culture systems. Higher bio-security- reduces water pollution and mitigates the risk of introducing and spreading pathogens. Decreases reliance on protein-rich feed- reducing the cost of standard feed are the major advantage of BFT in comparison with other aquaculture systems

Species Suitable for Biofloc Culture

A key factor in designing a biofloc system is the species to be cultured. The biofloc system works best with species that can derive nutritional benefits from directly consuming floc. It is most suitable for species that can tolerate high solids concentrations in water and are generally tolerant of poor water quality.

Suitable species include:

- Genetically improved Farmed Tilapia (GIFT), ordinary tilapia
- **Air-breathing fish**: Singhi (*Heteropneustes fossilis*), Magur (*Clarias batrachus*), Pabda (*Ompok pabda*), Anabas/Koi (*Anabas testudineus*), Pangasius (*Pangasianodon hypophthalmus*)
- **Non-air-breathing fish**: Common Carp (*Cyprinus carpio*), Rohu (*Labeo rohita*), Tilapia (*Oreochromis niloticus*), Milkfish (*Chanos chanos*)
- **Shellfish**: Vannamei (*Litopenaeus vannamei*), Tiger Shrimp (*Penaeus monodon*) are gerally considered in saline affected areas.

Precautions: Before starting biofloc fish farming, the water/ source of water should be analysed for its microbial load including coliform bacteria.

Floc Preparation:

- Floc Powder: 15 gm + 100ml water (5m dia Pond)
- Mix thoroughly
- Add 80-100 lit water
- Add carbon source (Jaggery, Sugar, Rice soup, wheat, Sugar cane Bagasse, etc).

- Vigorous aeration
- Keep it for 24 hrs
- Add it to Pond Water/ biofloc tank
- Allow 7 days to multiply/develop floc.
- Then after stock the pond with suitable fish seeds
- Daily feeding, Aeration, management of pond through analysing various water quality parameters, removal of waste products, water exchange and floc density.

Conclusion

Although research on the precursors to biofloc systems has been ongoing since the early 1990s, and commercial applications have been in place since the early 2000s, several key issues regarding the function of biofloc systems remain poorly understood. One major risk factor is the periodic increase in total suspended solids, which can clog the gills of shrimp and fish and require more energy to meet oxygen demands. Additionally, farmers' lack of knowledge about this technology is problematic. Another issue is the focus on shrimp and tilapia, which makes it difficult to develop general criteria for system configuration. Species diversification is necessary for the successful advancement of this technology. The probiotic effects of bioflocs also require further investigation. Some studies have reported the presence of Vibrios in bioflocs, but a mechanism appears to exist that can either promote or discourage disease outbreaks. Biofloc technology typically involves the co-culture of aquaculture species and heterotrophic bacterial biomass by adding a carbohydrate source. However, the rapid multiplication of heterotrophic bacteria can cause excessive turbidity, which may negatively affect sensitive fish species that are not adapted to turbid water. A thorough understanding of the microscopic mechanisms, particularly those involving microbes and bacteria in bio-flocculation, is crucial for the future of BFT practice. Further research is needed to investigate the effects of physico-chemical parameters on flocculation and the shifting of microbial populations. Over performance of filamentous bacteria can lead to floc bulking, resulting in system instability, incomplete nitrogen removal, and immediate settling of flocs. Despite these challenges, biofloc technology remains an eco-friendly, probiotic, and stable system that recycle nutrients in situ. Understanding its complexities is essential for future advancements.

References

Avnimelech, Y, 1999. Carbon-nitrogen ratio as a control element in aquaculture systems, Aquaculture,176:227–235.