



Biofloc Technology in Aquaculture

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The rapid expansion and intensification of aquaculture have increased the demand for water, land, feed and energy, while also increasing the generation of nutrient-rich wastes. Biofloc Technology (BFT) is a microbial-based aquaculture approach that promotes the conversion of nitrogenous wastes and organic matter into microbial biomass within the culture system. The resulting microbial aggregates, known as bioflocs, can contribute to water-quality management and serve as a supplementary natural food source for suitable cultured species. Biofloc systems can reduce water exchange and improve nutrient recycling, making them attractive for intensive aquaculture. However, successful implementation requires continuous aeration, appropriate carbon management, control of suspended solids, regular water-quality monitoring and skilled farm management. The present article discusses the principle, functioning, applications, advantages, limitations and future prospects of BFT in aquaculture.

Keywords: Aquaculture, biofloc technology, microbial biomass, carbon–nitrogen ratio, nutrient recycling

Introduction

Aquaculture is an important source of aquatic food and livelihoods and is increasingly moving towards intensive production systems. Intensification can increase productivity from limited land and water resources, but it also increases the loading of organic matter and nitrogenous wastes into the culture environment. Conventional systems generally manage these wastes through water exchange and other treatment practices. Biofloc Technology provides an alternative approach in which a considerable proportion of these nutrients is retained and recycled within the production system. Biofloc Technology is a microbial-based culture approach that encourages the development of suspended microbial aggregates in the culture water. The technology combines nutrient recycling, microbial water-quality management and supplementary natural food production. Rather than viewing organic and nitrogenous wastes only as pollutants, BFT attempts to convert part of these wastes into microbial biomass that can subsequently be utilized by cultured organisms. The technology has attracted considerable attention in fish and shrimp farming because of its potential to reduce water exchange, improve feed utilization and support intensive production. Nevertheless, BFT is not a maintenance-free technology and requires careful management of oxygen, carbon, solids and stocking density.

Principle of Biofloc Technology

The basic principle of BFT is the microbial assimilation of nitrogenous wastes. Fish and shrimp release nitrogenous compounds through excretion, while uneaten feed and faeces contribute additional organic matter and nitrogen. An appropriate source of organic carbon can be supplied to the culture system to stimulate the growth of heterotrophic microorganisms. These microorganisms utilize carbon and nitrogen to synthesize new microbial biomass. Consequently, a portion of dissolved nitrogen can be incorporated into microbial cells rather than remaining in the water. The microbial biomass, together with organic particles, extracellular substances and other microorganisms, aggregates into suspended particles known as bioflocs.

Feed and animal waste → nitrogenous compounds and organic matter → microbial assimilation → biofloc formation → nutrient recycling and supplementary food

The carbon requirement is not identical for every system. It depends on feed composition, protein level, nitrogen loading, carbon source, stocking density and microbial activity. Therefore, carbon addition should be based on system conditions rather than on a single universal carbon-to-nitrogen ratio.

Composition of Biofloc

Bioflocs are complex aggregates rather than a single bacterial culture. They may contain heterotrophic bacteria, nitrifying microorganisms, microalgae, protozoans, fungi, zooplankton, extracellular polymeric substances and organic and inorganic particles. The microbial composition changes with culture conditions such as temperature, salinity, dissolved oxygen, pH, carbon source, feeding rate, stocking density and age of the biofloc. Therefore, the microbial community of one biofloc system cannot necessarily be considered representative of another. The diversity of microorganisms is important because different groups perform different functions related to organic-matter degradation, nitrogen transformation, nutrient recycling and interactions with potentially harmful microorganisms.

Species Suitable for Biofloc Culture

Biofloc technology (BFT) is suitable for species that can tolerate high stocking densities and utilize suspended microbial biomass. Tilapia is one of the most widely studied species due to its adaptability and ability to consume biofloc. Among crustaceans, Pacific white shrimp (*Penaeus vannamei*) is extensively cultured in BFT systems, where bioflocs support nutrient recycling and can improve growth and survival. Giant freshwater prawn (*Macrobrachium rosenbergii*) has also shown potential, although its feeding behaviour and environmental requirements require species-specific management. Other fish and crustaceans are also being investigated for BFT culture.

Major Applications of Biofloc Technology**Reduced Water Exchange**

BFT can substantially reduce routine water exchange by recycling nutrients within the culture unit. This decreases water consumption and can reduce the discharge of nutrient-rich effluents. However, the term “zero-water-exchange system” should be used carefully. Water may still be required to compensate for evaporation, manage excessive solids or correct deterioration in water quality.

Nutrient Recycling

BFT converts a portion of dissolved and particulate nutrients into microbial biomass. This provides an opportunity to retain nutrients within the production system rather than releasing them directly into the environment.

Feed Utilization

Consumption of biofloc by cultured animals may contribute to improved feed utilization and, under appropriate conditions, reduce the quantity of formulated feed required. The magnitude of this benefit varies among species and production systems.

Animal Health

Biofloc may influence animal health through improved water quality, nutritional supplementation and interactions between the microbial community and the cultured animal. Studies in shrimp have reported improvements in immune and antioxidant responses and enhanced resistance to certain disease challenges. However, BFT should not be regarded as a substitute for biosecurity or disease prevention. Healthy seed, appropriate stocking density, good-quality feed, sanitation and disease surveillance remain essential.

Limitations and Challenges

Despite its advantages, BFT has several limitations. Continuous aeration creates considerable energy demand, particularly in high-density systems. Excessive suspended solids can negatively affect cultured organisms and increase oxygen demand. Farmers also require

adequate technical knowledge to manage carbon addition, feeding, solids and water quality. The initial investment for tanks, aeration equipment, blowers, pumps, monitoring equipment and backup power may also be higher than that of some conventional systems. In addition, the microbial community is dynamic, making it difficult to establish one universal protocol for every species and farming environment. Therefore, BFT should not be promoted simply as a low-cost or zero-water technology. Its economic and environmental performance depends on appropriate system design, energy efficiency, stocking density, feed management and skilled operation.

Future Prospects

Future development of BFT is likely to focus on improving system stability, energy efficiency and precision management. Automated monitoring of dissolved oxygen, pH, temperature, ammonia and suspended solids can help farmers respond rapidly to changes in system conditions. Integration of BFT with recirculating aquaculture systems, probiotics and other water-treatment approaches is also receiving research attention. Better understanding of microbial communities through molecular and genomic techniques may help develop species-specific management strategies. Research is also required to determine the economic performance and environmental footprint of BFT at commercial farm scale. Energy-efficient aeration, improved carbon sources and better solids-management techniques will be particularly important for wider adoption.

Conclusion

Biofloc Technology is an important microbial-based approach for improving resource efficiency in aquaculture. Its major strength is the ability to convert a portion of nitrogenous and organic wastes into microbial biomass, thereby supporting nutrient recycling, water-quality management and supplementary natural food production. The technology can be particularly valuable for intensive fish and shrimp production where water availability is limited. However, successful BFT farming requires continuous aeration, careful feeding, appropriate carbon management, control of suspended solids and regular monitoring of water quality. Thus, biofloc technology should be viewed not simply as a method of reducing water exchange, but as a carefully managed microbial ecosystem for nutrient recycling and sustainable aquaculture production.

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