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BIOFLOC TECHNOLOGY: A SUSTAINABLE APPROACH TO AQUACULTURE

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Abstract

Biofloc Technology (BFT) is an innovative and sustainable alternative to aquaculture that improves water quality, minimizes water exchange, and maximizes feed utilization by microbial metabolism. It has emerged as an eco-friendly system that promotes constant nutrient recycling, leading to minimal environmental impact. Initially developed for shrimp and tilapia farming, this system has now been successfully extended to many different fish species, proving its adaptability and economic viability. The technology reduces the operational costs of water usage, land use, and feed costs significantly while preventing the transmission of pathogens, thus enhancing fish health and overall productivity. With rising concerns over water pollution and outbreaks of diseases in aquaculture, BFT has gained attention for its ability to control nitrogenous waste and convert it into microbial biomass, which provides the cultivated species with a secondary source of nutrients. In addition to that, biofloc systems have biosecurity benefits by restricting the spread of pathogens and reducing dependency on antibiotics, contributing to more sustainable aquaculture practices. Fish raised in BFT systems have enhanced immune responses as well as higher survival under disease-challenged conditions. BFT have potential as a sustainable solution for aquaculture, addressing the urgent concerns of environmental protection, economic sustainability, and food security in the global fisheries sector.

Introduction

The global human population is increasing exponentially, leading to the destruction of natural resources as well as natural habitat, including the fisheries sector, like lakes, rivers, wetlands, and oceans. As a result, aquaculture production systems need to shift to ones that are less reliant on natural resources to promote sustainable farming. By 2050, the world population is projected to reach 9.8 billion, so the need for protein and food resources is likely to be one of the major challenges in human nutrition in the future (Avnimelech, 2009). Therefore, the aquaculture sector is a major contributor to the lowest cost of animal protein. Aquaculture production is increasing annually and contributing towards food security. One of the reasons is extensive aquaculture system and species diversification. However, an increasing population is leading to urbanization, which causes a major problem of scarcity of land for aquaculture. Therefore, it is not possible for horizontal expansion in aquaculture system. The way alternative is a vertical type of aquaculture system. In this context, Biofloc is a way better alternative for a vertical aquaculture system which uses a very small area of land as well as water, resulting a higher productivity throughout the year by utilizing natural feed made from waste materials. As a result, it reduces the feed cost and environmental degradation.

Biofloc culture system

Biofloc Technology (BFT) is an innovative, affordable, environmentally friendly aquaculture system that enables sustainable fish and shrimp farming through minimal or zero water exchange. It works on the principle of nutrient recycling. They utilize the recycled nutrients and organic matters as a food in the production system. The growth of heterotrophic bacteria, algae, and other microorganisms in the production system is aided by maintaining the carbon to nitrogen (C/N) ratio. Flocs are formed by natural aggregation processes that includes microorganisms, organic matter, and physical forces within the culture water. They serve as a natural, protein-rich feed which is directly consumed by the culture species of the biofloc system, improving the feed efficiency and reducing the dependency on commercial feeds. This biofloc system has various advantages, like sustainable use of water and land, also minimizing the entry of pathogens into the culture system, and leading to improved biosecurity in the farm. Facilitating higher stocking density, leading to higher production throughout the year.

History of biofloc development

An emerging substitute for the conventional fish production system is the biofloc system. At first, it was employed to raise commercially significant fish species, such as shrimp (*L. vannamei*) and tilapia (*Oreochromis niloticus*). Early in the 1970s, the French Research Institute for Exploitation of the Sea (IFREMER) in Tahiti, French Polynesia, developed the first Biofloc technology. One of the key pioneers of this technology was the renowned Researcher Gerard Cuzon. In the late 2000s, biofloc technology has been successfully applied to various aquaculture species, including shrimp, tilapia, catfish, and carps. In particular, BFT works nicely with tilapia and shrimp culture. Because they can adapt to dense water conditions and feed on biofloc. Initially, BFT acceptance was slow. Fish farmers believe that clear waters are better for fish farming. However, the switch to BFT was prompted by a disease outbreak in shrimp farming, which resulted in its increased acceptance. Research and training programs focused on BFT have increased its knowledge around the globe. Though it offers many benefits but commercial expansion is still limited. This is primarily because of the high energy cost, skilled management, and constant water quality control needed, which makes it difficult for BFT to expand in small-scale farming operations.

Concept of biofloc working

Like other types (RAS, cage, pen, aqua ponics, and pond culture), BFT is also a culture system but is different from others by use the of bioflocs (microorganisms like heterotrophic and chemoautotrophic bacteria, microalgae, yeast, and fungi). In BFT there is enough nitrogen (mainly from uneaten feeds and fish waste), but we can supplement them with carbon-rich and protein-poor materials like starch and cellulose to keep the ratio of carbon to nitrogen (C/N) greater than 10. Heterotrophic bacteria consume the excess nitrogen, particularly ammonia, since they require nitrogen to form their cells, and they extract it from the water and turn it into the bacterial biomass or biofloc also clean the water. The basic principle of the biofloc technology is based on producing a protein-rich feed from the waste material present in the culture system, which is used by the culture species for growth and development. By preserving the ratio of carbon to nitrogen (C/N), which promotes the growth of heterotrophic bacteria and other microbes. They stick with the waste material (uneaten feed, feces etc. by the help of bacterial exopolysaccharides (EPS) enhances their nutritional value and stabilizes the structure. Constant water flow and aeration help particles to be equally dispersed and suspended. This facilitates the production of macro-aggregates (bioflocs) by halting sedimentation and encouraging collisions and aggregation.

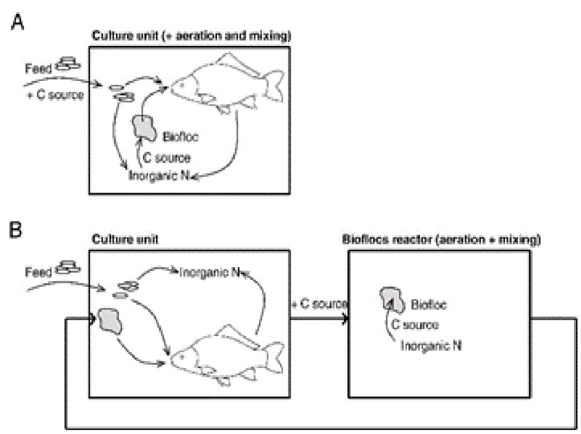

Figure 1. Diagrammatic illustration of the application of bioflocs in aquaculture systems (Crab *et. al*. 2012)

Compatible species for biofloc culture

Biofloc technology (BFT) has been successfully applied for culture of various species, which are capable of living in a crowded area, having the capacity to survive in the low water exchange system as well as tolerance to suspended solids**,** ability to utilize biofloc as a feed supplement**,** and adaptability to intensive culture conditions. Species like Tilapia (*Oreochromis spp*.), shrimps, catfishes, common carp (*Cyprinus carpio*), rohu (*Labeo rohita*) and milk fish (*Chanos chanos*) etc. are main culturable species because they have the capacity to live in the biofloc culture system.

Prospect of Biofloc Technology in India

India ranks first in the global population which, 71.1% of peoples consume fish leading by the state Tripura. Biofloc technology is one of the best aquaculture production systems to address the year-round demands of the expanding population. Its main benefits is effective water quality control because it enhances the growth of various microbial species, which are as beneficial and an alternative source of biomass, enhancing general water quality leading to higher stocking density by controlling waste and recycling nutrients and gives higher production in per unit area. BFT also greatly decreases the environmental burdens by reducing the nutrient-rich effluent release and contributes to the eco-friendly aquaculture activity.

The microbial biomass produced within the culture system is very rich in protein which act as a natural food source for the cultured species, minimize the dependency on external feeds and reduced the feed cost. Additionally, BFT also prevent disease by enhancing immune responses and inhibiting pathogen activities via probiotic effects and competitive exclusion. The system can operate throughout the year, particularly under controlled environment production, whereby fish or shrimp of desired quantities can be achieved at any time. This practice gives the flexibility of aquaculture diversification since this practice is applicable many species and allows the use of nearby available resources as agricultural by-products plus it promotes resource efficiency and economic sustainability.

Constraints of biofloc technology (BFT)

Although there are numerous benefits of BFT but it has some limitations also like it needs to be continuous aeration and mixing leading to consumption of higher energy increased the energy expenses. To operate BFT it needs some technical knowledge to manage properly (ammonia, nitrite, pH, C/N ratio). In the developing countries it is difficult for small scale farmers to manage the electricity backup as well as they are lack of technical knowledge. Also, farmers are not willing to adopt the technology because they are not familiar to this novel technology as well as installation cost is higher.

Conclusion

The innovative concept of biofloc technology has added a new chapter in aquaculture through the transformation of snitrogenous waste pollutants into protein-rich microbial biomass, BFT can have a positive environmental impact of minimizing burdens of aquaculture while complementing the nutritional requirement of cultured species and at the same time reducing operation costs.

BFT due to its low water exchange but high aeration potential is of paramount interest for the extensive culture systems development especially in the water scarcity or drought affected regions. However, its high temperature requirement limits the use for more extreme climates, showing the room for innovative technologies such as renewable heating, passive insulation and waste heat recovery to take place in more temperate regions.

The ability to address the promotional and monetization challenges that arise when applying BFT more widely and effectively requires us to address:

- Training and scalability.
- Optimization of microbial cultures and feed inputs.
- Monitoring and standardizing production data.
- Life Cycle Assessment (LCA) for sustainability assessment.
- Understanding probiotic and immunostimulatory effects of biofloc.

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