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Biofloc Technology: An emerging tool for sustainable aquaculture

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Abstract
As the global population continues to grow, food production industries such as aquaculture will need to develop in a sustainable way. Increasing aquaculture production is limited, because of severe limitations of water and availability of suitable land. To overcome these problems adopting the concepts of recycling and converting the metabolites into efficient feed by zero/minimal water exchange, conserving the water and land with high shrimp/fish production. Hence the best environmentally acceptable "Biofloc Technology" has been developed. Biofloc technology (BFT) has beneficial effects in aquaculture management, including water quality, feeding and disease control. Application of BFT in aquaculture offers a solution to avoid the environmental impact of high nutrient discharges and to reduce the use of artificial feed. In BFT, excess of nutrients in aquaculture systems are converted into microbial biomass, which can be consumed by the cultured animals as a food source. This technology, to a certain extent, has also the capacity to control pathogens in aquaculture. An attempt has been made to summarize the features and management aspects of the environmental friendly biofloc farming system to achieve sustainable aquaculture.

Keywords: aquaculture, Biofloc Technology, C/N ratio, water quality, sustainability

Introduction

Aquaculture is an efficient protein production sector offers ample opportunities to alleviate poverty, hunger and malnutrition, generates economic growth and ensures better use of natural resources [1, 2]. It has rising at an average annual rate of 6.6% since 1995 [3]. Globally, India occupies the second position after China, with sharing 10.0% of world's aquaculture production which is about 0.9% of the country GDP during 2015-16 [4, 5]. The vast resources in terms of water bodies and species of fish and shellfish in different agro-ecological regions of the country provide for a wide array of culture systems and practices [6]. However, various obstacles hampered the successful production [7]. The aquaculture industry has sought new innovative ways to reduce the impact on the environment, and maximize efficiency. Much of the focus on alternative approach towards sustainable and environment-friendly technology for enhancing large-scale production. Biofloc technology has gained attention recently as an environment-friendly and sustainable aquaculture [8, 9]. Hence, the present attempt has been made to summarize the features of the environmental friendly biofloc farming system. The different aspects of such a system can be summarized under the following headings.

(1) Biofloc
(2) Concepts of Biofloc Technology
(3) Nutritional composition of Biofloc
(4) Application of Biofloc Technology
(5) Strengths of Biofloc Technology
(6) Disadvantages of Biofloc Technology
(7) Future Research

1. Biofloc

Biofloc is a conglomeric of heterogenous bacteria, algae, fungi, protozoans, metazoans, rotifers, copepods, nematodes, colloids, organic polymers, particulate organic matter such as uneaten feed, feaces and detritus [10, 11]. The floccules are loosely held together in a matrix of mucus secreted by bacteria and electrostatic attraction. Bioflocs vary in size 1-200µm and can reach more than 1000µm. They are irregular in shape, easily compressible, highly porous and permeable to fluids. Color generally ranges from brown to green, depending upon the constituents. Bioflocs have slow sinking rate, kept floating by aeration increasing the opportunity to derive nutrients from water column. Normally flocs comprise 2-20% living microbial cells, 60-70% organic matter, and 30-40% total inorganic matter. A typical biofloc contains 4 components: bacterial colony, filamentous bacteria, absorbed matter and algae. Biofloc volume is measured with Imhoff cones. Desirable floc volume ranges between 1-40 ml/L in fish culture and 2-15 ml/L in shrimp culture. Besides the volume, color and various physico-chemical parameters and nutritive value like protein levels, fatty acids etc., have also been used to characterize the flocs. The biofloc is an assemblage of more than 750 operational taxonomic units [OTUs] and recently as many as 2000 OTUs were identified [12].

2. Concepts of Biofloc Technology

The main principle of Biofloc technology (BFT) is to recycle nutrients and nitrogenous wastes by maintaining a high carbon/nitrogen (C/N) ratio in the water to stimulate the growth of heterotrophic bacteria [13]. Bacteria growth increases when carbon sources such as molasses, wheat bran and cellulose are applied in pond with continuous aeration [14]. Through maintaining the C/N ratio in culture system by adding carbon source the water quality can be improved along with the production of high-quality single-cell microbial protein [15]. The BFT, not only maintain water quality, but also provide essential and higher quality nutrition to the shrimp in achieving fast growth, lesser FCR and possibility to prevent diseases [16, 10]. The Promotion of floc formation is influenced by a combination of physical, chemical and biological interactions such as temperature, pH, dissolved oxygen, organic loading rate etc.

3. Nutritional composition of Biofloc

Studies indicated that biofloc contains high levels of protein 38- 50%, lipid 3%, fiber 6%, ash 12% and 19 kj/g energy [17, 11]. Protein levels in biofloc depend on the crude protein in the diet and carbon sources applied. Poly unsaturated fatty acids in biofloc contain 27-28%, mono-unsaturated fatty acids 28-29%, and 30-35% of saturated fatty acids [18]. The number of bacteria in biofloc pond can be 10^6 to 10^9 per ml of floc, which contains 10-30 mg dry matter and bacteria produce 60-600 kg/ha/day of protein for fish [14]. Even though biofloc have sufficient protein to maintain significant fish growth, however, supplementary feed is essential and its quantity has to be adjusted on the basis of biofloc volume.

4. Application of Biofloc Technology

BFT has been applied to culture various shrimp and fin fishes. Not all species are candidates to biofloc technology. Desirable characters are the filter feeding habit, omnivorous habit and digestive system adoptable to assimilate the microbial protein. The BFT has been adopted successfully in nursery [19, 20], grow out phases [21, 15], and even to enhance breeding capacity [22]. BFT has been used successfully in culturing different crustacean species such as *L. vannamei* [18], *P. monodon* [23], *F. paulensis* [24], *F. brasiliensis* [25] and *F. setiferus* [26]. Among the fin fish *Oreochromis niloticus* [17], *Cyprinus carpio* [28] and catfish (*Clarias gariepinus)* [29] has been cultured. Nowadays, BFT has been successfully applied in aquaponics. The presence of rich-biota (microorganisms of biofloc) and a variety of nutrients such as micro and macronutrients originated from un-eaten feed seems to contribute in good nutrition.

5. Strengths of Biofloc Technology

The BFT strengths in aquaculture has been well documented which includes water conservation potentiality, because of zero or minimal water exchange, maintaining temperature and heat fluctuations [29]. It supports nitrogen removal even when organic matter and biochemical oxygen demand of the system is high [12]. It will reduce the pollution of pond water, and improves the water quality, lowering the concentration of toxic ammonia, nitrite and hydrogen sulfate. The major advantage of this technology is that it reuses the waste nutrients through microbial protein into fish or shrimps, these microbial flocs contribute nearly 50% requirement of fish protein and lowered the feed conversion [30]. It maximizes the growth, survival and promises healthy rearing system with less introduction of pathogen and diseases [31-33]. In addition, BFT makes it possible to avoid the usage of antibiotics and enhances the meat quality. Moreover, it serves as a natural probiotic and immunostimulants [34].

6. Disadvantages of Biofloc system

The most obvious disadvantages are continuous aeration to maintain high dissolved oxygen level > 5 ppm, hence high energy cost. Significantly higher skills and better equipped laboratories are necessary to monitor and operate the biofloc system efficient. This system can be practiced in intensive system and extensive systems. The ponds must be lined with HDPE sheet, or concrete ponds, are required for the efficient organization of this system. In concrete ponds, high levels of nitrite lead to Exuvia Entrapment of shrimp. Accumulation of total suspended solids leads to proliferation of protozoans like *Vorticella* and *Zoothamnium* these protozoans feed on heterotrophic bacteria, reducing their number which inturn effects the quality and quantity of biofloc [35].

7. Future Research

The effects of water quality, microbial mechanisms involved in the process and environmental factors on the biofloc are largely unknown and warrant investigation. Research should be focused on the optimal way to manage biofloc in aquaculture ponds, with respect to optimal floc morphology, compositional and nutritional value of the floc. An additional challenge is to promote the technology, which can convince the farmers to implement it. Therefore, sharing technical knowledge to the farmer in a clear, practical and straight forward way that can emphasize its economic benefits and to implement BFT in future aquaculture systems.

Conclusion

Biofloc technology offers benefit in improving the production and contribute towards a sustainable aquaculture. This technology serves as environmentally friendly approach, reducing pollution, zero/minimal water exchange, recycling in- situ nutrients, improving biosecurity, improvement of FCR by augmenting natural food, providing stress free environment and eliminating the antibiotics and chemicals. In India the biofloc technology is still in infant stage. A lot more research is needed to optimize the system. In addition, research findings will need to be communicated to farmers to implement it. By adopting this technology, it can revolutionize the aquaculture sector.

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