# Biofloc technology – new blue revolution technique in intensive culture of tilapia

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## Introduction

Fish in a pond assimilate only 15–30% of the nitrogen added in the feed, remainder being lost to the system as ammonia and organic N in feces and feed residue. The organic N in feces and uneaten feed also undergoes decomposition and produces ammonia. Therefore, a high protein level in fish feed results in high concentration of ammonia in the water column which is detrimental to cultured animals. The most influential factor in aquaculture is feed cost and the most limiting factor is water/land supply. High stocking rates and aquatic animal rearing need wastewater treatment. Biofloc method is a wastewater solution that has acquired significance in aquaculture.

## What is Biofloc technology?

Bioflocs are aggregates (flocs) of algae, bacteria, protozoans and other kinds of particulate organic matter such as feces and uneaten feed. Each floc is held together in a loose matrix of mucus that is secreted by bacteria. The bacterial cells are made up of proteins and they have to maintain a fixed carbon/nitrogen (C/N) ratio in their cell. Biofloc technology (BFT) is a technique of enhancing water quality through the addition of extra carbon to the aquaculture system, through an external carbon source or elevated carbon content of the feed. BFT is considered the new “blue revolution” since nutrients can be continuously recycled and reused in the culture medium, besides the benefit of minimum or zero-water exchange.

Biofloc technology was introduced by Dr. Yoram Avnimelech in Israel. The main concept is that producers could piggyback off the nitrogen cycle and let beneficial bacterial colonies proliferate in culture water. The biofloc system was developed under the same principle that regular waste water treatment plants have, in which the microbes grow from feces of the cultured organisms being, transforming it into less complex organic products that can be consumed. Common practices in BFT systems consist of indoor tank BFT culture of Nile tilapia; outdoor culture of tilapia in BFT tanks; the raceway system with biofloc for *L. vannamei* broodstock family selection; the *Penaeus monodon* culture in BFT ponds; and the *L. vannamei* culture in BFT tanks. The biofloc fish farming materials system was developed to improve environmental control over the development of aquatic animals.

## Advantages of biofloc technology

The BFT is an ecofriendly culture system. It improves land and water use. Other benefits include reduction in environmental impact and zero water exchange; higher productivity (enhances survival rate, growth performance, and feed conversion ratio in culture system); cost-effective feed production; reduction in utilization of protein rich feed and cost of standard feed; higher biosecurity; and reduction in water pollution and risk of introduction/spread of pathogens.

## Tilapia and biofloc

Tilapia (MS, GIFT, Chitralada, Red Tilapia etc.) are ideally suitable for biofloc system. About 90-120 fish per Cubic Meter can be stocked. This attains higher growth in a short period. As a quarantine measure, fingerlings purchased from a certified dealer shall be dipped in 3% salt solution for 30 seconds followed by a dip in 5% Potassium permanganate for 15 minutes.

The filter-feeding herbivores adapt to the harvest of biofloc suspended in the water, and the strong, stable fish grow and flourish in dense systems. A very high biomass is an essential feature of biofloc tilapia production system, especially as compared to shrimp system. It is important to note that the application of biofloc technology has focused on primarily omnivorous aquatic organisms. Assessment of candidate species for BFT should include their adaptability to intensive farming conditions, the phase of their production cycle, tolerance to low-medium levels of ammonia, nitrogen, nitrite and suspended solids, possess an adequate morphological structure that will enable the cultivated species to graze the biofloc properly, and capacity to digest and assimilate the microbial aggregates.

## Steps involved in BFT

Various steps involved in BFT include Tank/ Pond preparation, Aeration, Water preparation, Pre- Seeding of microbes, Strict monitoring of water Parameters, Feed Management etc.

### 1. Tank/pond preparation

It is best to start with a canvas pond, concrete pond or tank. Tanks shall have slope at the centre to facilitate easy removal of waste. Polyfoam sheets (250mm) or HDPE sheets (550-750GSM) can be used for lining. Also, shall have shade nets In-house soil does not affect water parameters or biofloc process. Indoor system has an advantage over the outdoors in Kerala, especially in monsoon when heavy rains cause abrupt changes in alkalinity and pH. Covered ponds are a good choice. Biofloc ponds need not always be circular, can be oval, rectangular etc.

2. **Aeration**

Biofloc systems require constant motion to maintain high oxygen levels and to keep solids from settling. It requires up to 6mg of oxygen/l/hr. It is recommended to install 120 HAP aerator for 10,000L tank, and two 120 HAP aerators for 20,000L tank. Tanks and ponds often use paddle wheel aerators. Care should be taken to avoid anaerobic conditions in Biofloc fish farming. Electricity backup is therefore a very important component. Hailea's air pumps and aeroxy tubes are the most commonly used in Biofloc fish farming. High-flow tubes help in sustaining excellent water quality by providing adequate amount of dissolved oxygen.

3. **Water preparation**

Any source other than well water should be chlorinated with 5 ppm chlorine or 50ml /L clorox aerate for 2 days. In normal water, TDS will be 300-500 and hence salt has to be added @ 3-5kg /1000 L. The testing of TDS needs to be repeated till the value reaches between 1800 and 2000 . Test PH & Alkalinity. Dolomite, baking soda, and calcium oxide is added in the ratio 500g: 50g: 50g respectively in 1000 ltrs. PH of 7.6 is best with Alkalinity > 150 mg/L.

4. **Pre-Seeding of Microbes**

Day-wise activities to be performed for attaining desired flock density is as follows.
For 1000 ml water, algae water, 24 % feed and jiggery to be added in the ratio 100L:1.0 Kg: 500 gm respectively and aerate. Check Ammonia level on 4$^{th}$ day. Feed and fermented jaggery to be added. Continue this practice daily till the Ammonia level becomes zero. Water turns Golden brown between 10$^{th}$ and 12$^{th}$ day. Flock density of 5ml per Litre shall be obtained between 15$^{th}$ and 20$^{th}$ day. Stocking can be done thereafter. Carbon to Nitrogen (C/ N) ratio shall be maintained as 13:1.

**Calculation of C/N ratio and ammonia control**

C/N ratio in BFT is divided in two stages

**Calculation based on protein content of feed-floc development stage**

Floc development stage means the first 20 days of the culture period when floc density reaches 5ml/L. C/N ratio of 13:1 will be maintained during this period. Carbon in 1 kg feed with 24% crude protein = 1kg * 0 .9 (dry matter) *0.7 (70% waste) /2(50% C based on dry matter)
= 315gms of C

Nitrogen in 1 kg feed with 24 % crude protein = 1 kg* 0.9 (dry matter) * 0.7 (70% waste) *0.24/6.25 (constant)
= 24.19 gms Therefore, the C/N ratio is 13.02:1

**Calculation based on Total Ammonia Nitrogen (TAN) during maintenance stage**

Carbon application based on feed is followed till 5mL floc density. Then, carbon is applied on TAN concentration. When values of TAN are higher than 1mg/L, external carbon source is recommended with C/N ratio 6:1

For e.g., 2mg/L of TAN in 10000 L tank
= 0.002g * 10000 L
= 20gm of TAN, to get C/N ratio of 6:1, 20 g of TAN in water * 6
= 120 gm of C or 285 gms of sugar (42%c)

## 5. Monitoring of Water Parameters

In high-density fish farming, it is important to take good care of the fish ponds as the flocks keep growing along with the fish. Always check for ammonia, pH, nitrate, nitrite, and floc density in the pond water.

| Parameter | Ideal and/or normal observed ranges | Observations |
|---|---|---|
| Dissolved oxygen (DO) | Above of 4.0 mg $L^{-1}$ (ideal) and at least 60% of saturation | For correct TILAPIA FISH microbiota respiration, and growth |
| Temperature | 28-30° (ideal for tropical species) | Besides fish/shrimp, low temperatures (~20° C) could affect microbial development |
| pH | 6.8-8.0 | Values less than 7.0 is normal in BFT but could affect the nitrification process |
| | | 13 |

| TAN | Less than 1 mg $L^{-1}$ (ideal) | Toxicity values are pH dependent |
|---|---|---|
| Nitrite | Less than 1 mg $L^{-1}$ (ideal) | Critical parameter (difficult to control). Special attention should be done, e.g., on protein level of feed, salinity, and alkalinity |
| Nitrate | 0.5-20 mg $L^{-1}$ | In these ranges, generally not toxic to the cultured animals |
| Alkalinity | More than 100 mg $L^{-1}$ | Higher values of alkalinity will help the nitrogen assimilation by heterotrophic bacteria and nitrification process by chemoautotrophic bacteria |
| Settling solids (SS) | Ideal: 5-15 mL $L^{-1}$ (shrimp), 5-20 (tilapia fingerlings) and 20-50 mL $L^{-1}$ (juveniles and adult tilapia) | High levels of SS (measured in Imhoff cones) will contribute to the DO consumption by heterotrophic community and gill occlusion |
| Total suspended solids (TSS) | Less than 500 mg $L^{-1}$ | Idem to SS |

## 6. Feed management

Feed requirement in BFT system shall be 30% less than that of conventional aquaculture systems. Fingerlings in nursery pond should be fed with 40% crude protein. Percentage of crude protein and size of pelted feed depends on the fish body weight.

| FISH BODY WEIGHT (gms) | FEED % (TBW) | FLOATING FEED SIZE (mm) | PROTEIN % |
|---|---|---|---|
| 3-5 | 6 | .5 | 40 |
| 5-25 | 4 | .8 | 32 |
| 25 -100 | 3 | 1.8 | 24 |
| 100-250 | 3 | 3.0 | 24 |
| 250-400 | 2 | 4.0 | 24 |

## HARVEST

If all the above-mentioned steps are properly followed, a farmer can expect increased growth rates and survival, thus reducing overhead costs and improving profitability. It is possible to achieve a biomass of 30-35 kg / cubic meter. Farmers need to be aware of the market. With higher stocking densities fish attains 280g and at lower density 450g in 5-6 months.

## Budget

BFT is a budget-friendly technology. The total cost involved in setting up a biofloc tank of 20,000L would be approximately Rs.1, 40,000. Capital investment for 20,000L tank (tank, shade net, aeration, electrification, plumbing, invertor/generator would be about Rs. 93,000 and the variable cost (fingerlings, feed, medicine, carbon source, electricity etc.) Rs. 47,000. The biofloc system in rearing tilapia earns good profit as the investment is less compared to other fish farming methods.

## Challenges in future research and development of BFT

Selection and positioning of aerators.

Integration in existing systems (e.g., raceways, polyculture systems).

Identification of micro-organisms yielding bioflocs with beneficial characteristics (nutritional quality, biocontrol effects) to be used as inoculum for biofloc systems.

Development of monitoring techniques for floc characteristics and composition.

Optimization of the nutritional quality (amino acid composition, fatty acid composition, vitamin content).

Determination of the impact of the carbon source type on biofloc characteristics

## Conclusion

Under ideal conditions, biomass of 30-35 kg / cubic meter can be harvested through BFT. The chances of disease outbreak are very remote in such a culture practice in addition to being an ecofriendly and budget-friendly technology BFT proved to be ideal for industrial aquaculture as it improves farm efficiency, production, biosecurity, immune system of the animals etc. More studies can be taken up for species diversification in BFT aquaculture system.