Introduction

The costliest factors in aquaculture are high-quality feeds, filtration systems and the investment needed for ample space to grow targeted aquaculture species. With continuously rising production costs, farmers and researchers are looking for alternative ways to produce more fish while utilizing fewer resources and be cost effective.

Originally conceived as a natural way to clean water, biofloc systems are becoming increasingly popular as a low-cost means of cleaning the culture water of fish farms while simultaneously providing an additional source of feed. Best of all, implementing biofloc principles requires little investment – as only sunlight, a carbohydrate source and plenty of aeration are needed.

Biofloc systems bank on photosynthesis to convert uneaten feeds, faeces and excess nutrients into food. While breaking down toxic ammonia and nitrates into free nitrogen, both primary-producing autotrophic and heterotrophic bacteria multiply to attract an ever-growing host of organisms – including diatoms, fungi, algae, protozoan's and various types of plankton. Loosely bound by bacterial mucous, most of these floating clumps or "flocs" are microscopic. Larger aggregations can be seen by the human eye, resembling brown or green sludge. Though not too appealing for humans, this is a delicious food for fish and shrimp.

By recycling proteins, biofloc systems overcome concerns associated with high animal-stocking densities and low filtration capacity – like decreased water quality and increased risk of disease outbreaks. In traditional farming systems, only about 25 percent of the protein content of feeds are actually utilized by farmed species. By converting ammonium into microbial proteins that can be consumed by filter feeders, biofloc systems are able to double this figure, and thus helping farmers to save some money. Biofloc systems reduce the spread and effectiveness of pathogens while simultaneously improving fish health through better water quality and support feed availability. As such, biofloc systems can give us a natural way of producing more fish sustainably, while concurrently improving farm profitability.

It's important to understand that biofloc systems and their underlying principles are relatively new and complicated aquaculture concepts. There are still many unknown and some are yet to be discovered. It is encouraged to conduct further research and to share their experiences to maximize everyone's chances of success.

Steps to be followed in fish farming through Biofloc Technology

Step 1: Tank or pond setup

Though it's possible to convert traditional fish ponds without any liner into a biofloc system, it's a challenging task. Microbes, minerals and heavy metals naturally based in the soil easily influence the parameters of the pond water and can affect the natural processes underlying the biofloc system.

For those who are new to biofloc, it's best to start with lined pods, concrete ponds or indoor tanks where soil has no influence over water parameters or biofloc processes. In most tropical countries, indoor systems have a big advantage, we experience heavy rainfall and because of that alkalinity and pH are easily affected in outdoor systems, Covered ponds are good options.

Indoor tanks or raceways can be used as well, but without the presence of natural sunlight, algae won't grow sufficiently or won't grow at all – creating a biofloc system based solely on bacteria, and these are called "brown biofloc systems".

If you use large ponds you should install bottom drains to occasionally remove excess sludge. This is especially important when adding carbohydrates on a regular basis, which adds considerably more sludge to the pond. A second option is to use biofloc reactors to accelerate the conversion of pond sludge to bioflocs.

Step 2: Aeration

After you have selected the right pond or tank, it's time to work on the aeration system. All biofloc systems require constant motion to maintain both high oxygen levels and to keep solids from settling down in the bottom of the tank. Areas without movement will rapidly lose oxygen and turn into anaerobic zones which release large amounts of ammonia and methane.

To prevent this, every pond, tank or raceway system needs a well-planned layout of aerators. Ponds typically use paddlewheel aerators. Biofloc systems require up to 6 mg of oxygen per liter per hour and it is recommended to start with at least 30 HP of aerators per hectare. But, depending on the intensity and productivity of the system, this number can reach as high as **200** HP per hectare.

Paddlewheel aerators should be installed strategically so that a current is created in the pond. You also need to regularly move some of the aerators to ensure that the solid particles don't get settled in areas with little or no current.

Step 3: Pre-seeding beneficial microbes

To accelerate the development of your biofloc system and stabilise your pond faster, it is advisable to pre-seed the culture water. This can be done by adding a number of commercial or homemade recipes to the culture water. There are many well-known companies that provide starter cultures for various probiotic microbes, but there are many locally produced brands available. A simple homemade recipe to quickly produce probiotic and prebiotic microbes uses wheat bran, De-oiled Rice bran and Jaggery mixed in a closed drum and left to ferment for 48 hours, after which the contents can be added to the pond.

Step 4: Species selection and stocking densities

Though most species would benefit from the improved water quality of biofloc systems, you want to select species that best benefit from the extra proteins generated, by feeding and digesting the bioflocs themselves. These species are wholly or partially filter feeders. Fresh water prawn (M.rosenbergi), singhi, mangur, Pangasius and Tilapia are excellent species, as they gobble up bioflocs, thereby dramatically improving the feeding efficiency and FCR (food conversion ratio) of our farming operation.

Even non-filter feeders like jade perch and different groupers have been farmed in indoor biofloc systems, with very positive results. It is however important to avoid species which dislike murky waters with a high solid content, like IMC. These species simply won't perform as well.

Thanks to the strong aeration and self-filtering capacity of culture water, high stocking densities can be considered and it is common to stock prawns at densities of 100 to 150 post-larvae per square meter. A safe stocking density for tilapia would be 200 to 300 fry per cubic meter. Many farmers try to use higher stocking densities but this significantly increases the risk of disease, compromising both the health and growth of the animals.

Step 5: Balancing carbon source input

To prevent ammonia peaks (mostly originating from the nitrogen in feeds) at the start of the farming cycle, the growth and development of biofloc is recommended in pond or raceway system by ensuring the sufficient availability of carbohydrates. The carbon in these carbohydrates enables heterotrophic bacteria to multiply and synthesize ammonia, thus maintaining water quality.

It is advised to select only carbon sources and feed mixtures with a carbon-to-nitrogen (C/N) ratio above 10 as this favors the growth of these heterotrophic bacteria. Since most fish and prawn feeds have a C/N ratio of 9:1 or 10:1, additional inputs are needed to raise this ratio to between 15:1 and 20:1. Any material that contains simple sugars and breaks down quickly can be used, such as molasses, Tapioca, hay, sugarcane or starch. Another solution is to reduce the protein content of the used feeds.

To prevent ammonia peaks at later stages of the production process, this step should be repeated, especially when using high stocking densities in combination with large amounts of artificial feeds.

Step 6: Biofloc growth

With plenty of aeration, natural light (in most systems) and a readily available source of carbon, biofloc numbers should start to multiply quickly. Depending on a variety of factors, including water temperature, available nutrients and sunlight, plus the number of seeded bioflocs at the start of the operation, the number of flocs will increase from close to zero to about four to five units per milliliter within a few weeks. Eventually an incredible density of up to 10 billion bacteria per cubic centimeter can be expected with, "An incredible diversity of over 2,000 species," all working hard to minimize the ammonia content in the water column and maintain good water quality.

Monitoring the growth of these flocs can be done by using a cone-shaped beaker or imhoff cone to collect several water samples at a depth of 15cm to 25cm, preferably in the late morning. The solid particles should be left to settle down for 20 minutes. They will stick to the sides of the cone-shaped beaker, making it easy to count them.

Step 7: Monitoring and control of biofloc development

From this point onwards, water samples must be regularly taken to monitor the pond water and determine the activity of the two biofloc types plus their respective densities. In simple terms, outdoor bioflocs consist of green algae and brown bacteria: the algae mainly utilize sunlight for their growth, while the bacteria mostly consume leftover feeds, their byproducts and associated wastes.

Since algae initially tend to multiply faster, this means that a pond looks green at first, turning brown over the following weeks as bacterial colonies start to dominate. With the stock growing and feeding volumes increasing, a tipping point will be reached wherein the water will remain brown. This brown color is more quickly reached with tilapia as they are fed with more feeds, while it takes a bit longer with prawn.

Step 8: Monitoring and control of water parameters and associated farm infrastructure

Once the biofloc system has turned brown, aeration must be significantly increased to sustain the high respiration rate. Respiration rates at this stage can reach 6mg per liter per hour, requiring up to six times more energy per hectare as compared with when the operations are started.

Any power failure at this stage can quickly result in total crop failure due to lack of oxygen, because in a low-oxygen environment many heterotrophic bacteria actually start producing ammonia. It is vital for the aeration system to stay functional at all times.

This means good maintenance and monitoring of the aerators themselves, plus the power system that provides the energy to run this system. As the power is not too reliable, especially in the rural areas where many farming operations are based, it is advisable for farmers to invest in off-grid solutions. Several manufacturers of paddlewheel aerators offer solar-powered versions. These are however more costly and not always that powerful. A large diesel generator, including a second back-up generator set, might be the best option for most large-farm operations.

Regular monitoring of water-quality parameters, especially dissolved oxygen and ammonia levels, will give a good idea if the system is working well, or if aeration needs to be increased further.

Step 9: Monitoring and control of farm stock

Besides maintaining water quality at lower cost and without water exchange, the second goal of a biofloc system is to improve growth rates and feeding efficiencies, thereby improving the profitability and sustainability of farming operations.

To check how the farm is doing, regular monitoring of the performance of the farm stock, calculating and recording growth rates, overall appearance, FCR and stock survival is required. It has been estimated that for every unit of growth in stock from feed, an additional 0.25 to 0.5 units of growth can come from the biofloc. One should thus notice a big jump when comparing current farm records with previous, traditional non-biofloc farm operations.

Step 10: Harvest and clean-up

For prawn, a harvest of 10 to 15 tons per hectare can be safely expected. If all steps have been followed properly, a farmer can expect increased growth rates and survival, thus reducing overhead costs and improving profitability.

Often forgotten and underestimated, proper cleaning and preparation of the pond set-up or raceway is vital after harvest time. Although it might seem appealing to reuse the culture water since it took intensive effort to build up the population of microorganisms, this is not advisable. Pathogens might have built up the culture and can pose a serious biosecurity risk. Research has also indicated that over time, heavy metals can build up in the culture water, which can accumulate in stock, making it unsuitable for human consumption. It is highly recommended to cleaning up well before starting next profitable batch.

Advantages of Biofloc

1. Biofloc is an eco-friendly culture system.
2. Biofloc system reduces environmental impact.
3. Efficiently improves land and water use.

4. Limited or zero water exchange.
5. Productivity will be high (it enhances survival rate, growth performance, feed conversion in the culture systems of fish).
6. Higher biosecurity.
7. Reduces water pollution and the risk of introduction and spread of pathogens.
8. Cost-effective feed production.
9. It reduces the use of protein-rich feed and the cost of standard feed.
10. Biofloc system reduces the pressure on capture fisheries that means the use of cheaper fish food and trash fish for fish feed formulation.

Disadvantages of Biofloc

1. Increased energy requirement for mixing and aeration.
2. Reduced reaction time because water respiration rates are elevated.
3. Start-up period required.
4. Alkalinity supplementation required.
5. Increased pollution potential from nitrate accumulation.
6. Inconsistent and seasonal performance for sunlight-exposed systems.

Recommended water parameters of biofloc system	
Parameters	**Units**
D.O. (Dissolved Oxygen)	>5.0 mg/lit
Temperature	28-30°C
pH	6.8-8.0
TAN (Total Ammonia Nitrogen)	< 1 mg/lit

Nitrite	< 1 mg/lit
Nitrate	0.5-20 mg/lit
Alkalinity	> 100 mg/lit
T.S.S (Total Suspended solids)	< 500 mg/lit

(विवरणी–II)

Cost Estimates of 1 Bio-flocUnit having 5 tanks:				
Sl	Component	Unit	Cost @ (Rs)	Total (Rs in lakhs)
(A) Capital cost				
1	Setup of Tarpaulin/Fibre /Cement tanks (15,000 Litres capacity)	5	35000/Tank	1.75
2	Shed material and accessories fixing charges	150 m^2	120000/150 Sq m	1.20
3	Water supply borewell (3HP)	1	100000/Unit	1.00
4	PVC pipe fittings for air, water flow	LS	75000	0.75
5	Nets and accessories	5	3000/Unit	0.15
6	One Blower (1 HP), Air stones and other accessories	1	30000/Unit	0.30
7	Electrification	LS	10000	0.10
8	Power generator (2 KVA)	1	45000/Unit	0.45
9	Weighing balance	2	5000/Unit	0.10
10	Miscellaneous expenses			0.20
Total (A)				**6.00**
(B) Input cost for one crop				
1	Seed cost(including transport cost)	7500 pcs (Stocking 1500 nos fingerling/Tank)	4/ fingerling	0.3
2	Feed (including transport cost)/Benificiary can install Fish Feed Machine also within amount limit for feed.	3500 Kg	42/Kg	1.47
3	Probiotics, Jaggery (and raw salt etc	LS	6000 /per tank	0.3
4	Test kits (water quality and bio-floc quantity)	LS	10000	0.1
5	Power charges	LS	15000	0.15
6	Miscellaneous expenses	LS		0.18
Total (B)				**2.5**
Grand Total (A+B)				**8.5**

नोट :– उपर्युक्त वर्णित घटक/अवयव तथा उसका मूल्य सांकेतिक एवं अनुदान आकलन के लिए है। वास्तविक घटक/अवयव एव मूल्य में निर्धारित कुल राशि 8.50 लाख के अन्तर्गत परिवर्त्तन हो सकता है।

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03/02/2020

सरकार के अपर सचिव

 Sanjay Kumar,Yojna.\19-20\ Govt Order-35/2019\07-01-2020.

(विवरणी–III)

Sl	Component	Unit	Cost @ (Rs)	Total (Rs in lakhs)
Cost Estimates of 1 Bio-flocUnit having 10 tanks:				
(A) Capital cost				
1	Setup of Tarpaulin/Fibre Cement tanks (15,000 Litres capacity)	10	35000/Tank	3.50
2	Shed material and accessories fixing charges	250 m^2	150000/250 Sq m	1.50
3	Water supply borewell (3HP)	1	100000/Unit	1.00
4	PVC pipe fittings for air, water flow	LS	120000	1.20
5	Nets and accessories	10	3000/Unit	0.30
6	Two Blower (1 HP), Air stones and other accessories	2	30000/Unit	0.60
7	Electrification	LS	25000	0.25
8	Power generator (2 KVA)	1	45000/Unit	0.45
9	Weighing balance	2	5000/Unit	0.10
10	Miscellaneous expenses	LS		0.10
Total (A)				**9.00**
(B) Input cost for one crop				
1	Seed cost(including transport cost)	15000 pcs (Stocking 1500 nos fingerling/Tank)	4/ fingerling	0.6
2	Feed (including transport cost)/Benificiary Can Install Fish Feed Machine also within amunt limit for feed.	7000 Kg	42/Kg	2.94
3	Probiotics, Jaggery (and raw salt etc	LS	6000 /per tank	0.6
4	Test kits (water quality and bio-floc quantity)	LS	10000	0.1
5	Power charges	LS	29000	0.29
6	Miscellaneous expenses	LS		0.07
Total (B)				**4.6**
Grand Total (A+B)				**13.60**

नोट :– उपर्युक्त वर्णित घटक/अवयव तथा उसका मूल्य सांकेतिक एवं अनुदान आकलन के लिए है। वास्तविक घटक/अवयव एव मूल्य में निर्धारित कुल राशि 13.60 लाख के अन्तर्गत परिवर्त्तन हो सकता है।

3/2/2020
सरकार के अपर सचिव

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