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Biofloc Quality and Quantity Biofloc as a Feed Ingredient, Stocking of Fish and Shellfish Species

Sagar Vitthal Shinde[1]
[1]Ph.D. student, Division of Aquaculture, ICAR-CIFE, Panch Marg, Off Yari Road, Versova, Andheri (W), Mumbai, 400061

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Introduction

Capture fisheries has shown stagnated figure in the recent years. The global population in 2018 was around 7.7 billion and it is anticipated to reach more than 9 billion by 2050.The growing population demands more protein sources and thus increasing the dependence on aquaculture production. To meet the increasing demand of fish, intensification of culture systems is being practiced and new intensive culture technologies are being taken up. Intensive culture practices are more input based and contribute to environmental degradation and pollution. Rampant use of antibiotics and frequent disease out breaks has been very common in aquaculture industry. Ecologically and socio-economically sustainable practices must be practiced to achieve higher production. Hence, there is an urgent need to search for better aquacultural production systems that, despite of their high productivity and profitability, utilize fewer resources such as water, energy, land, and capital and have negligible impact on the environment. Biofloc technology (BFT) is one of the most promising sustainable aquaculture systems which takes into account the intensive culture of aquatic species, zero water exchange, and improved water quality as a result of beneficial microbial biomass activity, which, at the same time, can be utilized as a nutritious aquaculture feed, thus lowering the costs of production.

Bio loc Technology (BFT)

Bio-floc is an assemblage of beneficial microorganisms such as heterotrophic bacteria, algae (dino flagellates & diatoms), fungi, ciliates, flagellates, rotifers, nematodes, metazoans &detritus (Panigrahi *et al.*, 2018). Bio floc technology is based on the cycling/recycling of nutrients and their reuse in the same system, which is designed as a zero-exchange or minimal exchange (water) system (Emerenciano *et al.*, 2017). BFT was 1st developed in early 1970s at Ifremer-COP (French Research Institute for Exploitation of the Sea, Oceanic Center of Pacific) with different penaeid species including *Penaeus monodon*,

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Fenneropenaeusmerguiensis, Litopenaeusvannamei and L. stylirostris(Emerenciano*et al*.,2012,2013).Later, Prof. Yoram Avnimelech from Israel, contributed immensely for the further modification and promotion of this encouraging technology. The technique developed in Israel subsequently spread to many other countries due to its several advantages.It relies on heterotrophic process where uneaten feeds, faecal matters and excess nutrients are converted into edible flocs, also called singe cell proteins (SCP). The SCP are loosely bound by bacterial mucous to form visible floating clumps, which are nutritious food materials for cultured fish or shrimps. In an efficient BFT system, the cost of fish feed is reduced by 30% as each pellet is basically eaten twice (i.e., as fresh pellet, and, as SCP), thus leading to high aquaculture productivity and profitability. BFT works under zero water exchange too, which also makes the system more bio secure. In biofloc system, ammonia is consumed by bacteria and nitrite increases, with tolerance upto a higher level. There is a need to correct the declining alkalinity which must be maintained >75-150 ppm. Another important requirement in the bio-floc system is to meet the high oxygen demand. Vigorous and uninterrupted aeration is provided The bioflocs not only contain essential nutrition but has probiotic effect that ensures bio security in the BFT systems (Ogello*etal*.,2021).

Composition of Biofloc

Biofloc consists of microorganisms such as heterotrophic bacteria, algae (dinoflagellates and diatoms), fungi, ciliates, flagellates, rotifers, nematodes, metazoans and detritus that conglomerate together and perform symbiotic processes to maintain the water quality and maintain bio-security (Manan *et al*.,2017).Control of the predominantly heterotrophic bacterial community over autotrophic microorganisms is achieved by the use of high carbon to nitrogen ratios (Avnimelech et al., 1989; 1992; 1994; Kochva et al., 1994; Avnimelech, 1998; 1999). Regarding to age of bioflocs, in “young” biofloc heterotrophic bacteria is mainly presented as compared to “old” biofloc dominated by fungi. Common zooplankton and phytoplankton observed in the biofloc treatments tintinnids, Ciliates, Copepods, Spirulina, Nematodes. (M Rajkumar et al.,2015).

Types of Biofloc

On the basis of whether the cultured animals are cultured in the Biofloc system or not, it is of two types-

1. **In-situ**

- In-situ bioflocs are formed in culture ponds or tanks by manipulating the carbon: nitrogen ratio (C: N). The fishes or shrimps are cultute in the same system where they graze upon the flocs as feed.
- This is accomplished by supplementing a carbon source such as sucrose, molasses, glycerin or calcium acetate. The C:N ratio is maintained taking into the account of the nitrogen produced from the feed waste and faecal matter in the system. Under high C: N ratio conditions heterotrophic bacteria are the primary components of bioflocs. Shrimp and fish can graze on these bioflocs for nutrition.

2. **Ex-situ**

- Bioflocs are formed in suspended growth biological reactors.
- These flocs can be fed to the cultured species separately or can be incorporated in feed.
- Biological reactors are employed to remove accumulated solids and nitrate from aquaculture production effluent waters.

On the basis of exposure to light, it is of two types:

1. Exposed to light:

Biofloc systems exposed to natural light include outdoor, lined ponds or tanks for the culture of shrimp or tilapia and lined raceways for shrimp culture in greenhouses. A complex mixture of algal and bacterial processes control water quality in such "green water" biofloc systems. Most biofloc systems in commercial use are green water. In outdoor BFT systems, photosynthetic pathway that produces algae normally precedes the bio-flocking process. The algae provide substrate to which the bioflocs attach, and are usually referred to as green bioflocs.

2. Not exposed to light:

Biofloc systems (raceways and tanks) are installed in closed buildings with no exposure to natural light. These systems are operated as "brown- water" biofloc systems, where only bacterial processes control the water quality.

Measurement of Biofloc

The floc volume is measured using Imhoff cone. In the Imhoff cone, one lite of the water is taken from the Biofloc system and left undisturbed for 15-20 minutes for settling. The volume of the total suspended solidis noted. Flocs in a typical green water biofloc system are rather large, around 50 to 200 microns, and will settle easily in calm water. Large bioflocs can be seen with the naked eye, but most are microscopic. Ideal Volume of Floc in Imhoff cone for shrimp is 10-15 ml/L and for Fish 25-35 ml/L. When the floc volume becomes more than required, some of the water along with flocs is drained out and the same amount of water is replaced in the system. In large culture systems, a central drainage is provided to remove the extra sludge from the system

Biofloc as a feed Ingredient

Biofloc contains 12 – 50% protein, 0.5 – 15% lipids 14 – 59% carbohydrates and 3 - 61% ash (Azim & Little, 2008). Nutritional composition of biofloc differs according to environmental condition, carbon source applied, TSS level, salinity, stocking density, light intensity, phytoplankton and bacteria communities and ratio, etc.It contains proteins, lipids, minerals, vitamins, amino acids, and fatty acids as well as enzymes, immunostimulants and probiotics (Md.E. Hosain*et al*.,2021). Kuhn *et al*. (2009) reported that microbial floc incorporated fish diet enhanced that mean growth up to 65%, when compared with the control diets. The microbial protein, aggregated in microbial flocs serves as a rich source of amino acids and growth factors for fish and shrimp, leading to significant recycling of protein and higher utilization of feed (Avnimelech et al., 1994; Chamberlain et al., 2001; Tacon et al., 2002).Azim and Little (2008) found that the BFT treatment contributed 44-46% greater individual weight gain and net fish production than those in the control. Emerenciano *et al.*(2012) investigated the influence of BFT as a food source in a limited water exchange nursery system on the growth performance of pink shrimp (Farfantepenaeusbrasiliensis) post-larvae. The authors reported that rearing post-larvae in the BFT system without commercial food supply did not affect the growth performance of the animals. Moreover, no significant differences in final biomass and weight gain were noted between shrimp reared in BFT with or without commercial diet supplementation. The good growth performance of the larvae was attributed to the diverse microbial community that

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consisted of protozoa grazers, rotifers, cyanobacteria, and diatoms, which were utilized as a food source. In another study, Emerenciano et al., Avnimelech and Kochba, 2009 found that tilapia can uptake 240 mg N kg−1 of biofloc, which is equivalent to 25% of the protein in fish diets. It is worth noting that the nutritional value of bioflocs is highly dependent on the microbial community that encompasses it and, as mentioned in the previous section, certain factors such as carbon sources and C/N ratio influence the biochemical composition of bioflocs.Table. 1 shows the proximate composition of Biofloc in different studies.

Table 1. Proximate composition of Biofloc reported in various studies

Crude Protein(%)	Carbohydrate (%)	Lipids (%)	Crude Fibre(%)	Ash (%)	Reference
43.0	-	12.5	-	26.5	McIntosh et al.,2000
31.2	-	2.6	-	28.2	Tacon et al.,2002
12.0 - 42.0	-	2.0 - 8.0	-	22.0 - 46.0	Soares et al.,2004
31.1	23.6	0.5	-	44.8	Wasielesky Jr et al.,2006
26.0 - 41.9	-	1.2 - 2.3	-	18.3 - 40.7	Ju et al.,2008
30.4		1.9	12.4	38.9	Ju et al.,2008
49.0	36.4	1.13	12.6	13.4	Kuhn et al., 2009
38.8	25.3	<0.1	16.2	24.7	Kuhn et al., 2010
28.8 - 43.1	-	2.1 - 3.6	8.7 - 10.4	22.1 - 42.9	Maicá et al.,2012
30.4	29.1	0.5	0.8	39.2	Emerenciano et al.,2012
18.2-29.3	22.8-29.9	0.4-0.7	1.5-3.5	43.7-51.8	Emerenciano et al.,2012
18.4-26.3	20.2-35.7	0.3-0.7	2.1-3.4	34.5-41.5	Emerenciano et al.,2013
28.0-30.4	18.1-22.7	0.5-0.6	3.1-3.2	35.8-39.6	Emerenciano et al.,2012

Biofloc Meal

Biofloc meal is a concentrated, dewatered and dried form of biofloc harvested from the system. Harvesting biofloc would be a costly process, which may add cost to the

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product. It needs to be simplified in an economical way. Collected in tanks/ponds or produced in bioreactors biofloc is a raw material to produce "biofloc meal". In bioreactors, biofloc production can clean up effluent waters from aquaculture facilities, converting dissolved nutrients into single-cell protein. Harvesting biofloc would be a costly process, which may add cost to the product. It needs to be simplified in an economical way. Biofloc meal is highly nutritious which can be added to the feed as a feed ingredient or can directly be fed to the fishes. The cost pf fish meal is increasing day by day and its increase demand leads to pressure on overfishing. Biofloc meal can be used to replace fish meal as an ingredient in feed.

Biofloc and fish health

- **Improves Fish health-**Various studies have proved that biofloc improves the health status of the fish and it also has probiotic effect on the fish health. Biofloc systems positively affected immune parameters as well as growth performance in common carp (A. Azimi et al.,2022)
- **Lowers FCR-**As the cultured animals consume biofloc as feed, the feed requirement from outside is reduced and thus feed conversion ratio is also lowered. It results in the increase in the feed margin.
- **Improves digestion** -Finger millet based BFT positively influences the water quality and the metabolic growth response of *P. hypophthalmus*catfish (P. Nageswari et al.,2022).
- **Imparts probiotic effect -**Beneficial micro-floras enveloped in the system helps to prevent colonization of pathogenic bacteria and improve animal health through the induction of the immune system (Panigrahi et al., 2014).
- **Increases survivility-** In biofloc based system the preferred fingerling (7-8cm with 4-5 g size) size of *Chanoschanos*was attained after 30 days with 80% of survival whereas it took around 45 days in the clear water culture system and the survival was 52%. The net profit generated in biofloc system was higher than clear water. (Sontakke and Haridas, 2018).
- **Improves immunity against disease causing pathogens-**Bio-flocs can act as a natural probiotic which could act internally and/or externally against, Vibrio sp. and ectoparasites (Panigrahi et al.,2014).

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Status: National & International

Commercially in 1988,Sopomer farm in Tahiti (French Polynesia) using BFT in 1000m² concrete tanks and limited water exchange achieved a world record in production (20–25 ton/ha/year with two crops). BFT have been successfully expanded in large-scale shrimp farming in Asia, Latin and Central America, as well as in small-scale greenhouses in USA, South Korea, Brazil, Italy, China and other countries. In India BFT culture is emerging as a sustainable and high profit-making business among the people. In India institutes like CIBA and TNFU have recognized the potential of this technology and its environmental benefits and projects are going on to further standardizing a set pattern; so that the farmers can adopt this in nursery and grow-out production practices. Some farmers are successfully culturing fish and shrimp in various states like TamilNadu, Andhra Pradesh, Kerala, Maharashtra, Bihar, Odisha etc.

Government Schemes

To encourage the farmers to adopt new technologies, government is providing subsidies under various schemes to the farmers. Biofloc has been identified one such new technology which has the potential to give production and income generation. To promote high yielding intensive fish farming in small area and encourage farmers and unemployed youth to income earning through biofloc system, National Fisheries Development Board (NFDB) is providing subsidy for biofloc fish farming (60% subsidy for SC/ST/Women & 40% for general category). Under Pradhan Mantri MatsyaSampada Yojana (PMMSY) 3 models (Large unit, medium unit & small unit) are included with input cost 50 lakh,25 lakh and 7.5 lakh respectively. The scheme also gives a subsidy of 60% subsidy for SC/ST/Women & 40% for the general category.The state govt of Odisha has introduced a scheme to promote fish culture through biofloc technology which provides 60% subsidy for SC/ST/Women & 40% for the general category.

Stocking of Fin Fish and Shell fishes

BFT technology has been widely adapted with Tilapia production in aquaculture, which is suitable for high-density culture of species like *P.vannamei* which are effective at utilizing natural productivity in the biofloc based culture system. Other penaeid shrimp species like P. monodon, P. stylirostris and Macrobrachium sp. may not be suitable for the purpose, at high density.

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Species suitable for culture in Biofloc:

- **Air breathing fishes:** Singhi (*Heteropneustesfossilis*), Magur (*Clariasbatrachus*), Pabda (*Ompokpabda*), Anabas/Koi (*Anabas testudineus*), Pangasius (*Pangasianodanhypophthalmus*)
- **Non air-breathing fishes**: Tilapia (*Oreochromis niloticus*), Common Carp (*Cyprinus carpio*), Rohu (*Labeorohita*), Milkfish (*Chanoschanos*)
- **Shellfishes**:Vannamei (*Litopenaeusvannamei*) and Tiger Shrimp (*Penaeus monodon)*

Shrimp culture in Biofloc

It is possible, to produce 1.0 kg of shrimp in just over 100 liters of water in a biofloc system, while traditional systems use about 64,000 litters (Otoshi et al., 2007). Shrimp culture in biofloc systems is practiced in 0.5 to 1.5 ha pond lined with plastic HDPE. Shrimp are stocked at high density (125 to 150 PL10 per m^2). After 90 to 120 days, yields of, 15 to 20 metric tons/ha are harvested. Intensive lined raceways in standard greenhouse with dimension 100 feet long × 25 feet wide are also being used for shrimp culture using biofloc technology. Shrimp (SPF) juveniles are stocked at 300 to 500 PL per m ^{2}(up to 750 to 1,000 PL per m^2) in BFT systems. Yields of 3 to 7 kg/m^2 are typical, with yields of 10 kg/m^2possible with pure oxygen supplementation.

Tilapia culture in Biofloc

Biofloc systems that are exposed to natural light include outdoor, lined ponds or tanks are used for the culture of tilapia. In this system, a complex mixture of algal and bacterial processes help to control the water quality and hence these systems are also known as the "green-water" biofloc systems due to the green discoloration of the water by the algae community. In BFT using Tilapia, 15N has shown that flocs supplied about 50% of fish protein requirement (Avnimelech). HighBiomass around 20-30 kg/m3 can be achieved from BFT using Tilapia as the cultured species. Tilapia may consume biofloc accounting for up to 50% of the regular feed ration (assuming daily feeding of 2% body weight). It would seem to be a good species to integrate with shrimp in a biofloc system, owing to its capacity to consume biofloc, as well as its hardiness and salt-tolerance (El-Sayed, 2006, Avnimelech, 2006).In a BFT treatment, tilapia are able to efficiently utilize single-cell microbial protein

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produced through TAN in the heterotrophic bacterial community. These characteristics of tilapia favor them to be suitable fish species that can be cultured using BFT.

IMC culture in Biofloc

BFT was applied to culture Labeorohita (monoculture) and the results demonstrate excellent growth rate with net fish yield of 1912 ± 16.4 kg/ha, with zero mortality during a culture span of 90 days (Mahanand et al., 2013).Therefore, biofloc containing 30-35 % crude protein is suitable for carp culture (De Silva and Anderson, 1995; Emerenciano et al. 2012; Deb et al. 2017). Some recent studies confirmed enhanced immunity of rohu and oxidative status and resistance to acute crowding stress in common carp cultured in BFT (Adineh et al., 2019; Kamilya et al. 2017). Due to suitable FCR, feed utilization and minimum nutrient load, biofloc based IMC culture reported to be sustainable and economical (Sarker et al. 2019).Stocking density of rohu, catla, and mrigal: 1.42, 2.85 and 4.28 fish/m3 (Insitu Biofloc). When various carp species with different feeding habits were compared, the bottom feeder mirror carp (Cyprinus carpio) had no growth improvement when cultured using BFT, but the filter feeding carps, that included silver carp (Hypophthalmichthys molitrix) and bighead carp (Aristichtys nobilis) had substantially improved growth in the same system (Zhao et al., 2014).

Cat Fish culture in Biofloc

Several studies have shown that African catfish grow well in BFT aquaculture systems (Yusuf *etal.*, 2015; Hapsari, 2016). The application of biofloc technology at a density of 8 fish/L could be recommended to increase the production and profitability of African catfish nursery culture (Fauji et al., 2018).African catfish broodstock (5fish/m^2) in biofloc systems significantly affected the embryonic development rate and the larval quality. Improvements in survival and growth were observed in the larvae housed in biofloc systems (Ekasari et al., 2016).Tolerances to elevated nitrogenous waste are highly species specific, and although African catfish (*Clarias gariepinus*) are robust to water quality deteriorations (Ip et al., 2005), they are reportedly less efficient collectors and consumers of bioflocs (Dauda et al., 2017, 2018).

Economics of Biofloc

In any technology, the economics is of utmost importance. For the farmers to adopt any technology, it should be economically profitable. The economics of biofloc technology

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using Tilapia as the cultured animal is as follows which includes the cost details using seven tanks in an area of 200 m². The project details, cost estimation and economic feasibility is given in Table.2 ,3 and 4 respectively.

Table 2. Project details of Biofloc using Tilapia in 7 tanks

Component	Details
Area for 7 tanks	200 m²
Biofloc Tank size	4 metre diameter and 1.5-meter height (1.20 m water depth)
Water holding capacity of each tank	15,000 Litres capacity
Water quality parameters	Dissolved Oxygen-5mg/L, Temparature-26-34°C, pH-7.5 to 8, TDS-600ppm, Floc density-25-40 mg/l, Ammonia-0.5 ppm, Nitrite-0.3 ppm, Nitrate-150ppm, Alkalinity-120-280 ppm
Tanks Made-up of	Tarpaulin/Fibre/HDPE
Stocking density	100 nos/m³ (1000 no.s per 15,000 litres tank -depending on species)
Species cultured	GIFT Tilapia (*Oreochromis niloticus*)
Survival (%)	80
Type of feed to be used	floating pellet feed
% of feed	2-3% per Average Body weight
Feeding frequency	4 times early stage, later 2 times per day
FCR	1:1.2
Duration of culture	6 months
Size/weight of the species(gm)	500 gm average weight
No. of crops per year	2
Production	4.2 Tonnes per crop (600kg per tank per crop)
Farm gate price (Rs)	130/- kg fish
Capital cost	6.00 Lakhs
Input cost	1.5 lakhs per one crop

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Total project cost	7.5 lakh

Table 3. Cost Estimates of Biofloc Unit with 7 Tanks

Sl.No	Component	Nos	Cost (Rs)	Total (Rsinlakhs)
Capital cost				
1	Set up of Tarpaulin/Fibre tanks (15,000Litres capacity)	7	25,000	1.75
2	Shed material and accessories Fixing charges	200 m^2	120000	1.20
3	Water supply bore well (3HP)	1	100000	1.00
4	PVC pipe fittings for air, water Flow	LS	75000	0.75
5	Nets and accessories	5	3000	0.15
6	One Blower (1HP),Air stones and other accessories	1	30000	0.30
7	Electrification	LS	10000	0.10
8	Power generator (2KVA)	1	45000	0.45
9	Weighing balance	2	5000	0.10
10	Miscellaneous expenses			0.20
Total Capital Cost				**6.00**
***Input cost for one crop**				
11	Seedcost, Feed cost, Probiotics, Testkits etc.			1.50
Total Input cost (perone crop)				**1.50**
Grand Total				**7.50**

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Table 4. Economic feasibility (one crop) from7Tanks

Sl. No	Components	Amount (Rs in lakhs)
1	Capital Cost	6.00
2	Operational Cost	1.50
3	Total project Cost	7.50
4	Gross income per crop	5.46
5	Gross income at the end of one crop after deducting the recurring cost for the second crop	3.96
6	Gross income from the second crop	5.46
7	Gross income at the end of second crop	9.42
8	Depreciation / maintenance@15% of capital cost	0.975
9	Interest @ 12 % of TPC	0.90
10	Repayment @ 1/7 of the TPC	1.07
11	Recurring cost for the next crop	1.50
12	Net profit at the end of second crop 9.42-(0.975+0.9+1.07+1.50)	4.975

SWOT Analysis

S-Strength

- **Negligible or zero water exchange-**

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Water quality management is done by the bacteria which convert the waste material into microbial protein, thus producing protein out of waste and reducing the water requirement very significantly.

- **Increased bio security: -** Due to lower water exchange, the risk of disease transfer is less and bacteria also have proven to impart some probiotic effect thus enhancing biosecurity in the culture system.
- **Reduced feed requirement: -** As the floc protein contributes significantly as a feed to the fishes, the feed requirement is reduced which reduces the feed cost.
- **Environmentally friendly: -** The nitrogen waste from the system is efficiently converted into protein thus, helps in water conservation as well as waste management in the system.
- **Higher production potential: -** As high stocking density can be maintained in the system and continuous aeration is provided, the production per volume of water increases.
- **Less land requirement: -** Land requirement is very less as compared to the traditional culture systems in case of Biofloc and hence can be developed in backyard and in urban areas.
- **Imparts positive health benefits to fishes: -** It has been seen in various studies that fishes cultured in Biofloc systems have increased immunity, higher growth rate, better feed utilization etc.

W-Weakness

- **Continuous energy requirement:** - There is a need of constant aeration in the system and hence 24*7 power supply is required. The power cost is very high thus increasing the total operational cost of the culture system.
- **Technical labour requirement: -** The person managing the system needs to be highly skilled and should know the technical know hows and should have scientific knowledge to understand the carbon nitrogen dynamics and its management.
- **Higher initial set up cost:-**The initial set up cost is very high as it includes setting up aeration system, power back up system and other tank infrastructures.
- **Increased aeration cost:-**There is a requirement of continuous and vigorous aeration to keep the flocs suspended. Hence the cost of aeration adds up to increase the total operation cost.

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- **Pond lining required: -** For outdoor Biofloc systems, pond lining is a must which again adds to the initial set up cost of the system.
- **Needs warm up time for floc development: -** A start up or warm up period of around one month is required to develop the floc in the system which reduces the total culture period.
- **Needs continuous water management: -** The water quality parameters specifically ammonia and nitrite levels have to be regularly checked and depending on their levels, carbon sources need to be added to the system.

O-Opportunity

- **Reduction of unemployment:-**The increasing unemployment problem of the youth can be reduced by adopting fish culture using Biofloc technology as an employment opportunity. It has great potential of high profit generation using less resource.
- **Can be developed with limited land or in backyard:-** As the land requirement is very low, Biofloc tanks can be set up in backyards and also in urban areas to cater domestic demands.
- **Higher production potential: -** As high stocking density can be maintained in the system and continuous aeration is provided, the production per volume of water increases.
- **High profit margin: -** As higher production can be achieved from less area, higher profit can be made using biofloc technology.

T-Threat

- **Risk of failure in case of power failure:-** If power fails at any point of time, there is chance of the whole system to crash within some hours.
- **Accredited trainers are very less: -** Many people are claiming themselves to be experts in Biofloc technology. As this technology needs prior training of the farmers, government must accredit trainers.

Researchable Issues

Biofloc technology is in a nascent stage in India. There are a lot of problems which needs to be researched upon .Some of the problems are as follows:

- Artificial intelligence and sensor-based control needs to be developed
- Brood stock rearing in biofloc systems for different species needs to be studied.

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- Improvement of floc nutritional value (i.e., using different carbon sources or a mixture of phytoplankton and bacteria) needs further investigations.
- Elucidating the mode of action of the microbial interventions through bioremedial and ecological approach.
- Nutritional characterization of different types of bio-floc and optimization of their inclusion in feeds. Scaling up for bio-floc and mass scale production for further application as feed ingredient.
- Customized biofloc preparations (with inoculums of defined probiotics and algae), modulating the bio-floc yield by C: N ratio manipulation and their evaluation for host performance is a matter of further research.
- Molecular and biochemical characterization of microorganisms (quorum sensing), constituent of biofloc including heterotrophic-autotrophic organism through community approach.

Conclusion

BFT is a sustainable and more environmentally friendly food production system characterized by zero water exchange and intensive culture of aquatic species. This technology permits the utilization of bioflocs as a nutritious feed source, hence lowering feeding and production costs as well as dependency on fishmeal. Bioflocs also stimulate the immune system of the animals, thus lowering the risk of pathogen-associated disease outbreaks in the system. Several studies have indicated that probiotic addition in BFT systems and/or their dietary administration improves the immunity of cultured fishes and crustaceans. Despite the increasing popularity of BFT systems, more research is needed to optimize the operational parameters (such as energy needs) with lower costs of production for the system in order to ensure that they are acceptable and feasible for small-scale farmers and those from developing countries**.** It can help to reduce higher unemployment among the youth and help to fulfil the protein requirement of the rising population.

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