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An Optimistic Aid in Improving Aquaculture Production: Biofloc Technology

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ABSTRACT: In the rapidly urbanizing world, there is growing realization to increase aquaculture productivity for food and nutritional security. In an attempt to preserve the natural resources and environment, the expansion must take place in a sustainable manner. Biofloc technology is a prudent aquaculture tool for boosting water quality, enhancing feed utilization and mitigates external pathogens. It has been marked as a novel "blue revolution" since the nutrients in the culture is recycled and reused continuously with zero or minimum water exchange, which facilitates a high stocking density and increased fish productivity in aquaculture system. Biofloc, a macro-aggregation of various bacteria, algae, detritus and other microorganisms converts the toxic nitrogenous compounds into useful and proteinaceous microbes also called as Single cell protein (SCP) serving as a feed supplement to the cultured organisms. It stimulates the development of aerobic and heterotrophic bacteria in the presence of carbon and constant aeration in the environment. Microorganisms play a major role in natural aquatic resources, and the intensity of solar energy, organic matter density and added carbon sources affect their activity. Hence, an optimal C: N ratio is essential to improve production and recycling of nutrients. However, there is a need to develop techniques for the monitoring of floc characteristics and its composition. Optimization of the nutritional quality of the floc, identification of beneficial micro-organisms and integration of biofloc technology in the existing system required to be fulfilled for a prominent result. With the proper monitoring of the biofloc system, the implementation of this technology may proves handy to the fish/shrimp farmers.

Keywords: Biofloc, water quality, microorganism, aquaculture, environmental friendly.

I. INTRODUCTION

Aquaculture and fisheries production is at an all-time high record, and plays an crucial role in the future endeavoring passable opportunities to alleviate poverty, hunger and malnutrition, as well as generating high economic growth and safeguarding its natural resources for future generations. According to FAO (2022), 214 million tonnes of fisheries and aquaculture were produced in 2020, with 178 million tonnes of aquatic animals and 36 million tonnes of algae. The growth in aquaculture, particularly in Asia, greatly contributed to this record level of production. With a population statistics of almost eight billion, the urging for aquatic food increases rapidly and thereupon, expansion and intensification of aquaculture are highly requisite. But, the development of the aquaculture industry is challenged by the limited natural resources and the negative impact of the industry on the environment [16; 61].

Aquaculture industry has been found to be liable as an unsustainable activity because of the harmful discharges released into the environment which have a high amount of organic matter, nitrogenous waste, toxic metabolites and an enhanced COD and BOD. Furthermore, the industry has to persistently face other problems such as non-availability of the required infrastructure, ingredient and their high prices. As a result of these limitations, the development of sustainable aquaculture should emphasize conceptualizing systems that uses fewer resources, including water, space, energy, and ultimately capital, while at the same time minimizing their negative impact on the environment [3]. Such a system would provide a neutral cost benefit ratio to sustain social and economics of the aquaculture industry [6]. All the above imperative preconditions for sustaining development of aquaculture can be fulfilled by Biofloc Technology.

II. BIOFLOC TECHNOLOGY

Biofloc Technology has achieved great success recently as an environmentally advantageous, cost effective and sustainable aquaculture technique which improves water quality in addition to production of microbes (Figure 1).The technology deals with the flocculation principle in which heterotrophic bacteria and algae are co-cultured. Maintaining in-situ high level of microbial bacterial floc using constant aeration and incorporation of carbon source allows the aerobic decomposition of the organic material [5], thus converting the uneaten feeds, feaces and extra nutrients into edible bioflocs also called Single cell Protein (SCP).In accordance with a known C/N ratio of 12-20:1 and constant aerations, development of dense microorganism (basically heterotrophic microbes) occurs, hereby the microbes uptake the ammonical waste for naïve biomass production. Heterotrophic bacteria are more efficient at absorbing nitrogen compounds than denitrifying bacteria, thus growing faster and producing more biomass per unit substrate. Therefore, if organic carbon source is sufficient, ammonia is usually immobilized rapidly within hours or days in bioflocs by heterotrophic bacteria [31]. Consequently, ammonical waste concentration can be managed at low and non-toxic level so that water replacement is no longer needed.

It is important to note that nitrification [23], phototrophic nitrogen uptake [28] and denitrification [33] are all nitrogen conversion mechanisms facilitated by the biofloc system (depending on the prevailing environmental conditions), in addition to heterotrophic bacteria being the primary nitrogen conversion agent. Moreover, protein and lipid rich biofloc is available all the time to the culture fish/shrimp due to association of organic matter, physical components and high extent of microorganism. In addition, Biofloc due to its limited water exchange, provides a safer environmental system by creating a biological and physical barrier against the pathogen and improves immune system of the fishes cultured. Hence, the microorganisms are accounted for (i) enhancing water quality by uptake of nitrogenous compounds producing microbial protein; (ii) increasing culture potentiality by reducing FCR and decreasing feed costs (iii) biosecurity. Biofloc technology can be marked as a novel “blue revolution” since the nutrients in the culture is recycled and reused continuously with zero or minimum water exchange, which also facilitates a high stocking density and increased fish productivity in aquaculture system. It is imperative to note that the high production of fish/shrimp in Biofloc tank in a small area has outshined its sustainable approach. As a result of these attributes, BFT is economically attractive to aqua-preneurs [6].

Luo *et al*. (2014) [43] concluded that biofloc based Tilapia culture system consumes 40% less water than that of RAS. Brito *et al*. (2016) [11] and Bossier and Eksari (2017) [10] reported that biofloc culture can facilitate elimination of ammonia nitrogen (TAN) and nitrite, lessens utilization of water and waste generation, enhances feed utility and increase body-bound crude protein. Comparing biofloc systems with non-biofloc systems like conventional and recirculating aquaculture, Ekasari (2014) [23] reported that biofloc systems increase net productivity by 8–43%.Futhermore, studies conducted by [39] and [35] confirmed that microbial biofloc enhances the growth performance of the system by maintaining quality of water.

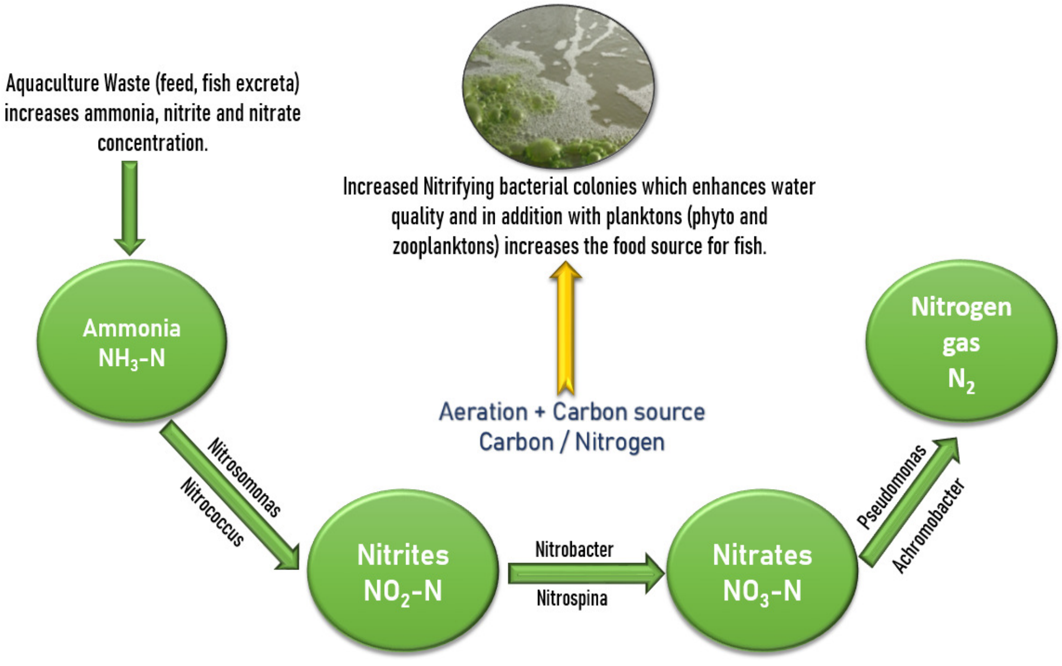

Fig. 1. Biofloc Technology Process.

Ju *et al*. (2008) assessed the growth effect of shrimp in biofloc and concluded that health status of the culture shrimps was boosted by the presence of bioactive compounds present in the biofloc culture. By improving the reproductive function of aquaculture animals and enhancing the immunity and robustness of larvae, Biofloc technology may also help to supply good quality seeds (26, 27, 28].

III. BIOFLOC FORMATION AND ITS FLOCCULATION PROCESS

Biofloc is a conglomeric aggregation of microbial communities such as phytoplankton, bacteria, diatoms, filamentous algae, protozoa, micro or marco invertebrates, aquatic waste and leftover feed. The biofloc forms the basis of the food chain in aquatic ecosystem by converting to SCP. Therefore, biofloc initiates nutrient cycling process in aquatic ecosystem. There are several characteristics of flocs, including irregular shapes, a large size distribution, fineness, ease of compression, porosity (up to more than 99%) and fluid permeability [15]. For determining the floc shape factors and porosity measurements, the most successful methods were proven to be photography and microscopy (Fig. 2).

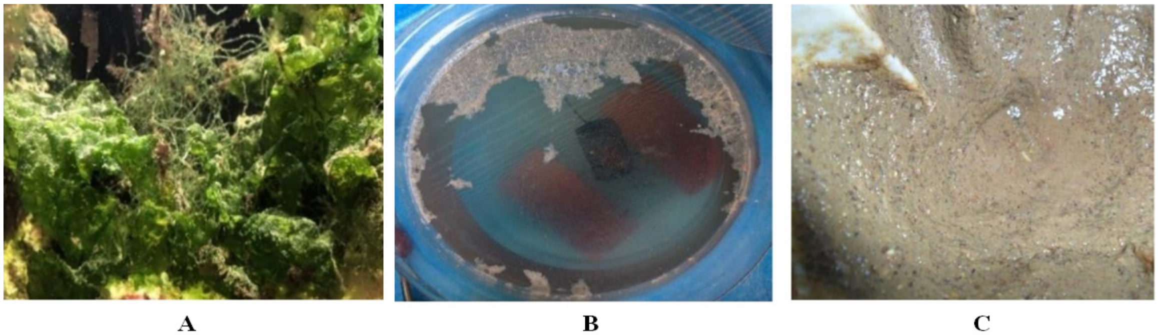

Fig. 2. Various forms of Bioflocs. (A): Amalgmation of biofloc, detritus and algae; (B): Biofloc (white foams) in plastic tub; (C): Aerobic biofloc mass.

As a part of creating biofloc, firstly the tanks should be filled with water following the addition of a specific amount of aquatic feed or urea fertilizer as source of nitrogen and for the purpose of supplying carbon source, organic material such as molasses, wheat flour, sugar, sugar or tapioca flour can be added. Usually, biofloc starts to colonize soon after the organic waste starts to accumulate. Through a complex flocculation process controlled physically, chemically and biologically the microbial cell starts to form floc matrix [21]. After softening and passing through the sieve, clay is added to the microbial reservoir to assist in the formation of microbial mass. One liter of water can be stimulated to form biofloc by making an inoculum of 20 grams of clay, 10 milligrams of ammonium sulfate, and 200 milligrams of carbonaceous organic matter such as molasses. It has been demonstrated in a number of studies that using clay and water as the primary inoculum improves microbial mass formation in a biofloc production cycle [64]. National Fisheries Development Board, Department of Fisheries Government of India has called biofloc system as active suspension ponds or heterotrophic ponds or even green soup ponds and even specified the preparation of inoculum. For the floc development in 15000 litres of fresh water, 150 litre of inoculum is required. The two methods of inoculum preparation is depicted in Fig. 3. Furthermore, a regular addition of carbon source is required to maintain the development of biolfoc. For every 1 Kg of feed given, carbon source of 600 gm should be added to maintain a C: N of 10:1 or as per the requirement. When the floc volume reaches 15-20 ml, carbon source should not be added further.

After the system is fully equipped with its necessities, aeration is provided to magnify the bacterial activity. In the presence of carbonated organic matter, the activity of heterotrophic bacteria is much greater than any bacteria and tends to remove N and C from water by absorption producing microbial mass, as well as other organisms present in the environment adhere to them feeding on the microbial biomass and form biofloc [38]. Following the biofloc development period, firstly algae appears and then foam forms, and ultimately, appearance of the brownish matter stipulate the existence and activity of heterotrophic bacteria. The microbial mass's appearance, stability, and formation are influenced by multiple mechanisms. The presence of polymeric components of polysaccharides, humic and proteins on the outer surface are repelled by many organisms. In contrast these viscous polymeric substance functions as an adhesive to amalgamate various cells and particle to form a biofloc. The equilibrium between the electrostatic repulsive force and the gravitational force is another mechanism determining biofloc formation. A majority of organisms are negatively charged, so they create a counter repulsive force making it strenuous to develop the floc. Ions like calcium and aluminium vivify a stable floc formation and aids in binding algae, fungi or bacterial organism to bond between the components of various flocs [21, 6].

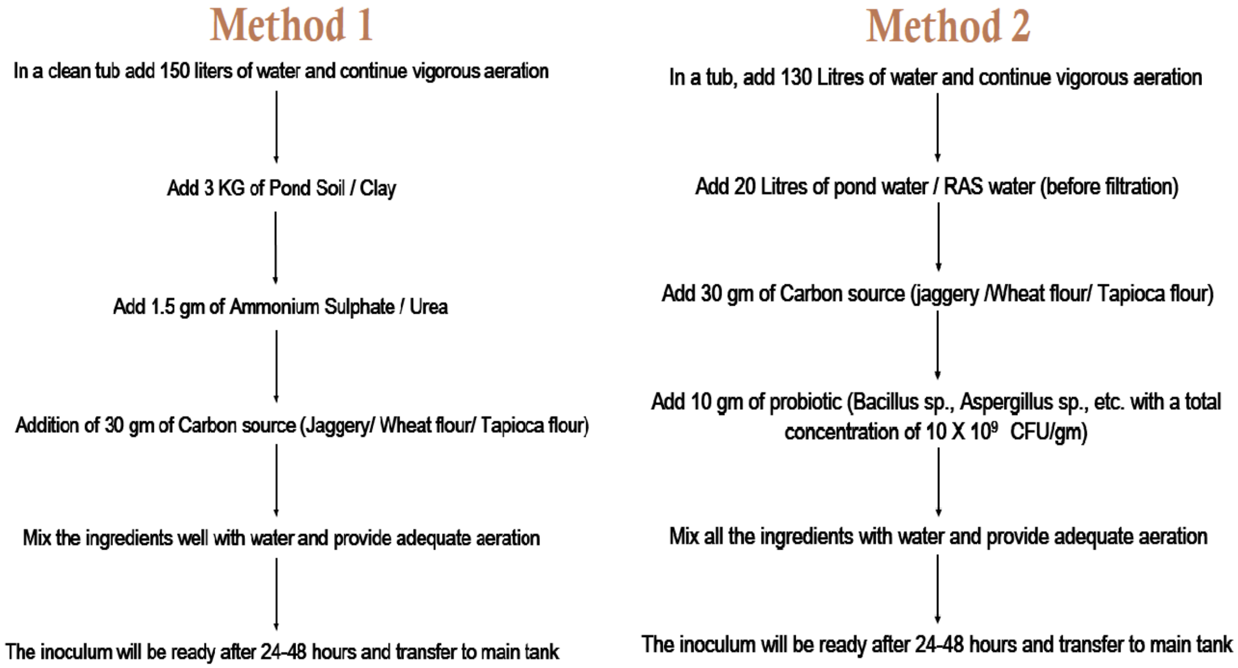

Fig. 3. Different methods of preparation of inoculum for biofloc technology by NFDB.

Frequent groups of microorganism like fungi, rotifer, copepod, ciliate, protozoa and nematode has a great influence on floc formation and plays an imperative role in recycling of organic matter in Biofloc Technology system. High porosity biolfoc suspends in water thus reducing its sedimentation rate [6].

IV. C/N RATIO AND DIFFERENT TYPES OF CARBON SOURCES

To maintain a necessary Carbon to nitrogen ratio is obligatory for producing microbial communities and controlling nitrogen toxicity in the biofloc tanks [2, 28]. The conversion of nitrogenous wastes into useful single cell protein (bacterial cells) act as a direct source of food for the cultured fishes/ shrimps. At the beginning of the culture cycling, attainability of sufficient carbon is ensured avoiding the harmful ammonia from ranging high. The presence of carbon activated the heterotrophic bacteria to multiple and assimilate ammonia nitrogen in the water, thus compensating its concentration. However, maintaining the C/N ratio is the most demanding task for a successful buildup of biofloc system. It has been reported that changing the C/N ratio can significantly alter the diversity and community of heterotrophic bacteria in the water [51]. Heterotrophic bacteria strives against the autotrophic bacteria for space and dissolved oxygen and thrive best in a high C/N ratio environment. In contrast, autotrophic bacteria thrive well in a low C/N ratio environment [46]. Kuhn *et al.* (2019) [41] observed that removal rate of Total ammonia nitrogen (TAN) increased by 26% / hour after carbon supplement was added as compared to 1%/ hour in control. Various researchers have conducted their work to report the most promising C/N ratio to boost the biofloc formation and ultimately increases the yield of the culture season. Lancelot and Billen, 1985 [42] reported that a C/N ratio higher than 10 is must for the immobilization of the nitrogenous compounds. Similarly, [12] and [52] also reported C:N ratio must be above 10:1 to have an optimum growth. However, according to [55], the finest C: N ratio is approximately 15:1. Similar result was also obtained by [51], indicating the C/N ratio of 15:1 was optimal for improved survival, growth and immune activity of Pacific white shrimp *Litopenaeus vannamei* in a biofloc-based rearing system. Study by [62] demonstrated the C: N ratio ranging from 14:1 to 30:1 was ideal for microbial floc with prevalence of heterotrophic bacteria. A biofloc system with C/N 19:1 showed improved water quality and growth performance of common carp while not negatively affecting its carcass analysis [47].

Studies have been motivated by the urgent need to find the best source for biofloc technology. The Biofloc technology can be achieved by using various types of organic carbon sources such as molasses, glycerol, sugar, sugarcane bagasse, tapioca flour, wheat flour, rice flour, corn starch, jaggery etc. (Fig. 4). While choosing the best carbon source, local availability, cost, biodegradability and efficient bacterial assimilation should be taken into consideration [54]. Silva *et al.* (2017) [56] attempted to evaluate the effect different carbon source on Nile tilapia reared in a biofloc system. Circular fiberglass biofloc tanks were prepared and molasses, sugar and cassava starch were used as the carbon source with a C/N ratio of 10:1 and 20:1 for each treatment. The result of the study concluded that the growth performance of Nile tilapia in Biofloc System fertilized with various carbon source was not significantly different ($P<0.05$) between treatments. The study also suggested that molasses used to fertilize the biofloc system helps to reduce the production costs in regions where the product is easily available. However, in countries like India where the usage of molasses is legally restricted due to illegal arrack fermentation of molasses, jaggery satisfies all the consideration as the new carbon source due to its low cost and easily availability. The effect of different carbon sources *i.e.* sugarbeet molasses, sugar and corn starch for biolfoc system was carried out for 10 weeks feeding trial on common carp (*Cyprinus carpio* L.) culture. The study suggested that microbial floc formed in corn starch based biofloc improves common carp growth performance [8]. Table 1 represents the different studies carried out using different carbon source on different aquatic species.

(A) Molasses **(B) Jaggery** **(C) Wheat Flour**

(D) Sugar **(E) Tapioca Flour** **(F) Sugarcane bagasse**

Fig. 4. Different types of Carbon source used in Biofloc technology.

Table 1: Studies conducted on various species using different carbon source in BFT.

Carbon Source	**Experimental species**	**Reference**
Glucose	*M. rosenbergii*	Crab *et al.* (2010) [18]
Wheat flour + molasses	*Oreochromis niloticus*	Mirzakhani *et al.* (2019) [48]
Starch	*L. vannamei* & *M. rosenbergii*	Asaduzzaman *et al.* (2008) [2]
Wheat flour	*Oreochromis niloticus*	Avnimelech (2009) [6]
Dextrose	*Litopenaeus vannamei*	Suita (2009) [58]
Molasses	*L. vannamei* & *P. monodon*	Burford *et al.* (2004) [13]
Glycerol	*Oreochromis niloticus*	Kishawy *et al.* (2020) [40]

V. MICROBIAL COMMUNITY IN BIOFLOC

The two main category of bacteria principally responsible for maintaining water quality are chemoautotrophic nitrifying and heterotrophic ammonia-assimilative bacteria [31, 22]. Biofloc consists about 60-70% of organic matter, 30-40% inorganic substance such as colloids, polymers, ions, salt etc. and heterogeneous combination of microorganisms like algae, fungi, bacteria, rotifers, ciliates, nematodes, protozans. The transition from algal to bacterial community can be observed by the appearance of biofloc which changes from green to brown during its formation. The number and types of bacterial community produced in biofloc tanks/ponds vary greatly. Avnimelech, (2007) [4] suggested that the bacterial number can be 10^6 to 10^9 colonies/ml with each ml of biofloc contains 10-30 mg of dry matter. Heterotrophic bacteria number 3.36 × 10^7/ml in the biofloc represents its maturation [36, 37]. Ju *et al.* (2008) [34] estimated that collected biofloc collected from tanks rearing Pacific white shrimp consist of 3% biomass of bacteria (both Gram +ve and –ve bacteria), 24.6% of phytoplankton (*Navicula*, *Thalassiosira* and *Chaetoceros*), few protozoans communities (0.5% amoeba, 11.5% rotifer and 98% flagellates), 39.25% ash and 32.2% detritus. Another study by Yunos *et al.* (2017) [63] also reported the structural composition of biolfoc containing 12% zooplankton, 24% fungi, 29% microalgae and 34% bacteria. The predominant bacterial species found in the biofloc includes *Bacillus*, *Actinobacteria* and *Proteobacteria*, additionally, some minor sources includes the genus *Roseobacter* and *Cytophaga* [65]. For the identification of the bacterial colonies, method like DPC can be employed. Monroy-Dosta *et al.* (2013) [49] identified seven genera of ciliates and *Vorticella* and *Epystilis* were two of them. Moreover, rotifers from the *Philodina*, *Lecane* and *Keratella* genera were also detected. Microorganism is imperative to natural aquatic resources, and the presence of organic matter, solar intensity and added carbon source affects their activity. And in the biofloc system, the microbial community is dependent upon organic matter and a strong aeration to maintained C: N ratio [53].

VI. NUTRITIONAL VALUE OF BIOFLOC

Biofloc is considered a complete aquatic food source as it possesses robust nutritional value [25] and also supplies bioactive compounds [1]. Biofloc's particle size, biochemical composition and digestibility decides its nutritional value. Ekasari *et al.* (2014) [24] stated that biofloc particle size greater than 100 µm contained the highest level of protein (27.8%) and lipid (7.5%) whereas the biofloc particle of less than 48 µm is rich in essential amino acids. The nutritional quality of biolfoc was evaluated by [32] and the reported the protein content of biofloc about 20% to 50%, fat content 0.5 to 15 %. Moreover, limiting amino acid such as methionine and lysis was also detected, in addition to vitamin and minerals especially, phosphorus. They also contribute to the probiotic activity ensuring better immunity, thus reducing the impact of pathogenic bacteria. According to Azim and Little, 2008 [7] reported the dry matter of biofloc contains 3% lipid, 6% fiber, 12% ash, 38% protein and 19 KJ/g energy. Ballester *et al.* (2010) [9] also estimated the nutritional components of biofloc and as per their results, the biolfoc contains 4.7% lipid, 8.3% fiber, 29.1% free nitrogen, 30.4% protein and 39.2% ash on dry matter basis when the carbon source used was bran and molasses. Thus, the different variety of carbon source changes the nutritional index of the biofloc. Additionally, it also impacts the appetizing and digestibility of the cultured species [17, 19]. Biofloc amplifies assimilation, rate of ingestion and nutrient absorption and stipulate a complete profile of nutrition [60]. Ju *et al.* (2008) [34] analysed the biofloc amino acid profile and found out histidine and taurine was the most ample amino acid with an amino acid index of 0.92 to 0.93. Nevertheless, arginine and lysine came out to be the limiting amino acid in the biofloc system.

Improved growth, FCR and weight gain in shrimps and tilapia have been observed in biofloc system beside removal of excess nutrients [13], Wasielesky *et al.* 2006). A noticeable decline in Feed Conversion Ratio (FCR) around 1.20 – 1.29 and an incline in feed efficiency of 78.61 – 66.81% was observed by Khanjani, 2015 [36] in comparison with fresh water treatment with 1.52 FCR and 66.81% feed efficiency. Ekasari *et al.* (2010) [25] reported that biofloc system with carbon source as glycerol involved a higher amount of polyunsaturated fatty acid (PUFA) than those of glucose. Cardona *et al.* (2016) [14] explained the contribution of biofloc particulate as a source of dietary glutathione and lipids, especially essential phospholipids and highly unsaturated fatty acids (HUFAs) for shrimp culture increasing their spawning rate and frequency, in addition to a higher gonado-somatic index and maintaining the number of spawned eggsThe bioactive compounds of bioflocs comprises of free amino acids, carotenoids, chlorophyll, minerals, proteins, lipids, essential fatty acid and Vitamin C which boost the antioxidant activity, growth and reproduction of aquatic species reared in biofloc tanks. Thus concluded that the nutritional values of the biofloc is vital and the micro biota directly controls its nutritional profile.

VII. IMPLEMENTATION OF BIOFLOC TECHNOLOGY IN AQUACULTURE

One of the major hurdle in expanding biofloc culture practice is to convince the farmers to implement the technique, since the concept goes against conventional wisdom that the pond water should be clear [6]. The most imperative factor needed to be taken in consideration for implementing biofloc system into the field is the choice of the species to be cultured. Biofloc system works best with species that would be able to acquire the maximum nutritional benefits by consuming the floc directly. Moreover, the species that can tolerate high solids concentration in water would be the best suited. Some of the species that are advisable for the culture are: Tilapia (*Oreochromis niloticus*), Magur (*Clarias batrachus*), Pangasius (*Pangasianodan hypophthalmus*), Common carp (*Cyprinus carpio*), Singhi (*Heteropneustes fossilis*), Anabas/Koi (*Anabas testudineus*), Milkfish (*Chanos chanos*), Shellfishes like the giant river prawn (*Macrobrachium rosenbergii*), Tiger shrimp (*Penaeus mondon*) and Vannamei (*Liptopenaeus vinnamei*).Fish species like hybrid striped bass and channel catfish are not good candidates for the biofloc system because of their low tolerance against solid concentration. Another very important aspect in execution of BFT is the monitoring of the biofloc culture ponds. During the culture period, when the aquatic animals are reared in biofloc tanks, the physicochemical parameters such as pH, temperature, dissolved oxygen, alkalinity, total nitrogen, nitrite, nitrate and ammonia should be regularly measured and certain responses mentioned should be adopted as soon as possible when disturbances occurs [6, 36]

- If ammonia levels (TAN) goes higher (<0.5 mg/L), addition of carbohydrates is suggested along with reduction of protein in feed. For every 1 kg of 30-38% protein feed addition, 0.5 to 1 kg of carbohydrates is recommended.
- If nitrite level goes higher, removal of collection, putting aerators, adding carbon and checking of low-oxygen area is advisable as increase in nitrite signifies the presence of anaerobic areas thus negatively impacting the culture species.
- If microbial mass is low, then it can be increased by adding carbon source
- If volume of biofloc exceed a particular level, then waste material and some of the biofloc must be excreted.

The amount of floc in the biofloc culture tanks measured using Imhoff cone (Fig. 5) must be monitored for a better management of the system. The Floc volume (FV) should be in the range of 5-50 ml/L. Maica *et al.* (2012) [44] concluded that the increase in salinity of the water increases the biofloc density and the types of carbon source also affect the quality of the flocs. The concentration of Total Suspended Solids (TSS) must be under control and should be around 500mg/L but may reach up to 100mg/L [6]. Elevated level of suspended solids increases the turbidity and reduce the visibility, hence a rise in FCR is observed with a decreased production. Azim and Little 2008 [7] observed meager growth and FCR due to elevated concentration of TSS i.e. more than 500mg/L in tilapia. And the same finding was stated for the shrimp growth performance by [29]. In a recent study biofloc technology (BFT) has been integrated with aquaponics named as FLOCponics focusing on soilless plant production.

Fig. 5. Floc volume measurement with Imhoff cone.

Various studies have been successfully conducted in rearing fish/shrimps in biofloc culture ponds. In a study conducted during winter season by [19]on hybrid tilapia (*O. niloticus* × *O. aureus*) for 50 days, they reported an average daily growth rate of 0.27 -0.29 g/fish stocked at an initial size of 50g and 100g in biofloc culture ponds. Avnimelech, 2007 [4] recorded 200-300 tons/hectare of tilapia biomass harvested from a well-managed biofloc pond. Azim and Little, 2008 [7] evaluated the growth performance of Nile tilapia reared in 250 Litre light limited biofloc tank culture. The biofloc system was constructed using wheat flour as carbon source to maintain C:N ratio for production of heterotrophic bacteria, the TSS was around 50 mg/L and tilapia fish with an initial weight of 3 Kilogram was stocked in each tanks. The study revealed that there was no significant difference between the clean water tank and biofloc tank performance specifying biolfoc does not cause any stress conditions. Nahar *et al.* (2015) [50] conducted and an experiment on GIFT Tilapia to demonstrate the suitability of Biofloc Technology in farming system. Four treatments i.e. Commercial tilapia feed, wheat bran, biofloc technology and a mixture of rice bran + wheat bran were designed with three replica of each biofloc tank. With no significant difference in survival of the fishes in three treatments, at the harvesting time (after 6 months) the overall yield of the fishes fed with commercial feed was 3803 kg/acre while the net profit was Taka (Bangladeshi currency) 99,453.3/acre/6 months. A comparison was made for rearing juvenile common carp between biofloc and recirculating system in terms of its growth performance, haemato-immunological indices, water quality and microbial community. With no significant difference in hematological and immunological parameters, the study concluded that Biofloc treatment improved water quality and feed utilization with a lower FCR and high production [59]. Biofloc system is more profitable than the freshwater system due to the reduction in commercial feed consumption thus consequently lowers food prices. It has been found that biofloc can reduce cost by 33% [45] and 10% [20] for the production of One kilogram of green tiger shrimp (*Penaeus semisulcatus*) and tilapia (*Oreochromis niloticus*). These reductions depend on species, diet, biofloc consumption, and carbohydrate prices. Through the biofloc system, organic and inorganic fertilizers are eliminated, and only carbon sources need to be purchased. Its ability to reduce cultivation time, increase growth rate, and increase survival rate have made the biofloc system more useful than clear water systems [57].

VIII. CONCLUSIONS

Biofloc technology has proven its potential by improving aquaculture production that directly aids in the attainment of sustainable development goals. By producing a higher productivity and lesser impact on environment, this technology not only act as an eco-friendly and sustainable method but also minimizes land and water resources. Biofloc a rich source of microbial protein when acquainted with the commercial feed creates a nutritious and healthy food chain and improves the growth performance of aquatic life in addition to minimizing the dependency on costlier fish meals. So concluded from the review that biofloc technology is full of assets by improving biosecurity, diminishing pathogenic interaction, lowering feed utilization, increasing growth and survival and hence boosting productivity of the system. Farmers must be trained practically about the successful experience of the biofloc technology along with its economic benefits.

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