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Biofloc: Floc Types and Their Importance in Aquaculture

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Abstract

Biofloc is an emerging alternative system to recycle and reuse the nutrients in the aquaculture system. The sustainable approach of such a system depends on the size of the floc and its properties in the culture system, mainly consist of the beneficial heterotrophic microbial community. Therefore, the microorganism maintains the water quality by maintaining the uptake of nitrogen compounds and increases the nutrient availability in the culture which reduces the feed conversion ratio and reduces the feed cost. The article discusses the properties of floc and its types in the culture system, in brief.

Introduction

In intensive fish farming, a kind of high stocking density based aquatic animals rearing system; the cultured or spent water cannot be released as such into the open environment. The water contains a huge amount of nutrients and drug residuals which pose a severe environmental threat; therefore, it needs proper wastewater treatment before its discharge from the farm. On the other side, the common bacterial pathogens (*Aeromonas* sp., *Vibrio* sp., and *Edwardsiella* sp.) and other viral diseases are threatening the industry since their intensification. In addition to this, feed cost is the major influencing factor in aquaculture which alone accounts for about 60% of the production cost. Another most limiting factor of modern aquaculture is the availability of productive water and land. Therefore, the sector is looking for an intensive culture technology that provides a complete package of safety from emerging issues.

The biofloc, a macro aggregate made of organic material and micro-organisms rich in protein, consists of live bacteria, protozoa, diatoms, algae, fecal pellets, remains of dead organisms, and other invertebrates. In the early 1970's, the first biofloc technology was developed for rearing shrimps, however, commercial application of biofloc was initiated in 1988 and achieved a higher production of 20-25 $ton^{-1}ha^{-1}crop^{-1}$ with two crops (Emerenciano *et al.*, 2013). In aquaculture practices, biofloc technology is used to improvise environmental control over aquatic animal production. In general, the biofloc system is a wastewater treatment and, in recent times, it has attained more importance in aquaculture. Biofloc technology produces a floc, a combination of organic matter by a heterogeneous mix of microorganisms, which can be effectively consumed by other culture organisms to improve their health condition and reduce the feed-associated operational cost. Presently, in India biofloc technology is suitable only for farmers who are doing large-scale commercial intensive farming with expertized technicians. However, it has been recommended to use biofloc technology in shrimp hatcheries and nursery

systems to obtain good quality seed which later yields better grow-out production (20 $ton^{-1}ha^{-1}crop^{-1}$). In India, species like white leg shrimp, GIFT tilapia, and rohu were successfully reared using a biofloc system.

Floc

Floc, small flocculent material, is a loosely aggregated mass particle either suspended particles or precipitated particles from a liquid. In the settled water, the maximum size of floc observed was less than 120 µm. Based on the size, shape, and structure flocs have been classified into different types (Table 1).

Table 1: Floc Development stages (Vol.) observed in pond

Stages	Abundance	Quantity
1	Rare	-
2	Small Quantity	< 1.0 ml $litre^{-1}$
3	Moderate	1.0-5.0 ml $litre^{-1}$
4	Abundance	5.1-10.0 ml $litre^{-1}$
5	Abundance	> 10.1 ml $litre^{-1}$

Properties of Floc

Shape

Different types of floc shapes have been observed, however, round to distinctly irregular shapes are most commonly seen in aquaculture practices. Based on the floc shape, the settling velocity (speed of the particle when it falls through a liquid medium) of floc changes. The irregular shape floc is formed when the farm uses a diffuser-type aerator to aerate the water. On the other hand, rounded flocs are not round but rather angular. The flocs in treatment plants are more or less rounded and this is the most common shape of flocs.

Structure

In the compact flocs, bacteria are closely attached to one another. An open floc, in which the water can flow through the floc particles. Flocs settle faster if they are more compact. The combination of a diffused aeration system yields compact flocs, even in the presence of filamentous bacteria. During high aeration, the compacted flocs can break open and form irregular or open-shaped flocs. The less compact flocs are formed using surface aerators which consist of various smaller floc particles. Near the zone of an aerator, the flocs are battered into pieces. In the open flocs, floc particles are bound together by filaments.

Strength

In the case of strong floc, liquid surroundings of the floc are distinctly separated when a floc is disturbed. On the other side, in weaker floc, the floc itself is separated when it is disturbed. Therefore weaker flocs can be easily damaged rather than a stronger ones (Jarvis *et al.*, 2005).

Size

The macroscopic flocs with a diameter of 10 mm, hardly show any cohesion and disintegrate easily which is made up of numerous much smaller particles. The size of flocs can vary from 10 to 20 µm to sometimes as much as a few millimeters (Table 2). The diameter of flocs is determined using a standard micrometer.

Table 2: Size of Flocs (µm)

Floc size	Diameter
Small	< 25 µm
Medium	25-250 µm
Large	250-500 µm

Three size classes are distinguished;

The type of aeration system used in the culture influences the floc size. In surface aerators, the floc size ranges from 25-250 µm, whereas, in diffused air aeration system, the flocs are noticeably larger in size (range; 25-1000 µm; often > 500 µm).

Types of Floc

1. Fragmented Floc

Fragmentation is the breakdown of flocs into pieces of a similar size without an increase in primary particle concentration (Figure 1). The breakdown of flocs takes place during aeration. Fragmentation occurs due to the tensile stress (the maximum tensile stress or strength applied to the material before breaking) acting normally across the whole floc. The flocs break in the culture system due to aeration, agitation, and flow rate (Jenkins *et al.*, 2003). The daughter fragments are similar fragments that are split from the parent ones. The horsepower of the aerator must be co-related with the stocking density to avoid the formation of fragmented floc.

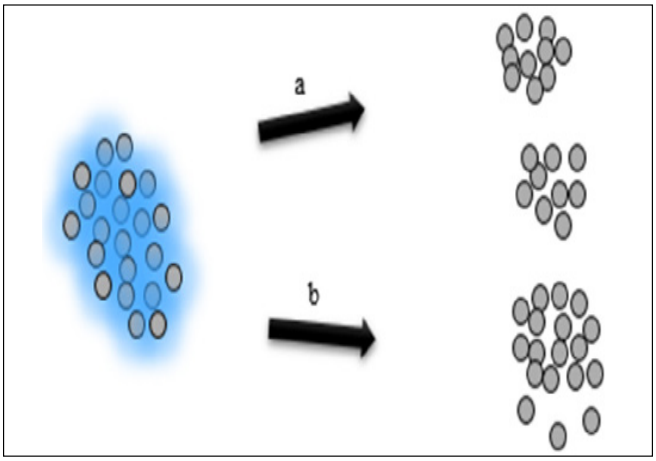

Figure 1: Floc fregmentations

2. Filamented Floc

Filamentous bacteria contribute to the formation of large, irregular, and open flocs. Filamentous bacteria provide a free surface on which the bacteria are attached and form

a floc network. However, the growth of filamentous bacteria is slower than non-filamentous bacteria.

Under microscopic observation, three groups of shapes such as straight, bowed, or bent, and twisted or coiled have been noticed in filament floc (Figure 2). A large amount of filamentous microorganisms builds bridges between the flocs which interferes in compaction, settling, and thickening of sludge floc. The development of filamented floc in our culture system leads to a high sludge volume index which indicates the presence of heavy sludge load in the pond bottom. The settled sludge needs to be removed from the culture system to provide better environmental conditions for the cultured animal. In intensive culture systems, sludge is removed once in a three-week interval using a small boat-mounted drudge.

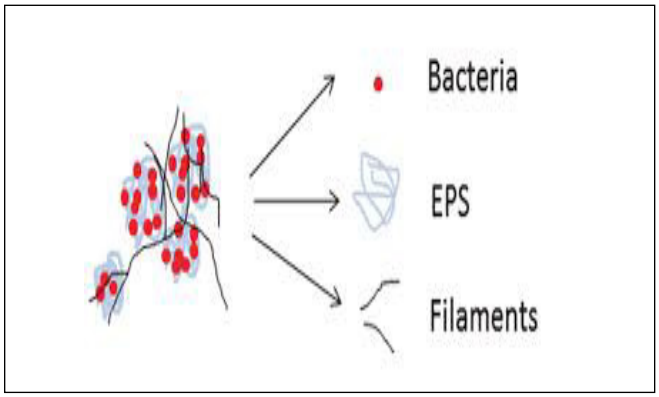

Figure 2: Types of floc filaments

3. Pin-Point Floc

Pin-floc in activated sludge may be defined as very fine floc particles with poor settling characteristics and it can be accessed through visual observation (Figure 3). The filamentous bacteria are believed to be the backbone of activated sludge flocs in which the floc-forming bacteria attach using EPS and form a strong floc. In the absence of filament bacteria 'pin-floc' is formed in the culture systems.

It is small compact, weak, and roughly spherical in shape. Due to its smaller size, it does not settle out in the sedimentation water basin. Larger flocs settle quickly, whereas the smaller one settles slowly. The formation of pin point floc increases the suspended solids concentration in water which clogs the gills and creates respiratory problems for the culture animals. In addition to this, the excess suspended solids consume more amount of oxygen which leads to hypoxic conditions in the culture ponds. The presence of pin point floc can be identified by the presence of a low sludge volume index.

Importance of Aeration

• Aerators need to be positioned correctly to accumulate sludge in the system.

• Continuous suspension is required for the biofloc in pond water, therefore, high dissolved oxygen levels should be maintained in the culture system, so that the animals will be grown healthier.

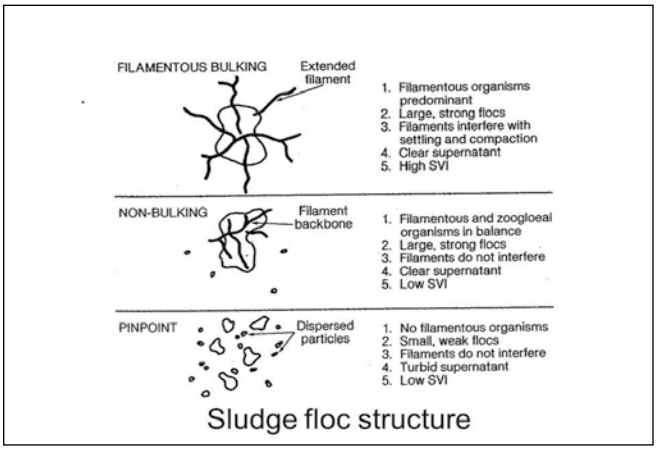

Figure 3: Pin-point floc illustration

Conclusion

Biofloc system offers stable and sustainable production as they support self-nitrification within fish or shrimp ponds with zero exchange of water system. The majority of the large shrimp farms that initiated biofloc technology did not experience any kind of white spot syndrome outbreaks which indicates that biofloc can provide biosecurity from the threatening diseases. However, there are different types of floc that have been found in the biofloc system which involve in growth of fish and shrimp by providing the required amount of essential nutrition to the fish. On the other side, there are certain types of floc that involve in formation of sludge and suspended particles which should be either removed or maintained at an optimum level throughout the culture. The improper management of sludge and suspended particles lead to various environmental and health problems. Therefore, the knowledge on the type of floc and floc properties would help in the proper maintenance of sludge in the culture system by stakeholders.

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