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Biofloc systems: a technological breakthrough in aquaculture

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ABSTRACT

Aquaculture is an activity in constant growth that requires maximizing resources and spaces, which is why different technologies has been developed seeking to solve the main problems observed in factory farms.
One of this recently technologies is "biofloc systems" which seeks to solve the problems of water pollution and improve the use of water resources, in addition to recycling the nutrients found in the water by a community of heterotrophic bacteria. This system has allowed aquaculture farms to reduce and in some cases eliminate water exchange, while providing added value through the products resulting from microbial metabolism.

Key words: Bioflocs, aquaculture, heterotrophic bacteria, microbian control.

INTRODUCTION

To increase aquaculture production, problems related to this activity like increasing the area required for the facility, water conduction carriage and building ponds drains for residual water must be resolved. Introduction of exotic species has created a risk by provoking the transition of new microbes and diseases to local organisms (De Schryver *et al*. 2008; Emerenciano *et al*. 2011; FAO, 2010).

On intensive aquaculture business the highest production cost is feeding the organisms, that added to the fact that around 60% of it is wasted by the organisms, which causes phosphorus, carbon, nitrogen, to name some, to prevail in water as suspended matter or dissolved chemicals or are expelled from the system by gasification or water change polluting other water bodies and near-by soils producing economic losses to producers (Gutierrez-Wing & Malone, 2006).

One alternative to reduce the environmental damages caused by aquaculture and to optimize production is the usage of the "Biofloc" Technology (BFT), this technology was developed in the 70's, and it is based in the microbial communities that help minimize or avoid water exchange and, as an additional benefit, the production of microbial protein that can be used as food (Avnimelech, 2009a).

BIOFLOC SYSTEM

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 by other organisms and return to the food chain (Avnimelech & Kochba, 2009).

In aquaculture, the "biofloc" system acts like a retention trap for the nutrients in the pond, and reduces maintenance costs because it can be used as food supplement for the commercial organisms being cultured, which provides an added value by improving the food consumption rate (Azim & Little, 2008).

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The term "biofloc" applies to a compound made out of 60 to 70% of organic matter, which includes a heterogeneous mixture of microorganisms (fungus, algae, protozoans, and rotifers) and of 30 – 40% of inorganic matter such as colloids, organic polymers, and dead cells. They can reach a size up to 1000 µm, irregular shape, full of pores, and allow the pass of fluids (Chu & Lee 2004) (Fig 1).

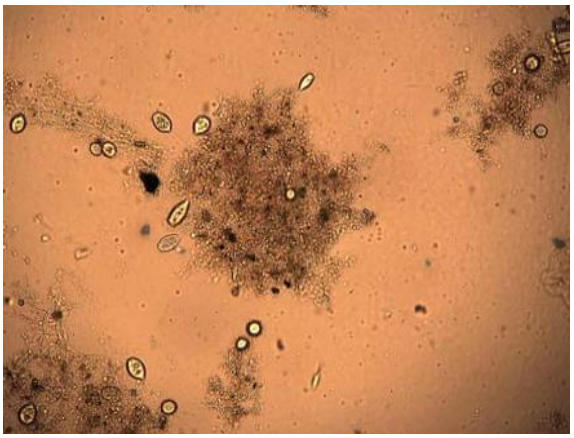

Figure 1. "Biofloc" structure (Ray *et al*., 2010a).

To stablish the BFT is necessary that the pond has a cover that prevents the accumulation of solid organic matter at the bottom, adding carbon sources that stimulates the growth of heterotrophic bacteria, and to keep constant aeration in the water column, which will help the combination of physical, chemical, and biological factors required for the floc formation (Azim & Little, 2008; Emerenciano *com pers* 2010).

BIOFLOC DEVELOPMENT

To develop the bioflocs, biological polymers substances are required to keep the components together, creating a matrix that encapsulate the cells. This matrix protects the microorganisms from their predators, provides direct access to nutrients and works as substrate (De Schryer *et al.* 2008).

Species biodiversity that inhabit the flocs depends on the microbiota found in the water body; some of them may function as biological control agents against pathogens through competitive exclusion or due to probiotic capabilities (Ray *et al.* 2010a). However, to achieve the establishment of heterotrophic bacteria in the biofloc, it is necessary to adjust the carbon/nitrogen (C:N) relation in the water body, and is required around 20 units of carbon to assimilate one nitrogen unit, this is obtained by adding a food of low protein and one carbohydrate such as molasses in sufficient amount (Avnimelech 1999a; Emerenciano *com pers.* 2011). When this rate is adequate, bacteria that grow inside of the microsystem starts to use compounds that can be toxic to the culture such as organic carbon, ammoniac nitrogen, nitrates, nitrites, and phosphates as energy sources, oxidizing them so algae, fungi, and other bacteria and filtering organisms can use them (Avnimelech 1999a; Avnimelech 2007).

The non-consumed nitrogen by the organisms in the culture can be used to produce microbe protein, instead of generating toxic compounds which also helps controlling toxic inorganic nitrogen, residual food, and the rest of the phytoplankton production will also be broken down into simpler compounds (Avnimelech 1999b). It is very important to note that this process reduces the total amount of dissolved oxygen available for the organisms, so the existence of an adequate concentration of this element in the water becomes very important (Abarzúa *et al*. 1995; Avnimelech 1999a; Mc Graw 2003).

Proliferation of bacterial colonies and microorganisms generates an increase in the biofloc biomass, it increase must have a density between 10 and 15 mL so the system can keep functioning properly. The excessive can be used as source of protein for the organisms, sometimes directly or in the form of flour or feed (Avnimelech 1999a; De Schiver *et al.* 2008; Emerenciano *com pers.* 2011).

BIOFLOC'S NUTRITIONAL VALUE

The nutritional value the bioflocs have for the animals in cultivation will depend on their food preference and their capacity to ingest and digest suspended particles (Tabla 1) (Azim & Little, 2008).

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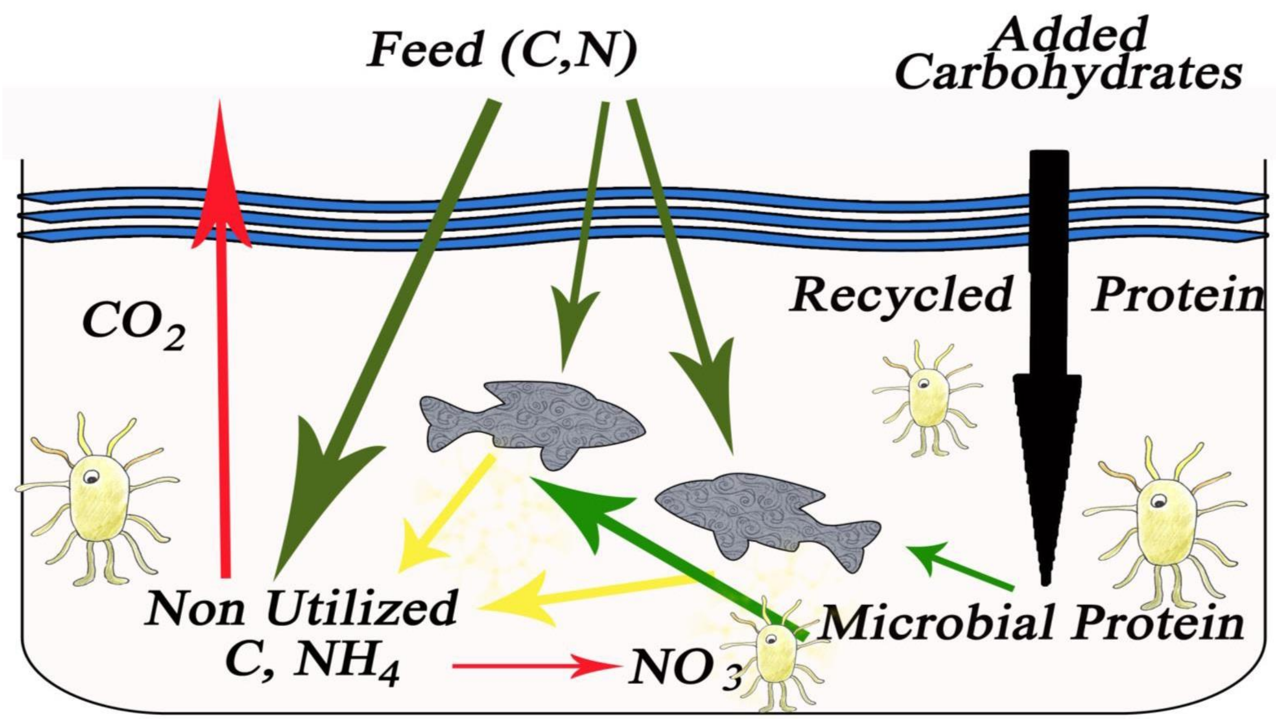

Fig. 2. “Biofloc” system operation in a pond (Avnimelech, 1999).

The specie in culture has the capacity to resist high population densities, and the water quality improved the improvement in water quality allows increase the number of organisms by m^3 (Ray *et al*. 2010b).

BIOFLOC SYSTEM APPLICATIONS

Biofloc system applications have examples of successful applications observed in countries such as South Korea, Indonesia, Malaysia, Thailand, China, Australia, Hawaii, Brazil, Ecuador, Peru, USA, Mexico, Guatemala, and Belize (Emerenciano *com pers*. 2011).

There are diverse examples of the success that this system has had (Fig. 3), in Mississippi, USA, The John Ogle Biosecurity System farm, reported 69.85% survival in the cultured, with a production of 15.4 to 17.5 ton/ha/cycle in densities of 100-150 animals per m^3 of the shrimp *Panaeus vannamei* (Boone, 1931), with an estimate production cost of 2.4-2.80 USdlls/kg.

The CreveTope farm in Shanghai, China, reached 25 ton per year of *P. vannamei* production with no water exchange.

Another example Marvesta Shrimp Farms in USA, reached a production of 120 to 170 ton/yr of *P. vannamei* production with sizes of 20-30 gr and with a minimum water exchange.

CONCLUSIONS

To establish the biofloc technology provides benefits to the production systems, such as lowering the density of the toxic components that can affect the culture, it can also help reducing or eliminated the water exchange in the ponds, which is of great help when there is shortage of water; also help to avoid contamination, since improve the water health due to the heterotrophic bacteria that inhibit the growth of pathogenic bacteria, reducing the possibilities toinfect the organisms preventing contagion and massive deceases.

The optimal use of the nutrients by the biofloc bacterias, diminish the cost of food, for the fish flour that is consumed in large amounts in the

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Table 1. Chemical composition on dry matter basis of microbial aggregates ("biofloc").

Bibliography source	Protein (%)	Carbohydrates (%)	Lipids (%)	Fiber (%)	Ashes (%)
Mcintosh *et al.* (2000)	43.00	-	12.5	-	26.5
Tacon *et al.* (2002)	31.20	-	2.6	-	28.2
Soares (2004)	12.0 – 42-0	-	2.0 – 8.0	-	22.0 – 46.0
Emerenciano *et al.* (2006)	30.40	29.10	0.47	0.83	39.20
Wasielesky *et al.* (2006)	31.07	23.59	0.49	-	44.85

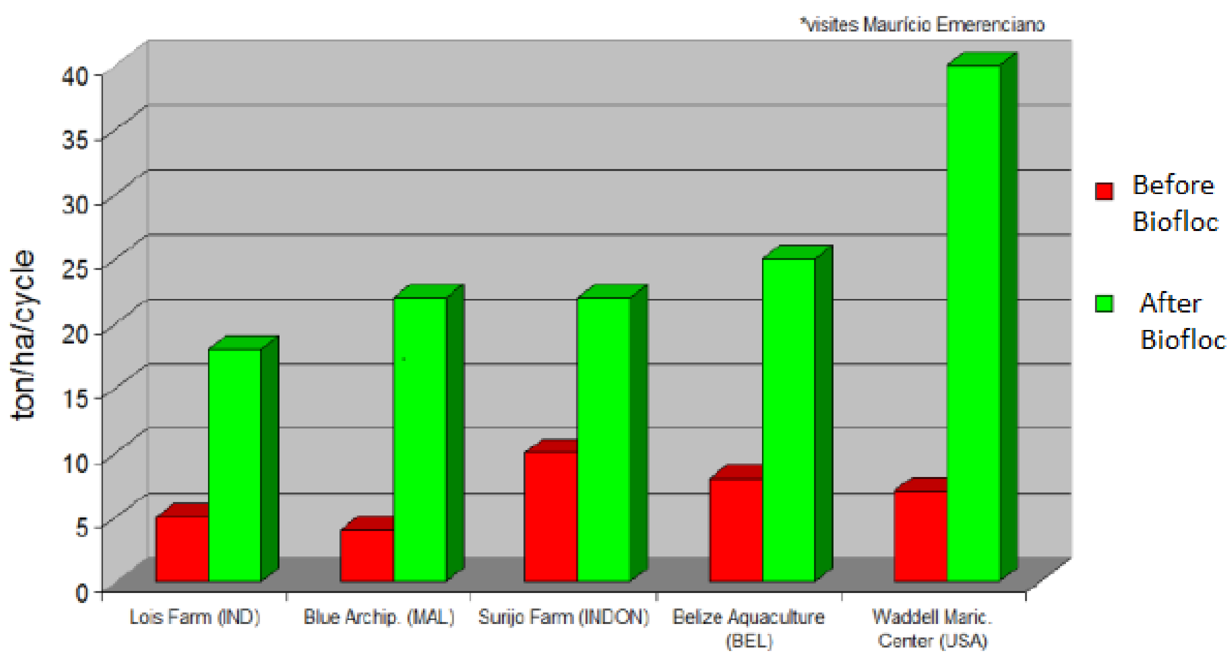

Fig. 3. "Biofloc system" importance in *P. vannamei* farms in different localities (Wasilesky *et al*. 2006 Panorama da Acuicultura) (*com pers*. Emerenciano 2011).

world and its availability sometimes is scarce and get high costs. This system permit to the production farms not to be dependent since the biofloc can work as food when the feed prices become too high.

The biofloc in the ponds allows an increase in populations of the cultured organisms, and thus the harvests intensify without increasing the amount of space that can be for other activities.

The future of this system is very promissory because it can help to get high productions required to satisfy the growing human population needs.

Another advantage in the use of the biofloc system is the decline of the production costs, this is not only beneficial for producers but it could allow the access of more people to this source of animal protein, and improve of human being with scarce economic resources.

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