AfroBeyondistCivilization

BEYONDIST BIOFloc TECHNOLOGY

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ABSTRACT

The global population is expected to reach 9.6 billion by the year 2050 and as the demand for animal protein is increasing year by year it is a challenge to provide quality protein by safeguarding its natural resources for future generations. As capture fishery sector continues to decline, aquaculture industry must be accelerated to bridge the fish supply gap especially in Africa. However, in most African countries, aquaculture sector is characterized by low productivity due to inefficient technologies, hence the need for innovative aqua-technologies that can stimulate back yard fish production, for enhanced livelihood security among smallholder farmers. BioFloc Technology (BFT) is considered as new "blue revolution" since nutrients can be continuously recycled and reused in the culture medium, benefited by the minimum or zero-water exchange. BFT is an environment friendly aquaculture technique based on *in-situ* microorganism production. BioFloc is the suspended growth in ponds/tanks which is the aggregates of living and dead particulate organic matter, phytoplankton, bacteria and grazers of the bacteria. It is the utilization of microbial processes within the pond/tank itself to provide food resources for cultured organism while at the same time acts as a water treatment remedy. Thus, this system is also reffered as active suspension ponds or heterotrophic ponds or even green soup ponds.

INTRODUCTION

Food and nutrition insecurity is a visible indicator of poverty in Africa. High prevalence of poverty has been linked to limited application of Technology Innovation Management Practices (TIMPs), and effects of changing climate in most agricultural production value chains. In the recent past, the capture fishery sector supplied enough fish for human consumption, and promoted general socioeconomic stability in most African countries. Today, the capture fishery sector cannot supply sufficient fish for the growing human population, hence the need for sustainable aquaculture production technologies to bridge the fish supply gap.

In Africa, aquaculture has been recognized as a quicker means of enhancing livelihood security and economic growth through its value chain linkages. However, the aquaculture sector is still characterized by low productivity due to lack of quality inputs and poor culture technologies. The low fish production has contributed to a lower fish consumption per capita of < 5 kg / person / year in most developing countries compared to 20 kg / person/ year in developed countries.

BEYONDISM advocates for creating an aquaculture production paradigm and shifting it towards innovative, highly productive, cost-effective and eco-friendly farming systems. The innovative aqua-systems should promote back yard fish production and stimulate livelihood security activities e.g. good health and wealth creation.

BioFloc technology (BFT) is a climate-smart technology that works on the basis of mass production of *in situ* microorganisms. The microorganisms are credited for:

(i) Maintaining good water quality.
(ii) Increasing culture feasibility by reducing feed conversion ratio (FCR) and feed costs.
(iii) Biosecurity.
(iv) Sequestration of greenhouse gasses (GHG).

These four biological functions of microorganisms in BFT units are factors of high fish production, profitability and environmental protection. One visible strength of BFT is that the initial investment cost is less than most conventional fish production systems, because only sunlight, a carbon source and sometimes aeration are needed.

<u>Important facts to remember:</u>

- ✓ In the ponds, fish are fed with a lot of feed.
- ✓ About 70-80% of it remains in the pond, in the water or the sediment.
- ✓ Ponds contain a high load of nutrients.

<u>What are the outcomes??</u>

- ✓ We waste Feed/Money (Quite a lot!)
- ✓ Toxic residues (Sulphides, Ammonia etc) accumulate.
- ✓ Fish growth is affected.
- ✓ Intensification is limited.

History of BFT

The first BFT was developed in the 1970s at Ifremer-COP (French Research Institute for Exploitation of the Sea, Oceanic Center of Pacific). Israel and USA (Waddell Mariculture Center) also started Research and Development with Tilapia and *L. vannamei* in the late 1980s and 1990s.

Commercial application started at a farm in Tahiti (French Polynesia) in 1988 using 1000m^2 concrete tanks with limited water exchange achieving a record of 20–25 tons/ha/year in 2 crops. A farm located in Belize, Central America also produced around 11-26 tons/ha/cycle using 1.6 ha poly-lined ponds. Another farm located in Maryland, USA also produced 45-ton shrimp per year using ~570 m^3 indoor greenhouse BFT race-ways. BFT has been successfully practiced in large-scale shrimp and finfish farms in Asia, Latin, and Central America, the USA, South Korea, Brazil, Italy, China, India, and others.

BioFloc systems were developed to improve environmental control over production. In places where water is scarce or land is expensive, more intensive forms of aquaculture must be practiced for cost-effective production. There are strong economic incentives for an aquaculture business to be more efficient with production inputs, especially the costliest (feed) and most limiting (water or land). High-density rearing of fish typically requires some waste treatment infrastructure. At its core, BioFloc is a waste treatment system.

BioFloc systems were also developed to prevent the introduction of disease to a farm from incoming water. In the past, standard operation of shrimp ponds included water exchange (typically 10 percent per day) as a method to control water quality. In estuarine areas with many shrimp farms practicing water exchange, disease would spread among farms. Reducing water exchange is an obvious strategy for improving farm biosecurity. Shrimp farming began moving toward more closed and intensive production where waste treatment is more internalized.

BioFloc systems use a counter-intuitive approach— allow or encourage solids and the associated microbial community to accumulate in water. As long as there is sufficient mixing and aeration to maintain an active floc in suspension, water quality can be controlled. Managing BioFloc systems is not as straightforward as that, however, and some degree of technical sophistication is required for the system to be fully functional and most productive.

FUNCTIONALITY

The BFT rely on heterotrophic process where uneaten feeds, feces and excess nutrients are converted into edible BioFloc, 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.

The BioFloc not only contain essential nutrition but has probiotic effect that ensures biosecurity in the BFT systems. The BioFloc consume ammonia to make own proteins, thus maintains good water quality in the culture systems. The BFT requires minimal water exchange in aquaculture systems to maintain the flocs and allows high stocking densities and increased fish productivity.

The above attributes make BFT economically attractive to aqua-preneurs. BFT can be used for live food production in hatcheries to ensure supply of quality fish seeds throughout the year, for aquaculture. Bioflocs are also efficient sinks of atmospheric carbon thus facilitates adaptation and mitigation of effects of GHG.

What BioFloc systems do

BioFloc provide two critical services—treating wastes from feeding and providing nutrition from floc consumption. BioFloc systems can operate with low water exchange rates (0.5 to 1 percent per day). This long water residence time allows the development of a dense and active BioFloc community to enhance the treatment of waste organic matter and nutrients. In BioFloc systems, using water exchange to manage water quality is minimized and internal waste treatment processes are emphasized and encouraged.

Research with shrimp indicates that culture water contains growth-enhancing factors, such as microbial and animal proteins, that boost production. Flocs are a supplemental food resource that can be grazed by shrimp or tilapia between feedings of pelleted diets.

A potential benefit of BioFloc systems is the capacity to recycle waste nutrients through microbial protein into fish or shrimp. About 20 to 30 percent of the nitrogen in added feed is assimilated by fish, implying that 70 to 80 percent of nitrogen added as feed is released to the culture environment as waste. In BioFloc systems, some of this nitrogen is incorporated into bacterial cells that are a main component of BioFloc. Consumption of this microbial protein, in effect for a second time, contributes to growth.

Research with shrimp and tilapia suggests that for every unit of growth derived from feed, an additional 0.25 to 0.50 units of growth are derived from microbial protein in BioFloc systems. In other words, 20 to 30 percent of shrimp or tilapia growth is derived from the consumption and digestion of microbial protein. This benefit is reflected in improved feed conversion, one of the best predictors of system profitability and business sustainability. However, the value of flocs in nutrition is limited at the highest levels of production intensity because the contribution of feed to growth of cultured animals is overwhelming.

BioFlocs and flocculation process

BioFlocs are heterogeneous macro-aggregates of planktonic materials in the water column, which constitute a consortium of floc forming bacteria, diatoms, filamentous microalgae, micro-and macro-invertebrates, protozoa, feacal matter and uneaten feed. The BioFlocs form the basis of the food chain in aquatic ecosystems by converting to SCP. Therefore, BioFlocs are responsible for the initial nutrient cycling process in aquatic ecosystems.

Bio-flocculation mechanisms

BioFlocs normally colonize new systems soon after accumulation of organic wastes. Microbial cells form matrix flocs through a complex flocculation processes controlled by physical, chemical and biological processes. In this process, the main constituents of the floc matrix are the extracellular polymeric structures that form microbial capsules, which bind the BioFloc components. The flocs are typically made up out of polysaccharides, protein, humic compounds, nucleic acids and lipids, and are mainly produced as slime or capsule layers under nitrogen limitation.

Under favorable conditions, BioFloc aggregates vary in size from the microscopic to > 1 mm, which is similar to the size of most commercial fish pellets for juvenile fish. Densities of the microbial biomass average slightly above 1.0 g wet weight ml^{-1} floc aggregate that make the BioFlocs slow sinking particles (1–3 m h^{-1}). The flocculation and sinking ability of the BioFlocs is an adaptation mechanism to escape adverse ecological impacts e.g. of light and grazing pressure by organisms in higher-trophic chain. In the process of sinking the BioFlocs attach to available substrates and create mats that attract other aquatic microorganisms. The culture fish are able to graze upon the mat of microorganisms.

The concept of BFT

The BFT operates on the principle of nutrient recycling by maintaining a higher carbon / nitrogen (C/N) ratio e.g. above 15 to stimulate mass growth of heterotrophic bacteria. Higher C/N ratio is maintained when more carbon source e.g. molasses, cassava, hay, sugarcane, starch, wheat bran, cellulose etc., is sprayed on the surface of pond water with continuous aeration. Under favorable BFT conditions, up to 0.5 g of heterotrophic bacterial biomass g^{-1} substrate of carbon can be produced. With the information that 1 g of carbon produces 0.5 g of bacteria, farmers are able to estimate quantities of floc in the culture systems. The BioFloc process stimulates natural growth of macro-aggregates of organisms that enhance self-nitrification in the culture 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. Under indoor conditions, BioFlocs are mainly bacteria, and are referred to as brown BioFlocs. With addition of adequate carbon source bacterial floc stimulates a secondary production line that involves degradation of organic wastes by bacteria to produce more billions of bacterial cells (heterotrophic cycle) under optimum aeration condition.

During this process, autotrophic and heterotrophic bacteria proliferate and attract billions of other cells including diatoms, fungi, algae, protozoans and various types of plankton. The traditional aquaculture ponds lack injection of carbon source, aeration mechanisms and thus harbors fewer and less diverse bacterial communities, as opposed to BFT. Small quantities of bacteria cannot form substantial flocs in the culture system. The sediment of traditional ponds accumulates higher quantities (49%) of nitrogenous wastes while the BFT pond sediments have less (5%) nitrogenous wastes

Species selection and stocking densities in BFT

BFT culture species should be wholly or partially filter feeders to exploit BioFloc and detritus particles. Both shrimp and tilapia are excellent candidates because of their ability to gobble up BioFlocs, thereby improving the feeding efficiency and feed conversion ratio (FCR).

It is recommended to stock tilapia seeds at 12.5 g l^{-1} in tank-based BFT. The optimal carrying capacity of a 10,000 l BFT tank is estimated at 0.4 kg l^{-1} (Aqua-doctor solutions, India). The fish should be fed with feeds of high buoyancy and crude protein content of between 20 - 18%, if the BFT is working efficiently.

Due to high productivity, farmers are sometimes tempted to use higher stocking densities. However, the carrying capacity of BFT should not be exceeded as this may compromise both the health of the cultured animals and productivity of the units.