Understanding biofloc in aquaculture production systems

By Stephen G. Newman

Since 2009, protein from aquaculture production has surpassed that of fisheries for the first time in history. Aquaculture is simply a water-based agricultural system with a long history. It is also an ever increasingly important role in feeding the Earth's burgeoning population.

However, as aquaculture practices intensify, environmental concerns and economic pressures oblige companies to conform to what are being termed 'best aquaculture practices'. These approaches to management are an attempt to bring consistency and ensure sustainability to the myriad of diverse practices worldwide. Control of waste streams and minimising environmental impacts at all levels are critical.

Recycling waste products

Aside from protein for consumption and by-products of processing (often, the major by-product of the production process from the fish culture systems is sludge. This sludge is rich in nutrients, typically nitrogen and phosphorus, as well as a host of macron and micronutrients. After each crop, it must be disposed of properly, in a manner that is consistent with avoiding nutrient enrichment (e.g. run-off) of the surrounding water environment. There are a number of different ways to get rid of this material including in-situ digestion with bacteria (conceptually confused with probiotics). Many microbial based products in the market today being sold as 'probiotics' function by digesting accumulated waste organic matter.

In sedimentation ponds, there is biofloculation and direct disposal into receiving waters or burial into pits, etc. Floculation refers to changes in the nature of suspended particulate materials that allow them to form aggregates or small clumps. In many waste treatment systems, this is done using chemicals such as alum, chitosan or other similar materials that impact the electrical charge of the particulates. It can also be done as well by the use of microbes and/our their metabolites (biofloculation). These processes allow for handling of excess nutrients for easier disposal and are commonly used in the treatment of high organic content waste materials produced in human sewage treatment plants.

Biofloc

In aquaculture, this flocculation process is being exploited in a modified form in fish and shrimp culture ponds. The term biofloc has been coined to apply to these particulate materials when they are generated in very low or zero exchange water systems principally through the action of bacteria and other microorganisms. Actually, the concept is not new as it has been used for a long time in sewage treatment plants. It is only within the last two decades, that this concept is widely applied in aquaculture.

In pond environments, this is recycling in the truest sense of the word. Almost 30 years ago, Steve Surber discovered the potential of biofloc in the production of tilapia. Considerable research has been done since then and biofloc systems are often found in intensive shrimp and fish farming systems globally.

Explaining biofloc

The term biofloc is synonymous with many others, including microbial floc, organic detrital soup, intensive microbial reuse systems, etc. Usually there is never a consistency in terms of composition between forms (and even ponds) within a farm. These particulate suspensions of organic matter are composed of a wide variety of living organisms and in many cases inorganic matter as well. The total composition can include a myriad of different species of bacteria, fungi, algae, protozoa, nematodes and other microorganisms. This is a complex ecosystem and is in some aspects related to biotrons that typically colonise surfaces.

The generation of biofloc depends on high levels of organic matter in the ponds; usually the common by-products of culture such as faecal material, uneaten feed, dead algae and other plant and animal materials and a proper balance between carbon and nitrogen levels. As with all ecosystems, there is a succession of stages and the process will eventually result in a stable floc.

Why biofloc?

The primary advantage of these systems is with high density production systems. Here there is limited or no water exchange, resulting in economic, environmental and production advantages. This means savings is in electrical costs with a reduction in pumping water. However, the risk is that high levels of aeration for oxygenation and water aeration is essential to ensure that the particles remain suspended in the water column. Some of the reported benefits are:

- A low or zero exchange system will have a decreased reliance on water during the production cycle. In turn, with a concomitant increase in biosecurity, the closed system decreases the risk of introducing pathogens or potential pathogens that may be present in the incoming water.
- There is a significant decrease in the amount of water resources required to produce the crop. Many of these systems require no water exchange during the cycle and typically, any incoming water is to make up for evaporation.
- The more of the pond water translates to a very small environmental footprint, both from the standpoint of water usage and the potential for impact from effluent that is discharged during harvest, etc.
- Reusing water is a component of sustainability. Furthermore, effluents, which are largely free of nutrients, will reduce the environmental footprint.
- The system allows for in-situ nutrient recycling. In conventional open culture systems, most of the nutrients that are not consumed and the rich nutrient content of faecal material and the huge biomass of shrimp that exists in ponds are wasted. In biofloc systems this is not the case. This applies to nitrogenous nutrients particularly protein and carbohydrates as well. Microalgae are also recycled in this manner.
- There is less reliance on external sources of feed for growth. Bioflocs are highly nutritious and are readily consumed by many species of fish and shrimp. Less costly foods containing lower levels of nitrogen (protein) with concomitant lower feed conversion ratios can be used as supplementary feeds.
- The cost of production is reduced and also lessens the potential environmental impact of these operations by allowing production of animals that require less fish meal and fish oil to produce. Positive impacts on animal health include immunity and nutritional status. The biofloc system supports denitrification by the breakdown of ammonia nitrogen into biologically benign forms of nitrogen such as nitrates.

A tool and not a solution

It should be noted that biofloc system is a tool. It is not a solution and is not a substitute for progressive management strategies that encompass proper hygiene protocols, appropriate feeding regimes and feed management strategies, monitoring for water quality parameters, that can negatively impact animals, proper disposal of accumulated