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FLOCponics: The Integration of BFT and Aquaponics System

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Abstract

FLOCponics is such as a modern integrated agri-aquaculture system in its initial stage of development. Flocponics combines the intensive production of aquatic organisms using biofloc technology with the production of vegetables in hydroponics systems, an alternative type of aquaponics that integrates biofloc technology (BFT) with soilless plant production. The biofloc aquaculture systems are based on promoting the growth of specific microbial communities that recycle the nitrogenous waste directly fomented in the aquaculture tank to intensify and increase the biosecurity of fish and shrimp production. The microorganisms are responsible for maintaining water quality and serving as food for the cultivated organisms, decreasing the need for water renewal and the use of commercial feed. Aiming the improvement of its efficiency and reduce the environmental impact of both systems, flocponics uses the excess nutrients from the biofloc to nourish hydroponics plants.

Introduction

Aquaculture the production of aquatic organisms is one of the ways to provide healthy food for the growing population with an annual production of 114.5 million tonnes in 2018, aquaculture is the fastest-growing animal production activity in the world 5.3% from 2001 to 2018 (FAO, 2020). Aquaculture contributions are expected to continue the fastest growing animal through an intensive production system. However, most intensive production worldwide is carried out in conventional ponds or cages monoculture systems with concerning management. Integrated agri-aquaculture aquaponics systems typically combine a recirculating aquaculture system (RAS) with soilless plant production in hydroponics-based sharing and reusing nutrients and water. In addition, these traditional pond and cage aquaculture systems depend on large volumes of water, extensive areas of land, and in some critical scenarios the use of antibiotics to achieve high productivity. All these environmental problems undermine aquaculture's sustainability.

A new addition to the multitude of integrated agriculture-aquaculture systems is 'FLOCponics' a combination of biofloc technology and aquaponics that was first described by (Pinho *et al.*, 2021), and used for co-culturing tilapia and lettuce. Aquaponics and biofloc-based aquaculture are considered environment-friendly approaches to food production. Both are intensive aquaculture systems with a strong focus on nutrient recycling and water-saving. The terms 'FLOCponics' to identify and unify the systems that have been called is defined as 'BFT+hydroponics', 'BFT+aquaponics', or 'BFT+plant production' (Figure 1).

FLOCponics is defined as the integration of biofloc-based aquaculture with hydroponics (Kotzen *et al.*, 2019). Thus,

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FLOCponics is an alternative type of aquaponics system where RAS is replaced by a system based on Biofloc technology. Dauda (2020) suggest that FLOCponics may offer an advantage regarding plant growth, the main characteristics that make BFT effluent a promising fertilizer are: (i) the high concentration of nutrients; (ii) the diversity of microorganisms, which are constantly recycling nutrients and may increase their availability or help their absorption by the plants; and (iii) the low investment in filters for water treatment.

Figure 1: FLOCponic

Biofloc Technology

Biofloc technology (BFT) has been used in intensive fish and shrimp production, enabling high animal yield on small land area and minimum water exchange. The "Biofloc" are aggregates that include microorganisms (bacteria, fungi, flagellates, protozoans, ciliates, algae, and others) and particulate organic matter such as faeces, and uneaten feed (Avnimelech, 2015). Biofloc-based culture system is characterized by the growth of specific microorganisms, usually in situ in the fish tank for improving water quality, disease prevention, and waste treatment. The Biofloc technology is based on the manipulation of a microbial community through the addition of a carbon source that promotes the development of heterotrophic bacteria. The microorganisms, especially heterotrophic bacteria and nitrifying bacteria play an important role in the organic matter degradation and nitrogen cycle. These bacteria use the organic carbon and the inorganic nitrogen present in the water to produce their biomass by removing toxic ammonia from the culture system. This system facilitates the production of aquatic animals at high stocking densities in a sustainable and bio-secure fashion.

In some cases, the protein content of feed can be reduced due to partial protein supplementation by the microbial community (Figure 2). The biofloc in fish and shrimp culture to recycling organic and inorganic nutrients by the overall microbial communities promotes a complex heterotrophic food web, based on a microbial loop that includes the cultured fish. Biofloc-based shrimp farming has a great opportunity to fine-tune for better production. Biofloc technology can be further improved by better biosecurity, fine-tuning the stocking density, and physical, management of water quality. Feed management and carbon addition strategies are the major two cornerstones in biofloc technology and this aspect should be handled with the most care for maximizing the profit.

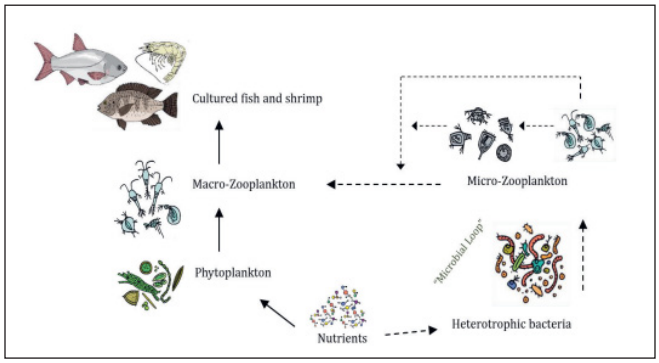

Figure 2: Heterotrophic food web promoted in Biofloc-based culture

Aquaponics

Aquaponics is the integration between aquaculture (fish farming) and hydroponics (crop farming) in order to attain mutual benefit from each other (Figure 3). This system ensures the production of fish and crops. Basically, it is a clean and green technique of rearing fish and plants together in a closed recirculatory system. The fish are raised in tanks that facilitate development in a soilless environment. The waste produced by the fish is taken up by the plants and then reimbursed to the fish for growth. In this way, the plant acts as a water filter that purifies the water and redirects it to the fish tank. Therefore, in an aquaponics system, the fish feeds and excretes the faecal matter more than 50% of the waste produced by fish is in the form of ammonia secreted in the uneaten feed and fish faecal matter. The residue of the fish excretes the faecal matter and uneaten feed undergoes a process called mineralization, which occurs when heterotrophic beneficial bacteria consume fish waste, decaying plant matter, and un-eaten food, converting all three to Ammonia (NH_3) and other compounds such as Nitrite (NO_2) and Nitrate (NO_3).

	Nitrosomonas sp.		*Nitrobacter* sp.	
Ammonia (NH_3)	----------	Nitrite (NO_2^-)	----------	Nitrate (NO_3^-)

Insufficient quantities of ammonia are toxic to plants and fish. Nitrifying bacteria naturally live in the soil/ mud and water. Aquaponics helps in the process of nitrification which can reduce the ammonia from high toxicity to lower. Nitrifying bacteria convert toxic ammonia into less harmless nitrate, a form of nitrogenous waste taken by vegetable plant roots from water and soil.

Benefits of FLOCponics

- The main benefit of this system is the ability to grow fish and plants in the single system.
- FLOCponics share many of the advantages of reduced land area requirement, reduced water consumption, accelerated growth rate, and year-round production under controlled environmental conditions.

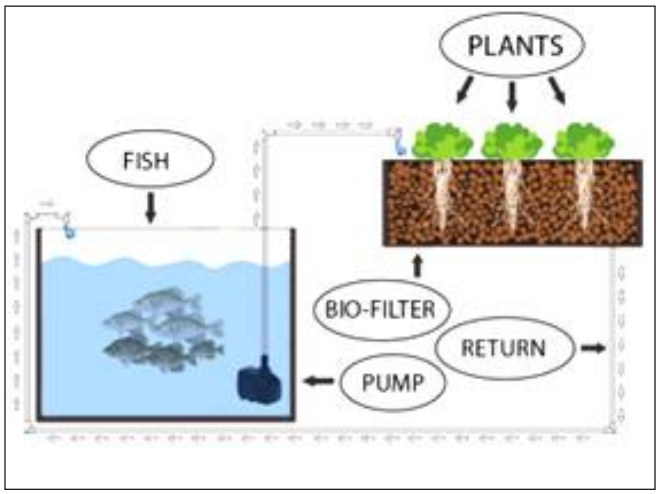

Figure 3: Aquaponics System

- Higher fish and plant production in a single system.
- Less required manpower.
- Increased biosecurity.
- Increase sustainability of BFT.
- Diversification of BFT.

Challenges in FLOCponics

- Higher initial cost to build the system (Gren house, pump, *etc.*).
- Required skills and need to learn how to use this technique.
- Pets and disease can be devastating if set up in an uncontrolled environment.
- High solid content can clog plant roots if unmonitored.

Conclusion

FLOCponics presents a unique opportunity for year-round production of fish and plants. Out-of-season production of fruits and vegetables can be a major source of income for FLOCponics producers, as they take advantage of much higher seasonal prices, the ability to produce multiple food components in a single system. Adoption of FLOCponics fulfilled nutritional requirements for food including fish and vegetables in buyers.

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