# Re-circulating aquaculture biofloc systems in deserts

Science, Biology

Re-circulating Aquaculture System Biofloc for Shrimp in Desert Introduction Re-circulating aquaculture systems (RAS) are known to be enclosed-up facilities which have the capacity of retaining and treating water within the system (Zohar and Yonathan, 22). In this case, the water flows from the tank through a treatment process then later returns back to the tank. In relation to this, it is evident that RAS suits the desert environment where there is scarcity of water. The desert of interest is located in Yanbu Saudi Arabia where the Shrimp farming is to be staged. Also, the designing of RAS is in a way that it is environmentally sustainable, whereby it can use 90-99% less water as compared to other acquaculture systems. The waste discharge as well as the use of chemicals or antibiotics to fight diseases is minimal. It is known that for at least 30 years, it has been under development. Unlike other methods which clean water from fish tank, there has been incorporation of aquaponics to some RAS fish farms (Lee and Richard, 18). Since biofloc systems are designed to improve environmental control over production in areas where there is water scarcity, such as desert in this case, or where land is expensive, more intensive aquaculture forms are required to be practiced for production that is cost effective. Economic incentive is considered to be strong for aquaculture business to be efficient in terms of production inputs, particularly limiting water or land. Biofloc systems were as well designed to prevent disease from being introduced into the system from the incoming water. Basing on the above, it can be affirmed that this system well fits the project that is to be staged in a desert where there is scarcity of water among other limiting factors.

Literature Review

History

Shrimp farming, marine shrimp production in ponds, tanks and impoundments origin can be traced to South Asia. In this case, farmers were seen to raise wild shrimp incidental crops in tidal fishponds (Mungkung, 4). The birth of shrimp farming was in 1930s the time Motosaku Fujinaga , a Tokyo University graduate became successful in Kuruma shrimp spawning(Penaeus japonicas) (Mungkung, 8). The larvae were cultured by him in the laboratory whereby in so doing this, he was successful in mass-production of these shrimp on a commercial scale. He then shared his research findings for at least 40 years and his work was published in 1942, 1941, 9167 and 1935. Emperor Hirohito had to honor him in 1954 with the title Inland " Japonicus Farming Father" (Mungkung, 4). Hatcherymen and fishermen started to supply large quantities of seed stock in the mid 1970s, at this point in time; rapid expansion of fish farming began. Currently, at least 50 nations do shrimp farming, Brazil, Mexico and Ecuador being the leaders in the Western hemisphere. Export of shrimp is seen to generate a lot of revenue in hundreds of millions of dollars in a single year (Mungkung, 4).

Major Problems with Diseases

In early 1990s, after solid growth for two decades, challenges started to face the traditional shrimp farming development. These challenges were related to viral diseases as well as to the environmental community (Hernández et al., 23). After a few years, it was observed that viral diseases alone had to cost the industry about a billion dollar in a single year. Similarly, the environmental community was seen to chip away at some of the flaws of shrimp farming such as local people displacement, destruction of habitat, effluents as well as any other related issue they had to pose a fundraising campaign on (Hernández et al., 13). Currently, there is an invention of a new shrimp farming method which protects the environment from shrimp farming as well as shrimp from diseases. This is seen to create the likelihood that farming of shrimp might emerge to be the cleanest agriculture industry globally (Hernández et al., 11). Merging of American science and Asian intensive shrimp farming considered to be a new technology, incorporates pieces and bits of successful farming of shrimp globally. It is as well considered to be very expensive and intensive at the start of commercial development.

Bio-floc Shrimp Farming and the way it Works

Mostly, farming of shrimp is carried out in outdoor ponds which are known to depend on robust algal community as well as sun for nitrogenous wastes processing from the shrimp and oxygen supply to the water of the pond. Some of the essential nutrients are also picked up by shrimp from algae and this creates a nifty arrangement but a relationship that is complicated. The blame is on the algae. It blooms, it takes the day off on cloudy day, it crushes, it works against you during the night and there are a times when it does its own things (Avnimelech et al., 18). For instance, for a ten shrimps ponds that are identical and all in a row, it will be observed that each will exhibit a slight and in other cases dramatically algal community that is different, resulting to wild swings variables of water quality that will be seen to slow the growth of shrimp as well as creating endless problems related to management to a shrimp farmer (Avnimelech et al., 12).

Bio-floc shrimp farming is known to encourage the community of bacteria in the pond. Once maintained as well as established, bacteria ponds are considered to be more stable as compared to algae dominated ponds. There is accumulation of bacteria in clumps referred to as flocs, and in this case, the nitrogenous waste is globbed up 10-100 times more efficiently as compared to algae. The bacteria are known to work day and night and little attention is paid to the weather whereby, the nitrogenous wastes are turned into feed for shrimp rich protein (Avnimelech et al., 12).

Materials and Methods

This paper involves designing a system for starting up a business for the production of pacific white shrimp. The project is to be located at Yanbu, Saudi Arabia. The place is located in the western part of Saudi Arabia. The city is considered to be an appropriate site for starting up the business because it's near the airport. According to the plan, the business is to commence in early 2017 and it is required to be completed in the beginning of 2018. The team to be involved in the project include Saudi national Prawn Company which will play a big role to make sure the business meets its objectives. The budget to be input is approximately 6 million dollars. In this case, two million will be allocated for buying land, two million for tanks, systems and hatchery. Then the other two million for feeding

Bio-floc shrimp farming is possible anywhere including the desert, close to town, in green houses, in the tropics in buildings and in temperate climates. This is a clear indication that shrimp farming will be revolutionized. Surprisingly, about all the knowhow and equipment required to put up a bio-floc shrimp farm can be got right off the shelf. Unfortunately, it is very expensive to make it a success as well as the costs of operation are too high. Below are some of the requirements for putting together a bio-floc shrimp farm

Settling tanks and reservoirs for water treatment

Filters for excluding disease from the water that is incoming

High stocking densities of genetically, disease free shrimp such as the peaneus vannamei, which do graze on organisms that occur naturally in the ponds.

Pond liners

Water recycling within the farm in order to eliminate the sludge as well as maintaining the desirable balance of bacteria, algae and nutrients.

Zero exchange of water with the environment

Bio-security for keeping the disease out

Lots of mixing and aeration of pond water

Removal of sludge from center drains

An appropriate source of cheap carbohydrate such as wheat and molasses for bacteria-based food chain stimulation

Buildings or greenhouses for keeping temperature above 30degrees centigrade

A laboratory for water quality assessment and disease diagnosis

Methods to be applied

Nursery and Grow-Out

By definition, nursery phase is an intermediate step that exists between grow-out phase and post larvae that are hatchery-reared. Several benefits are presented by this phase and they include increase in survival, farm land optimization and growth performance that is enhanced in grow-out ponds (49). Biofloc technology can be applied successfully in this nursery phase in various shrimp species such as pacific white shrimp. The benefit observed is associated with appropriate nutrients through continuous biofloc consumption, which could influence positively the performance of grow-out. Furthermore, farm facilities optimization offered by high stocking density in biofloc technology nursery phase tends to be a critical in achieving profitability in small farms.

Breeding

The application of biofloc technology has been a success for grow-out, but there is little known about the benefits of biofloc on breeding. For instance, in the industry of shrimp with a wide spread of viruses globally, the application of closed-life brood stock tends to be a priority in terms of guarantee biosecurity, hence vertical transmission is prevented (Emerenciano et al., 12). Furthermore, such industry puts a consideration on penaeid breeding program. Alternative to this, breeders which are raised in biofloc technology that is limited or system that is zero water exchange are considered to benefit nutritionally through natural production (bifloc) which is available for 24 hours a day (Panjaitan et al., 8). In regards to the management of shrimp broodstock, one critical management procedures is related to control of stocking as well as stocking density (McIntosh et al., 21). High solids level affects negatively the health of shrimp.

The “ natural probiotic” impact of biofloc

Biofloc could be a novel approach for management of diseases in contrast to conventional strategies like probiotic, antibiotic, prebiotic and antifungal application. The effects of natural probiotic in biofloc technology might act globally against vibrio sp. for instance as well as ectoparasites respectively. Such effect is enhanced by large microorganisms groups, but majorly bacteria considered being the 1st level in the system (McIntosh et al., 11). Bacteria together with its compounds synthesized, internally could be bio-control agents that are effective, as well given a beneficial microbial balance of the host in the gut. Externally, the biofloc microorganisms' working mechanism against pathogens tends to be through completion of nutrients, substrate and space. Certain essential nutrients like nitrogen are needed by both groups that limit their growth.

Aquaponics

It is a food production system that is sustainable and it combines hydroponics with traditional aquaculture in an environment that is symbiotic. There is efficient recirculation of water as well as the water is reused for maximum benefits through natural biological recirculation and filtration. The excreted waste by uneaten feed or aquatic species is converted naturally into nitrate as well as into other nutrients which are beneficial in the water. Such nutrient are later absorbed by fruits and vegetables in a " natural fertilization manner"

Currently, biofloc technology has been used successfully in aquaponics. Rich –biota (biofloc microorganism presence) as well as nutrient variety like macro and micronutrients emerging from non digested and un-eaten feed tends to contribute in nutrition of plants(Ray et al., 13). The most common example of aquaponics and biofloc interaction was as well developed by UVI. The Biofloc technology application in aquaponics however requires a specific attention, majorly on solid levels management in water (Ray et al., 23). High solid concentration could result to excessive microorganism adhesion on the roots of plants (biofilm), hence damaging it, poor growth and lowering oxygenation. Settling and filtering devices are frequently required.

System management during startup

In biofloc system, changes in water quality during start up are similar to the conventional re-circulating systems. There are time lags in peaks concentration of ammonia then later nitrites in the course of the development of bacteria for this system startup. In case there is a rapid increase in feeding rate, the ammonia concentration or nitrite might increase to a level where it will be toxic, hence affecting the growth of shrimp, disease resistance, feed conversion as well as survival (Emerenciano et al., 7). The startup duration is based on a wide range of factors that include feeding rate, temperature, and pre-seeding. The biofloc system acclimation protocol is not standardized and different techniques have been developed by most system operators through hard-won experience. Before stocking, the nitrifying bacteria could be grown in tanks referred to as stand-alone which are later added to rearing tanks. Addition of water or sludge from the system that was previously acclimated is as well an effective strategy to seeding a new pond or tank despite the exercise represents a biosecurity risk (Emerenciano et al., 4).

Discussions and Recommendations

There is increase in interest on closed aquaculture systems because of environmental, biosecurity and marketing advantages over semi-intensive and conventional extensive systems. In case there is reuse of water, certain risks like waste water discharge and pathogen introduction are reduced or eliminated. In addition, due to reduced water use and high productivity, marine species could be raised at in land locations as well as desert. Biofloc consumption by shrimp has indicated several benefits like growth rate improvement and decrease in related costs in feed. The enhancement of growth is attributed to both algae and bacteria nutritional components. Brood stock at a hatchery will be cultured to post larvae (PLs) (Emerenciano et al., 6). These are prepared for culture farms. Larvae can be cultured in small tanks. The sea water can be pumped from the central reservoir. The water will be removed through a drain or by siphoning. The culture temperature will be maintained at 27-32 degrees centigrade while the salinity at 33ppt and the pH of 8-8. 3. (Forbes, 1992)

In conclusion the development of re-circulating systems have reached a point where they are applied in research for staging and maturing brood fish, for tropical/ornamental fish culture and for advanced production of fingerlings. They continue being a venture that is expensive and it is more of art than science, mostly in terms of management. Basing on these, it is advisable to do extensive research before making a decision on investing in a re-circulating system. It is appropriate to investigate the compatibility, efficiency, as well as maintenance component requirements. The operating and management cost as well as the marketing of the shrimp need to be estimated without any return on investment for a period of about 2 years (Ray et al., 15). The species to be grown, their environmental requirements, the diseases that are most common in their culture as well as the way these diseases are treated should be known. The potential market for this particular species to be grown should be known as well as the way this species need to be prepared for that particular market . It is essential to be realistic about effort, time and money that is to be invested while still learning how to manage the re-circulating system. Lastly, the system is required to be designed with an emergency aeration system, backup system components and backup power. The water quality should be monitored as well as maintaining at ranges that are optimal. At stocking it is essential to exclude diseases. Routine diagnostics checks is important and always be prepared in treating diseases. The stress reduction is essential hence be alert always (Ray et al., 19)

Biosecurity implies that RAS can be operated with no drugs, chemicals or antibiotics. These leads to the production of product that is natural to the consumers. Pathogen entry is normally through water supply and it’s considered to be a regular route. Therefore, RAS water is usually disinfected first or the water is got from water that has no vertebrates considered to be pathogen carriers. The requirements of biosecurity considers that designing of systems should allow easy cleaning; frequently and completely so that the pathogens can be reduced. RAS being cleaner as well as self-contained, it implies that the system can be situated anywhere including land locked areas or near markets rather than near the natural water sources like rivers or oceans. There is no need to stage RAS near water supply for drainage or water supply (Ray et al., 14). In case, RAS is located near the communities, and this implies that the community might have a minimal carbon footprint because of shipping distance that is reduced as well as fresher products supply to consumers. The production levels of RAS are seen to be higher when compared with the other aquaculture types. The environmental conditions are observed to be controlled by RAS. Hence, as a result, there is high production and this enables optimal annual growth.

In RAS, the standard water parameters include temperature dissolved oxygen, ammonia suspended solids, pH, alkalinity, carbon dioxide and nitrite. There is interrelation between these parameters in a complex series of chemical, physical as well as biological reactions. In order to maintain the total system’s viability, it is very critical to monitor as well as make adjustments in the system. There might be a variation in the components considered to address such parameters in the systems. In the shrimp culture, external settling chambers are considered to be the mechanism employed in controlling the concentration of suspended solids (Emerenciano et al., 12). The facilities of RAS need energy in varying quantities in order for the machinery to run to move water through the system as well as in the treatment processes. There is fewer machinery pieces used in facilities for shrimp farming and in aquaponics . Hence this means that there is reduction in energy consumption or demand.

Systems of biofloc shrimp culture are considered to be the best alternative to traditional shrimp aquaculture. Basing on the shrimp producer goals, the systems could be operated as super intensive when the microbial communities are managed according. Although the risk involved is that there could be biological or mechanical related problems like depletion of oxygen . Consequently, shrimp crops might be generated with use of limited water or land (Emerenciano et al., 9). There should be a unique management and engineering criteria for these super intensive systems. Biofloc systems location is considered to have economical implications. The most critical consideration in these systems includes solid management, oxygen, water propulsion, required shrimp density etc. There is need for development of these super intensive biofloc to contribute to the development of aquaculture.

Works Cited

Ray AJ, Lewis BL, Browdy CL, Leffler JW. Suspended solids removal to improve shrimp (Litopenaeus vannamei) production and an evaluation of a plant-based feed in minimal-exchange, superintensive culture systems. Aquaculture 299: 89-98. 2010. Print

Panjaitan P. Field and laboratory study of Penaeus monodon culture with zero water exchange and limited water exchange model using molasses as a carbon source. Ph. D. Thesis, Charles Darwin Univ., Darwin, NT, Australia. 2004. Print

McIntosh D., Samocha T. M., Jones E. R., Lawrence A. L., McKee D. A., Horowitz S. & Horowitz A. The effect of a bacterial supplement on the high-density culturing of Litopenaeus vannamei with low-protein diet in outdoor tank system and no water exchange. Aquac Eng 21: 215–227. 2000. Print

Avnimelech Y, Mokady S. Protein biosynthesis in circulated ponds. In: Pullin RSV, Bhukaswan T, Tonguthai K, Maclean JL, editors. Proceedings of Second International Symposium on Tilapia in Aquaculture, Departament of Fisheries of Thailand and ICLARM, Manila, Philippines, pp. 301–309. 1988. Print

Emerenciano M, Ballester ELC, Cavalli RO, Wasielesky W. Effect of biofloc technology (BFT) on the early postlarval stage of pink shrimp Farfantepenaeus paulensis: growth performance, floc composition and salinity stress tolerance. Aquac Int 19: 891- 901. 2011. Print

Emerenciano M, Cuzon G, Arévalo M, Gaxiola G. Biofloc technology applied to intensive broodstock farming of pink shrimp Farfantepenaeus duorarum (Part II): spawning performance, biochemical composition and fatty acid profile. Aquac Res. 2012. Print

Zohar and Yonathan. " Environmentally compatible, recirculated marine aquaculture: addressing the critical issues." Clean, Green, Sustainable Recirculating Aquaculture Summit. Washington D. C.: hosted by Food and Water Watch. 2009. Print

Lee and Richard. " Rapid growth of black sea bass Centropristis striata in recirculating systems with geothermal cooling, solar heating, tilapia diet and microbial mat/seaweed filter." Clean, Green, Sustainable Recirculating Aquaculture Summit. Washington D. C.: hosted by Food and Water Watch. 2009. Print

Mungkung, R. T. Shrimp aquaculture in Thailand: application of life cycle assessment to support sustainable development. PhD. thesis. Center for Environmental Strategy, School of Engineering, University of Surrey, United Kingdom. 2005. Print

Hernández, C., Olvera-Novoa, M. A., Aguilar-Vejar, K., González-Rodríguez, B., Abdo de la Parra, I.,. Partial replacement of fish meal by porcine meat meal in practical diets for Pacific white shrimp (Litopenaeus vannamei), Aquaculture 277, 244–250. 2008. Print