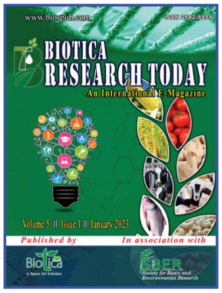

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Recirculatory Aquaculture System

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Abstract

Aquaculture is primarily important for food production around the world. A recirculatory aquaculture system is a unique way to produce fish that requires less than 200 days. In aquaculture, biofilters play an important role by removing ammonia, which reduces the overall cost of the system and saves more than 99.5% of water use. This method is focused on limited water exchange by bio-filtration. Recirculation allows for complete control of parameters such as salinity, dissolved oxygen, temperature, pH, alkalinity, and so on.

Introduction

Aquaculture is one of the main sources of food and food products in the world. Recirculatory aquaculture was established in Japan in the 1970s. The RAS system is a unique way to produce fish and is a closed system. RAS technology saves more than 99.5% of water, enabling production under optimally controlled conditions, making it the most efficient and environmentally friendly solution for land-based fish farming. This method is mainly dependent on limited water exchange and biofiltration. It requires only a short duration, which is less than 200 days. RAS is also suitable for high stocking densities. In California, they are developing polyculture farming using the RAS system. This system produces approximately 60 metric tonnes of fish per year from an area of 1/8 hectare or 1/6 hectare. RAS methods have advantages over aquaculture methods, such as biosecurity, controlled water parameters, higher earnings from high production, limited water usage, *etc*. Recirculatory systems can be housed in buildings like prefabricated metal buildings, green houses, and warehouses (Davidson *et al*., 2011).

Culture Method

After spawning, eggs are periodically collected from female fish housed with males. The collected eggs are washed and hatched in separate containers. After 30 days, juveniles are collected and kept in separate tanks called the RAS Juvenile System. The juveniles are fed zooplanktons for two months to help them grow. When juveniles are grown to the fingerling stage, dry pellets can be used as feed. The feeding ratio is dependent on the species of fish. The feed should consist of 36% protein, and the feed-to-fish weight ratio should be 1.6:1. The feed conversion ratio (FCR) of RAS is lower than the FCR of the biofloc method. Water quality is maintained throughout RAS by different stages of filteration: biofiltration, carbon dioxide degassing, solids collection, and a biological container. And the final step before returning the filtered water is treating it with oxygen using bubble contactors. Thus, 8.85% of the water is reused with the help

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of this technique. The solids and ammonia-laden waste water is routed to waste water treatment.

Recirculatory Process

In this process, water is recirculated multiple times with the gradual addition of fresh water to the system. The fish tank water goes to a mechanical filter where feed particles and fish excreta are filtered out. Then the water is passed through a carbon dioxide degasser, where the carbon dioxide content in the water is dissolved. After the removal of dangerous gases, oxygen is added to the water with the help of oxygenation technologies so that the water can be used by fish when it goes back to the tanks (Figure 1).

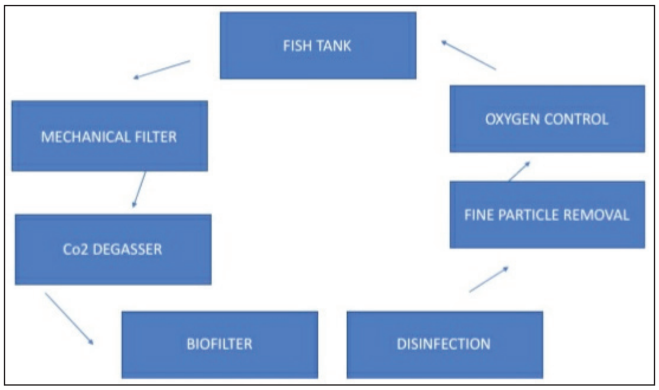

Figure 1: Recirculatory Aquaculture System (RAS) Process

Requirements of RAS System

Recirculation components: Pump house, 3-phase electricity, generator, and bulk feed storage.

Shape of the tank: It should promote uniform mixing and removal of solids as quickly as possible. Circular and octagonal tanks provide the above properties.

Size of the tank: Larger tanks are better in terms of cost and management. Tank sizes of 50 m^2 to 300 m^2 have been used commercially for grow-out systems.

Removal of Nitrogen Excretory Products

Nitrogen is the major waste product of aquatic animals. Nitrogen can be removed by bacteria (Nitromonas and Nitrobacter). Denitrification is the process by which bacteria convert ammonia in their excreta to nitrate. It involves two steps: Bacteria use ammonia to produce nitrate Nitrogen is the major waste product of aquatic animals. Nitrogen can be removed by bacteria (Nitromonas and Nitrobacter). Denitrification is the process by which bacteria convert ammonia in their excreta to nitrate. It involves two steps: Bacteria use ammonia to produce nitrate. This nitrate is further converted into nitrite by the bacteria. Free ammonia is toxic to fish at low levels (0.02-0.6 mg L^{-1}). When the pH is acidic, a higher fraction of ionised ammonia is present, and when the pH is basic, a higher concentration of free ammonia is present. The RAS allows a total ammonia nitrogen (TAN) level of 3 mg L^{-1}.

Table 1: Parameters in RAS

Parameter	Optimum level
Oxygen	70-100%
Nitrogen	80-100%
Carbon dioxide	10-15 mg L^{-1}
Ammonium	0-2.5 mg L^{-1}
Ammonia	< 0.01 mg L^{-1}
Nitrite	0-0.5 mg L^{-1}
Nitrate	100-200 mg L^{-1}
pH	6 5-7.5
Alkalinity	1-5 mmol L^{-1}
Phosphorus	1-20 mg L^{-1}
Suspended solids	25 mg L^{-1}
COD	25-100 mg L^{-1}
BOD	5-20 mg L^{-1}
Temperature	28 °C

Biological Filter

The aim of a biological filter is to maximise the surface area available and provide a suitable environment for the growth of nitrifying bacteria. Examples: bead filter, RBC, moving bed biofilter, k1 media, k5 media.

Oxygen Supply

Dissolved oxygen is the first factor that limits increased carrying capacity and production in intensive recirculation systems. Aeration supports a maximum of about 40 kg m^{-3} of biomass. Diffusers are used to bubble atmospheric air into water. When aeration is used, CO_2 buildup is not generally a problem. Pure oxygen is injected into the fish tank through an oxygen cone to increase the gas transfer efficiency (nearly 90%).

Disinfection

Reduce the load of pathogenic bacterial load. Normal UV dose on the range 30 to 35 mWs cm^{-2} for bacteria and 100 to 200 mWs cm^{-2} for viruses. Commercial system

Table 2: Advantages and disadvantages of RAS (Guttman and Rijn, 2008)

Advantages	Disadvantages
Greatest control	Increased cost
Flexible location	Technical knowledge
Waste control	Power required
Minimal space	Back-up power needed
Efficient production	

utilities both ozone and UV disinfection.

Conclusion

This system is critical for long-term fishery sustainability. This principle can be used to maintain ecological balance while increasing the productivity of cultural species. This is an economical method where the treatment cost of water pollution is reduced. Since the nutrient-loaded water in the tank might pollute the water. Pond management in the RAS is simple. Thus, adapting RAS will transform the fish farm into a highly productive one.

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