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Recent trends in aquaculture

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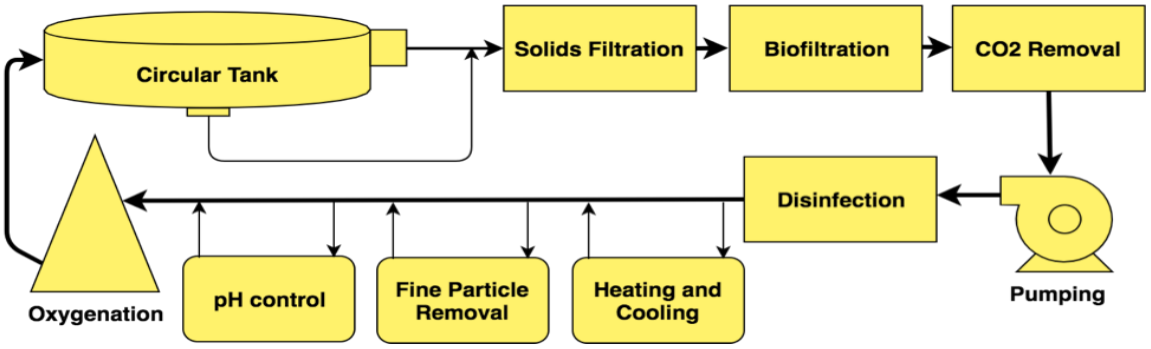
Introduction

Recirculatory Aquaculture System (RAS) is a technology where water is recycled and reused after mechanical and biological filtration and removal of suspended matter and metabolites. This method is used for high- density culture of various species of fish, utilizing minimum land area and water. It is an intensive high density fish culture system where fish are typically reared in indoor/outdoor tanks in a controlled environment. Recirculating systems filter and clean the water by recycling it back to fish culture tanks. New water is added to the tanks only to make up for splash out, evaporation and that used to flush out waste materials. Less than 10% of the water in the regulated indoor or outdoor tanks used to raise fish is replenished every day. The management of recirculating systems relies heavily on the quantity and quality of feed and the type of filtration. Numerous filter designs are used in recirculating systems, but the overall goal of all filtration is to remove metabolic wastes, excess nutrients, and solids from the water and provide good water quality for the aquatic organisms. However, to encourage small-scale fish farmers and entrepreneurs and to facilitate fish production in urban and semi-urban areas where land and water are scarce, it is proposed to promote Backyard Recirculation Aquaculture Systems.

What is a recirculating aquaculture system?

In a recirculating aquaculture system, the culture water is purified and reused continuously. It is an almost completely closed circuit. The produced waste products; solid waste, ammonium and CO_2, are either removed or converted into non-toxic products by the system components. The purified water is subsequently saturated with oxygen and returned to the fish tanks. By recirculating the culture water, the water and energy requirements are limited to an absolute minimum. It is however not possible to design a fully closed recirculating system. The non-degradable waste products must be removed and evaporated water must be replaced. Still our recirculating systems can reuse 90% or more of the culture water. To ensure good water purification, recirculating systems consist of several components with specific functions.

Both systems are perfectly capable of removing the ammonia from the system water. The choice of biological filtration is depending on many factors (e.g. available space, outside temperature, energy costs, etc.)



Objectives:

- To encourage small-scale farmers and women to take up fish culture in household backyards.
- To enhance fish production and consumption in daily diet.
- To promote income generation from small-scale fish farming and to improve livelihoods

What is required to set up an RAS unit?

- Land of approx. 100 sq. m land
- Good water source
- Source of seed and feed

Basic principles of a recirculating aquaculture system:

A basic Recirculating system consists of the following components:

- Water supply
- Fish tank
- Mechanical Filter
- Biological Filter
- Pump tank
- Pump
- Other items (e.g. UV-C light, oxygenation devices, aeration devices, feeders, monitoring, etc.)

Water supply:

A good supply of water, adequate in both quantity and quality, is essential to a successful fish farming in RAS as well as other. Ground water obtained from deep wells or springs is the best source of water for fish culture. As it is generally free of pollutants and has relatively high hardness levels, which are beneficial under some circumstances. Municipal

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water supplies also can be used after chlorine, fluoride, and other chemicals are removed. Other sources of water, particularly surface waters from streams, rivers, ponds, and lakes, are not recommended for fish culture. Surface waters may contain fish diseases, parasites, pesticides, and other pollutants that can kill or slow the growth of fish. Testing the quantity and quality of the available water supply is one of the first steps for a prospective fish farmer to take to insure an adequate supply of high-quality water. Because RAS recycle most of their water, they consume considerably less than other types of culture and are especially well adapted to areas with limited water supplies. The required quantity of water needed to grow fish varies with the species of fish selected, size of the culture system, and investment size. As a general rule, a minimum water volume of 1-5 gallons is needed for every pound of fish reared and minimum water flows of 10-25 gallons per minute (more for trout) are needed to grow 50,000 pounds of warm water fish per year.

Fish culture tanks:

Fish can be cultured in tanks of nearly every shape and size., but for easy cleaning and improved water circulation, circular or oval tanks with central drains are recommended, as they are easier to clean and circulate water than rectangular ones. Rectangular tanks are usually built with or set upon inclined floors to facilitate cleaning and circulation. Rearing tanks range in size from 500 to 500,000 gallons capacity. The size of the tank depends on a variety of factors including: stocking rates, species selected, water supply, water quality, and economic considerations. To ensure proper synchronization, tanks must be compatible with other system elements, particularly the sump and biofilter. Tanks can be constructed using plastic, concrete, metal, wood, glass, rubber, or any other sturdy, non-toxic, non-corrosive material that retains water. Fish injuries can be avoided and cleaning is made easier with smooth interior surfaces. Smooth surfaces inside of the tanks are recommended to prevent skin abrasions and infections to the fish, and to permit cleaning and sterilization. Light weight, durable, plastic tanks can be conveniently moved and readily cleaned, when necessary, but they require special support to prevent stretching when filled with water. Stainless steel is also good, but can be expensive. Marine-grade plywood tanks are inexpensive, but leak if not properly sealed and are not as durable as tanks of other materials. Concrete tanks may be the most economical to build, but they are relatively permanent and immovable structures once constructed. Non-toxic plastic or rubber liners can be used over frames made of wood, metal, concrete, or other materials.

Mechanical filter:

In a RAS system the mechanical filter is used to remove the suspended solids from the system water flow. These solids, primarily faecal matter, need to be removed to maintain water quality.

Biological Filter:

As a waste product of breaking down proteins, fish produce ammonium that is toxic if it accumulates. Beneficial bacteria in moving bed (up flow) filters and bio towers in RAS convert ammonium into nitrite, which is further reduced to the less harmful nitrate. Under these optimal conditions for nitrifying bacteria, these filters ensure fish-safe water quality.

Other RAS Components:

RAS may consist of UV-C units, oxygenation and aeration equipment, automatic feeders, and monitoring systems in addition to core filters. Depending on what the cultivated species needs, these elements are added.

UV-C Light

To manage microorganisms in system water, UV-C light (200–280 nm) is a potent germicidal radiation. Even at low dosages, it successfully inactivates bacteria, viruses, and fungus while preserving clear, particle-free water.

Components of RAS:

- Insulated shed/ Building
- Store cum office for feed and accessories
- Pump house
- Grow out tanks: Circular cement tanks/ FRP tanks, including inlet, outlet central drainage
- Settling tanks for sludge
- Water Storage (sump) tanks
- Overhead tanks.
- Mechanical (Hydraulic) filters, Drum filter, Glass wool/ muslin cloth filter
- Pumps and motors ã Power generator ã Sludge collector, settelable/ solid collectors
- Biofilters, UV units
- Electrification
- Automatic feeder (wherever required)
- Aeration system (air/ oxygen), Carbon dioxide trapper system (degasser)
- Water testing kit
- Water supply system, bore well etc. (wherever required)
- Inputs such as Seed, Feed, additives and supplements, electricity/ Diesel, man power etc.

Fish species selection:

Numerous freshwater and marine species can be cultured using RAS. While red drum

and soft-shell blue crabs are popular maritime species, hybrid striped bass, channel catfish, and tilapia are common freshwater options. RAS works well for high-value species like striped bass or aquarium fish because it demands a large initial expenditure.

Because of their high market demand, well-established culture requirements, year-round fingerling availability, tolerance to crowding, rapid growth, and strong disease resistance, channel catfish and rainbow trout dominate U.S. aquaculture. However, with warm, recycled RAS water, cold-water species like trout and salmon usually perform poorly. On the other hand, warm-water species that are ideally suited for RAS farming include catfish, hybrid striped bass, shrimp, and mussels.

Species suitable for RAS

- Baramundi/ Asian Seabass/Bhetki (*Lates calcarifer*)
- Cobia (*Rachycentron canadum*)
- Silver/Indian Pompano (*Trichinotus Blochii/ Trichinotus mookalee*)
- Tilapia (*Oreochromis niloticus*)
- Pearl spot/Karimeen (*Etroplus suratensis*)
- Pangasius (*Pangasianodon hypophthalmus*)
- Rainbow Trout (*Oncorhynchus mykiss*), especially in Hilly/cold water Region

Feed and Feeding:

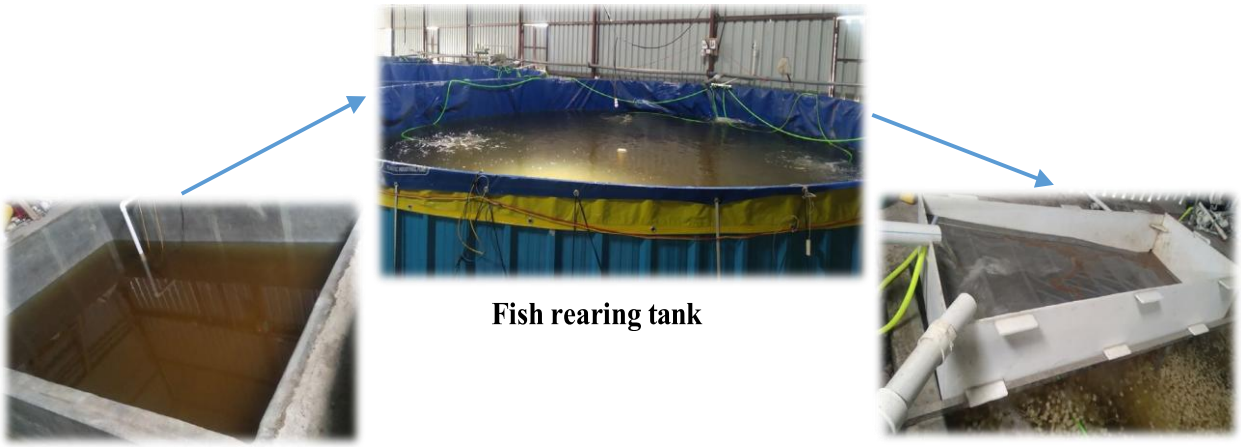
For RAS cultivation, a full, species-specific feed with all necessary nutrients is essential. Because various species need varying amounts of protein for optimal growth, only commercial fish feed should be used. It is advised to use floating pellets that are the same size as the fish in order to track eating habits and fish health. Small orders for feed should be placed, and it should be kept dry and refrigerated. If problems with feed contamination occur, it is helpful to have a frozen sample of every batch. Usually, fish are fed three to five percent of their body weight, or as much as they eat in five minutes. Avoiding uneaten feed is recommended because it lowers the quality of the water. A sharp decline in feeding is frequently a precursor to illness, low oxygen levels, or poor water quality. Feeding should be regular, ideally at the same time every day. Growth and feed efficiency are frequently enhanced by several short feedings. To avoid uneven growth, feed should be distributed equally. Automatic feeders can save labor in commercial RAS plants, even though manual feeding is still popular.

What & how to feed the fish?

- Pellet feed with 28-30% protein
- 2-4 times a day
- A high protein feed, containing all the essential minerals and vitamins

- Species specific feed
- Feeding can be done @ 3-5 % of the body weight of the fish depending on the quality and protein content of feed.
- More frequent feedings (several times per day) shall result in better growth rates and thus improved feed conversion ratio.

How RAS works?



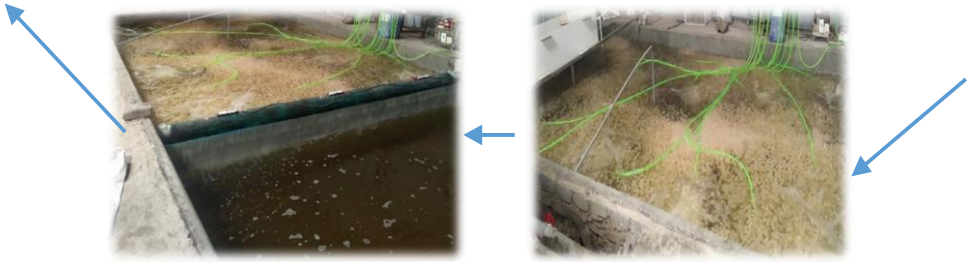
Fish rearing tank

Aeration/ oxygenation

Removal of CO_2

Mechanical filter

Removing the solid particles



Ozone and UV treatment

Biological filter

Ammonia removal by beneficial nitrifying bacteria

Advantages and Disadvantages of RAS:

Advantages:

- Extended durability of tanks and equipment
- Reduced dependency on antibiotics and therapeutants hence, advantage of getting high quality fish.
- Reduction of direct operational costs associated with feed, predator control and parasites.

- Potentially eliminate release of parasites to recipient waters.
- Risk reduction due to climatic factors, disease and parasite impacts.
- RAS production can promote flexibility in terms of location for farming, proximity to market.
- Enable production of a broad range of species irrespective of temperature requirements.
- Feed management is considerably enhanced in RAS when feeding can be closely monitored for 24 hrs.
- Exposure of stock to stress on RAS can be reduced for some factors such as adverse weather, unfavourable temperature conditions, external pollution and predation.
- Enable secure production of non-endemic species.
- Judicial use of water and land areas

Disadvantages:

- Constant uninterrupted power supply is required if electric power fails then backup of electricity is required.
- Capital cost of starting a recirculating aquaculture system is high as compared to ponds and raceways.

Desirable water quality to maintain:

Temperature	:	26-30 ^{0}C
Dissolved Oxygen	:	4-6ppm
pH	:	7-8
Alkalinity	:	120-150ppm
Ammonia	:	<0.5ppm
Nitrite	:	<0.5ppm
Nitrate	:	<5ppm
Hydrogen sulphide	:	Nil

Water Quality in Recirculatory Aquaculture System (RAS):

1. Temperature

Depending on the species, the ideal temperature can be as low as 14°C for Arctic char to as high as 30°C for *Penaeus vannamei*. Continuous monitoring is crucial since temperature has an impact on oxygen levels and biofilter efficacy.

2. Tank Water Level

Evaporation, fouling, valve adjustments, clogging, and leaks can cause variations in

water levels. Fish stress and system failure are avoided by ongoing electronic monitoring.

3. Recirculation Water Flow Rate

Maintaining water quality and eliminating waste depend on the right flow rate. Flowmeters or manual methods (timed collection) can be used to check flow. Regular assessments are necessary because fouling or blockage causes flow to steadily decrease.

4. Oxygen

In intensive systems, oxygen is frequently the first limiting factor. Depending on the system design, levels should be maintained between 70 and 250% saturation. Temperature and feeding increase the need for oxygen. Centralized systems in conjunction with individual tank oxygenation provide steady levels and offer emergency backup.

5. Nitrogen Gas (N_2)

Gas bubble disease can be brought on by too much nitrogen. TGP, or total gas pressure, must not exceed 101%. The system should be checked for pressured air leaks if supersaturation takes place.

6.Carbon dioxide (CO_2)

Fish release a lot of CO_2 gas, which lowers pH and has an impact on fish health. CO_2 levels should not exceed 25 mg/L. Alkalinity and pH sensors can be used to keep an eye on it. Adequate degassing capability must be maintained, as biomass grows.

7. Ammonium/Ammonia (TAN)

Above 0.025 mg/L, ammonia becomes poisonous. As pH rises, toxicity increases. Unionized ammonia is calculated using temperature and TAN levels. For acceptable ammonia levels and optimal biofilter performance, pH should be maintained between 7.0 and 7.5.

8. Nitrite (NO_2^-)

Even at concentrations as low as 0.10 mg/L, nitrite is dangerous. Adding salt (up to about 0.3 salinity) lowers toxicity if the biofilter isn't working well.

9. Nitrate (NO_3^-)

Nitrate levels exceeding 100 mg/L may inhibit growth, despite being less harmful. Increasing water exchange or employing denitrification are two ways to regulate it, particularly when water use is less than 300 L per kg of feed.

10. Alkalinity and pH

Fish health, ammonia toxicity, and biofilter effectiveness are all impacted by pH. Keep the alkalinity above 100 mg/L and the pH between 7.0 and 7.5. Carbonates or hydroxides are used to restore alkalinity, ideally through regulated dosage systems.

11. Phosphate

Phosphate is primarily eliminated by mechanical filtration and is not harmful. It is a vital plant nutrient in aquaponic systems (DAPS) and may require supplementation.

12. Total suspended solids (TSS)

Uneaten feed and faeces are included in TSS. 10–25 mg/L are the target levels. Solids are eliminated using filters such as beads, sand, drums, and settling basins. To preserve water clarity and prevent system redesign, adequate size is essential.

13. Oxidation-Reduction Potential (ORP)

When employing ozone, ORP is essential because it shows the equilibrium of reduced and oxidized molecules. Keep the voltage between 200 and 400 mV; fish are harmed by values above 500 mV.

14. Salinity

Each species has different salinity requirements. Electrical conductivity makes it simple to monitor and can be expressed in ppt or g/kg.

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