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# RECIRCULATING AQUACULTURE SYSTEM: A HIGHLY PRODUCTIVE CLOSED FISH FARMING METHOD

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India is the second-largest aquaculture fish producer and third largest fish producing country in the world. Fish and fisheries product accounts 10% of total production and 20% of agriculture products, contribute 1.24% of the national GVA and 7.28% to the agriculture GVA (Gross value added) of the country (2018-19). This sector emerged as the largest group in agriculture product, its product account 13.93 lakh metric tons in terms of quantity and Rs. Forty-six thousand five hundred eighty-nine crores in value during 2018-19.

This sector has vast potential to enhance fisheries and fish farmer income. Because of this, the Government of India launched a scheme "**Pradhan Mantri Matsya Sampada Yojana (PMMSY)**" that approved a total estimated investment of **Rs 20,050** crores in the fisheries sector to enhance blue revolution. To gets the benefits of this scheme, and for enhancing the income, farmers have to adopt the best techniques and method for fish production. Aquaculture, which contributes 65% of inland fish production, can increase the income of farmers. Different type of aquaculture system, such as cage culture, pen culture, irrigated or flow-through systems, tanks and raceways, etc., have been adopted by farmers. Nevertheless, these systems and methods required a larger land area, so, the farmer who does not have a larger land area is incapable of adopting this farming system. To solve this problem, scientist developed a closed fish farming system, which occupies the lesser area in comparison to other farming systems, known as Recirculatory aquaculture system. RAS system uses only a limited amount of water and reuses it if any farmer lives in limited water resources area can adopt this system. This system is ecofriendly because of low waste production, efficient utilization of feed and reuse of water.

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## What is RAS

Recirculation aquaculture system is a technology for farming of fish and other aquatic organisms, in which different type of mechanical and biological filters are used to remove the waste component from water, and after some treatment, water is reused again for culture the organism.

**Fig.1:** An Indoor recirculatory system.

## Equipment of RAS

**A)Tanks:-** Fish density determines the sizing of the fish tank. Three types of tanks commonly used for RAS.

I) **circular tank**:- fingerling and broodstock culture is dominate in a circular design. The inherent structure and hydrodynamic nature dominate the circular tank in ras industry. The walls of this tank are constructed by thin polyethene plastic or sturdier fibreglass materials. Solids waste eas remove due to its sloping centre bottom.

II) **Rectangular tank**: - In compare to circular tank, rectangular tanks are 20% more efficient in space utilization and easily harvested. However, solid waste movement is

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poor in this tank. Water quality problem rises if waste particle accumulated on the floor of the tank. So, the aeration system is used to clear these waste particles.

III) **Raceway tanks**: -This type of tank often seen in marine culture. To facilitate the control of water's circulation, a third wall is situated along the length of the tank. It is the best tank in all the three tanks.

B) **Circulation units**: - Major source of energy consumption in the RAS system is water pump or air blower which circulate the water in tanks. Failure of this unit creates severe water problems. Mainly three types of pumping system used in tanks are centrifugal, axial flow and airlift pumps.

C) **Carbon Dioxide Removal unit**: - carbon dioxide is highly soluble in compare to oxygen a tremendous amount of carbon dioxide gas produce by fish and bacteria in poorly managed RAS system. Due to the high level of $CO_2$, pH level decrease and functioning of nitrifying bacteria are reduced; resulting in a rise in ammonia level. For better production removal of CO2 is very necessary and it is done by blown air system or by unpressurized packed columns (spray tower).

D) **Solids removal**: - Fish, crustacean and other aquatic organism excrete faeces in the form of solid, after feeding. These solid materials break down into excellent particles that promote bacterial growth which interferes with water quality and odour of water. Waste solid is removed by Sedimentation, Swirl separators, Screen filters, Bead filters, Double drain.

E) **Biological filters unit**: - this unit help in the removal of solid waste by the help of bacterial action. The essential function of biofilters unit is the removal of dissolved organic material such as sugar, starches, fat, protein, which is excreted by aquatic culture organism. Nitrification process, conversion of ammonia (toxic nitrogen form) into nitrate (a nontoxic form), in the water is done by the bacteria which is cultured on the filters in suspension or fixed-film attached form. Different type of filters such as Fluidized bed filters, Mixed bed filters, Trickling filters, Rotating bio contactor, etc. are used to remove waste from water.

F) **Aeration (oxygen addition) unit**: - this unit transfers the oxygen into the water. Oxygen is a limiting factor in culturing of species because it is low solubility in water. Warm water RAS system is operating at 5 to 6 ppm, and cooler RAS system is operating at eight ppm of oxygen concentration. It is a most critical unit of RAS system because fish and bacterial

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organism continually consume oxygen, a sho term of interference with this unit lead a complete loss of cultured fish. Aeration in the tanks in done by Airstone diffuser, Packed column, Down-flow contactor, Low head oxygenator, U-tube, etc.

G) **Disinfection unit**: - It is a necessary process in recirculation. This unit is mainly required when stock is highly valuable, and the threat of disease is high. Many time water source and fingerling or new stock are infected with bacteria or other microorganisms which leads to severe loss in production. So, disinfection of water is necessary which is done by UV light and ozone treatment, due to its easy installation and operation UV light mostly used as a disinfectant.

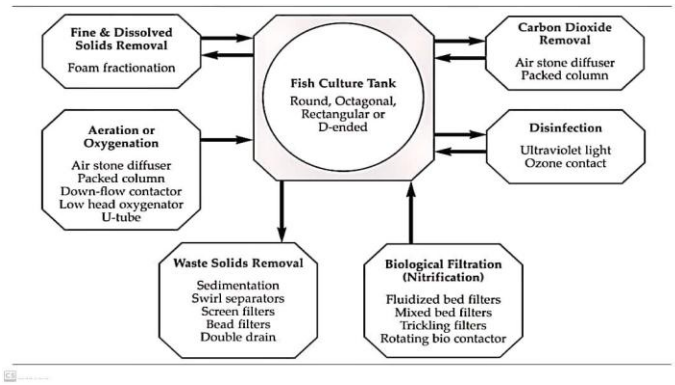


**Fig 2:** Required unit processes and some typical components used in recirculating aquaculture production systems.

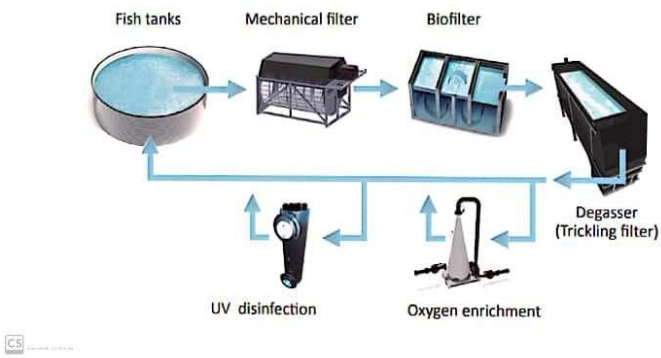


**Fig 3:** Recirculatory system with required units.

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## Water quality management

In the recirculatory system, water quality management is essential because of better fish production and for active growth of bacteria in biofilters. Water quality parameter, which is essential, is described below.

A) **Temperature**: -Each species has its optimum range of temperature for growth. So, the temperature of water in the RAS system should be maintained according to species. At optimum temperature, fishes convert feed efficiently and show resistance to many diseases. Biofilters also affected by water temperature.

B) **Dissolved oxygen**:- for optimum fish growth, should be maintained at 5ppm in the fish tank. In biofilters, maintain of DO is necessary so that it can remove maximum ammonia and nitrite from the tank. Nitrifying bacteria become inefficient at or below two ppm level of DO. High feeding rate increase the respiration in fish which leads to high CO2 in tank decrease the DO level. So, a small amount of feeding at an interval of time is beneficial in the fish tank. To maintain all of this things aeration system should be work efficiently at 24 hrs.

C)**pH**:- Fish can tolerate a ph range from 6 to 9.5, but sudden change up to 2 unit in ph can be fatal for fish, especially fry. The optimum range of ph for biofilter bacteria is from 7 to 8. Bacteria in biofilters produce acid and CO2, which leads to a decline in ph. Nitrifying bacteria are inefficient below ph 6.8 and not able to remove toxic nitrogenous substances from the water below 6.8. this condition creates stress for fish culture and leads to death. So, the optimum range of ph in RAS tanks can be maintained by adding alkaline buffers, which are sodium bicarbonate, calcium carbonate, calcium hydroxide, calcium oxide etc.

D) **Solids**:- un-eaten feed particles and faeces are suspended down at the bottom of the tank in the form of solid waste. It should be removed quickly because it starts to decompose, which consume oxygen and produce ammonia and harmful gases( hydrogen sulphide). It can be removed by screen filters or settling.

E) **Water exchange**:- in RAS system, 5 to 10% should exchange each day so that water quality remained at the optimum level. It prevents the build-up of nitrogenous and soluble organic waste in tanks. Water should be exchanged entirely after each production cycle to reduce the build-up of wastes in tanks.

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A unit of water reserve should be made nearby tanks so that during emergency situation whole water of tanks can be flush and freshwater supplied for fish culture. Temperature and water quality should be maintained at the optimum level of this reservoir tank.

| **Guidelines for recommended water quality requirements of recirculating systems.** | |
|---|---|
| Component | Recommended value or range |
| Temperature | the optimum range for species cultured – less than 5°F as a rapid change |
| Dissolved oxygen | 60% or more of saturation usually five ppm or more for warmwater fish – >2ppm in biofilter effluent |
| Carbon dioxide | less than 20 ppm |
| pH | 7.0 to 8.0 |
| Total alkalinity | 50 ppm or more |
| Total hardness | 50 ppm or more |
| Un-ionized ammonia | less than 0.05 ppm |
| Nitrite | less than 0.05 ppm |
| Salt | 0.02 to 0.2 % |

## Suitable species

Selectivity of species for culture in RAS tanks depends on several factors, such as the profitability, environmental concerns, biological suitability. Small fish always recommended for RAS, because small fish grow at a faster rate, and environmental condition can be controlled easily until they reach optimum size.

It depends upon the commercial feasibility of growth, fish species grouped into different categories which are described below:

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| **Following fish have excellent biological performance and acceptable market condition** | | |
|---|---|---|
| **Common name** | **Scientific name** | **Optimum temperature for survival** |
| Arctic char | *Salvelinus alpines* | 14 °C |
| Atlantic salmon, smolt | *Salmo salar* | 14 °C |
| Eel | *Anguilla Anguilla* | 24 °C |
| Grouper | *Epinephelus spp* | 28 °C |
| Rainbow trout | *Oncorhynchus mykiss* | 16 °C |
| Seabass/ Seabream | *Dicentrarchus labrax / Sparus aurata* | 24 °C |
| Sturgeon | *Acipenser spp.* | 22 °C |
| Turbot | *Scophthalmus maximus* | 17 °C |
| Whiteleg shrimp | *Penaeus vannamei* | 30 °C |
| Yellowtail amberjack | *Seriola lalandi* | 22 °C |

| **The following fish have a low market price( good marketing and sales efforts are essential)** | | |
|---|---|---|
| **Common name** | **Scientific name** | **Optimum temperature** |
| African catfish | *Clarias gariepinus* | 28 °C |
| Barramundi | *Lates calcarifer* | 28 °C |
| Carps | *Cyprinus carpio* | 26 °C |
| Pangasius | *Pangasius bocourti* | 28 °C |
| Perch | *Perca fluviatilis* | 17 °C |
| Tilapia | *Oreochromis niloticus* | 28 °C |
| Whitefish | *Coregonus lavaretus* | 15 °C |

## Comparison between RAS and traditional culture

The water source of traditional culture system is mainly river, lakes or canals, which may contain harmful bacteria which can affect the production. Nevertheless, in the case of ras system, water sources are mainly borehole in which chances of bacterial contamination is very less. Traditional culture system mainly depends on natural foods so that production is deficient, and all water parameters can be affected by the natural condition. However, in the case of ras system, artificial feed is provided to the fish and all the parameter controlled

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artificially, so the impact of natural conditions is negligible. So, in all point of view, ras system has benefits over traditional culture system.

## Diseases control

Fish is a susceptible animal; a little change in water quality and temperature leads to stress in fish. The productivity of the farm can lose if stress condition remained for a long time and leads to diseases on the farm. Poor handling and water quality management lead many diseases on the farm. Before stocking of fish, it should be confirmed that eggs are diseases free. Otherwise, it leads to a significant loss of culture. There will always be the risk of diseases, such as IPN (Infectious Pancreas Necrosis), BKD (Bacterial Kidney Disease) and possibly herpes virus, that living inside the egg and cannot be eliminated even after disinfecting the eggs.

Most of the parasite diseases, even bacterial gill disease in the freshwater system can be kill by using ordinary salts. If any parasitic organism remains in tanks even after application of salt, then you can use formalin (HCHO) or hydrogen peroxide (H2O2). To cure ectoparasitic diseases, bathing of fish in the solution of praziquantel and flubendazole is efficient. Mechanical filters reduce the chances the spreading of ectoparasite in tanks, use of 70-micron filter cloth remove certain stages of Gyrodactylus, and 40-micron cloth remove different stages of the parasite in the tanks. Dipping techniques of eggs disinfect the eggs in a large amount within a short period, for example, a dipping solution of salt (7%) for 20 minutes is required to disinfect the eggs from fungus (Saprolegnia).

It is not always easy to find out the recommendation and exact amount of chemicals for treatment in recirculation. The application does vary according to the species, size, water quality, amount of organic matter, water exchange ration, etc. The guideline below is, therefore, very approximate.

- **Salt:-** In freshwater culture uses of salt is safe to treat diseases, such as Ich (Ichthyophthirius multiplies or white spot disease) and the common fungus Saprolegnia. Ich in pelagic phase can be killed at 10% and bottom-living stages at 15%. A concentration of 3-5 % of salt in hatcheries prevent infection with fungus.
- **Formalin(HCHO):-** For the treatment of following disease Ichthyobodo necator (Costia), Trichodina sp., Gyrodactylus sp., sessile ciliates, and Ich, low

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concentration of formalin(15mg/L) for an extended period (4-6 hrs.) is recommended. It also affects the working efficiency of biofilters and degraded fast at the rate of 8mg/h/m2 in biofilters.

- **Hydrogen peroxide($H_2O_2$)**: - It is not widely used but shows promising result in the substitute of formalin at the rate of 8-15mg/ml for 4-6 hrs. The biofilters efficiency decreases for 24 hrs. After the application of hydrogen peroxide, but it gains its working performance after some time.
- Use of other chemicals such as chloramine-t and copper sulphate are not recommended, these promising chemical result in the treatment of bacterial gill disease but this chemical severely affect the biofilter and damage all the recirculation process and production.
- The use of antibiotics to cure the bacterial infectious disease, such as furunculosis, vibriosis or BKD, is the only way in recirculation. Antibiotics are mixed with feed and fed for several days, for example,7-10 days.
- Treatment against IPN, VHS (Viral Hemorrhagic Septicemia) or any other virus is not possible. The only way to get rid of viruses is to empty the whole fish farm, disinfect the system and start all over again.

## Advantages and disadvantages of the RAS system

- Requires less water amount in comparison to ponds
- Can be located in more areas
- Its intensity is high (culturing more fishes in the lesser area)
- High environmentally compatible
- It is expandable (we can add new units on the bases of demand)
- In poorly managed RAS system, component failure, poor water quality, stress, diseases are common. Experts are required to maintain all of these things.
- An electrical failure can lead to catastrophic loss of fish in RAS.
- Biological filters can be damaged due to application of chemicals for disease treatment.
- High initial capital investment investments required for set up new RAS technology.

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## Conclusion

Pisciculture holds an immense potential, especially for the marginal farmers, to improve their financial condition. RAS system which has less area requirement at the same time higher monetary can be a good fantastic option for future fish farming.

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