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Design Specifications of Various RAS (Recirculating Aquaculture System) Filtration Components in Haryana, India

Paramveer Singh*[1], Rachna Gulati[1], Reecha Sharma[2] and Ashutosh Lowanshi[1]

[1]Department of Aquaculture, College of Fisheries Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India
[2]Department of Zoology and Aquaculture, College of Basic Sciences and Humanities, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

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ABSTRACT

This study provides a comprehensive analysis of the components and specifications employed in Recirculating Aquaculture Systems (RAS) by farmers in Haryana, India. The research surveyed 20 RAS farms, revealing diversity in the number of components used, with 40% of farmers utilizing five key components, including production tanks, drum filters, biofilter units, degassing aerators, and ultraviolet (UV) lights. Drum filters were the primary choice for 85% of farmers, with 82.35% using a 50-micron mesh screen. The study highlights the prevalence of Molecular Biofilm-Based Reactor (MBBR) for biological filtration, with all surveyed farms adopting this technology. Notably, 60% of farmers opted for K5 MBBR media. Production tanks, a fundamental component, were predominantly 50,000 liters in capacity, with some variations. Degassing aerators, UV sterilization, ozone units, and oxygen generators were commonly integrated into the RAS setups, showcasing the farmers' commitment to water quality management. Intriguingly, sand filters were preferred by only 40% of farmers, with diverse flow rates observed. The results also present insights into the mesh sizes of drum filters with 82.35% of farmers using 50 micron mesh size, emphasizing the farmers' consideration for efficient solid removal. The findings shed light on the technology choices made by RAS farmers in Haryana, providing valuable information for aquaculture practitioners and researchers aiming to enhance RAS efficiency and sustainability.

Key words: *Mesh screen size, Sand filter, Ozone, MBBR, Production tank*

Introduction

Recirculating aquaculture systems (RAS) are utilized to produce fish in areas with low water circulation, and biofiltration is necessary to minimize ammonia toxicity. Other methods of filtration and environmental management are frequently required to keep water clean and offer a suitable home for fish (Potnis *et al.*, 2022). Recirculating aquaculture systems (RAS) are intended to reduce or eliminate the need for water exchange and flushing fish culture units (McGee and Cichra, 2000). Modern recirculating aquaculture technology has been evolving for more than 40 years, but innovative technologies are increasingly offering methods to shift the paradigms of traditional RAS, including advances on basic processes like as solids collection, biofiltration, and gas exchange (Espinal and Matuliæ, 2019). Besides this, information on organic waste properties in recirculating systems is required for the correct design of equipment capable of extracting dissolved and fine organic wastes (Singh *et al.,* 1999). As a result, the components must be properly developed and placed. According to Modella (2007), the system comprises of (a) the water intake after total treatment, (b) the fish culture tank, (c) the reservoir tank, (d) the sand (physical) filter, (e) the bio filter, (f) the aerator-low head oxygenator, (g) the pump, and (h) the new water input. Moreover, recirculatory aquaculture system (RAS) is a very significant and helpful technique that necessitates the employment of a reliable manufacturer for its filetration system (Anonymous, 2022). The construction of an effective water treatment system is the most significant factor in the design of recirculating systems. Many key waste treatment procedures must be included in recirculating production systems (Ranjan *et al.,*2022).Whereas, micro-screen drum filters are a common option for the removal of suspended solid particles and are nominally graded by their screen aperture size measured in microns (Dolan *et al.,* 2013). On the curved surface of the drum, a minimum of 60 and a maximum of 200 micron-screen is normally included (Cripps and Bergheim, 2000). The usage of a 50 micron drum filter has a direct influence on the rate of filtration since 30-40 micron drum filter screens are better capable of filtering the smaller total suspended particles (TSS) that lead to RAS system pollution (Singh *et al.,* 2022). On the other hand, RAS biological treatment is essential for water reuse, and a biological filter's capacity is normally limited by its nitrification capabilities. Biological filters of various sorts are employed in RAS units (Malone and Pfeiffer, 2006). The kaldnes K1 biocarrier (AnoxKaldnes Company, Lund, Sweden) is used in the (Moving Bed Biofilter Reactor) MBBR, and several design modifications of the original Kaldnes K1 biocarrier have been created for use in the MBBR (Pfeiffer and Wills, 2011). Besides this, fluidized-sand beds are a cost-effective, efficient, and compact technique for eliminating dissolved wastes from recirculating aquaculture systems (Summerfelt, 2006).Fluidized bed filters are simply sand filters that work constantly in an enlarged backwash mode. Water runs up through a sand bed at a pace sufficient to raise and expand or fluidize the sand and maintain the particles in motion so that there will be short in touch with each other during filtration process.In RAS technology water flows through the contact chambers and into a shared receiving area. Pure oxygen is injected into the (Low head oxygenator) LHO at one end of the device into a single column segment (Vinci *et al.,* 2016). Dwyer and Peterson (1993) and Wagner *et al.* (1995) reported oxygen absorption efficiencies for LHO operation in freshwater fish hatcheries ranging from 65 to 91%, with a trend for decreasing oxygen absorption efficiency with increasing volumetric oxygen gas flow to water flow ratios (G/L ratio). Ozonation and ultraviolet (UV) irradiation have been utilized to treat relatively large aquaculture flows, including flows in recirculating systems (Summerfelt *et al.,* 2004). UV exposure can denature the DNA of bacteria, resulting in death or inactivation (Liltved, 2002). The germicidal range of 200-300 nm exhibits significant DNA absorption, resulting in a good first disinfection at 254 nm (Potnis *et al.*, 2022a). Maintaining healthy fish in a recirculating system entails maintaining acceptable dissolved oxygen levels, removing solid wastes, and ensuring proper ammonia nitrification (Ebeling and Timmons, 2009). Ozone is used in RAS as a disinfectant, as well as to eliminate organic carbon, turbidity, algae, color, odor, and taste. A variety of bacterial, viral, fungal, and protozoan fish diseases can be successfully inactivated by ozone (Gonçalves and Gagnon, 2011). The quantity of ozone necessary for treatment in a RAS is typically determined based on the daily feed rate. To decrease accumulated organics, rates of 10-15 g ozone per kg feed are commonly advised (King, 2001). Filtration and environmental management are frequently required in RAS to maintain clean water and offer a suitable home for fish (Potnis *et al.,* 2022).

Materials and Methods

Selection of RAS fish farm

Contact information of RAS farmers was obtained with the assistance of the State Fisheries Department and local fisheries advisors. Thirty RAS farmers were chosen at random from several districts in Haryana for this study, but following preliminary telephone conversations, only 20 RAS farmers agreed regarding the face-to-face interview based survey. These farmers are from the Haryana districts of Ambala, Bhiwani, Fatehabad, Gurgaon, Hisar, Jind, Kaithal, Karnal, Rohtak, Rewari, and Sonipat. Three farmers were chosen from

Fatehabad, two from Jind, Gurgaon, Karnal, Rohtak, and Sonipat, and one from Ambala and Kaithal (Table 1).

Table 1. Frequency distribution of Recirculatory aquaculture system (RAS) farms in Haryana

Districts	Total RAS Frequency	Percentage
Ambala	1	5
Bhiwani	1	5
Fatehabad	3	15
Gurgaon	2	10
Hisar	2	10
Jind	2	10
Kaithal	1	5
Karnal	2	10
Rewari	2	10
Rohtak	2	10
Sonipat	2	10
Total	20	100

Survey questionnaire preparation

The primary goal of this survey was to collect data on the specifications of various RAS filtering components. The questionnaire was created using literature and was discussed with fish farmers and academics from the Department of Agricultural Economics, College of Agriculture, CCSHAU, Hisar. Based on discussions and accessible research, the greatest number of closed and open-ended questions was included in this questionnaire.

Results and Discussion

RAS unit components and drum filter specifications used by RAS farmers of Haryana

In the present survey, 2 to 8 components in RAS unit were used by Haryana farmers (Table 2). Majority of farmers around 40 percent RAS farmers used 5 components *viz.*, production tanks, drum filter (Fig. 1), biofilter unit (Fig. 1), degassing aerators, ultra violet (UV) light (Fig.1) followed by 7 components; production tanks, drum filter, biofilter unit, degassing aerators, oxygen generator unit (Fig. 1), ozone unit (Fig. 1), ultra violet light by 30 percent farmers, 4 components (production tanks, drum filter, biofilter unit, ultra violet light) by 15 percent farmers, 2 (production tanks, biofilter unit), 3 (production tanks, biofilter unit, degassing aerators) and 8 (production tanks, drum filter, biofilter unit, degassing aerators, oxygen generator unit, Sand filter, ozone unit, ultra violet light) pump system (Fig. 1) components by 5 percent farmers each (Table 2). Ranjan *et al*. (2022) presented an overview of a typical RAS construction design and its components which include a total of 11 different components (tanks, pipelines, sedimentation tank, mechanical filters, storage pump, pump-

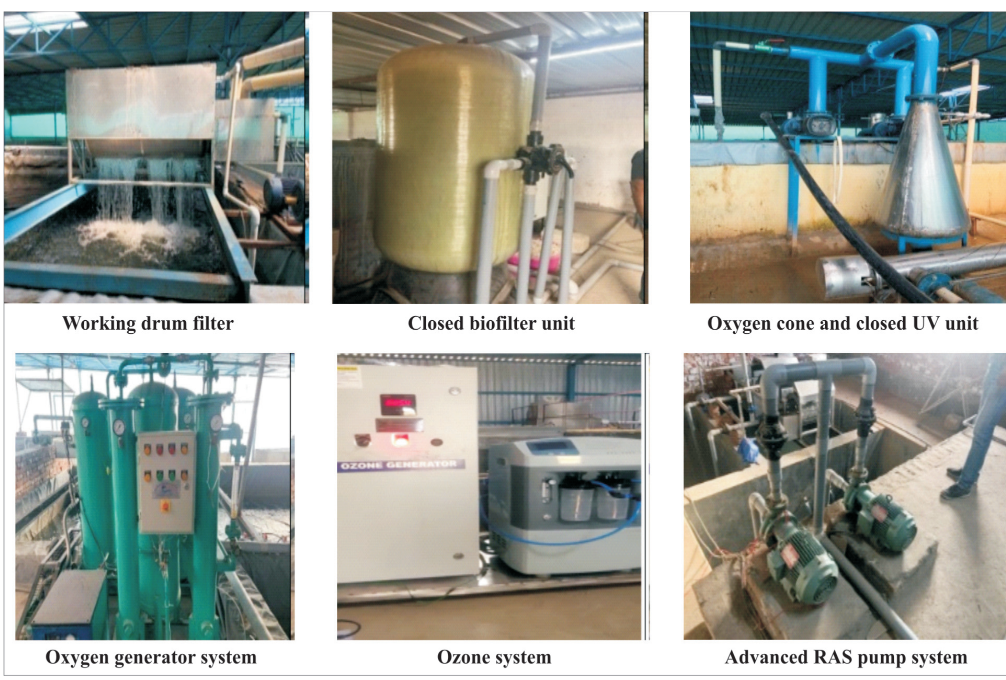

Fig. 1. Different RAS unit components used by RAS farmers of Haryana

ing system, biological filter, Protein skimmers, Degassing generator/Aeration system and Disinfestation). The functional parts of a RAS was also designed by Helfrich and Libey, 1991 which mainly included 5 components (Growing tank, sump of particulate removal device, (3) biofilter, (4) oxygen injection with U-tube aeration and, (5) water circulation pump). They also indicated the use of Ozone and ultraviolet sterilization which may be advantageous to reduce organic and bacteria loads. Aich *et al*. (2020) also included these 5 components into their RAS design. Zarazua *et al.*(2010) also constructed a RAS using low cost materials which included 4 components (production tank, Gravel filter, sand filter and biological filter). A 7 component RAS was designed by Potnis *et al.* (2022) including a main culture tank, racks, mechanical filter, biological filter, UV filter, Pumps and circulation pipes and lastly feed delivery system.

During study, it was also found that 85 percent RAS farmers in Haryana preferred to use drum filter as primary filtration component in comparison to 15 percent farmers who have not installed drum filter (Table 2). Out of the 85 percent, 82.35 percent

Table 2. RAS unit components and drum filter specifications used by RAS farmers in Haryana

Profile information	RAS unit components		Profile information	Drum filter	
	Frequency	Percentage		Frequency	Percentage
2 components	1	5	Yes	17	85
3 components		1	5	No	3 15
4 components	3	15	Total	20	100
5 components	8	40		Drum filter screen size (n=17)	
7 components	6	30	40 microns	2	11.76
8 components	1	5	50 microns	14	82.35
Total	20	100	80 microns	1	5.89
			Total	17	100
	Sand filter		Biological filter (MBBR based)		
Yes	8	40	**Yes**	20	100
No	12	60	**No**	0	0
Total	20	100	Total	20	100
	(RAS) Production tanks			Type of MBBR media (n=20)	
Yes	20	100	K1	8	40
No	0	0	K5	12	60
Total	20	100	Total	20	100
	RAS tank capacity		Degassing aerators (DA)		
50,000 litres	18	90	Yes	17	85
80,000 litres	1	5	No	3	15
1,00,000 litres	1	5	Total	20	100
Total	20	100			
	Powerof DA (n=17)		Ultra violet (UV)		
2 HP	7	41.18	Yes	18	90
4 HP	10	58.82	No	2	10
Total	17	100	Total	20	100
	Specification of UV (n=18)			Ozone unit	
100 watts	8	44.45	Yes	7	35
150 watts	6	33.33	No	13	65
200 watts	4	22.22	Total	20	100
Total	18	100			
	Efficiency of ozone unit			Oxygen generator unit	
50 mg/l	6	85.71	Yes	7	35
60 mg/l	1	14.29	No	13	65
Total	7	100	Total	20	100
	Oxygen generator specification (n=7)		Sand filter (n=8)		
50 LPM	2	28.57%	50,000 LPH	4	50
100 LPM	5	71.43%	1,00,000 LPH	4	50
Total	7	100	Total	8	100

drum filters were equipped with 50-micron mesh screen, 11.76 percent with 40 micron and 5.89 percent with 80-micron mesh screen, respectively (Table 2). Langer *et al.,* 1996 installed drum filter equipped with a 40 µm filter panel with a maximum flow capacity of 24 L/s at maximum solid load of 25 mg/l. Ali (2013) preferred drum filter that consisted of a woven metal mesh 100 µm. Mortensen, 2000 used three different mesh sized (30, 60 and 100 microns) and concluded that true efficiency of solids removal for the 30 micron mesh was estimated to be approximately 75 percent. In taken in account the usage of sand filters, only 40% of farmers preferred to use sand filter whereas the rest of farmers (12 farms) does not include sand filters into their RAS. Huguenin and Colt, 2002 stated that and filters of a variety of configurations remove suspended particulate matter and provide surface area for establishment of biofiltration biofilms, including those needed for nitrification of ammonia. Additionally, sand filters, found in 50% of farms, exhibit diverse flow rates of 50,000 LPH and 1,00,000 LPH, each constituting 50% of the sand filter installations. Huisman and Wood, 1974 demonstrated the slow sand filters which was built with smaller 0.15–0.35mm diameter media and operated continuously without backwashing at hydraulic loading rates of 0.1-0.4mh^{-1}.

MBBR based biological filter was used by all of the RAS farmers of Haryana. In support of the study, Johnson *et al*. (2021) also selected MBBR biofilter for their study because it provides the necessary removal rate of TAN for the expected carrying capacity of the system while affording ease in maintenance and operational energy use. Majority of farmers around 60% used K5 MBBR media whereas the rest used K1 MBBR media. Pfeiffer and Wills, 2011 reported that the K1 kaldness media was not efficient in reducing the influent TAN. Whereas, Johnson *et al*. (2021) preferred to use 1.0 m^{3}3 K3 media providing a total surface areas of 500 m^2 in their RAS setup. Molleda *et al*. (2007) experimented included two RAS system with and without biofilter and demonstrated that the biofilter was removing ammonia out the system but not in high amount to keep the TAN concentrations of the water outlet from the biofilter. Each RAS farms in Haryana had production tank and the production tanks in all surveyed farms have a capacity of 50,000 litres, except for one farm (5%) with a capacity of 80,000 litres and another (5%) with a capacity of 1, 00,000 litres. Edet *et al.* (2018) observed that 53.4 percent fish farmer's preferred small size of operational ponds (less than 5 in numbers) on their production sites, 33.3 percent had 5 to 10 production ponds and 13.3 percent had more than 10 ponds. Near about 17 RAS farms (85%) adopted Degassing aerators (DA), with a fairly even distribution between 2 HP (41.18%) and 4 HP (58.82%). CO_2-degassing units studied in literature are mainly operated as separate treatment units in the water treatment train of a RAS and are operated at high hydraulic surface loads of 61-86 m^3/m^2.h (Timmons and Ebeling, 2010), 90 m^3/m^2.h (Terjesen *et al*., 2013) and 60-84 m^3/m^2.h to 100-250 m^3/m^2.h (Summerfelt *et al*., 2001).

Ultraviolent sterilization is prevalent (90%) among the 18 RAS farms of Haryana, mostly utilizing 100-watt specifications (44.43%). Whereas 33.33% (6 RAS farms) utilized 150 watts of UV and rest 22.22% (4 farms) used 200 watts of UV. Bregnballe, 2015 stated that in order to control bacteria and viruses the water needs to be treated with roughly 2 000 to 10 000 µWs/cm^2 of UV light to kill 90% of the organisms, fungi will need 10 000 to 100 000 and small parasites 50 000 to 200 000 µWs/cm^2. Ozone units are present in 35% of farms (7 RAS farms), with an 85.71% efficiency at 50 mg/l, whereas only 1 RAS farm (14.29%) utilized 60 mg/l efficiency of Ozone unit. According to Bregnballe, 2015, ozone treatment is an efficient way of destroying unwanted organisms by the heavy oxidation of organic matter and biological organisms. In the context of oxygen generator units, it is noteworthy that they are utilized in 35% of surveyed farms, with a significant majority (71.43%) opting for units with a capacity of 100 liters per minute (LPM). In practice, respiration efficiencies for fish were recorded higher with pure oxygen (Mitchell and Kirby, 1976), when RAS was equipped with various sources of pure oxygen which includes compressed oxygen cylinders, liquid oxygen and on site oxygen generators (Losordo *et al*., 1999).

Conclusion

In summary, the study on Recirculating Aquaculture Systems (RAS) in Haryana reveals diverse configurations among farmers, showcasing varying choices in tank capacities, filtration components, and disinfection methods. Drum filters, MBBR-based biological filters, UV sterilization, and ozone units are commonly used, reflecting a commitment to water quality and fish health. The adoption of oxygen generators underscores the emphasis on maintaining dissolved oxygen levels. The findings highlight the dynamic nature of RAS technology and provide insights for both practitioners and researchers seeking to optimize aquaculture systems in different contexts.

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