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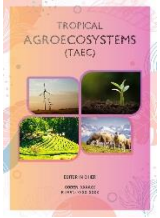

RESEARCH ARTICLE

RECIRCULATION AQUACULTURE SYSTEMS: COMPONENTS, ADVANTAGES, AND DRAWBACKS

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ABSTRACT

The culture of aquatic animals and plants under controlled or semi-controlled conditions is the world's fastest-growing food-producing sector. Many technologies are being innovated to date to enhance the assembly. But Recirculation Aquaculture System (RAS) is a far better option, with minimal environmental impacts, thanks to low effluents production from aquaculture ponds. It is a technology of farming aquatic organisms by reusing the water in production based on the use of mechanical and biological filters. RAS also minimizes water usage, disease occurrence, acts as a water treatment system, improves feed conversion, and shortens the production cycle. Overall, the principal components of the RAS and therefore the potential of this technique to be utilized in modern aquaculture have been discussed in this review paper to help scholars to understand the basic principle and its application with its merits as a water treatment system. Further research on the development of the RAS system with low price and high energy efficiency should be conducted. Moreover, the implementation of RAS in the natural systems and earthen pond may also benefit the farmer.

KEYWORDS

Biofiltration, water quality, nitrification, water treatment

1. INTRODUCTION

Aquaculture is the culture of aquatic animals and plants under controlled or semi-controlled conditions i.e., underwater agriculture. It's the world's escalating food-producing sector and possesses an appeal that allows it to be one among the foremost efficient sectors to supply high-quality animal protein with low environmental impact (Tidwell and Bright, 2018). Aquaculture in ponds requires an outsized number of water resources and acreage and produces a polluted effluent, which affects the environment in the future (Lin et al., 2003). Consistent with Losordo, Masser, and Rakocy for 1 acre of water area, approximately 1 million gallons of water is required to fill the pond and to compensate for evaporation and seepage during the year. This can be diminished by using the RAS within the fish farming business. RAS is one of the popular technologies throughout the world. It is a technology of farming aquatic organisms by reusing the water in production based on the use of mechanical and biological filters (Bregnballe, 2015).

It is designed to raise large quantities of fish in relatively small volumes of water by treating it to remove the toxic waste like ammonia and reusing it to grow the fish (Rakocy, 2003). This system provides an alternative production method for more cost-effective production when prevented by temperature, salinity, disease, water supply, and land availability (Malone, 2013). This system finds a new way to farm fish. Instead of farming fish traditionally outdoor, this system suggests farming fish at high densities in indoor tanks within the controlled environment (Helfrich and Libey, 1990). It uses a series of water treatment steps to depurate the fish-rearing water and facilitate its reuse. Recirculation aquaculture can be carried out with different intensities depending on how much water is recirculated or re-used (Bregnballe, 2015). New water is only added to the system when there is a loss of water due to splash or evaporation and to flush out the waste materials (Helfrich and Libey, 1990). This system can be efficiently used in places where a water source is very scarce by setting down the waterborne wastes into a concentrated and relatively small volume of effluent (Sharrer et al., 2007).


a. Circular with slopy bottom **b. Rectangular with circular edges**

Figure 1: Shape of tanks used for RAS (Malone, 2013)

Mostly the system uses tanks for production, so requires a relatively small production area (Losordo et al., 1998). Recirculating system filters and cleans the water that was used for fish culture and recycles it back to the fish culture tanks (Helfrich and Libey, 1990). A high amount of water volume of the production system is circulated through the mechanical or biological filters to be reused in the tanks (Almeida et al., 2019). For the rapid growth of the fish in the system, fish should be fed with high-protein pelleted diets with CP ranging from 1.5 to 15 percent of their body weight per day according to the size and species of cultured fish. In this system, almost all organic matter produced within the system from uneaten

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feed/diets, dead bodies, and excreta of fish, is not thrown with the effluents but are mineralized by the heterotrophic bacteria by both the filter materials and also in the rearing water (Losordo et al., 1998; Sugita et al., 2005). The system can be designed in a way that can raise large quantities of fish in a relatively small volume of water where water is treated to remove toxic waste products and then reusing the water (Farghally et al., 2014).

Another reason for the expansion of the RAS is that it provides possible solutions to key problems like lack of space for expansion and new sites, limited freshwater availability, and concerns over pollution and it is also an opportunity to further develop aquaculture (Badiola et al., 2012). Most of the RAS is used for on-growing followed by juvenile and hatchery farms according to a survey conducted (Badiola et al., 2012). Apart from a few species that are cultured in RAS, others are rather limited (Martins et al., 2010). Currently, high-value species are being used to raise or fish that can be effectively marketed in RAS (Modella, 2007). One of the case studies from around the world is on Lake Victoria. Thousands of people who depend on Lake Victoria were at risk as pollution levels from different sources increased. Among those, aquaculture effluent was one. But after the use of RAS as water treatment, the water has been cleaned and the production has been increased. So, aquaculture sustainability is the management of the waste products from production with reduced conflict with other resource users.

2. COMPONENTS OF RAS

For the establishment, proper design of equipment capable of removing dissolved and fine organic wastes requires information on organic waste characteristics in recirculating systems (Singh et al., 1999). So, the components should be carefully designed and installed. According to Modella 2007 consists of (a) water inlet after total treatment, (b) fish culture tank, (c) reservoir tank, (d) sand (physical) filter to remove solid particles which are composed of fish feces, uneaten feed, and bacterial flocs, (e) biofilter to oxidize ammonia excreted by fish to nitrate, (f) aerator-low head oxygenator to remove carbon dioxide expelled by the fish as well as/or adding oxygen required by the fish and nitrifying bacteria, (g) pump and (h) new water inlet. Other facilities like ultra-violet light or ozone disinfection, automatic pH regulation, heat exchanging, denitrification, etc. are often added counting on the precise requirement of the farmer or researcher (Bregnballe, 2015). Each step of the treatment system reduces the system water exchange according to the need for the next limiting waste component (Martins et al., 2010).

2.1 Tanks

Tank properties suitable for the RAS should have a self-cleaning effect, a low retention time of particles, oxygen control and regulation, and space utilization. The fish rearing tank should provide an environment that must meet the needs of the fish, both in terms of water quality and tank design. The factors to be considered while choosing the right tank design are size and shape, water depth, self-cleaning ability, etc. which can have a considerable impact on the performance of the species reared and stocking density (Bregnballe, 2015; Malone, 2013). Brood stocks are commonly stocked at low density whereas fingerlings, baitfish, and ornamental fishes have moderate density but the grow-out fish can be highly dense (Malone, 2013). Accordingly circular tanks used in the system give uniformity of the culture environment, allow a range of rational velocities that optimize fish health and condition, and easy removal of settable solids (Farghally et al., 2014; Malone, 2013).

The circular tanks with a sloping bottom provide uniform water quality and are good for culturing (Lee et al., 2013). A circular tank with a drain at the center is naturally good at solids removal because even a small circulation will tend to accumulate solids in the center (Malone, 2013). The other shapes of tanks like rectangular tanks with rounding corners are also used mainly in ornamental fish, baitfish, soft crab, and tilapia industries. Raceways can also be used in the RAS as it combines a self-cleaning effect of the circular tank with efficient space utilization (Bregnballe, 2015). As the initial capital of the system is high compared to earthen ponds, the carrying capacity of the tanks should be higher to provide cost-effective production (Losordo, 1998).

2.2 Physical Filters

Settable solids are easiest to remove and should be removed as rapidly as possible from the tank through sedimentation tanks (clarifier), mechanical filter (granular or screen), or swirl separator (Losordo, 1998). Physical filters functions to filter out relatively large coarse impurities such as feces, mucus, leftover feed, etc despite chemical filter which filters out the particles that cannot be processed by physical filters i.e., charcoal. Mechanical filtration of outlet water is proven to be only a practical solution for the removal of organic waste but almost all recirculated farms filter outlet water using a micro-screen fitted with a filter cloth typically 40 to 100 microns (Bregnballe, 2015). Using micro-screen showed significant improvement in water quality than the control groups in an experiment experiment comducted by Fernandes et al. (2015).. However, water quality using 20 µm didn't improve significantly as compared to 100 µm mesh size. It might be due to prolonged operation on constant conditions which weaken the mesh size of 20 µm and lead to cake formation disrupting efficient water removal. In some systems, different kinds of filters like screened sedimentation, up-flow sand, as well as plastic bead filter, can be combined for accomplishing mechanical filtration (Al-Hafedh et al., 2003).

2.3 Foam Fractionator

Some suspended solids that cannot settle down at the bottom but exist in the water column may obstruct the gill function of the fish and limit the growth. Fine solids increase the oxygen demand in the system and also causes gill irritation This type of solids can be removed using a foam fractionator which is also referred to as protein skimmer and it also helps to control the foaming agents which can accumulate in systems with long water reuse (Losordo et al., 1998; Malone, 2013).

2.4 Biological Filters

Biological filters are the processor of nitrogen compounds in water such as bio ball and bio-ring and are used to maintain acceptable water parameters to larvae and juveniles by decreasing ammonia concentrations (Tanjung et al., 2019; Pedreira et al., 2016). It is also used for the removal of dissolved organic (Malone, 2013). Biofilters are either classified as a suspended or fixed films (Golz, 1995). The fixed-film reactors are more stable than suspended growth systems (Malone and Pfeiffer, 2006). Different kinds of plastic biofilter media with different configurations are available i.e., plastic rolls, PVC pipes, and scrub pads which have different organic waste removal efficiency from the effluents in RAS. Plastic rolls tended to have a higher TAN (Total Ammonia Nitrogen) reduction rate than PVC pipes and scrub pads (Al-Hafedh et al., 2003). But all the filter media are known to sustain water quality within a suitable range for fish growth. Plastic rolls have many open areas for easy passing of water that made the oxygen dissolution efficient and the bacteria were never under oxygen stress (Al-Hafedh et al., 2003). The efficiency of the biofilter depends on the water temperature and pH level in the system (Bregnballe, 2015). Bio ball has a larger surface area so that the decomposition of ammonia is better as greater surface area facilitates the surface for bacterial growth which decomposes ammonia (Tanjung et al., 2019).

According to an experiment conducted, the greater larval performance of Nile Tilapia and water quality was provided by the use of quartz gravel and porcelain as a biofilter (Pedreira et al., 2016). In an experiment conducted by Singh et al (24), trickling biofilters performed better as compared to those in systems with bead filters (Singh and Wheaton, 1999). The advantages of trickling filters as compared to other filters are the stability of the process is high due to constant high oxygen levels, degassing removes CO_2, simple design, construction, operation, and management, and water cooling in summertime (Eding et al., 2006). Bacteria that grow in the recirculation system with filter media change the harmful compounds (Ammonia and Nitrite) into compounds that are not harmful to fish i.e. Nitrate (Tanjung et al., 2019). Most of the system requires the nitrification process to remove ammonia and nitrite from the water. A group of researcher demonstrated in their experiment that nitrifying bacteria product addition in the system improves the nitrification efficacy of the system i.e. reduced amount of ammonia and nitrite and increased nitrate levels (Kuhn et al., 2010). Biological treatment can be explained as the process in which bacteria is used to convert the dissolved wastes present in the culture tanks to cell mass and other stable products (Golz, 1995). The control of the nitrification process in the RAS by a better understanding of nitrifying populations is important and can increase production volume, reduce discharged water and enhance the profitability of the system owners and managers (Auffret et al., 2013).

Result of nitrification:

NH_4 (ammonium) + 1.5 $O_2 \rightarrow NO_2$ (nitrite) + $H_2O + 2H^+ + 2e$
NO_2 (nitrite) + 0.5 $O_2 \rightarrow NO_3$ (nitrate) + e

$NH_4 + 2\ O_2 \leftrightarrow NO_3 + H_2O + 2H^+$

The capability of nitrification of a system depends on the biofilm it forms. The biofilm formed on the biofilters is seen as bacterial attachment sites that encounter varieties of flow and quality while maintaining their innate ability to process waste (Malone and Pfeiffer, 2006). The major benefit of biofilm formation is that the biofilms provide guard from the effects of an adversative environment and host immune defense (King, 2001). Biofilms can be found in different materials of RAS including fiberglass, plastic, PVC, glass, stainless steel, rubber, aluminum, foam, and cement (King, 2001). The biofilter in which the media remains stationary and untouched most of the time remains largely undisturbed as no filter backwash is required but in bead filter the media is frequently back washed to remove entrapped solids, causing significant damage to the biofilm which indicated the significant delay in the re-establishment of *Nitrobacter* in bead filter media (Singh et al., 1999).

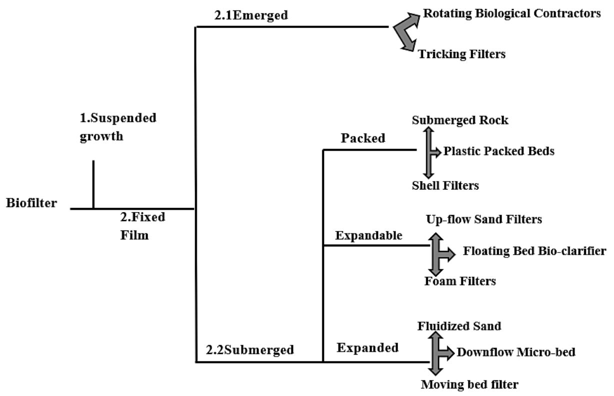

Figure 2: Different type of Bio-filters in RAS (Singh and Wheaton, 1999)

2.5 Aerators

The oxygen concentration within the tank is also very important. The required concentration of oxygen can be supplied to the system through continuous aeration, either with atmospheric oxygen (air) or pure gaseous oxygen using aerators and air diffusor systems (Losordo et al., 1998).

2.6 Pump

A group of researchers described that to achieve low cost, only one pump is used in his overall design to connect the culture tank with a reserved tank (Lee et al., 2013). Direct injection of the oxygen can also be done by the diffusers in the tank (Bregnballe, 2015). This leads to enough oxygen in the tank to maintain suitable growing conditions for fish.

2.7 Ozone Disinfection

After 3 to 4 hours of feeding the fish, concentrations of ammonia, dissolved organics, and other waste products reach maximum and this is a potential time for ozone application. According to feeding frequencies, the waste level is different thus series of ozone treatments can be introduced into the system (Goncalves and Gagnon, 2011). The required amount of ozone for the treatment of water in a RAS is usually calculated using the daily feed rate data. Ozone efficiently destroys bacteria, viruses, fungi, algae, and protozoa by unruly cell membrane function, entering the cell and terminating the nuclear chemistry of the cell (Lawson, 1995). The use of ozone in freshwater systems can be beneficial, but we should be careful while using it in seawater or saltwater systems. Ozone is very reactive to bromide and chloride ions in the saltwater to form toxic hypobromite and hypochlorite ions. That is why residuals after the ozone treatment of salt water should be thrown out or removed before the water will be reused in the systems(32 and 31). Also, the ozone can cause the depletion of trace elements in saltwater, especially manganese and calcium (Lawson, 1995).

3. WATER QUALITY

Fish are raised in an environment where they are exposed to their wastes which can quickly become toxic to them (Golz, 1995). All the production systems must provide an appropriate environment to market the fish growth with optimal values of critical water quality parameters like dissolved oxygen, un-ionized ammonia-nitrogen, nitrite-nitrogen, and CO_2 in water (Losordo et al., 1998). The reduced amount of makeup water i.e. new water entering the system causes system flush to reduce and water quality within the system is consequently degraded (Sugita et al., 1992; Good et al., 2009). Water quality issues are difficult to assess because they are produced by various causes like the poor approach to the overall system and production quantities, equipment failure, or poor maintenance of the system (Badiola et al., 2012).

The water quality in the RAS is mostly associated with the low dissolved oxygen (DO) conditions and high fish waste metabolite levels in the culture water (Molleda, 2007). So in this system, it is necessary to treat the water continuously to remove the waste products excreted by the fish and also add oxygen so that the fish will be provided with enough oxygen to be alive and well (Bregnballe, 2015). In the RAS to ensure the optimal condition of various water quality, many physical and chemical parameters need to be controlled including ammonia, nitrites, nitrates, carbon dioxide, biological oxygen demand (BOD), alkalinity, pH, and others (Mongirdas et al., 2017). Biofilters and solids removal are the most important to optimize the water quality for healthy fish and good system performance (Badiola et al., 2012). A variety of factors is present inside or outside the system that affects the water quality associated with the occurrence of off-flavors (Auffret et al., 2013). The high rate of feed utilization is seen as beneficial as it minimizes the amount of excreta lowering the impact on the water treatment system. The temperature must be maintained within the optimal range depending on the species cultured for consistent rapid growth, good feed efficiency, and disease resistance (Masser et al., 1992).

Table 1 : Guidelines for recommended water quality requiremnts of recirculating systems (35)

Component	**Recommended value or range**
Temperature	The optimum range for species cultured- less than 5°F as rapid change
Dissolved oxygen	60% or more of saturation usually 5ppm or more to warm water fish->2 ppm 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 0.005 ppm

Dissolved oxygen is generally the most important water quality parameter in intensive aquatic systems because low DO levels may quickly lead to high stress in fish, nitrifying biofilter malfunction, and also significant fish losses (Mongirdas et al., 2017; Espinal and Matuli, 2019). BOD in RAS remains unaffected by the type of biofilter used in the system (Singh et al., 1999). Two major factors affect the pH of the culture water i.e. production of CO_2 and biological activity of the biofilter. DO level below 2ppm in the biological filters start to show negative effects on activities of *Nitrobacter* and *Nitrosomonas* because the rate of O_2 diffusion into bacterial film begins to limit the nitrification process. Accumulation of free CO_2 lowers the pH, especially when alkalinity is low due to the formation of carbonic acid. CO_2 is problematic in RAS under high stocking density where fish consume a large amount of oxygen and liberate a large amount of CO_2 through respiration. This adversely affects the growth of the fish (Al-Hafedh et al., 2003).

Solid removal and nitrification in the RAS can impact the nutrient fluxes and aeration and oxygenation can cause an increased concentration resulting from increased biomass carrying capacity (Piedrahita, 2003). For reaching an acceptable nitrification rate, water temperature should be maintained at 10-35°C and pH levels between 7 and 8. The pH value greatly influences the biochemical processes of the water such as the nitrification process ending at a low pH (Tanjung et al., 2019). In the system, the pH tends to decline as bacteria produce acids and carbon dioxide is generated by the fish (Masser et al., 1992). So, water temperature and pH should always be maintained at an acceptable level to keep on the nitrification process in the water. Phosphorus once released in the water is mostly discharged with the effluent from the RAS without being utilized by the system (Barak and Van Rijn, 2000).

The primary objective of the RAS is to control the concentration of un-ionized ammonia-nitrogen (NH_3-N) in the culture tank (Rakocy et al., 2006). pH is a very important parameter because various processes such as nitrification and optimum fish health are related to the range of pH in water. Decreasing pH converts ammonia into less toxic ammonium form whereas increasing pH converts ammonium into ammonia in the system. Total ammonia nitrogen (TAN) is the most critical water quality parameter in intensive recirculating systems. TAN should be kept, at less than 1 ppm in intensive recirculating systems. TAN consists of unionized ammonia (NH_3) and ionized ammonia (NH_4^+), of which the first one is extremely toxic to fish. NH_3 concentration is dependent on temperature and pH. The higher the temperature and pH, the higher the amount of NH_3 in water. Nitrite-nitrogen (NO_2-N) and nitrate-nitrogen (NO_3-N) are the product of ammonia oxidation. NO_3-N (Nitrate-Nitrogen) is not much important concern to and it has been shown to have greater than 100ppm

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tolerance by aquatic species. NO_2-N (Nitrite-Nitrogen) is not as toxic as (NH_3-N) ammonia-nitrogen but is harmful if not removed from the system. It should not exceed 0.5ppm. Water quality should be measured/recorded at the outlets of biofilters.

Da Silva [39] proposed a novel toxicity-warning sensor for water quality monitoring in RAS with the use of the luminescent bacterium, *Aliivibrio fischeri* (da Silva et al., 2018). As the feeding rate or feed intake of the fish is dependent on water temperature and DO, so an improvement of water quality is important in RAS to increase the feed intake (Zhang et al., 2011). Using trash fish may increase the pollution of the system heavily and also increases the infection of the disease, it should be avoided and only dry feed should be used. Increased FCR and lower retention time of feed in the water also may benefit the maintenance of water quality in the culture tanks. Aquaculture production systems must always maintain good water quality during the period of rapid fish growth which in turn cost-effectively ensures the production of fish. The rate of water exchange is also important to maintain good water quality as well as flush out the waste from the system. Most of the recirculating systems are designed to exchange 5 to 10 percent of the water volume each day to prevent the build-up of nitrates and soluble organic matter (Masser et al., 1992).

4. ADVANTAGES OF RAS

The Recirculating Aquaculture System reuses the water partially after undergoing the proper treatment thereby reducing the water usage and improving the effluent quality (Ramirez-Godinez et al., 2013). This system provides potential advantages over a pond or cage culture like flexible site selection, less water usage, lower volume of effluent which gives better environment management, provides a higher intensity of production, and has better environment control (Goncalves and Gagnon, 2011). One of the abilities of RAS is to regulate the temperature which is advantageous as this accelerates the development of various reared fish and also avoids the seasonal prevalence of fish (Mongirdas et al., 2017). Despite being water-conserving, RAS offers many advantages like less disease occurrence, improved feed conversion, a shorter production cycle due to a controlled environment, and consistent product quality (Singh et al., 1999). These systems are uniquely engineered ecosystems that help to minimize environmental perturbation through the reduction of nutrient pollution discharge (Bartelme et al., 2017).

It is also recognized as an appropriate system that gives minimal effluent discharge, efficient water reuse, and optimal water conservation (Rakocy et al., 2006). The grouper (*Epinephelus coioides*) juveniles with a stocking density of 25 fish/L showed the highest growth compared to 15 and 20 Fish/L when reared for 70 days in an experiment conducted without affecting the survival rate of fish in all treatments proving that RAS can be used for increasing the production (Agus et al., 2014). The study also indicated that greater effects on fish growth performance, water quality, and feed utilization were seen due to RAS and stocking density. Farmers can also get benefit by combining RAS with plant culture i.e., Aquaponics. The plant grows rapidly using the dissolved nutrients in fish cultured water, which is directly excreted by fish or generated by microbial breakdown of fish wastes (Rakocy et al., 2006). Farmers can sell the plants grown in aquaponics and earn extra income. The vegetable varieties that can be grown are tomato, lettuce, cucumber, squash, and Chinese cabbage.

5. RAS AS WATER TREATMENT SYSTEM

Pond effluents are often considered a source of pollution in the receiving waters. The effluents cause problems like (1) water pollution and destruction of mangroves, (2) salinization of land and water, (3) spread of aquatic animal diseases, and (4) negative effects on biodiversity (Boyd, 2014). RAS has also been used as one of the water treatment systems in recent years. In most outdoor RAS, waste reduction is achieved within the recirculating loop through an integrative approach where organic carbon and inorganic nutrients are assimilated by phototrophic and heterotrophic organisms (Van Rijn, 2013). In outdoor RAS, water treatment is achieved within the recirculating loop. Extractive organisms like phototrophs and detritivores are cultured in relatively large treatment compartments where a substantial amount of solid waste produced by the fish is converted into biomass (Van Rijn, 2013).

RAS makes intensive fish farming compatible with environmental sustainability and reduces the ecological impact of effluent load (Martin et al., 2010). Incubation of the trickling filter of RAS in absence of oxygen resulted in a decrease of nitrate and phosphate concentrations in the medium. Also, the study demonstrated that crude denitrifying consortia and denitrifying isolates store phosphorus over their metabolic requirement, which doesn't let the effluent rich in phosphorus and nitrates (Barak and Van Rijn, 2000). The aquaponics system is a recirculating aquaculture system that incorporates the production of plants without soil by using the water that is used for aquaculture. This efficiently removes toxic wastes from water and reuses the water for fish culture (Rakocy et al., 2006). This makes the effluent water safe for disposal without a heavy load of nutrients.

6. DRAWBACKS OF RAS

RAS being capital-intensive operations, requires high funding for the equipment, infrastructure, influent and effluent, treatment systems, engineering, construction, and management. In the system, there is a continuous circulation of the same water which challenges the prevention and treatment of the diseases. The pathogens spread throughout the system and the addition of chemicals and antibiotics can disrupt the microbiome of the biofilters (Almeida et al., 2019). Failure in the biofilter may result in varying levels of ammonia or nitrite, both of which are toxic to fish and may end in health issues, suppressed growth, and mortalities of aquatic animals cultured (Khun et al., 2010). Low water exchange RAS has more chance of infections to the aquatic animals than high water exchange systems like flow-through tanks (Good et al., 2009). Although RAS has a lot of advantages, it poses a potential risk of latent disease and public health risks. As the water is reused, pathogens introduced into the system could remain incorporated into the biofilm, feeding to recurring exposure of fish to pathogens and the presence of asymptomatic carriers. The most significant human pathogens that were found are *Bacillus cereus, Shigella* species, and *Vibrio* species which all are responsible for the gastrointestinal disease (King, 2001).

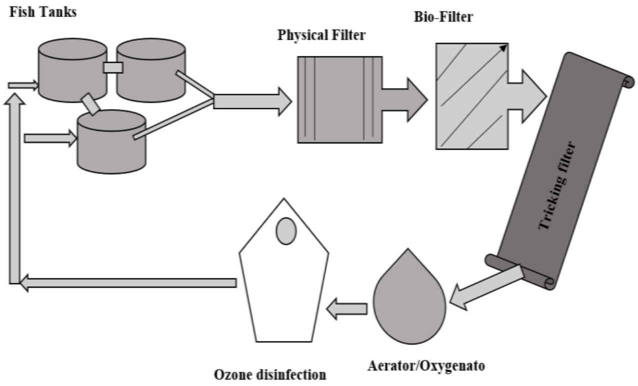

Figure 3: Components of RAS (Sugita et al., 2005)

7. CONCLUSION

Recirculating aquaculture system is employed increasingly throughout the planet for fish farming and aquaponics. It is used to attenuate the water use, reduce a high nutrient load within the effluent, and perform a high-density intensive culture of fish and shrimps. It provides high production indoors within limited areas and fewer volumes of water. It is also environmentally friendly because it produces less polluted effluent than normal pond water effluents. Fewer disease risks are seen in RAS tanks as they are a closed system. Despite these advantages, RAS has some downsides too. Biofilter failure can prompt the death of all cultured animals and continuous circulation of water requires a large amount of power supply. To make sure the high growth of fish within the system, high protein feed must be supplied consistently to the species cultured.

Shifting from the normal way to RAS doesn't make things easier because it requires more knowledge and skill. So, a call for pieces of training and education for guiding the farmers is often an honest approach henceforth. Within the coming days, there may be various ways to overcome the problem and new research can be conducted to find better filtering materials and circulation systems. Research should be conducted for the efficient use of recirculating aquaculture systems in small scale with designs of affordable RAS components. Further, research on the development of the RAS system with low price and high energy efficiency should be conducted. Moreover, the implementation of RAS in the natural systems and earthen pond may also benefit the farmer.

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