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RECIRCULATING AQUACULTURE SYSTEM FOR ORNAMENTAL FISH PRODUCTION (LITERATURE REVIEW)

Sistem Resirkulasi Akuakultur Untuk Produksi Ikan Hias (Telaah Pustaka)

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ABSTRACT

Ornamental fish have their own charm due to the beauty of their shapes and color patterns. Ornamental fish have good sales prospects and have high economic value, so many ornamental fish hobbyists and breeders are involved in them. Cultivating ornamental fish is certainly not free from obstacles, such as ponds or aquariums that have been contaminated with microbes which can cause fish to get sick or even cause death. One way to maintain fish health while increasing ornamental fish production is to monitor water quality. Efforts that can be made to overcome the above problems are to apply a recirculating aquaculture system. This study aims to provide information on the use of an effective aquaculture recirculation system to increase ornamental fish production while reducing ornamental fish mortality rates. The information that will be provided is a study from several journals regarding circuits for recirculation systems and optimizing the use of filter combinations in recirculation systems.

Keywords: filters, ornamental fish, water quality, production, recirculation aquaculture systems

ABSTRAK

Ikan hias memiliki daya tarik tersendiri dikarenakan keindahan bentuk dan corak warnanya. Ikan hias memiliki prospek penjualan yang baik dan memiliki nilai ekonomis tinggi sehingga banyak penghobis sekaligus pembudidaya ikan hias yang berkecimpung didalamnya. Budidaya ikan hias tentu tidak terlepas dari kendala, seperti kolam atau akuarium yang telah terkontaminasi mikroba dapat menyebabkan ikan sakit atau bahkan dapat menyebabkan kematian. Salah satu cara untuk menjaga kesehatan ikan sekaligus meningkatkan produksi ikan hias yaitu dengan memantau kualitas air. Usaha yang dapat dilakukan untuk menanggulangi permasalahan di atas adalah mengaplikasikan sistem resirkulasi akuakultur. Kajian ini bermaksud untuk memberikan informasi penggunaan sistem resirukalasi akuakultur yang efektif untuk meningkatkan produksi ikan hias sekaligus menekan angka kematian ikan hias. Informasi yang akan di berikan merupakan kajian dari beberapa jurnal tentang Rangkaian untuk sistem resirkulasi serta optimalisasi penggunaan kombinasi filter dalam sistem resirkulasi.

Kata kunci: filter, ikan hias, kualitas air, produksi, sistem resirkulasi akuakultur.

INTRODUCTION

The development of ornamental fish cultivation has undergone various developments in the last two decades. The purpose of ornamental fish cultivation has now developed not only to include hobbies and businesses, but has also expanded into research, conservation, and economic development needs. The high market demand in the ornamental fish sector makes this commodity have a market advantage compared to other business sectors. Cultivation in the ornamental fish sector has a success rate that greatly influences the quality of the seeds developed. The quality of these seeds is greatly influenced by the main factor, namely water quality. This attraction is caused by the survival of seeds which are highly dependent on the quality of the water in their place of residence (Situmorang, 2017).

The main obstacle in ornamental fish farming is how to maintain water quality. Such water media are very susceptible to pollution due to the closed environment coupled with biota activities and feeding that can increase ammonia levels in the water (Situmorang, 2017). Water quality is a crucial factor in fish farming, playing an important role in supporting optimal growth and preventing fish health problems such as pests and diseases. Consistent monitoring and management of water quality is essential to maintain the health of the aquaculture ecosystem.

Recirculating aquaculture systems (RAS) are one of the effective solutions to overcome water quality problems. In RAS systems, water that has been used in cultivation is reprocessed through a series of filtration and treatment stages for reuse (Badiola *et al.*, 2012). This system allows better control over environmental parameters such as temperature, water quality, and feeding, which in turn can improve fish growth and survival rates. In addition, RAS also offers significant environmental benefits by reducing water consumption and minimizing organic waste discharge. Recent studies have shown that RAS can save up to 90% of water use compared to conventional culture systems, while maintaining or even increasing productivity (Martins *et al.*, 2010). Thus, RAS not only improves production efficiency but also contributes to more sustainable aquaculture practices.

Recirculating Aquaculture System (RAS) is a technological innovation that enables sustainable water reuse in fish farming. The working principle of RAS involves circulating water from the rearing tank through a series of filters before being returned to the original tank, creating an efficient closed cycle (Bregnballe, 2015). The advantage of RAS lies in its ability to increase the carrying capacity of the cultivation environment with better water quality control, more efficient water use, and minimal environmental impact (Djokosetiyanto *et al.*, 2006).

The key component in a RAS system is the filtration unit, which generally consists of various media such as activated charcoal, bioballs, zeolite, and sand. Each of these media has a specific function in removing various types of pollutants, maintaining optimal water quality for fish growth and health. Recent research has shown that the right combination of filters can significantly increase system efficiency. For example, the use of high-tech biofilters such as the Moving Bed Biofilm Reactor (MBBR) has been shown to increase nitrification efficiency by up to 80% compared to conventional systems (Rusten *et al.*, 2006).

RAS plays an important role in maintaining the quality of the maintenance environment in the context of ornamental fish farming. A study by Sahetapy *et al.,* (2016) on ornamental fish Blue Devil (*Chrysiptera cyanea*) showed that the use of a double bottom filter recirculation system with dacron and sand was effective in reducing ammonia and increasing survival rates by up to 90% compared to other filter combinations. Thus, the development and optimization of the RAS system, especially in the filtration and monitoring aspects, offers great potential to increase productivity and sustainability in ornamental fish farming. Further research is needed to explore the optimal filter combination and integration of the latest technology to maximize system efficiency and minimize environmental impacts.

RESEARCH METHODS

The method used in compiling this journal is the literature study method (systematic review). Literature study is an activity that includes collecting data from various library sources, reading, taking notes, and managing research materials (Zed, 2008). The data used in this journal comes from 39 references from various literatures and previously conducted research that are loaded into databases such as Science direct, Web of Science, Elsevier, Google Scholar, and other database sources.

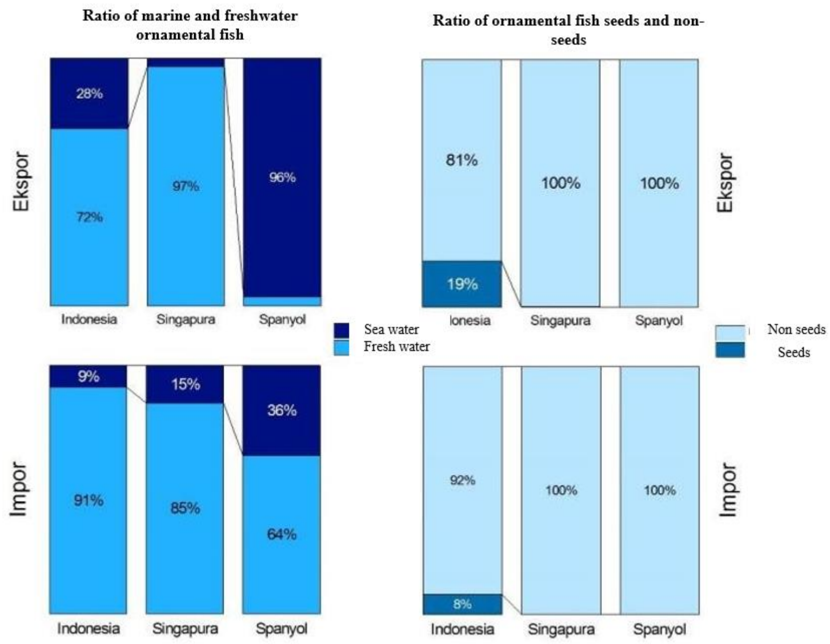
RESULTS

Ornamental Fish Cultivation

Freshwater ornamental fish farming has proven to be able to provide income for many people. Many people make money by cultivating and marketing various types of ornamental fish because they like them. Not a few farmers who previously focused on cultivating fish for consumption such as catfish, tilapia, and gourami, have now switched to ornamental fish farming. This shift occurred because ornamental fish farming offers greater business prospects and economic benefits compared to fish for consumption. Seeing its promising prospects, many fish farmers have now begun to switch to seeking income from raising ornamental fish, which was previously only done by hobbyists. This is because cultivating ornamental fish can generate money even in a narrow area with limited water (Lesmana & Damawan, 2001).

Nowadays, ornamental fish are no longer just entertainment or hobbies. Instead, they have developed into objects used for nature conservation, education, research, and health purposes. Freshwater ornamental fish commodities are still one of the mainstays of non-oil and gas exports in the fisheries sector which make a large contribution to the country's foreign exchange. Due to the large availability of ornamental fish in Indonesia, the opportunity to become an exporter of this commodity is very large. Therefore, ornamental fish cultivation should be promoted in the community.

Indonesian ornamental fish are dominated by freshwater commodities, as is Singapore. Different conditions are shown by Spain whose ornamental fish trade is dominated by saltwater commodities. Based on the composition of ornamental fish seeds and non-seeds traded, Indonesia appears to still be exporting and importing ornamental fish seeds. Furthermore, if we look at the types of ornamental fish traded, the commodities commonly exported by Indonesia consist of Arowana, Botia, Discus, Koi ornamental fish to marine ornamental fish. The same information is also mentioned by BKIPM (2016) which reports that ornamental fish exported by Indonesia consist of Super Red Arowana, Golden Red Arowana, Jardini Arowana, Brazilian Arowana, Other Arowana, Discus, Botia, Rasbora, Cupang, Cardungan, clown fish, wrasse, other marine ornamental fish, and other ornamental fish (Figure 1).



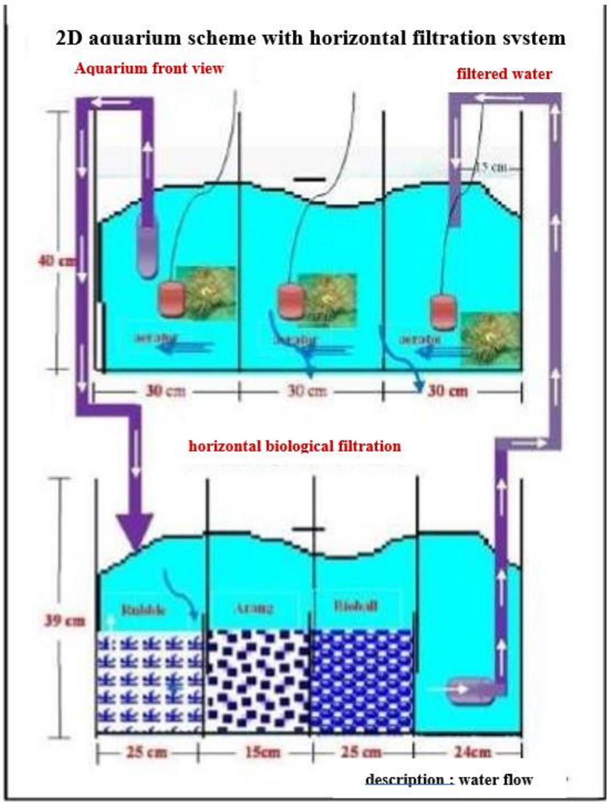
Picture 1. The average ratio of marine and freshwater ornamental fish (a) and the average ratio of seeds and non-seeds in ornamental fish trade (b) in Indonesia with competing countries 2012-2016 (Source : processed from ITC, 2017)

Recirculating Aquaculture System (RAS)

Recirculating Aquaculture System (RAS) technology can be used to control dissolved solids, which can be adapted to less than ideal cultivation environmental conditions. With this closed system, fish and shrimp production can take place throughout the year. Recirculating Aquaculture System technology produces healthier fish with more efficient feed consumption compared to conventional fish farming methods in ponds (Rahmat *et al*., 2010). The density of fish in the Recirculating Aquaculture System can reach 0.350 kg/liter or more, unlike ordinary ponds. The types of RAS systems vary, from the simplest to the most automatic and fully operated by a computer system.

Recirculating aquaculture systems also utilize pond water after the filtration process. Areas with low water discharge and limited land are ideal places for this system. RAS not only reduces water use and hazardous ammonia waste, but also allows for more productive fish farming. The aquarium recirculating system uses filtration techniques to absorb residual feed, metabolic waste, and other organic residues, which can reduce the quality of the maintenance water. This is because the aquarium water is continuously circulated and reused for a certain time. Recirculating aquaculture production usually uses tanks, which require significantly less land. Recirculating aquaculture systems offer an alternative culture technology that allows for water treatment and reuse. Although this technology is relatively expensive, aquaculturists have been attracted to it because of its advantages, especially year-round production and the ability to be established in major marketing areas with minimal water use. Recirculating Aquaculture System technology has been developed by many facilities in recent years to increase fish production.

Closed recirculating systems can recycle all of the water used, while semi-closed recirculating systems only recycle part of the water and require additional water from an external source (Sidik, 2002). Some types of simple recirculating systems include two bottom layer filters or now updated to multilayer or filter components that have more than two layers. Filters that are generally made of zinc, corrugated plastic, or fine wire provide space for clean water between the filter and the bottom of the aquarium, with the use of materials such as sand, gravel, dacron, bioballs, and activated charcoal to bind substances harmful to aquatic life.



Picture 2. System Scheme closed recirculation double layer

In the RAS system, each component has a significant and relatively small role, so that each one is very important. The fish farming system includes several main components such as maintenance tanks, aerators, mechanical filters, biological filters, water sterilization systems, temperature regulators, lighting regulators, water pumps, and recirculation pumps. In addition, additional components such as clean water channels, water pump houses, electricity sources, generators, feed warehouses, cultivation buildings, and other equipment storage spaces are also needed (Setyono, 2012). The application of recirculation techniques to ornamental fish maintenance for 2.5 months that has been tested resulted in a relatively low mortality rate of around 10%. While without recirculation, almost 30-50% usually die (Hatimah & Heruwati, 1997). This technique is widely used in ornamental fish by hobbyists on a small aquarium scale, namely maintenance for display and is generally quite good. However, studies for cultivation with this technique have not been widely reported. Experiments on recirculation techniques or filter systems for cultivation that are widely used are for the enlargement of ornamental fish manfis.

Filtration in RAS

Filtration techniques consist of three types of filters: mechanical or physical, biological, and chemical, which are distinguished by their respective roles.

1. Filtration physical/mechanical

Physical filters in recirculating aquaculture systems (RAS) function as part of a complex water treatment system. These physical filters are used to remove large and medium-sized particles from water, such as dust, dirt, and food waste. These physical filters usually consist of materials such as gravel, rocks, sand, or coconut fibers that are used to capture these particles.

RAS systems with physical filters have been used in several studies to improve water quality and increase fish growth. For example, Darmayanti *et al*. (2018) showed that rock and sand filters have the ability to process mineral compounds and function as a place where decomposing bacteria attach. By using coconut fiber filters, you can bind food and dirt from large to small sizes. However, physical filters also have several disadvantages. For example, physical filters cannot remove harmful chemical compounds such as ammonia and nitrite which can be harmful to fish. Therefore, physical filters are usually used in combination with biological and chemical filters to achieve better results.

Some applications use physical filters in RAS systems to increase fish growth and improve water quality. For example, research conducted by Jubaedah et al. (2020) shows that the use of physical filters in the RAS system can improve water quality by reducing ammonia, research conducted by Sari et al. (2022) shows that the use of physical filters in the RAS system can improve water quality and increase the growth of absolute length and weight of fish. Research conducted by Rahayu (2004) shows that charcoal as a filter in recirculation can increase the best fish growth after coir treatment. According to research conducted by Lesmana (2001), coir filters are effective in absorbing food waste when supported by sufficient water flow. According to research by Spotte (1979), sponge filters are only effective in separating large dissolved particles (> mm) by sedimentation and filtration.

2. Biological Filter

Biological filtration is the process of passing water over a medium rich in good bacteria. These good bacteria will break down ammonia and nitrite in the water and convert it into nitrate compounds, which are safer for fish. This biological filtration is very important in the aquaculture recirculation system to maintain good water quality and reduce the risk of disease in fish. In the recirculation system, biological filtration is usually carried out using media such as pumice, bioball, ceramic ring, crystal bio, sand, gravel, and coconut fiber. These media can absorb and convert dangerous chemical compounds such as ammonia and nitrite into safer compounds.

Decomposer bacteria can live and colonize on the surface of the filter because of its highly porous structure. As a result, the number of bacteria will increase. Therefore, organic substances produced from fish metabolism will be easier to decompose and water quality will improve quickly. By looking at the process described, biological filters are actually living things that require oxygen, food, shelter, and metabolites. Because decomposer bacteria are needed, this is called a living organism. Nitrate bacteria waste is not toxic, but its feed contains ammonia and nitrite. However, its habitat consists of a very large surface, such as pores. Bacteria will grow well with these living conditions if properly conditioned, so that the filter can function properly.

It is highly recommended to create a biological filter with a slightly slow flow or current because it will allow bacteria to produce better metabolites and improve filter function. Temperature and pH have a major influence on bacterial growth. The ideal pH is 7.0–7.5 and the temperature is 28–30°C. If this pH or temperature is lower, bacterial performance will decrease, resulting in decreased filter effectiveness. The ideal temperature for most freshwater ornamental fish is 22°C to 27°C, which can slow down filter performance. Therefore, the use of chemical filters or absorbents such as resin, zeolite, and activated carbon is more recommended, although water changes must be done more often. The effectiveness of biological filters also depends on the time the bacteria grow and work well, which is approximately 15 days to 180 days after manufacture. Clear, fresh-smelling water is a sign that bacteria have developed. Filter stability is usually achieved within six months, depending on the size and number of fish. If you want to speed up bacterial growth, inoculation can be done by adding old water or water from a container that has been contaminated with bacteria. If ammonia and nitrite levels increase due to excessive fish density or small filter size, the filter will quickly become saturated and bacteria cannot work optimally. This causes the filter to be ineffective and the water remains unsafe for fish. Therefore, water changes are essential.

3. Filter Chemistry

This type of filter consists of absorbent chemicals and binds harmful metabolite residues in water. In certain conditions, chemical filters are used for fast reactions or to mineralize organic substances quickly. The efficiency and duration of this filter work greatly depends on the materials used and their absorption capacity, unlike biological filters which are more durable.

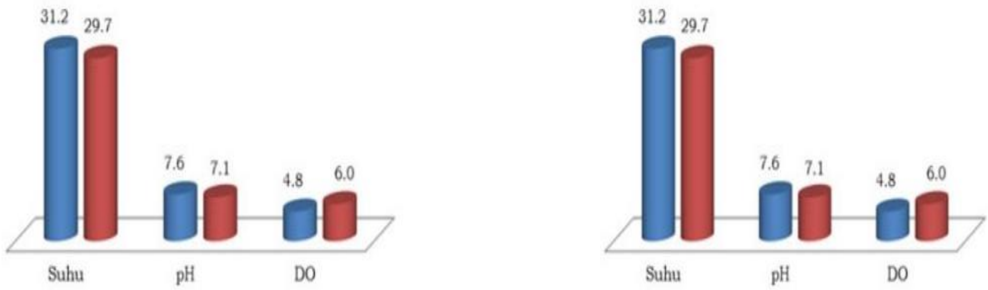
Activated charcoal, ozone, ultraviolet light, peat, resin, and zeolite are some examples of materials used in chemical filters. Activated charcoal, also known as activated carbon, has a wide absorption spectrum. Physicochemical filters, including mechanical and chemical, are usually available in granular or powder form. Activated carbon destroys phosphates, heavy metals, chlorine, chloramines, colors, and various toxic materials at different levels. This material is very suitable for pre-filters, especially for removing toxins from drinking water (PAM). However, activated carbon is unable to remove or absorb ammonia, nitrite, and nitrate, making it unsuitable as a biological filter. It is very unsuitable to use carbon as a filter media for a long period of time because the active period of carbon is usually only a few hours or days. In addition, the high mineral absorption capacity of this activated charcoal material causes minerals in the water to run out quickly, making it unsuitable for fresh water. However, if used in seawater, this activated charcoal will be more effective and beneficial than in fresh water.

Pathogenic microorganisms in fish, including viruses, bacteria, fungi, and protozoa, are usually eradicated using Ozone (O_3) and ultraviolet light. In addition, ozone can break down toxic ammonia into nitrate. The ozonator converts oxygen that is circulated through the air into ozone, which is then channeled into the fish maintenance water. While purple neon lights (violet) are used to produce ultraviolet light. This neon light is located at the top of the aquarium, the purple light functions to clean the water. The use of ozone or ultraviolet light can prevent disease attacks on fish by killing the source of the disease. The use of this system is rarely done, usually only applied to marine ornamental fish in display aquariums. The reason ozone is rarely used is because it is expensive and must be careful in using it. The ozone content must be proportional, if it is used too little it will not be effective, and if too much it will damage the fish gills. In addition, exposure to ozone can cause headaches and nausea. However, ultraviolet (UV) only works in clear water. In dirty water, the disinfectant's ability is limited to only a few centimeters from the water's surface. Ultraviolet light also has effects on humans. It can cause skin cancer in human skin and damage eye tissue if it comes into contact with the eyes. As a result, aquariums equipped with UV lights are usually tightly closed.

Water Quality

The experiment of recirculation technique to improve the quality of media or water in ornamental koi and goldfish cultivation is one of the observed case studies. Water is a problem both in terms of quantity and quality. Recirculation technique, namely the technique of using filters in general, is able to improve the quality of maintenance media, so that it can help reduce water consumption.

Water quality measurements include parameters such as pH, temperature, dissolved oxygen (DO), and ammonia. These measurements were carried out twice, namely before and after the recirculation process for one month. This was done to determine the effect of recirculation on quality. Measurement of water quality in recirculation in this study focused on DO and Ammonia only because it was carried out in closed cultivation so that the temperature and pH were considered the same.



(a) (b)

Picture 3. Quality water System RACE On maintenance Fish Decorate Koi (a) And Fish Chef (b)

1. Temperature

Temperature fluctuations in fish farming are influenced by weather conditions in the farming area. Based on information from BSN (1999), the best temperature for fish farming is between 25-30°C. The measurement results show that the average water temperature in ornamental fish farming before recirculation ranges from 23-25°C at night and reaches 30-32°C during the day. These results indicate that the temperature before the recirculation process is not yet at an ideal level for the survival of koi fish. Temperatures that are too high can cause stress to fish and increase the risk of disease. The changing water temperature is influenced by the surrounding environment, for example the temperature will drop during rainy weather and rise during sunny weather. After the recirculation process, the recorded water temperature was in the range of 25-27°C, indicating that the temperature quality increased after recirculation. With the recirculation system, it produces water movement that makes the temperature more stable and consistent (Jumaidi *et al*., 2016). Optimal temperature will help koi fish grow well. Based on research Jumaidi *et al*. (2016), high temperatures can accelerate fish metabolism, thereby increasing dissolved oxygen consumption and reducing oxygen levels in the water. On the other hand, temperatures that are too low will slow down fish metabolism and reduce appetite.

2. Dissolve Oxygen (DO)

RAS technology plays a role in increasing dissolved oxygen (DO) levels due to the filtration process that cleans aquaculture wastewater, thus improving water quality. The filtration process in RAS technology serves to reduce cultivation waste such as leftover feed and fish metabolism. This process prevents oxygen depletion because aerobic bacteria use oxygen to decompose waste.

According to Boyd & Tucker (1998), concentration oxygen Good dissolved oxygen for aquaculture is generally more than 5 mg/L, but for koi fish farming, the optimal concentration is 5.9 to 6.9 mg/L. (Sutiana *et al.*, 2017). Aquatic biota respiration, growth metabolism, and aerobic oxidation of organic and inorganic waste all require dissolved oxygen (DO). Before recirculation, DO measurements showed 4.8 mg/L. Then after the recirculation process, this value increased to 6.0 mg/L. These results indicate that the DO level before recirculation was not optimal for koi fish farming, but after the recirculation process, the DO level increased to 6.0 mg/L. The use of RAS technology has succeeded in increasing dissolved oxygen levels thanks to a filtration system that improves water quality by reducing cultivation waste, such as leftover feed and fish metabolism. This waste can reduce oxygen levels through aerobic oxidation by bacteria that require oxygen to decompose the waste, resulting in low dissolved oxygen in the water. The recirculation system helps ensure an even distribution of dissolved oxygen throughout the water, which plays a role in maintaining stable oxygen levels. High oxygen levels are essential for the growth of koi fish, as oxygen is needed in the metabolic process. If oxygen levels are low, the fish will experience stress because the brain does not get enough oxygen. In extreme conditions, lack of oxygen can lead to death because the respiratory process cannot occur without oxygen (Siegers *et al.*. 2019).

3. Ammonia

Ammonia in water is divided into two forms, namely ionized form (ammonium, NH_4^+) and non-ionized form (ammonia, NH_3). Ammonia in this non-ionized form is dangerous for aquatic organisms because it is toxic (Masser *et al.,* 1999). The NH_3 value in water is influenced by pH and temperature. The higher the temperature and pH of the water, the higher the percentage of NH_3 (Boyd, 1990). Ammonia with high concentrations in water affects the permeability of the fish's body to water and reduces the concentration of ions in its body. In addition, ammonia also increases oxygen consumption in the tissue, damages the gills, and reduces the blood's ability to transport oxygen (Boyd, 1982). Ideally , the level of free, unionized ammonia (NH_3) in water should not exceed one milligram per liter

Bioball is a biological filter media that relies on microorganisms or bacteria to function. In addition to filtering, bioball is also a place for microorganisms or bacteria to live and grow (O-Fish, 2012). According to Jacqueline *et al.* (2021), bioball is a very effective medium in absorbing ammonia and providing space for the nitrification process in the recirculation system. Overall, bioball has a function in reducing ammonia and nitrogen with the help of nitrobacter bacteria, as well as filtering small particles dissolved in water. In other filter variations such as in the treatment design in the form of sand, dacron, activated charcoal, bio-ring, and zinc. These tools also help reduce ammonia according to their respective functions. For example, activated charcoal or activated carbon is used to absorb toxic substances in water, as well as separate the ammonia content by absorbing existing toxins. Toxic substances will be caught in the pores of the charcoal, which will then absorb them, thereby reducing the amount of toxic substances (Ristiana *et al.*, 2009). The working process of activated charcoal is through absorption, which means that every material that passes through it will be absorbed by the material. This activated charcoal can remove a number of harmful contents from polluted water, while also functioning to clarify water, remove odors, absorb chlorine, and create a fresh taste in the water.

Other filter variations, such as dacron/polyethylene, have a very small and tight pore structure because the basic material is synthetic fiber. The function of this dacron is to filter particles in the water. Dacron has advantages as an aquarium filter because it is durable and easy to clean. In addition, there are other filter variations, namely sand, which is often used as a filter medium in cultivation. Sand is used as a water filter because of its ability to clear cloudy water from dissolved substances, filter mud, sediment, and other foreign particles, making it effective in reducing ammonia levels.

Different types of filters have different functions, but all help reduce ammonia concentrations. High levels of ammonia in water can affect fish growth and can be fatal, namely death in fish being raised. The results of research conducted by Jacqueline *et al* . (2021), showed an ammonia range of 0.2-0.9 mg/L for various treatments, indicating that a recirculation system with a multi-layer filter is effective in reducing nitrogen waste, especially ammonia. According to Kordi (2004), fish farming requires water with an ammonia concentration of no more than 1 ppm for optimal quality. In fish farming, there is often a risk of water media pollution from various sources, such as environmental activities and land waste. In addition, feed containing high protein can also cause an increase in ammonia levels in water. (Situmorang, 2017). The RAS system using zeolite, charcoal, cotton, coral, and coral fragments filters has been proven to reduce ammonia levels in the recirculation process. (Noorjanah 2015).

4. pH

The degree of acidity (pH) indicates the content of mineral salts in water and indicates the acidic, neutral, or alkaline nature of the water. The optimal pH value for aquaculture is generally in the neutral range, namely between 6-8 (Arifin, 2016). For koi fish cultivation, the ideal pH value is in the range of 6.5-8.5 (Rizky *et al*., 2015). In study Which done Sanda & Lie (2021), the pH of the water before recirculation was recorded at 7.6, but dropped to 7.1 after the recirculation process. This decrease was caused by a decrease in temperature during the recirculation process, although the RAS filter was effective in maintaining pH stability. Zeolite has a function to maintain pH stability because it has a negative charge that can balance ions by binding [H+] ions in the water, thus preventing a sudden decrease in pH. (Heriyani & Mugisidi 2016).

DISCUSSION

RAS System on Ornamental Fish Cultivation Productivity

Recirculating Aquaculture Systems (RAS) play a vital role in ornamental fish farming by offering a sustainable and environmentally friendly method for ornamental fish farming (Kültz 2022). RAS technology helps maintain water quality, reduce environmental impacts, and ensure sustainable production of superior quality fish (Jacinda *et al.*, 2021). The system involves processes such as solid waste removal, biofiltration, aeration, and disinfection to create a conducive environment for fish farming. In addition, RAS can help address the challenges of limited availability of high-quality water and regulatory pressures on discharge in aquaculture operations. By combining innovative techniques such as biofloc fermenters and aquaponics, RAS not only supports the growth of ornamental fish but also enables plant cultivation using stable breeding water with high oxygen concentrations (Lee *et al*., 2022). RAS offers many benefits, the system is known for its environmentally friendly benefits, high efficiency, and sustainable cultivation, making it a promising technology to reduce the environmental impact of aquaculture (Li *et al.*, 2023). This system minimizes dependence on water, land, and climate factors, providing a resource-efficient and climate-independent approach to fish farming (Rajalakshmi *et al.*, 2022).

The problem of sustainable water sources with stable quality and disease prevention needs to be addressed. The recirculating aquaculture system is a technology that can be used to minimize pollution and ensure sufficient high-quality water for ornamental fish farming. The rapid development of the arowana fish farming industry in recent years has led to high water quality requirements that affect the health and productivity of arowana (Atiqah *et al.*, 2013), the water quality parameters required for arowana fish farming are a temperature of 29oC to 31oC and a pH of 6.5 to 7.0 Then the results of water quality measurements in the study by Medipally *et al*., (2016), showed that the instability of water quality parameters, so that adaptation and application of aquaculture technologies such as the RAS System are needed because they guarantee good water quality and also ensure a constant and adequate water supply during the dry season when water is limited.

The results of water quality measurements in a study conducted by Sanda & Lie (2021) showed that the water temperature in koi fish farming before recirculation was not optimal, namely at 31.2°C. After recirculation, the temperature measurement results decreased to 29.7°C. The optimal temperature in fish farming is 25-30°C. This shows that the temperature measurement after the recirculation process is better. In addition to temperature, pH also decreased and DO p increased after the application of recirculation. The pH which was initially 7.6 decreased to 7.1 and DO which was initially 4.8 mg/L increased to 6.0 mg/L after recirculation. With this, RAS has been proven to improve and stabilize physical, chemical, and biological processes which overall, the application of RAS in ornamental fish farming will increase sustainability, efficiency, and high-quality production.

In a study conducted by Sutarjo & Hany (2023) at Karang Taruna Singo Joyo regarding the application of RAS in the cultivation of several freshwater ornamental fish such as ornamental snakehead fish (*Channa* sp.), Betta fish (*Betta* sp.), Louhan fish sp., koi fish, and Guppy, showed that the application of RAS technology succeeded in reducing the pH value from the initial 6.9-8.2 to 6.9-8 after the RAS system was implemented. In addition to the pH decreasing, the temperature and DO also increased, the temperature value before the application of the RAS system was 25-27o C and DO 2-3 mg/L. After the application of the RAS system, the temperature and pH values increased to 27-30o C and 4-5 mg/L.

CONCLUSION

Based on the results of the study that have been presented, several important conclusions can be drawn regarding the production of ornamental fish in the recirculating aquaculture system (RAS):

1. The use of the recirculating aquaculture system has been proven to increase the productivity of ornamental fish in terms of growth and survival of ornamental fish.
2. The water quality in the recirculating aquaculture system has a more stable value compared to not using RAS, expressed by a stable temperature value due to the even distribution of water due to the current that is run, a high DO value because there is direct oxygen capture with continuous water input, and finally proven by a low ammonia value due to a combination of physical, biological and chemical filtration.
3. The productivity of ornamental fish increases in RAS because fish can be compacted in one place, small land use, intensive feeding and maintained water quality.

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