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Effectiveness of Rotary Drum Filter (RDF) Engineering 2024 in Freshwater Lobster (*Cherax quadricarinatus*) Cultivation

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Abstract

This study aims to analyze the effectiveness of Rotary Drum Filter (RDF) in maintaining water quality in the Recirculating Aquaculture System (RAS) for the cultivation of freshwater lobster Cherax quadricarinatus. The study was conducted in Cimahi, West Java, for 30 days using a Completely Randomized Design (CRD) with three treatments and three replications, namely RDF filtration, mechanical filtration and control (siphoning and aeration only). The parameters observed included water quality (temperature, DO, pH, ammonia, nitrite, and nitrate), survival rate (SR), specific growth rate (SGR), and feed conversion ratio (FCR). The results showed that the use of RDF significantly improved water quality, which had a positive impact on lobster survival and growth compared to the control. These findings indicate that RDF has the potential to support the efficiency and sustainability of freshwater lobster cultivation.

Keywords: Aquaculture, Cherax quadricarinatus, RAS, RDF, Water Quality

1. Introduction

High quality of water parameters are the absolute need of Intensive aquaculture. Many kinds of methods were made by aquaculture practitioners to eliminate waste that is produced by aquaculture system production. The Recirculating Aquaculture System (RAS) is a technological innovation widely applied in intensive aquaculture to efficiently manage water quality. In this system, mechanical filtration plays a crucial role in removing suspended solids from the water. One filtration technology that is increasingly being used is the Rotary Drum Filter (RDF), which can automatically and efficiently filter solid particles with minimal maintenance. Several studies have shown that the use of RDF in RAS systems can improve the efficiency of water quality management and reduce the frequency of manual water changes. However, research on the effectiveness of RDF in freshwater lobster cultivation, particularly in local contexts such as Sukabumi, is still very limited.

In intensive systems, the waste stream is characterized by a significant fraction of micro-particles, often smaller than 60 mu (Gregersen, 2018). These small particles possess a large surface area relative to their volume, promoting intense bacterial activity (Gregersen, 2018). The decomposition of this particulate organic matter leads to the continuous release of highly toxic dissolved nitrogenous compounds, specifically ammonia (Total Ammonia Nitrogen (TAN) and nitrite (NO2-N) (Masser et al 2011).

Crustaceans are particularly sensitive to these compounds. Ammonia toxicity (NH3-N), the un-ionized form) is lethal at relatively low concentrations, with the 96-hour LC_50 for juvenile C. quadricarinatus reported in the range of 0.36 mg/L to 0.54 mg/L (Jiang et al 2013, Meade et al 1995). Nitrite is also a major concern; it enters the circulatory system across the gills and binds to hemocyanin (the oxygen-carrying molecule in crustaceans), effectively inducing methemoglobinemia, a form of hypoxia, which leads to physiological stress and potential mortality (Masser et al 2011, 28). The 96-hour LC_50 value for nitrite (N-NO2) in freshwater crayfish has been determined to be around 4.8 mg/L (Kopecký and Pálková 2005).

The objective of this study was to determine effectiveness of rotary drum filter (RDF) between mechanical filter and non-filter system.

2. Theory

A foundational challenge in operating high-density (RAS) is the management of suspended solids (SS), which are composed primarily of uneaten feed and fecal matter (Ebeling & Timmons 2011). The effective removal of SS is considered the critical first step in water treatment (Ebeling & Timmons 2011). Failure to adequately separate these solids has two major

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detrimental effects: it impairs the welfare of the cultured animals and severely hinders the efficiency of the downstream biological filter, which is responsible for converting toxic ammonia (Summerfelt & Bebak-Roth. 2004, Masser et al 2011).

Effective mechanical filtration is indispensable for achieving system stability in RAS (Ebeling and Timmons, 2011). Rotary Drum Filters (RDF), which utilize micro-screening (typically meshes ranging from 40 to 200 mu), are the current standard for high-efficiency solids removal in intensive aquaculture (Vriyantama and Pramesti, 2022). Unlike intermittent or static filters, RDF operates continuously, maintaining consistent flow rates while automatically backwashing captured solids, thereby preventing flow interruption and minimizing the time organic matter spends in the water column (Lekang and Snekvik, 2013).

This superior capacity to capture small particulates is essential, as effective clarification treatment reduces Total Suspended Solids (TSS), stabilizes water quality by increasing dissolved oxygen (DO) and pH availability, and has been directly correlated with significantly higher growth performance and survival rates in cultured crustaceans (Audelo and Voltolina, 2021).

The most basic solids removal method, represented by the control treatment (siphoning and aeration), relies primarily on gravitational sedimentation, which only effectively captures large, heavy particles (Cripps 1995, Ebeling & Timmons 2011). This approach leaves the critical micro-particulate fraction to circulate and decompose, establishing a chronic sub-lethal accumulation of nitrogenous compounds that diverts the crayfish’s metabolic energy away from growth (SGR) and survival (SR) towards detoxification and stress management.

3. Method

This study used a Completely Randomized Design (CRD) with three treatments and three replications. The first treatment (P1) used a Rotary Drum Filter (RDF) as a filtration method to remove solid particles from the water, while the second treatment (P2) used a mechanical filter, and the third (P3) treatment was a control, where only water siphoning and aeration were used to maintain water quality. Every day, approximately 30-50% of the water was changed to ensure optimal water quality in both treatments. By using this design, it is hoped that valid data can be obtained regarding the effectiveness of using RDF in the RAS system for freshwater lobster cultivation.

The Rotary Drum Filter is a water filtration device that operates by having water enter a rotating drum with a fine filter. After a set period of time, the drum is rinsed using a pressurized water sprayer, causing debris trapped inside the rotating drum to move to a reservoir and be directly removed from the machine. Meanwhile, debris trapped inside the drum and unable to rise is collected in the drum and, after a set period of time, is removed by tipping it, allowing coarse debris to be directly discharged from the Rotary Drum Filter. Pool debris that can be filtered using the Rotary Drum Filter includes mud, moss, plastic, grass, and leaves.

The test animals used were adult Cherax quadricarinatus with an average weight of 30.75+8.66 grams and an average length of 10.32+0.82 grams. The stocking density was 48 individuals/m2.

The first production parameter, the Survival Rate (SR), is calculated using the following formula (Darmawan and Tahapari, 2017; Ni'matulloh, Rejeki, and Ariyati, 2018):

$$SR = \frac{N_t}{N_0} \times 100$$

SR: Survival Rate (%)
Nt: Number of fry at harvest (fish)
No: Number of fry at initial stocking (fish)

The second production parameter, the Specific Growth Rate (SGR), can be an important parameter for evaluating the system's success in supporting fish growth.

$$SGR\ (\%) = \frac{\ln W_t - \ln W_o}{t} \times 100$$

SGR: Specific Growth Rate (% day-1)
Wt: Average body weight at the end of the study (grams)
Wo: Average body weight at the beginning of the study (grams)
t: Maintenance time (days)

Water quality measurements are conducted routinely to monitor the condition of the rearing environment. Observed parameters include: Temperature, dissolved oxygen (DO), pH, and Total Dissolved Solids (TDS) are measured daily at three different times: morning, afternoon, and evening. This aims to determine fluctuations in water quality during the rearing period.

Nitrate (NO_3^-), Nitrite (NO_2^-), and ammonia (NH_3) are measured weekly using a testing kit or through on-site analysis. These measurements are conducted to ensure water chemistry remains within safe limits for lobsters.

Data from these measurements are used to evaluate the effectiveness of the rearing system with and without RDF and its relationship to lobster growth and survival.

We used ANOVA for data analysis of production parameters and water quality parameters.

4. Results and Discussion

4.1. Results

Survival Rate (SR) is a crucial indicator in assessing the success of a cultivation system, particularly during the nursery phase. Based on the data presented in Figure 1, the highest SR value was achieved by RDF at 83%, meanwhile, the siphon pond only achieved an SR of 67%.

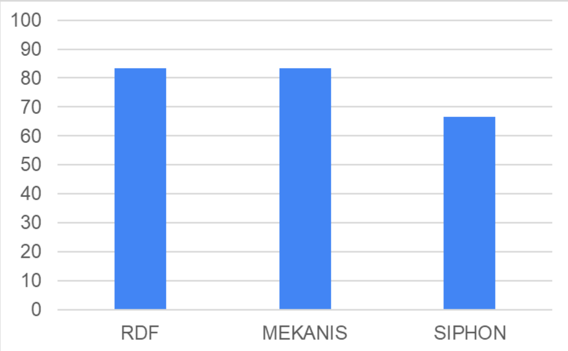

Figure 1. Diagram of Survival Rate (%)

Referring to Indonesian National Standard (SNI) 01-6483.4-2000, the minimum survival rate required in the nursery phase of freshwater fish is 80%. Therefore, although the control pond still met the minimum requirement, the treatment performance using a Rotary Drum Filter (RDF) proved superior in maintaining freshwater lobster survival.

The increased SR value in the treatment pond indicates that the RDF system plays a role in maintaining stable water quality. This is crucial for supporting lobster physiological processes such as molting, which directly affects mortality rates. Mortality in the control ponds was largely due to molting failure, indicating higher environmental stress compared to the treatment ponds.

Overall, the application of RDF in the recirculation system had a positive impact on freshwater lobster survival. With SR values exceeding minimum standards, RDF can be relied upon as part of a water quality management strategy in intensive aquaculture.

Figure 2 shows that RDF is more capable of supporting lobster growth, as indicated by the significantly higher SGR value for weight compared to the other treatments. The RDF SGR was 0,51+0,14% per day better than the other treatments ($P<0,05$). However, the long SGR did not show a significant difference.

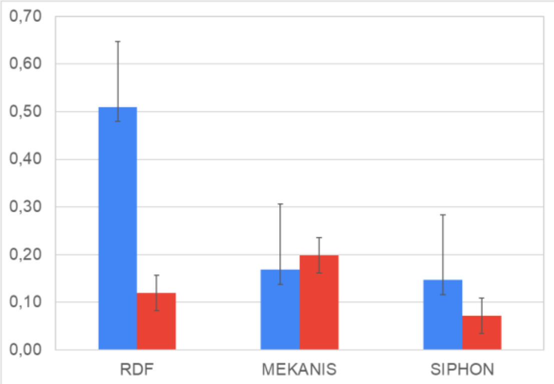

Figure 2. Diagram of SGR Weight (Blue) and SGR Length (red)

Specific Growth Rate (SGR) in Cherax quadricarinatus has been documented in various RAS studies utilizing different filtration technologies (Syzdykov et al., 2024, 2025; Lagutkina et al., 2020; Barki et al., 2025; Borisov & Nikonova, 2018). Factors such as optimal dietary protein levels (e.g., 31% CP for juveniles) and stocking density significantly influence the achievable SGR in crayfish (Thompson et al., 2004).

The growth performance of Cherax quadricarinatus during the adult stage in a Recirculating Aquaculture System (RAS) is significantly influenced by stocking density management and stable water quality. Recent research indicates that lobsters stocked at an initial weight of between 5.0 and 17.0 grams require a rearing period of 60 to 150 days to reach marketable size (Syzdykov et al., 2024; Lagutkina et al., 2020). In intensive RAS systems, stocking densities for adult size are generally maintained at a relatively low range, 5 to 25 individuals/m², to suppress aggressive and territorial behavior (Syzdykov et al., 2025). In fact, the use of individual compartment systems, or "battery systems," can significantly improve survival by isolating each individual (Barki et al., 2025).

Monitoring results indicate that the survival rate in the RAS system is quite high, ranging from 75% to more than 95% (Borisov & Nikonova, 2018; Barki et al., 2025). Although this system is able to maintain an optimal environment, the Specific Growth Rate (SGR) in the adult phase tends to be lower than the juvenile phase, with an average daily weight gain of around 0.4 to 0.5 grams per day (Syzdykov et al., 2024). As an illustration, research by Syzdykov et al. (2025) reported that lobsters can reach a consumption weight of 60–80 grams within 5 months of maintenance. This phenomenon of decreased SGR in adult individuals is caused by a greater allocation of energy to maintain physiological and reproductive functions compared to somatic growth (Borisov & Nikonova, 2018; Lagutkina et al., 2020).

Recirculating Drum Filters (RDFs) effectively remove particulate matter from culture water, which is a crucial step in maintaining water quality within Recirculating Aquaculture Systems (RAS) (Timmons & Ebeling, 2013). By removing suspended solids, drum filters significantly reduce particulate organic matter, particulate BOD, and microbial activity in the water column (Hagspiel et al., 2024). Reductions in these factors lead to a more stable environment, which has been linked to improvements in feed utilization and increased biomass production in cultured species (Hagspiel et al., 2024). The efficient and quick removal of solids by the RDF prevents their degradation into finer particles or breakdown by bacteria, which helps stabilize water parameters essential for growth (Westerman et al., 2023).

Figure 3 shows the nitrate (NO_3^-) at the end of the rearing period for both treatments. In the treatment pond with a Rotary Drum Filter (P1), nitrate levels were observed to be stable at 250 mg/L from beginning to end. Conversely, in the siphon pond (P3), there was a drastic decrease from 217 mg/L to 67 mg/L at the end of the rearing period.

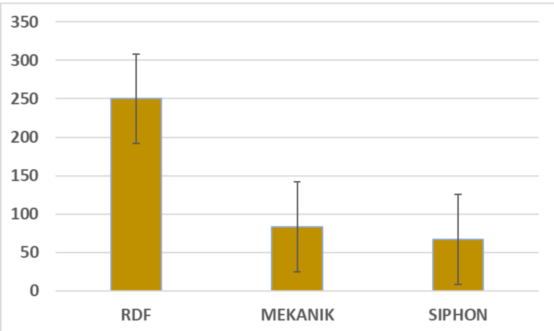

Figure 3. Diagram of Nitrate Concentration (mg L^{-1})

The stable nitrate levels in the RDF ponds indicate that the nitrification process is proceeding efficiently and consistently. In RAS systems, ammonia from organism excretion and feed waste is converted into nitrite (NO_2^-) and then into nitrate (NO_3^-) by nitrifying bacteria. The presence of RDF in the system can increase filtration efficiency and water circulation, indirectly supporting the sustainability of the nitrifying bacteria population.

Nitrate is the least toxic form of nitrogen compared to ammonia and nitrite. A nitrate level of 250 mg/L is within the tolerable limits for freshwater crayfish (Meade et al., 1995), although prolonged high concentrations can be a concern in the long term. However, this stable concentration indicates a balance between nitrogen input and utilization or excretion processes.

On the other hand, the drastic decrease in nitrate in the siphon pond (P2) could be caused by several factors, such as low nitrification efficiency due to the accumulation of organic waste that is not optimally decomposed, or nitrate loss through relatively high daily water changes (30–50%). Although the final values were lower, this does not necessarily indicate better system quality, as the control pond also exhibited an accumulation of toxic compounds such as ammonia early in the culture.

The application of Rotary Drum Filter (RDF) in the Recirculating Aquaculture System (RAS) system has a significant mechanistic effect on the stability of the cultivation environment and the biological performance of freshwater lobsters (Cherax quadricarinatus). The continuous use of RDF is able to filter suspended solid particles automatically using micro-screening with mesh sizes ranging from 40 to 200 μm2. This step is crucial to prevent the accumulation of organic waste, such as leftover feed and feces, before they decompose into toxic nitrogen compounds.

This condition creates a stable environment with a survival rate (SR) reaching 83%, which is significantly higher than the siphoning control system which only reaches 67%. The low SR rate in the control system is triggered by environmental stress due to the accumulation of micro particles which causes the failure of physiological processes such as molting in lobsters.

In addition to increasing survival, RDF filtration efficiency has been shown to optimize the growth performance of adult lobsters through metabolic efficiency. The specific growth rate (SGR) of weight in the RDF treatment reached 0.51+0.14% per day, which was statistically better than other treatments ($P<0.05$).

Mechanistically, the rapid removal of suspended solids by RDF reduces the workload of the biological filter in the nitrification process. This is indicated by the nitrate level which remains stable at 250 mg/L in the RDF pond, indicating that the nitrification process runs efficiently and consistently. This stability of water quality allows lobsters to allocate their metabolic energy maximally for somatic growth rather than for detoxification of nitrogen compounds or stress management due to poor environments.

5. Conclusion

RDF is the best choice for lobster rearing in the Recirculating Aquaculture System. RDF in RAS is the most effective system because of its ability to get the best SR, SGR and nitrification.

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