



WATER RECOVERY SYSTEM FOR INCREASING ECONOMIC VALUE OF FISH AND SHRIMP FARMING

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ABSTRACT

Currently shrimp farming is still unreliable as an economic commodity due to climate and environmental conditions around the pond waters. When both of them are environmentally friendly, harvest of shrimps can make farmers rich. Instead, farmers could go bankrupt because of the invasion of a disease caused by a virus. Efforts usually carried out by farmers are to let their ponds neglected until conditions are restored, and it could be years left neglected ponds. Prospective efforts are needed to address chronic problems that always afflict farmers in this sector to improve water quality and provide adequate nutrition so that shrimp farming can be sustainable. Water recovery system configuration will provide quality of water that meets water quality standards for shrimp farming system water. Roughing filters have been shown to reduce levels of turbidity, bacteria, organic, and detergent by 60%, 88%, 40% and 10% respectively. While slow sand filter proved to lower turbidity, bacteria, organic, and detergent by 96%, 99%, 45% and 18% respectively. With a perfect insulation system, the treated water is returned to the pond and only small amount of water from another source is flowed, so that the cultivation of freshwater or brackish shrimps will be recovered.

Keywords: water recovery system, shrimp aquaculture, roughing filters, slow sand filters, cultivation.

INTRODUCTION

Global shrimp market has grown less than \$ 1 billion to \$ 5.8 billion (US) from 2000 until 2005. To meet this demand, the shrimp industry shifted from conventional maintenance system into a system of intensive maintenance. However, environmental factors (i.e. waste disposal ponds) and economic constraints (the price of feed, including fish meal) can inhibit this growth. Expansion of aquaculture production is limited because of the pressures on the environment that is the sewage ponds into water bodies and their dependence on fish oil and fish meal (De Schryver *et al.*, 2008). To successfully manage the aquaculture, it is needed to find technology to sustain the economy as well as the environment (Kuhn *et al.*, 2010).

Shrimp farming produce large amounts of wastewater containing solids (e.g., feces and feed eaten) and nutrients (e.g. nitrogen and phosphorus) that can damage the environment if improperly managed. Solids and nutrients from fish feed and feces, including urea/ammonia from the fish/ shrimp (Maillard *et al.*, 2005 and Sharrer *et al.*, 2007), if discharged directly into the environment, solids and nutrients that can pollute the environment like eutrophication or can be directly toxic to aquatic fauna (Timmons *et al.*, 2002 and Boardman *et al.*, 2004). The most common method to address this pollution is continuous replacement of pond water with new water or treated water from the water source (Gutierrez-Wing and Malone, 2006).

This study proves that the closed aquaculture system can maintain the water quality is acceptable for the cultivation of shrimp. Shrimp can grow well at a stocking density of 50 shrimp per m². In addition, a closed shrimp farming systems can reduce the loss of nutrients through the waste being dumped and thereby

minimize the environmental impact of shrimp farming. The total amount of nutrients in a closed shrimp culture system may be similar to the system of exchange of water, a small volume of concentrated waste produced in the closed system should be easier for shrimp farmers to treat prior to discharge into the environment.

To enhance the macro economic of Indonesia and strengthening the micro economic of shrimp farmers, all of the cultivation technology components should be completed, i.e. choosing the healthy seed shrimps, applying the best shrimp feed, providing the best shrimp cultivation structures and infrastructures, using the best water and probiotic and constructing raw water and contaminated water treatment plant structure for recycling to provide healthy water (Hamdani, R.M., 2005).

Water is a very important for the healthy environment for the shrimps to grow maximally. Probiotic may suppress the existence of pathogenic bacteria in the contaminated water in a certain time frame, expecting the shrimps are growing normally, but in the long run and in another extreme climate condition, the shrimp growth may decline or even undergo mass death.

Shrimps have no immunity within their bodies. Virus and pathogenic bacteria in the raw water and in the water after a period of cultivation, will kill the shrimps. In other word, healthy water for shrimp or milkfish cultivation is very important.

There are some ways for the disposal of organic waste from aquaculture: agricultural land application, waste composting, vermiculture and reed drying beds [Tchobanoglous, G.; Burton, F.L., 1991 and Summerfelt, S.T., 1999]. Sludge produced from the cultivation of a good fertilizer in agriculture is high concentrations of organic matter, nitrogen and phosphorus, but with a low potassium content [Bergheim, A.; Kristiansen, R.; Kelly,



L.A., 1993 and Wang, J.-W., 1993, Bergheim, A.; Sanni, S.; Indrevik, G.; Hølland, P., 1993, and Westerman, P.W.; Hinshaw, J.M.; Barker, J.C., 1993, and Wang, J.-W., 1993].

The wastewater treatment using wetland is more costly than roughing and slow sand filter. It is therefore necessary to consider a water treatment plant structure with low capital and OM costs to provide healthy water for the milkfish, as well as for shrimp.

Roughing and slow sand filters are proven to treat raw and contaminated water to produce healthy water in terms of turbidity, coliform bacteria, organic, and detergent (Huisman, L & Wood, W.E. 1974; and Wegelin, Martin, 1996.

In terms of growth of milkfish in 8 different plastic containers with 30 cm diameter within 30 days of experiment, it can be concluded that recirculation of treated waste water from milkfish cultivation back to the containers, increased the weight of the milkfish significantly, as can be seen from Figure 1, 2 and 3 (I Dewa Gde Krishna Ramadia Wijaya and Wahyono Hadi, 2010).

In Figure-1, R refer to recirculated treated water, N refer to non recirculated water. F refer to similar quality of feed applied, and V refer to similar vitamin applied for enhancing the health of the milkfish. Both containers were aerated sufficiently. The different in growth is started from day 12 up to day 30.

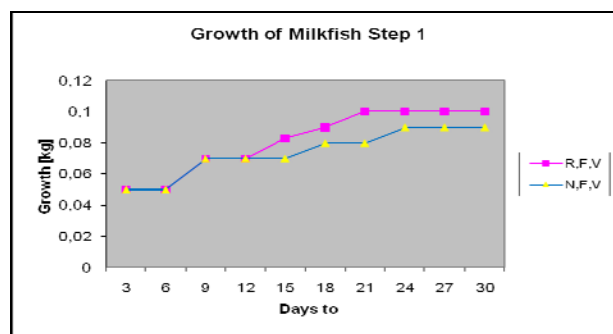


Figure 1. Growth of Milkfish at different media (with and without treatment) but similar feed and vitamin applied.

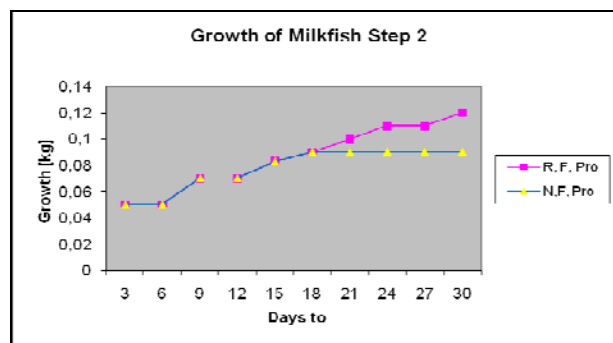


Figure-2. Growth of Milkfish at different media (with and without treatment) but similar feed and probiotics applied.

In Figure-2, R refer to recirculated treated water, N refer to non recirculated water. F refer to similar quality of feed applied, and P refer to similar probiotics applied for enhancing the health of the milkfish. Both containers were aerated sufficiently. The different in growth is started from day 18 up to day 30.

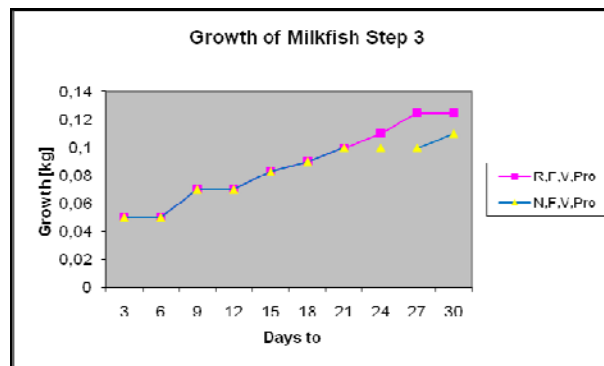


Figure-3. Growth of Milkfish at different media (with and without treatment) but similar feed, vitamin and probiotics applied.

In Figure-3, R refer to recirculated treated water, N refer to non recirculated water. F refer to similar quality of feed applied, and V refer to similar vitamin applied and Pro refer to similar probiotics applied, for enhancing the health of the milkfish. Both containers were aerated sufficiently. The different in growth is started from day 21 up to day 30.

MATERIALS AND METHODS

Eight 30 cm diameter of plastic containers were used for the cultivation of shrimps with a stocking density of 100 shrimps/ m² or 7 shrimps per container. Variations applied to the containers were: (1) with or without probiotic applied, (2) with or without vitamin applied, (3) with or without treated wastewater recirculation.

All shrimps in the containers are fed in accordance with the percentage of weight of shrimps in each container. Recirculation performed only on container which is planned to be done to water recirculation cultivation. The quality of water in each container at each stage was analyzed. Shrimp growth was also analyzed by weighing at each stage to see the difference of each variation.

Materials used in the water treatment for providing healthy water for shrimp applying roughing and slow sand filters consist of : (1) reservoir of raw water from existing river water/ sea water and contaminated water from shrimp cultivation pond, (2) feed water pump to the treatment units, (3) roughing filter in PVC pipe with 1 m/ hour flow velocity and 2-10 mm gravel (0.2 m free board), (4) slow sand filter in PVC pipe with 0.25 m/ hour flow velocity, 0.3 m height of water and 0.15-0.35 mm sand (1 m height) and 2-10 mm broken tiles (0.2 m height) and (0.2 m free board), (5) healthy water



reservoir, (4) distribution water pump. The Rouging Filter and the Slow Sand Filter can be seen from Figure-4.

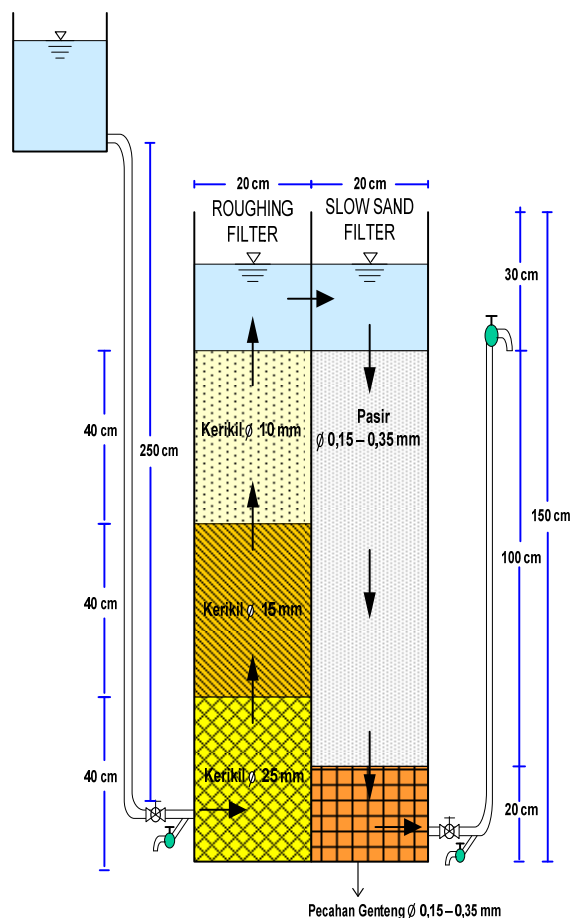
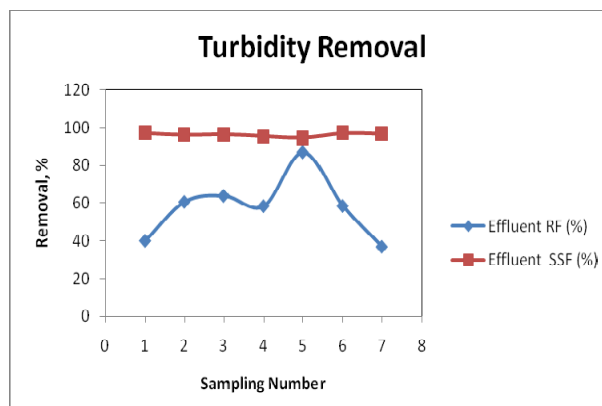


Figure-4. Roughing filter and slow sand filter for treating pond effluent (Note: pasir-sand, kerikil-gravel, pecahan genteng-broken tiles).

RESULTS AND DISCUSSIONS

Without the use of probiotics and recirculation of water in shrimp farming causes impaired growth and even some dead shrimp at some stage. The use of probiotics produce varied shrimp growth, so it is difficult to establish the type of probiotics seeded. For container cultivation of water recirculation conducted through water treatment, shrimp growth seen increased compared with both other variations.

Removal efficiencies of turbidity, total coliform bacteria, organic matter and detergent for filtration rate for RF was calculated as well as for SSF. Turbidity removal efficiency of the roughing filter was around 57 % for filtration rates of 0.25 m/ hour. Turbidity removal efficiency of the slow sand filter was around 96.3 % for the filtration rate of 0.25 m/ hour, as can be seen from Figure-5.



Source : Lab and data analyses

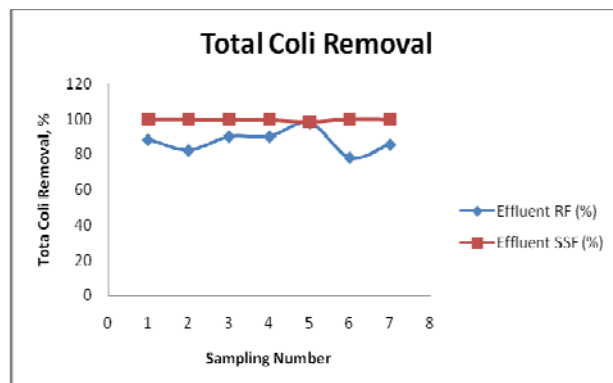
Note : RF – Roughing Filter; SSF – Slow Sand Filter ;
Filtration Rate – 0.25 m/ hour

Figure 5. Turbidity removal in roughing filter and slow sand filter.

The turbidity removal efficiency of SSF of more than 95% for 0.25 m/ hour filtration rates indicates the suitability of SSF in removing turbidity with no chemicals involved and low operation and maintenance (Al-Layla, M.A, Ahmad, S & Middlebrooks, E.J. 1978; Galvis, C. G. and 1999 and Levine, A 1999). No single treatment unit that can perform a better result as showed by the SSF. One always think of the high capital cost caused by the wider area needed compared to RSF (rapid sand filter). But with the all operation & maintenance costs faced by RSF, one may think of the simplicity and the best results encountered with the SSF (Losleben, T. R., 2008).

The average total Coli removal efficiency in the roughing filter was around 88 % for filtration rate of 0.25 m/ hour, as can be seen from Figure 6. It seems that at filtration rate of 0.25 m/ hour, removal efficiency shows the best applicable velocity. Total Coli removal efficiency of 88 % by roughing filter is considered high, since this unit functioned only as a precipitation unit, due to the bigger porosity than that of slow sand filter.

The average total Coli removal efficiencies in the slow sand filter was around 99.6 % for filtration rate of 0.25 m/ hour. It was not so easy to conclude that smutsdecke had been there for removing total coliform bacteria. But the end results indicate the high removal efficiency of total coliform bacteria. The short period of sampling for the filtration rate limit the growth of the bio-film (smutsdecke). It is important therefore, that the upper sand surface be acimated by putting the sand media into a flowing raw water in more than 2 weeks.



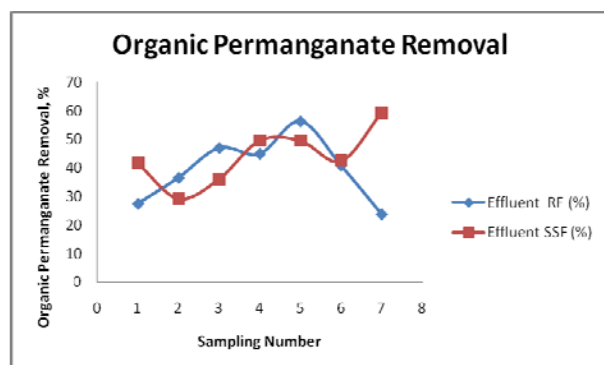
Source : Lab and data analyses

Note : RF – Roughing Filter; SSF – Slow Sand Filter ;
Filtration Rate – 0.25 m/ hour

Figure-6. Total coli removal in roughing filter and slow sand filter.

Organic removal efficiency in the roughing filter was around 11.66 % for the filtration rate of 0.25 m/ hour, as can be seen from Figure-7. The low removal efficiency of organics were fully understood, because the process occurred in roughing filter was only precipitation. In other word, organics removed were only the suspended organic matter present in the raw water, as seen on Figure-7.

Organic removal efficiency in the slow sand filter was 44.04 % for filtration rate of 0.25 m/ hour, as can be seen from Figure-7. The low removal efficiency of organic in the slow sand filter was probably due to the incomplete presence of smutsdecke. It means that not enough bacteria presence in the slow sand filter to degrade the organic in the water.



Source : Lab and data analyses

Note : RF – Roughing Filter; SSF – Slow Sand Filter ;
Filtration Rate – 0.25 m/ hour

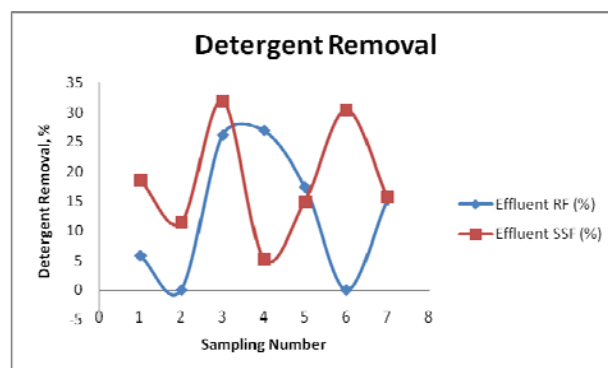
Figure-7. Organic permanganate removal in roughing filter and slow sand filter.

Detergent removal efficiencies in the roughing filter was 15.26 % for filtration rate of 0.25 m/ hour, as can be seen from Figure-8. The low removal efficiency of detergent was fully understood, because the process occurred in the roughing filter were only precipitation. In

other word, detergent removed were only the suspended detergent present in the raw water.

Detergent removal efficiency of the slow sand filter was 18.33 % for filtration rate of 0.25 m/ hour, as can be seen from Figure-8. The low removal efficiency of detergent in the slow sand filter was probably due to the incomplete presence of smutsdecke. It means that not enough bacteria presence in the slow sand filter to degrade the detergents in the water.

Roughing and slow sand filter configuration is seem very good in removing turbidity and total coli bacteria, but moderate in removing organic and detergent contents in the raw water. The main key process is filtration through the slow sand filter. If smutsdecke formation is through, the removal efficiencies of turbidity, total coli, organic and detergent will undoubtedly be significant.



Source : Lab and data analyses

Note : RF – Roughing Filter; SSF – Slow Sand Filter ;
Filtration Rate – 0.25 m/ hour

Figure-8. Detergent removal in roughing filter and slow sand filter.

CONCLUSIONS

The advantage of using Roughing and Slow Sand Filters is the reliable output qualities in terms of turbidity, detergents, organic content and coliform bacteria counts.

Other advantages of applying roughing and slow sand filters are the simplicity of the operation and maintenance. This is due to the relatively simple technology used, and the avoidance of chemicals used for coagulation and flocculation. In other word, raw water are treated only physically by gravels and sands.

Most of the reluctances to put roughing and slow sand filters into application are among others, the unpredicted performance of the units, cleaning system of the units, and requirement of the larger area compared to the conventional ones, but the advantage of avoiding applying chemicals, high energy inputs, and expensive building structures, may be of future consideration especially for aquaculture.

By knowing all of the advantages and the disadvantages of the roughing and slow sand filters,



further studies on automation of cleaning system of roughing filter may be of an important leap to overcome the obstacles. By applying roughing and slow sand filters in a high rise stucture, requirement of large spaces may be cut.

Another obstacle is scraping procedure in the slow sand filter operation. One may think of providing automatic scraper on the surface of the sand. Sand is scraped within 2 cm depth and put the dirty sand on the moving escalator leading to a backwashing tank. Clean sand is then put back to the slow sand surface. The depth of the sand material is therefore can be minimize as shallow as possible, i.e. 80 cm.

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