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Feasibility of using Bivalve Molluscs to Reduce the Suspended Solid Content in Shrimp Farm Effluents

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Abstract

The shrimp industry is now constrained by problems linked with environment due to direct discharge of farm effluent to the water source. In treatment systems, some bivalves can be utilized to reduce the suspended solid content in farm effluents and the present study was carried out whether species of bivalves namely *Meretrix casta* and *Perna perna*, can be used for this purpose in Sri Lanka.

Different densities of bivalves (20 m^{-3}, 40 m^{-3}, 60 m^{-3} and 80 m^{-3}), from each species were separately allocated in effluent water and suspended solids were measured after 6 hours. Twenty bivalves from both species were separately subjected to the effluent water (2 m^3) at two different salinity levels (20 ppt and 30 ppt) and suspended solids were measured at 6 hour intervals. Two different volumes of water (1 m^3 and 2 m^3) were allowed to be utilized by 20 bivalves from each species and suspended solids were measured at 2 hour intervals.

In both species, with the increase in the number of individuals, the suspended solid concentrations reduced. *P. perna* was found to be significantly more efficient in reducing the suspended solids than *M. casta* ($P<0.05$). At 30 ppt salinity, there was significant difference ($P<0.05$) between the two species in their suspended solid reduction ability. The species which was capable of reducing suspended solids at both salinity levels was *P. perna*. *M. casta* showed a significantly lower ($P<0.05$) suspended solid reduction ability at 30 ppt salinity. Significantly higher ($P<0.05$) reduction in suspended solid concentrations for both species was observed when total volume used was 1m^3. However, after 30 hours of purification no significant difference ($P>0.05$) was found between the two volumes.

Results of this study revealed that bivalves such as *P. perna* and *M. casta* can be utilized in effluent treatment systems and suspended solid concentration can be

reduced from 850 mg/m^3 to less than half of the concentration within a period of 24 hours using 20 bivalves in 1 m^3 of water.

Introduction

Shrimp culture played an important role as one of the fastest growing industries in Sri Lanka during the last decade, making a significant contribution to the foreign exchange earning from the fisheries sector. However, rapid expansion of shrimp industry over the recent years has resulted in several noticeable environmental changes in coastal areas of the world shrimp producing countries like Thailand, Indonesia, Taiwan, Philippines, Sri Lanka etc. Now it is being increasingly constrained by problems linked to the environment and diseases (Corea et al. 1995). The release of farm effluents loaded with nutrients into water bodies deteriorates the quality of water and deteriorating water quality conditions has been often found responsible for outbreaks of infectious diseases in shrimp culture systems (Enander & Hasselstrom 1994). Treatment of farm effluents will improve the quality of effluent waters, minimising the risk of disease outbreaks. Thus it plays an important role in maintaining the sustainability of shrimp culture, mitigating most of the present constraints which have arisen due to the farm effluents. In biological treatment systems, bivalves, sea weeds, planktivorous fish and holothuroids can be utilised to improve the quality of water (Chamish 1995). In general, bivalve molluscs are filter feeding organisms. They feed by pumping water through their gills and filtering through the particulate organic matter which they can consume. Thus bivalves are capable in reducing suspended solids in the water where they grow and can be used in effluent water treatment systems to reduce the suspended solid loading in the water. Preliminary investigations in Sri Lanka have identified six species of bivalve molluscs including *Meretrix casta, Perna perna, Perna viridis, Gafrarium tumidum, Crassostrea madrasensis* and *Macia opima* as potential candidates for the treatment systems. The present study investigates the capability of two bivalve species namely *Meretrix casta* and *Perna perna*, in reducing suspended solid content in the shrimp farm effluent water.

Materials and Methods

The experimental site was a private shrimp farm at Chilaw. Effluent water for the experiments was collected from the outlet canal of the farm, into plastic water tanks which were considered as experimental units. Two species of bivalves were subjected to three sequential experiments with three replicates.

Different densities of bivalves (20, 40, 60 and 80 per m^3), from both species, were used separately in effluent water and suspended solid concentrations were measured after six hours. Twenty bivalves from both species were separately subjected to the effluent water (2 m^3) at two different salinity levels (20 ppt and 30 ppt) and suspended solid concentrations were measured at six-hour intervals. Two different volumes of water (1 m^3 and 2 m^3) were individually allowed to be utilized by twenty bivalves from each species and suspended concentrations were measured at two-hour intervals. At the relevant time of measuring suspended solids, water samples of 250 ml were taken out from the water tanks, filtered using GF/C filter papers with 1.2 μm particle retention ability, oven dried at 105^0C for 45 minutes and dry weights of suspended solids were measured.

Data were analyzed using MINITAB statistical computer package. Experimental design was Complete Randomized Design (CRD) and resulted mean values were compared for their significance in the differences, using Duncan's New Multiple Range Test (DNMRT). The curvilinear relationships were adjusted to linear lines using log transformation and the resulted linear regression lines were compared with each other for their significance in the difference.

Salinity, pH, temperature and dissolved oxygen were the physico-chemical parameters of the effluent water, checked throughout the experimental period.

Results and Discussion

Effect of density of bivalves on suspended solids reduction

The suspended solid concentration in the effluent water decreased with the increase in the number of bivalves (Fig. 1). When mean values of suspended solid concentrations were compared, *P. perna* showed significant reduction ($p<0.05$) with the increase in the number of bivalves from 0 to 80 , whereas *M. casta* showed significant reduction ($p<0.05$) only up to the level of sixty bivalves. The rate of reduction of suspended solid concentrations was observed to be significantly different ($p<0.05$) in the two bivalve species. *P. perna* was found to have significantly higher ability ($p<0.05$) in reducing the suspended solids than *M. casta*.

The suspended solid reducing capacity per bivalve has reduced with increasing density (Fig. 2) and the main reason for that would be the competition which would have arisen among the individuals.

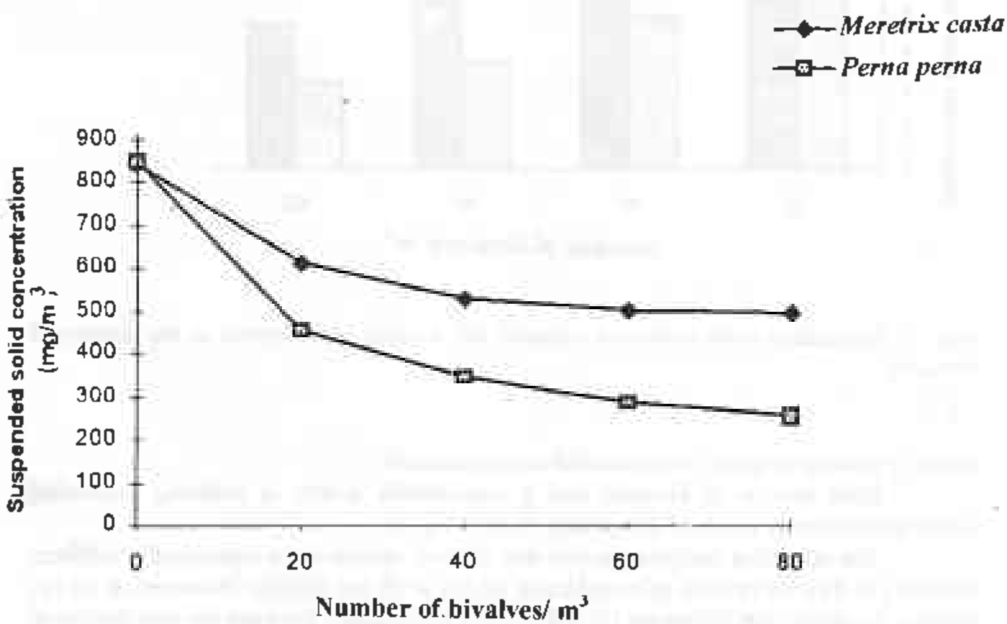

Fig. 1. Suspended solid concentrations of the effluent water, after 6 hrs of purification with two species of bivalves at different densities.

Though both species used in the present study belong Class Bivalvia, *M. casta* is a clam species of family Veneridae and *P. perna* is a mussel species of family Mytilidae (Morton 1979). Being a clam species, *M. casta* dwells in the bottom habitat, feeding mainly on detritus and their position at the bottom of the water column is horizontal. *P. perna* is attached to hard or gravel surfaces by their byssal threads and can live at any position in the water column. Therefore, they can take in more water through their valves than *M. casta*. Mussels also depend mainly on phytoplankton and possess higher rate of water movement through their gills than clams (Byne 1976). Because of these reasons, significantly higher suspended solid reduction in the effluent water could always be observed for *P. perna* than for *M. casta*.

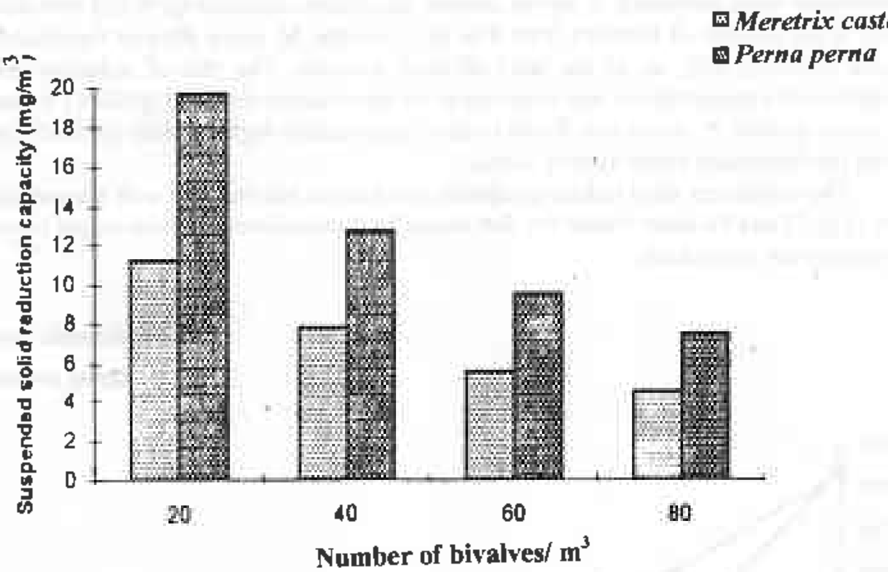

Fig. 2. Suspended solid reduction capacity per bivalve with respect to the density of bivalves.

Effect of salinity of water on suspended solid reduction

Both species of bivalves had a considerable ability in reducing suspended solids at the salinity levels of 20 ppt and 30 ppt (Fig. 3).

The statistical analysis showed that the two species were significantly different ($p<0.05$) in their suspended solid reduction ability at 30 ppt salinity. However, at 20 ppt salinity, no significant difference ($p>0.05$) could be observed between the two species in their suspended solid reduction ability.

When two species were considered separately, *P. perna* showed no significant difference in ability of suspended solid reduction at the two salinity levels, whereas *M. casta* showed significantly lower ($p<0.05$) reduction ability at 30 ppt salinity level.

Effect of volume of water on suspended solid reduction

The pattern in the rates of suspended solid reduction, at two different volumes of water by the two species of bivalves is shown in Fig. 4.

Comparatively high rate of reduction of suspended solids by *P. perna* was observed at both the volumes of water. The main reason for this is the higher filtering capacity of mussel species than clams. In both species, the difference of suspended solid concentrations in two volumes of water was significant only up to thirty hours of purification. Each bivalve species shows their own rate of filtering which is unique to the species under given conditions. Therefore, in any volume of water the suspended solid reduction will take place according to their inherent rate of filtering. Because of this, when the same number of bivalves was used for two different volumes of water, the suspended solid concentrations remain always higher at high volumes of water than at low volumes of water. Accordingly, the threshold level of concentration of suspended solid for filtering is reached by the low volume of water quicker than the high volume of water. After the threshold point, the filtration would be drastically reduced or completely stopped. Due to this reason, when both volumes of water are allowed to be utilized for a longer period of time, there would not be a significant difference in the suspended solid concentrations in the two volumes.

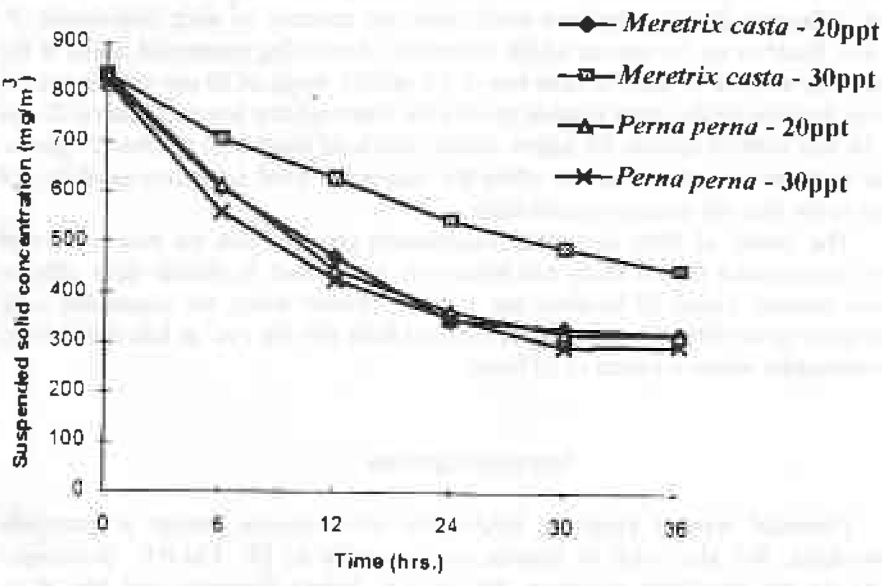

Fig. 3. Reduction of the suspended solid concentrations with time by two species of bivalves at two different salinity levels of water.

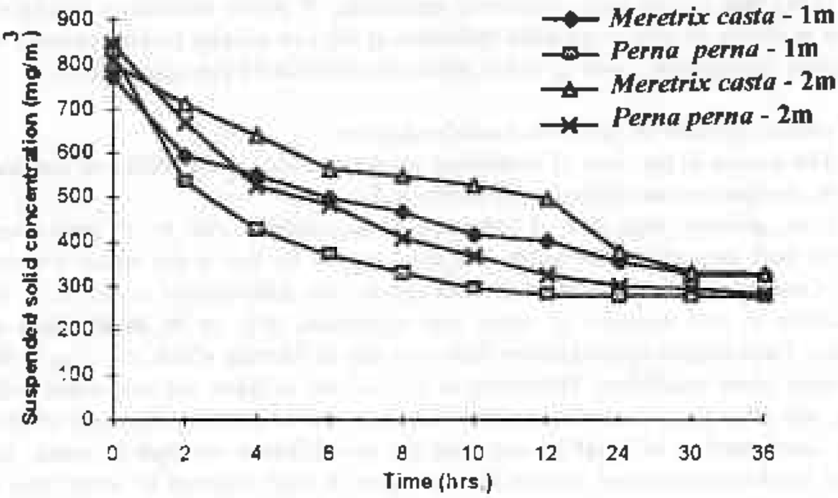

Fig. 4. Reduction of suspended solid concentration, with time by two species of bivalves at two different volumes of water.

Conclusion

The total suspended solid concentration in the effluent water reduced with the increase of density of bivalves. However, the increase of density of bivalves showed negative influence on the suspended solid reduction capacity of each individuals. *P. perna* was found to be the species which is capable of reducing suspended solids in the effluent water at more or less the same rate at the salinity levels of 20 ppt and 30 ppt. *M. casta* was found to be the more suitable species for lower salinity levels of around 20 ppt and to be less suitable species for higher salinity levels of around 30 ppt than *P. perna*. Volume of water was also found to effect the suspended solid reduction capability of bivalves in the first few hours of purification.

The results of three sequential experiments revealed that the two species of bivalves investigated in this study can effectively be utilized in shrimp farm effluent treatment systems. Using 20 bivalves per 1 m^3 of effluent water, the suspended solid concentration in the effluent water can be reduced from 850 mg / m^3 to less than half of the concentration within a period of 24 hours.

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