APPLICATION OF GREEN MUSSEL (*PERNA VIRIDIS*) IN BIOLOGICAL TREATMENT OF EFFLUENTS FROM AN INTENSIVE MARINE SHRIMP FARM

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ABSTRACT

Green mussel *Perna viridis* were exposed 10 days to effluents from an intensive marine shrimp farm (0.55 ha., stocking density 34 shrimp m^{-2}, and 1 month old) for biological treatment of the water. Densities of green mussel were 1, 3, 5, and 7 kg mussel per ton effluent. One control without mussels was included. The experiment was repeated three times. Effluents were monitored for chlorophyll *a* , ammonia-nitrogen, nitrite-nitrogen, orthophosphate, and total suspended solids before and after each experiment. Average temperature, salinity, and pH were 26-29 °C, 31-33 ppt and 7.9-8.7 respectively. We conclude that 1 kg green mussel is a suitable stocking density for the treatment of 1 ton of stagnant waste water per 10 days. Survival was not significantly different among the experiments, but there was a tendency toward increased mortality at higher stocking densities.

INTRODUCTION

Marine shrimp have been cultured in Thailand for nearly 80 years. But from 1985 till now intensive marine shrimp culture has rapidly developed, and the cultured area has increased from 40,700 ha to 80,000 ha. Shrimp farms are now found along the coastal provinces in the Gulf of Thailand and the Andaman Sea. Production has increased sixteen times from 15,841 tons in 1985 to 250,000 tons in 1995. It has given very high economic return compared with other agricultural activities (Tookwinas 1996).

Unfortunately, the intensive marine shrimp culture has had a negative influence on water quality of the coastal zone. Effluents from intensive farming contain much organic matter and high density of plankton, which can lead to plankton blooms, eutrophication, and oxygen deficiency.

Tookwinas et al. (1994) found that water drainage from intensive marine shrimp farms in the eastern part of Thailand was 67,000 tons hr^{-1} during a culture period of 5 months. The BOD_5^{20} loading was 67,400 tons ha^{-1} $crop^{-1}$. The average BOD_5^{20} for the 5 months was 8.47 mg l^{-1}. Lin (1992) linked a collapse in shrimp farming to water pollution in the upper Gulf of Thailand (provinces of Samutsongkram, Samutpakan and Samutsakon). The coastal area was overloaded with effluents. MacIntosh & Phillips (1992) also explained that these collapses were related to the limited water supply in the canals which were totally inadequate for the needs of large scale intensive shrimp culture.

Treatment of shrimp pond effluents offers considerable potential for reducing impacts on the water released to the surrounding environment (MacIntosh & Phillips 1992). One major problem is the diluted and large volumes of aquaculture effluents in comparison with traditional forms of waste water (Muir 1982).

Treatment can be divided into physical, chemical and biological methods. A biological method based on culturing suitable aquatic organisms is a possible solution. A benefit for the farmers is to get more cultured products. Mussels can consume phytoplankton in the effluent thereby reducing the impact on the coastal environment. Anderson (1989) reported that one mussel with a weight of 10 g can filter 50 litre sea water in 24 h and reduce the BOD considerably.

MATERIALS AND METHODS

Effluent from a 0.55 ha shrimp farm with a stocking density 34 shrimp m^{-2}, and 1 month of age, was used in experiments. Green mussel (*Perna viridis*) in the size class of 50 mussels kg^{-1} were put in 1 ton fibreglass tanks at four stocking densities (1, 3, 5 and 7 kg mussels ton^{-1} effluent), and one control without mussels, at a private shrimp pond in Samutsongkram province during August to September 1990. A total of three experiments were carried out.

The effluent was stored in fibreglass tanks for 1 night. Water samples were collected for analysis before green mussels were introduced at four densities. After 10 days, the sea water was analysed in the experimental tanks and the control. The green mussel were also checked for growth and survival.

Water, chlorophyll *a* and total suspended solids were analysed according to Chuan & Sugahara (1984). Dissolved oxygen, and orthophosphate were analysed by a standard method (APHA 1989). Ammonia-nitrogen and nitrite-nitrogen were analysed by the method of Grasshoff (1974). pH, temperature and salinity were checked by pH meter, mercury thermometer and refractosalinometer respectively. The results were analysed by SYSTAT version 4.1 (Program GRAPHER version 1.2), and covariance (ANCOVA), using the quality of effluent as the covariate factor and stocking density as the treatment. The suitable density of green mussel for effluent treatment was analysed by multiple regression.

RESULTS

Water quality

The water quality values in the outlet of the experimental tanks before and after the treatments in each experiment are shown in Fig. 1. Chlorophyll *a*, dissolved oxygen, and suspended solids decreased in every experimental tank. However, ammonia-nitrogen, nitrite-nitrogen and orthophosphate did not clearly show any decrease.

The effect of mussel quantity on treatment efficiency

Analysis of covariance (ANCOVA) showed that the filtering efficiency expressed as chlorophyll *a* removal depended on the density of mussels. A stocking density of 1 kg mussel per ton effluent was significantly different in chlorophyll *a* removal compared to the stocking densities of 3, 5 and 7 kg mussel per ton effluent. Chlorophyll *a* removal was not significantly different when the stocking density of 3 kg mussel per ton effluent was compared with 5 and 7 kg per ton effluent respectively ($P<0.05$). The filtering efficiency of green mussel increased with the increasing chlorophyll *a* concentration.

We found that the stocking density of 1 kg mussel per ton effluent significantly decreased NH_3-N, NO_2-N, DO, and PO_4 in the effluent, but removal efficiency of dissolved nutrients was not significantly different when the stocking density of 3 kg mussel per ton was compared with 5, and 7 kg per ton effluent respectively.

One kg mussel per ton effluent significantly reduced the concentration of total suspended solids, but the removal of total suspended solids was not significantly different when the stocking density of 3 kg mussel per ton effluent was compared with 5 and 7 kg per ton effluent respectively.

Growth and survival of green mussel

Green mussel grew visibly in the experimental tanks but during the periods of 10 days were too short to give meaningful estimates. In the first test, survival of green mussel in tanks with stocking densities of 1, 3, 5 and 7 kg per ton effluent were 96, 97, 96, and 91 % respectively. In the second test 90, 89, 87 and 56 %; and in the third test 95, 94, 93, and 75 % respectively. Survival was not significantly different in comparisons of the experiments, but there was a tendency toward increased mortality at higher stocking densities.

DISCUSSION

Experiments on chemical treatment of waste water (Tookwinas & Neumhom 1995) showed that calcium oxide (CaO) at 0.3 mg l^{-1}, zeolite at 3.0 mg l^{-1} and alum at 1.0 mg l^{-1} with aeration can reduce the effluent concentration down to an acceptable level in 24 hrs. The reduction efficiencies were from 92 to 90 %.

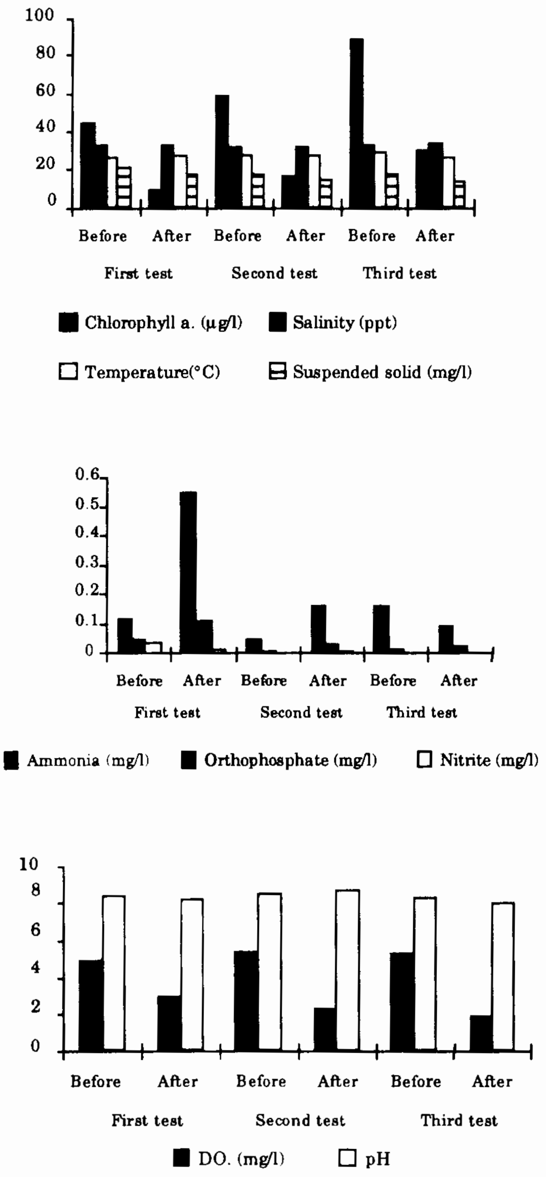

Figure 1. Variables analysed before and after mussels were stocked in the experimental tanks. Average values for 3 experiments.

Experiments on seaweed cultivation in the effluent from shrimp culture were conducted in Chanthaburi and Songkhla provinces (Daroonchoo 1991; Chiyakam & Tunvilai 1992). In 24 hrs, ammonia-nitrogen was absorbed by seaweed at 100 % efficiency and BOD_5^{20} reduced by 39 %.

Experiments using *Artemia* and green mussel were conducted by Tunvilai & Tookwinas (1991) and Chaiyakam & Tunvilai (1992). The results showed that in 24 hrs, green mussel could reduce ammonia-nitrogen, chlorophyll *a*, total suspended solids and BOD in effluents with an efficiency of 67, 87, 13, and 77 % respectively.

CP Aquaculture News (1994) reported that mussels can be cultured in drainage canals of intensive marine farms in order to decrease the concentration of effluent. A suitable biomass would be 1 kg mussel for an effluent load of 4 tons per day, reducing the concentration of organic matter by approximately 50 %. However, the stock of green mussel would defecate and excrete pseudofeces which might create other problems for shrimp farmers.

Based on the present study we conclude that biological treatment of effluent, from intensive marine shrimp farming, is possible. A suitable quantity of mussels would be 1 kg mussel per ton effluent. But a test to confirm this is recommended. Green mussels filter chlorophyll *a* (phytoplankton) effectively from shrimp farm effluents. But other organisms are needed to minimise dissolved nutrients. Further studies are needed to throw light upon the culture management of green mussels in waste water control. Details of waste material from green mussel and residence time for biological treatment should also be studied. The integration of mollusc culture with seaweed and herbivorous fish, or brackish water fish, is recommended because various organism would have the potential to absorb or reduce different kinds of effluent compounds.

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