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BIOLOGICAL TREATMENT OF AQUACULTURE DISCHARGE WATERS BY SEAWEEDS

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ABSTRACT

Treatment with seaweeds confirmed that nutrients from the aquaculture farm discharges could be converted in to seaweed biomass in a laboratory scale treatment experiment *Enteromorpha flexuosa* removed 87.2% of nitrite 87.2 % of nitrate, 82.5% of ammonia and 84.1% of phosphate and *Gracilaria verrucosa* removed 94.5% of nitrite 91.4% of nitrate, 99.3% of ammonia and 100% of phosphate from the discharge waters of aquaculture farm in a period of 20 days. Concentration of dissolved oxygen level increased from 4.2 to 5.1 mg/L with *E. flexuosa* and from 3.3 to 5.1 mg/L in with *G. verrucosa*. The biomass of seaweed has increased from 20 to 27.1g in the case of *E. flexuosa* and from 20 to 28.1g in the case of *G. verrucosa*. With increasing shrimp farming activities considerable quantity of discharge waters, will be generated and that may lead to some negative impacts on coastal and land environment. Biological treatment system is the best of all the treatment systems for a tropical country like India because of low cost and simple operations.

INTRODUCTION

Pollution and environmental degradation in coastal areas due to aquaculture farms is a serious problem in many developing countries. Most of the aquaculture farms do not have any treatment systems for treating aqua farm discharges. The most common way to reduce pollution is to treat the discharge water by an appropriate treatment method at the source itself. Another way is to reuse the wastewater for secondary aquaculture. Generally in India, two

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types of aquaculture farming technologies have been adopted i.e. modified extensive method and semi-intensive method. In modified extensive method shrimp forage is exclusively done on naturally occurring food items, water exchange is done throughout the farming period to introduce additional source of forage prey. Hence, in this method the chance of pollution is very much reduced. Whereas, in semi-intensive system, they have to be maintained through artificial feed, fertilizers and periodic water exchange by pumping large amount of water, which create water quality problems in receiving waters. Since this receiving water serves as inlet water for neighboring farms and the chances for the outbreak of diseases are increased (Pruder, 1992). The major constituents of the discharge waters are uneaten food, faecal waste, exoskeleton, plankton, fertilizers and nutrients. The quality and quantity of the waste products naturally depend on culture operations and management.

The presence of different kinds of pollutants in the wastewater makes it almost impossible to treat all the wastewater in the same manner. The wastes originate from various sources and can be broadly divided into two categories such as biological waste and non-biological waste. Aquaculture waste mostly comes under biological wastes and is biodegradable. The biological wastes are those, which originate primarily from living resources. Such wastes predominantly consist of degradable organic matter and nutrients and are generally treatable. Even we can use this treated water for other biological cultivation/ culture purposes. Generally, three treatment methods are available to treat the wastewater i.e., physical, chemical and biological method. Of all these methods, biological method is most advantageous, "low cost" and simple to operate. Such a low cost system may be more suitable for developing countries like India.

The extent or degree of treatment varies greatly depending upon the ultimate disposal of the discharge waters. In aquaculture, biological treatment includes three methods 1. Using filter feeder, 2.Using water plants and 3. Using both filter feeder and water plants. Of all these biological treatment methods seaweed treatment is the best suitable method for aquaculture wastewater treatment and this method is easy to adopt by even uneducated farmers. The efficiency of removal is 80 to 90% for inorganic nutrients and nitrogen from the aquaculture wastewater. Harvested seaweeds can be utilized for manure, for fodder or bio-energy production and to provide raw materials for chemical and pharmaceutical production. Since, the seaweeds are rich in proteins, carbohydrates, vitamins and minerals, seaweeds grown in the pond discharge waters may be profitably used for human and animal consumption. Mc. Garry and Tongkasame (1971) reported a yield of seaweed as 112 ton/ ha/yr. from aquaculture pond waters. Vittal Rao and Krishnamoorthy have also reported that aquaculture pond waters could yield up to 114 tons of sea weeds/ha/yr. There is a need to adopt low-cost treatment methods in order to reduce the cost of treatment. With this view, the efficiency of nutrient removal by seaweeds form aquaculture pond discharge water was evaluated in the present study.

MATERIALS AND METHODS

The aquafarm discharge waters were collected from the semi-intensive aqua farm at the time of harvest in plastic containers. The collected water was filtered through blotting cloth having a mesh size of 20µ to remove the phytoplankton and the discharge water samples were transferred to five glass tanks of 50 L capacity each. The seaweeds. *Gracilaria verrucosa* and *Enteromorpha flexuosa* were collected from the Marakkanam estuary (Cuddalore) and was stocked at a density of twenty grams in each tank except control. The water was continuously aerated from the initial period to the end of the treatment. The nutrient content (nitrite, nitrate, ammonia, and phosphate) and the dissolved oxygen level of the discharge waters were analyzed once in two days from the initial period to the end of the treatment period (20 days) using standard methods (APHA, 1995) Experiments were conducted for a period of 20 days, since it is known that the biomass of *G.verrucosa* and *E.flexuosa* doubles every seven to ten days (Reddy *et al*. 1995) to assess the nutrient removal efficiency. The increase in wet weight of the seaweeds was also estimated from the initial period to the harvest period to assess the biomass production.

The experiments were carried out using glass tanks of 58x30x28 cm size with a volume of 50 L. The glass tanks were filled with 20 L of aqua farm discharge water. Seaweeds grown in seawater in the tanks served as control.

For estimating biomass, the water was removed as much as possible by a filter paper and was weighed with an electronic balance. Biomass of seaweeds was calculated as the difference between the final and the initial weight.

RESULTS AND DISCUSSION

A biological treatment system with seaweeds was designed to treat the discharge waters from the semi- intensive shrimp pond. Two species of seaweeds were used. In unit I *E. flexuosa* with a stocking density of 1g/L was used. The algae effectively removed nitrite content from 0.110 to 0.014 mg/L, nitrate content from 0.244 to 0.031 mg/L, ammonia content from 1.21 to 0.211 mg/L and phosphate content from 0.518 to 0.082 mg/L (Table 1). At the end of the experiment, the biomass of seaweed has increased from 20 to 27.16 g. In unit II *G.verrucosa* was used. These algae removed nitrite from 0.110mg /L to 0.006 mg/L, nitrate from 0.244 to 0.021mg/L, ammonia from 1.21 to 0.008 mg/L and phosphate from 0.518 to BDL (Table 2). Assimilation of nutrients by the seaweeds resulted in the production of 8.12 mg of biomass of *G.verrucosa*. Thus, the algae utilized the nutrients present in the discharge waters. Similar studies were also carried out by Michael (1995). He showed that seaweeds could absorb nutrients from the discharge waters.

After growing seaweeds, the wastewater was observed to contain only trace level of nutrients and appears to be suitable for discharging into coastal waters or any other receiving waters. Nutrient concentrations (initial) of discharge waters and control water were given in Table 3 and 4. Growth rate of seaweeds observed in the present study was comparable to Sphigel *et al.* (1993) results. Commercial application of fertilizers in the aquaculture may cause increase in nutrient levels of the farm waters and could affect water quality of receiving waters. These effects can be minimized by using seaweeds because they are capable of utilizing large quantities of fertilizers sufficient for their

Table 1
Percentage of nutrient removal/consumption by *E.flexuosa* from aqua farm wastewater

Parameters	Initial	Final	Amount assimilated	%of Removal
Nitrite	0.110	0.014	25	87.2
Nitrate	0.244	0.131	38	87.2
Ammonia	0.809	0.211	39	82.5
Phosphate	0.518	0.082	42	84.1

Table 2
Percentage of nutrient removal / consumption by *G.verrucosa* from aquafarm wastewater

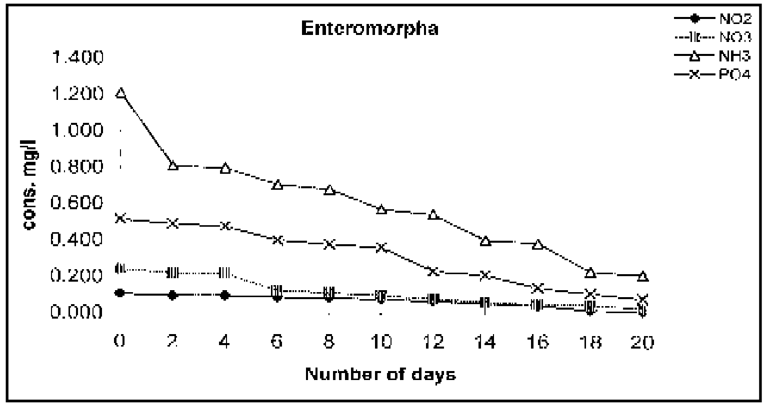
Parameters	Initial	Final	Amount assimilated	%of Removal
Nitrite	0.110	0.006	50	94.5
Nitrate	0.244	0.244	48	91.4
Ammonia	0.809	0.809	36	99.3
Phosphate	0.518	0.518	50	100

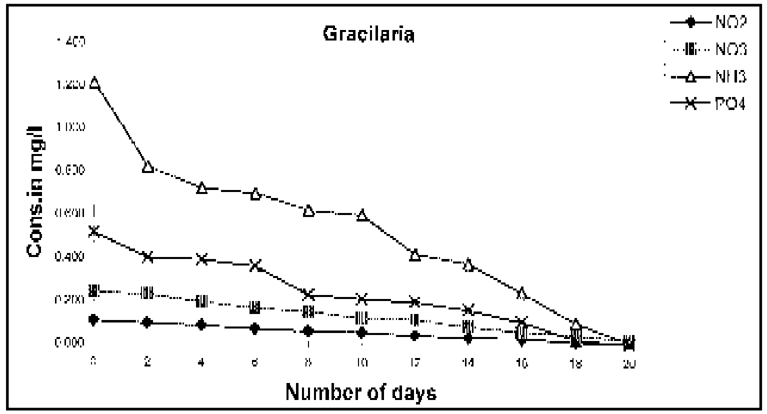
All the values are mg/L

need for several days in a short period (Tseng *et al*. 1962). They concluded from their studies that with commercial fertilizers at different concentration and duration of treatment under laboratory condition *G.verrucosa* effectively assimilated urea, potash and super phosphate for the growth. Chennubhotla and Kaliaperumal (1987) reported that the growth of seaweed was generally high when co-cultivated with shrimp or some other organisms.

G.verrucosa removed more amounts of nutrients than *E. flexuosa*. *G.verrucosa* was able to remove during the 20th day period a maximum of 98.8 % of nutrients from the aquaculture discharge water, while *E. flexuosa* removed only 84.1 %. Fujita *et al*. (1989) observed that, the green seaweed Ulva was capable of removing 30-50% of ammonia from the discharge waters water. Ryther (1991) reported that *G. foliferra* removed 90 % of ammonia from fishpond discharge waters. Similar results were also reported by Cohen and Neori (1991). In the present study, *G.verrucosa* was able to remove a maximum of 94.5 % of nitrite, 91.4 % of nitrate, 99.3 % of ammonia and 100 % of phosphate at the end of the study period (Table 1). *E. flexuosa* removed 87.2 % of nitrite, 87.2 % of nitrate, 82.5 % of ammonia and 84.1 of phosphate from the aquaculture wastewater (Table 2). Phillips (1990) highlighted the importance of biological treatment for improving the water quality of brackish water aquaculture pond discharge waters. Treatment with seaweeds confirmed that the plant nutrients could be converted into the weed biomass. The high yield of algae from treatment plants was possible, because nutrient rich discharge waters acted as natural medium and, nutrients required for algal growth were continuously released by microbial activity. Secondly, suspended solids present in the discharge waters may also contribute to the increased seaweed yield. Results of present study showed that seaweed removed 85. 2 to 96.3 % of nutrients from the discharge waters. Dumas *et al.* (1998) studied similar experiments in the biotreatment of aqua farm discharge waters using Cynobacterium *Phormidium*

Nutrients removal by seaweeds





bohneri. Their results also indicated 82 to 85% removal of nutrients from the wastewater. Brown et al (1999) showed removal of 99% of the total phosphorus from the aquaculture wastewater system by halophytes. Hauglund and Pedersen (1993) investigated the potential of seaweed when co-cultivated with rainbow trout for the removal of nitrogen and phosphorus from the fishpond. They showed that the seaweed removed 30-50 % of the ammonia in the salmon culture discharge waters. Cohen and Neori (1991) recorded a reduction of 40-90 % of the incoming ammonia. Dissolved Oxygen concentration was increased with increasing days of seaweed culture from the initial period to end of the treatment period. Since, the nitrogen content of the discharge waters posed a threat to the health of the receiving coastal water bodies, use of seaweed treatment is the best way to reduce the environmental impact and also providing for an additional income from culture operation.

CONCLUSIONS

Waste disposal and pollution problem due to aquaculture is increasing through out the world. Most of the plants capable of growing in waste water can absorb and incorporate the dissolved nutrients. Discharge waters treated with the plants are stripped off its nutrients and could be reused for aquaculture, agriculture and industrial purpose. For many developing countries, wastewater aquaculture of fast growing plants will provide an indigenous source of cheep fertilizer. Biological treatment of aquaculture discharge waters can be inexpensive to build and maintain, with very less energy cost. The harvested plants could be used in a variety of ways such as feed for various animals, fish and birds for providing raw materials and even for human beings (i.e *Gracillaria* used in pharmaceutical industries and is also edible). In the present study seaweeds reduced the nutrients up to 85.2 to 96.3 % from the wastewater. This kind of technology appears to be viable and is a best alternative method for countries like India.

REFERENCES

APHA, 1995. *Standard Methods for the Examination of Water and Wastewater*, 19th edition. American Public Health Association. 10-157.

Brown, J.J. Glenn, E. P and Smith, S.E. 1999. Halophytes for the treatment of saline aquaculture discharge waters. *J. Aquaculture*. 175 : 3255-268.

Chennubhotla, V.S.K. and Kaliaperumal, P. 1987. Marine algal flora from selected centers along the madras coast. In : *Mar. Fish. Infor. Serv. Tand E Ser*. 72 : 19.

Cohen, I. and Neori, D.M. 1991. Ulva lactuca biofilters from marine fish ponds effluent waters. *Journal Bot. Mar*. 34 : 475-480.

Dumas, A. 1998. Bio-treatment of fish farm discharge waters using the cyanobacterium Phormidium. *Journal Aquaculture Engineering*. 17(1) : 57-68.

Fujita, R., Lund, M. and Levin, D. 1989. Integrated Salman- Seaweed mariculture (Research note), North West. *Env. Journal Focus. on Aquaculture*. 5164.

Hauglund, K.& Pedersen, M. 1993. Outdoor pond cultivation of the subtropical marine red algae Gracilaria in brackish water in Sweden, growth, nutrient uptake, co-cultivation with rainbow trout & epiphyte control. *Jr.App. Phycol*. 5271-284.

McGarry, M.G. and Tongkasame, M. 1971. Water reclamation and algae harvesting. *Journal Wat. Poll. Control Fe*. 43 : 824 -835.

Michael, M.J. and Phillips, 1995. Aquaculture and the Environment. In: Aquaculture towards 21st century, Nambiar K.P and SinghT (eds) *Journal Infofish*. 26-55.

Pruder, G.D. 1992. Marine shrimp pond effluent water characterization and environmental impact. In : *Proceedings of the special session in shrimp farming*. World Aquaculture Society, USA. 187-194.

Phillips, M.J. 1990. *Environmental aspects of seaweed culture, Tech paper reg work shop on the culture and utilization of seaweed.* Inst. Aquacul. Univ. Steriling. UK 51-62.

Reddy, R., Rao, R.S. and Rao, V.V. 1995. Pollution aspects of prawn culture in semi-intensive system. *Journal Environ. Prote*. 16 (10) : 775-778.

Ryther, J. H, Goldman, J. C, Gifford, C. E et al. (1975) Physical models of integrated waste recycling-marine poly culture systems. *Journal Aquaculture*. 5 : 163-177.

Sphigel, M.A., Neori, M., Popper, R. and Gordin, H. 1993. Proposed model for environmentally clean land-based culture of fish, bivalves and seaweeds. *Journal Aquaculture*. 117 : 115-138.

Tseng, C.K., Wu, C.Y. and Sun,K.Y. 1962. Studies on the absorption of nitrate & ammonium nitrogen by Laminasia Japonica Aresch, In: Collected papers of the 5th meeting of Western Pacific Fisheries Res. Comm., Sci. Press, Beijing. 21-32.

Vittal Rao, M. and Krishnamoorthi, K. 1979. Potentialities of facultative stabilisation ponds for algal harvest intropics Indian. *Journal Envt. Health*. 21 : 368-376.