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Biofiltration Efficiency of Three Sea Weed Species

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ABSTRACT:

Rising global demand for seafood and declining catches have resulted in the volume of aquaculture doubling each decade, a growth expected by the FAO to persist in the decades to come. The use of technologies with economical and environmental sustainability would influence aquaculture growth. In aquaculture, feed accounts for about half the cost in current high-volume fed mono-species culture such as in fish net pens or shrimp/fish ponds with most of this feed going as waste or uneaten. As a result, immense impact on the environment, hampers the further growth of aquaculture. In traditional polyculture systems, the nutrient-assimilating photoautotrophic plants use solar energy to turn nutrient-rich effluents into profitable resources and improve to a large extent the aquatic environment. Additionally some of these aquatic plants are commercially exploited for the preparation of various products. Thus the dual role of some of these aquatic plants can be effectively used in shrimp aquaculture ponds in the maintenance of good water quality through regulating toxic gases such as ammonia and nitrite and hence improve the shrimp production. A study was conducted to evaluate different marine algal species with respect to good water quality maintenance. The study showed that *Gracilaria crassa* can improve water quality more effectively compared to *Ulva reticulate* and *Enteromorpha* in all the three water systems namely sea water, pond water and shrimp culture effluent water.

Keywords:
Seaweed, Waste water, Aquaculture, Biofilteration, *Gracilaria crassa.*

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INTRODUCTION

Aquaculture, also known as aquafarming, is the farming of aquatic organisms such as fish, crustaceans, mollusks and aquatic plants. Aquaculture involves cultivating freshwater and saltwater populations under controlled conditions. On the other hand it refers to aquaculture practices in marine environments such as the farming of marine fish in enclosed pens or nets, mariculture, and also is the farming of marine crustaceans, molluscs and seaweed. The other methods include, which integrates fish farming and plant farming in water. Thus the output, as reported, from aquaculture would supply one half of the fish and shellfish that is directly consumed by humans (FAO. 2006). Further, in current aquaculture practice, products from several pounds of wild fish are used to produce one pound of a fish like salmon. One drawback of many methods is the discharge of nutrient rich effluent in to the environment. This discharge includes feed –derived wastes composed of dissolved components such as nitrogen, phosphorus and suspended solids (Losordo and Westers 1994).

So, aquaculture probably being the fastest growing food-producing sector and has high potentials to fulfill the nutritional needs of a growing population, it now accounts for almost 50% of the world's food and is perceived as having the greatest potential to meet the growing demand for aquatic food. It is estimated that at least an additional 45 million tones of aquatic food will be required by 2030 to maintain the current per capita consumption (FAO. 2009). Further, in view of ensuing food crisis there is a call for turning to aquatic plants for human food needs (Shpigel *et al.,* 1993). China produces nearly 10.7 million tones of plants from aquaculture most of which are used as human food (FAO. 2006).

Need of Seaweed in aquaculture

On noticing the increasing pollution in our rivers and streams, the pollutants are ever increasing which are affecting most of the industrial and domestic systems functioning. So there is a need to identify agents other than manual or chemical treatments with more cost affective simple technology. Today, seaweed and mussels as a possible "natural cleaning system" (similar to what aquaponics does...). Thus, Extractive Aquaculture has come to the rescue wherein aquatic plants like seaweed have significant positive role. Some of the basic seaweeds functions are:

- Seaweeds farms acts as nutrient sinks
- Seaweeds farms increase the primary productivity
- The farms act as habitat for certain fish and shell fish
- Seaweeds farming provides a sustainable lively hoods
- Many old people are engaged in tying and drying of seaweeds
- Since it is a sustainable and lucrative business, it prevents migration
- Since seaweeds are cash crops it gives instant money to the farmers
- In many island nations, these seaweeds have become the crops with highest export earnings, limited usage having higher priority.

There are two main areas where seaweeds have the potential for use in wastewater treatment.

The first is the treatment of seawage and some agricultural wastes to reduce the total nitrogen- and phosphorus-containing compounds before the release of these treated waters into rivers or oceans.

The second is for the removal of toxic metals from industrial wastewater (Schramm. 1991).

The aim of this project was the development of a seaweed biofilter system to reduce the environmental pollution impact of marine eco system. Specifically, we sought to evaluate three species of seaweeds (*Ulva reticulate, Gracilaria crassa, Enteromorpha comprassa*) with their performance for a biofilter. The pH, Temperature, salinity of water samples, and also check the capability of sea weeds in reducing ammonia and nitrite content were considered here.

MATERIALS AND METHODS

Environmental concerns and limitations in water availability are some of the factors that make recirculation an important option for the aquaculture industry. However, water reuse is limited by the accumulation of waste product excreted by fish such as carbondioxide, ammonia –nitrogen and dissolved faecal solids. In addition, nitrate and phosphate levels accumulate in the water of recirculation system as a result of biofilteration at a rate dependent on fish density and water replacement flow rate.

Study location

The present experimental studies on shrimp using locally available algae were carried out at Central Institute of Brackish water Aquaculture (CIBA) in Muttukadu experimental station, Chennai.

Experimental species

Ulva reticulata, Gracilaria crassa, Enteromorpha species of seaweeds obtained from Kovalam and coastal areas of Chennai

Experimental set up

The experiment was conducted for 36 days in 3 different water samples namely sea water, pond water and shrimp culture effluent water with four groups namely group1 ,group2, group3 and group -4 (control) with three replicates each. Where group-1 contain seaweeds *ulva reticulata* , group - 2 *Graccilaria craasa* , group- 3 *Enteromorpha* and group-4 control with no seaweeds. Uniform sized Fibreclass Reinforced Polypropylene (FRP) tanks of 100L capacity were used. Each were cleaned and disinfected with bleaching powder before starting the experimental trial. The tanks were filled with 40L of sea water, pond water and shrimp culture effluent water and continued aeration was provided throughout the experimental period. The seaweeds were weighed approximately as 20g and stocked into the tanks.

Maintenance

Water was not exchanged in tanks through out the process. Every day, checked the aeration; a biotic parameters like salinity, pH and temperature were recorded. The estimation of Ammonia and Nitrite were done in every alternate day. Once in 15 days DO value was calculated. And it is observed that the seaweeds stocked in the tanks were alive and maintained.

Water quality analysis

Before stocking seaweeds, the abiotic parameters including water, temperature, salinity and pH were recorded and after stocking the seaweeds the abiotic parameters were maintained everyday. Temperature was recorded using a mercury thermometer; salinity was recorded using a refractometer. After standardizing with distilled water and pH was recorded using a portable pH meter, every alternate day, water samples were collected from each tank and analysed for the ammonia and nitrite. Ammonia content was estimated by the method of (Solorzano.1969). Nitrite was estimated by the Nitroprusside method by (Strickland and Parsons, 1972).and expressed in ppm. Dissolved Oxygen given by Winkler's method, Lipid by (Bligh and Dyer, 1959)and protein by (Bradford, 1976).

RESULTS AND DISCUSSION

Annual consumption of seafood has increased dra-matically over the past three decades worldwide, but supply from wild capture fisheries appears to have reached an uppermost limit (FAO. 2007). Accordingly, aqua-culture production has been growing by more than 10% annually and will reach 50% of world's seafood supply in 2030 (FAo, 2007). However, intensive fish aquaculture has caused serious ecological problems, such as coastal eu-trophication due to the release of excess nutrients (Read and Frenandes 2003). Moreover, this release may negatively influence the aquaculture activity itself by increasing the ammonium toxicity and water turbidity (Troell *et al.,* 1999). Accordingly, various approaches are being taken by government authorities to reduce excess nutrients in effluents, including effluent regulations that limit maximum allowed nutrient concentrations in effluents discharged by aquaculture facilities (Tacon and Foster 2003).

The 30 days experimental trail with different species of seaweed stocked in tanks showed better results in water quality management than in the controls.

Hence the, effectivity of different seaweeds in different water samples are as follows

Sea water ammonia & nitrite content:

It is identified that all the three species (*Ulva reticulata, Gracilaria crassa, Enteromorpha*) can reduce Ammonia and Nitrite content from Seawater (Table1,2) Pond water (Fig1,2) and most effectively from Effluent water (Table-3,4). And among all the three Algal species Gracilaria crassa is identified to remove ammonia nitrite content more effectively in all three water samples.

The use of seaweeds as biofilters to remove dissolved nitrogen from fish pond effluents has been widely studied (De Boer and Ryther, 1977). (Harlin *et al.,* 1979) used Gracilaria sp. to remove the ammonium produced by the fish Fundulus heteroclitus, removing lightly more ammonium than was produced by an equal biomass of fish. Similar results were reported by (Haglund and Pedersen 1993).in a system of Gracilaria tenuistipitata. (Jiménez del Río *et al.,* 1996) described that *Ulva spp.* not only show a higher N-removal capacity than *Gracilaria spp.* but also a higher resistance to epiphytes.

Our results are similar to that of (Seema and Reeta Jayasankar, 2005). who have reported that the green seaweed *Ulva* reticulata used as co-culture species for monitoring the changes in toxic nitrogenous wastes in the shrimp culture system was found to efficiently remove ammonical nitrogen from 249.5 to 17.39 pmol nitrogen (94%). The nitrate nitrogen reduced from 28.39 to 24.21 pmol nitrogen (5%) and nitrite nitrogen from 14.51 to 9.03 pmol nitrogen (22%). The removal of total nitrogen from the aquaculture system was found to be 45% when treated with seaweeds .The concentration of toxic nitrogen wastes was found to be always at a lower level in the integrated system when compared to the monoculture system. Seaweed of economical importance can be used in aquaculture system to improve water quality and generate revenue for the industry.

According to (Neori *et al.,* 1996) and (Ahn *et al.,* 1998). ammonia is assimilated as much as two to three times faster than the oxidized nitrate by many types of seaweed. (Rosenberg and Ramus 1984). Cohen and Neori (1991). who have reported that the highest growth rates were recorded in *Ulva* reticulata followed by *Eucheuma denticulata* and *Gracilaria crassa* at the same stocking densities. This may be attributed to high surface area of *Ulva* reticulata. The difference in the ratio of surface area to volume (S:V) may lead to difference in nutrient uptake rates among macro algae. Although the macro algae were grown at a low irradiance their high ability for photoacclimation might have contributed to the high growth rate and nutrient uptake rates. It is also possible that light limitation had negative effects on growth rates and nutrient uptake rates.

Water from shrimp aquaculture ponds were circulated through a mangrove woodlot, Oyster beds, and seaweed ponds in biofilter experiments designed to reduce environmental loads (Toru *et al.,* 2006).

Dissolved oxygen content:

Presence of Algal species also helps in improving DO content in water medium, thereby improving water quality. *Ulva reticulata and Gracilaria crassa* improves Oxygen content in different water samples (Fig-3,4,5).

Associated with the presence of seaweed as an natural filters in these sedimentation tank, where the seaweed, naturally have a function as a filter of carbon dioxide, which are absorbed and converted into the oxygen element. So the measurement of dissolved oxygen concentrations was done at the fish culture tank with the combination biofilter system and control.

Table-1 Seawater Ammonia

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Control	0.031	0.043	0.049	0.091	0.089	0.042	0.043	0.065	0.202	0.221	0.175	0.213	0.173	0.184	0.171	0.183	0.189	0.185
Group I	0.031	0.034	0.032	0.032	0.03	0027	0.025	0.04	0.044	0.085	0.046	0.073	0.032	0.014	0.02	0.061	0.042	0.05
Group II	0.031	0.033	0.031	0.028	0.033	0.025	0.019	0.042	0.033	0.061	0.038	0.051	0.03	0.018	0.019	0.02	0.056	0.048
Group III	0.031	0.03	0.029	0.03	0.027	0.026	0.03	0.034	0.042	0.066	0.042	0.048	0.05	0.024	0.019	0.031	0.042	0.059

Table-2 Sea water Nitrite

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Control	0.08	0.081	0.83	0.84	0.089	0.091	0.95	0.95	0.098	0.098	0.99	0.136	0.158	0.194	0.143	0.379	0.394	0.039
Group I	0.072	0.071	0.071	0.07	0.064	0.063	0.063	0.065	0.079	0.068	0.07	0.069	0.068	0.027	0.074	0.062	0.076	0.087
Group II	0082	0.049	0.044	0.046	0.041	0.044	0.045	0.045	0.042	0.043	0.041	0.041	0.039	0.041	0.038	0.043	0.058	0.045
Group III	0.083	0.053	0.046	0.046	0.043	0.042	0.045	0.044	0.042	0.04	0.039	0.041	0.0042	0.045	0.039	0.041	0.041	0.045

Table-3 Effluent water Ammonia & Nitrite

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Control	0.038	0.036	0.041	0.039	0.048	0.031	0.044	0.074	0.097	0.104	0.1	0.147	0.145	0.106	0.111	0.095	0.092	0.101
Group I	0.038	0.033	0.03	0.031	0.036	0.042	0.048	0.049	0.055	0.062	0.05	0.074	0.06	0.061	0.072	0.076	0.076	0.071
Group II	0.038	0.039	0.036	0.029	0.038	0.03	0.034	0.036	0.038	0.042	0.049	0.06	0.03	0.031	0.024	0.028	0.05	0.058
Group III	0.038	0.039	0.035	0.031	0.037	0.029	0.024	0.037	0.046	0.055	0.05	0.062	0.039	0.041	0.036	0.043	0.053	0.065

Table-4 Effluent Water Nitrite

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Contro l	0.065	0.066	0.052	0.054	0.052	0.063	0.062	0.075	0.079	0.086	0.095	0.107	0.118	0.123	0.129	0.147	0.173	0.177
Group I	0.059	0.056	0.056	0.051	0.048	0.051	0.054	0.071	0.071	0.073	0.081	0.082	0.087	0.087	0.094	0.101	0.014	0.126
Group II	0.059	0.051	0.047	0.039	0.043	0.044	0.046	0.044	0.047	0.053	0.055	0.062	0.061	0.064	0.071	0.072	0.071	0.06
Group III	0.055	0.045	0.051	0.046	0.043	0.052	0.061	0.069	0.061	0.073	0.095	0.089	0.091	0.085	0.086	0.089	0.1	0.108

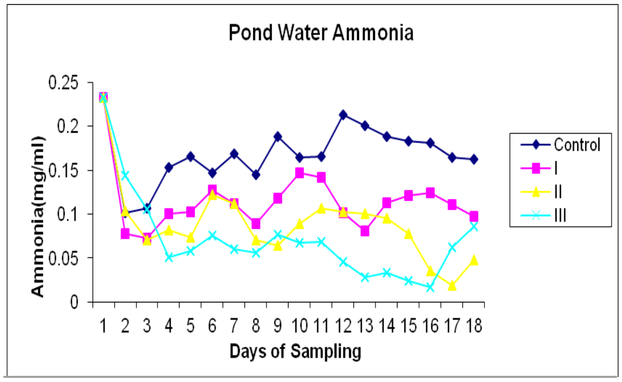

FIGURE-1.

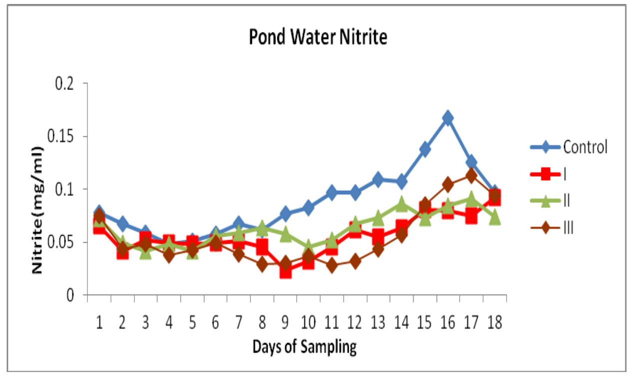

FIGURE-2.

The result showed that DO levels that exist in the fish culture tanks with filtration system are 5.0 to 6.9mg/l, while the DO concentration at control tank were 4.7 to 5.3mg/l.

One of the main benefits of integrating animals and plants is the improvement in water quality by the plant component. Many seaweeds prefer nitrogen in ammonium form and all produce oxygen and remove carbon dioxide through the process of photosynthesis. With the exception of solids removal, these are the main functions of water treatment in a recirculating aquaculture system. Unfortunately, the contribution of seaweeds to improved water quality mainly occurs during light hours, as these functions which include oxygen production, carbon dioxide and ammonia uptake are predominantly correlated to photosynthesis. In a RAS, each kg of *Ulva* produces enough oxygen daily for 2 kg of fish stock (Neori *et al.,* 2004). Based on a lower metabolic rate, 100 kg of *Ulva* could maintain enough oxygen for 500 kg of abalone. Therefore, to improve water quality parameters such as oxygen levels, a relatively low quantity of seaweed is required as a ratio to the abalone component.

Lipid deposition:

The lipid deposition indicates that Algae is reducing ammonia and nitrite content from water samples (Table-5,6,7). All the three species can deposit lipid where the average lipid percent in tissues of *Ulva reticulata* is 6.89, *Gracilaria crassa* is 7.14, *Enteromorpha* is 5.54. Hence *Gracilaria crassa* is consider a bit more effective.

All the algae were low in lipid (2–2.4% DW) but within the range of other species of red seaweeds (1–3% DW) reported previously (Mabeau and Fleurence, 1993). (Wong and Cheung, 2000). Nevertheless, abalone species show low lipid requirement, typical of herbivore molluscs and fish (Mai *et al.,* 1995). This low lipid requirement has been associated by some authors

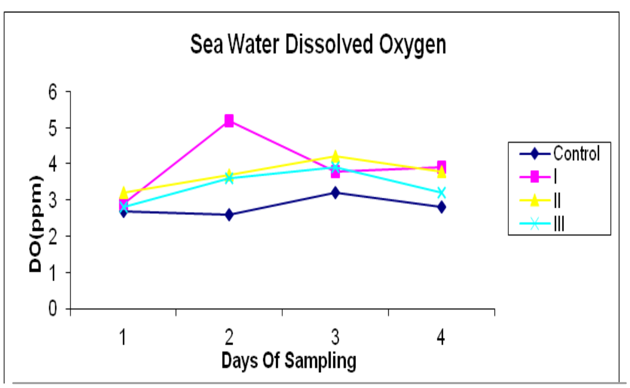

FIGURE-3

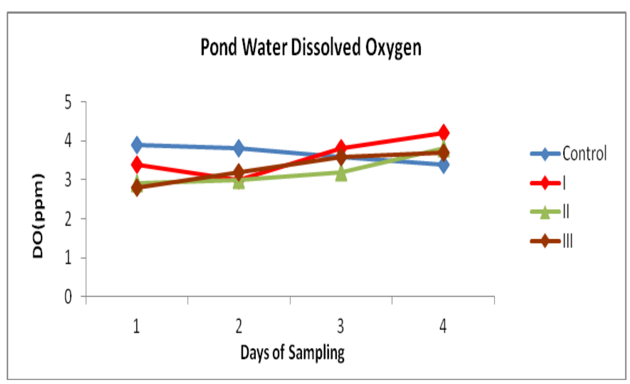

FIGURE-4

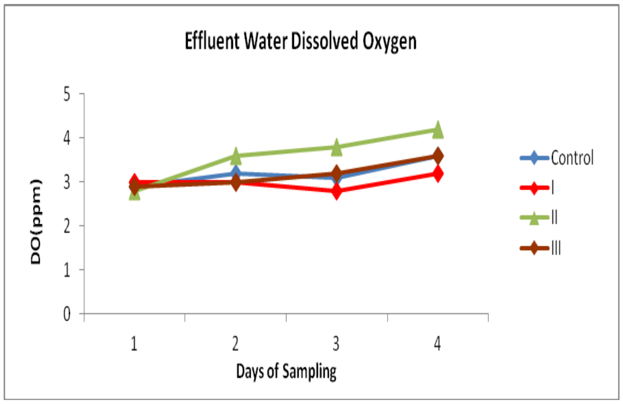

FIGURE-5

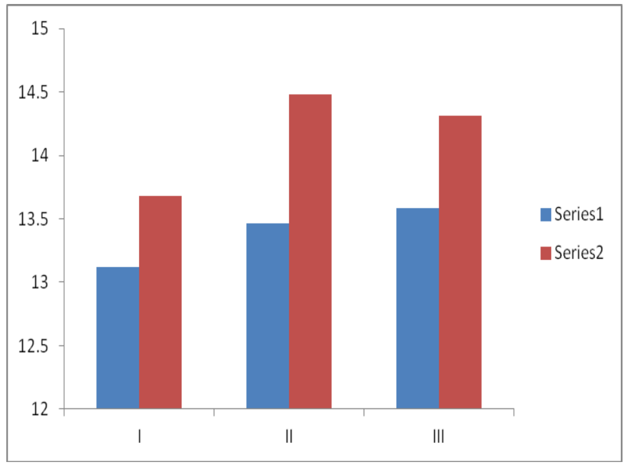

PLATE -1 Protein deposition in Sea water

Table-5 Lipid Deposition in Seawater

Species	Initial	Final
Group I	4.31	4.869
Group II	4.96	5.67
Group III	4.48	5.44

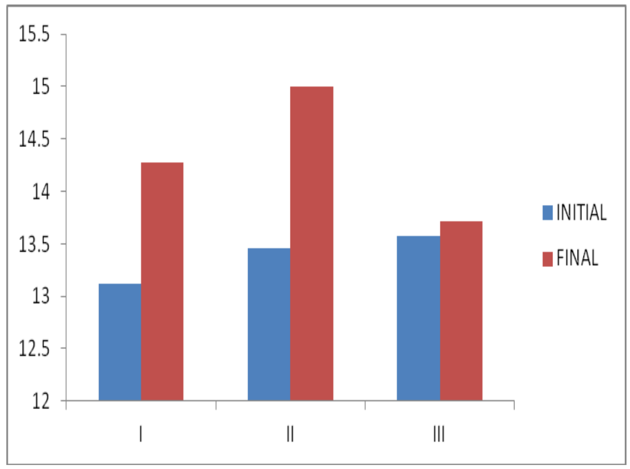

PLATE -2 Protein deposition in Pond water

Table-6 Lipid Deposition in Pond water

Species	Initial	Final
Group I	4.31	6.09
Group II	4.96	7.89
Group III	4.48	5.54

Table-7 Lipid Deposition in Effluent water

Species	Initial	Final
Group I	4.31	9.72
Group II	4.96	7.87
Group III	4.48	5.66

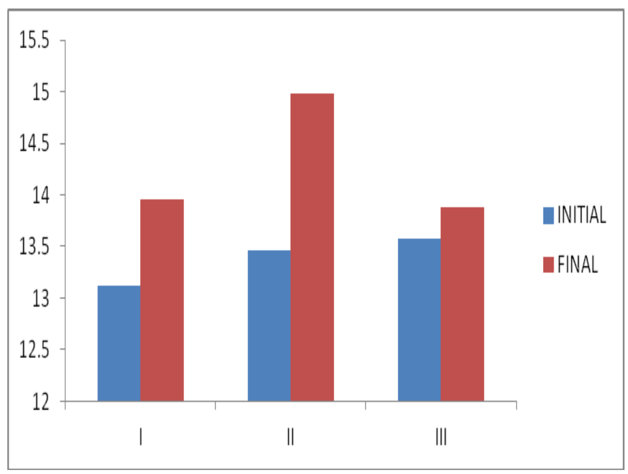

PLATE -3 Protein deposition in Effluent water

(Durazo-Beltra´n *et al.*, 2004). with the low use of dietary lipids as energy source by abalone based upon its low metabolic rate. Indeed, high levels of dietary lipid seem to negatively affect abalone growth (Thongrod *et al.,* 2003).

Protien deposition:

The protein deposition indicates that Algae is reducing ammonia and nitrite content from water samples (Plate-1,2,3). All the three species can deposit protein where the average protein content in tissues of *Ulva reticulata* is 13.95,*Graccilaria crassa* 14.82 and *Enteromorpha* 13.97. Hence, *Graccilaria crassa* is considered a bit more effective. Our results are similar to that of (Neori *et al*., 2000). Cultured *Ulva* and *Gracilaria* can be rich in protein and so can be a good food source for shellfish, such as abalone or as an ingredient in fish feed as used at the Makoba integrated system (Mmochi *et al.,* 2002).

Physical parameters:

pH (all the three species maintain the pH constantly in all these water samples). Temperature (25 to 27°C). Salinity (26-31ppm for seawater, 15-17ppm for pond water, 26-29ppm for effluent water).

Our results are similar to that of (Rijin and Rivera, 1990). (Sato *et al*., 2000). (Chen *et al*., 2006). who have reported that physicochemical parameters of water and their fluctuation play a decisive role in treatment efficiency. Some environmental factors could affect ammonia and nitrite oxidizers such as substrate; DO Concentration, organic matter, Temperature, Alkalinity, Salinity, turbulence level, product inhibition and light intensity.

CONCLUSION

As seaweeds are plants that utilize ammonia nitrite level in water without leaving any harmful solutes. These seaweeds convert ammonia and nitrite in water to lipid and carbohydrates during metabolic activity and store in there tissues. Estimating protein deposition and percentage lipid of deposition shows us that the used seaweeds are capable of improving water quality. Hence seaweeds in integrated aquaculture farms decrease the pollution and improve water quality. Hence seaweeds are ecofriently and economical method of waste water treatment.

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