IMPACT OF SHRIMP FARMING ON WATER QUALITY IN THE MANGROVE ECOSYSTEMS IN PAMBALA, CHILAW

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Summary

The study site Pambala (07°30' N, 79°49' E) is a part of the Pambala–Chilaw Lagoon Complex. ,in the west coast of Sri Lanka. The present study attempts to assess the impact of shrimp farming on mangroves in Pambala by assessing the composition of mangrove flora, selected invertebrates as well as the changes in water quality. Five mangrove areas bordering moderate to large prawn farms and three mangrove areas which did not have prawn farms wihin a radius of 100 m were selected for the study. All species of mangroves, mangrove associates and selected invertibrates were identified and enumerated within the five 5mx5m quadrates established in each of the selected sites while data for seven water quality parameters were recorded at five locations in the lagoon and at each of the eight sample sites. A total of 14 species of mangroves and eight species of mangrove associates were recorded. The mean floral species richness in non shrimp farming sites was significantly greater than that in shrimp farming areas. Trends in abundance were similar. The mean abundance of organisms was greater in reference sites than in prawn farming sites. The turbidity in shrimp farming sites was double than that of reference sites. Similarly the salinity level in shrimp farming sites was five fold higher than that in reference sites. Average water temperature in shrimp farming sites was in the range of 26 °C, while non shrimp farming sites recorded an average of 28.8 ° C. Shrimp farming sites were also less acidic than the reference sites. For dissolved Oxygen mean values of 5.6 mgl^{-1}(±0.23), and 6.7mgl^{-1}-(± 0.05) were recorded in the shrimp farming sites and the reference sites respectively. Plant nutrients were also much greater in shrimp farming sites (range of nitrates 0.08 - 0.28 mgl^{-1} and phosphates 0.20 - 0.36 mg l^{-1}) than in reference sites (nitrates 0.02 - 0.03 mg l^{-1} and phosphates 0.01 - 0.08 mg l^{-1}). Analysis of data have shown that shrimp farms in Pambala area has serious negative impacts on the mangrove ecosystems as well as on the lagoon environment.

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INTRODUCTION

Mangroves are the coastal equivalent of tropical forests and hence of important ecological and environmental significance. In Sri Lanka as in many other countries, conversion of mangrove forests to other uses has resulted in a considerable decline of these ecosystems.

At present it is estimated that the total extent of mangroves in Sri Lanka covers only 87 km^2, which amounts to 0.1 - 0.2 % of the total land area of the country. In 2001 Valietel (2001) reported that conversion of mangrove areas to shrimp aquaculture is responsible for 38 % of total mangrove loss in the island. In addition to direct destruction of mangroves, shrimp farming has caused the degradation of water quality in lagoons and the loss of biodiversity in the remaining patches of vegetation. (De Silva and de Silva, 2002; Wolanski et al.2000)

MATERIALS AND METHODS

Five mangrove areas bordering moderate to large functioning shrimp farms in Pambala of the Pambala–Chilaw Lagoon Complex, that have been in operation for at least 10 years and three mangrove areas which did not have shrimp farms wihin a radius of 100 m, as reference sites, were selected for the present study . At each site five quadrates of 5 m x 5 m were established using poles and ropes. All mangroves and associate species were identified and enumerated within the quadrates. The regenaration capacity of the species was assesed by counting the seedlings and saplings within a subquadrate of 1 m x 1m located inside the main quadate. The Shannon-Weiner Diversity Index [$H' = -\text{"}(Pi\ ln\ Pi)$] and Evennes ($E=H'/S$) where Pi is the proportinal abundance and S is the number of species, were calculated for each site.

Crustaceans, polychaetes and molluscs were also identified and enumerated within these quadrates. Seperate counts were taken for benthic fauna and epifauna. Seven water quality parameters i. e. temperature, pH, turbidity, salinity, diissolved ôxygen, nitrates and phosphates were assessed at five locations in the lagoon and at each of the eight sites, using satndard protocols. The rate of sedimentation was also assessed using a simple gauge. For each parameter, the one way ANOVA and Tukey's tests were used to examine for significant differences between shrimp farming and reference sites.

RESULTS

Floral diversity and composition

A total of 14 species of mangroves and eight species of mangrove associates were recorded which is lower than the numbers recorded in this area previously. The mean floral species richness in non shrimp farming sites was (18($\pm$0.69) significantly greater than that in shrimp farming areas.(12$\pm$0.36) Trends in abundance were similar with significantly greater values recorded in the reference sites(shrimp farming sites 84$\pm$0.76, reference sites 114$\pm$0.69

Composition was also altered with certain species being present only in areas not affected by shrimp farms whilst others were more abundant in shrimp farming sites. In contrast, the Shannon-Weiner Diversity Index, in shrimp farming sites and reference sites was not markedly different with the former and latter having values of 0.24 ± 0.005 and 0.28 ± 0.05 respectively. There was no significant difference between the mean number of seedlings/saplings in reference sites (14.2 (± 0.76) and shrimp farming sites 6.6 (± 0.53) (Figure 1).

Leucacena leucocephala (ipil ipil) which is an invasive species was recorded in the shrimp farming sites whilst it was totally absent in reference sites. There were other species that were recorded at both sites but were more frequent in references sites (e.g. *Bruguiera gymnorrhiza*)

Faunal diversity and composition

It was interesting that no variation with the number of species was observed between individual reference sites although a marked variation was observed within shrimp farming sites (3 to 8 species). The mean abundance of organisms was greater in reference sites (59 ± 2.76) than in shrimp farming sites (38 ± 1.83). Variation was also evident between individual sites with a range of 52 - 70 in reference sites and 25 - 75 in shrimp farming sites. In comparison to the flora, where diversity was near similar in shrimp faming and reference sites, faunal diversity was greater in reference sites (H' = 0.29 ± 0.10, E=0.14) than in shrimp farming sites (H'=0.22 ± 0.09, E=0.15).

Considering fauna, total species richness of molluscs, crustaceans and polychaetes were similar in both shrimp farming and reference sites. (figure 2) While for abundance the composition was significantly different between them. Considering composition, in general molluscs and oysters formed a greater proportion of the invertebrate fauna in mangrove habitats. The shrimp farming sites had some species (e.g. *Thalassina*) that were not found in reference sites. Abundance values also show that molluscs preferred reference sites than prawn farming sites. (figure 3)

Physical parameters

Water quality in sites near shrimp farms was markedly different to that of reference sites and with the exception for phosphate, the differences between shrimp farming an non shrimp farming sites were significant. The turbidity in shrimp farming sites (28.6 NTU ± 1.73) was double than that of reference sites (14 NTU ± 1.21). Similarly the salinity level in shrimp farming sites ($16.8 mgl^{-1} \pm 1.46$) was five fold higher than that in reference sites ($3.33 mgl^{-1} \pm 0.43$). Salinity was generally low because of the considerable rainfall received during the sampling period.

Average water temperature in shrimp farming sites was in the range of 26°C, while non shrimp farming sites recorded an average of 28.8°C. Shrimp farming sites were also less acidic (pH values 7.2 - 7.8) than the reference sites (pH values 6.2 - 6.7). Although slight, the differences in pH between shrimp faming and non –prawn farming sites were also significant.

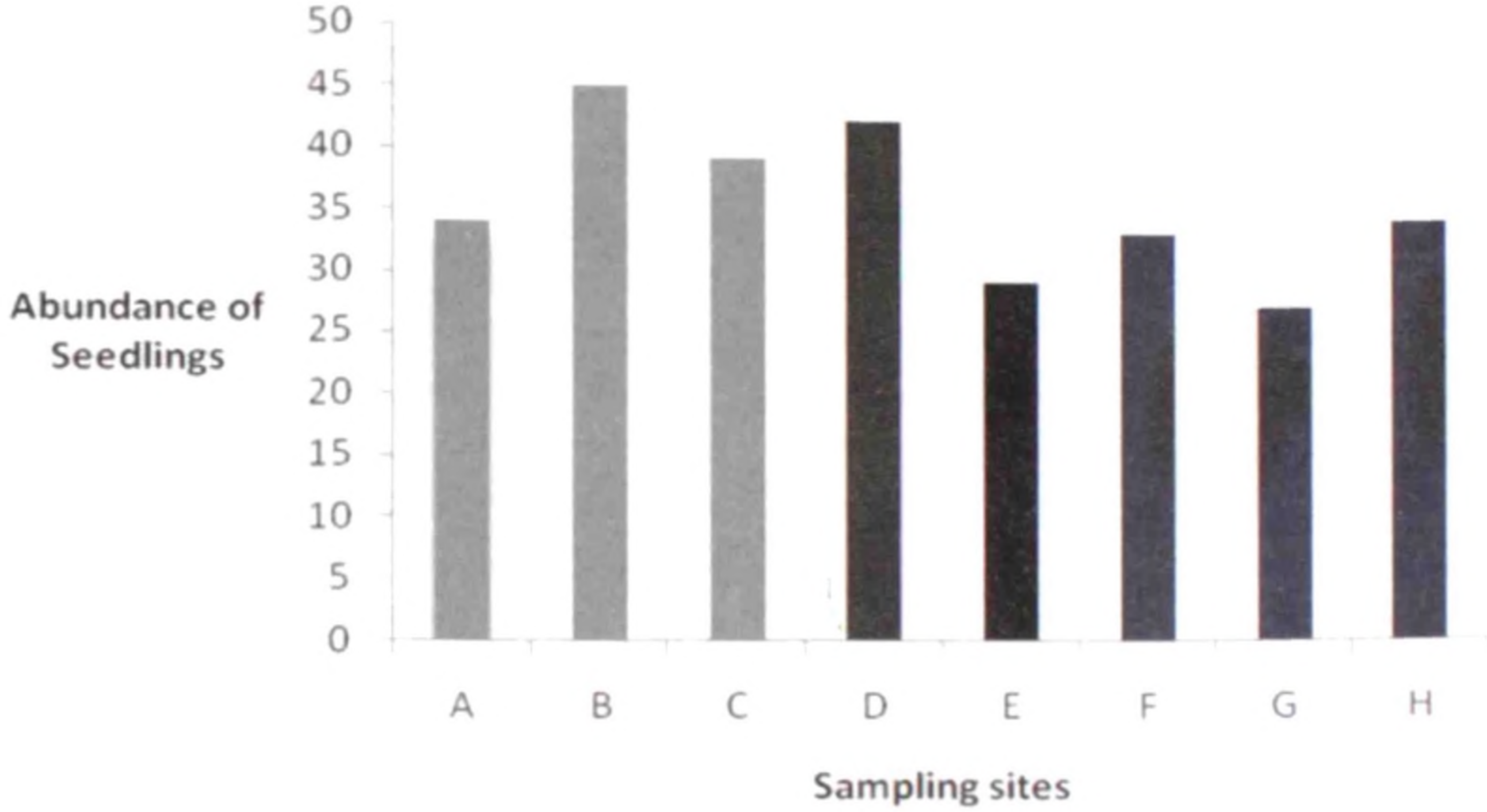


Figure 1: The abundance of seedlings in reference sites (Site A to C) and prawn farming sites (D to H).

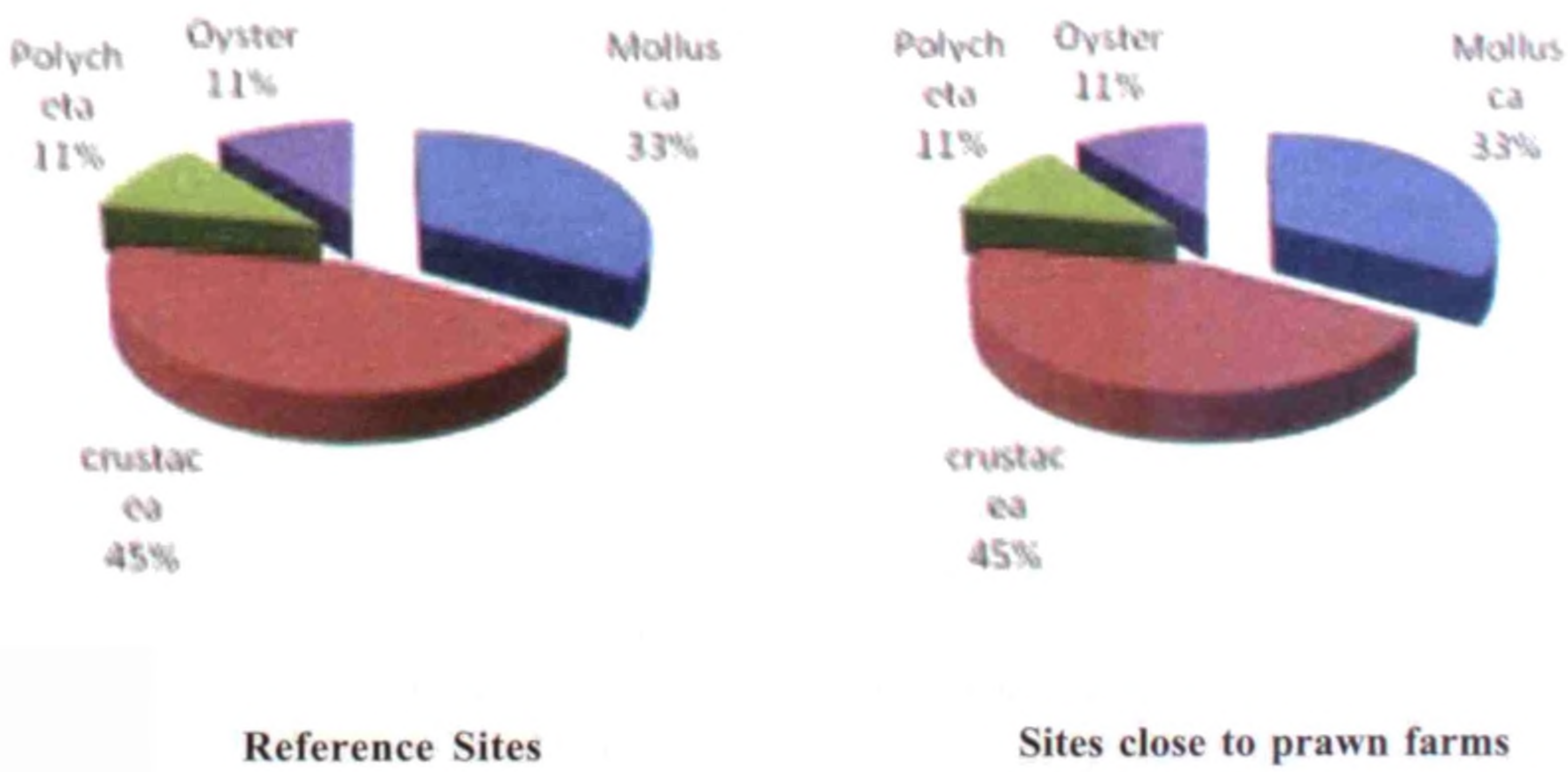
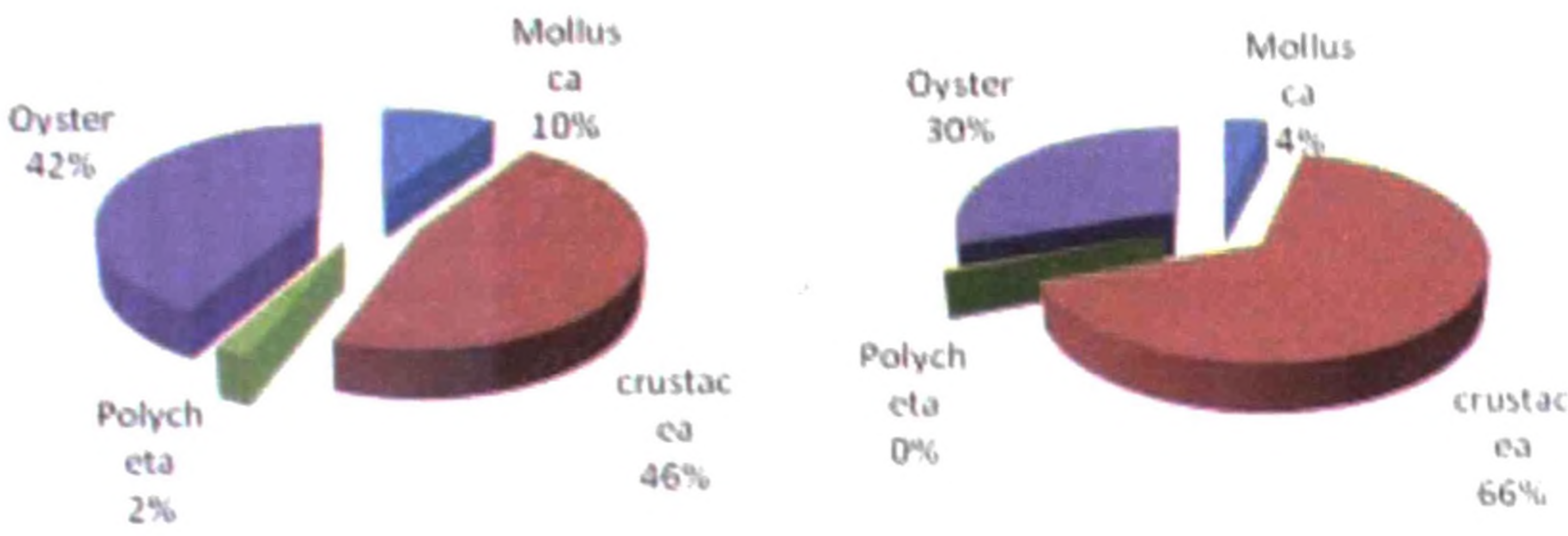


Figure 2: Species richness of invertebrate fauna in the Pambala area



Reference Sites **Sites close to prawn farms**

Figure 3: Species abundance of invertebrate fauna in the Pambala area

Dissolved oxygen values of 5.6 mgl^{-1}($\pm$0.23), and 6.7mgl^{-1}-($\pm$ 0.05) were recorded in the shrimp farming sites and the reference sites respectively. Plant nutrients were also much greater in shrimp farming sites (nitrates 0.08 - 0.28 mgl^{-1} and phosphates 0.20 - 0.36 mg l^{-1}) than in reference sites (nitrates 0.02 - 0.03 mg l^{-1} and phosphates 0.01 - 0.08 mg l^{-1}). No significant differences in sedimentation were noted over the duration of the study although there were signs of sediment accrual.

DISCUSSION

Impact of prawn farming on biotic components of mangrove ecosystems

Mangrove ecosystem is home to over 23 species of mangrove and 18 species of mangrove associates (Jayathissa, *et al*, 2001). The Pambala Chilaw Lagoon System is known to harbor 16 species of mangrove species and 13 species of mangrove associates (Jayathissa, *et al* 2001). A slightly lower number of species of mangroves (14) and mangroves associate (8) were recorded during the present study.

In general, changes in species compositions were also noted. A rare species of mangroves *Bruguiera cylindrica* recorded previously by Jayathissa 2001 in the Pambala-Chilaw was not recorded in the present study. Furthermore mangrove associates, *Clerodedron inerem*, *Dolichandrone spathacea*, *Phoenix zeylanica* and *Premna integrifolia* commonly found in the area in 2001 and also *Tamarix galica*, a rare species, were not recorded during the present study.

A similar scenario was observed with the fauna where signs of adverse effects were noted in areas close to prawn farming sites. It is observed that lower species richness and abundance was noted in the present study.

Impact of shrimp farming on water quality in the mangrove ecosystems

Water exchange is carried out daily in shrimp farms particularly during the final month of cultivation, with the mean volume of water estimated at 3000m^3 per hectare being released into the lagoon system (Senerath, 1998). Thus it is inevitable that the lagoon water quality will, to a great extent, be affected as a result of this process.

Some studies in the Chilaw lagoon has recorded salinity ranges similar to those recorded in the present study - 5-31 ppt (NARA 1997), 39.6 ppt, 8 - 45 ppt (Senerath, 1998) and 5 – 60 ppt (Katupotha, 2002; Senerath, 1998). Wolanaski (2000) and Tobay (1998) pointed out that surface and subsurface salt water intrusion generated by new ponds may lead to changes in the salinity of water in areas adjacent to mangroves. Increased salinity may also result from excessive sedimentation and the release of organic pollutants from ponds (Larsson *et al.*, 1994).

In the present study the highest turbidity recorded in reference site was 9 NTU while that is in shrimp farming site was 42 NTU, about four times more value in reference sites. High turbidity may cause a greater possibility of sedimentation, though the present study indicated that there was no sedimentation at least over the brief period of four months. This suggests that sediment trapped in mangrove areas are constantly washed into the deeper parts of the lagoon where there is accrual.

Results from previous studies are broadly consistent with those of the present study for water temperature and pH (temperatures recorded for the Chilaw Lagoon System – 25 – 34 °C (NARA, 1997), 26 – 33 °C (Katupotha, 2002), 23 – 32 °C (Senerath, 1998); pH values 7.4 (NARA, 1987 and 1991; de Silva, 1992), 6.0-8.1, 7.3-8.6 (NARA, 1997), 4.8-8.7 (Senerath, 1998). The present study also revealed that the water close to prawn farms were more basic than the water away from prawn farms. Contrary to these results, IUCN (1996) reports that discharge from shrimp farms which were constructed on acid soils during pond preparation stages in Pambala area was more acidic (pH 2.7 - 3.9)

Chemicals such as Chlorine, Dolomite and Lime are used extensively in shrimp farming specially to regulate pH. It is possible that this is the reason for the changes in pH in lagoon water which receives effluent from the culture ponds.

Several studies done in Chilaw lagoon have recorded values in the range of 0.1 - 0.9 mgl^{-1} for nitrates (NARA, 1997, Senerath 1998; Corea, 1995; Jayasinghe,1997/1998) and 0.030 - 2.0mgl^{-1} for phosphates (NARA 1997 ; Corea, 1995; Senerath, 1998). The values recorded in the present study are in a similar range for nitrates but lower for phosphates.

The values recorded for dissolved oxygen was between 4.2-6.9 ml^{-1}. Nevertheless, there was an indication that some shrimp farming sites had a lower content of oxygen. Shrimp farming leads to discharge high levels of suspended matter resulting in the loss of dissolved oxygen in water.

Consequences of alterations in biotic and abiotic factors

High nutrient loads added on from shrimp farms can cause unfavorable conditions, (Gain, 2002). potential toxicity to mangrove fauna (Kathiresen and Bingham, 2001) and flora and eutrophication. Further, increase in levels of ammonia may have considerable adverse impacts on aquatic fauna in acidic water (Corea *et.al.*, 1995).

Increase in soil and water salinity in shrimp farming areas (Sompom, 2002) has dangerous consequences on the growth and regeneration of crops and mangroves as well as on biodiversity in the coastal region (Spalding, 1997; UNEP, 1999).

Recommendations

The structure of mangrove flora and fauna could be a useful tool for habitat assessment.

- There is a need to reintroduce species that were once common, but are no longer found in reasonable numbers.
- Stringent measures should be adapted to control sediments that are discharged into the lagoon as well as to curtail in discriminate use of fertilizers and other chemicals.
- Implementation of sustainable pond management strategies as recommended by Patric 2002.
- Shrimp farmers should be encouraged to use less- intensive and/ or traditional shrimp aquaculture systems, which are more likely to be within the carrying capacity of the environment.

CONCLUSION

The present study has shown that the rapid growth of shrimp farming in Chilaw area has serious negative impacts on the mangroves and the lagoon. This was evident through its impacts on both biotic and abiotic components of this ecosystem. The composition and diversity of flora and selected faunal taxa were seriously altered in the vicinity of shrimp farms in comparison to reference sites. Despite the constant flushing, water quality of the lagoon had deteriorated as apparent by the greater levels of nutrients and turbidity. implying risks of eutrophication and the potential toxicity mangrove flora and fauna. If the current trends continue, it may have serious implications for biodiversity conservation and ecosystem integrity , and for the future of the shrimp farming industry as well.

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