CHAPTER 6

CONCLUSION

6.0 CONCLUSION

This work was conducted to study the distribution of selected heavy metals in different components of the coral reef ecosystem at Cape Rachado over a study period of 14 months; to determine the bioaccumulation factors; and to assess the effect of environmental parameters on metal bioaccumulation.

The following conclusions are drawn based on the findings of this research:

1. The environmental parameters of both sites of Cape Rachado were within the expected range and were representative of tropical waters.

2. Metal concentrations in seawater and sediment of Cape Rachado showed temporal changes over the study period as a response to the short-term environmental changes over time.

3. Metal concentration ranking in seawater and sediment was in the decreasing order of: Fe > Zn > Pb > Cu for Sites B and C.

4. Metal concentrations in seawater and sediment were within the range of metal concentrations in areas with no history of metal contamination, suggesting that Cape Rachado is a relatively unpolluted area as far as Fe, Cu, Zn and Pb are concerned. The low metal concentrations in sediment of Cape Rachado may only be reflecting the concentration of the residual fraction (natural constituent).

5. Metal concentrations (Fe, Zn, Pb and Cu) in *Sargassum baccularia*, *Padina tetrastomatica* and *Turbinaria conoides* showed different concentration trends over the study period.

6. Metal concentrations (Fe, Zn, Cu) in the three seaweeds were within the concentration range of the previous studies. Metal contents in the three seaweed species indicated the increase of Pb concentration in the water as result of the shipping activity and the oil refinery in the vicinity.

7. Metal concentrations in the three seaweed species were ranked similar to the ranking of these metals in seawater and sediment ie. Fe > Zn >Pb>Cu, in decreasing.

8. No previous data for metals in soft coral are available to state the status of metal concentration in the soft coral *Sinularia* sp. of Cape Rachado. Metal concentrations in *Sinularia* sp. were 25.0 ± 3.0 μg g^{-1} dry wt with the exception of Cu which was about 8.0 ± 0.2μg g^{-1} dry wt for Sites B and C. *Sinularia* sp. had the highest Cu concentration among the ecosystem components studied suggesting it's high affinity of Cu accumulation.

9. The sea cucumber (*Holothuria atra*) was only available in Site C. No regional data concerning metals in sea cucumber are available. However, metal concentrations in *H. atra* of Cape Rachado were much lower than those reported for deep-sea holothurians (NE Atlantic). Metals in *H. atra* were ranked in decreasing concentrations as follows: Zn > Fe > Pb > Cu.

10. Fe and Cu concentrations in the deposit feeder *H. atra* were more correlated to Fe and Cu concentration in water rather than in sediment.

11. Most of the environmental parameters including metal concentrations were similar at both study sites (B&C).

12. The concentration trends were different between metals over the study period at both sites.

13. Most of the environmental parameters and metal concentrations were similar at both study sites (B&C).

14. The four metals (Fe, Cu, Zn and Pb) were distributed differently amongst the various components (seawater, sediment, seaweeds, soft coral and sea cucumber). The distribution of each metal in Site C was similar to that in Site B with the exclusion of sea cucumber which was not present in Site B.

(i) Fe concentration was distributed with the following decreasing order:

Sediment > *P. tetrastomatica* > *S. baccularia* > *T. conoides* > *Simularia* sp.> *H atra* > seawater.

(ii) Cu concentration was distributed with the following decreasing order:

Simularia sp.> *P. tetrastomatica* > *H atra* > *S. baccularia* > *T. conoides* > Sediment > seawater.

(iii) Zn concentration was distributed with the following decreasing order:

P. tetrastomatica > *H atra* > *Simularia* sp.> *S. baccularia* > *T. conoides* > sediment > seawater.

(iv) Pb was distributed with the following decreasing order:

Simularia sp. > *H atra* > *P. tetrastomatica* > *S. baccularia* > *T. conoides* > sediment > seawater.

15. The four metals were distributed differently amongst the trophic levels (primary producers, filter feeder and deposit feeder) according to the accumulation ability and the intrinsic factors between species.

16. The distribution patterns of the metals suggest that Cu and Pb were accumulated more in marine animals than the primary producers (seaweeds).

17. The four metals were distributed similarly in each seaweed species following the decreasing order: Fe > Zn > Pb> Cu.

18. All the four metals studied were ranked similarly in their distribution within the three seaweed species following the decreasing order:

P. tetrastomatica > *S. baccularia* > *T. conoides*.

19. The surface area of the seaweed plays an important role in: (i) the uptake of the dissolved metals from water; (ii) adsorbing or trapping and scavenging of metals on the leaf surfaces from the particulates.

20. Bioconcentration factors of the four metals in the three seaweed species were ranked similarly to the metal concentration ranks in the seaweed species and metal concentration ranking in seawater and sediment (Fe > Zn >Pb > Cu).

21. The higher the ambient metal concentration, the higher is the metal accumulation and bioconcentration factor in seaweeds.

22. For soft coral and sea cucumber, different ranking for the bioconcentration factors of the metals, where Cu > Pb > Zn > Fe in soft coral and Pb > Zn > Cu >Fe for sea cucumber suggested some regulation of metal accumulation.

23. Soft coral showed a particular affinity for Cu while sea cucumber showed more affinity for Pb.

24. The bioconcentration factors obtained here are low which is mainly due to the low ambient metal concentrations of the study area rather than the metal-species accumulation ability.

25. *P. tetrastomatica* showed the highest bioconcentration factor for all metals among the seaweed species, followed by *S. baccularia* and *T. conoides*. The bioconcentration factors of *P. tetrastomatica* and *S. baccularia* for all metals were higher than for soft coral and sea cucumber except Cu in soft coral and Pb which was slightly higher in sea cucumber suggesting the potential of these two seaweed species as biomonitors for the heavy metals concerned.

26. Heavy metal contamination can be indicated by metal content in seaweeds. Seaweeds indicate concurrent and time-integrated responses (bioaccumulation) of metal concentration in the environment.

27. Metal bioaccumulation process is more affected by the past ambient environmental parameters rather than the concurrent or present parameters.

28. The effect of environmental parameters on metal bioaccumulation is biotic species-metal specific.

29. Synergistic interactions between metals were also observed suggesting the synergistic interaction with the binding sites and the increase in metal binding affinity.