CHAPTER 8

SUMMARY AND CONCLUSION

CH$_4$ and N$_2$O were supersaturated in all seasons studied indicating that Pichavaram mangroves act as a source for trace gas emission to the atmosphere. Spatially high concentration of both CH$_4$ and N$_2$O were observed in the upper reaches of the estuary due to input from terrestrial sources such as agricultural runoff and considerable quantity of aquafarm outlet contributing the elevated nutrient loading in Pichavaram mangroves and thereby more emission was observed. The concentration of CH$_4$ and N$_2$O found to be higher during dry season indicating that the temperature mediated microbial processes enhance the high emission rates.

The effect of tidal amplitude was important in determining the extent of variations in CH$_4$ and N$_2$O concentrations in the mangrove surrounding water column. During low tide, high concentrations of both CH$_4$, N$_2$O and dissolved inorganic nitrogen showed the “tidal pumping” mechanism in which porewaters with elevated concentration of dissolved nutrients invade the creek waters from surrounding mangrove sediments following the gradual release of hydrostatic pressure towards the low water. Calculations relating to high/low tide ratio of nutrient oscillations in Pichavaram mangroves are due to dilution of nutrient-depleted seawater intrusion into the mangrove region during flood tide.

Seasonal changes in the trace gas (CH$_4$ and N$_2$O) fluxes indicate that Pichavaram mangroves acts as a source for both CH$_4$ and N$_2$O to the
atmosphere and the emission from intertidal mangrove sediments of Pichavaram fall within ranges of most published data for other mangrove ecosystems worldwide. High efflux rate was observed during dry season due to the high nutrient input from terrestrial sources, occurrence of low O$_2$ conditions in the subsurface and high temperature. During all the seasons studied, increased efflux of both CH$_4$ and N$_2$O was found to be correlate positively with number of pneumatophores (CH$_4$, r=0.78; N$_2$O, r=0.59).

In order to study the other major part of the N- cycle, the rate of sediment denitrification was determined in Pichavaram mangroves. It varied from 5.6 µmol m$^{-2}$ d$^{-1}$ (wet season) to 7.1 µmol m$^{-2}$ d$^{-1}$ (dry season). Since denitrification is a microbially mediated process, it is reasonable to assume that temperature would have an influence on the denitrification rate. NO$_3^-$, which is a precursor of denitrification was found to be high during the dry season (5.81 µM) compared to the wet season (2.04 µM), fuelling higher denitrification rates. Hence, it can be concluded that high temperature and high NO$_3^-$ inputs would have played a major role in influencing the denitrification rate during the dry season.

The sediment accretion rates using $^{210}$Pb excess method was ranged from 2.5 to 3.0 mm yr$^{-1}$ and the accretion rates showed an increase towards estuary. The highest accumulation rate was measured in CR (Coleroon estuary), which is most likely due to the sediments have undergone extensive reworking and resuspension causing a severe disturbance to the surface sediments after the Indian ocean tsunami, December 2004 and frequent exposure of the estuary to tidal activities. The lowest rate of sediment accumulation was measured at the back mangrove area (CR6), which characterized with poor inundation of both river and sea water. The sediment
accumulation rates in Pichavaram mangroves falls within ranges of the most published data reported in various estuaries and mangroves worldwide.

The sediment core collected in Pichavaram mangroves provides an ongoing and historical record of pollutant discharge into the mangrove region. OC and TN concentration were high in the top 10 cm layers and its decline gradually towards depth. Vegetation based analysis of sediments indicated higher accumulation of OC in the Rhizophora zone (CR3) as compared to the other zones. TN concentration followed mainly parallel to OC content with high concentration in Avicennia zone (CR1) and low concentration in the unvegetated zone (CR5). The results for OC and TN indicated some interesting observations which are as follows:

- Both OC and TN were enriched in the surface sediments irrespective of the nature of the vegetation.
- When depth profile considered, the amount of OC and TN followed a negative correlation with each other at the surface, while it was a positive correlation towards the deeper layers irrespective of the vegetation zone it occupies.
- Rhizophora sp. was found to concentrate high amounts OC in the sediments relative to Avicennia sp.
- The contrary was true for TN, where the sediments in the Avicennia zone had a high concentration of TN relative to Rhizophora zone

C/N ratios were highly variable, ranging from 3.5 to 6.4 showing a significant difference between low ratios at Avicennia zone (CR1; 3.58±0.54, n=42) and high ratios at Rhizophora zone (CR3; 6.4±1.14, n=40). C/N ratios
of sediment samples were rising simultaneously at all depths from the Avicennia-dominated to the Rhizophora-dominated zones, suggesting a proportionally higher increase in OC than in TN values towards the Rhizophora-dominated area.

OC burial rate averages 1.83 mol C m\(^{-2}\) yr\(^{-1}\) in Pichavaram mangroves and the highest burial rates was observed at the Rhizophora zone (CR3; 2.56 mol C m\(^{-2}\) yr\(^{-1}\)) and the lowest was observed at the Avicennia zone (CR6; 1.36 mol C m\(^{-2}\) yr\(^{-1}\)). This high burial rate is the result of a highly seasonal supply of riverine sediment deposition, high productivity and supply of organic matter by leaf litter decay. The OC burial rate was comparatively lower in Avicennia zone (CR6) and it is probably the result of low OC concentration in the sediment mixed layer and this region located in the back mangrove area which does not accumulate fine organic sediment due to low penetration of estuarine waters. Moreover, low burial rate suggests that the OC production is nearly completely decomposed and recycled. Most planktonic and benthic OC production on mangroves must be digested and dissolved by benthic organisms or exported to the Bay of Bengal. River Coleroon and Uppanar canal carrying eroded soils and organic matter from land derived sources to the mangrove region which contributes nearly 30 to 40% organic carbon load to the sediments. About 75% of the mangrove surrounding area in Pichavaram is agricultural lands and most of this are paddy fields which are located close to the mangrove region and it expected most of the POC and DOC to come from this land derived sources utilizing the photosynthetic pathway. The carbon burial rates in Pichavaram have been accelerated by land-use change in the mangrove surrounding areas and the Coleroon and Vellar Rivers.
Metal concentrations in sediments are following the sequential order: Fe>Mn>Pb>Cr>Ni>Zn>Co>Cu>Cd. Pichavaram mangroves receives considerable quantity of agricultural, domestic sewage and aquafarm discharge were considered as major sources of metal input into the system. Most of the metals studied show significant correlation with OC. This indicates that OC is the main geochemical carriers of these metals in all coring locations. The metals concentrations in the 20-40 cm soil depth were significantly lower than in the surface 0-20 cm. This suggested that anthropogenic heavy metals were mainly localized in the top few centimeters and moved downwards only when the retention capacity of the surface soil mass became saturated.

A significant deposition of Zn, Pb, Cr, Co, Fe and Mn were observed in the surface sediments. It is also interesting to note that the elevated concentrations of these metals all appeared in the most recent period (from the 1970s to recent). This increase could be attributed to the increased natural weathering of soil materials and inputs from intensive agricultural practices and changes in land use pattern in the last few decades.

To summarize, Pichavaram mangroves have evolved to be a major anthropogenically altered ecosystem in the recent past. Sediment of this mangroves have been quantified to emit increased efflux of trace gases (CH₄ and N₂O), accumulation of high quantity of organic carbon, nitrogen and metals. These results are evidences of intense human activities to the fragile mangrove ecosystem, which acts as a sink for any anthropogenic input. Therefore, it is essential to constantly monitor the health of this ecosystem for a sustained management of the values and the services the mangrove offer.