BIOGEOCHEMICAL AND BIOPHYSICAL ASPECTS OF PICHAVARAM MANGROVE ECOSYSTEM, SOUTH INDIA

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ABSTRACT

Mangroves are the woody halophytes living at the confluence of land and sea and presently occupy about 1,81,000 km^2 of tropical and subtropical coastline. Over the past 50 years, approximately one-third of the world's mangroves have been lost due to anthropogenic activities which enhance the rates of trace gas fluxes, trace metal accumulation and sedimentation. Recent studies in tropical mangrove ecosystems have confirmed that mangrove ecosystems are significant sources of trace gas emission to the atmosphere. Apart from this, mangrove habitats have often received inputs of sediments may show significant metal contamination and high sedimentation rates. The overall aim of this research work is to evaluate and understand the dynamic interaction between various biogeochemical processes and changes affecting the Pichavaram mangrove ecosystem, South east coast of India.

The entire water column was supersaturated with CH_4 relative to the atmosphere indicating that the Pichavaram mangroves acts as a constant source of atmospheric CH_4. The CH_4 saturation was ranged from 2924% to 10722% with a mean value of 6493% and had a strong seasonal signal with a high concentration during dry season and low concentration during wet season. The percentage saturation of N_20 was ranged from 112 to 157% with a mean value of 131%. Similar to CH_4, high concentration of N_20 was observed during dry season and low concentration was observed during the wet season. It is due to the poor freshwater input, substantial addition of agricultural runoff and aquafarm outlet from the surrounding areas of the mangrove region.

The diurnal and tidal variations of dissolved CH_4 and N_20 showed strong seasonal pattern where high concentration was observed during dry season. The water height negatively correlates with CH_4 and N_20 indicate the tidal dilution apparently affects trace gas concentration in Pichavaram mangroves. A significant negative correlation has been observed between trace gases (CH_4 and N_20) and salinity during wet and dry seasons indicate the tidal dilution of sea water which affects both CH_4 and N_20 concentration. In the present study, the effect of tidal amplitude was important in determining the variations in CH_4 and N_20 concentrations which showing the "tidal pumping" mechanism.

Seasonal changes in the CH_4 fluxes indicated that high CH_4 efflux was recorded during dry season (61µmol m^{-2} hr^{-1}) subsequently reduced during the wet season (47 $µmol^{-2}$ hr $^{-1}$). The positive correlation between CH_4 flux and temperature was significant by linear regression (r^2= 0.83). Furthermore, the high rate of decomposition of organic matter during dry season creates oxygen debt, eventually resulting in the formation of CH_4 in the

subsurface. In the present study it is observed that the Pichavaram mangrove acts as a source of CH_4 to the atmosphere with an annual average of 7.31 gCH_4 $m^{-2}yr^{-1}$.

Distinct seasonal variation of N_20 flux was not observed in this study. However, highest efflux was recorded during dry season (1.60 µmol m^{-2} hr^{-1}) when the temperature was high and lowest N_20 flux was observed during the wet season (1.13 µmol m^{-2} hr^{-1}). The positive correlation between N_20 flux and temperature was significant as indicated by linear regression (r^2= 0.65). During dry season the increase in temperature caused increased level of microbial activity which in turn elevates the decomposition of organic matter. This enhances the process of nitrification and denitrification in the mangrove sediments. In the present study, the N_20 flux was correlated positively with dissolved inorganic nitrogen (r^2 = 0.85) indicating the significant allochthonous inputs by terrestrial runoff from the Uppanar drainage canal. The N_20 flux inversely correlated with DO (r^2 = -0.74) which indicates that the N_20 is produced as a by product of nitrification process at low 0_2 concentrations. During all the seasons studied, increased efflux of both CH_4 and N_20 was found to be correlate positively with number of pneumatophores (CH_4, r^2=0.78; N_20, r^2=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. $N0_3$-, 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. So, it can be concluded that high temperature and high $N0_3$' inputs would have played a major role in influencing the denitrification rate during the dry season.

As mangroves are areas of high sediment retention, it was important to study and quantify the sediment accretion rates in these ecosystems. The overall trend of the ^{210}Pb excess profiles suggests more or less constant rates of sediment accumulation (2.5 to 3.0 mm yr^{-1}) in Pichavaram mangrove ecosystem. As expected high accumulation rate were observed both in Coleroon estuary (3.0 mm yr^{-1}) and the Uppanar Canal (2.9 mm yr^{-1}), which are the two major entry and exit points of the estuary respectively. The higher accumulation rate was due to frequent exposure to tidal activity and also due to flocculation under high saline conditions.

Subsequently, the organic carbon content observed in these sediments was also high. 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). Organic carbon burial rate averages 1.83 mol C m^{-2} yr^{-1} and the highest burial rates was observed at Rhizophora zone (CR3; 2.56 mol C m^{-2} yr^{-1}) as compared to other zones. Leaf litter decay, reduced freshwater inflow and high microbial action at increased temperature were all found to contribute-to the high burial rates of OC in these mangroves.

The metal concentration was determined in the Pichavaram mangroves which follows the sequential order: Fe> Mn> Pb> Cr> Ni> Zn> Co> Cu> Cd. Inputs from agricultural, aquaculture and perhaps negligible quantity of sewage inputs into the mangroves are major sources of metal input into this system. Most of the metals studied showed a significant correlation with OC which indicates that OC is the main geochemical carrier of these metals in all locations. High metal concentration was observed at Avicennia zone (CR6) which acts as a trap of trace metals. Significant deposition of Cr, Pb, Fe and Mn were observed in the surface sediments. It is also noticed that the elevated concentrations of these metals all appeared in the most recent period (from 1975s to recent). Thus the temporal distribution of metals in the mangrove sediments of Pichavaram is influenced by many factors including geochemical, biogeochemical and anthropogenic sources in the last few decades.

To conclude, the evidence of human perturbations is very clear in this study. Any developmental activity must be complimented with an equal degree of environmental protection. In this scenario of changing climate, marginal ecosystem such as mangroves is extremely vulnerable to anthropogenic forcing.