

**BIOGEOCHEMISTRY OF THE HOOGHLY ESTUARY AND THE ADJOINING
SUNDARBANS MANGROVE, INDIA**

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MARCH 2012

ABSTRACT



The present study is based on two globally significant coastal ecosystems; estuarine and mangrove. The Hooghly estuary is one of the world's major estuaries, fed by one of the world's largest rivers, the Ganges. The Sundarbans mangrove is the world's largest mangrove, which is situated on the Ganges-Brahmaputra delta. Lack of long-term data and the ability to distinguish natural from anthropogenic changes are the major problems in predicting ecosystem responses to human impacts. This study was an attempt to understand the role of mangrove and estuary, in controlling biogeochemical interactions and the transformations of nutrients, chemical contaminants, and radiatively active trace gases, by natural and anthropogenic forcing.

Present study was carried out on June 2008 (monsoon), December 2008 (post monsoon) and May 2009 (pre monsoon) and it clearly showed a strong seasonal and spatial variability of nutrients associated with the salinity in both the systems. In both the systems, highest concentrations of nutrients (DIN, DIP, DSi) during the monsoon are attributed to high freshwater discharge along with anthropogenic inputs. The non-conservative relationship of nutrients with salinity, underlines the importance of terrestrial runoff with a significant contribution of nutrients of anthropogenic origin from local and

upstream agricultural field, industries and urban areas. The comparative study revealed that eastern sector of the Sundarbans is more productive compared to the western sector. The present study depicted that phytoplankton growth and primary production in the Hooghly estuarine, and the Sundarbans mangrove environment was not exclusively dependent on nutrient availability; rather, it was majorly dependant upon a proper combination of physico-chemical parameters (transparency, salinity, SPM, temperature, etc.). During pre and post monsoons due to gradual increase of productivity, both the systems became P limiting.

The seasonal C-N-P-Si budgeting of the Hooghly estuary using the LOICZ biogeochemical model was done considering both the presence and absence of mud and to determine the magnitude of mud's effect on the estuarine metabolism. During the wet season (monsoon), residual flux was 64% more than the mixing flux, which indicated that the estuary had a net positive water balance. The water exchange time (λ) of the estuary was calculated to be ~41 days during the dry season, to ~18 days during the wet season. The estimation of mixing salt flux of the estuary denoted an overall positive salt balance in both the seasons from the system. Net positive values for Δ DIC, indicated that the system served as a source of DIC during both the seasons. The consideration of mud in the NEM computation clearly showed heterotrophy while without mud, effect explained the system as an autotrophic, which was an incorrect interpretation. Despite high nutrient concentrations in the water column, heterotrophy dominated in the Hooghly

estuarine system due to high particulate matters and autochthonous DOC import to the estuary from the adjacent Sundarbans mangrove.

In both the study areas, during the monsoon, highest $p\text{CO}_2$ [HG = $11338 \pm 5706 \mu\text{atm}$; SUN (W) = $477 \pm 82 \mu\text{atm}$; SUN (E) = $470 \pm 76 \mu\text{atm}$] and dissolved CH_4 [HG = $268 \pm 114 \mu\text{atm}$; SUN (W) = $35 \pm 11 \mu\text{atm}$; SUN (E) = $52 \pm 17 \mu\text{atm}$] concentrations were observed followed by pre and post monsoons. The estimation of air - water gas exchange revealed that both the systems were source of CO_2 and CH_4 . It also showed higher concentrations in the Hooghly estuary compared to the Sundarbans mangrove and as well as the western sector of Sundarbans contributed more. This clearly showed the direct impact of anthropogenic activity and mangrove's presence on the emission of these gases. If the total emission of CO_2 (mmol y^{-1}) [HG = 254×10^{12} ; SUN (W) = 28.83×10^{12} ; SUN (E) = 25.13×10^{12}] and CH_4 (mmol y^{-1}) [HG = 0.213×10^{12} ; SUN (W) = 0.022×10^{12} ; SUN (E) = 0.030×10^{12}] of the present study were taken for comparison, it is likely to be within the range with other tropical ecosystems. Several biogeochemical factors (Salinity, SPM, DIC, DOC and mangrove species density) and processes (mineralization, dilution with seawater, organic carbon burial, and sedimentation) controlled the concentration of $p\text{CO}_2$ and dissolved CH_4 and their water - air fluxes.

To understand the biogeochemical processes, the study of land-ocean interactions was also considered. Three cores (SC1, SC2 and SC3) from the Sundarbans mangrove and one from the Hooghly estuary (HC1) were collected to establish the mass accumulation rate. The average mass

accumulation rates ranged from $0.41 \text{ g cm}^{-2} \text{ y}^{-1}$ in the estuarine region to $0.66 \text{ g cm}^{-2} \text{ y}^{-1}$ in mangrove regions in the following order of $\text{SC2} > \text{SC1} > \text{SC3} > \text{HC1}$. Sedimentation rate in the Hooghly estuary was found to be low compared to the Sundarbans mangrove in spite of former receiving tremendous quantity of suspended sediments. As the Hooghly is a high-energy system, sediment which entered the estuary directly flushed down to the Bay of Bengal due to high river discharge. Whereas energy got dissipated towards the mangrove region and sediments got trapped in the complex mangrove roots of the Sundarbans.

To understand the sediment geochemistry and the pollution status of the present study milieu, trace metals were estimated in the sediments. The average trend of trace metal concentrations in bed sediments of the Hooghly and the Sundarbans, were in the following sequential order of $\text{Fe} > \text{Mn} > \text{Zn} > \text{Cr} > \text{Ni} > \text{Pb} > \text{Cu} > \text{Co}$. As in both the systems, OC content was comparatively lower (<1%) than the average estuarine and mangrove organic content, a general association of trace metals with sediment mud (silt and clay) content, Fe, Mn was observed. The Hooghly estuary is a high-energy system with comparatively high pollution input but did not show higher trace metal concentrations than the Sundarbans mangrove. This could be due to high discharge rate of water and considerable amount of dilution in the system. In the Hooghly, the extremely high tidal regime redistributed the pollutants onto fine and reduced sediments in adjacent the Sundarbans mangrove areas. In general, environmental indices showed both the systems

to be moderate to considerably polluted with respect to Zn, Pb, Cr and Co, while high level of contamination was observed by Cu, Ni, Mn.

This research was an effort to project the role of tropical estuaries and mangroves in the coastal biogeochemical processes and to understand the importance of anthropogenic effects on coastal ecosystems as a whole on climate change. Such information would aid in evaluating coastal mitigation strategies.