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Seasonal variation of $\delta^{18}O$, δD and $\delta^{13}C$ in the Hoogly estuary, India

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The Hoogly river, a channel of river Ganga, flows through the State of West Bengal, India and enters into the Bay of Bengal near Sunderbans, forming an estuarine environment with unique bioclimatic zone in the land ocean boundary of Bay of Bengal and Indian subcontinent. Several discrete islands constitute Sunderbans, largest being Sagar Island covering an area of 300 km^2 of Mangrove forest. Recent studies on fluxes of carbon from Sagar Island showed large temporal variability indicating response of the ecosystem towards micro-meteorological conditions influencing the productivity and emission [1] . We studied seasonal variation of isotopic tracers in the water, especially $\delta^{18}O$ and δD, to understand the physical and chemical processes influencing the biota and environment in this region. In addition, we also measured carbon isotopic composition of dissolved inorganic carbon (DIC) for deciphering mixing and carbon exchange between sea water and river water at different times during the year.

For this purpose, water samples were collected for three years (1999, 2000 and 2001) twice a month during high and low tide periods from Kakdweep locality of Ganga Sagar estuary. Samples were preserved in bottles, capped with rubber septum to avoid carbon dioxide exchange and evaporation. Oxygen isotopic composition of the samples were determined following the Epstein-Mayeda method with 1 ml of water equilibrated with CO_2 at 35ºC using on line water equilibration bath and analysing the isotope ratios in a GEO 20-20 Isotope Ratio Mass Spectrometer (IRMS). $\delta^{13}C$ of dissolve inorganic carbonates were measured with an aliquot of 2 ml of water reacting with 85% H_3PO_4 following the standard procedure [2].Salinity of the samples was measured with a multi-parameter probe.

The results of oxygen isotopic composition in different seasons are summarized in Figure 1.a. The meteorological conditions of the region in the mixing zone of Hoogly estuary can be divided into three main seasons: monsoon (June-September), post-monsoon (October –January) and pre-monsoon (February-May). The average discharge rates of water regulated by Farakka barrage during monsoon and post-monsoon months were 2975 and 1875 m^3sec^{-1} respectively. Release of water during early pre-monsoon was considerably lower at 1100 m^3sec^{-1}. Figure 1.a shows time plot of $\delta^{18}O$ during post-monsoon time (October to January) with values around –7 to -9‰ ; during pre-monsoon time (February to May) they become slightly enriched and remain around -5 to -6‰. During monsoon season (June to September) $\delta^{18}O$ maintains a near constant value of -4±1‰. The depletion in isotopic composition during October to January is probably due to relative increase in glacial melt water in river discharge and less influence of sea during tides. During February to May the river discharge decreases and influence of sea water becomes higher causing enrichment in ^{18}O. Despite large discharge of river water during monsoon season the sea water

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influence in this estuary remains impressive due to high rainfall in the sea compared to the land [3]. This favors enriched isotopic ratio in the Hoogly estuary water during monsoon time (June to September). Above interpretation is also supported by the salinity and δD results of the samples (see Figure 1.b).

Analyses of $\delta^{13}C$ of dissolve inorganic carbonates were made to find the variation of carbon isotopes in the dissolved bicarbonate of the water during wet and dry seasons. We used CO_2 flux measurement data from Mukhopadhyay et al (2002) [1] and compared it with $\delta^{13}C$ in our samples to evaluate the dynamics of carbon mixing in the estuary during 1999 to 2002. Figure 2.a shows $\delta^{13}C$ values at different months in the year 1999, 2000 and 2001. During October to January $\delta^{13}C$ value varies between -9 to -19‰ while during February to May the DIC gets relatively enriched to around -4 to -6‰, with maximum enrichment at April. During the subsequent period covering June and July $\delta^{13}C$ remains constant at -4 ± 0.5‰ before dropping to -15‰ in September. The large depletion during September to January in association with CO_2 emission and productivity data from the basin suggests increasing contribution of depleted carbon dioxide from the respiration of estuarine biota during September. Subsequent enrichment of $\delta^{13}C$ may be linked with decrease in the magnitude of respiratory CO_2 emission and slow increase in productivity in the basin. The net emission flux of CO_2 (respiration minus productivity) from the basin matches with our interpretation of carbon isotope ratio in DIC (see Figure 2.b).

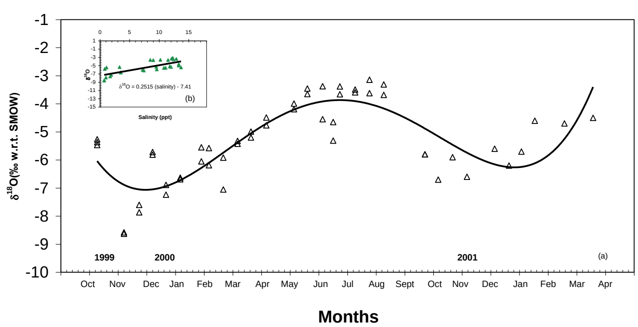

Figure 1.a Variation of $\delta^{18}O$ for water from Ganga Sagar estuary collected between 1999- 2001.
1.b (inset) Strong correlation between Salinity and $\delta^{18}O$ indicating influence of river discharge

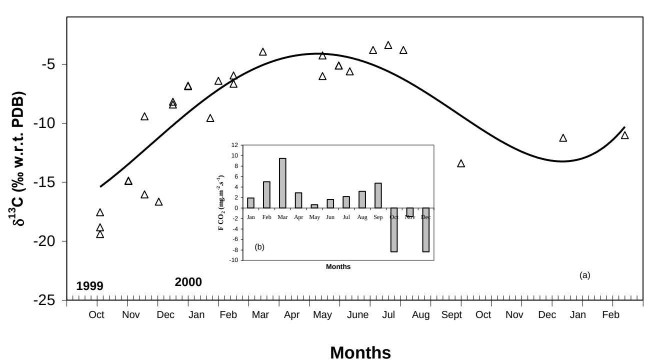

Figure 2.a Variation of $\delta^{13}C$ for DIC in water from Ganga Sagar estuary collected between 1999- 2001.
2.b (inset) Monthly variation of CO_2 fluxes at Sagar Island (from Mukhopadhaya et al., 2002)

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