Sources of water in the Ganga (Hooghly) River estuary, India

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Estimation of relative contributions of various sources of freshwaters in estuaries is essential to quantitatively assess their role in regulating the chemical and isotopic composition of estuaries. This study is aimed at determination of freshwater sources in the Ganga (Hooghly) River estuary based on comprehensive measurments of salinity and $\delta^{18}O$ in water samples collected in six periods of contrasting water discharges during 2012 and 2013. Salinity and $\delta^{18}O$ depict strong positive correlations (r^2 ranging from 0.96-0.99) suggestive of efficient mixing in the estuary. The values of the intercepts of regression lines, in the $\delta^{18}O$ vs. salinity plots, suggest that average $\delta^{18}O$ values of freshwater during the post-monsoon periods were the lowest (–8.1 to –8.4‰) whereas those during the pre-monsoon periods were the highest (–6.2 to –6.6‰). Observed seasonal variation of $\delta^{18}O$ of freshwater is consistent with the seasonal variation of measured $\delta^{18}O$ values of rainfall at Kolkata, indicating that freshwater is sourced mainly from rainwater. Higher $\delta^{18}O$ values of freshwater during the pre-monsoon periods suggest that contributions from snow/ice melt is insignificant in the overall freshwater budget of the Hooghly River.

In the plots of $\delta^{18}O$ vs. salinity, $\delta^{18}O$ values are generally above the line defined by theoretical mixing of freshwater and seawater. This is suggestive of internal source(s) of water in the estuary, most likely the groundwater. Proportions of riverwater, seawater and groundwater all along the estuary were estimated by inversion modelling of data on salinity and $\delta^{18}O$. The results indicate that the freshwater budget of the etsuary is dominated by riverwater contributions. The estimated fractions of groundwater are insignificant in the upper estuary but increase towards the lower estuary. The largest groundwater contributions in the lower estuary (ca. 30–40%) were observed in the monsoon period. Additionally, the groundwater proportions were in general higher in the year 2012 than in the year 2013.

This study provides for the first time temporal and spatial variation of contributions of water from various sources to the Hooghly estuary.