Sources of Shallow Groundwater Salinity in the Ganges Delta of Bangladesh

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In Bangladesh, unconsolidated fluvio-deltaic sediments host highly productive aquifer systems that are generally classified as shallow aquifers (depth less than 150 m below ground level, mbgl) and deep aquifers (depth more than 150 mbgl). Elevated groundwater salinity in shallow aquifers underlying the southern deltaic areas, in addition to mass poisoning of arsenic, aggravates freshwater scarcity in the country. However, little is known about the origin of salinity and mechanisms of salinization. Therefore, we analyzed both measured and previously published data on pH (n=585), electrical conductivity (EC, n=737), chloride and bromide (n=120 each), stable isotopes of water (oxygen-18 & deuterium, n=175 each), and radiogenic isotopes (C-14, n=18 & tritium, n=29) to discuss these issues for the upper shallow groundwater (depth around 60 mbgl) in the Ganges delta covering much of the coastal areas of Bangladesh. Stable isotope data from two GNIP (Global Network of Isotopes in Precipitation) stations in the delta were incorporated in this study. A paleo-shoreline, representing the maximum extent of last marine transgression at around 7 ka, was retrieved from a previous study and incorporated as well.

The upper shallow groundwater shows slightly acidic to alkaline in nature (6.1-8.5) over the delta. EC ranges from 210-29,400 microsimens/cm with lower salinity in fluvial area (210-2,000 microsimens/cm) than those in tidal domain (383-29,400 microsimens/cm). Cl^-/Br^- molar ratios are higher in tidal area (160-540,000) than those in fluvial setting (42-2,800). The cross plot between oxygen-18 and deuterium isotopes shows that groundwater data fall on or slightly below the local meteoric water line (Figure 1). Most of the brackish groundwater (n=43, EC>2,000-10,000 microsimens/cm) contains depleted isotope signatures. In EC vs oxygen-18 cross plot, EC mostly increases with almost constant isotopic signatures and this trend does not follow seawater mixing. Tritium concentrations are either low (0.1-2.9 TU, n=6) or below detection limit (<0.3 TU, n=9) in tidal domain, whereas around 57% of data show 0.2-7.2 TU in fluvial area. Radiocarbon (C-14) signatures are also higher in fluvial area (around 50-88 pMC) than those in tidal domain (around 36-86 pMC).

These results indicate that present-day seawater intrusion or connate seawater/estuarine water entrapped within sediments is not a major source of elevated salinity in groundwater. Current seawater intrusion is being occurred probably only in limited areas, i.e., near the coast. Also, it is hypothesized that groundwater salinity was possibly provided through the dissolution of soluble salts in paleosols by paleo-precipitation and concurrent infiltration to aquifers. During the transgression, intertidal environment was dominated in the study area, where evaporites and mud-cracks were likely to be developed during prolonged dry season. Subsequently, the monsoonal precipitation dissolved these evaporite minerals and vertically infiltrated into aquifers through mud-cracks or sediments. The future tasks should concentrate on analyzing whether these processes are occurring currently in the delta as well as reconstruction of paleo-geography for validating the hypothesis.

Keywords: Elevated salinity, Upper shallow groundwater, Electrical conductivity, Isotopes, Intertidal environment, Evaporite minerals

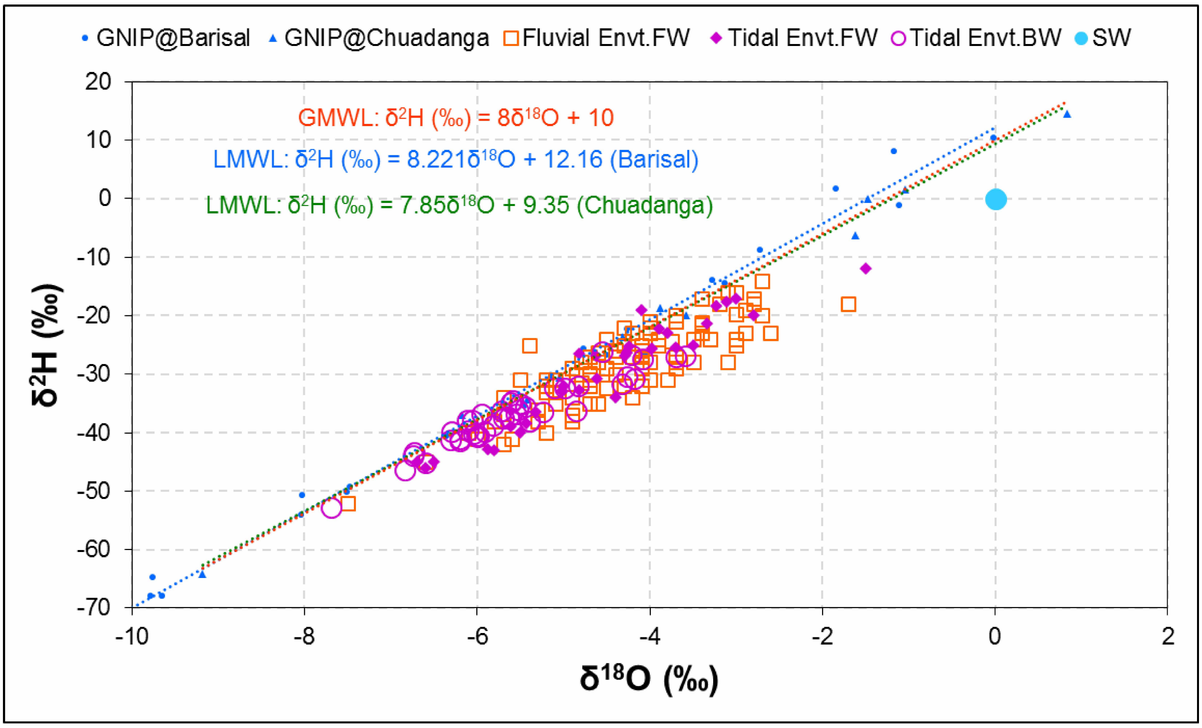

Figure 1: Cross plot between stable oxygen ($\delta^{18}O$) and deuterium ($\delta^{2}H$) isotopes

GNIP: Global Network of Isotopes in Precipitation, Envt.: Environment, FW: Freshwater (≤2000 μS/cm), BW: Brackish water (>2000 μS/cm), SW: Seawater