Environmental isotopes and hydro-geochemistry to determine the groundwater flow systems of Bengal Delta, Bangladesh

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In order to investigate the origin, recharge mechanisms and groundwater flow systems of Bengal Delta, shallow (less 70 m) and deep (over 70 m) groundwater, major river water and monthly rainfall samples were collected throughout the region for major ions and environmental isotope (^{18}O and ^{2}H) analysis. The shallow groundwater is dominantly Ca-Mg-HCO_3 type , which changes as it flows toward the south to Na-Ca- HCO3 in Ganges flood plain and to Na-Mg-HCO3 type in Brahmaputra flood plain. In shallow groundwater, the loss of Ca or Mg are exchanged for Na in clays, which are initially enriched in Na^{+}. The groundwater in deep aquifers is of Ca-Mg-HCO_3 type, which appears as Na-Mg-HCO_3 type in the coastal region with relatively high pH (over 7.5). The HCO_3 dominated shallow aquifers is caused by the dissolution CO_2 with groundwater. Electrical conductivity (EC) values for both shallow and deep groundwater gradually increases from N-S along the flow paths. The stable isotope data have been used to understand the interrelationships between the rainwater, surface water, shallow and deep groundwater of this region. The regression line constructed from monthly rainfall data is described by the equation: D/H = $8.9^{18}O/^{16}O$ + 19.9, the high d-value shows strong (kinetic) evaporation due to variations in high tropical humidity, wind speed and sea surface temperature during primary evaporation from the Bay of Bengal. The isotopic compositions of ^{18}O and ^{2}H of deep groundwater have relatively small variation and plot close to GMWL (Global Meteoric Water Line) and below the LMWL (Local Meteoric Water Line). The ^{18}O values of coastal deep groundwater range from -2.9/1000 to -3.5 /1000, which indicates marine influence along the coastal aquifers. Shallow groundwater have considerably wide variations (-1.5/1000 to -6.7/1000) in isotopic compositions, which reflect active flow and mixing of ground causing seasonal groundwater fluctuations. There is no significant sign of river water infiltration to the groundwater. Groundwater recharge in the shallow aquifer also occurs through stagnant water pools in low elevation areas where surface water run-off collects. The Pleistocene Terraces groundwater samples show stable isotopic signal with a narrow range (-3.7/1000 to -5.9/1000) of values, probably indicating similarity in timing and/or mechanism of recharge. These are palaeowaters probably recharged under a climatic condition that is different from today. Surface water samples from major rivers (Ganges, Jamuna, Meghna, Old Brahmaputra, Tista and Madhumati) fall on and above the GMWL with an wide range of ^{18}O values (-4.2/1000 to -9.3/1000). The more negative river water (Ganges, Jamuna, Tista and Madhumati) originates from higher altitude Himalayan regions. The less negative river waters (Meghna and Old Brahmaputra) show stable isotopic compositions similar to those of average rainfall of the region. The combination of isotopic composition in terms of ^{18}O and ^{2}H and major ions concentrations are the basis for separating the studied groundwater into three groups (shallow, deep and Pleistocene Terraces aquifers) that reflect the recharge sources and, chemical and isotopic modifications during flow.