Abstract

With increasing population and urbanization in the deltas of mega-river basins and coastal areas across globe, groundwater stress is increasing due to changing ocean-land disposition, increasing hydroclimatic extremes, over-exploitation and natural/anthropogenic contamination. The present study was conducted in the ecologically-vulnerable, UNESCO World Heritage site of the Sundarbans delta-front aquifers, demonstrating unique examples of hydrogeological intricacies and complexities. High-resolution, temporal, depth-dependent hydraulic connectivity and hydrochemistry were studied, by applying solute chemistry, isotope geochemistry, physical hydrology, and applied geophysics at the complex lithostraticgraphic unit of Ganges delta front to understand the process-based surface water-groundwater interactions. The study results revealed that in spite of complex aquifer-aquitard framework, shallow and deep aquifers are hydraulically connected locally, however, solute exchanges are mostly reserved in shallow depths at local-scale.

The declining groundwater level (GWL) is one of the controlling factors that aggravates the solute exchange between groundwater and seawater locally and regionally. The rainfall pattern positively correlates with the GWL at 5% level of significance. The shallow groundwater have >47% and deep groundwater have only <6% of seawater component. At shallow depth [14-25 meter below ground level (m bgl) and 30 to 50 m bgl] $\delta^{18}O$ signature vary within the range of -3.63 to -0.7 and -3.5 to -1.2‰, whereas, deep groundwater (115 and 333 m bgl) have more depleted signature (-5.04 to -1.61 and -4.43 to -2.38‰). The seasonal rise of salinity from 1 to 4 ppT of deep groundwater is major concern. Annually the salinity content of regional groundwater is also increasing due to the increasing hydraulic gradient differences.

The groundwater of coastal aquifers is respondent to the global climate events and ocean tides in a varied period from diurnal to seasonal scale and even in extreme climate conditions. The rise of GWL due to ocean wave surge is rapid and higher than the diurnal rise, which is a possible measure of the acute and long-term aquifer vulnerability. Thus, the increasing rates of extreme climatic events in recent times and in impending future can pose a previously unexplored potential threat to groundwater-sourced drinking water quality, exposing millions of inhabitants of coastal areas to risk.

Keywords: *Coastal-aquifer; hydraulic-connection; groundwater-salinization; extreme climate; hydro-climate*