Evolutionary process of saline groundwater influenced by palaeo-seawater trapped in coastal deltas: A case study in Luanhe River Delta, China

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Coastal aquifers provide fresh drinking water to over 20% of the world’s population. In recent times, they have come under immense pressure due to salinization. This study aims to investigate the origin of groundwater salinity and elucidate the major processes controlling shallow groundwater (depth of 0~50m) evolution in the Luanhe River Delta since the Holocene. Rapid increase in Electric Conductivity (EC) profile was observed in the area, as such, based on the vertical distribution of EC and sedimentary history, shallow groundwater was generalized into two zones for analysis: the groundwater in Holocene stratum (HSG) and groundwater in Late Pleistocene stratum (PSG). The isotopic (δ¹⁸O, δ²H and δ¹⁴C) analyses showed that the HSG is recharged by modern surface water, while the PSG having enriched isotopic values could have been recharged during a warmer Holocene transgression period. The hydrochemistry analyses demonstrated that seawater is the major source of salinity in groundwater and overtime a series of geochemical processes (mineral weathering and/or cation exchange) modified the chemistry of the groundwater. The combined use of Cl⁻ and δ¹⁸O yielded four classes of groundwater (fresh water, brackish water, saline water and brine), while the mixing phenomena between fresh water and seawater was identified to be the main evolutionary process of the shallow groundwater. To improve understanding of evolution of multiple groundwater types in a spatial context, a conceptual model was developed integrating the results derived from the presented study in a vertical cross-section. The conceptual model shows that the residual seawater mixes with freshwater from surface recharge at the shallow aquifer of the delta plain where the lagoon environment provides salinity concentration conditions for the formation of hyper-saline water. Due to the precipitation and accumulation of the salinity from hyper-saline water, some brine might form in late Pleistocene continental stratum.