Groundwater Dynamics in the Vietnamese Mekong Delta: Trends, Memory Effects, and Response Times

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Abstract

Understanding groundwater behavior is essential for water resources management in alluvial deltas. This study investigated the trends of groundwater levels (GWLs), the memory effect of alluvial aquifers, and the response times between surface water and groundwater across the Vietnamese Mekong Delta (VMD). 88 time series of GWL between 1996 and 2017 were collected at 27 national stations. Trend analysis, auto- and cross-correlation, and time-series decomposition were applied within a moving window approach to examine nonstationary behavior. Our study revealed high ratios of the seasonal component in shallow aquifers, and dominating ratios of the trend component in deep aquifers. These findings indicate an effective connection between the Holocene aquifer and surface water, and a high potential for shallow groundwater recharge. On the other hand, low-permeable aquicludes separating the aquifers behave as low-pass filters that reduce the high-frequency signals in the GWL variations, and limit the recharge to the deep groundwater. Declining GWLs (0.01-0.55 m/year) were detected for all aquifers throughout the 22 years of observation, indicating that the groundwater system is currently not fully recharged. Stronger declining trends were detected for deep groundwater. While the slight decline of GWLs in the Holocene aquifer (0.01-0.11 m/year) is likely caused by natural conditions, the significant decline in the Pliocene and Miocene aquifers (0.30-0.55 m/year) is attributed to the overexploitation of groundwater. The time-variant trend analysis indicates that the decrease of GWL accelerated continuously. The groundwater memory effect varies according to the geographical location, being shorter in shallow aquifers and flood-prone areas and longer in deep aquifers and coastal areas. Variation of the response time between the river and alluvial aquifers is controlled by groundwater depth, seasonal variability, and the location with shorter response times for shallow groundwater, during the flood season, and in flood-prone areas. Our findings are not only essential for groundwater resource management in the VMD, but they also characterize general mechanisms of aquifer systems in alluvial settings.

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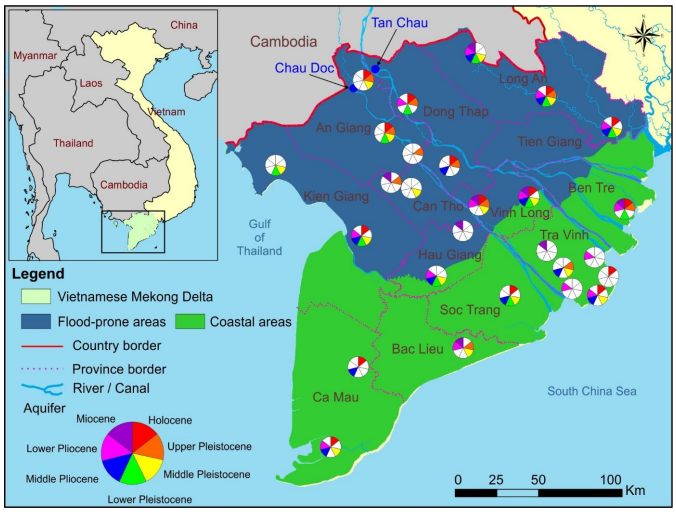

Figure 1: Study site in the Vietnamese Mekong Delta. The pie charts indicate the location of national stations monitoring groundwater levels within seven aquifers. Color/white pie segments denote that a monitoring borehole is available/unavailable at a given aquifer, respectively.

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