Abstract

The mega river basins in South Asia are facing extreme stress due to exponentially increasing urbanization, unprecedented groundwater abstraction, changing hydroclimatic extremities and increasing pollution thus risking long-term availability of sustainable water. Presently Ganges river basin, the 6th largest prolific fluvial system and sustaining a huge population, is witnessed to face i) aquifer vulnerability through surface waterborne pollutants and ii) groundwater stress due to summer drying of river as a result of indiscriminate groundwater abstraction. This study is one of the first in South Asia that deals with a multidimensional approach on river water-groundwater interaction and its hydrodynamics on both temporal and spatial scales. This study aims to delineate the groundwater-river water interaction and potential groundwater pollution pathways in the Central Gangetic aquifer system, using an enriched high-resolution primary dataset distributed spatially and on a sub-hourly scale, through various statistical analyses, computations, and modelings.

In the studied region, Varanasi, the groundwater contribution to the river baseflow during dry season reaches a maximum of 25-30% when the river acts as gaining stream, whereas during monsoon the river water infiltrates into the adjacent aquifer thus transforming into a losing stream. Impermeable clay capping throughout the Varanasi aquifer system restricts direct surface infiltration. A major part of groundwater storage in the study area is dependent on the river infiltration during monsoon. The deeper aquifer and the northwestern part of Varanasi show signatures of disconnected aquifer systems. Pressure head propagation is observed up to almost 8 km inland in shallow aquifer having a time lag with increasing distance thus exhibiting proper river-aquifer connectivity. The aquifer sediments consist of both Himalayan-derived and cratonic-derived deposits. Sediment-groundwater interaction is one of the major processes controlling groundwater chemistry. Groundwater-river water interaction process is majorly responsible for the groundwater quality deterioration besides surface water infiltration from irrigational/sewage canals and municipal disposal sites. The aquifer underlying Varanasi is although safe from geogenic pollution has high susceptibility towards anthropogenic pollution. Implementation of proper water management policies can secure the aquifer from extreme vulnerability and provide long-term sustainable water for the residing population.

Keywords: River water-groundwater interaction; Ganges River; Varanasi; Groundwater evolution; Urban hydrology; Aquifer vulnerability