Isotope technology in pursuit of water security in India

In the Middle Ganga Plains belonging to Indo-Gangetic Aquifer System, the dominant sources for groundwater recharge, inter-aquifer hydraulic connections, residence time and sustainability of groundwater in various zones have been understood with the aid of isotope indicators.

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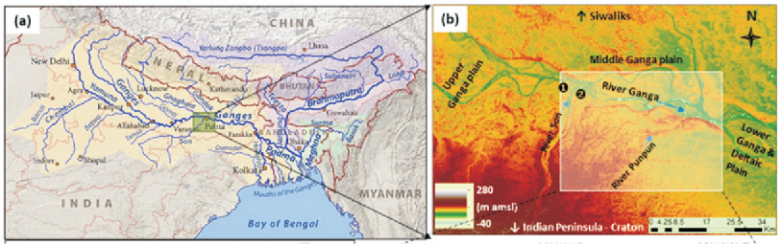

Fig.1: a) Ganga Basin, b) Middle Ganga Plains

Growing water scarcity is a major concern for India and many other developing nations. Irrigation through groundwater pumping has expanded at a very rapid pace in India since 1970s and currently over 60% of the total irrigated area is dependent on groundwater resources. Besides, as high as 85% of the drinking water supplies is met from groundwater. A whopping increase in the bore well construction across India, about twenty-seven million as per current data, obligated the planners to shift strategies from groundwater development to groundwater management. In this regard, a national level action plan was taken up by Central Ground Water Board in the form of "Aquifer Mapping" (CGWB, 2019). Initially studies on aquifer mapping were mainly focussed on geological, hydrogeological and hydrochemical characterization of aquifers techniques. However, it was later realized that tracing groundwater flow paths and assessing groundwater dynamics is quintessential for evaluating the future security of water resources. In this regard, isotope techniques, especially environmental isotopes, have proven to be potential tools in addressing such complex challenges in hydrology.

A pilot isotope study was carried out jointly by Isotope and Radiation Application Division (BARC) and Central Ground Water Board in Bihar State (Patna site). The study region is a part of Middle Ganga Plains (MGP) belonging to Indo-Gangetic Aquifer System, which caters to freshwater needs of several million people in India and Bangladesh. About 28 billion cubic meters (BCM) of groundwater is extracted annually in MGP, amounting to 10% of the India's annual groundwater extraction. Recently, a research paper in Science of the Total Environment has been published providing details on the application of isotope technology for aquifer mapping studies (Keesari *et al.*, 2021).

A total of 120 water samples were collected covering ~550 km^2 area, mostly confining to the Sone-Punpun-Ganga interfluve region (Fig. 1). The isotope information along with available lithological and hydrogeological data helped in achieving the spatial and temporal integration of the groundwater occurring in different depths. The dominant recharge sources for groundwater recharge, interconnection between surface water and groundwater, hydraulic interactions between aquifers, residence time and sustainability of groundwater in various zones have been understood in a precise manner. Isotope indicators not only delineated the groundwater zones based on their dynamisms, but also traced the groundwater flow paths with reference to their sources and origin. This aquifer system starts as a single unit near the southern upland regions located ~ 100 km south of the River Ganga and vertically segregates into different aquifer units.

Three major aquifers are observed with diverse recharge history. The top aquifer (I) is recharged through paleochannels while the intermediate aquifer (II) is being recharged from distant sources and vertical percolation from top aquifer-I is limited. The deep aquifer (III) is very old (~4000 years) and can serve as a strategic future resource in case of any serious crisis (Fig. 2). The inferences from isotope techniques have great bearing on the water security of not only Middle Ganga Plains but also the entire Indo-Gangetic Plains.

The research work discussed in the cited article was conceptualized by Isotope Hydrology Section of Isotope and Radiation Application Division, BARC and carried out in collaboration with Central Ground Water Board, Ministry of Water Resources, Govt. of India.

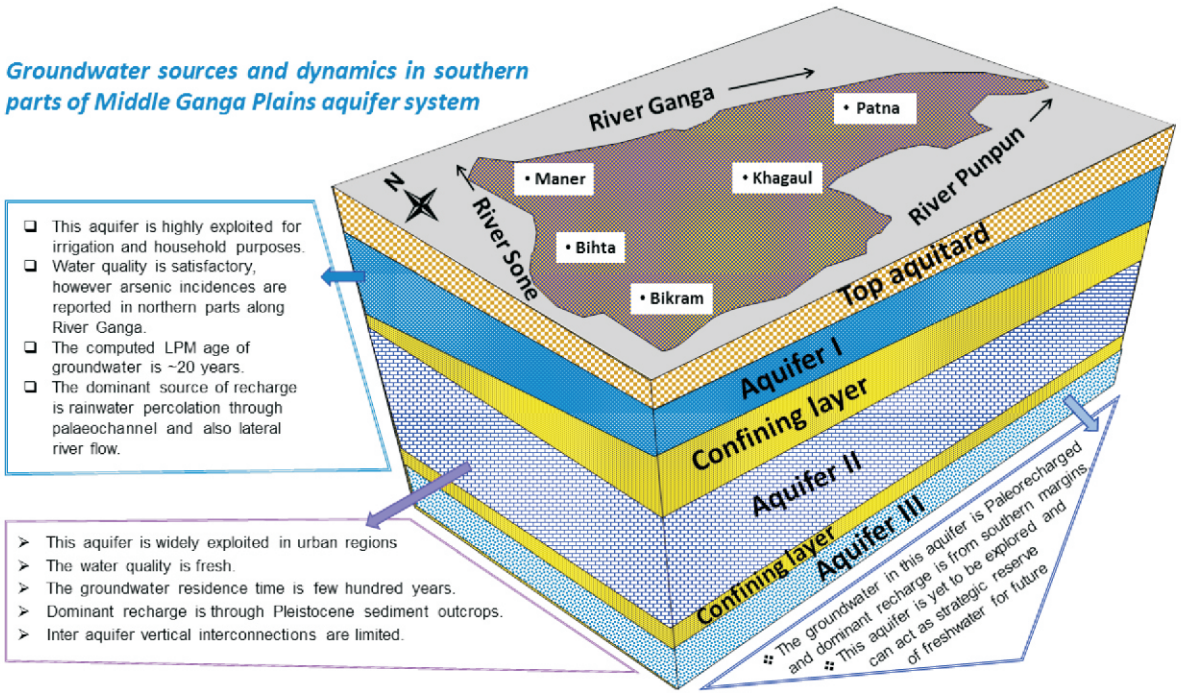

Fig.2: Groundwater distribution, water quality and aquifer dynamics in Southern Part of Middle Ganga Plains, Patna, Bihar.

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