

# Groundwater mixing and flow system evolution in the Quaternary aquifers of the Manas River Basin, arid northwest China: Hydrochemistry and environmental tracer indicators



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## ABSTRACT

Groundwater flow system characterization and evolution are critical for developing sustainable groundwater use strategies in arid water-stressed basin. For this end, hydrochemistry (major ion and selected trace elements) and environmental tracers ( $^2\text{H}$ ,  $^{18}\text{O}$ ,  $^{87}\text{Sr}/^{86}\text{Sr}$ , CFCs,  $^{14}\text{C}$ ) of various waters from precipitation, river, reservoir and groundwater have been used to investigate groundwater mixing and flow system evolution in the Manas River Basin (MRB), a typical mountain-oasis-desert ecosystem in the arid region of northwest China.

Stable isotopes reflect a meteoric origin and little evaporation or isotope exchanges between groundwater and rock and soil minerals throughout the MRB. Groundwater  $\delta^2\text{H}$  and  $\delta^{18}\text{O}$  values show more homogenized values along the groundwater flow paths and with well depth, indicating inter-aquifer mixing processes. A regional contrast in the Quaternary aquifers allows the  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios and  $\delta^{18}\text{O}$  values to be useful in a combination with selected ion concentrations. Both the groundwater mixing and flow system characteristics are identified. Lateral flow mixing and local groundwater flow systems with groundwater ages younger than 55 a are delineated in the piedmont alluvial-oasis plain. Leaching and vertical mixing in the intermediate and regional groundwater flow systems corresponding to the longer flow paths and residence times (e.g. groundwater ages between 1.16 and 11.96 ka) from the north oasis plain to the desert. Three regimes are identified in the local groundwater flow system based on the CFC-12 and CFC-113 binary mixing model. 1) A recharge zone with fraction of 0.70-0.83 young water (groundwater ages of 29-35 a) is from the south mountain to the Shihezi (SHZ) west. 2) A discharge zone is characterized by a mixing fraction of 0.37-0.64 young water (37.5-42.5 a) in the SHZ north to the piedmont oasis plain. 3) A stagnant zone with fraction of 0.09-0.50 young water (40-55 a) is in the SHZ east and Manas River east.