

Characterization of the Groundwater Flow System of Southern Baldwin County, Alabama Using Multi-Isotope Data

Southern Baldwin County Alabama has experienced continuously increasing growth and development over the last decade. Consequently, groundwater in the deeper aquifers in this area has been increasingly targeted for the region's growing municipal and industrial water needs. Expanding use of groundwater resources requires better knowledge about groundwater recharge and flow of the regional groundwater system. Therefore, assessment of the evolution of groundwater is necessary. The purpose of this study was to develop a better understanding of the regional flow system, with respect to recharge mechanisms and groundwater residence times of the aquifer system in southern Baldwin County. Stable and radioactive isotope analyses of the aquifers in the region were implemented to assess primary recharge sources, groundwater ages and associated residence times, and evolution of groundwater along major flow paths. Groundwater samples from wells screened at different depths were analyzed for radioactive and stable isotopes such as Carbon-14 (^{14}C) and carbon-13 ($\delta^{13}\text{C}$), oxygen-18 ($\delta^{18}\text{O}$) and hydrogen-2 (δD), and oxygen and nitrogen isotopes of groundwater nitrate ($\delta^{18}\text{O}\text{-NO}_3$ and $\delta^{15}\text{N}\text{-NO}_3$), respectively. The $\delta^{13}\text{C}$, $\delta^{18}\text{O}$, and δD isotope of groundwater data followed a relative narrow range regardless of aquifer depth. This narrow variation can be explained by modern environmental conditions and mixing processes. This is further supported by the ^{14}C activities that indicate the occurrence of unexpected older groundwaters in the upper aquifer A2, and younger groundwaters in the deeper parts of aquifer A2 and aquifer A3. The data further suggest high vertical gradients and recharge likely due to the nature of the permeable sediments and potentially to increased gradients as a result of significant pumping. The lack of variation of $\delta^{18}\text{O}$ values and the similarity to the regional precipitation $\delta^{18}\text{O}$ data reflects primary mixing of different end-member waters, and the permanent input of local recharge waters to greater depths. Moreover, given the regional patterns of $\delta^{13}\text{C}$, $\delta^{18}\text{O}$, and δD , and ^{14}C isotope data, the results of the study suggest that multiple recharge areas within this geographic area exist and are controlled by mixing during transport (due to naturally occurring and induced gradients), accounting for the groundwater homogeneous isotope signature. Furthermore, the $\delta^{18}\text{O}\text{-NO}_3$ and $\delta^{15}\text{N}\text{-NO}_3$ values are influenced by mixing processes that occur in a regional and highly developed groundwater system such as that of southern Baldwin County. These isotopes studies support the fact that the aquifer system in southern Baldwin County is a highly dynamic system experiencing mixing of recent recharged waters with older, ambient groundwaters.

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