A multi-tracer study on groundwater flow and impacts of regional development and climate change in a sedimentary multi-aquifer system: Peel Region, Western Australia

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Agriculture and horticulture in the Peel Region south of Perth (Western Australia) are heavily reliant on groundwater resources which are currently poorly understood. Major knowledge gaps include a poor understanding of (i) recharge to the different aquifers and connectivity between them, (ii) the evolution of groundwaters, and (iii) the effects of land use changes and climate change on the aquifer system. To address these knowledge gaps, a multi-tracer study was undertaken, involving noble gases (He, Ne, Ar, Kr, Xe), ^{2}H and ^{18}O, ^{3}H, ^{13}C, ^{14}C, ^{36}Cl, ^{87}Sr/^{86}Sr, ^{222}Rn, and hydrochemistry.

A hydrochemical cluster analysis and groundwater dating tracers indicate the aquifer system consists of an eastern and a western part. The eastern part (recharge area) contains younger water (up to a few centuries) and there is vertical groundwater flow through all geological formations (several hundred meters thickness). In the western part, groundwater is older (thousands of years), flows more horizontally and cross-formational fluxes are low. Vertical groundwater velocity in the east and horizontal groundwater velocity in the west have been estimated at approximately 0.15 m/yr and 0.5 m/yr, respectively.

To assess the hydrogeochemical evolution of the system, mineral saturation indices are plotted as a function of He concentrations (representing mean groundwater residence times over a wide range) to identify likely sequences of mineral phases that control hydrochemistry. Based on the absence of ^{3}H and an increase in excess N_2, while ^{14}C is still relatively high, we identified groundwater that likely recharged between 1950 and European Settlement in the 1830s. Concentrations of noble gases and stable isotopes of water show significant changes over time, reflecting anthropogenic effects and paleoclimatic changes. Interpretation of these signals is complicated by the suggested dual-porosity nature of the aquifer system (inferred from ^{14}C and excess N_2), which may dampen climatic signals.