IAHS2017-64-1
IAHS Scientific Assembly 2017

Using stable isotopes, geochemistry and pumping tests to investigate recharge and groundwater flow processes in a catchment underlain by fractured and faulted Hornblende-biotite-gneiss, Rivirivi Catchment, Malawi

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Faults and fractures have been shown to control groundwater dynamics in some geologies and overburden soil conditions. In this study, recharge and groundwater flow processes in a catchment underlain by fractured and faulted hornblende-biotite-gneiss were investigated using stable isotopes, geochemistry and pumping tests. Spatial and temporal geochemical distributions in the study area consistently showed Mg-Ca-HCO_3 dominated water facies. Shallow groundwater (SGW) along the ridges (with thin overburden soil up to 30 mm) showed Mg-HCO_3 facies while deeper groundwater (DGW) in the valley (with thick overburden soil up to 3 m) and river samples showed Ca-HCO_3 type in both seasons. Spring water changed from Mg-HCO_3 in dry season to Ca-Na-HCO_3 in rainy season. Concentrations of major ions in DGW remained higher than SGW in both seasons. SGW along the ridge exhibited the most enriched isotopic values in both seasons. The slope of the regression lines of the less varied SGW values were lower than those of Local Meteoric Water Line (LMWL), that is, δD (‰) = 6.3(δ^{18}O (‰)) - 5.2 against LMWL: δD (‰{) = 7.8(δ^{18}O (‰)) + 9.7suggesting that isotopic fractionation during rainwater evaporation could be the cause of the enrichment. Since the ridge section has very thin overburden soil and visible fractures, it is suggestive that rainfall events with this enriched stable isotope composition could effortlessly and preferentially recharge SGW. The similarities in stable isotopic and geochemical compositions for boreholes juxtaposed across Ntcheu Fault (-8.7‰ and -8.3‰ in dry season and -5.4‰ and -5.1‰ in rainy season) and the evidence from lithological data from a borehole drilled in the fault zone itself at Wanyemba Village, strongly suggested permeability across the fault. The thicker overburden soil (up to 3 m) seemed to suggest that only large rain events could recharge groundwater, letting small event infiltrated soil water evaporate completely, leaving no evaporation signal. Hydraulic head measurements, log-log plot and derivative plots of drawdown data from pumping tests revealed inter-aquifer, local and regional groundwater flow systems which are greatly affected by fracture connectivity.

KEYWORDS: Recharge; fractures; fault; stable isotopes; geochemistry; pumping test, Rivirivi Catchment