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How old is upland catchment water?

Harald Hofmann (1,5), Ian Cartwright (2,5), Uwe Morgenstern (3), Benjamin Gilfedder (4,5)

(1) School of Earth Sciences, University of Queensland, St Lucia, Queensland 4072, Australia, (2) School of Geosciences, Monash University, Clayton, Victoria 3800, Australia, (3) GNS Science, Lower Hutt 5040, New Zealand, (4) Department of Hydrology, University of Bayreuth, 95440 Bayreuth, Germany, (5) National Centre for Groundwater Research and Training (NCGRT), Flinders University, South Australia, Australia

Understanding the dynamics of water supply catchments is an essential part of water management. Upland catchments provide a continuous, reliable source of high quality water not only for some of the world's biggest cities, but also for agriculture and industry. Headwater streams control river flow in lowland agricultural basins as the majority of river discharge emerges from upland catchments. Many rivers are perennial and flow throughout the year, even during droughts. However, it is still unclear how reliable and continuous upland catchment water resources really are. Despite many efforts in upland catchment research, there is still little known about where the water is stored and how long it takes to travel through upper catchments. Resolving these questions is crucial to ensure that this resource is protected from changing land use and to estimate potential impacts from a changing climate.

Previous research in this important area has been limited by existing measurement techniques. Knowledge to date has relied heavily on the use of variation in stable isotope signals to estimate the age and origin of water from upland catchments. The problem with relying on these measures is that as the water residence time increases, the variation in the stable isotope signal decreases. After a maximum period of four years, no variation can be detected This means that to date, the residence time in upland catchments is likely to have been vastly underestimated. Consequently, the proportion of water flow out of upland river catchments to the total river flow is also underestimated.

Tritium (^{3}H) combines directly with water molecules and enters the flow paths with the infiltrating water. Its half-life (12.32 years) makes it ideal to describe residence times in upper catchment reservoirs as it can theoretically measure water up to about 150 years old. The bomb pulse peak in the southern hemisphere was several orders of magnitude lower than in the northern hemisphere. Hence the Tritium activities in the southern hemisphere have long decayed down the natural background levels, which allows unique ages to be determined by single measurements.

In this study major ion chemistry, stable isotopes and Tritium were determined at 2 locations and various stages of discharge (18 Tritium samples in between April 2013 and January 2014) in a first-order perennial stream draining a 7.3 km^2 catchment in the Dandenong National Park, Melbourne, Australia. Even during major discharge event major ions and stable isotope data have little variation and Tritium activities remain low (1.4 to 1.8 TU) in comparison to local rainfall of $\sim$ 3TU. Age estimations based on an exponential flow model are 15 to 25 years indicating that water draining from upland catchments is much older than we have previously estimated using stable isotopes.