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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Using multiple methods to understand groundwater recharge in a semi-arid area" *by* Shovon Barua et al.

Anonymous Referee #1

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This paper presents an interesting case study of three methods to estimate groundwater recharge in two small catchments subject to landuse change. Chloride mass balance (CMB), tritium renewal rate (TRR) with carbon-14 in a lumped parameter modelling approach were demonstrated as complimentary methods to estimate recharge. However a third method, the water table fluctuation (WTF) method resulted in large overestimates of recharge. The study compared recharge for a pasture catchment (151 ha) and forest catchment (338 ha), both drained by intermittent streams, at the head of the Glenelg river in western Victoria, Australia.

GENERAL COMMENTS

Although an interesting case study, the study provides limited justification and context, with some broad statements that should be better supported. How does this study

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inform sustainable management of groundwater (from the opening line of the abstract)? The description of the study area does not mention groundwater use in lower in the catchment, or reference to estimates of sustainable yields on a larger scale. A context of groundwater management issues in the region is not provided. How do the authors reconcile their view of the importance of recharge estimates with the 'water budget myth'? A related myth that sustainable development of groundwater resources can be defined by groundwater residence times has recently been highlighted by Ferguson et al 2020, citing classic papers on the water budget myth. The paper is well written and presented, although some additional figures to provide context and explanation would be helpful. Specific suggestions are provided below.

SPECIFIC COMMENTS

A number of more specific queries and comments follows:

1) The objectives of study were to examine uncertainties in varying methods of estimating recharge. However, there is no discussion of how the method comparison is similar or distinct from other recharge studies in semi-arid areas. Have other studies also found the WTF method overestimates recharge for example?

2) Comparing methods for recharge rates is interesting, but the authors argue (Line 481) that it is 'fundamentally important to asses the impacts of land clearing'. Why?

3) Section 5.1 on impacts of reforestation only considers the TRR method, which surprisingly does not find significant difference in recharge between pasture and forest. Other evidence indicates the forest is using more water, so the study appears to demonstrate the limitations of recharge estimation methods?

4) How do the authors recommend these results inform groundwater modelling ? Line 495

5) Both WTF and TRR rely on estimating the effective porosity (or effective specific yield). Mean porosity was previously reported as 0.15 and 0.1 respectively for the

pasture and forested catchments, but is unclear how this was determined, and how sensitive the WTF and TRR methods are to the range of possible values. Line 385 states Sy is 'not well known' which is an understatement, as the parameter is highly uncertain. There is also a possibility of semi-confined conditions to develop at very shallow depths and that hydraulic loading could account for part of the water level response to rainfall.

6) CMB method is most reliant on assumption of long term rate of Cl delivery, and can only be applied in catchments with negligible runoff and sedimentary Cl inputs. How are the results sensitive to 8% runoff measurement from the catchments?

7) The limitations of lumped parameter models (LPMs) should be discussed, as the dimensionless ratios assumed vary over a very wide range (eg. 0.05 to 1). Are the estimated residence times linearly related to these lumped parameters? Also, can it be clarified why the PEM and DM lumped parameter models were applied and not the exponential-piston flow model?

8) Clarify Line 295, regarding Cl/Br ratios 'and do not indicates that Cl is predominantly derived from rainfall and concentrated by evapotranspiration'.

9) Schematic cross-sections could help explain the relationship between regional vs. riparian groundwater. An additional map that shows the regional catchment context of the catchment divides for groundwater vs. surface water would also be helpful, as the current mapping provides very large scale and small scale maps.

10) Mean residence times, estimated from both 3H and 14C , were ∼4K in pasture and ∼24K in forest. Yet the forest was planted only ∼20 years ago, after ∼160 years of pasture. The CMB method suggests chloride accumulation over ∼10K years of rainfall inputs, to account for relatively high salinities. These differential time scales should be discussed further.

Ferguson G, Cuthbert MO, Befus, K, Gleeson T, McIntosh J (2020).The groundwater

age-sustainability myth. https://eartharxiv.org/gq2m3/

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