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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Theory of the generalized chloride mass balance method for recharge estimation in groundwater basins characterised by point and diffuse recharge" *by* N. Somaratne and K. R. J. Smettem

Anonymous Referee #1

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Additional and important observations should be added to my previous review of Somaratne and Smettem's manuscript. These relate to scale and spatial variability, as follows:

1. The method described by Somaratne and Smettem requires a runoff calculation to obtain the preferential recharge. They abandon the two-part Cl end-member approach contained in their methodology, and simply add Qp to their groundwater-based "diffuse recharge" estimate. Hence, the method is no longer a Cl-based one. The implications

of this are explored further below. They most certainly do not apply a generalised CMB method as the title suggests. It is, essentially, a recharge exaggeration tool, because it takes evidence for recharge from a groundwater system and adds poor approximations of bypass recharge to it.

2. The Somaratne and Smettem method is written as though it applies to the basin scale, and that the method somehow determines basin-scale diffuse and preferential recharge from two uniform end-member Cl concentrations. However, the aquifers in question show variability in Cl concentrations, reflecting spatial variability in recharge rates, and probably variability in end members. A reasonably minded hydrogeologist would not attempt to develop a single-recharge value across such an area (e.g. around Poocher swamp) in light of these observations, as suggested by Somaratne and Smettem as being standard practice. Rather, there would be some attempt to average or partition the aquifer into recharge zones. Also, it is unimaginable that one would use the highest Cl values to determine the basin-scale recharge, as suggested by Somaratne and Smettem as current contemporary practice. They adopt this mal-practice scenario to exaggerate differences between their method and conventional CMB. Rather, a reasonable hydrogeologist would consider each Cl measurement on its merits and consider recharge variability across the system. Certainly, there is no basis to start taking groundwater Cl-based recharge estimates and adding runoff to them. The implications of doing this are discussed below.

3. Somaratne and Smettem ignore groundwater flow patterns, and are basing their investigation entirely on Cl distributions. Flow in the SE of South Australia, around Blue Lake, is regionally in somewhat of a south-south-westerly direction. Flow at the boundaries of Uley South is driven by inflows from other carbonate basins to the north. Any groundwater bubbles will move with the groundwater flow, and mix with both recharging water and water from elsewhere. Mixing and groundwater flow together violate the notions of diffuse-only Cl values suggested by the authors. The only place these can be found will be in lower unsaturated zones, that are free from the flushing effects of

preferential flow.

4. Looking closely at the Cl distributions shown for Uley South, Figure 1, shows that there are Cl values amongst the "sinkhole region" that are higher than some of the "diffuse only" Cl values. How can this be? It violates every aspect of the methodology and its application.

5. A simple calculation for Uley South can be made to bring the methodology into complete disrepute. According to Somarantne and Smettem: the Cl value for diffuse only recharge is 147 mg/L and diffuse-only recharge is 56 mm/year; Cl for point recharge is 14.2 mg/L and point recharge is 75 mm/year. If the authors apply their own theory (see previous review equations R1 and R2) to obtain Cg, one obtains a value of mixed groundwater of 71 mg/L. There is no groundwater of this salinity in Uley South. Therefore, either their recharge rate is too high, or there is no mixing and every observation of Cl in Uley South is remarkably avoiding the freshwater bubbles. Or perhaps their end member concentrations are wrong. No matter what scenario for groundwater processes one might adopt - mixing or no mixing, there is no way to use the current method to get a reasonable basin-scale recharge. The remarkable no-mixing scenario renders the current method entirely impractical, because there is no manner in which to measure these elusive freshwater bubbles, and the user has no way to discern the proportion of the aquifer that is avoiding Cl measurement.

6. Given 1. to 5., it is clear that the method over-estimates basin-scale recharge. However, a modified form of the method might offer some insights into the spatial variability of contributions from sinkhole recharge. If one is somehow able to isolate diffuse and bypass Cl values, a two-end member approach would allow for a "% sinkhole recharge" map to be produced, but ultimately, there is no way to obtain the recharge values of Somaratne and Smettem for Uley South aquifer without violating mass balance constraints, as shown in the simple calculations of comment 5. above.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 307, 2014.