Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2018-341-AC1, 2018

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Managed aquifer recharge with reverse-osmosis desalinated seawater: modeling the spreading in groundwater using stable water isotopes" *by* Yonatan Ganot et al.

Yonatan Ganot et al.

yonatan.ganot@mail.huji.ac.il

Received and published: 12 August 2018

We would like to thank the referee Prof. Alex Furman for his review and comments. We provide below our detailed response to each comment.

General comment: Sincerely, I am not sure how to treat this manuscript. On one hand addresses a question of increasing concern (globally, not only in Israel), and it describes a work properly conducted, including a very nice combination of isotopic work and a flow and transport model. On the other hand, I'm asking myself at the end of the

day "what's new?" Is there something that can really be learned from this manuscript? Is it describing something that was not clear from the beginning? The innovation that I see in this paper is very specific, the use of stable isotopes to very specific types of waters. The uniqueness of the specific case is the specific O-H numbers that create very distinct end members, that possibly can lead to the ability to distinguish the mixture at very wide range of mixing ratios (this however is not explored). But mixtures of two end members, including by O-H isotopes, is not new, as the authors acknowledge. Therefore, my requirement for this paper to be accepted is to improve the description of the unique case study throughout the manuscript, so that the innovation will be much better explained, highlighted, and discussed. If properly done this can probably be a good reference study.

Response to general comment: We will emphasize the uniqueness of this work in the revised manuscript as detailed below:

1) The uniqueness of this case-study and its importance The uniqueness of this study, as the reviewer stated, is based on the specific case where reverse-osmosis desalinated seawater (DSW) are being recharged into natural fresh groundwater (GW). There are currently only a few places that are practicing managed aquifer recharge (MAR) with DSW, but this practice will grow due to the increasing use of DSW globally. Practically all the known case studies of MAR with DSW involve brackish-water aquifers (in the Gulf countries) and not necessarily reverse-osmosis DSW. These two features are important for the contrast in heavy isotopes concentrations to be large enough to enable simple mixing calculations.

2) The novel use of isotope-transport modeling The advantage of using stable water isotopes to trace DSW in the SAT site of the Shafdan MAR system, Israel, was recently reported by Negev et al. (2017). However, to the best of our knowledge, this is the first paper reporting groundwater modeling of reverse-osmosis desalinated seawater using isotope data. Combining a calibrated flow and transport model with isotope data enables prediction of the DSW plume spreading in the aquifer in future scenarios. This

is a quantitative step ahead of previous isotope-analysis studies related to reverse-osmosis DSW in aquifers.

3) The robustness of the two end-member assumption and its validation In this work we use two features of stable water isotopes that are mutually related, in order to trace reverse-osmosis DSW in the aquifer: (1) the distinct difference between isotope composition of reverse-osmosis DSW and natural fresh water; and (2) the relative similarity of isotope composition among natural fresh water, which simplify the system to a binary mixture. See section 3.1, lines 139-140 and 151-154. The binary simplification is a robust tool for modeling DSW spreading in the aquifer, as it reduces considerably the amount of isotope data that needs to be collected and analyzed for boundary conditions. Other modeling studies that use water isotopes, implement detailed transient boundary conditions based on large data sets that vary spatially and temporally (e.g., Reynolds and Marimuthu, 2007; Liu et al., 2014) that in most cases are not available. Mixing of two end-members is indeed widespread in geochemical studies, and can also be found in few groundwater modeling studies that use stable water isotopes as tracers (e.g., Krabbenhoft et al., 1990; Stichler et al., 2008). However, in this work an original error analysis is used to estimate the validity of the two-end-members assumption (section 3.2.3). This error analysis is possible due to the unique use of the flow and transport models discussed previously. We showed in the analysis (Figure 6) that the assumption is valid for the current isotope-composition variability that is found in the aquifer (δ18O=–4.48 to –5.43‰ and δ2H=–18.41 to –22.68‰. We also note in the original manuscript the conditions that permit the use of a two end-members approach (lines 215-218).

All the above clarifications will be inserted to the revised manuscript to describe more explicitly the novelty and uniqueness of this work.

Comment 1: Since the authors describe model predictions, I'm not sure if past tense is the appropriate. In the same context, instead of "results show" I'd use "results suggest"

Response 1: We agree. We will revise the manuscript according to the reviewer's suggestion.

Comment 2: I do not think the model neglects fractionation (line 118). It is you (the authors) that neglect such a process. But why neglect? Is there a reason to think such a process is relevant here?

Response 2: Isotope fractionation processes such as evaporation or biogeochemical interactions are negligible in the transport of water-isotopes in deep groundwater (depth of water table » depth of root zone). There is strong evidence that local groundwater tends to be isotopically uniform (e.g., Krabbenhoft et al., 1990 and reference therein). Moreover, our measurements at this fast-percolating MAR site show similar isotope composition between the DSW source-water at the surface, in the variably-saturated zone and at the shallow GW (Ganot et al., 2018). Therefore, isotope fractionation even if exists in the aquifer to some extent as a slow process (centuries-millennia), it should defiantly consider negligible compared to the distinct difference between the isotope end-members. Note that the error analysis presented in section 3.2.3 (and discussed here previously) aimed to test the binary end-members assumption, justify the assumption that isotope fractionation is negligible in this GW system.

We will add this explanation to the revised manuscript (in line 118 and also in section 3.2.3).

References

Ganot, Y., Holtzman, R., Weisbrod, N., Russak, A., Katz, Y. and Kurtzman, D.: Geochemical Processes During Managed Aquifer Recharge With Desalinated Seawater, Water Resources Research, 54(2), 978–994, doi:10.1002/2017WR021798, 2018.

Krabbenhoft, D. P., Anderson, M. P. and Bowser, C. J.: Estimating groundwater exchange with lakes: 2. Calibration of a three-dimensional, solute transport model to a stable isotope plume, Water Resour. Res., 26(10), 2455–2462, doi:10.1029/WR026i010p02455, 1990.

Negev, I., Guttman, J. and Kloppmann, W.: The Use of Stable Water Isotopes as Tracers in Soil Aquifer Treatment (SAT) and in Regional Water Systems, Water, 9(2), 73, doi:10.3390/w9020073, 2017.

Liu, Y., Yamanaka, T., Zhou, X., Tian, F. and Ma, W.: Combined use of tracer approach and numerical simulation to estimate groundwater recharge in an alluvial aquifer system: A case study of Nasunogahara area, central Japan, Journal of Hydrology, 519, 833–847, doi:10.1016/j.jhydrol.2014.08.017, 2014.

Reynolds, D. A. and Marimuthu, S.: Deuterium composition and flow path analysis as additional calibration targets to calibrate groundwater flow simulation in a coastal wetlands system, Hydrogeol J, 15(3), 515–535, doi:10.1007/s10040-006-0113-5, 2007.

Stichler, W., Maloszewski, P., Bertleff, B. and Watzel, R.: Use of environmental isotopes to define the capture zone of a drinking water supply situated near a dredge lake, Journal of Hydrology, 362(3), 220–233, doi:10.1016/j.jhydrol.2008.08.024, 2008.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2018-341, 2018.