

Review of:

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Assessing land–ocean connectivity via Submarine Groundwater Discharge (SGD) in the Ria Formosa Lagoon (Portugal): combining radon measurements and stable isotope hydrology

By Rocha, C. et al.

General comments:

The manuscript by Rocha et al. presents a multi-tracer approach (^{222}Rn , ^{18}O , ^2H) conducted at Rio Formosa (Portugal) to “identify the sources of submarine groundwater discharge (SGD), distinguish its component parts and elucidate the mechanisms of their dispersion throughout the Ria Formosa”. The combination of different tracers to investigate SGD is a rather common standard in many SGD investigations. Yet, the intention to combine ^{222}Rn and $^{18}\text{O} / ^2\text{H}$ to obtain SGD quantities and its possible sources / pathways is, in the context of SGD, an interesting approach. Associated with this ambitious aim are several uncertainties, a huge amount of data and most of all an enormous effort starting with several conducted sampling campaigns and last but not least the data analyses. All this needs to be acknowledged.

At the same time the obtained data concert including its analyses needs to presented to the broader scientific community in a comprehensive and likewise clear manner. In parts this could not be achieved which reduces the overall quality of the presented manuscript at this stage of the process. Possibly due to the same reason it is likewise, to a certain extent, unclear whether or not all obtained data fulfil the aspect of comparability. This aspect is raised as the sampling campaigns cover a 4-year time span, but during none of the sampling campaigns all parameter were obtained. Instead, it resembles an unclear sampling strategy, being influenced by a multiplicity of influencing factors. In the following lines I will point at those passages that are unclear or lack a logical rigour (Specific comments) followed by technical corrections (Technical comments).

Specific Comments:

P12436 L9 *After Indeed, [...] please add ‘on a global scale an estimated 6%...’ as the anticipated percentile SGD contribution is different for oceans/ continents etc. as you certainly know.*

P12436 L14-19 I suggest rewriting this passage as:

1. I am sure hydrogeologists or any other expert do see SGD, if they are familiar with that term, as any fluid flow regardless of fluid composition or driving as defined by Burnett et al. 2003.

2. In this context, I suggest to simply state the given or any other definition and adapt the following lines accordingly.

- P12437 L 10 The authors may think about exchanging Lee 1977 with one or two of the rather new and partly very interesting publications concerning direct flux measurements.
- P12437 L 16 *'fail to include seawater recirculation'* this is not quite correct see e.g. Li, Hu, B., Burnett, W., Santos, I., Chanton, J. (2009) Submarine Ground Water Discharge Driven by Tidal Pumping in a Heterogeneous Aquifer. *Groundwater*. 47(4): 558-568. Please change.
- P12441 L12-23 I am not sure why the authors include nitrate contamination at that point. Undoubtedly, it is an important topic, but it does come out of the dark at that point since it is not mentioned in the title nor does anything points at its importance. Since neither ^{14}N nor ^{15}N is used to explain sources later on, do the authors intend to use the contamination aspect for a final assessment as pointed at in the title? If so, it should be better introduced to make the point clear.
- P12442 L4-19 From how I perceive it, so measured ^{222}Rn values do reflect an integral of ebb and tide status and is not corrected/normalized to its specific tide level? Is this correct?
- P12444 L7 *'Samples'* - Could the authors add some words on how the samples were obtained, from which depth, whether they were stored or directly analysed etc. to provide a comprehensible and reproducible sampling strategy?
- P12444 L24f *'which in combination with its location implied very low [...] so we neglected the term'* - I cannot follow the reasoning of neglecting surface water inputs. Rather intuitive would be to provide a salinity time series at this location that, if there is no surface water contribution, should be rather constant over time. Plus, did the authors check whether or not any floods occurred prior to the campaigns that might have changed the ^{222}Rn signal, if not at the outlet than possibly within the lagoon?
- P12446 L3 I am not sure in how far the comparability between samples of different campaigns is given. Please add, at a suitable point in the manuscript, a short passage on the comparability of samples as specifically during the isotope section the authors themselves point out that a variance of up to 50% exist between sampling dates. This questions many interpretations of the presented manuscript and needs to be clarified. Plus, use consistent dates/ periods for the isotopic data. Sometimes, the author's use 2007, 2009-2010, sometimes it is 2007 and 2013, sometimes it is 2007 and 2009-2011. This is very confusing and raises questions.
- P12447 L19-22 If both, activity range and spatial distribution of ^{222}Rn , are similar I do not understand the neglecting of the winter campaign. I suggest including it, as it may even provide more insights into temporal dynamics despite the associated uncertainties.

- P12449 L11-12 Here and also during the following lines, one SD is almost similar in value as the given mean value. In turn, i.e. the representativeness of the given SGD mean value is rather low and associated with a lot of uncertainty. This even leads to the fact that the resulting advective radon input to the lagoon of $1.36 (\pm 1.28) \times 10^6 \text{ m}^3 \text{ day}^{-1}$ may result in an filtering of the entire tidal-averaged volume of the lagoon ($140 \times 10^6 \text{ m}^3$) through its sandy beaches within 100 days, as given by the authors but, with an almost similar probability, it may also be only 74 or 2450 days if we include the SD.
- P12451 L17f How is the strategy influencing the range, specifically the $\delta^{18}\text{O}$ range?
- P12455 L17 I would encourage the authors to double-check the percent-values. Corresponding to my calculation it would be 3.16, 0.97 and 0.04 (based on the mean value and the mean daily flood prism of $140 \times 10^6 \text{ m}^3$).
- P12451 L1f This comment is similar as one I have given before, but should underline the importance. On the given line, I started getting very confused. Despite stating in the text that isotope samples were taken 2007 and apparently at least twice between 2009 and 2011 (otherwise the authors would have given only one year) Fig. 5 states sampling years 2009-2010 and the supplement even 2012. I strongly encourage the authors, and this does account for all parameter and samplings to give a clear overview, which samples have been taken at what date and to discuss the comparability between parameter (R_n , ^{18}O , ^2H) in the context of the intended aims the authors follow within the presented manuscript.
- P12458 L11f I assume the authors mean the WWTP. If so please state so, for clarification aspects.
- P12463 L16-18 I cannot follow. I agree, rainwater plots at a d -excess of $\sim 25 \text{ ‰}$, but how do the authors derive the point that water for public consumption was mainly withdrawn from a meteoric source? On the other hand, isn't that somewhat logical? I assume this arid region to use shallow GW to large extents, which should have a meteoric origin.
- P12463 L20 Do the authors mean the mixing line P4? If so, the reasoning is not clear to me as I do not understand the distribution of the surface water and porewater samples? How can surface water plot above the porewater samples? Or, are these the sample points, the authors discuss earlier when mentioning the influence of the WWTP?
- P 12463 L23f Again the question of comparability? Was the tidal status the same during both samplings? Or could it be that during 2007 it was a low tide during which all the porewater was sampled plus a wet period just before the sampling campaign? Both in combination might also explain the differences to the 2009-2011 data that might reflect a rather dry period before. Additionally, S1 shows the different porewater samples but there is no information whether they show different depths, or different

close by locations with a constant depth, nor how they were retrieved. Please clarify and state some words to the comparability.

P12464 L13-16 *'the activity of the SGD subterranean pathway into the Ria becomes dependent on whether groundwater levels in M12 are sufficient to establish a hydraulic gradient driving the flow as was apparently the case in 2007 (Fig. 7a).'* - I agree, but could the authors underpin this aspect with recorded precipitation amounts in the period before the campaigns?

P12465 L12-27 Instead of referring to N, I would suggest to briefly list the direct findings of the study and to assess the connectivity as the title suggests. From my perspective, this last paragraph, if intended as assessment, is not at all suitable as such as none of the direct results of the manuscript are used except (possibly) a measurement for N in 2006 but here it is unsure whether it is an own measurement or by Leote et al. (2008).

Technical Comments:

P12435 L21-25 It is a very long sentence that is hard to follow. I suggest to shorten or to rewrite it.

P123439 L25 *'six tidal inlets'* – Fig 1 shows only 3 inlets. I assume the other three are east of the region Fig. 1 shows. And this is one point I would encourage the authors to change. Throughout the text, several times locations, rivers, stream (ephemeral and perennial) and inlets are mentioned that are not shown on the map. Please include them to provide a comprehensive and complete picture of the area. Plus, please add all sampling sites and possibly indicate the time they were taken (e.g. colour coded)

P12440 L12-15 Please change from *'The surrounding watershed covers 740 km² and receives effective precipitation of 152mm yr⁻¹ (Salles, 2001). This corresponds to a potential annual rainfall of 1.2 10⁶ m³, very small compared to the tidal exchange flux – hence the high average salinity of 35 found throughout the year in the lagoon (Mudge et al., 2008).'*

to

'The surrounding watershed covers 740 km² and receives effective precipitation of 152mm yr⁻¹ (Salles, 2001) corresponding to an annual rainfall amount of 1.2 10⁶m³.

P12441 L5 *'The two units'*-It is unclear which two units are meant here. Aforementioned is the M12 as multi-layered aquifer only but no specific units. Please clarify.

P12443 L3 *'Faro Channel Fig.1'* - Where exactly are the two fixed stations located, is it station 3 and 4? Please clarify.

P12444 L23 There is no Table S1, neither at the end of this document nor in MS manuscript overview of HESSD. Please add it as at least from my perspective it is crucial for the understanding of certain processes and samplings and its evaluation.

- P12445 L11 Please explain 'T'
- P12445 Eq4a/4b Although possibly being pedantic, please move the Rn_{net} to the end of the equation to match Eq. 3
- P12446 L 13f '*western sector*' - the 'western sector' is explained later on and may lead to confusion here. Either the author's add the locations in Fig.1 (what I suggest) or they explain the western sector at that point.
- P12446 L 13f '*Barra Nova*' – this term is not shown on the map but used several times in the text. Please add it to Fig. 1 in order to allow a clear understanding of the spatial context.
- P12448 L1-4 The spatial distribution is explained at the example of Rn activity but Fig. 2 shows inventories. To make it easier to follow I suggest to use either inventory or activity, but to use the same for the verbal explanation and Figure 2.
- P12450 L22 '*for the Great Barrier Reef*' – is this relevant? If not, I would suggest to delete it.
- P12450 L21/25 Equations – Is it relevant to show them in the text, especially the coefficient of determination r^2 and later on the p-value? I would suggest putting them in the plots as it disturbs the text quite a bit.
- P12451 L27 '*proper*' – I assume the word is wrong here. Please delete.
- P12460 L20-25 Very long sentence that I would suggest to split or rewrite.
- P12476 Fig1 Please,
1. add all names, places, sampling locations etc. the authors mention throughout the manuscript and extend the figure to the east,
 2. add a colour legend,
 3. add a colour to M10-M12 to be able to differentiate it from water
 4. add a coordinate system to be able to locate sampling locations from the supplement
- P12477 Fig2 Is ebb and tide (a and b) erroneously exchanged, as more data points to the west are available for the ebb subset (a) which I would assume for the flood with more water in shallow reaches?
Please provide some names in Figure 2 that the authors use during the description of the spatial distribution and, if the authors have it, a bathymetric chart would add some value.