REVIEW

HESS-2013-449

Intensively exploited Mediterranean aquifers:
resilience and proximity to critical points of seawater intrusion

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Hydrol. Earth Syst. Sci. Discuss., 10, 13817–13854, 2013
www.hydrol-earth-syst-sci-discuss.net/10/13817/2013/
doi:10.5194/hessd-10-13817-2013

NB: In this review I use the abbreviation "SWI" for "Sea Water Intrusion"….

/ TITLE ----------

The last part of the title is somewhat curious ("proximity to critical points of...")...this piece should be modified/clarified.

/ ABSTRACT ----------

The abstract is concise and (but) informative enough, and to the point. It covers (briefly): the study sites, concepts & methods of analyses, and also the main results (qualitatively).

/ MATERIAL & METHODS → SITES ----------

The sites are well presented (text and figures). The plane view as well as vertical cross-section configuration of the aquifers is presented (*see comments about Figures-->Fig.*3)…

/ INTRODUCTION + *First comments on assumptions & results (to be continued in / Figures)*--

The "thresholds" that appear in a nonlinear response are also named "tipping points" (in this paper). The objective of the paper is to analyse nonlinear+threshold behavior of SWI w/respect to changes of various quantities, such as sea levels, intensity of irrigation, pumping well positions, …. (*perhaps this statement should be made more complete in the introduction*).

The paper relies mainly on a quasi-analytical solution of quasi-static seawater intrusion based on sharp interface assumptions, etc. The main reference invoked in this respect *Mazi et al 2013* (a recenbt paper published by the same authors) and references therein:

> *See my discussion on "**/ References**" further below…*

Looking at the rest of the paper, it appears that the **results** are expressed and plotted in terms of dimensionless horizontal distance of toe of saltwater interface, as follows:

- in **Fig.4+Fig.5,** the distance of the toe is plotted versus the total discharge to the sea (implicitly it is I believe the freshwater discharge to the sea: yes?).
- in **Fig.6,** the distance of the toe is plotted for a few different specific locations of the "pumping well" vs. the so-called "remaining" discharge to the see.

  *See my comments below **(/Figures→Fig.6**) concerning clarifications needed on **Fig.6**…*

See also my comments **(/Figures→Fig.A**) concerning *the special interpretation of "pumping wells" under the authors' assumption of plane symmetry…*

/ *Sec.3.2.* ANALYSIS APPROACH

The authors chose not to include any equations in **Sec.3.2**: the equations are left for the analytical Appendix A.

But at least all the quantities defined in Sec.3.2 should be followed by their S.I. units, including the dimensional terms that are used to form dimensionless quantities.

In fact, following up from the previous remark about plane symmetry and "wells", the best way to clarify the issue is to *provide the physical units of quantities like the "pumping rate qw": is it (m3/s) or (m3/s/m)?*

/ REFERENCES ----------

This paper is closely related to two previous publications in 2013 and 2012 (*both cited*):

> Koussis A.D., Mazi K., Destouni G. (2012): Analytical single-potential, sharp-interface solutions for regional seawater intrusion in sloping unconfined coastal aquifers, with pumping and recharge, *Journal of Hydrology* 416–417, 1-11, 2012.
>
> Mazi, K., Koussis, A. D., and Destouni, G. (2013): Tipping points for seawater intrusion in coastal aquifers under rising sea level, *Environ. Res. Lett.*, 8, 014001, doi:10.1088/1748-9326/8/1/014001, 2013 (6 pp.).

➔In particular, *Mazi et al 2013 (Envir. Res. Letters)* is cited by the authors in the introduction. It is very recent; and it is authored by the same three authors as the present submitted paper under review for HESSD. It appears to be available freely online (*Envir. Res. Letters*).

> *Now, upon inspection, the contents of the Mazi et al. 2013 paper appear quite close to the current submission, in terms of methods and perhaps in terms of application sites as well. This last point should be elucidated by the authors.*
>
> In conclusion*: the differences and the* possible *overlaps between the Mazi et al. 2013 paper and THIS submitted paper should be outlined more explicitly (not only in Appendix A but also right at the beginning of the paper in "1.Introduction").*

➔In addition, the authors cite a recently submitted paper by Destouni et al. 2013 which may or may not have *some* overlaps with the present HESSD submitted paper (*same remark: this point also should be clarified more explicitly*):

> Koussis, A. D., Mazi, K., Riou, F., and Destouni, G.: Sea-intrusion in unconfined coastal aquifers: submarine outflow correction for Dupuit-type sharp-interface models, J. Hydrol., submitted, 2013.

➔Additional references. Finally, additional references could be provided to broaden the scope of the paper (at least in the literature review).

For instance, analyses of the effect of heterogeneity and uncertainty have been developed in an analytical framework similar to that used in this submitted paper (sharp interface solutions), e.g., see the few references indicated below:

- **Chang C.-M., H.-D. Yeh (2010):** Spectral approach to seawater intrusion in heterogeneous coastal aquifers. Hydrol. Earth Syst. Sci. (HESS), 14, 719-727, 2010. www.hydrol-earth-syst-sci.net/14/719/2010/ DOI:10.5194/hess-14-719-2010.
- **Al-Bitar A., R. Ababou (2005):** "Random Field Approach to Seawater Intrusion in Heterogeneous Coastal Aquifers: Unconditional Simulations and Statistical Analysis". In : *GeoENV : Geostatistics for Environmental Applications*, Renard P., Demougeot-Renard H., Froidevaux R. (eds.). ISBN:3-540-26533-3. Springer 2005.

One of the three coastal aquifers (Cyprus Akrotiri Aquifer) cited in "1.Introduction" has been extensively studied using various semi-analytical & numerical models in the recent years (2000's). Some have focused on the relative influence of SWI and of soil salinization due to

intensive irrigation/pumping cycles. The corresponding references are probably worth citing in the introduction. For references, see:

- **Milnès E. et al. 2000's**: *one* or several papers, in the *J. of Hydrology* and other journals.

/ FIGURES + *Second set of comments on assumptions and results*----------

Here I use the figures as a basis to comment on some assumptions & results….

I note, first, that the Figures are generally informative and of reasonably good graphic quality…except where mentioned otrherwise in trhe comments below (Fig.3).

/Fig.3.

This figure presents vertical cross-section configuration of the aquifers, a key feature in this paper.

It is a bit of a pity that the sub-figures are so small (especially the text legends); also the B&W textures should be replaced with greyscales to improve graphic quality if possible…

/Fig.6.

Fig.6 *is a bit hard to follow. It shows the dependency of "toe distance" versus "remaining submarine flow to the sea", and this for a few different distance of the "well". The figure is a bit overloaded. The caption is detailed, but not informative enough. In particular, it would be useful to recall in this caption the meaning of the negative/positive dimensionless distance(s) shown in abscissa (distance of the "toe" as well as the distance of the "well"). Concerning the "well" under planar symmetry…see also the remark about Fig.6.*

/Fig.A.

This figure is of good quality, and it is essential to this paper, but it raises some key points (*see also other comments / references -- about the Mazri et al 2013 previously published paper)*:

This figure illustrates the so-called "generalized" analytical solution of SWI, on which the entire paper is based (the vulnerability assessments of the 3 sites are based on it).

The term "well gallery" used in one of the legends of this figure is probably due to the fact that the SWI analytical solution is assuming plane symmetry along the shorewise direction (yes?). This assumption implies that the so called "well" is in fact a linear trench or gallery running parallel to the shore. In summary: the so-called "well gallery" may represent a line of wells parallel to the coast…but not a well.

So, unless I misinterpreted the "well gallery", the above mentioned limitation should be commented more explicitly with respect to real pumping patterns (and, if this reviewer misinterpreted…, then some clarification would still be required).