

***Interactive comment on***  
**“Desiccation-crack-induced salinization in deep  
clay sediment” by S. Baram et al.**

**Anonymous Referee #3**

Received and published: 18 February 2013

This paper investigates salinization in an unsaturated deep clay soil underlying a wastewater pond in a dairy farm located in a semi-arid region of Israel. The specific study locations included i) the centre of the flooded wastewater pond (the pond area), mainly matrix flow from waste pond; ii) the waste source banks (the edge of waste source), dominant preferential flow through desiccation cracks from rainwater and wastewater; and iii) the waste source margins, dominant preferential flow from rainwater. Vadose-zone monitoring systems were installed in these study locations for measurements of water content and temperature as well as for water sampling. Thermal gradients calculated from the measured temperature in desiccation cracks are direct evidence that thermally driven air convective flow induces evaporation in desiccation cracks. The paper presents detailed measurements of water content, salinization,

C6796

and isotopic concentration in the subsurface soil. A desiccation-crack-induced salinization (DCIS) conceptual model was developed based on the measured data to explain water flow mechanisms of evaporation and flushing around crack networks. The paper topic is suitable to HSS.

Specific Comments (1)

1. Introduction – 1<sup>st</sup> paragraph; The authors may want to reference selected works by Kodikara on the relationship between the onset of cracking and soil properties (see <http://www.eng.monash.edu.au/civil/research/centres/geomechanics/cracking/index.htm>)
2. Page 13157
  - (a) Line 15-20; Regions are generally defined as arid or semi-arid based on precipitation and evaporation. It would be useful to report evaporation data.
  - (b) Line 20; sentence appears a bit awkward and maybe could be rewritten for clarity
3. Page 13158
  - (a) Line 1-5; It was difficult to find a single summary of the author’s conceptual model which builds on literature review. Would be useful to have a clear summary of the conceptual model along with primary assumptions regarding physics/boundary conditions etc.
  - (b) Line 15-20; maybe helpful to not that it isn’t thermal gradients themselves but the density gradients created by the thermal regimes
4. Page 13159
  - (a) Section 2.1 – line 15-17; ‘phreatic’ aquifer . . . . Means ‘unconfined’ aquifer?

C6797

(b) Line 26 – what was significance of 'lactating' descriptor?

5. P. 13160

- (a) Line 5-10; is there a 'water balance' undertaken on storage pond?
- (b) Line 15-20; would be useful to know something about clay plasticity – are there Atterberg limits available for the clay?
- (c) Line 25-28; VMS ... not enough details .... And description seems a bit vague. For example; continuous measurements of chemical characteristics(?). Very broad statement.

6. P. 13161

- (a) Line 1-5; References provided for VMS but some description of system is required to help the reader understand the methods used to generate the data

7. P. 13162

- (a) Line 10-15; Is there a reference as to stable isotope analyses methods (e.g. how were sediment pore-water measurements made (vapour equilibration?); were there corrections made for interference from high salinity or presence of methane?)
- (b) Line 20-25; Were there any measurements made within the cracks of relative humidity? RH. Seems that more than temperature these measurements would help to validate the conceptual model.
- (c) P. 25-30; Lots of references to other work – but reader needs at least the basis on which the calculations were made.

8. P. 13163

C6798

- (a) Line 1-5; The description of the method of calculation of evaporation from the fractures is not clear – needs more clarity, specificity.
  - i. Also note that it is assumed that  $RH=100\%$  ... was it measured? Seems like a relatively straightforward measurement to make.

9. P. 13164

- (a) Line 15; not sure of the basis for the statement; 'representing an average of more than 50% of the total precipitation'

10. P. 13166

- (a) Line 1-5/Figure 5; Only background sites shown. Is there a difference in slope between background sites and sites close to storage. Is there any data for isotopic composition of storage pond waters? Would be helpful to plot some other locations against the LMWL
- (b) Line 10-15; Discussion seems a bit overly complex. The profiles below waste pond simply support a heavier signature from pond mixing vertically with 'normal' profile as defined by background site.
- (c) Line 25-30; Interference from CH<sub>4</sub>, H<sub>2</sub>S etc on stable isotopes. This was the question I noted previously. How did you ensure you were not getting problems with interference.

11. P. 13167

- (a) Line 13; Interesting question – if you do a 'mass balance' ... why would deeper profiles below waste pond return to 'background' isotopic profiles with depth unless leakage was very small relative to recharge from adjacent land area.

12. P. 13168

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- (a) Line 15-25; The CI profiles beg the question as to why the stable water isotopes return to background levels within a few meters while the CI profiles from waste pond extend to depth?

13. P. 13169

- (a) Line 15-20; The authors seem to suggest that the CI and stable water isotope data are in agreement – not sure they are entirely as noted in earlier comment.
- (b) Line 23; Focus seems to be on temperature (granted that this is a prerequisite condition) but the argument would be strengthened substantially if RH was also measured.

14. P. 13170

- (a) Line 1-5; Having a plot of the temperature-time relationships (air, and within cracks at various depths) would be useful.
- (b) Line 18; Sentence beginning 'Additionally. . . .' – not sure what this means.
- (c) Line 25-30; I would suggest that the authors' revisit this statement regarding 'small capillary gradients'. During evaporation from a soil surface the suction at the surface must be at the same 'energy' level as the air above (or beside) the surface. You can calculate that relationship using the Lord Kelvin equation. As RH values drop slightly below 100% RH the suctions rapidly exceed several thousand kPa.

15. P. 13171

- (a) Line 1-5; I think the conceptual model here might be modified. Not sure adding water 'enhances' the capillary gradient as much as it increases soils water storage within the matrix. The cycle and ability of the matrix to store

C6800

and release of water is likely central to degree to which this phenomena is developed.

- (b) P. 25-30; Was there any attempt to close a water balance using the CI and isotope profiles? Appears CI was used (Section 3.4) but what about stable water isotopes?

16. P. 13172

- (a) Line 25-28; 'higher water contents were in agreement with high infiltration rates'. Water content data alone cannot define water fluxes (or directions of water flow). Essential to also know suctions. Could the authors provide the water content – suction, and hydraulic conductivity – suction (or water content) relationships for the clay?

17. P. 13173

- (a) Line 1-5; If the authors provide the fundamental relationships (K, water content vs suction) then these flux ranges would be easier to evaluate by the reader.
- (b) Line 5-10; Need more details on this method.

18. P. 13174

- (a) Line 19; why sorptive contaminants?

Some specific comments (2)

1. The paper mainly focuses on desiccation cracks and their impact on subsurface salinization in vadose zone. Although the authors referred to the previous publication (Page 13160, Line 20-23, "the method in which the desiccation cracks

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were surveyed and their dimensions can be found in Baram et al., 2012a”), it is review’s opinion that it will help readers’ understanding if a summary of statistical data of desiccation cracks can be provided in the paper. These data should include cracks’ density, average aperture, depth, macro porosity, etc. Preferential flow and evaporation through cracks are dependent on enrichment of cracks. It is anticipated that desiccation cracks are different in the three study areas.

2. Fig 1 presents measured water content under waste source pond, waste pond banks, waste channel, and waste channel margins. It is easy to be understood that water content under waste channel margins is larger than that under waste channel due to desiccation cracks (hence evaporation) enrichment in the waste channel margins. However, water content under waste pond banks is less than that under waste pond. Is soil texture under waste pond banks is different from soil texture under waste pond or is it due to cracks effect on TDR in the waste pond banks area?
3. Fig 6 indicates that  $\text{Cl}^-$  concentration increases from under waste pond to waste pond banks, and to waste channel margins. This implies that desiccation-crack-induced evaporation increases from waste pond area to waste pond banks area, and to waste channel margins area. The developed DCIS conceptual model can be further improved to reflect these three zones characteristics including desiccation crack development, evaporation, water content, and salinization distributions. Also, the  $\text{Cl}^-$  concentration under the waste pond did not really reach to 8000 ppm according to measured  $\text{Cl}^-$  concentration presented in Fig 6.
4. Both “pore water” and “pore-water” are used in the paper. The use of “pore-water” should be consistent over the paper.
5. Fig 3 caption is a bit confused. (a)\* and (a) are both used. It should be re-organized.

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6. (e-f) in Fig 4 caption should be (e, f).
7. Fig 7 needs a legend to show depths of sensors for presented curves.
8. Page13164, Line13-14,  $\delta^{18}\text{O}$  -5 and  $\delta^2\text{H}$  -2should be  $\delta^{18}\text{O}$  -2 and  $\delta^2\text{H}$  -5according to Fig 4.
9. Page 13166, Line11, a reference is needed after statement of “Unlike isotopic enrichment that may be attributed to evaporation, isotopic depletion of a water source is usually attributed to mixture with a more depleted water source.”
10. Page 13167, Line 24, VSPs should be explained for its first use in the text, although it is explained in Table 1.
11. Page 13168, Line 10, [20] is extra and should be deleted.
12. Page 13173, Line3,  $9.7 \text{ m}^3 \text{ m}^{-3}$  should be  $0.097 \text{ m}^3 \text{ m}^{-3}$ .

(Recommendation:

It is recommended to accept the paper for publication after major revision.)

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 13155, 2012.

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