Hydrology and Earth System Sciences Discussions

Interactive comment on "Mass transfer effects in 2-D dual-permeability modeling of field preferential bromide leaching with drain effluent" *by* H. H. Gerke et al.

Anonymous Referee #2

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GENERAL COMMENTS

This manuscript analyzes and discusses the effects of diffusive mass transfer on Bromide transport within the soil. How mass transfer affects solute movement between soil domains, and therefore the overall solute response of fields and catchments, is a major problem; studies like this are needed to improve our understanding. The manuscript is generally well written although in some cases, especially in the results Section it lacks of clarity. I think this study can potentially provide an important contribution to the work that has already been done in the area and therefore be suitable for publication

in HESSD. However I have a couple major concerns that may strongly limit the results of this work. If am correct, this work might benefit from some further analysis as it will be explained in what follows. I would like the authors to carefully revise the manuscript to address these concerns.

SPECIFIC COMMENTS

Major concerns:

5931 Lines 23-28: I believe this a big limitation for the current study. The overall effect of mass-transfer coefficient is likely to be affected by the initial mass distribution between the two domains. I think that if a fraction of Bromide enters the soil in the PF domain, the model predictions shown in Fig. 6 would be rather different so if this assumption is not correct, the matching obtained with the different values of α_{ss} (Fig. 6) is biased, and the conclusions from page 5944 line 22 to page 5945 line 4 do not hold. In particular, the relatively high sensitivity to α_{ss} shown in Fig. 6 might not turn up that high if a fraction of Br enters the soil in the preferential flow domain. I suggest the evaluation a different scenario where the initial infiltration in the PF domain is larger than zero, this would strengthen the results.

5933 Lines 20-22: The results of this paper seem to be mostly based on mass flows at the drain outlet (rather than concentrations). For this reason I think that this overestimation of discharge may affect the results because mass fluxes are not directly measured but rather computed from concentration and discharge, so, if the model consistently overestimates the discharge, the comparison between observed and modeled mass flow will be affected by this overestimation. This is a major problem especially if the parameters were calibrated referring to the mass flow predictions, which is not clear from the manuscript and should be clarified. If so, calibrated parameters are likely to be affected by this inaccuracy of the hydraulic model because they have to make up for this consistent underestimation of the observed discharge. Also, could you clarify if the Nash and Sutcliffe coefficient is computed on the basis of instantaneous mass flow

values or instantaneous concentration values? In any case I would consider also some other efficiency indicator (e.g., the coefficient of determination) as there are known issues with the NS coefficient, for example this coefficient is affected by the variance of the data and just including a period with high variance will give a higher NS value. Anyway, given the high resolution of concentration measurements I do not see the necessity to use instantaneous mass fluxes and would rather consider concentrations and cumulated mass only. Moreover, as shown in Fig. 6 while the model seems to decently capture the mass fluxes, it does not capture the peak of concentration; this again is due to the fact that mass-fluxes are closely related to discharges, so why not just showing concentrations in Figure 6 and refer NS or other efficiency indexes to the concentration data?

Figure 11 and its comment on page 5937 are very interesting. I have the following questions/comments that should be clarified in the paper: It seems like the advective mass transfer is the dominant process in the overall transfer between PF and SM. Isn't this somehow in contrast with what stated at page 5929 lines 17-18 and 21-23? Moreover, if advective mass transfer is the dominant component, I believe that a change in α_{ws} (which is assumed constant in the analysis) would determine very different response of the model; this is because the diffusive mass transfer is driven by the gradient of concentrations between the two domains and concentrations are also affected by the advective mass transfer. Therefore for different values of α_{ws} the results obtained in this study on the sensitivity to α_{ss} can potentially be very different. This should be at least thoroughly discussed but I think results would definitely benefit from considering also a scenario with a different α_{ws}. Finally I would also plot the total (advective+diffusive) mass transfer curves, this also helps visualizing the statements on page 5937 (lines 10-11 and 14-16).

Other comments:

The introduction is detailed and generally well written; however I believe that, while talking extensively about the dual-domain modeling approach, it lacks of a general

discussion on the (many) studies that have already been published on the problem of mass transfer between the soil domains, which is the main topic of the paper. Some of these studies are reported in Section 4.3 but I believe that they (or even others) should be also acknowledged and discussed in the introduction.

5928 Line 5: "... imitating a reduction ..." does not sound right. What does this mean anyway? I also do not understand the frequent use of "reduced mass transfer" throughout the manuscript. Is it reduced with respect to what?

5928 Line 17-18: This sounds like a very important result for the present study. Is it something already published or a sensitivity analysis that was done by the authors for this paper? If it does not refer to previous studies I would discuss it a bit more.

5928 Line 20-21: According to Equation 2 the inter domain-water transfer depends to K_a, which is a function of the conductivities and the pressure in both the domains. So maybe stating that the saturated hydraulic conductivity in the soil matrix is low is not enough to claim a low inter-domain water transfer. Could you better justify this statement? Anyway, the aim of this sentence is apparently to justify the fact that you are only considering the effect of α_{ss}, so it should probably be moved after line 18.

5931 Lines 15-18: Does the Bromide mass infiltrate during the redistribution of ponding water at the end of the first irrigation period? It does not seem so from Figure 3, although this ponding water is likely to carry a high concentration of Bromide given the long contact time with the solute. Could this be the reason why the model is never able to capture the highest peak of concentration?

5945 Lines 13-15 I do not see justification for this throughout the test. Was the same analysis done using the 1-D model? If so the differences/similarities in the results should be made more explicit as I believe they are very interesting. Was there a reason to use the 2-D model instead of the 1-D? Also, could you please clarify the sentence "but more complex for the plot-scale and still significant at the field-scale." and specify to which part of the study it refers to?

TECHNICAL CORRECTIONS

5917 Line 8: Why is diffusive between quotation marks? Quotation marks for words like "diffusive" and "advective" are also used throughout the manuscript. I would avoid the use of quotation marks without a specific reason.

5917 Lines 9-10: "Flow and transport is simulated in a 2-D vertical cross section using parameters and boundary conditions..." The fact that you use parameters and boundary conditions is quite obvious. I would just say that results from a 2-D model are compared with data of Br tracer experiment etc.

5920 Lines 14-15: "It is likely to assume that ..." does not make much sense.

5920 Line 29 and 5921 Line 1: This sentence is not clear.

5921 Lines 2-6: This sentence should be rephrased and maybe divided into two sentences.

Equations 1 through 7b: It would be clearer if the time dependencies were specified.

5926 Line 17: I do not see where θ_a and θ_{as} are defined. Please define.

5931 Line 9: Again, why using the quotation marks? I would rather be more specific.

5931 Lines 14-15: Could you please state more in detail how the concentration of application was calculated? It is not enough to say "using the cumulative infiltration flux and the total applied Br mass".

5931 Line 20: I do not think "largely proportional" is correct, something is either proportional or not. Maybe you should say "strongly related".

5931 Line 21: "Imposing these conditions is based on..." does not sound right to me. Maybe saying "this condition is based on" is better, or something along those lines.

5931 Line 27: please explain what "allows for a more contrasting analysis" mean. This is not clear right now. Also, what is "mass transfer reduction"?

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5932 Line 25: "integrating" is more of a mathematical term. How about up-scaling?

5933 Line 20: Please explain "similar". They do not seem similar to me.

5934 Line12: "Time series".

5935 Line 29: "Positive rates or increasing cumulative values, indicating water transfer from the PF to the SM domain..." Is this correct? What are positive rates? I would only say "increasing cumulative values" as even if there are positive values in the plot there is still transfer from SM to PF when the curve is decreasing.

5936 Line 1: "reflect" instead of "are reflecting"?

5936 Lines 1-2 "During distribution.." is not a "situation", should be rephrased.

5936 Line 5: without irrigation the cumulative water transfer is always negative! I think you mean that the trend is first decreasing and then increasing. If so pleas rephrase.

5936 Lines 8-9: It seems to me that the water transfer reverses after the end of rain even in the scenario without irrigation.

5936 Lines 9-10: the sentence "the water transfer direction reverses after the end of the rain (after Day 100) as long as the PF domain pressure head increased" is not clear.

Please consider rewriting all the description of Figure 9 it is very unclear and there are many inaccuracies. Also in Figure 9 it is confusing that the grey curve represents the scenario without irrigation and the irrigation is represented in gray too, maybe switching the colors of the curves would be better.

5937 Line 4: the second Fig. reference should be Fig. 9?

5938 Line 21-25: Could you please specify? Right now I don't see how you can say that "the differences in the effluent curves ... are attributed almost entirely to the diffusive component", since in Fig. 7 you are only considering a variation in the diffusive

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coefficient α_{ss}. Maybe I am missing something.

5939 Lines 5-6: please explain what a "preferential flow event is"

5940 Line 27: "characterize" instead of "are characterizing"

5941 Line 4 "change" instead of "is changing"

Section 4.3 Maybe this section can be embedded in Section 4.1.

5945 Lines 20-22: What does this sentence mean?

Table 3: Please specify in the caption whether NS refers to mass flows or concentrations.

Fig. 3: If possible I would merge Figure 3a and 3b, maybe using two different y-axes. Fig. 3b is mostly white so it seems like a waste of space.

Fig. 4 caption: last line, I think there is one extra "without" or I do not understand the sentence.

Fig. 5: it is not clear what the legend in the upper part of the figure refers to.

Figure 9 and 11: the labels "Negative: SM->PF" and "Positive: PF->SM" are somehow misleading, since you are plotting cumulated values you can have SM->PF even for positive values and vice-versa. It should rather be "Negative slope" or "Negative trend".

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