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Hydrology and Earth System Sciences Discussions

Interactive comment on "Meta-analysis of the effects of soil properties, site factors and experimental conditions on preferential solute transport" *by* J. K. Koestel et al.

Anonymous Referee #1

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This paper presents a comprehensive collection of data derived from the transport experiments that were published in the literature. Such a compilation of information is essential to obtain a general understanding of transport processes in soils and the parameters and properties that control these processes. In contrast to previous studies, this study focuses on parameters that quantify preferential transport. I consider this study as highly relevant and would recommend its publication. However, I have a few major comments. First, I think that the authors should define what is actually meant by 'preferential transport'. That is, when is transport considered to be preferential and when is it not? What is for instance the difference between preferential transport and

heterogeneous transport? Is transport with a high apparent dispersivity but perfectly described by a CDE preferential or not? Second, it should be made clear why the parameters such as the p0.05 and the holdback factor are good measures for preferential transport and which typical characteristics they measure which are not captured by another often used parameter: the apparent dispersivity. Being very critical, one could question whether the p0.05 and the holdback factor are characteristics that are suited to quantify preferential transport. The dataset illustrates that they are both strongly correlated with the apparent dispersivity so that I wonder about their additional value. I would propose another characteristic: a normalised p0.05, normalized by the standard deviation of the (normalized) travel time, as a characteristic that contains additional information about the transport process, which is not captured by the apparent dispersivity. I suspect that this characteristic returns the same value independent of the apparent dispersivity length and the transport distance when the breakthrough can be described by a CDE model. Deviations of this CDE 'value' would then be a measure of anomalous transport. Third, when analyzing certain effects of certain parameters (e.g. transport distance, flow rate, texture, . . .) on the preferential flow characteristics, it should be avoided that observed effect is not due to other parameters that vary together with the parameter of which the effect is investigated. For instance, I suspect that the flow rate effect is also linked with the transport distance effect since I do not expect that high flow rates could be achieved easily in long soil column. The flow rate effect might also be linked to texture since high flow rates are more difficult to obtain in fine textured soils.

Detailed comments: p 10011 I agree with the authors that it comparability can be improved if only flux concentrations are used. Comparing results from resident concentrations with results from flux concentrations always requires a certain concept of the transport process. A drawback of focussing on flux concentrations is that flux concentrations can hardly be measured in field experiments.

p 10012: I am critical of using results from measurements in tile drains. The largest part of the transport direction towards tile drains is horizontal whereas the vertical part of the trajectory through the soil is small. Therefore, breakthrough curves measured in tile drains lump transport in the soil with transport in the aquifer or perched groundwater layer on top of the confining layer. A paper by Radcliffe et al. (1996) illustrates the effect of this lateral transport on breakthrough curves measured in tile drains (Radcliffe, D.E., P.M. Tillotson, P.F. Hendrix, L.T. West, J.E. Box, and E.W. Tollner. 1996. Anion transport in a Piedmont Ultisol: I. Fieldscale parameters. Soil Sci. Soc. Am. J. 60:755–761.). I think that the results from experiments in tile drained fields should be treated with care and flagged in the dataset. After reading the paper completely, I noticed that this was the only tile drained study included in the dataset.

p 10012: Using the studies for which only CDE parameters were available could be critical. It could be the case that the CDE in these studies did not fit the data as well as the MIM would have fitted the data. If this is the case, then this would lead to a bias in the derived preferential flow indicators for this part of the dataset.

p10015, Eq. 9: The cumulative pdf, Fn should be a function of T, where T should be the upper limit of the integral in equation 9. For T is infinity, Fn =1.

p10015: p0.05 is said to be negatively correlated with the degree of preferential transport. But how is the ‘degree of preferential transport’ defined. Transport with a high degree of dispersion would also lead to small p0.05 since p0.05 is negatively correlated with the dispersion coefficient. Is this also considered as ‘preferential transport’? I would rather propose to use (1-p0.05) that is normalized by the standard deviation of the arrival times.

p10015: Again, a large H may also be due to a large heterogeneity in the transport.

p10015: What is meant by BTC-deconvolution? Calculation of H requires an integration of the BTC followed by an integration of the cumulative BTC. How is this related to a ‘deconvolution’?

p10015: I think there is no place for belief in a scientific paper.

p10016: The apparent dispersivity is said to be an indicator of the heterogeneity of the transport process. But what is fundamentally different from the measures p0.05 and H which are in fact also indicators of heterogeneous transport? It would be interesting to see what is the variation of p0.05 and H that are derived from CDE predicted BTCs using the apparent dispersvitiy. I am pretty sure that this variation will cover a large part of the variation of the H and p.005 that are derived from the MIM fits. From this point of view, one could equally well say that the p.005 and H are rather measures of transport heterogeneity. I think that this reflects the problem of not clearly defining what is meant by ‘preferential transport’ and how it differs from ‘heterogeneous transport’.

p10016: the authors should clarify why the apparent dispersivity is less robust to BTC-deconvolution. They should also explain what is meant by ‘BTC-deconvolution’.

p10018: ‘two of the three investigated indicators for preferential transport were strongly negatively correlated. ‘ Why is only this correlation mentioned? There is also a strong correlation of these indicators with the apparent dispersivity.

p10020: ‘For a given apparent dispersivity, p0.05 increases with column length. This suggests that the strength of the preferential transport decreases with travel distance’ p0.05 will be constant with travel distance when the coefficient of variation of the travel time remains constant with travel distance. This is the case for a stochastic convective transport process, i.e. when the apparent dispersivity increases linearly with travel distance. For a convective dispersive transport, the coefficient of variation of the travel time will decrease with travel distance, which would correspond with a decrease in p0.05 with travel distance. I think an interpretation of the behaviour of p0.05 in these terms could give an understanding of its dependence on travel distance. It could also be helpful to define what is actually meant by ‘preferential transport’.

p10020: ‘Figure 7a–c shows that not only the medians of v and apparent dispersivity monotonously increase with the respective water flux class but also the strength of preferential transport (there is negative relationship between p0.05 and q).' The fact that the apparent dispersivity increases with flow rate, isn't that also a sign of preferential transport? I do not understand why the strength of preferential transport is only measured against p0.05. The increase of the apparent dispersivity with increasing flow rate is automatically related with a decrease in p0.05 with increasing flow rate, as long as the same column lengths are used for the high and low flow experiments. However, I would expect that the high flow rate experiments were mostly carried out in small cores whereas in the longer cores, experiments are mostly carried under lower flow rates. Therefore, the increase of p0.05 with decreasing flow rate could also be due to the fact that the length scale of the experiments increased with decreasing flow rate.

p10021: I would propose to replace Figure 8 by box plots (similar as Figure 7). Form figure 8, I cannot derive that samples containing both top and subsoil have higher apparent dispersivities and lower p0.05 than samples from the top or subsoil only. This will become clearer in a box-plot.

p10021: Also to illustrate the effect of texture, box plots might be better.

p10022: If Figure 10 illustrates the effect of texture clearer than figure 9, couldn't figure 9 be skipped then?

p1024: 'Anionic tracers exhibited larger apparent dispersivities than neutral tracers.' Were experimental conditions: soil types, flow rates, column lengths similar between the experiments that were carried out using the different tracers or could this also explain the differences?

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 10007, 2011.