

## ***Interactive comment on* “Experimental study of fingered flow through initially dry sand” by F. Rezanezhad et al.**

### **Anonymous Referee #2**

Received and published: 31 October 2006

#### General comments.

The manuscript presents experimental results for infiltration into a 2-D chamber of initially dry sand. The purpose was to investigate the formation of fingers. The content of the manuscript is relevant or appropriate for the J. Hydrol. Earth Syst. Sci. The experimental results presented are very much similar to experiments that have been presented by others. The differences between the experiments reported in this manuscript and those reported elsewhere are:

1. Applied a filter to the acquired light transmission data to sharpen up the resulting distributions of water saturation.

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2. Ran an experiment with a layered medium (in one case). This was also done by Sililo and Tellam (2000) but without the light transmission measurement.

3. Did not measure soil water potential.

4. Identified a local minimum in the water saturation right behind the saturation overshoot. This had not been reported by any other investigators.

If there were no shortcomings in the results interpretation there would be enough difference in the content presented and previous work to justify the publication of the manuscript. However, while the manuscript presents a lot of interesting results, after sufficient contemplation of the results the outcome seems to be shallow (that is, the results are not really that new).

As a result I would judge that in the present form the manuscript does not qualify for publication. It could be improved, because the experimental data appears to be substantial. Improvement will require significant revision of the manuscript.

Specific scientific questions/issues.

A. First I will consider the conclusions of the study as these point to the main shortcomings of the manuscript. I comment on the conclusions as they are listed.

1. Fingers in coarse textured sand are destroyed by finer textured inhomogeneities.

The authors do not reference the study by Sililo and Tellam (2000) where a similar experiment without light transmission was performed but with contrasting conclusions regarding the effect of the layer. I am not claiming that Sililo and Tellam (2000) is correct, but the authors should review the article and explain why the results from the two studies contradict each other.

Sililo, O.T.N. and J.H. Tellam, 2000. Fingering in unsaturated flow zone: a qualitative review with laboratory experiments on heterogeneous systems, *Ground Water*, 38:864-871.

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## 2. Experiments confirmed previously observed saturation overshoot.

Confirmation is a fine result to report, but in this case it should not be the main point of the study.

## 3. Found a minimum in saturation right behind the saturation overshoot.

This is clearly shown in the experimental data. One could argue that this was not seen in previous experiments using light transmission because those other studies did not use the data filter. Bauters et al. (1998) used x-ray measurements at a 5 mm resolution to measure moisture content as a finger passed a point in the chamber. In Figure 7a of that article one can see a slight drop in saturation below the quasi-stable condition. But that drop might be attributed to experimental error. Or it might be real. The drop in saturation shown by the authors if the present manuscript is much larger, and therefore an explanation of the phenomenon is needed. However, they do not provide a plausible explanation for how this minimum might occur. They do claim to explain the process in the text and with Figure 10, however, that figure does not show the local minimum. So what is the cause of this minimum? The description of the mechanism for this minimum is missing.

Bauters, T.W.J., DiCarlo, D.A., Steenhuis, T.S., Parlange, J.-Y., 1998. Preferential flow in water repellent sands. *Soil Sci. Soc. Am. J.* 62, 1185-1190.

From a mathematical point of view I think that this minimum would not be allowed if we assume that the Richards equation applies behind the finger tip. While the Richards equation is not accepted for describing the flow over the whole domain, it seems to be (maybe) that it does apply in the regions behind the tip. If that is the case, then the minimum should not occur. Essentially, the lateral flow that occurs at the tip and just behind the tip will affect the rate at which the saturation behind the tip approaches the quasi-steady saturation, but the saturation should not drop below this value of quasi-steady saturation. The results given by DiCarlo (2004) do not show this to occur. Of course his were for 1-D flow, while yours are for 2-D flow. But the freedom to move

laterally should affect only the rate of drop of saturation from the tip, and should not lead to a minimum just behind the tip and then a rise again.

4. The width of fingers continues to increase until the saturation in the core reaches a quasi-steady state.

Again, this is confirmation of work done in previous studies.

5. The water flow in the core is rapid and convective while the flow in the fringe is slow and diffusive.

This also is a confirmation of work done in previous studies, by Liu et al. (1994) for instance.

B. Other points.

1. The authors did not measure soil water potential and yet they refer to positive pressures in the abstract, and also describe the phenomenon of fingering and finger persistent by using both water content and water pressure as variables. Not having measured the pressure the authors should not describe the phenomenon of fingering as if they have the data to describe the phenomenon completely. In section 3.3 they give an explanation that was essentially presented by Glass et al. (1989b) and Nieber (1996). The only new ideas here are that they include the effect of the flow velocity and capillarity. The explanation presented falls short of explaining the minimum behind tip and the subsequent rise to the quasi-steady saturation.

2. I hope that my criticism is taken to be constructive (it might sound like it is not). The main feature of the present study is the filter correction of the light transmission data, and the local minimum in saturation behind the tip. This local minimum has not been reported by other investigators. This fact does not mean that the phenomenon does not exist, because the authors show this clearly from the data. But one needs to wonder about the existence of the phenomenon when a plausible explanation for its occurrence is not presented. Also, maybe the authors should show some result using

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the unfiltered data. Do you still see the saturation minimum behind the tip when you use the unfiltered data? Or is the 'discovery' of this minimum the result of filtering the data.

Technical corrections.

Page 2596.

Line 2. The word should be 'unstable' rather than 'instable'.

Line 4. Again use 'unstable'.

Line 12. The chamber was rectangular and relatively narrow in thickness. So I think that the growth of a finger will not be 'radial' but rather 'lateral'.

Line 19. Change 'by' to 'be'.

Line 20. You refer to positive pressures, but you did not measure pressures in your experiment. So how do you know the pressures were positive?

Page 2597.

Line 1. Delete 'of' before 'oil'.

Line 9. Use different words than 'made' and 'making'. Seems too redundant in phrasing.

Page 2598.

Line 7. Replace 'newer' by 'of the recent'.

Line 18. It should be 'hysteresis' rather than 'hysteretic'.

Line 24. Add '(0.3 cm)' between 'apart' and 'and'.

Page 2599.

Line 2. What do you mean 'mechanical stability' of the chamber?

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Lines 5-8. This is not clear. Need to rewrite it.

Line 13. Change 'to' to 'for'.

Page 2600.

Line 6. Put 'the' after 'using'.

Line 8. Change 'visualization of' to 'visualize'. Put 'the' after 'at'.

Line 10. Change 'sequences' to 'sequential'.

Line 13. Insert 'the' before 'fine'

Line 14. Insert ',' after sand

Line 18. Insert 'and' before Tidwell.

Line 20. Insert 'an' after 'in'

Line 21. Insert 'the' before 'dynamics'

Page 2601.

Line 19. You use 'd' for the cell thickness, but you previously used 'd' for the characteristic particle size for the Bond number.

Page 2602.

Line 4. Insert 'the' before 'LTM'

Page 2603.

Line 9. Delete 'a' before 'light'

Line 11. You say the PSF is constant. Is this constant over the entire domain even for the case of heterogeneous media?

Line 16. You refer to measuring an 'important aspect'. It is not clear what you refer

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to here. I think you do not measure and aspect, but you measure something that is important to you. Need to specify what the important thing is you want to measure.

Line 22. What do you mean, 'outside' the slits?

Page 2604.

Line 1. Insert 'a' after 'Using'

Line 11. The sentence 'This is supported by the x-ray results' seems to be redundant.

Line 12,13. Maybe explain briefly what the technical reasons for the technical reasons for the time lag.

Page 2606.

Line 1. Delete 'of' before 'the tip'

Line 4. Insert 'from' after 'distance'

Line 5. Delete 'at larger distance'

Line 7. Delete 'additional'. There is a lateral gradient, but not an additional one.

Line 9. Replace 'to' with 'from'

Page 2607.

Lines 18. Replace 'radially' with 'laterally'.

Lines 22, 27. Replace 'radial' with 'lateral'

Page 2608.

Line 5. Replace 'instable' with 'unstable'

Line 20. Replace 'by' with 'be'

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 3, 2595, 2006.

S1315

**HESSD**

3, S1309–S1315, 2006

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