

Interactive comment on “Preferential Flow Systems Amended with Biogeochemical Components: Imaging of a Two-Dimensional Study” by Ashley R. Pales et al.

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Received and published: 28 August 2017

General comments:

The work is very interesting, relevant, and contributes to our need for a more complete understanding of how the complex soil physics and biochemistry of the soil zone impacts vadose zone processes. The technical work appears to be very well performed and no concerns are raised. The comments below are all associated with the communication of the work and how it fits into present day understanding and existing literature. A few suggestions are made for additional calculations, figures and tables.

C1

Overview comments

1. The paper could be shortened. The introduction and background is too extensive. Unless there is an intent of making this paper a review paper on preferential flow, the introduction should be limited to a brief note of the importance of preferential flow and then be focused on the specific background that is relevant to this study, which is the effect of fluid properties on finger flow development, stability, and the presence of different solutes in the rhizosphere.
2. The Bond number is calculated but its relevance is never discussed in the Background or Discussion sections.
3. There is too much emphasis on the statistics of the contact angle and surface tension. The number of figures and the discussion can be reduced. This work is about how these two parameters affect finger flow development, and does not attempt to characterize the relationship between interfacial properties and concentration for different solutions. The information on contact angle, surface tension, fluid densities, Bond number, etc. can be captured in a table summarizing fluid properties (I realize that this is in separate tables at present), eliminating the need for figures 6 and 8. The graphs showing time dependent values of contact angle and surface tension are useful.
4. The discussion on finger geometry (or morphology), saturation overshoot, finger width and moisture content distribution needs some improvement. For example, (A) Finger properties are compared to contact angle values and solution concentrations, but a more complete analysis would be to compare finger geometry to capillary pressure at the wetting front. This may solve the problem that tannic acid (whose contact angle does not change with concentration) contradicts the apparent general result. (B) A graph of finger properties with capillary pressure (using the Young-Laplace equation) which takes both contact angle and surface tension into account would rapidly demonstrate in a visual fashion any trends seen.
5. The technical work, results and data are valuable but the discussion and conclusions

C2

are weak. Some of the concepts associated with capillarity and sorptivity and miss-stated.

6. Equation 2 is noted in the Discussion section but not used in the work. Should this equation be moved to the background section? Can it be used to compare observations with predictions? 7. Significant editorial work is necessary before it is ready for publication or public review. A few editorial comments are noted below but the focus of this review is on the technical content.

SPECIFIC COMMENTS

Abstract

1. Line 27. Should 'processes' be 'properties'?
2. Line 28. Change to "...the control with a contact angle of 64.5 deg, and a surface tension of 75.75 N/m..." There are three problems with the sentence as is: (1) You have not defined the symbol 'theta' as a contact angle yet. (2) even if you had defined it, "64.5 " is not traditionally how it is written but rather it is written " = 64.5". Same changes required on line 29. (3) I thought surface tension units were N/m, not Nm/m.
3. Line 29: "changes" should be "differences". The last sentence is not a complete sentence. Page 2
4. Line 7: change 'element of' to 'contributes to'
5. Line 9: change 'especially' to 'by controlling' and add 'supporting prior to vegetation.'
6. Line 10: sentence starting with 'consequently', needs to be move to the end of this paragraph. As is, 'consequently' is the incorrect word because the previous statement discusses the existence of water and life at the land atmosphere interface, not groundwater issues. You need to add the logical linkage, that in addition to controlling soil moisture and plant life, soil controls deep drainage of infiltrated water, its rate and quality.

C3

Page 3

1. Line 22: 'without' should be 'with'
2. Line 23: change 'instance' to 'interaction'
3. Line 25:
4. The soil hydraulic properties (aka, permeability) and the moisture content are properties that 'set the conditions but the instability is caused by the interplay between the two forces, capillarity and gravity.

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5. Line 2: "thus" insinuates that the fact that there are two forces leads to instability. IN reality, both stable and unstable regimes are affected by both gravity and capillary forces. It is when the forces are of nearly equal but opposite in magnitude, that small irregularities, such as small heterogeneities (which are inevitable, even in a practically homogeneous media) will lead to the condition where gravity dominates, at that point the wetting front breakthrough will occur and a finger will begin to form. Re-reading the glass papers may clarify this point. All instability conditions require a trigger to progress into the next favorable stage.
6. The next two paragraphs (starting with 'The non-linearity', and 'In addition)are too extensive since this paper does not discuss how any of the work will affect or change the present understanding of the mathematical or numerical work. I think the authors could move directly from the points made in the first paragraph of page 4, to the fact that change in contact angle will control capillarity and therefore the propensity for instability. Then mention the relevant work associated with this issue, such as the repellency work, etc.

Page 5.

7. The paragraph starting with 'The vadose zone...' I do not think the vadose zone

C4

needs to be defined here, again. The instability you are studying is occurring due to plant and soil solutes, so the soil zone is what is relevant.

Page 6

8. The paragraph starting with 'The plant root . . .' is interesting but not relevant to this paper. The change in repellency caused by the dehydration of the mucilage is a change in the properties of the solid, not the solute. This paper focuses on the properties of solutes.

Page 7

9. The paragraph starting with "Indeed" is not necessary. While noting good examples of serious groundwater contamination, these may not be relevant to development of unstable finger flow issues, nor are these associated with plant exudates. In addition, the two examples given, while associated with preferential flow, they are more closely related to fracture flow than unstable finger flow. More relevant to finger flow instability through soil media are agricultural contaminants.

Page 8

10. Line 10: regarding the word monitored. The dynamics were not monitored via surface tension or contact angle. The dynamics were monitored via visualization. The fluid properties were quantified by measuring contact angle and surface tension. 11. Line 25: what is the relevance of a hydroponic system? 12. Line 25: why was NaCl+HNS rather than DI water used as a control? Not suggesting it's wrong, but should explain the rationale.

Page 11

13. Materials and methods: you state that statistics were performed on the contact angle and surface tension measurements, but there was no mention of how many reps were done.

C5

14. Line 9-14: It is unclear to me how the calibration was performed. How did you measure the moisture content for the different intensities? Or did you preset the moisture content and then measure the intensities? Also, I did not understand the comment about the 80%.

15. Line 18: what does it mean that the 0% and 100% intensity values "were found"? Did you look for locations where you had 100% and 0% and measure the moisture content there?

16. Line 22: describe the packing device? Was the sand poured in? How did you avoid horizontal layering of sand during packing?

Page 12

17. Line 14: the "flow velocity" is the velocity of what? The fluid in the peristaltic pump line, or the raindrop speed, or the surface area averaged input flux rate?

18. Line 29: dynamic contact angle: the term "dynamic" contact angle is usually associated with the dependence of the contact angle on interface velocity, or in a larger scale the wetting front velocity, but fig 5 it is graphed per unit time, so is this the time-dependent contact angle or the dynamic contact angle?

Page 13

19. Line 9: delete the extra "for"

20. You report contact angle values through time up to 90 seconds, and discuss in detail how much these angles have changed over time. But, you do not discuss the significance of these changes to the dynamics of the finger flow system.

21. Line 19: is this "dynamic" or "time dependent"?

22. Line 22: add "over time" following the word 'tension'

23. Line 23 and 24: the word "changes" should be "differences"

C6

24. Line 26: delete the word 'respectively'

25. Line 28: sentence needs clarifying that the 'groups' are of surface tension values.

Page 14

26. Line 9-11: since none of your graphs or images use the terms "plant constituents" or "soil constituents" you should either include their proper names in parenthesis to help the reader.

27. Lines 13-26: can this be put into a table format?

Page 15

28. Lines 1-19: It may help to illustrate the differences if the data was grouped according to contact angle, surface tension or Bond Number groups rather than chemistry, since it is those properties that should control finger formation.

29. Line 21-31: can this information be displayed in graphical form? The changes in finger saturation cross-section are interesting. Again, it would be interesting to see if there is a grouping according to chemistry concentration, or interfacial properties.

Page 16:

31. Line 27: you mention the intrinsic sorptivity but there is no linkage to the relevancy of this statement to the work presented here. It is true that the intrinsic sorptivity is independent of fluid properties because it is a normalized property.

32. What is the relevancy of Equation 2. It was not used in the work? It would be valuable to see how the predictions based on this equation compare to the observations.

Page 17

33. Top paragraph needs to be improved for clarity. The statement "reduction in sorptivity" and "decrease in contact angle" suggests that it was reduced from some earlier value. But in truth the reason there is overshoot is that the sorptivity at the front is lower

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than the hydraulic conductivity of the media above it. At the wetting front the advancing contact angle is greater, and therefore the sum of capillary and gravitational forces results in lower rate of forward motion. The pressure overshoot is simply associated with hydraulic pressure of water building up above the (way too slow) wetting front. It is also very likely that what is being seen at the front is the 'dynamic contact angle' which is a contact angle that is even greater than the static contact angle measured at 90 sec mark. The dynamic effect is caused by a competition between inertia, motion below the interface, the flexibility of the interface and the movement (stickiness) of the triple line. The contact angle changes in value with the speed of the wetting front. While it may be valuable to measure the dynamic contact angle of these substances, it is not an easy measurement to take. However, you may be able to obtain it from data you already have since there are a few theoretical relationships that can approximate the value of the dynamic contact angle based on the Capillary Number, the static contact angle and the velocity. There is a relationship between the Capillary Number and the Bond Number.

34. Line 11: why would the contact angle be close to zero during the initial stages?

35. Lines 14-16: This sentence is confusing. The way it's written, the first half appears to contradict the second half.

Page 18

36. Line 1: use "differs" instead of "changes"

37. Line 2: change "simulated . . . concentrations" to "solution chemistry and concentration."

38. Line 4-5: The sentence is unclear. Also, you note a relationship between finger morphology and matric potential of the media. Did you measure the matric potential?

39. First paragraph: There is quite a bit of repetition with two previous paragraphs where the overshoot mechanisms are also described.

C8

40. Line 13: What is meant by “wettability changes in the flow patterns”, do you mean how the wettability changes the flow pattern? Or that the wettability is changing within the flow pattern?

41. Line 16: what is meant by “present themselves as” do you mean “result in” ?

42. Line 21, add “(except for Tannic acid)” following the word ‘angles’

43. Line 22: by ‘prevalent’ do you mean ‘greater’?

44. Line 22-24: I think that the comparison needs to be made between finger geometry and capillary potential (using Young-Laplace eq), not individually with contact angle. The reason for this is that you will note that tannic acid did not show a difference in contact angle between low and high concentrations, but it did show a large difference in surface tension, and in finger geometry. The capillary pressure calculation would capture that difference. This applies through line 27 in this paragraph.

Page 19

45. Line 1: Describe the behavior observed by Bashir etc., so that the reader does not have to go to that citation to understand what is being discussed.

46. Line 5: the media’s hydraulic properties do not change, it is the fluid’s properties that are changing.

47. Line 12: I do not follow how the research presented in this paper is relevant to a discussion associated with the apparent repellency effect of dry mucilage. The study is of a wetting experiment onto dry mineral base (not organics), with a well saturated organic in solution.

48. Line 13-21: Section needs restructuring. What is being said is unclear. Wrong words are being modified, and some of the thoughts are incomplete.

49. Paragraph starting on line 23 needs sharpening. (A) Line 23-25: sentence needs restructuring. (B) Line 26: mucilage is a type of root exudate. (C) Line 27: what is

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meant by “stabilizing”? mucilage does act as a glue, and it does create interstitial spaces but it also absorbs water by osmotic processes.

Page 20

50. Line 16: change ‘special’ to ‘spatial’

51. Line 26-27: change “both. . .constituent” to “solution chemistry and concentration”. Change “when compared to the control” to “and the resulting infiltration profile”

52. Line 28: No changes in what?

Page 21

53. Line 2: What is meant by “more normalized”

54. Line 7: delete “or anything”, this paper is focused on fluids.

55. Line 8: do you mean efficiency or effectiveness?

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2017-486>, 2017.