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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Soil–aquifer phenomena affecting groundwater under vertisols: a review" *by* D. Kurtzman et al.

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Response to comments made by Anonymous Referee #2 (Authors answers follow the referee comments)

1) This paper reviews published research related to several aspects of water and solute transport to aquifers overlain by vertisols. Four main sections cover the topics of preferential flow through shrinkage cracks, processes of salinity enhancement at depth in vertisols, effects of cultivation on the flushing of salts to the aquifer under vertisols, and properties of vertisols that inhibit the transport of nitrate to the aquifer. This is a broad range of subject matter, important for agriculture, contaminant hydrology, and understanding of unsaturated zone processes. The literature selected for inclu-

sion is pertinent to these subjects, and the organization is appropriate. The reasoning is sound, and the material is presented in an easy-to-understand way. However, the manuscript needs further development and revision before publication in HESS.

1) We thank the referee for the good and positive summary of the study.

2) The paper does not follow a typical pattern of scientific journal articles. As a review, it is not very comprehensive. The articles cited represent a smaller portion of the relevant literature, and their contributions are not presented in as much detail, as normally expected for a review article. For example, a quick literature search on one of the subtopics, related to salinization, turned up at least three works that were not included but possibly worthwhile (Adams and Hanks, 1964; Rhoades et al., 1997; Ben-Hur and Assouline, 2002).

2) We agree with the referee the paper reads in some ways more as a critical review than as a comprehensive review and we prefer not to define it as either in the title. As the reviewer acknowledged in comment # 1" the material is presented in an easy-to-understand way" which is the rational that led to the structure and also dictated a not-to long manuscript. The 4 subjects structure lead in some cases to a situation in which a citation of a work reflects the contribution of that work to the section's subject and significant parts of that work will not be mentioned. This is perhaps what gives the referee the feeling that some citations' contributions are not presented in as much detail, as normally expected for a review article. For example Hardie et al., 2011 are cited for their observation that more than 94% of matrix in the vertic horizon was bypassed due to preferential flow and transport in the dye experiment rather than the comparison preferential flow at wet versus dry conditions which is in the focus of that study. This is done, in section 2.2 to bring a relatively high number of works that report the bypass flow in tracer experiments in a relatively short writing that builds up the referees acknowledgment: "The reasoning is sound, and the material is presented in an easy-to-understand way". Going into a more detailed report of every reference would have weakened the review overlook which is in this case: Many evidence of bypass trans-

port in vertisols including tracer tests, and observation of different types of contaminant transport. We thank the referee for pointing out more relevant works, and we are sure there are many more. The citations are biased towards works from the hydrological arena and literature because it is a study in hydrology. Whereas relevant agronomical, land-conservation studies, like those suggested by the referee were missed. This is partly due to the main search combinations which included the soil type and a hydrological term: e.g. (Vertisol or vertosol or cracking clay) and (groundwater or aquifer or recharge or preferential). Nevertheless the referee's citations contribute to the review and were included (lines 128-132; 282-289).

3) The authors define and limit the scope of the review, especially in lines 15-21. A limited scope is necessary for a broad and much-studied subject as the hydrology of vertisols. However, even with the four chosen subtopics, the treatment here is less complete and less fully developed than is needed for a major hydrologic journal. It should be extensively augmented, perhaps with a further-reduced topical scope, to be a good review article in HESS.

3) We disagree with the referee suggestion to reduce the topical scope and to augment on a narrower range of phenomenon. This review concerns only soil-aquifer phenomenon and it does not aim to be a general view on the hydrology of vertisols: topics like surface run off and erosion are not discussed, nor details of classical porous medium characteristics of these clays (e.g. hydraulic functions). Phenomena related to soils are often neglected by hydrogeologists when investigating aquifer dynamics (salinization, and other spatial and temporal trends in water levels and quality). As described in this review article, in cracking clays some phenomenon are more intense due to the more complex flow of water and gases and transport of solute through this type of soil, and the more dramatic change in the flow regime that is caused by cultivation, therefore a topical review discussing these phenomenon is worthwhile. The fourth chapter concerning nitrate contamination is less connected to flow and transport regimes in vertisols, yet it covers a topic that is of most interest worldwide – trends

in contamination of aquifers with nitrate, and recently a few works showing a similar trend were reported. Therefore we thought it is valuable to include it in the review as it is certainly a soil-aquifer phenomenon in which the clays make the difference. Nevertheless, as suggested by the referee and accepting suggestions made by Referee # 1 the article is now more comprehensive in a few issues including: observation of deep drainage through lysimeters (section 2.1); evaporation through cracks (section 3); deep drainage after cultivation in rain-fed versus irrigated cultivated vertisols (Section 4).

4) To some extent the paper progresses toward particular conclusions, such as the inhibition of nitrate transport, and discussion of causes and implications. In this way it reads less like a review paper and more like the discussion section of a paper on a more specific topic. This manuscript could be recast as a different sort of paper. It would be possible to build a paper around the issues it concludes with, without the comprehensiveness of a review paper. But because this manuscript has very little unpublished original research, this direction would require considerable effort. A review article on these topics with a much deeper and more detailed reach into the existing literature would be an extremely valuable contribution. In addition to a more thorough treatment of previous work, it would be very useful to make comparisons between preferential flow through cracks in vertisols and preferential flow through the macropores of other sorts of soils. I recommend that the authors pursue this course, with reductions of scope as necessary.

4) We agree with the referee that the paper does not read as a comprehensive review in some parts. The nitrate section, especially has a relatively high discussion/citation ratio as acknowledged by the referee, also due to the fact that there are not many publications that deal with the comparison of nitrate contamination in aquifers under different soils. As of a comparisons between preferential flow through cracks in vertisols and preferential flow through the macropores of other sorts in soils, section 2.3 points out the development of mobile-immobile models first in the general dual domain of soil porosity that are used also for cracking clays and the further development to

more crack specific models. We do not think a general comparison between the different types of macropore phenomena will sharpen the significance of the common and important soil-aquifer phenomenon in vertisols we review in this paper.

5) Following are minor comments, referenced by page and line number. 9576/21 – The section is limited to solute transport, so the heading would be better as “Preferential solute transport in vertisols.”

5) Collides facilitated transport is reported as well, hence we prefer not limit to solute transport in the section title.

6) 9576/27-28 – What sort of VZ propagation, as contrasted with transport to groundwater?

6) The next sentence in the text explains:” Bronswijk et al. (1995) concluded that large cracks control the rapid transport of Br- to the groundwater, and preferential paths made up of tortuous “mesopores” control transport in the unsaturated zone.

7) 9577/15-16 – What were the K values? How determined?

7) 6.2*10-8 cm/s for the clay matrix measured with a remolded cylinder by a standard rising tail water method. 4.2*10-5 – 2.8*10-4 equivalent hydraulic conductivities derived from tracer peak arrival time, porosity and surface area and depth of lysimeter.

8) 9578/17-20 – Awkward sentence. Reorganize.

8) Thanks, the sentence was reorganized and split to 2 sentences in the revised manuscript (lines 216-220).

9) 9578/26 – More critical than what?

9) We thank the reviewer for the comment, the word more was deleted in the revised text. The mainstream mechanistic modeling approach for unsaturated flow is with the Richards Equation (HYDRUS and other codes). The Kinematic Wave formulation (e.g. MACRO) is another approach and Beven and Germann (2013) are critical on the

mainstream Richards equation approach. Therefore the interested reader is referred to this critical review rather than the other more comprehensive reviews (and maybe biased towards the Richards Equation).

10) 9583/22 – Citation of research from a personal communication is inappropriate for a review article.

10) There are seldom data dealing with nitrate concentrations in groundwater of the same aquifer analyzed with respect to the soil above the well area (that include vertisols). I happened to see this work of Dafny E. upon personal communication, unfortunately the work was not published yet, therefore I asked Dafny E. if I can mention the work under personal communication. Since now days communication is easy the motivated reader can easily locate the referred person, for more details. Therefore we prefer to include the reference, although it is not ideal.

11) Adams, J.E., and R.J. Hanks. 1964. Evaporation from Soil Shrinkage Cracks. Soil Science Society of America Journal 28(2):281-284. 10.2136/sssaj1964.03615995002800020043x. Ben-Hur, M., and S. Assouline. 2002. Tillage Effects on Water and Salt Distribution in a Vertisol during Effluent Irrigation and Rainfall. Agronomy Journal 94(6):1295-1304. 10.2134/agronj2002.1295. Rhoades, J.D., S.M.Lesch, S.L. Burch, J. Letey, R.D. LeMert, P.J. Shouse, J.D. Oster, and T. O’Halloran. 1997. Salt Distributions in Cracking Soils and Salt Pickup by Runoff Waters. Journal of Irrigation and Drainage Engineering 123(5):323-328. doi:10.1061/(ASCE)0733-9437(1997)123:5(323).

11) Thanks for the references

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 9571, 2015.