

***Interactive comment on* “Saturated and unsaturated salt transport in peat from a constructed fen” by Reuven B. Simhayov et al.**

Anonymous Referee #2

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Simhayov et al. Saturated and unsaturated salt transport in peat from a constructed fen.

The tar sand industry of Alberta, Canada is mandated by law to restore the natural landscape they excavate to some semblance of its original state. Two of the major challenges they face to meet this ambitious goal are 1) restoring the minerotrophic fens, which are a major component of the regional landscape and 2) mitigating the transport of saline groundwater through the profiles of their restored peatlands. This manuscript by Simhayov et al. provides important new insights on solving these problems with special reference to the transport of dissolved salts through reconstructed fen peats. The authors performed a series of breakthrough experiments using laboratory permeameters packed with excavated fen peat. The experiments were run with both reactive and

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non-reactive tracers and the results were interpreted with the aid of several mathematical models including the classic convection-dispersion equation (CDE), non-equilibrium transport (MIM or Mobile-Immiscible Model) and adsorption (OSA or On site Adsorption model). The CDE model provided the best fit for their data indicating that solute transport in their permeameters was dominated by convection-dispersion. They also found little evidence to support matrix diffusion from the dead or immobile pore space. They interpreted this later finding in terms of the anatomical structure and degree of decomposition of the plant materials that make up their peat samples. Specifically, they note the low abundance of Sphagnum remains in their samples and the breakdown of cell walls in the sedge and moss particles. This interpretation specifically identifies the empty hyaline cells of Sphagnum and the intact cells of sedge tissues as the sites for dead pore space. While this interpretation appears faithful to their rigorous experiments and analyses I think it would also be prudent to consider other possible explanations for these result.

Could the absence of experimental evidence for matrix diffusion also be the result of artifacts introduced by their sampling plan? The authors first removed coarse plant materials (roots, twigs, leave) from the excavated peat samples and then packed the finer fraction into laboratory columns. This invasive procedure likely destroyed the original fabric of the excavated peat samples by altering the bulk density of the peat mass and geometry of the pore networks. It also could have created new macropores that dominated water transport through the columns. In addition, the excavation process itself could have greatly altered the original fabric of the peat in the donor peatlands. Because of the importance of this topic I would hope that the authors insert a paragraph providing a rationale for their method of packing their laboratory columns along with its advantages and limitations. I also hope that they could address the potential broader relationship of their study. Is it relevant just to the peat excavated by the tar sand industry (as I suspect) other excavated peat deposits elsewhere or are there also implication that can be drawn on the hydraulic properties of "pristine" undisturbed peatlands.

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Overall this impressive experimental study is noteworthy for the rigor of its analysis and will set a high bar for future work in this field. But the authors could still improve the text by minor adjustments to its dense written style, particularly the occasional use of stand-alone pronouns, which are ambiguous, closer attention to syntax, and avoidance of overly complex constructions. The insertion of an extra paragraph discussing possible artifacts related to sampling procedures and potential application of this work would also be helpful

Detailed comments

Lines 9-10. This opening sentence is overly complex and confusing as written. I would advise revising the sentence by playing more careful attention to syntax and shortening the sentence. For example it can be changed to: The underlying processes governing solute transport were analyzed in peat from an experimentally constructed fen peatland by performing saturated and unsaturated solute breakthrough experiments using Na⁺ and Cl⁻ as reactive and non-reactive solutes, respectively. A good rule of thumb with regard to syntax is to keep like elements of a sentence together,

Line 16: Please don't begin a sentence with a stand-alone pronoun (e.g. "This"), which in this context is ambiguous. Add the appropriate words or words after "This" to clarify the subject of this sentence.

Line 17: change "(→infinity)" to "(which approaches)"

Line 17: See my note about stand-alone pronouns above. It is always preferable to avoid introducing unintended ambiguity by avoiding this usage altogether.

Lines 27-28: Does this study have broader implications beyond the specific experimental setting and its selective process of constructing the peat columns in the lab? The concluding sentence of the abstract should address this question and point out the broader significance of these findings. Are these results specific to this experimental apparatus, study site, other reconstructed fens. Can the results provide new insights

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on the limitations of the dual porosity model of pristine peatlands as well?

Lines 32-33. The subject of this sentence is too long. Please shorten the subject and move the verb to the beginning of the sentence.

Line 35: Change "which" to "that"

Line 40: Change "Generally, Sphagnum" to "Generally, in Sphagnum"

Lines 32-49: First two paragraphs: Some of the ideas expressed in these opening paragraphs should be reduced and incorporated into the Abstract to provide a better rationale for this study and its broader significance.

Line 64: Please avoid using (especially at the beginning of a sentence) a stand-alone pronoun. In this case the subject of this sentence is not clear.

Line 71: A dangerous assertion since any person's knowledge of the literature is always limited. For example, the authors could also cite Comas, X. and L. Slater (2004) Low-frequency electrical properties of peat Water Resources Research, Vol. 40, W12414, doi:10.1029/2004WR003534, 2004.

Line 77: Please add the appropriate word or words after the stand-alone pronoun "this" to clarify its meaning. Otherwise the subject of this sentence is ambiguous.

Line 85: The authors may want to consider the possibility that interactions between NaCl and dissolved organic matter (e.g. organic acids) may induce changes in the pore size and geometry as originally proposed by Ours et al. 1997 and supported by Comas & Slater 2005 or Levy et al. 2016?

Line 88: Change "We approach this" to "We approach this objective"

Lines 88-89: Were these experiments conducted in the field or lab? It would be a good idea to specify the later here.

Lines 109-112. I am confused. The previous text describes the peat used in this

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experiment was dominated by sedge remains. However, but figure caption suggests that the peat was composed of Sphagnum moss. Please provide an explanation in this figure caption if possible.

Lines 112-125: How were these samples collected? A very brief description would be crucial since any method to secure peat samples for laboratory experiments will produce deformations to the original peat fabric, which will alter the hydraulic properties of the peat and therefore the affect results of the experiments. I realize that artifacts are unavoidable regardless of the sampling methods used but it would still be a good idea to address this issue here.

It appears that the material used in this experiment were collected from a pile of peat that was excavated from an intact fen and then dumped in a pile. It would probably be a good idea to add a sentence or two to describe how peat was collected from this excavated pile. Please remember that peat is a generic term covering a wide and heterogenous range of porous media.

Line 118: The authors should provide a rationale for adapting this unusual plan for packing peat into their permeameter columns. The approach will alter the fabric of the original in situ peat by preferentially removing coarser material and rearranging the packing and intra particle porosity of the finer-grained material.

Line 384: How can the bulk density and porosity be similar if they have different units of measure (gm/cm³ vs %)? Do you mean instead that they are statistically related?

Lines 307-310: Is this conclusion specific to soils that have high levels of Cl and other salts?

Line 342: Place the non-restrictive clause ("which is the ratio of advective vs diffusive transfer") directly after the subject it modifies (=Peclet number).

I suggest changing this sentence to: The Peclet number, "which is the ratio of advective vs diffusive transfer, was 33.9. for the fitted Cl- breakthrough data."

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Line 356: change "this" to "this finding" to clarify the meaning of the stand-alone pronoun "this"

Lines 352-357: "Additionally, evidence found in the SEM scans of the peat used in this study (Fig. 1), shows that the cell walls have decayed, with only the skeleton of the cell remaining,"

I suggest clarifying this sentence since it is not clear whether the authors are specifically referring to the slender chlorophyllose cells (which I think is their intention) or the much larger hylaline cells that have rigid reinforcing structures and microfibril reinforcing structures that are resistant to decay (and will therefore retain their shape when dead). This paragraph also seems to contradict the opening description of the fine-grained peat that was packed into the lab permeameters.

Lines 354-355: Please add the appropriate citations to support the statement that "solute transport in peat has to be simulated using the MIM."

Lines 358-359: Either delete the adverb "As" at the beginning of this sentence or add an appropriate verb to complete this sentence.

Lines 362: Delete "these" to avoid a run on sentence. "and the robust estimates of v and D for the CDE, these were"

Line 401: Change "With this" to "With this approach"

Line 409: Did the authors consider chemical interactions between the ionic composition of the pore waters and organic acids as suggested by Ours et al. 1997?

Line 401: I suggest changing "With this we tested if the common assumption" to "With this approach we investigated whether the common assumption"

Line 410: Please add the appropriate word or words after "this" to clarify the subject of this sentence. I think they are referring to "this result" but I am not certain.

Line 411: Was the peat primarily composed of Sphagnum? Elsewhere in the text the

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peat was described as sedge peat extracted from a fen.

Line 419-420: How can this statement ("has decayed enough to lose the cell walls but not enough to break the cell skeleton ") be true if the cell walls provide the structural basis of all plant cells. Please revise this statement both here and elsewhere in the text.

Line 421: Another possible reason could be the sampling plan, which selectively packed the finer-grained peat particles into the permeameters. This procedure altered the fabric of the original peat fabric, which was probably first altered by the extraction of an intact fen and the deposition of the peat into a spoil heap.

Lines 437-438:

"From the industry perspective, choosing and peat with dead end pores would allow a potential for significant attenuation."

Remove "and" from this sentence.

Are the authors concluding that partially decomposed peat (preferentially dominated by Sphagnum) provides the best material for optimizing solute attenuation in reconstructed peatlands?

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