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Discussions

Interactive comment on "Geophysically-based analysis of BTCs and ion exchange processes in soil" *by* Shany Ben Moshe et al.

Anonymous Referee #2

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General comments

This manuscript presents experimental findings from simple laboratory column experiments. Spectral Induced Polarization (SIP) was measured in three column parts and signals of real and imaginary conductivity were used to describe solute transport and ion exchange in the columns. While the paper is condensed and clearly written, I am in line with the first referee that (1) novelty of the findings is rather limited and (2) that the applicability the method to real world problems in more complex systems is not proved. However, if the authors present additional data from a more complex experiment, and this is relatively easy, because they just have to fill their laboratory columns with a "real-world matrix" and use pollutants rather than salt, I see potentials for an essentail scientifc contribution.

Specific comments

(1) Novelty and research gap: SIP is an established tool and has been extensively used to investigate processes in laboratory columns. Some papers are cited in the results and discussion section, but no elaborate literature review is included in the introduction. As a result, a clear research gap is missing. The following two examples (and there are many more) exemplify the fact that the underlying processes and the different behaviour of chloride and cations in the laboratory columns have been documented by SIP before: Ion exchange in columns already 10 years ago by Vaudelet et al., WRR 2011. More recently, SIP was also used to study calcite precipitation (Izumoto et al., 2020, https://doi.org/10.1093/gji/ggz515). Thus, I agree with Referee#1 that the results of the present study are rather predictable and not surprising.

(2) Applicability to real world problems: Scientific column experiments are mainly carried out for two types of problems: (a) Solute transport in complex media (e.g. soil columns, etc.) is evaluated. Then the studied matrix inside the column is highly heterogenous and produces a complex SIP signal that can hardly be interpreted, because a variety of different factors influence the geoelectrical signature. This has been documented by various studies and is stated by the authors themselves. (b) Solute transport of specific compounds (e.g. organic pollutants, heavy metals) is studied. The transport of sodium chloride (and exchanges with calcium) are by no way representative for the transport other pollutants. For both types of problems the real value of SIP cannot be evaluated from the data presented in the present study. The only value shown in the manuscript is to evaluate transport of ions through a simple (sandy) matrix and to provide additional insights compared to EC-measurements at the column outflow. However, it is established theory that electric conductivity is a summary parameter related to the ionic strength of a solution and hence cannot be used to assess the concentration of a single ion inside a changing ion mixture.

Here the authors must present additional data that SIP is a tool for real world problems, e.g. is SIP able to detect preferential flow patterns in a heterogeneous soil matrix; or:

is SIP a tool that adds to the understanding of pollutant transport? If they do, this would increase the value of their paper and produce a piece of work worth publishing in a journal like HESS. For this, I propose that the authors fill their column with more heterogeneous media and additionally repeat their experiments also including a typical pollutant. Here heavy metals seem most promising. With their approach - fitting HYDRUS-1D to SIP-conductivities to predict breakthrough curves - they could then produce more solid knowledge on chances and limitations of SIP-data for solid transport studies in column experiments.

Technical corrections are not meaningful at this stage.

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