Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2018-181-AC2, 2018

Hydrology and Earth System Sciences Discussions
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Interactive comment

Interactive comment on "Reactive Transport with Wellbore Storages in a Single-Well Push-Pull Test" *by* Quanrong Wang and Hongbin Zhan

Quanrong Wang and Hongbin Zhan

zhan@geos.tamu.edu

Received and published: 17 October 2018

General Comments: 1. The authors presented a study to extend the Phanikumar and McGuire (2010) model for the single-well push-pull (SWPP) tests in homogeneous, isotropic aquifers by replacing the oversimplified boundary conditions with more complex conditions to account for wellbore storage effect (the Model). The Phanikumar and McGuire (2010) model is a polar coordinate mathematical model used to interpret SWPP tests involving multi-species reactive transport problems with non-linear reactions. The aim of the study was to reduce the potential errors that may be introduced by ignoring the storage effect in the previous models. The authors verified the accuracy of the Model by comparing the breakthrough covers (BTCs) modeled by the proposed mode with those generated by the Wang et al. (2017) model. The Wang et al. (2017)

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model is a similar expansion the Phanikumar and McGuire (2010) model accounting for wellbore storage with respective to groundwater flow. The difference is that the Model accounts for wellbore effects with respect to solute concentration, in addition to flow. Lastly, the authors used the Model to interpret the breakthrough curves (BTCs) of a SWPP field test reported by McGuire et al. (2002) and compared with interpretation of the same BTCs by the Phanikumar and McGuire (2010) model. I have no issues with how the wellbore boundary conditions are formulated. However, I have concerns on the approach the authors taken to verify the Model, which may cast doubts on the practical usefulness of the Model, Reply: Implemented. We have verified the model of this study using MODFLOW/MT3DMS (See Figure 3).

2. Figure 2 shows the comparison between the BTCs modeled by the Model versus those modeled by Wang et al. (2017). But models were used to model the BTCs of hypothetical SWPP tests in three different porous media of fine, medium and coarse sands with typical hydraulic parameters found in textbooks. Figures 3 and 4 illustrate the differences in the BTCs attributable to the wellbore concentration effects. The authors argued the numerical solution of Wang et al. (2017) was chosen to verify the Model because benchmark analytical solutions of the SWPP test with a finite hydraulic diffusivity are not available up to date. An alternative approach is to verify the Model using a solution given by a widely used modeling software, such as MODFOW-SURFACT or FEFLOW (The authors are incorrect to state that commercial numerical software packages are incapable of accurately incorporating the wellbore boundary efforts). Reply: Implemented.

Response to verify the model of this study: We used MODFLOW/MT3DMS to test the model of this study (See Figure 3).

Response to errors in MODFOW-SURFACT or FEFLOW: It is necessary to test the accuracy of the new models against the commercial numerical software packages, like MODFLOW/MT3DMS. Unfortunately, the current three-dimensional models in the MODFLOW/MT3DMS may create some errors in describe the solute transport in the wellbore-confined aquifer. The errors come from an assumption that the water volume in the wellbore is computed by a product of wellbore cross section and the aquifer thickness, which is incorrect. The actual water volume in the wellbore should be computed by a product of wellbore cross section and the water level in the wellbore (See Supplemental Materials for detailed explanation). The models of solute transport in MODFLOW/MT3DMS are the same with the models in MODFOW-SURFACT or FEFLOW.

3. To demonstrate it applicability, the Model was used to interpret the BTCs reported in McGuire (2002) in comparison with the Phanikumar and McGuire (2010) model (Figures 6, 7, and 10). Because both models were able to replicate the BTCs, the authors included additional scenarios with varied parameters to demonstrate the differences between the two models. It would be much more compelling to use the field test whose BTCs could not be replicated by the Phanikumar and McGuire (2010) but can be reproduced by the Model. This would alleviate the concern about the necessity of introducing additional complexity into a groundwater model which is known to be subject to parameter uncertainties. In case that such a field test is not available, the authors may consider using a data set modeled using a modeling software such as MODFOW-SURFACT or FEFLOW. Reply: As mentioned in reply to comment #2 of this reviewer, because of the problem of MODFLOW/MT3DMS for computing the wellbore water volume, it is not advisable to using a synthetic data set generated using a modeling software such as MODFOW-SURFACT or FEFLOW (See Supplementary Materials for detailed explanation of this issue).

4. Consider adding a list of acronyms defining the physical meanings of the different symbols. Reply: Implemented (See Nomenclature).

Specific Comments: 1. Abstract. The abstract should be revised to eliminate the discussion of the details such as the Freundlich, Langmuir and linear sorption models, one-site kinetic sorption model, two-site sorption model, and Monod or Michaelis-Menten kinetics. These are not the core subject of this study. Reply: Implemented

(See Abstract).

2. Page 2, line 7. Change to: "the model which is expected to properly represent the physical. . ." Reply: Implemented (See P2 Line 5).

3. Page 2, line 26-27, change to: ". . .however, such model only considered wellbore storage effects with respect to groundwater flow, but not solute concentrations." Reply: Implemented (See P2 Lines 26-27).

4. Page 2, line 33, change to: ". . .concentration of the solute in the wellbore is smaller than that of the original solution. . ." Reply: Implemented (See P2 Line 29).

5. Page 3, line 11. It is incorrect to state that none of the four software packages could deal with multispecies reactive transport problems with non-linear reactions. Both MODFLOW-SURFACT and FEFLOW can. Reply: Such a statement has been deleted.

6. Page 3, line 29. Define hydraulic diffusivity at its first appearance. Hydraulic diffusivity is a term used mostly in soil physics, not groundwater hydrology. Reply: Implemented (See P2 Lines 21-24).

7. Page 7, line 9. Change to: " . . .reactive processes considering wellbore effects not only for groundwater flow but also for solute contrations." Reply: Implemented (See P7 Line 10).

8. Page 9, line 1. It is not clear what does it mean by "Subject to the discharge or recharge of the well,.." Please revise. Reply: Implemented (See P9 Lines 9-10).

Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2018-181/hess-2018-181-AC2-supplement.pdf

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