## Comments from Referee #3

The manuscript is well organized and scientifically structured. However, the followings should be addressed: 1. Proposed solution Eq.(24) C(X,s) of analytical model Eq.(1) is not the solution C(x,t) of the model. Provide the details of the analytical solutions. However, it is plotted in C(x,t) for t=1 only why? 2. The seepage velocity and dispersion coefficient is too high. Justify it. 3. The proposed analytical model with the simple initial and boundary conditions are chosen like zero and constant value has not significant impact in the present scenario. This may be addressed with more general cases and therefore, it is not a novel analytical solution. 4. Damköler number and Peclet number with concentration profile should also be presented. 5. Bulk dry density of the solid grain, [kg L-1] however in line177, it is different [ML-3]. 6.Distribution coefficient, Ki [L kg-1] however in line178, it is different[M-1L3].

## Author's response

The authors sincerely thank the anonymous reviewer for his helpful comments and suggestions which will substantially improve the quality of the paper.

1. This paper attempts to develop an analytical model for multispecies transport subject to rate-limited sorption. Indeed, we obtain the analytical solution in the Laplace domain ($C_i^L(X,s)$) and the analytical inverse Laplace transform for Eq. (24) cannot be carried out to yield the solution in exact fashion at present. Alternatively, the numerical method is instead to complete the inverse Laplace transform to yield the solution in the original domain ($C_i(X,T)$). Generally, the solution that is obtained in the Laplace domain and the real concentration is achieved by using numerical Laplace inverse transform is referred to as a semi-

analytical solution. It is noted that the semi-analytical solution is exact in the space domain but approximated in time domain. Researchers have evaluated computation efficiency of semi-analytical solutions. For instance, Huang and Goltz (1999) derived an exact analytical solution to equations describing rate-limited soil vapor extraction of contaminants in the vadose zone. Their solution contained a summation of the infinite series expansion. Huang and Goltz (1999) compared their exact solution against the semi-analytical solution with the aid of numerical Laplace inversion presented by Goltz and Oxley (1994). The numerical Laplace inversion solution is useful for Peclet number (Pe) up to 1600, while the exact solution is only useful at values of Pe less than 12 because of problems accurately evaluating high-order Bessel functions of the first and second kind using double precision accuracy. Despite that the semi-analytical solution generally have better computational efficiency, there is still a need to obtain the exact solution. We will pursue the exact solution in the near future.

2. The simulation conditions and transport parameters adopted in this manuscript comes from the manual for the most commonly used public domain model BIOCHLOR provided by the Center for Subsurface Modeling Support. This example application has demonstrated that BIOCHLOR can reproduce plume movement from 1965 to 1998 at the contaminated site of Cape Canaveral Air Station, Florida. Therefore, we believe that the values of the seepage velocity and dispersion coefficient are reasonable.
3. The simple initial and boundary conditions used in this study has been adopted in many modeling studies and demonstrated practical applications. The work is a pioneering study to bring the rate-limited sorption into the problem of multi-species transport and the newly developed model will have more real world applications.

Therefore, the developed model is novel and the concept presented in this study can be extended to derive analytical models for more general cases.

4. Thanks the comments from the reviewers. We will include the corresponding Pectlet number and Damköler number.
5. Bulk dry density of the solid grain, [kg L-1] will be corrected as [kg liter$^{-1}$]
6. Distribution coefficient, $K_i$ [L kg$^{-1}$] will be corrected as [liter kg$^{-1}$].

**References**

Goltz, M.N., Oxley, M.E., 1994. An analytical solution to equations describing rate-limited soil vapor extraction of contaminants in the vadose zone. Water Resources Research, 30(10), 2691-2698.

Huang, J., Goltz, M.N., 1999. Solutions to equations incorporating the effect of rate-limited contaminant mass transfer on vadose zone remediation by soil vapor extraction. Water Resources Research, 35(3), 879-883.

## Author's changes in manuscript.

1. We have provided a discussion regarding the recovery of the numerical Laplace inversion of Eq. (24) into the original domain in the revised manuscript.
2. We have included the corresponding Peclet number and Damköler number in the revised manuscript.
3. Bulk dry density of the solid grain, [kg L-1] will be corrected as [kg liter$^{-1}$].
4. Distribution coefficient, $K_i$ [L kg$^{-1}$] will be corrected as [liter kg$^{-1}$].