Analysis of Mass Transfer Processes During Advective Air Movement in Contaminated Soil

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Cooperators:

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Goals: The objective of this research project is to analyze the mechanisms responsible for contaminant removal using remediation techniques that involve an advective air flux such as Air Sparging (AS) and Soil Vapor Extraction (SVE). The investigation will also consider the factors and parameters that influence the contaminant removal. This goal will be addressed theoretically using multiphase contaminant transport model that incorporates first order mass transfer kinetics. Furthermore, the results will be interpreted and verified using available field observation and experimental data. A Monte Carlo-based stochastic process will be used to address field variability.

Recent Publications:

Rahbeh, M.E. and R.H. Mohtar. 2005. Application of Multiphase Transport Models to Field Remediation by Air Sparging and Soil Vaper Extraction. Journal of Hazardous Materials. In review.

Rahbeh, M. and R.H. Mohtar. 2005. Modeling Multiphase Contaminant Transport in Porous Media

Statement of Problem:

Air sparging and soil vapor extraction (AS/SVE) systems have evolved as innovative, environmentally friendly, and cost-effective techniques for removal of volatile organic (VOC) contaminating soils and ground water. The mass transfer and removal processes that are usually associated with remediation by advective air flux should be well understood to enable scientifically-based design and operation guidelines to achieve the maximum potential of air AS/SVE.

Current Activities:

The development of multiphase contaminant transport model that incorporates non-equilibrium mass transfer in the form of first order kinetics is underway. The model accounts for heterogeneous domains and considers distinguished single-phase and multi-phase domains. This capability is especially important in the case of remediation techniques that involve an advective air flux such as air sparging and soil vapor extraction. In such systems, two domains may be considered, the advective domain, i.e. the air, and the non-advective domain, which may be either the domain outside the advective air domain but in the vicinity of the air plume, or any space or pocket inside the advective air domain that is not in direct contact with the advective air domain. Figure 1 represents three possible multiphase scenarios and the removal processes that may occur within each domain. The governing equations are solved numerically using finite element-Galerkin's formulation. Verification against analytical solutions showed that the numerical and analytical results are in full agreement. Furthermore, the model was used to analyze an air sparging experimental data. In addition to the modeling part, an experimental setup is put in place; experimental results along with field observations will be compared with numerical analysis.

using First Order Mass Transfer Kinetics. Transactions of the ASAE. In review.

Rahbeh, M., R.H. Mohtar, C. Jafvert. 2005. Analysis of Mass Transfer Processing during Air Sparging. Journal of Contaminant Hydrology. In review.

Benner, M.L., R. H. Mohtar and L.S. Lee. 2002. Factors affecting air sparging remediation systems using field data and numerical simulations. Journal of Hazardous Materials. B95(2002) 305-329. Presented also as ASAE Paper No. 98-3167.

Montas, H., R.H. Mohtar, A. Hasan, F. AlKhal. 2000. Heuristic space-time design of monitoring wells for contaminant plumes characterization in stochastic flow fields. Journal for Contaminant Hydrology. In press. Also presented as ASAE Paper No. 98-3173.

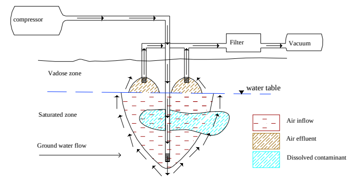
Benner, M.L., S.M. Stanford, L.S. Lee and R.H. Mohtar. 1999. Field and Numerical Analysis of In-Situ Air Sparging: A Case Study. HAZMAT, Elsevier 72(2000). Pp 217-236.

Mohtar. R.H., R. Wallace, and L. Segerlind. 1996. Finite element analysis for air sparging in porous media. Fluid/Particle Separation Journal Vol. 9, no. 3, 239-255.

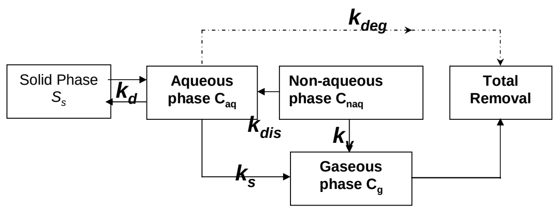
Aguire, C.G., A. Madani, R.H. Mohtar and K. Haghighi. 2004. Deterministic finite element solution of the unsteady water and transient transport through porous media: Part 1. Theory. Journal of Environmental Science & Engineering, Canada. (In review).

Aguire, C.G., A. Madani, R.H. Mohtar and K. Haghighi. 2004. Deterministic finite element solution of the unsteady water and transient transport through porous media: Part 2. Application. Journal of Environmental Science & Engineering, Canada. (In review)

Mass transfer processes during air sparging

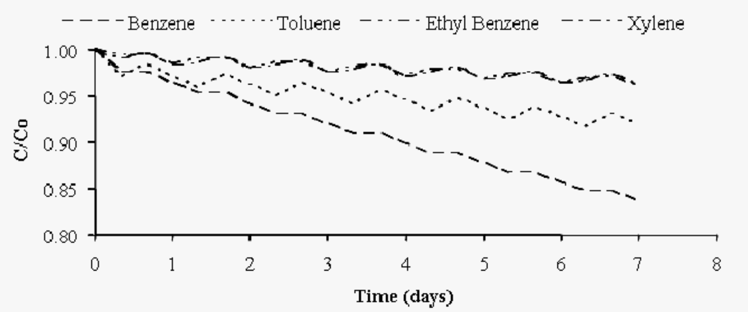


Typical setup of Air Sparging (AS)/Soil Vapor Extraction (SVE) system



k_d : Sorption/desorp
k_s: Stripping
k_v: volatilization
k_{dis}: dissolution
k_{deg}: biodegradation

Removal/rebounds cycle of BTEX constituents during first week of operation



K_{OC} Xylene > Ethyl Benzene > Toluene > Benzene