# Analysis of Mass Transfer Processes During Advection Air Movement in Contaminated Soil

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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:

## 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 multi-phase 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.


Mass transfer processes during air sparging

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

Saturated zone
Ground water flow
Vadose zone
compressor
Dissolved contaminant
Air effluent
Air inflow
VacuumFilter
water table

Solid Phase
Aqueous phase
Non-aqueous phase
Gaseous phase

Solid Phase $S_s$
Aqueous phase $C_{aq}$
Non-aqueous phase $C_{naq}$
Gaseous phase $C_g$

$k_d$: Sorption/desorption
$k_s$: Stripping
$k_v$: Volatilization
$k_{dis}$: Dissolution
$k_{deg}$: Biodegradation

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

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