Geophysical Research Abstracts
Vol. 13, EGU2011-8713, 2011
EGU General Assembly 2011

Experimental study of the influence of vapor density and pressure gradient on the vapor flux of Trichloroethylene in the unsaturated zone

Salsabil Marzougui, Gerhard Schäfer, Solenn Cotel, and Olivier Razakarisoa

Laboratoire d'Hydrologie et de Géochimie de Strasbourg, University of Strasbourg, Strasbourg, France
(salsabil.marzougui@etu.unistra.fr/ 0033368850402)

One of the key challenges in contaminated sites is accurately predicting the impact in the subsurface of organic pollution caused by volatile compounds such as trichloroethylene (TCE) in terms of concentrations in the soil gas of the unsaturated zone, in the atmosphere or inside of overlaying buildings.

To quantify the vertical mass transfer of TCE in a partially saturated porous medium, experiments were conducted in a large (25 × 12 × 3 m) well-instrumented artificial aquifer called SCERES during two months. 3 liters of TCE were injected as a pure phase 0.55 m beneath the soil surface. SCERES recreates a three-layer alluvial aquifer system made up of fine-size sand, a medium-size sand and coarser sand with. The hydraulic regime is defined by a 1 m thick saturated zone. A stainless steel bell having a volume of 1 m3 was installed on a cracked concrete slab with a porosity of about 0.2 and an intrinsic permeability of about 2,3.10-14 m^2 in order to represent the foundation of an overlaying building. Both were placed on the axis of SCERES. The source of TCE was created 1 meter down stream of the concrete slab.

A weather station is placed at the soil surface to register atmospheric pressure, humidity, temperature, and speed and direction of wind. Soil air pressure sensors are placed at different depths of the SCERES basin and two technical pits located at the upstream and downstream ends of the basin allow handling the rising and lowering of the water table. To measure the vapor TCE flux from the unsaturated zone to the atmosphere and through the concrete slab to the air of the bell, we used a flux chamber.

The vapor plume of TCE in the unsaturated zone is governed by both the diffusive flux and advective flux generated by the pressure gradient and densities of TCE vapors. Vapor fluxes and concentrations measured during the experiment strongly depend on the location of measurement from the source of pollution. For example, at 1 meter distance from the source area on the axis, the measurements show that the TCE flux is about 0.02 mg/m^2s, whereas at 2 meters laterally from the source a decrease of the flux of 85% is observed. After creation of the source zone, 3 types of variations of the initial boundary conditions were performed. In the first part of experiment, the vapor plume was only subjected to the natural variation of atmospheric pressure. The second stage characterized by applying a gas suction of 5, 10 and 20 Pa in the bell to create an ascendant gas flow to the concrete slab. In the third stage, a vertical pressure gradient in the unsaturated zone was applied by rising and lowering the water table which created a global displacement of the soil air. The latter one created local pressure variations of up to 8 Pa resulting thus in significant vertical advective vapor fluxes. We measured vapor fluxes and concentrations of TCE in every stage in SCERES and in the bell. The objective of the chosen three stages was to quantify individually the dominant part of every type of vapor flux. In stage 1, vapor fluxes were principally diffusion controlled and influenced by density driven advection. In stages 2 and 3, advective fluxes due to the vertical pressure gradient dominated the diffusive fluxes as well as the density driven advective fluxes. A novel quasi-analytic vertical 1D approach, based on Fick's law and Darcy's law, is used to evaluate the part of each flux in the total vapor flux measured at the soil surface and above the concrete slab.