Understanding TCE Vapor Generation from Dissolved Groundwater Plumes under Fluctuating Water Table Conditions

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Abstract. Intrusion of chemical vapor into subsurface structures and basements has received recent attention because of the health risks posed from inhaling contaminated air for long periods of time. Regulatory drivers require the evaluation of potential vapor intrusion (VI) when volatile chemicals are present in the soil and groundwater. The current approaches of evaluating the risk of VI involve the use of highly simplified screening models that make a number of assumptions with respect to how the processes contributing to mass transfer from entrapped non-aqueous phase liquid (NAPL) sources and from the NAPL dissolved in the groundwater plume are modeled. A research study is under way to improve our understanding of these basic processes through experiments conducted at different test scales. The goal is to use the experimentally generated data to test hypotheses on how mass transfer occurs and to develop and validate improved models that are up-scaled from the laboratory to heterogeneous field systems. This paper presents the preliminary results from an experimental study conducted in a small two-dimensional test tank where conditions are created to simulate mass transfer from TCE dissolved in the groundwater plume under fluctuating water table conditions. The basic hypothesis tested is that the mass transfer that occurs from the dissolved NAPL in the pore water in the unsaturated zone to the flowing air has to be modeled as a rate limited process. A set of experiments were performed in a 2-D tank with dimensions 40 cm x 30 cm x 5 cm with sampling ports to extract both water samples from the saturated zone and capillary fringe and air samples from the unsaturated zone. The results from some of these experiments are presented. In the first experiment, an aqueous solution of TCE with a dissolved concentration of 20 mg/L was placed in the tank and the water table was raised then lowered to create an unsaturated zone with contaminated residual water and capillary fringe. Steady airflow was blown through the tank and the effluent air samples were colleted and analyzed for TCE vapor concentration. Aqueous samples were extracted from the saturated zone to determine change in concentration of TCE in the plume. The preliminary data clearly shows that the effective mass transfer behavior is rate limited. The mass transfer rate decayed exponentially with time. The results suggest that the effective rate limited behavior in the whole test system is not only controlled by the mass transfer that occurs through water/air interfaces in the residually water saturated zone, but it is also a result of slow diffusion that occurs in the capillary fringe and within the stationary groundwater plume. Experiments for different airflow rates and plume concentrations will be conducted to generate a comprehensive data set. Next steps include investigating the mass transfer behavior under flowing groundwater and developing and validating models to estimate mass transfer rate coefficients.

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