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Vapor intrusion from entrapped NAPL sources and groundwater plumes

Tissa H. Illangasekare (1), Toshihiro Sakaki (1), John Christ (2), Bejamin Petri (1), Carolyn Sauck (1), and Abdullah Cihan (1)

(1) Center for Experimental Study of Subsurface Environmental Processes (CESEP), Colorado School of Mines, Golden, Colorado, USA, (2) US Air Force Academy, Colorado Springs, USA

Volatile organic compounds (VOC) are commonly found entrapped as non-aqueous phase liquids (NAPLs) in the soil pores or dissolved in groundwater at industrial waste sites and refineries. Vapors emitted from these contaminant sources readily disperse into the atmosphere, into air-filled void spaces within the soil, and migrate below surface structures, leading to the intrusion of contaminant vapors into indoor air through basements and other underground structures. This process referred to as vapor intrusion (VI) represents a potential threat to human health, and is a possible exposure pathway of concern to regulatory agencies. To assess whether this exposure pathway is present, remediation project managers often rely in part on highly simplified screening level models that do not take into consideration the complex flow dynamics controlled by subsurface heterogeneities and soil moisture conditions affected by the mass and heat flux boundary conditions at the land/atmospheric interface. A research study is under way to obtain an improved understanding of the processes and mechanisms controlling vapor generation from entrapped NAPL sources and groundwater plumes, their subsequent migration through the subsurface, and their attenuation in naturally heterogeneous vadose zones under various natural physical, climatic, and geochemical conditions. Experiments conducted at multiple scales will be integrated with analytical and numerical modeling and field data to test and validate existing VI theories and models. A set of preliminary experiments where the fundamental process of vapor generation from entrapped NAPL sources and dissolved plumes under fluctuating water were investigated in small cells and two-dimensional test tanks. In another task, intermediate scale experiments were conducted to generate quantitative data on how the heat and mass flux boundary conditions control the development of dynamic VI pathways. The data from the small cell and tank experiments were used to test whether the equilibrium mass transfer assumption is valid under normal pressure gradients generated from atmospheric pressure variations and fluctuations of pressure in the building. The data from the intermediate scale airflow experiments were used to validate a numerical models based on a multi-physics simulator. These analyses will help us to evaluate the significance of the boundary conditions at the land/ atmospheric interface on the development of dynamic air pathways that transmit vapors from contaminant sources to buildings. The experimental findings and models are used to design a set of experiments in a coupled wind tunnel/ porous media test facility where integrated models of atmospheric and shallow subsurface interaction and up-scaling theories will be tested and validated.