Mathematical Modeling of Unsaturated Water Flow in Wastewater Soil Absorption Systems

D. Huntzinger[1], J. McCray[1], S. Van Cuyk[2], R. Siegrist[2]
Dept. of Geology and Geological Engineering, Colorado School of Mines, Golden, CO
Environmental Science & Engineering Division, Colorado School of Mines, Golden, CO

Abstract. Soil clogging by the accumulation of suspended solids and organic matter at the infiltrative surface of wastewater soil absorption systems (WSAS) is a phenomenon known to occur as a result of continued wastewater infiltration. This clogging zone creates a barrier to flow, restricting the hydraulic conductivity and rate of infiltration. A certain degree of clogging may improve wastewater treatment by causing more widely distributed unsaturated flow and increased hydraulic residence times. However, excessive clogging can hamper system performance, diminish wastewater treatment, and eventually lead to system failure. Clogging zone development at the infiltrative surface of WSAS strongly influences the unsaturated flow regime within the system, and therefore plays a critical role in the treatment of wastewater pollutants. The numerical model HYDRUS-2D and representative hydraulic properties for clogging zones obtained from the literature are used to hypothetically simulate unsaturated flow within WSAS to better understand the effect of differing degrees of clogging zone resistance on unsaturated flow behavior and hydraulic retention times in sandy and silty soil. The simulations indicate that sand-based WSAS with mature clogging zones are characterized by a more widely distributed flow regime and longer hydraulic retention times. The impact of infiltrative surface clogging on water flow within the silty soils is not as substantial. In the sand case, by increasing the hydraulic resistance of the clogging zone by a factor or 2 to 3, ponding levels required to accept the same wastewater loading increase by as much as a factor of 5. Since the degree of resistance at the infiltrative surface directly impacts the level of ponding within a system, knowledge of the clogging zone's hydraulic properties, its genesis, and its associated impact on flow regimes is critical in optimizing system design to achieve desired pollutant treatment efficiency.

[1] Dept. of Geology and Geological Engineering, Colorado School of Mines, Golden, CO
[2] Environmental Science & Engineering Division, Colorado School of Mines, Golden, CO