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Gas Dispersion in Variably Saturated and Differently Textured Porous Media

Muhammad Naveed[1]*

[1]Saitama University Japan

Measurements of Gas Dispersion in Variably Saturated and differentially Textured Porous Media
M. Naveed (1), K. Kawamoto (1), S. Hamamoto (1), T. Komatsu (1), Dr. Takahashi (2), T. Sakaki (3), P. Moldrup (4)
(1) Graduate School of Science and Engineering Saitama University
(2) National Institute of Advanced Industrial Science and Technology (AIST) Japan
(3) Center for the experimental study of Subsurface Environmental Processes, Colorado School of Mines, USA
(4) Department of Biotechnology, Chemistry and Environmental Engineering Aalborg University.

The transport, fate and emission of gases in the soil are governed by gas advection, diffusion and dispersion phenomena. Among three gas transport phenomenas, gas dispersion is the least understood. Therefore the main focus of this study is to investigate the effect of porous media on gas dispersion both at air dry and at variably saturated conditions. The aim is to characterize the effect of particle size distribution, particle shape and water enhanced effect on gas dispersion as well as the relationship between gas diffusion coefficient and gas dispersion coefficient.

One dimensional laboratory column experiments, in an apparatus consisting of an acrylic column packed with porous medium and attached to inlet and outlet chambers (Hamamoto et al., SSAJ, 2009), were conducted. Various types of sands (Narita and Toyoura sand from Japan, and Granusils and Accusand from United States) with mean particle diameter (d50) ranging from 0.19 to 1.16 mm both at air dry and with variable moisture contents were used. Particle size distribution was characterized by sieve analysis whereas shape of the sand particles was characterized in terms of sphericity and roundness by using digital microscope and Youd (1973) method. The changes in the oxygen concentration along the porous medium column and in the inlet and outlet chambers were monitored. The measured oxygen breakthrough curves were fitted with the analytical solution to the advection-dispersion equation for the determination of the soil-gas dispersion coefficients. The measured soil-gas dispersion coefficient (DH) showed a linear increase with pore velocity (u0). Measured soil-gas dispersivity (DH/u0, where u0 is the average pore-air velocity) increased with decrease in air filled porosity.

The results showed that at air dry condition and at loosely and tightly packed state, gas dispersivity depends both on mean particle diameter (d50) and particle size distribution(s). Therefore gas dispersivity contour maps were developed between mean particle diameter and particle size distribution. In addition to this, two empirical exponential relationships between gas dispersivity and a porous media parameter (s/d50) have also been established both at loosely and tightly packed state. The effect of shape of sand particles both at air dry and at variable saturated conditions has been studied on granusils (angular) and accusand (rounded). It was found that there is a little effect of shape of sand particles on gas dispersivity.

Water enhanced effect on gas dispersivity has been studied by using various types of porous sands. Gas dispersivity varies from 0 to 3cm on reducing the air filled porosity from 0.51 to 0.28cm3/cm3. A predictive model was also developed as a function of gas dispersivity at air dry condition and normalized porosity (ratio of air filled porosity and total porosity), which fitted well the measured data.

Finally, a relationship has also been established between gas diffusion coefficient (Dp/D0) and gas dispersivity by using a pore characteristics parameter, gas phase tortuosity. Micro-focus X-ray CT Scanning analysis of sand samples at air dry and tightly packed conditions was carried out to obtain pore characteristics parameters directly for making a comparison with pore characteristics parameters obtained indirectly from gas transport parameters.

Keywords: Gas Dispersion, Dispersivity, Tortuosity