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Gas Transport Parameters for Landfill Cover Soils: Effects of Soil Compaction, Size Fractions and Water Blockage

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Landfill sites, being one of the largest sources of anthropogenic methane emission, have been potential area for the researchers to carry out intensive studies on hydraulic performances and gas transport characteristics of landfill final cover during the last few decades. Compared to the above different phenomena the effort for the gas transport has been minimal. Therefore, the researches on the effects of soil physical properties such as bulk density (i.e., compaction level), soil particle size (size fractions) and water blockage on the gas exchange in the compacted final cover soil are very much important.

The gas exchange through the final cover soils is controlled by advective and diffusive gas transport. Air permeability (ka) governs the advective gas transport while the soil-gas diffusion coefficient (Dp) governs diffusive gas transport. In this study, the effects of compaction level, size fractions and water blockage on ka and Dp for landfill final cover soil were investigated. The disturbed soil samples were taken from landfill final covers in Japan. Compaction tests were performed for the soil samples with two different size fractions (< 35 mm and < 2.0 mm). In the compaction tests at field water content , the soil samples were repacked into soil cores (i.d. 15-cm, length 12-cm) at two different compaction levels (2700 and 600 kN/m^2) correspondent to the modified and standard proctor compaction tests. After the compaction tests, ka and Dp were measured and then samples were saturated and subsequently drained at different soil-water matric potential (pF) of 1.5, 2.0, 3.0, 4.1, and with air-dried (pF 6.0) and oven-dried (pF 6.9) conditions. Further hand compaction was done at relatively low dry bulk densities (i.e., 1.40, 1.55 and 1.60 g cm^{-3}) at different water contents ranging from 0.0 to 17.5 %.

Results showed that difference of measured Dp/Do (where Do is the gas diffusion coefficient in free air, m^2s^{-1}) for both compacted levels and size fractions were not significant. This suggests that the gas diffusion was controlled primarily by the air-filled pore space and was less affected by the pore structure variations such as tortuosity and connectivity. On the other hand, measured ka values showed nonlinear relations with soil-air content and had the threshold values. This measured ka was highly affected by compaction levels, size fractions and water blockage. Further rapid increase in ka was observed in highly compacted , coarse-fraction (< 35 mm) materials which may be due to opening of gas flow paths after drainage of water filled in larger pores. (i.e., availability of gravel can enhance the ka significantly). This suggests that care should be taken to select the proper construction material for landfill final cover from the gas transport characteristic point of view, in addition to the hydraulic performances.