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Gas Transport Parameters for Landfill Cover Soil: Dry bulk density based models for gas diffusivity and air permeability

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Mitigation and emission of greenhouse gases such as carbon dioxide, methane as well as other environmental impact gases from terrestrial environments to the atmosphere gives increasing concerns for climatic, human and ecosystem health. Landfill sites, have been one of the largest sources of anthropogenic CH_4 emission over the last few decades. Gas exchange through compacted earthen final covers at landfill sites plays a vital role on emission of greenhouse gases, fate and transport of toxic landfill gases. Numerous studies have been done for the hydraulic performance of landfill final cover soil but studies on gas transport parameters and their dependence have adequately not addressed.

The gas exchange through the final cover soils is controlled basically by advective and diffusive gas transport. Air permeability (k_a) governs the advective gas transport while the soil-gas diffusion coefficient (D_p) governs diffusive gas transport. In this study, the effects of compaction level (different dry bulk density) size fractions (finer and coarser) on k_a and D_p for landfill final cover soil were investigated. The disturbed soil samples were taken from landfill final covers at Saitama prefecture in Japan. Compaction tests were performed for the soil samples with two different size fractions (< 35.0 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, height 12-cm) at two different compaction levels (2700 kN/m^2 and 600 kN/m^2) correspondent to the modified and standard proctor compaction tests. Having completed the compaction tests, two 100-cm³ intact core samples (i.d. 5.1 cm, height 4.1 cm) were taken each mold which 2 mm fraction soil were compacted at 9.0 and 10.0% moisture content. After the compaction tests, k_a and D_p were measured and then samples were saturated and subsequently drained at different soil-water matric potential 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 1.70 g cm^{-3}) at different water contents ranging from 0.0 to 17.5 %.

Based on the normalized relationships between measured gas transport parameters [D_p/D_f , ratio of measured D_p to D_p at total porosity (f), and $k_a/k_{a,pF4.1}$, ratio of measured k_a to k_a at 1235 kPa suction (= pF 4.1)] and air-saturation, predictive D_p and k_a models in an exponential form with a single parameter (M for D_p model and P for k_a model) were developed. The model parameters, M and P , were correlated linearly to dry bulk density values, and the effects of compaction on D_p and k_a well-expressed graphically for both coarser and finer fractions.

Keywords: Gas transport, Dry bulk density, Landfill final cover