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Effect of soil compaction on gas transport parameters for a landfill final cover soil

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In recent years, landfill sites have been implicated in greenhouse warming scenarios as a significant source of atmospheric methane. In addition, it is well known that toxic gases such as hydrogen sulfide and volatilized organic compounds emit from landfill sites and affect surrounding environments. Those greenhouse and toxic gases are typically produced by microbiological processes acting on waste materials under anaerobic conditions. Therefore, the landfill final cover soils should have functions of not only preventing the precipitation infiltration but also of enhancing gas exchange between the atmosphere and landfill wastes to maintain aerobic decomposition conditions. However, the requirements of the landfill final cover system have mainly focused on its hydraulic performance since the landfill management strategies have almost exclusively addressed the problem of groundwater contamination prevention. As compared to the intensive researches about hydraulic characteristics, there are few studies about gas transport characteristics of landfill cover soils, especially the effects of soil physical properties such as bulk density (i.e., compaction level) and soil particle size on the gas exchange in the final cover soil.

The gas exchange through the final cover soils is controlled by advective and diffusive gas transport. Air permeability (ka) governs the advective gas transport induced by soil-air pressure gradient, while soil-gas diffusion coefficient (Dp) governs diffusive gas transport by soil-gas concentration gradient. In this study, the effects of compaction level and soil particle size on gas transport parameters (ka and Dp) for the landfill final cover soil were investigated.

The disturbed soil samples were taken from a landfill final cover soil in Japan. A compaction tests were performed for soil samples with two different size fractions (? 35 mm and ? 2.0 mm) at different water content. In the compaction tests, the soil samples were repacked into soil cores (i.d. 15-cm, length 12-cm) at two different compaction levels (2700 kN/m2 and 600 kN/m2). After the compaction tests, ka and Dp were measured. The ka was measured by blowing air through the soil core sample at different constant flow rates, and was calculated from the flow rate at an applied pressure difference across the core sample using Darcy's law. The Dp was measured using a diffusion chamber method. Oxygen was used as a tracer gas and analyzed as a function of time inside the diffusion chamber initially flushed with nitrogen gas.

Results of the compaction tests showed higher bulk densities overall soil moisture conditions for soils with larger size fraction (? 35 mm) at the higher compaction level (2700 kN/m2). The optimum moisture content ranged from 0.08 to 0.12 (g H2O/ g soil) at each experimental condition. The measured Dp values for each sample varied depending on the experimental conditions, however, the measured Dp increased similarly with increasing soil-air content (?) . On the other hand, especially for soil samples repacked with a higher compaction level, measured ka showed a peak value at ? corresponding to the optimum moisture content. It may indicate that the formation of micro-aggregation of soil particles due to a higher compaction of soil samples with moderate soil-water content (i.e., optimum moisture content) enhanced advective flow through inter-aggregate pores (larger pores), resulting in higher ka values. The pore structure analysis based on the measured ka and Dp will be performed for investigating the effects of different compaction levels on the soil-pore characteristics for repacked soil samples with different size fractions.