Numerical Simulation of Quasi-steady-state Gas Flow in a Landfill

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Abstract

Landfill is currently the most dominating method to dispose wastes, which are caused by the lives of residents and constructions of cities and towns. Because of large amounts of organic substances in landfills, they will undergo continuous microbial degradation, which generates a lot of landfill gas. The gas consists mainly of CH4, CO2, O2 and N2, and it is also a promising source of renewable green energy. However, when CH4 reaches a certain concentration, it may cause terrible explosion, which is of great hidden danger to surroundings. Therefore, understanding of gas generation and transport in landfills is important for implementation of landfill gas collection and control. Mathematical models can help us understand the mechanism of gas generation and migration, and also predict the amount of the emission gas from landfill cover.
COMSOL Multiphysics was used to investigate the regular pattern of gas flow. This landfill is a simplified 2-dimension axisymmetric model (see Fig 1), with the radius being 50m and depth being 46m.[1] The gas extraction well is installed in the center of the landfill, whose radius is 0.05m and depth is 32.5m. The well is a passive system, because the gas goes through it just by its own pressure gradient. What's more, for preventing landfill gas escaping to the air, a final soil cover, which has low permeability, is capped above the landfill. The solid waste in the landfill is classified into three categories: readily biodegradable, moderately biodegradable and slowly biodegradable,[2] which have different degradation rates. Because the time scale of gas flow within the landfill isn't remarkable, the gas flow can be approximated as a quasi-steady state, and in this case gas flow is calculated by stationary interface. The pressure field is plotted in Fig 2 and the results show that the pressure lines close to the well are approximately vertical, which indicates that the gas moves almost horizontally and will be collected by the well. The black arrows show the direction of the gas flow and the pressure gradient. Fig 3 indicates that flow rate increases with increasing final soil thickness because the permeability of final soil cover is quite smaller than that of refuse, and the increase of final soil cover will cause greater resistance for gas to escape to the air. The influence of the final soil cover permeability on the flow rate from the well is plotted in Fig 4. The flow rate increase with the decreasing soil permeability of the cover, which means relative smaller permeability will also increase the resistance of gas emission. Above all, both increasing the thickness of final soil cover and decreasing the permeability of it can efficiently reduce the gas emission from the cover surface while increase the amount of gas extracted from the well.

Reference

[1] Chen Y C, Chen K S, Wu C H. Numerical simulation of gas flow around a passive vent in a sanitary landfill[J]. Journal of Hazardous Materials. 2003, 100(1-3): 39-52.
[2] Mehrdad Hashemi H I K T. Computer simulation ofgas generation and transport in lanfills I: quasi-steady-state condition[J]. Chemical Engineering Science. 2002.

Figures used in the abstract

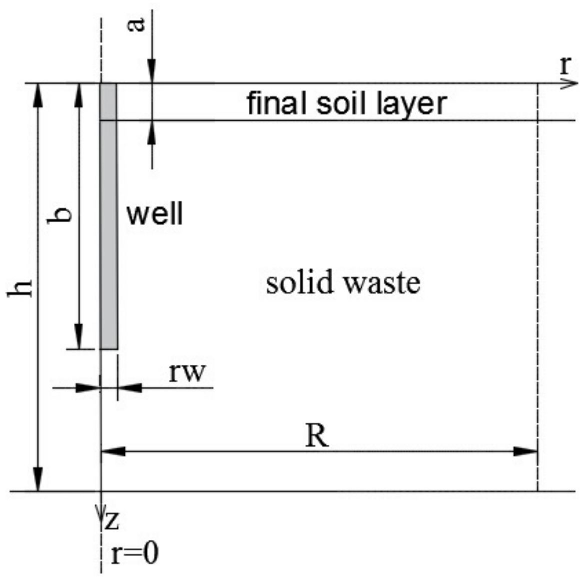

Figure 1: Fig 1 The landfill geometroy

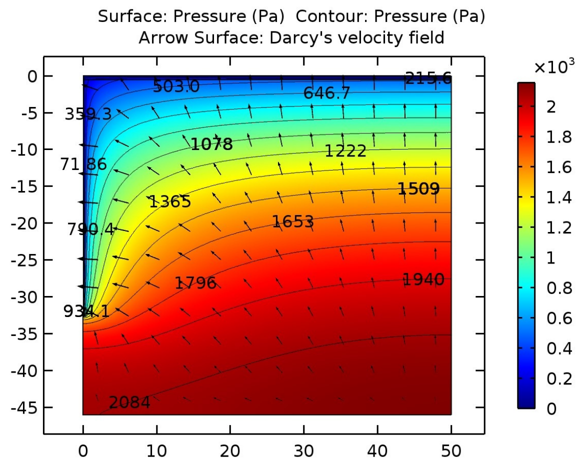

Figure 2: Fig 2 The pressure contour

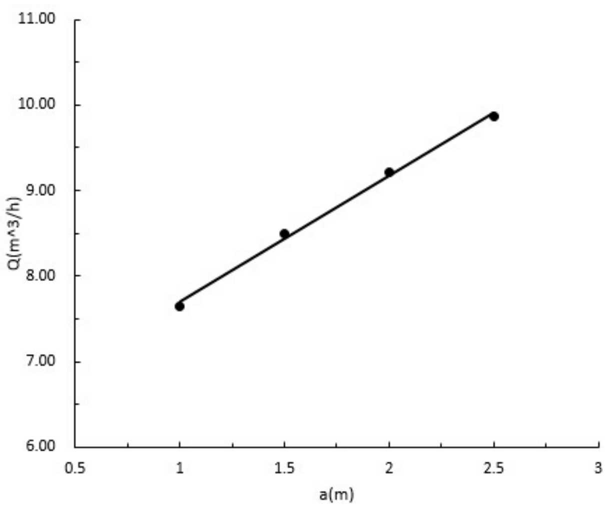

Figure 3: Fig 3 The variation of flow rate, Q, with the final soil thickness, a

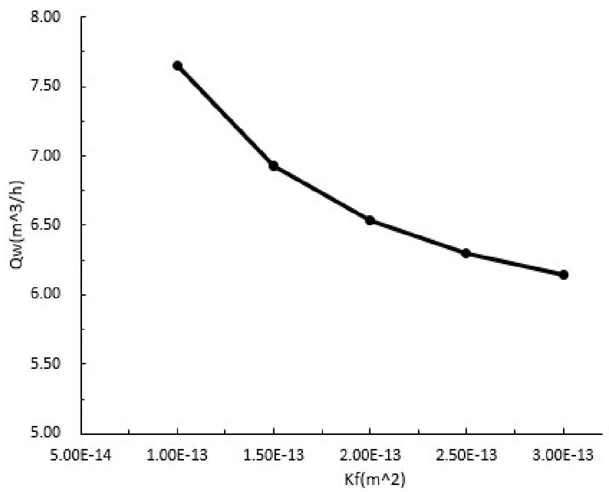

Figure 4: Fig 4 The variation of flow rate, Q, with the final soil permeability, Kf