Heat mitigation in compacted clay liners in municipal solid waste landfills

Keywords: waste; compacted clay liner; temperature; desiccation; rockwool; cooling pipe

In municipal solid waste (MSW) landfills, biodegradation of the organic MSW fraction results in elevated waste and basal liner temperatures which have the potential to cause the clay component of the basal liner to experience severe moisture loss over time and eventually undergo desiccation cracking. Cracking of the basal liner's clay component would result in an uncontrolled release of contaminants into the surrounding environment and ultimately give rise to a variety of major environmental concerns. Accordingly, this study examined the variation of temperature-moisture profiles along the depth of a compacted clay liner (CCL) exposed to different constant elevated waste temperatures (CETs) in the absence and presence of two heat reduction techniques, respectively.

Rockwool insulation layers with varying thicknesses and galvanized steel cooling pipes with varying flowrates were introduced separately as the two heat reduction techniques. The introduction of both techniques led to a significant attenuation of the temperature rise and desiccation experienced by the CCL in the face of different CETs.

A schematic cross-section diagram of a landfill profile following installation of the cooling pipe system is provided in Fig. 1(a).

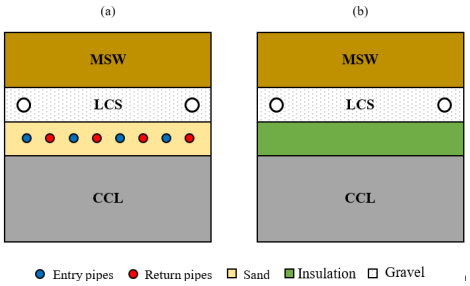

Fig. 1. Schematic landfill cross-section following the installation of a: (a) cooling pipe system; (b) insulation layer

In order to further analyse the effectiveness of cooling pipe utilization on CCL temperature reduction, the FT attenuation percentages (FTAPs) were calculated using Eq. (1) where the terms, T_{bc}, T_{cc},, refer to the base case FT and cooling case FT, respectively. The FTAPs calculated along the CCL depth denote the percentages by which the base case FT profile along the CCL depth reduced when cooling pipes were introduced.

$$TAP\ (\%) = \frac{T_{bc} - T_{cc}}{T_{bc}} \times 100 \qquad (1)$$

An increase in rockwool thickness increments led to a progressive reduction of CCL temperature, while an increase in flow rate under turbulent condition did not have a significant influence on the temperature and desiccation reduction of the CCL (Jayawardane, 2022). Nevertheless, the present study certainly highlights the potential of the two proposed heat reduction techniques to minimize desiccation and consequently increase the service life of CCLs exposed to different elevated temperatures in MSW landfills.

REFERENCES

Jayawardane, V. S (2022). Thermal and mechanical efficiency of municipal solid waste (MSW) landfill liners (Master dissertation, Monash University).