Countermeasures for alkaline leachate at coastal landfill sites

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1. Background and objectives

To close and utilize coastal landfill sites, the quality of leachate is required to satisfy the water quality standard. However, leachate dose not readily satisfy the standard. In some coastal landfill sites, leachate shows strong alkaline with pH higher than 11. For utilization of closed coastal landfill sites, pH needs to be lower than 9.0. Therefore, countermeasures to lower pH of leachate is strongly desired. In this study, to lower the pH of landfill leachate, three cost-effective measures which can be applied during landfilling process were studied. The three countermeasures are: (1) atmospheric aeration method by injecting CO_2 bubbles with nanobubbles size, (2) seawater introduction method by replacing inland seawater with fresh one and (3) downflow aeration through gravels [1]. In this study, the applicability and the effects of these three methods were evaluated by experimental and numerical methods.

2. Methodologies

1) Atmospheric aeration by nanobubbles: The effect of atmospheric aeration using CO_2 nanobubbles was tested. Water tank with a capacity of 25.5 L was used. Experimental water adjusted to pH 11 with CaO.
2) Seawater introduction: Pure seawater (pH 8.01) was continuously introduced into the alkaline water (pH 10.2) from the side of the water tank. The pH was continuously measured at three locations at horizontal distances of 6 cm (CH1), 30 cm (CH2), 54 cm (CH3), and depth of 12.5 cm. Furthermore, the experimental results were reproduced by calculation.
3) Downflow aeration through gravels: Containers with L 60.0 cm × W 17.0 cm × H 25.0 cm filled with gravel of 4-8 mm were placed in a water tank with L 5.0 m × W 1.0 m × H 2.0 m. Solution of pH 9.5 was circulated in water tank. Experiments were conducted with four cases, simulating a slope and a layered drainage.

3. Main achievements

1) In the nanobubble aeration experiment, it was confirmed that the pH of the simulated water was neutralized by the nanosized bubbles. The pH was neutralization from 11.0 to 9.0 by aeration for 7 days.
2) In the seawater introduction experiment, the pH neutralized from 10.28 to about 9.8 by injecting 4% of seawater to 25.5 L of alkaline water at the seawater injection position (CH1). In the numerical analysis, the experimental results were generally reproduced (Figure 1). The horizontal and vertical diffusion coefficients, D_H=0.186, D_{V1}=0.0035, and D_{V3}=0.0001 (cm^2/s) were obtained.
3) In the downflow aeration through gravels, the amount of CO_2 taken in the atmosphere by the gravel contact increased (Figure 2). Therefore, the neutralization of the pH was advanced. The pH was neutralized from 9.5 to 9.0 by installing a layered drainage about 42 m.

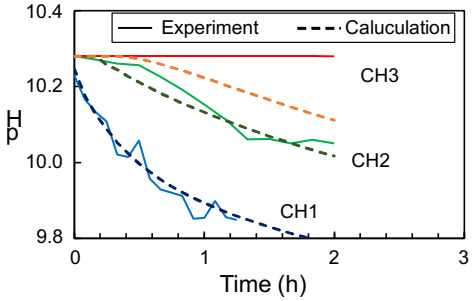

Figure 1 Results of seawater introduction experiment and analysis

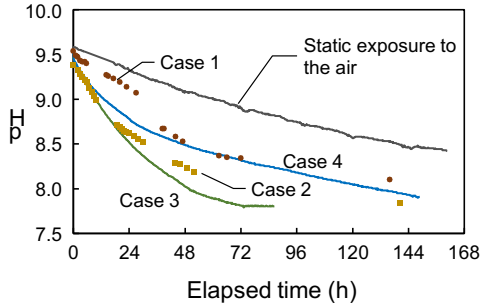

Figure 2 Result of gravel indirect contact experiment

Reference

[1] Yamasaki, T., et al. (2017): Proceedings of the 12th JGS Symposium on Environmental Geotechnics, pp.119-122.