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Assessment of internal condition of waste in a roofed landfill

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ABSTRACT

Recently, roofed landfills have been gaining popularity in Japan. Roofed landfills have several advantages over non-roofed landfills such as eliminating the visibility of waste and reducing the spread of offensive odours. This study examined the moisture balance and aeration conditions, which promote waste stabilisation, in a roofed landfill that included organic waste such as food waste. Moisture balance was estimated using waste characterization and the total amount of landfilled waste. Internal conditions were estimated based on the composition, flux, and temperature of the landfill gas. Finally, *in situ* aeration was performed to determine the integrity of the semi-aerobic structure of the landfill.

With the effects of rainfall excluded, only 15% of the moisture held by the waste was discharged as leachate. The majority of the moisture remained in the waste layer, but was less than the optimal moisture level for biodegradation, indicating that an appropriate water spray should be administered. To assess waste degradation in this semi-aerobic landfill, the concentration and flow rate of landfill gas were measured and an *in situ* aeration test was performed. The results revealed that aerobic biodegradation had not occurred because of the unsatisfactory design and operation of the landfill.

1. Introduction

Recently, the number of roofed landfill sites has increased in Japan. The first roofed landfill was built in July 1998, and as of 2010, 54 roofed landfills had been constructed or were under construction, accounting for approximately 2% of municipal solid waste (MSW) landfill sites (NPO·LSCS, 2009).

In a roofed landfill, the landfill area is enclosed by a roof and walls so that waste is not visible from the outside. The roof is either fixed after closure or removable. The latter type is used for landfills that are partitioned into several compartments, where a roof is moved from a closed area to the next active area. Eleven roofed landfills in Japan have a removable roof. The fabric of the roof is a translucent plastic membrane or steel folded plate. The landfill volume is relatively small, generally ranging from 1900 m^3 to 311,200 m^3, and there are only five roofed landfills in Japan that have a volume of 100,000 m^3 or larger. In Japan, a high percentage of MSW is incinerated, and thus landfilled waste consists mainly of incombustibles and incineration residues. Of the 54 roofed landfills, food waste is landfilled in only two sites.

The increasing popularity of roofed landfills stems from increasing awareness by residents and local governments of the advantages of this type of landfill. Roofed landfills (1) avoid the dirty image associated with landfills since waste is not visible from surrounding areas, (2) prevent the scattering of waste and dust and the spread of offensive odours, (3) produce a low and constant volume of leachate by controlling moisture input (cutting off natural rainfall and spraying regulated amounts of water), and (4) allow for easy use if the landfill is constructed underground or if the roof is constructed with concrete (Toge et al., 2004; Nagumo, 2004).

In roofed landfills, water supply is the key factor to promote stabilization. Otsuka et al. (2008) studied the removal of salt from several landfills containing different types of waste. The removal rate was correlated with the liquid/solid (L/S) ratio, and a macroscopic model was developed to determine the optimal precipitation rate. Ishii et al. (2004) performed experiments on the leaching of total organic carbon from incineration residue using a cylindrical acrylic column. The intensity and frequency of spraying water were modified to determine optimal conditions. Hasegawa et al. (2010) used a 20 m^3 lysimeter packed with incineration residue to determine the accumulated L/S ratio to meet effluent standards for biochemical oxygen demand (BOD), chemical oxygen demand (COD), and total nitrogen (TN). Nagata et al. (2004) and Kohinata et al. (2008) studied the leaching behaviour of organic matter (BOD, COD, TN) and inorganic matter (Ca, Cl, and electrical conductivity). Nagata et al. (2004) recirculated leachate in four experimental tanks packed with incineration residue. On the other hand, Kohinata et al. (2008) performed their studies in three real-scale landfills and measured the concentration of landfill gas and the waste temperature.

Most studies on roofed landfills have focused on incombustible waste and incineration residue, and there has been no previous report of a roofed landfill in which organic waste is deposited. However, because of the advantages described above, roofed landfills are expected to be attractive in other countries where mixed waste is landfilled without incineration or recycling of the organic

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fraction. Therefore, studies on roofed landfills with organic waste will be helpful for future use of this type of landfill.

This study examined a roofed landfill containing organic waste (including food waste). Landfill regulation in Japan obligates operators to monitor water quality of treated leachate discharging into environment and groundwater upper and lower point of landfill as environmental monitoring. Only after closure, landfill gas emission, temperature of landfilled waste, and leachate quality before water treatment are added in monitoring list for terminating aftercare. Therefore, data on monitoring internal condition of landfills is very limited.

In this study, the moisture balance and aeration conditions, which are the most important factors for promoting waste stabilization, were emphasized. Moisture balance was estimated based on waste characterization and the amount of waste landfilled, and internal conditions were estimated based on the composition, flux, and temperature of landfill gas. Finally, *in situ* aeration was performed to determine the integrity of semi-aerobic structures in the landfill.

2. Landfill description

2.1. Structure of the landfill site

Fig. 1a shows a general view of the studied landfill. The landfill covers an area of 27,000 m^2 and is divided into four compartments. The first compartment was used from October 2007 to August 2010, after which the roof was moved to the second compartment which was in use as of 2012. The roof is made of translucent plastic membrane, which allows for sun penetration to the landfill. This landfill has the second largest capacity among roofed landfills in Japan and is scheduled to be used until 2017.

The leachate collection and drainage pipe is made of perforated high-density polyethylene (HDPE). The diameter of the main pipe is 40 cm and the branch pipe is 20 cm. There are 12 branch pipes placed at intervals of 20 m in every compartment. The gas vent is made of perforated polyethylene pipe 20 cm in diameter. Six pipes are placed in each side at intervals of 20 m, but there is no gas vent in the centre of the compartment.

The internal arrangement is shown in Fig. 1b. The leachate collection and drainage pipe was covered with a protective layer (0.5 m depth). Collected leachate is drained gravitationally through the HDPE pipe (25 cm in diameter) to the leachate pit, where the leachate is automatically pumped to the regulating reservoir when leachate levels are increased and treated at the leachate treatment system. The volume of the regulating reservoir is 1300 m^3. This landfill is designed as a semi-aerobic landfill in which gas vents and leachate collection pipes are interconnected. Air is introduced from the lower end of the leachate collection pipe by natural convection (Matsufuji and Tachifuji, 2007). In addition, perforated polyethylene pipes (diameter 10 cm) are placed horizontally on the top of every waste layer to connect gas vents on the two sides. The length of the horizontal perforated pipe is 3240 m.

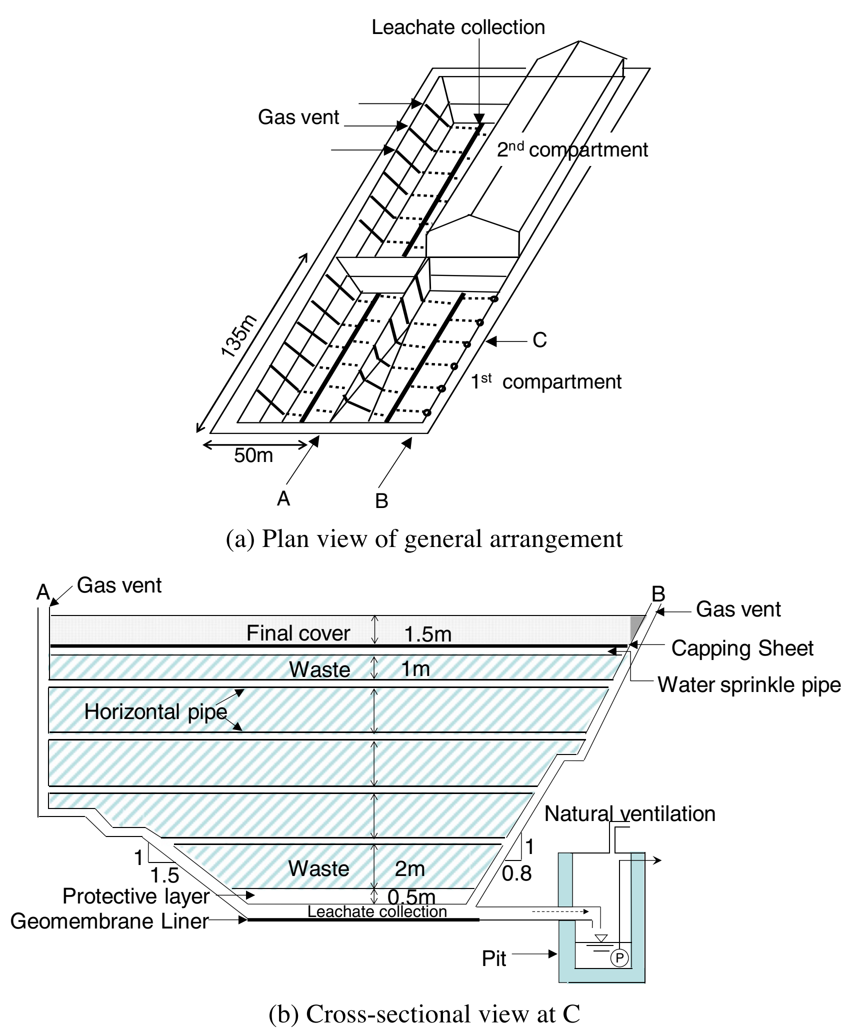

Fig. 1. Schematics of studied landfill.