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The impact of compaction and leachate recirculation on waste degradation in simulated landfills

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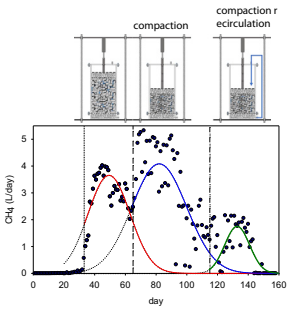
HIGHLIGHTS

- Waste compaction could result in either inhibiting methanogens or promoting methane production.
- Compaction reduced pore space and increased the contact surface area.
- Determining timing for compaction in wet waste is critical to control MSW degradation.

GRAPHICAL ABSTRACT



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ABSTRACT

This study investigated the impact of compaction and leachate recirculation on anaerobic degradation of municipal solid waste (MSW) at different methane formation phases. Two stainless steel lysimeters, C1 and C2, were constructed by equipping a hydraulic cylinder to apply pressure load (42 kPs) on the MSW. When MSW started to produce methane, C1 was compacted, but C2 was compacted when the methane production rate declined from the peak generation rate. Methane production of C1was inhibited by the compaction and resulted in producing a total of 106 L methane (44 L/kg VS). However, the compaction in C2 promoted MSW degradation resulting in producing a total of 298 L methane (125L/kg VS). The concentrations of volatile fatty acids and chemical oxygen demand showed temporary increases, when pressure load was applied. It was considered that the increased substrate accessibility within MSW by compaction could cause either the inhibition or the enhancement of methane production, depending the tolerability of methanogens on the acidic inhibition. Leachate recirculation also gave positive effects on methane generation from wet waste in the decelerated methanogenic phase by increasing mass transfer and the concentrations of volatile fatty acids.

1. Introduction

Waste placement, compaction, and/or leachate recirculation are common practices in a bioreactor landfill during or after landfilling municipal solid waste (MSW). These practices change the geotechnical properties of landfilled MSW and can affect the degradation of MSW. Due to the compressibility of MSW, landfilled MSW is densified by compaction. The densification of MSW can lead to increase biomass density as the result of void space reduction. Waste placements cause an increase in self-weight stress on landfilled MSW. Consequently, the void ratio of MSW is reduced and the unit weight of MSW increases with increasing waste depth (Chen et al., 2009; Machado et al., 2010; Stoltz et al., 2010). Chen et al. (2009) observed that the void ratio of the waste samples

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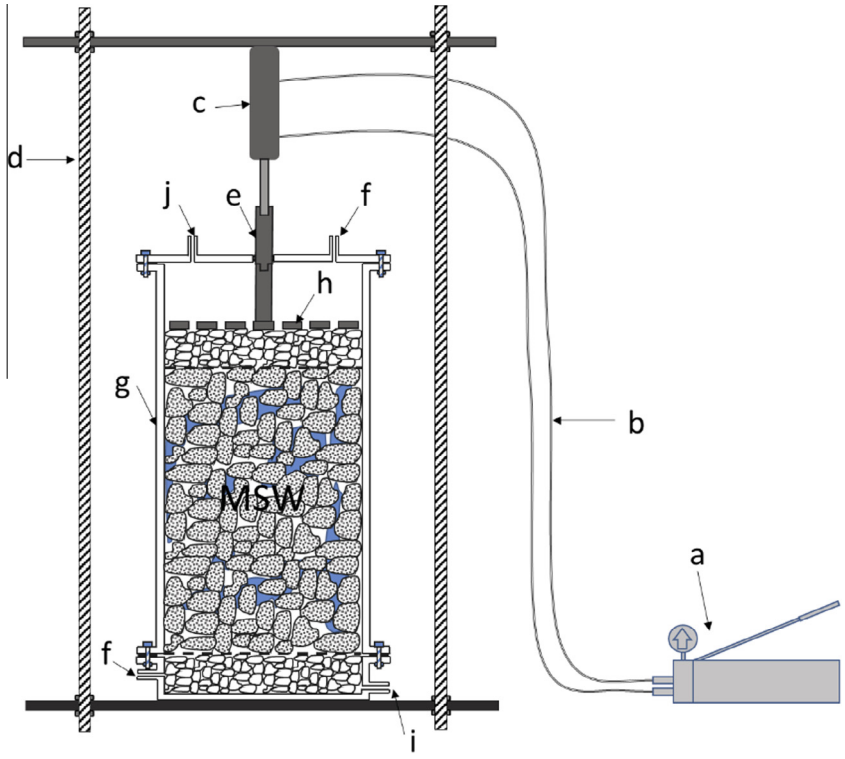

Fig. 1. Schematic diagram of a lysimeter. (a) Manual hand pump with a hydraulic pressure gauge, (b) hydraulic hose, (c) hydraulic cylinder, (d) metal frame, (e) extendable shaft, (f) gas collection ports, (g) stainless steel column, (h) compression plate, (i) leachate collection port, and (j) leachate recirculation port.

Table 1
The initial property of each MSW component in simulated reactors.

Component	Percent (%) w/w	Wet weight (kg)	Water content (%, w/w)	Total solid (kg)	Volatile solid* (%)
Food waste	57	5.13	77.3	1.17	73.8
Paper	9	0.81	5.3	0.77	76.1
Plastic	10	0.90	0.2	0.90	99.9
Glass	3	0.27	0.0	0.27	0.0
Metal	1	0.09	0.0	0.09	2.8
Soil	20	1.80	16.7	1.50	3.0
Total	100	9.00	–	4.70	–

* Dry weight basis.

Table 2
Summary of operation conditions of C1 and C2.

Bioreactor	Aerobic pretreatment	Anaerobic operation without compaction	Anaerobic operation with compaction but without leachate recirculation	Anaerobic operation with compaction and leachate recirculation
C1	• 27 day • Aeration gradually reduced (aeration 2 or one times/d, 2 h/time, 600 mL/min) • Leachate was recirculated	• 28–36 day • Not compacted • No leachate recirculation	• 37–113 day • Pressure load (42 kPa) was applied when CH% reached over 30%	• 114–158 day • Leachate recirculated every second day • 500 mL of water was added • Compacted
C2	• 32 day • Aeration gradually reduced (aeration 2 or one times/d, 2 h/time, 600 mL/min) • Leachate was recirculated	• 33–64 day • Not compacted • No leachate recirculation	• 65–113 day • Pressure load (42 kPa) was applied when CH% was over 60%	• 114–158 day • Leachate recirculated every second day • No additional water • Compacted

decreased from above 3 to around 1 with increasing depth of waste from 0 to about 35 m. Landfilled MSW has heterogeneous nature in both geotechnical properties and the distribution of microbial communities. Staley et al. (2011) observed the presence of large spatial differences in refuse pH, moisture content, and volatile fatty acids (VFAs) concentrations in a refuse lysimeter at the initiation of methanogenesis. They hypothesized that methanogenic sites might exist in very small scales before methanogenesis.