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Case study of landfill leachate recirculation using small-diameter vertical wells

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ABSTRACT

A case study of landfill liquids addition using small diameter (5 cm) vertical wells is reported. More than 25,000 m^3 of leachate was added via 134 vertical wells installed 3 m, 12 m, and 18 m deep over five years in a landfill in Florida, US. Liquids addition performance (flow rate per unit screen length per unit liquid head) ranged from 5.6×10^{-8} to 3.6×10^{-6} $m^3\ s^{-1}$ per m screen length per m liquid head. The estimated radial hydraulic conductivity ranged from 3.5×10^{-6} to 4.2×10^{-4} m s^{-1}. The extent of lateral moisture movement ranged from 8 to 10 m based on the responses of moisture sensors installed around vertical well clusters, and surface seeps were found to limit the achievable liquids addition rates, despite the use of concrete collars under a pressurized liquids addition scenario. The average moisture content before (51 samples) and after (272 samples) the recirculation experiments were 23% (wet weight basis) and 45% (wet weight basis), respectively, and biochemical methane potential measurements of excavated waste indicated significant ($p < 0.025$) decomposition.

1. Introduction

Bioreactor landfills are designed and operated to optimize the municipal solid waste (MSW) stabilization process rather than to simply contain the wastes as prescribed by most regulations (Reinhart and Townsend, 1997; Reinhart et al., 2002). Addition of liquids is the most common approach in bioreactor operations; leachate is the most common liquid supply, but other moisture sources can be used. Subsurface moisture addition techniques are the more feasible approach compared to surface application at large landfills. In subsurface systems, the liquids are added to the landfilled waste through devices such as trenches, wells, and galleries (Benson et al., 2007; Bareither et al., 2010; Barlaz et al., 2010), with pressure commonly applied to promote moisture distribution (pressurized addition is supplied by a pump or a standing head of liquid).

Horizontal leachate injection trenches are common but must be constructed at multiple elevations during waste placement to achieve even moisture distribution throughout the waste. Vertical wells allow the operator to retrofit landfill areas that are already filled with waste and minimize the interference of liquids addition device construction with routine landfill operations by waiting until waste placement is complete. While some field experience and experimental results from buried horizontal systems have been reported, similar data for vertical well systems have not been reported, although the practice of using vertical wells for leachate recirculation has been described (Benson et al., 2007; Bareither et al., 2010; Barlaz et al., 2010).

This paper provides a case study of liquids addition experience using small-diameter vertical wells at an operating MSW landfill in Florida (New River Regional Landfill [NRRL]). Results from various experiments at the site have been reported previously (e.g., estimating in-situ air permeability and hydraulic conductivity of

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landfill waste, Jain et al., 2005, 2006; assessment of in-situ moisture sensors, Kumar et al., 2009; experience with air addition, Powell et al., 2006; Ko et al., 2013).

In this study, 5 years of performance data and lessons learned from the operation of a vertical well liquids addition system are summarized. The paper reports on vertical well performance with respect to well depth, various leachate seep control techniques (e.g., installation of seep control collar, and limiting liquids head in wells), system operating issues, and an assessment of the degree of waste stabilization. The information presented is valuable for design, operation and monitoring of future liquids addition systems at landfills.

2. Material and methods

2.1. Site description

The NRRL receives mixed residential, commercial, and light industrial waste at a rate of approximately 700 metric tons (MT) per day. Clayey–sandy soil mined on site was used as daily cover. Approximately 4 hectares of Cell 1 and part of Cell 2, containing approximately 550,000 MT of MSW, were retrofitted to operate as a bioreactor landfill, as shown in Fig. 1. The leachate collection system for these cells, which are not hydraulically separated, was constructed with a saw-tooth pattern, with a total of eight leachate collection pipes each connected to a dedicated sump. Only 6 pipes are shown in Fig. 1 and the remaining two pipes were located in the eastern section of Cell 2 not shown in Fig. 1. Leachate from these sumps gravity drained to a wet well where it is then pumped to one of two 1900-m^3 capacity leachate storage basins (Fig. 1) – note that leachate from all other lined cells at the site was also pumped from different sumps to the storage basins. The maximum waste depth of the tested area was 22 m at the beginning of bioreactor landfill operation. Systems for moisture addition, air injection (air injection experiments in this site were reported by Powell (2005) and Powell et al. (2006)), gas extraction, as well as a range of instruments, were installed as part of research to examine several technical aspects of full-scale bioreactor landfill operation. More information on the bioreactor landfill and related infrastructure can be found elsewhere (Jain, 2005; Jain et al., 2005, 2006; Powell et al., 2006; Kumar et al., 2009; Jonnalagadda et al., 2010).

Due to concerns of potential accumulation of more than 30 cm of leachate on the liner, the state permit specified a maximum daily recirculation volume of 218 m^3 and 132 m^3 for the first 250 days and after 250 days, respectively. The permit also required cessation of liquids addition if the daily leachate collection volume from any of the eight leachate collection pipes exceeded 24 m^3. These limits were not exceeded at any point during the study period. The leachate inflow rate into each sump was measured using a 22.5° V-notch weir box and an ultrasonic meter (Ametek

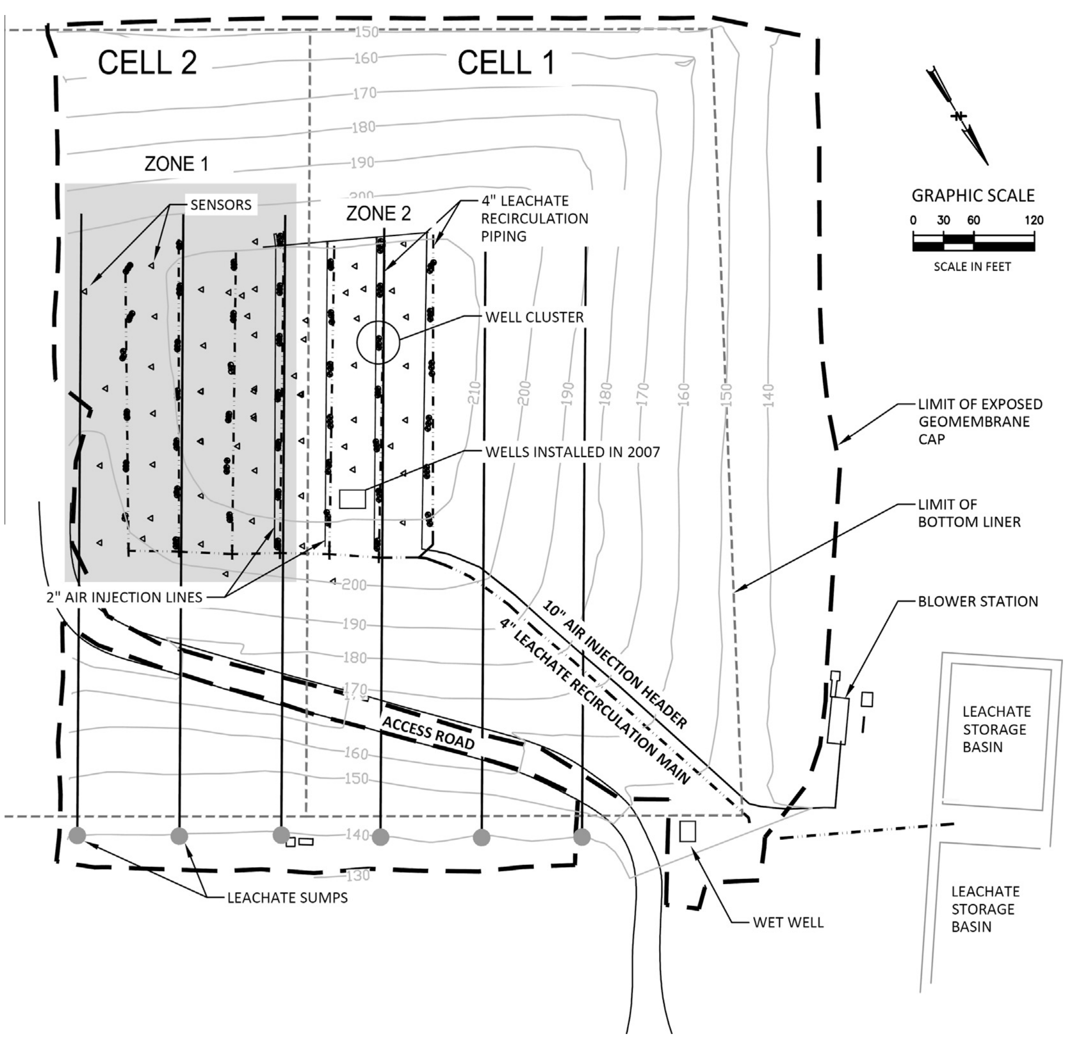

Fig. 1. Bioreactor well field layout.