IMPROVED MANAGEMENT PRACTICES FOR A GEORGIA LANDFILL

Matt C. Smith[1] and David K. Gattie[2]

AUTHORS: [1]Associate Professor of Biological and Agricultural Engineering, and [2]Instructor of Biological and Agricultural Engineering, University of Georgia, Athens, Georgia 30602.
REFERENCE: Proceedings of the 1999 Georgia Water Resources Conference, held March 30-31, 1999, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, the University of Georgia, Athens, Georgia.

Abstract. Uncontrolled anaerobic bioreduction in landfills is a slow metabolic process that generates high levels of methane and trace amounts of other noxious gases. To determine the potential for using leachate recirculation and air injection as a means for converting anaerobic processes to more rapid aerobic processes, and to significantly reduce production of methane, a $\pm$2.5 acre, 70000 yd^3 cell within a sanitary municipal solid waste landfill located near Atlanta, Georgia was selected as a test site where methane was used as the primary parameter indicating associative aerobic/anaerobic activity levels. Results indicate significant decreases in initial methane and CO_2 levels from 46% and 54% to averages of 10% and 20% respectively. Temperatures for the more exothermic aerobic reactions were kept under control through leachate recirculation while leachate quality was not negatively impacted. Respirometry data on bulk material indicated a high percentage of inert, high quality compost-like material after 10 months.

INTRODUCTION

Municipal solid waste landfill practices in Georgia have for some years now focused on protecting the surrounding environment from negative impacts that can result from the disposal of leachable solid waste. Environmental concerns regarding the impact of landfill leachate on ground water quality and noxious gas production from anaerobic decomposition have led to regulations under Subtitle D of the Resources Conservation and Recovery Act (RCRA) concerning bottom-lining, leachate collection and capping of landfills for a prescribed number of years to allow landfill waste to stabilize. One objective of these regulations is to limit the amount of water infiltrating the landfill matrix, thus reducing collected leachate and the possible adverse impacts it may have on surrounding groundwater. While such entombment serves the purpose of environmental protection for the short term, there remains the long-term monitoring of landfill gas emissions and groundwater quality. Moreover, handling of collected leachate remains a concern. This paper discusses a more progressive management approach where collected leachate is recycled through the landfill matrix and, combined with air injection, is used to enhance quiescent microbiological processes within the landfill to stabilize solid waste more rapidly while generating an inert compost-type by-product that could be mined for alternate applications. Such an aggressive approach would more quickly reclaim space and render the landfill reusable rather than entombed.

Municipal solid waste landfills (MSWL) are unique in that, because of bottom lining and capping, they are essentially isolated ecosystems where solid waste stabilization is carried out by indigenous anaerobic microbiological processes. Left ungoverned, stabilization of landfill waste could require up to several decades as anaerobic decomposition may become moisture-limited. With 83 MSWL's in the state of Georgia (Georgia Dept. of Natural Resources) a more advanced management approach towards landfill operation might be based in designing landfills to behave not as an entombed storage facility but as a treatment facility or bioreactor where such parameters as pH, moisture content, temperature, nutrients, particle size and redox potential are monitored and may be altered to enhance microbial activity. Of these parameters, moisture content is one of the most critical affecting microbiological processes within the landfill (Reinhart, et al, 1998). As pertains to the traditional landfill, moisture is generated from biological and chemical reactions within the landfill matrix while additional moisture results from infiltration of precipitation through the landfill cap. Moisture then migrates downward through the landfill matrix. The landfill matrix itself is spatially heterogeneous with regard to such parameters as resident microbial populations, available nutrients and enzymes, and presence of inhibitory compounds. Moisture migration serves to distribute nutrients and enzymes, buffer pH and dilute compounds that may inhibit microbial processes. Increasing moisture movement would enhance these already critical processes of landfill decomposition. Laboratory, pilot and full-scale studies have shown that the introduction of water into the landfill matrix can be highly effective at enhancing anaerobic activity resulting in a considerable decrease in landfill stabilization time (Tittlebaum, 1982; Doedens, et al, 1989; Leckie, et al, 1979; Natale, et al, 1985). In these studies, moisture content was regulated by recirculating collected leachate back into the landfill matrix. Also, leachate quality was used as an indicator of the progression of the landfill stabilization process as to which phase of stabilization it was in. Under these conditions, disposal of excess methane generation is a primary concern. While on-site combustion is the traditional approach, more recent efforts have been directed towards generating a clean methane by-product suitable for marketing.

Two aspects of the aforementioned approach give cause to consider alternate techniques. First, anaerobic decomposition is slow when compared with aerobic, and secondly, methane production is not always desirable. An alternative is to enhance aerobic microbiological processes which remain dormant under normal landfill conditions. Even with leachate recirculation, aerobic decomposition is significantly minimized or negated. While aerobic reactions are faster and more energy efficient, they are also more exothermic, which is why temperature control is a primary concern when converting landfills to aerobic decomposition. To achieve aerobic conditions and control temperatures, air must be introduced into the landfill matrix and the landfill must be cooled.

This paper discusses an approach taken to enhance normally dormant microbiological processes in a landfill test cell using aeration via air injection wells while dissipating heat through leachate recirculation. Specific objectives to the project were to:

1. significantly decrease generation of methane and other noxious gases by converting the landfill microbiological processes from anaerobic to predominantly aerobic
2. control landfill temperatures
3. promote measurable settlement of the landfill matrix
4. convert landfill waste into an inert, compost-like material suitable for alternate purposes

The landfill matrix was aerated using air injection wells while leachate recirculation wells were installed to provide necessary moisture content and to dissipate excess heat generated from the more exothermic, aerobic processes. Methane levels throughout the landfill matrix were used as indicators of associative anaerobic/aerobic activity and leachate quality was monitored to determine any adverse effects of leachate recirculation.

The successful operation of an aerobic landfill in the state of Georgia and subsequent reclamation of landfill space could set the precedent for future landfill practices that may have a significant impact on Georgia water resources.

EXPERIMENTAL PROCEDURE

Site Description

A ±2.5 acre test cell, designated 3A, containing approximately 70,000 cubic yards of waste within a landfill located in Atlanta, GA was the site of the project. The landfill conformed to Subtitle D regulations and standard landfill operations had been followed for the lifts and cover material prior to the experiment where lift covers were removed daily prior to dumping of new trash. Upon completion of the cell in the spring of 1996, a soil cap, 1- to 1.5 ft. deep, was installed. Initial land surveys of the completed test cell surface were conducted to establish topography and elevations, and monuments were set as references to determine subsequent settling of the landfill.

Overview of Project

The landfill test cell was closed down and capped in the Spring of 1996. 27 leachate recirculation wells and 18 air injection wells were bored into the landfill matrix in August 1996 along with 2 additional wells to monitor temperatures at shallow, mid and deep levels. Following well boring, distribution systems for both leachate recirculation and air injection were installed. Experimental checks on the wells and distribution systems were performed in early January 1997. Experimental procedures, starting with leachate recirculation, began in January 1997 and continued through September 1997. Approximately 100,000 gallons of leachate and supplemental water were recirculated through the test cell until mid-February, at which point air injection began. During the first few weeks of air injection, leachate recirculation wells were uncapped to allow venting of methane and carbon dioxide. Leachate sampling began in January 1997 on two week intervals and continued through June 1997 while bulk landfill material was sampled in May 1997. Throughout the experiment, the air and leachate distribution systems were used to regulate temperatures and gas levels, which were continuously monitored for each well. Following completion of the project, the landfill was left to naturally-occurring microbial decomposition.

Air Injection and Water Recirculation System

Grid points were established by survey to locate sites for the leachate recirculation, air injection and monitoring wells which were bored in August 1996. Auguring was very difficult due to the nature of material, as carpet, cloth, plastic and wire posed as obstructions. Initially, eighteen air- injection wells were installed at depths ranging from 15 to 20 feet along with twenty-seven leachate-recirculation wells at depths of 5 to 15 feet. Screen lengths were 10 to 15 feet for the air-injection wells and 2 to 5 feet for the leachate-injection wells. Because of the heterogeneity of waste material throughout the cell, which often impeded air and water infiltration, all wells were subsequently altered to accommodate air injection and leachate recirculation so as to provide increased homogeneity for oxygen and moisture throughout the cell matrix. Two additional wells for in-situ monitoring of temperature, methane, carbon dioxide and oxygen were placed at both the east and west ends of the test cell. Thermocouples were located on the exterior of the monitoring well casings at deep, mid and shallow levels. Moreover, since temperature was not homogeneous throughout the cell, nine additional injection wells were randomly chosen to include monitoring capabilities for temperature and gas levels. Thermocouples at these locations were located on the interior of the wells at the well bottom. Each well was completed above ground with a ball valve control, influent hose attachment and a removable cap. An additional control valve was installed to allow both air and leachate injection. Also, a sampling port was included to allow in-situ gas sampling.

MEASURED PARAMETERS AND SAMPLING

Landfill temperatures were measured in-situ using thermocouples. Methane, carbon dioxide and oxygen levels were also monitored in-situ using an in-field gas sampler. Leachate samples were taken from the on-site leachate tanks and transported to the Biological and Agricultural Engineering Department's laboratory. BOD, COD, percent volatility and respirometry were determined using standard analytical methods (Standard Methods, Greenberg, et al,1992). Simultaneous monitoring of gas levels and temperature was necessary to ascertain dangerous conditions of high methane generation and high temperature. This signaled increased anaerobic activity and was the cue for increasing air flow to reduce anaerobic metabolism and thus reduce methanogenesis. Beginning January 1997, leachate samples were collected every two weeks and analyzed for standard water quality indicators. Bulk landfill material was collected during the boring of the injection wells and also in late May 1997. Also, professional land surveying was done to determine landfill settlement.

RESULTS AND DISCUSSION

Initial additions of supplemental water and the subsequent recirculation of leachate from mid-January to mid-February resulted in little change in methane and CO_2 levels which initially were 46% and 54% respectively. However, within 24 hours of the 200 cfm air injection in mid-February these levels were reduced to averages of 10% and 20% coincident with significant increases in temperatures [FIGURES 1 & 2]. These reduced levels of methane reflect a significant decrease in anaerobic activity while temperature increase may indicate an increase in more exothermic aerobic decomposition processes. With methane levels down and temperatures peaking at 140+°F, it is assumed that anaerobic activity is primarily thermophilic. Spatial variability of temperature and gas levels existed indicating that air and water were not infiltrating uniformly throughout the test cell. This is most likely due to the heterogeneous nature of landfill material which may prohibit or hinder significant air and water flow.

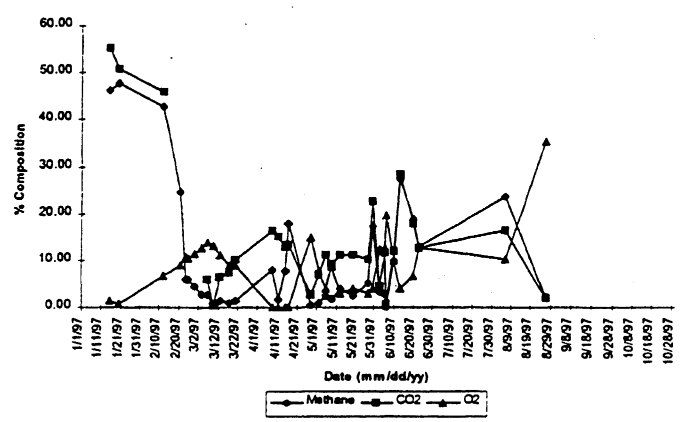

Figure 1. Landfill gas compositions.

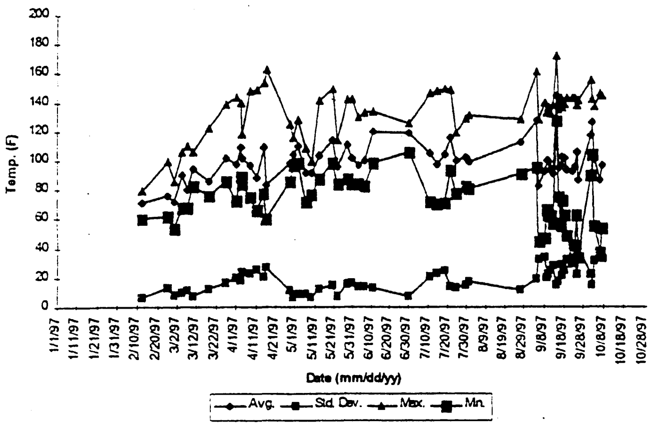

Figure 2. Average landfill temperatures.

With the exception of 3 days when temperatures peaked above 160°F, recirculated leachate and supplemental water additions were effective at maintaining temperatures at safe levels throughout the project.

Respirometry nalysis of bulk samples taken in May and September show little microbial activity which may indicate stability of bulk material (FIGURE 3).

Leachate was sampled through the end of June, 1998. BOD and COD showed similar increases until mid-May at which point BOD began to decrease significantly. It has been proposed that the ratio of BOD/COD might be used as one indicator of landfill stability where levels <0.1 indicate a measure of stability (Reinhart, 1998). A plot of BOD/COD shows decreasing ratios from May through the end of June where the ratio reached 0.25 (FIGURE 4). Surficial cracks and depressions were evident after eight weeks with major settlement of up to 1 foot after 14 weeks indicating settlement was appreciable.

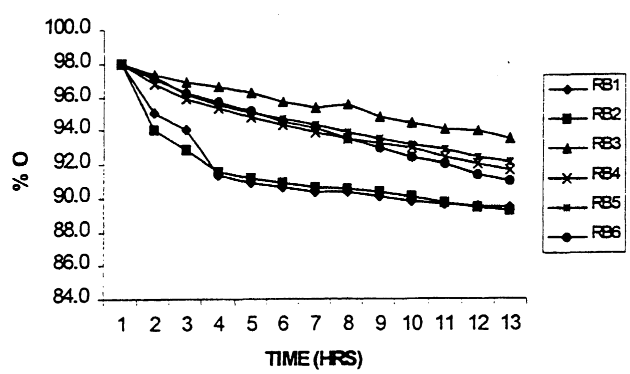

Figure 3. Respirometry of bulk material

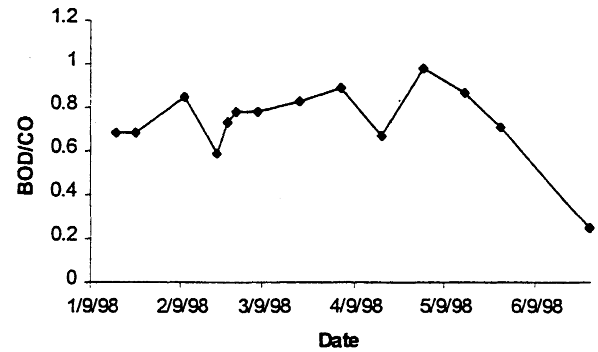

Figure 4. BOD/COD ratios of landfill leachate

DISCUSSION

This work represents a new direction where good management practices based on sound scientific and engineering principles could turn landfill operations into reusable bioreactors. Reducing the need for new facilities has immediate implications regarding environmental impact and translates directly into less land being tied up as entombed landfill space.

REFERENCES

Reinhart, Debra R. and Timothy G. Townsend., *Landfill Bioreactor Design and Operation*, Lewis Publishers, 1998.

Tittlebaum, M.E. 1982. Organic carbon content stabilization through landfill leachate recirculation. *J. Of Water Poll. Cntl. Fed.* 54:428.

Doedens, H. and K. Cord-Landwehr. 1989. Leachate recirculation. In *Sanitary Landfilling: Process, Technology and Environmental Impact*, T.H. Christensen, R. Cossu, and R. Stegmann, Eds., Academic Press, London.

Leckie, J. O., J. G. Pacey, and C. Halvadakis. 1979. Landfill management with moisture control, *J. of Env. Eng.* 105(EE2): 337.

Natale, B. R. and W. C. Anderson. 1985. *Evaluation of a Landfill with Leachate Recycle*. Draft Report to U.S. EPA Office of Solid Waste.

Greenberg, Arnold E., Lenore S. Cleseri, and Andrew D. Eaton, eds. *Standard Methods for the Examination of Water and Wastewater*. 1992. American Public Health Association.