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FULL-SCALE LEACHATE-RECIRCULATING MSW LANDFILL BIOREACTOR ASSESSMENTS

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INTRODUCTION

The integrated waste management hierarchy philosophy continues to develop as a useful tool to solve solid waste issues in an environmentally responsible manner. Recent statistics indicate that approximately two thirds of municipal solid waste in the United States is disposed in landfills. EPA research has continued to develop and refine the variety of technologies, materials, and operational techniques to further reduce risk from this most often used form of waste disposal.

Current landfill operational technique involves the preparation of a waste containment facility, the filling of the waste unit, installation of the final cover, and the maintenance of the unit. The goals being to isolate the waste from people, and to minimize infiltration of water, thus minimizing releases of moisture and decompositional gases into the environment. This method of operation has proven to be reasonably effective in waste disposal, effectively minimizing risk by collecting the liquid that percolates through the waste, called leachates, at the bottom of the landfill, and controlling landfill gas with collection systems. Effective gas collection often results in utilization of the gas for other purposes.

Concerns over the longevity of containment systems components present questions that cannot be answered without substantial performance data. Landfills, as currently operated, serve to entomb dry waste. Therefore, the facility must be maintained in perpetuity, consuming funds and ultimately driving up waste collection costs. Further, there is a concern about rare but possible environmental impacts from leakage through lining or cover components and possible catastrophic failures of the landfill system.

This presentation will describe a new form of solid waste landfill operation, it is a technique that involves controlled natural processes to break down landfilled waste, and further minimize risk to human health and the environment.

A landfill operated in an active manner will encourage and control natural decomposition of landfilled waste. This can be accomplished by collecting leachate, and reinjecting it into the landfilled waste mass. Keeping the waste mass moist will lead to a largely anaerobic system with the capacity to rapidly stabilize the landfilled waste mass via physical, chemical and biological methods. The system has proven the ability to breakdown portions of the waste mass, and to degrade toxic materials at the laboratory scale.

METHODOLOGY

Experiments are designed to compare similar landfill cells as each is operated in a different manner, either wet or dry. The experiments are time consuming and require long-term commitment to research. The projects are also very costly because of their magnitude. To gather data and analyze results, U.S. EPA embarked on a research program to study this operational technique for MSW landfills in the early 1980s. Bench-scale laboratory research on the anaerobic bioreactor in MSW landfills was conducted with the assistance of The Georgia Institute of Technology (1). Researchers found that by simply reinjecting common MSW landfill leachate under controlled sequences that the following benefits could potentially be realized at full scale:

- expansion of landfill capacity through volume reductions induced by biological decomposition of MSW in the landfill, reducing the actual number of landfills that must be sited

- improved quality and quantity of recoverable landfill gases (methane and carbon dioxide) through controlled biological reactions
- toxicity reduction of the MSW mass through biological decomposition and immobilization in the waste mass resulting in lower pollutant concentration in leachate
- reduced post-closure monitoring time due to toxicity reduction

Building upon this fundamental research, EPA sponsored further research to take this operational technique to the field in the form of pilot-scale landfill test cells (2). Anticipating the opportunity to build on this research, full-scale landfills were sought and selected to prove the technology at full-scale. One landfill was selected near Gainesville, Florida, and another landfill project is in the construction phase near Rochester, New York.

Table 1. U.S. EPA Landfill Bioreactor Projects in 1994

Location	Scale	Description	Status	Ref
Georgia	Lab	Model Landfill Lysimeters	Completed '93	1
Delaware	Pilot	Test Cells 2 each, 1 acre each, wet vs. dry	Covered	2
Florida	Full	Active Fill - 6 acres	Filling	3
New York	Full	Active Fill - 10 acres	Filling	4
Ohio	Full	Remediation of Existing Landfill	Planning	5

In addition to these activities, EPA is tracking related projects in the United States, and around the world. EPA is also pursuing the application of this technology in a remedial manner at an unlined, uncontrolled landfill.

Leachate-Recirculation Process

Prototype methods which have been utilized to date include surface spraying, surface ponds, vertical injection wells with and without wicks, and horizontal surface infiltration devices. Generally, additional costs for leachate recirculation materials are relatively low. For proper execution of a leachate recirculation system at a modern MSW landfill, the following components are generally considered to be necessary:

- a composite lining system comprised of a single or double composite compacted soil and a geomembrane, with leachate handling system.
- MSW placed at a density determined to accommodate leachate recirculation
- daily cover that does not significantly affect the continuous passage of moisture through the landfill from top to bottom (this rules out many traditional MSW landfill daily cover practices)
- a leachate reintroduction system that is concealed within the landfill enclosure, that only uses native landfill leachate
- an active gas collection system as part of a comprehensive landfill cap design
- a landfill cover capable of providing modern landfill cap functionality, that can maintain integrity as the leachate recirculation process causes landfill volumes to decrease,

- a trained landfill operator who understands the daily operational requirements of a leachate-recirculating landfill

Many of these issues remain as engineering challenges that need to be resolved in full-scale implementation.

The leachate-recirculation process is fundamentally simple, requiring relatively minor changes over the current designs. However, the number of variables involved to demonstrate control over the reactions in these studies are numerous, and every attempt is made during experimental design to control the number of variables. Operator training is critical, and outputs from these projects are aimed at operator control. As a matter of practicality, experiments to evaluate materials that may be added to the landfill during filling to enhance degradation have been relegated to future experimentation. Possible additions include waste pre-processing, microbiological additives, waste sludge, gases, or the control of temperature of the waste mass.

Concurrent with EPA research, other research projects are underway in the USA and around the world. There are new projects being initiated in California, Florida and New Hampshire, and underway around the world in Canada, Germany, Denmark, Italy, Sweden, Japan, and United Kingdom. The collective database formed in the study of these landfills will supply enough information to assess the performance of this operational technique in the field.

Landfilling in the Future

As landfills continue to evolve as sophisticated waste disposal and decomposition facilities, there are new goals anticipated for the future. Foreseen is a waste management park that will involve centrally located management of a variety of waste streams, of which a landfill will provide a necessary service. Waste water, sludges, composted waste and green waste, MSW materials recovery facilities, incinerators, and recycling facilities require inputs and outputs that can be integrated resulting in more efficient processing of MSW.

The landfill could produce an output of low to medium grade compost that could be used for soil amendments in roadways and earth works. Gas from the landfill could be used to generate electricity or power collection vehicles. The landfills could be arranged in a turntable-type arrangement so that cell #1 of the landfill can be constructed, filled, covered, and placed under leachate recirculation, then on to cell #2, where the process is repeated, and so on. When all cells are complete, the operator returns to cell #1, where the contents could be mined (7), with recyclables and compost removed, the bottom lining inspected and replaced when necessary, and the entire process again. While this technique will likely not eliminate the need to site new landfills, it will significantly increase the useful life of landfills when constructed to operate as bioreactors.

RESULTS

The status of active EPA sponsored projects are described here. The effort has benefitted from the active participation of major waste management companies in the USA, and from the collaborative research efforts of EPA's colleagues, and their participation is gratefully acknowledged. Results to date are derived from the following projects:

Laboratory Lysimeter Studies

Completed in 1993, the research performed at the Georgia Institute of Technology and University of Pittsburgh showed leachate recirculation offers rapid and complete stabilization of the landfilled waste masses. The system proved resiliency to toxic loadings that caused retardation but not defeat of the stabilization process. The study showed that landfills are capable of biological and physicochemical

reactions to attenuate waste constituents via reduction, precipitation, and matrix capture for heavy metals, and biotic and abiotic transformation, and sorption for organic materials. The study also showed that the performance of the bioreactor landfill can be monitored with leachate and gas parameters during significant phases of the reaction. The study concluded that the bioreactor landfill design is viable, and offers a significant improvement over traditional landfill operation (1).

Pilot-Scale Landfill Test Cells - Delaware

Two 1-acre pilot-scale landfill test cells are currently operated by the Delaware Solid Waste Authority in Sandtown, Delaware. Two identical cells were constructed, one operated traditionally (dry) and the other employing leachate-recirculation. The cells have been operating for approximately 1.5 years, and although the data is being analyzed, preliminary results have shown that the trends described in the early laboratory research are repeated in the field (2).

Full-Scale Landfill Project - Alachua County, Florida

The first of two full-scale landfill projects was selected near Gainesville, Florida. The landfill is operated by the City with assistance from The University of Florida, engineering firms, and others. The landfill is approximately half full, and leachate recirculation systems are being installed as filling progresses. A nearby landfill at that site has performed this technique in a less sophisticated manner, utilizing surface infiltration ponds in previous years with success (3).

Full-Scale Landfill Project - Monroe County, New York

The second full-scale landfill project is in the construction phase near Rochester, New York. EPA is assisting the New York State Energy Research and Development Authority (NYSERDA) in their efforts to study how this landfill operational technique may achieve complementary goals of environmental protection, and the potential for enhanced energy production through gas recovery (4).

Remediation Project - Ohio

An unlined landfill is under study in Cincinnati, Ohio for application of leachate recirculation as an alternative to pumping and treating groundwater at an uncontrolled pre-regulatory landfill. The project is significantly more complicated due to the absence of a bottom liner, but researchers are convinced that groundwater can be controlled and barriers can be constructed to accommodate leachate recirculation at the site (5). A feasibility study is in final draft status, and the project will soon enter its second phase to complete pre-construction details.

Comprehensive Study - University of Central Florida

A comprehensive evaluation of active landfill bioreactor projects is underway at the University of Central Florida (6). Researchers there are compiling data from these projects, other American projects, and data from projects from around the world by site visitation and interactions with specialty groups like the International Energy Agency's Landfill Gas Expert Working Group. Specific projects aim to assess moisture distribution of the leachate into the waste mass through computer models. This will assist designers in the configuration of the injection system, and may lead to guidance on placed waste densities that will accommodate leachate recirculation. A conference is planned for the autumn of 1994.

CONCLUSIONS

Landfills are currently designed and operated to serve as containment systems. While originally designed to entomb waste, the modern landfill has evolved into a more technically advanced containment system, with sophisticated controls and operational techniques. The landfill of the future will be protective of human health and the environment, will degrade the waste mass in the landfill, and will be reusable,

allowing the waste to be excavated for the cell to be inspected and refilled as part of an integrated waste management park.

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FOR MORE INFORMATION

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