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Project Summary

Liner Materials Exposed to Municipal Solid Waste Leachate

Henry E. Haxo, Jr., Richard M. White, Paul D. Haxo, and Michael A. Fong

A laboratory study was conducted to determine the potential of various lining materials for controlling the movement of leachate from municipal solid waste (MSW) landfills. In the course of the study, 65 materials were subjected to at least one of seven different tests in which they were exposed to MSW leachate. These exposure tests involved placing liner samples in (1) landfill simulators containing 8 ft of compacted, shredded refuse, (2) immersion tanks containing MSW leachate or water, and (3) polybutylene bags containing deionized water. Materials tested included 4 admix materials, 2 asphaltic membranes, 50 commercial polymeric membranes, and 9 miscellaneous materials.

Exposing a wide range of polymeric membranes to a typical MSW leachate in the landfill simulators for up to 56 months produced only limited changes in liner properties. Asphaltic materials did exhibit deficiencies that might affect their serviceability as linings for MSW waste disposal facilities. The properties of soil cement tended to improve during exposure.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Leachates generated by water percolating through sanitary landfills can seriously degrade suface and groundwaters, particularly in areas subject to high humidity and rainfall. Lining landfills with materials of very low permeability could provide a long-term solution to the problem of leachate pollution and could also make previously unacceptable sites usable as landfills. This project investigates the potential of various lining materials for controlling the movement of leachate from landfills by examining their properties after different types of exposure to municipal solid waste (MSW) leachate.

Little was known about the durability of lining materials in contact with MSW leachate when this project was initiated in 1973. The scope of the work and the objectives were updated periodically to reflect the changing liner technology. The principal objectives of the project were as follows:

1. to determine the long-term effects of MSW leachate on a wide variety of materials that could be used as landfill liners,
2. to determine the effective service lives of these materials when in prolonged contact with leachate or landfill conditions,
3. to develop laboratory tests for assessing the properties of membrane liners under simulated field conditions,
4. to generate a useful data base for MSW landfill liners, and
5. to analyze costs associated with the use of landfill liners.

Methods and Materials

In the course of this study, 65 materials were subjected to at least one of seven different exposure tests. These materials included 4 admix materials, 2 asphaltic membranes, 50 commercial polymeric membrane liners, and 9 miscellaneous materials. The number and types of liners and types of exposures are summarized in Table 1.

The exposure tests involved placing liner samples in (1) landfill simulators containing 8 ft of compacted, shredded refuse,

(2) immersion tanks containing MSW leachate or water, and (3) polybutylene bags containing deionized water. (The latter test was known as the pouch test because membrane samples were formed into pouches before immersion and filled with leachate or 5% salt solution.)

Exposure Tests in Landfill Simulators

Exposure tests in landfill simulators were performed on 12 different primary samples sealed into the bases of the simulators and on 40 different secondary samples buried in the sand above the primary liners (see Table 2).

The simulators in which the liners were exposed and in which the leachate was generated consisted of 10-ft columns containing 8 ft of compacted shredded refuse (see Figure 1). The primary liners were sealed into the simulator bases with a rapid-set epoxy resin to prevent the leachate from bypassing the liners. Thus any seepage through the liner could be measured. A hydraulic head of 1 ft of leachate was maintained on the liners, and leachate was collected continuously.

The leachate was generated by percolating 25 in. of tap water per year through the 8-ft column of ground refuse in each of the simulators. Leachate quality for all 24 simulators was in the normal range for leachate generated by full-scale landfills.

Liner properties were measured during the course of the exposure to determine changes. All specimens in the simulators were tested before and after 12 and 56 months of exposure. The asphaltic and the secondary polymeric membranes were also tested before and after 13 and 43 months, and miscellaneous secondary samples were also tested after 43 months. Seepage was collected continuously during the operation of the simulators.

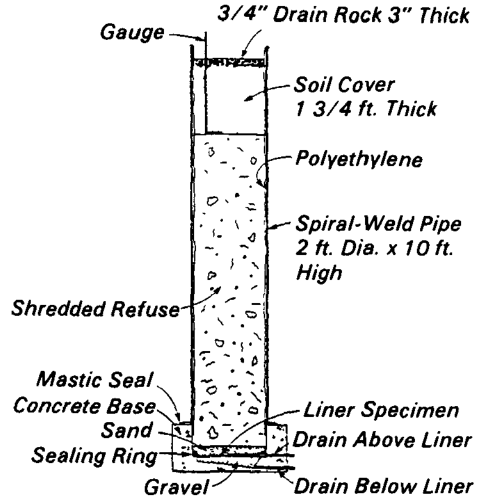

Figure 1. Landfill simulator used to evaluate liner materials exposed to sanitary landfill leachate.

Table 1. Scope of Exposure Tests

Type of exposure	Number of liners	Type of liner or material	Length of exposure, months
Primary, in simulators	6	Polymeric membrane	12, 56
	4	Admix	12, 56
	2	Asphaltic membrane	12, 43, 56
Buried, in simulators	31	Polymeric membrane	12, 13, 43, 56
	9	Miscellaneous materials	12, 43, 56
Immersion, in tanks	28	Polymeric membrane	8, 19, 31
Pouch test:			
With leachate	14	Polymeric membrane	11-40
With NaCl solution	12	Polymeric membrane	10-38
Water absorption (ASTM D570)			
At room temperature	11	Polymeric membrane	43
At 70°C	11	Polymeric membrane	43

Table 2. Materials Used in Landfill Simulator Exposure Tests

Primary liner materials	Secondary liner materials
Admixes:	Polymeric membranes:
Paving asphalt concrete	Butyl rubber
Hydraulic asphalt concrete	Chlorinated polyethylene
Soil asphalt	Chlorosulfonated polyethylene
Soil cement	Elasticized polyolefin
Asphaltic membranes:	Ethylene propylene rubber
Bituminous seal	Neoprene
Emulsified asphalt on nonwoven fabric	Polybutylene
Flexible polymeric membranes:	Polyester elasomer
Butyl rubber	Low-density polyethylene
Chlorosulfonated polyethylene	High-density polyethylene
Ethylene propylene rubber	Polyvinyl chloride
Low-density polyethylene	Miscellaneous materials:
Polyvinyl chloride	Asphalt roofing felt
	Polypropylene
	Thermoplastic rubbers
	Commercial gasket materials based on natural rubber
	Styrene-butadiene rubber
	Urethane
	Neoprene

The membrane liners were tested for absorption of leachate and for changes in tensile strength, tear resistance, puncture resistance, seam strength, and permeability. The other materials were tested for appropriate properties.

Because available information indicated that the seams in polymeric membrane liners were the most likely source of liner failure, seams were incorporated into as many of the test specimens as possible. Factory seams or seams made according to the manufacturer's recommended practice were used for all primary liner specimens in the landfill simulators. Adhesives supplied by the manufacturer were used in most cases. Test joints were also incorporated into the strips buried in the sand above the primary liners. Some systems suggested by manufacturers of other liners based on the same polymer were tested although they had not been recommended by the manufacturer of the specific material.

Exposure Tests in Immersion Tanks Containing Leachate and Water

To investigate the effects of immersion in MSW leachate, three sets of slab specimens of 28 different polymeric sheetings (Table 3) were immersed in MSW leachate generated in the simulators. Because MSW leachate is principally water (which by itself can be aggressive to many materials), water absorption tests were also conducted by immersing 11 membrane liners in water for up to 186 weeks, both at room temperature and at 70°C.

Similar immerson tests were attempted with admix specimens, but in their unconfined state, they crumbled apart when hung in the leachate.

The immersion system was designed to allow blended leachate from the 12 simulators to flow slowly through a series of high-density polyethylene tanks in which the membrane-slab specimens were hung (Figure 2). This arrangement was acceptable because polyethylene has low permeability to air, and only small changes in leachate composition were observed when the leachate was stored in these containers for a month at room temperature. Furthermore, this design exposed more specimens easily, exposed all specimens to the same leachate, and required considerably less time to construct and monitor than individual tanks or bags attached to the simulators. A Masterflex* pump delivered leachate at the rate of 14 mL/min through the tanks, recirculating the supply of leachate in about 12 days.

Three sets of the 28 membranes were immersed in the leachate so that one set could be removed after each exposure period (8, 19, and 31 months). The 8- x 10-in. specimens were hung vertically 0.92 in. apart in the tanks (Figure 2).

Pouch Tests

The pouch test involved fabricating a small pouch from the membrane liner, filling it with test fluid (such as leachate), and placing it in a deionized water solution in a polybutylene bag (Figure 3). This test offers the opportunity of exposing liner materials to two fluids at the same time--as would be the case in a landfill where leachate would contact one side of the membrane and goundwater the other.

The pouch test was used primarily to test permeability, but other properties of the membranes were also tested after exposure. Two fluids were tested in the pouches: one set of pouches was filled with leachate, and another set was filled with a 5% aqueous solution of sodium chloride. The latter solution was of known composition and was therefore used to measure the movement of ions and to set up a known concentration differential across the membrane.

The liner materials used in these pouch tests included chlorinated polyethylene, chlorosulfonated polyethylene, elasticized polyolefin, polyester elastomer, and polyvinyl chloride (three different formulations).

The following tests were performed during the exposure of these pouches:

1. The dionized water surrounding the leachate-containing pouches was tested periodically for pH, conductivity, and the odor of butyric acid.
2. The pouches containing the test fluid (leachate or salt solution) were removed periodically from the deionized water and weighed.

Results and Conclusions

Effects of Leachate Exposure on Liner Properties

Polymers

Exposing a wide range of polymeric membranes to a typical MSW leachate in the landfill simulators for up to 56 months produced only limited changes in their properties. Only one type of liner--the polyester elastomer--showed a potentially significant loss of properties.

Some of the polymeric membrane liners exhibited significant swelling during the

Table 3. *Liners Immersed in MSW Leachate*

Type of polymer	*Number of different sheetings immersed*
Butyl rubber (IIR)	*1*
Chlorinated polyethylene (CPE)	*3*
Chlorosulfonated polyethylene (CSPE)	*3*
Elasticized polyolefin (ELPO)	*1*
Ethylene propylene rubber (EPDM)	*5*
Neoprene (CR)	*4*
Polybutylene (PB)	*1*
Polyester elastomer	*1*
Low density polyethylene (LDPE)	*1*
Polyvinyl chloride (PVC)	*7*
PVC and pitch	*1*
	28

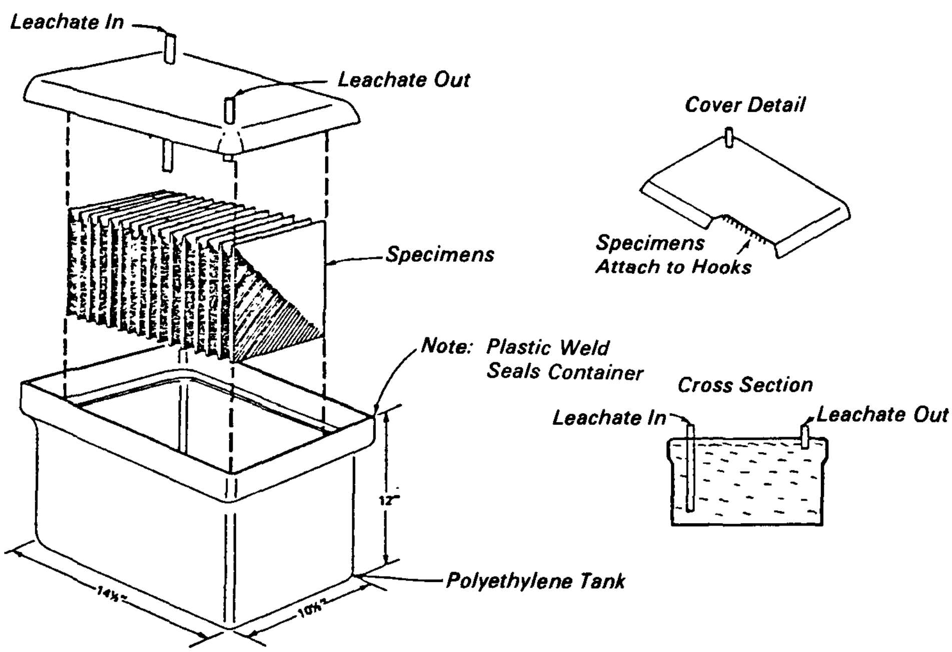

Figure 2. *Individual polyethylene immersion tank, showing method of holding speciments and the inlet and outlet for the leachate.*

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

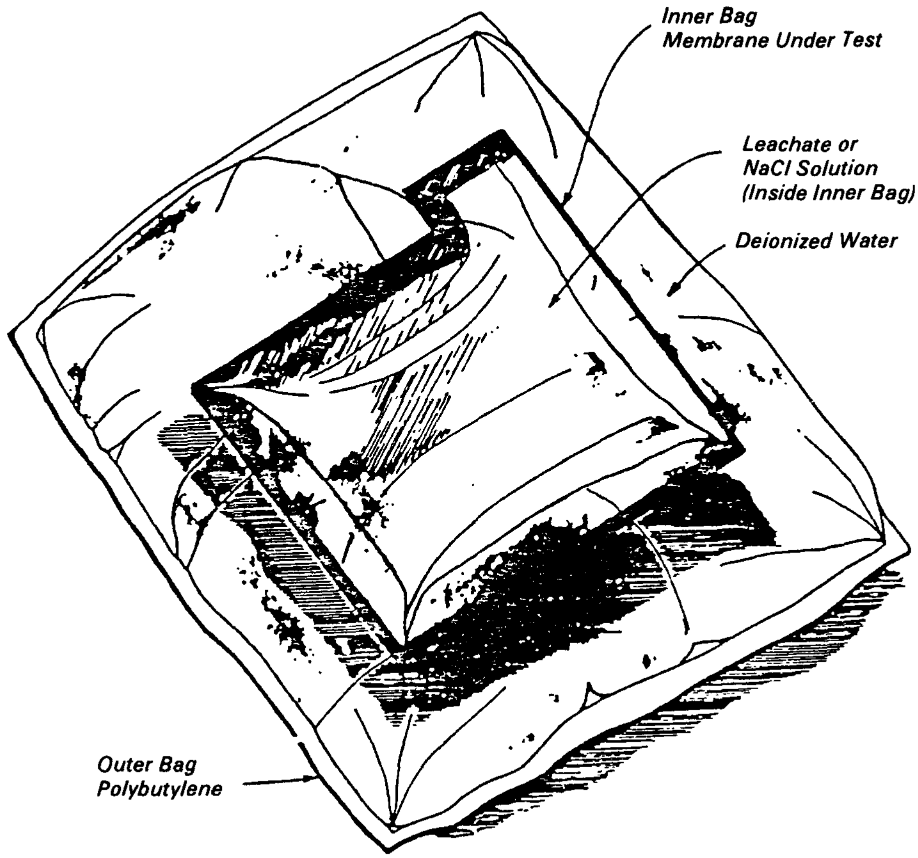

Figure 3. *Schematic of pouch assembly, showing inner bag made of membrane material under test. The inner bag is filled with leachate or 5% salt solution and sealed at the neck. The outer polybutylene bag, which can be easily opened, is filled with deionized water. The water in the outer bag is monitored for pH and conductivity; the inner bag is monitored for weight change.*

exposure periods and losses in tensile strength and other physical properties. Swelling of membranes in leachate was greater than that in water, which indicates the importance of the organic components of the leachate with respect to the swelling of polymeric materials.

The immersion of polymeric materials in leachate somewhat accelerated the effects of the leachate on the liner materials and demonstrated that the exposure to two sides of a sheeting was more severe than one-sided exposure.

Among the polymeric lining materials, the partially crystalline thermoplastic materials showed the least amount of swell and the fewest changes in properties.

Generic classification of polymeric materials by polymer type is not sufficient to predict the performance of a given liner. Variation in grade and the presence of other compounding ingredients affect the performance of a polymeric composition. Variations also arise with the use of fabric reinforcements.

Asphaltic Materials

The asphaltic materials, whether concretes or membranes, did exhibit some deficiencies after leachate exposure that might ultimately affect their serviceability as linings for MSW waste disposal facilities. The concretes tended to lose strength, and the membranes absorbed leachate and lost in ductility and elongation. The asphaltic membranes that had been exposed for 56 months showed areas that had lost inductility and elongation and had become "cheesy." On drying, the cheesy section of the ashpalt returned to normal and showed very little or no change in basic properties compared with the original asphalt.

Soil Cement

The properties of the soil cement specimen tended to improve during exposure. The specimen was very small, however (2 ft in diameter).

Effects of Leachate Exposure on Seams

The seaming of membrane liners by heat or welding with solvents or bodied solvents that are solutions of the liner compound appears to yield seams with the highest integrity. Results also showed that values could vary greatly as a result of poor workmanship. Adhesives that differ in composition from the liner introduce a new composition that must be assessed for compatibility in a given waste stream.

The low-temperature vulcanizing adhesives, which are required in the seaming of vulcanized or crosslinked sheetings, generally yielded lower seam strength values; but in some cases, they showed increases, probably because of additional cure. A significant problem with this type of adhesive system arises over time because of their fewer crosslinks compared with the vulcanized sheeting. That condition can cause the adhesive to swell considerably more during exposure and thus lose strength.

Simulator Design

The design of the simulator that was used in this project appears to be versatile and useful for investigating the characteristics of MSW, methane gas generation, liners, etc. The size was large enough to simulate landfills and to obtain exposure data on liner materials, but it was small enough to be manipulated by a forklift for examination of the materials inside during exposure. A better choice of epoxy resins would ensure complete sealing of the liner specimens without the degradation of the seal that took place in several of the simulators.

Recommendations

Feedback is needed from the field regarding the performance of lining materials in actual service so that laboratory results can be correlated with field performance. The open literature contains virtually no data on liner performance in full-scale landfills containing MSW leachate.

When liners are placed, samples should be retained and provisions should be made in the design to place samples in contact with the leachate that will be generated in the landfill. These samples should then be recovered at various times to measure the effects of the exposure on properties. Monitoring of the groundwater below a fill and the development of leak detection devices would also be helpful in assessing liner performance.

Information on liners for disposal facilities such as would be developed in the permit process should be accumulated along with performance data. This information could then be used to develop correlations with laboratory test methods and to help select materials for liner use.

Liner specifications should be established that relate liner performance in service to both the materials and the installation.

The use of the pouch test should be extended as a means for evaluating new liner materials for MSW landfills.

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Henry E. Haxo, Jr., Richard M. White, Paul D. Haxo, and Michael A. Fong are with Matrecon, Inc., Oakland, CA 94623.
***Robert Landreth** is the EPA Project Officer (see below).*
The complete report, entitled "Linear Materials Exposed to Municipal Solid Waste Leachate," (Order No. PB 83-147 801; Cost: $17.50, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
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