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Project Summary

Field Assessment of Site Closure, Boone County, Kentucky

Landfill performance was investigated before the closure of a 4-ha (10-acre) experimental landfill site located in Boone County, Kentucky. The site contained a field-scale landfill and four smaller test cells filled with compacted municipal solid waste. From 1970 to 1980, the landfill was operated by the U.S. Environmental Agency (EPA) to monitor gas and leachate production. The current project was undertaken before the scheduled site closure to obtain information useful to designers of future landfill facilities.

Information was developed on cover soils, refuse, leachate collection systems, and lining materials from the test cells. To examine and recover cell components, exploratory excavations were made through the refuse and base liners. Each of the cell elements (cover, refuse, liners, etc.) was thoroughly documented, and samples underwent extensive testing.

The project included the recovery and detailed inspection of the cover soils and of the clay and synthetic liners that had been exposed to leachate for approximately 9 years. Although the cover soils were constructed to maintain tight permeabilities, a vertical seepage plane did develop over the project life. Both field and laboratory testing showed little degradation of the liners and no leachate migration through these materials. The physical appearance of the refuse was similar in all excavated cells and showed little vertical difference. Decomposition was limited primarily to food wastes. Isolated incidences of gravel cementation were found in the upper leachate drain of one cell.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory 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

Landfill performance was investigated just before the closure of an experimental landfill site in Boone County, Kentucky. The object was to obtain information useful to designers of future landfill facilities.

The 4-ha (10-acre) tract contained a field-scale landfill (Test Cell 1) and four smaller test cells filled with compacted municipal solid wastes (see Figure 1). Known as the Boone County Field Site, the landfill is located at the top of a ridge 8 km (5 miles) west of the City of Walton in northern Kentucky. From 1970 to 1980, the U.S. Environmental Protection Agency (EPA) operated the site to monitor gas and leachate production.

The present project examined the test cells just before the site was closed to develop information on cover soils, refuse, leachate collection systems, lining materials, and contaminant migration from the test cells. Exploratory excavations were made through the refuse and base liners to examine and recover cell components. Each of the cell elements (cover, refuse, liners, etc.) was thoroughly documented, and samples underwent extensive testing.

Description of Test Cells and Conditions Immediately Before Closure

Test Cell 1

The field-scale sanitary landfill (TC-1) was constructed as a trench-type sanitary landfill 45.4 m (149 ft) long, 9 m (30 ft)

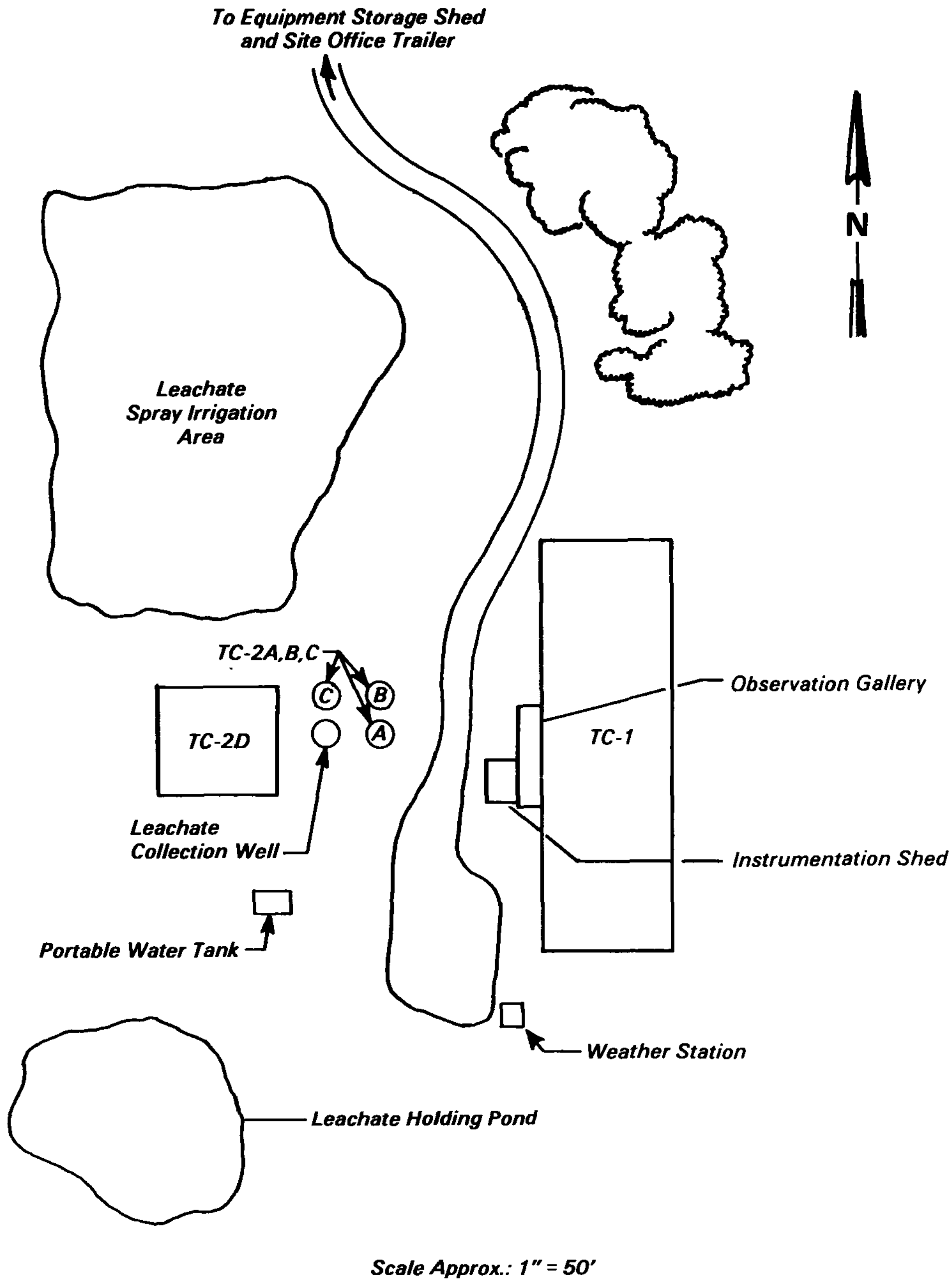


Figure 1. *Site layout plan.*

wide, and about 3 m (10 ft) deep (Figure 2). The central portion of the base of the cell was covered with a 0.76-mm (30-mil) chlorosulfonated polyethylene (CSPE) liner (Hypalon*), 9 by 15 m (30 by 50 ft) long. A clay soil liner 45 cm (18 in.) thick was placed directly above this synthetic liner, and a two-layer drain system was constructed to collect leachate migrating along the top of each liner (Figure 3). The drain system consisted of a slotted collection pipe along the transverse center line of the cell directly above the CSPE sheeting and a second pipe in a trench installed in the top 32 cm (13 in.) of the clay liner. The trench was lined with a 0.15-mm (6-mil), low-density polyethylene (LDPE) strip. The purpose of this second pipe was to prevent short circuiting of the leachate to the lower pipe. The space around both of the pipes was filled with clean silica gravel. The test cell contained 94 m^3 (869 yd^3) of refuse.

The closure investigation was conducted by means of seven exploratory trenches constructed in the cell. Three of these (B, E, and G) penetrated the refuse pile and liners to the subsoil beneath the landfill (Figure 2).

Cover Soils

TC-1 was capped with 60 to 90 cm (24 to 36 in.) of silty clay soil. Below a surficial, root-weathered zone, this tan clay layer became dense and difficult to shovel. Permeability determinations indicated that the cover at the BCFS was constructed to maintain tight permeabilities and thus minimize infiltration, but this apparent tightness was offset by the presence of a vertical seepage plane penetrating the full depth of the cover. This plane indicates that over an extended period, soil structuring could increase cover system permeability.

Refuse

Four test pits were excavated (Locations AA, B, E, and G) to expose a cross-section of the refuse. The reasonable well preserved condition of the waste was remarkable. Ten-year-old newspapers were quite legible and slightly discolored. Metal cans were only slightly rusted, and labels were only slightly discolored. Grass clippings were bright green. Except for corncobs, food material was reduced to a brittle residue. Little odor was detected from the excavated refuse. The most extensive degradation occurred at Location E, just above the clay liner. Here refuse was saturated, and a malodorous, black sludge covered the upper surface of the clay liner. Newsprint was covered with a black, gritty coating, and metal was brittle and corroded.

Moisture Content

The refuse was moist to the touch, and laboratory tests showed fairly consistent values of 43% to 63% moisture throughout the refuse on a wet-weight basis.

Chemical Analysis

Attempts to determine whether chemical composition varied vertically were inconclusive. Concentrations of K, Ca, and Mg tended to increase with depth, and TKN showed the opposite trend.

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

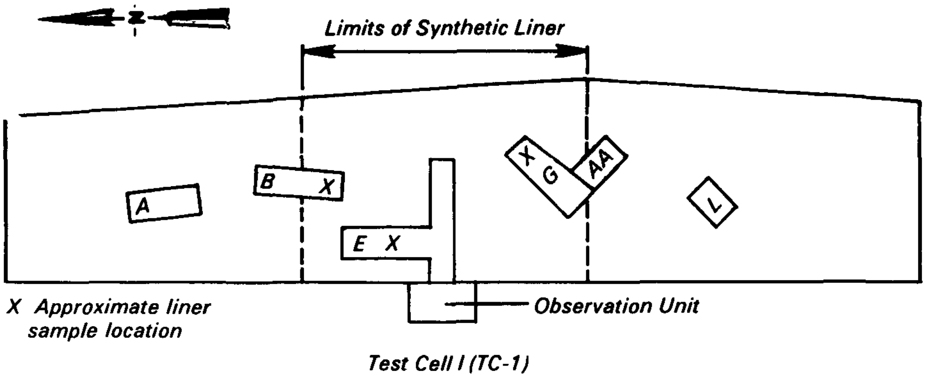
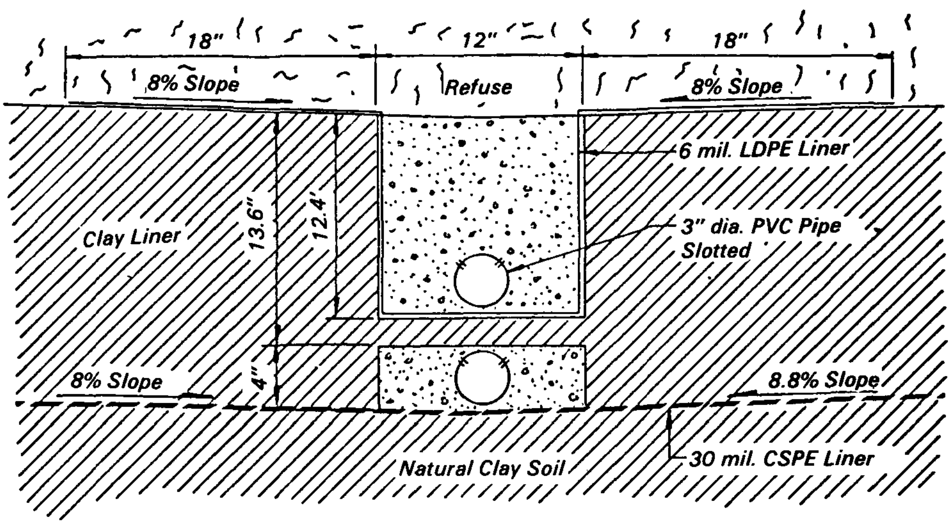
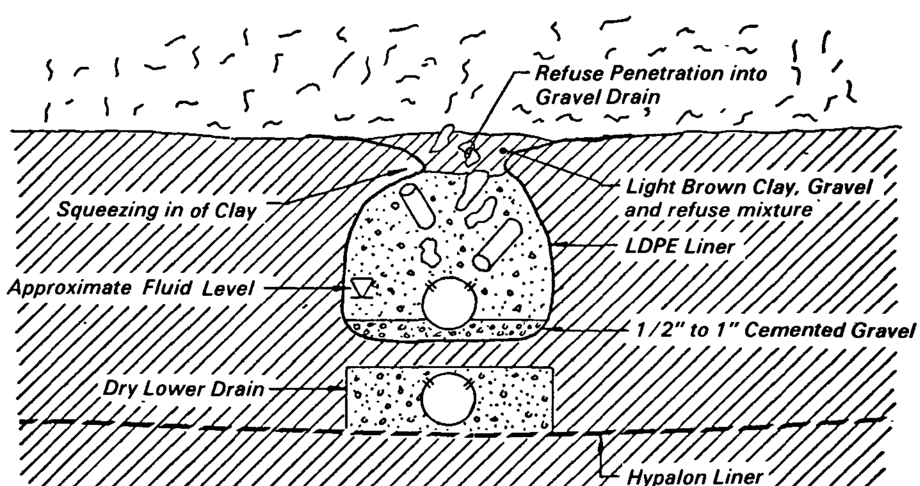


Figure 2. Sampling locations for TC-1.



(a) As-Built construction details for cross section at observation bulkhead



(b) Cross section as exposed 8 ft. from observation bulkhead

Figure 3. Leachate collection system for TC-1.

Leachate Production

Nearly continuous leachate seepage from refuse was encountered in a saturated zone about 30 cm (12 in.) above the clay liner. Most leachate was light in color and only moderately turbid, but two or three zones of concentrated rust-colored seepage were encountered in each trench.

Density

A dramatic 70% increase in refuse density was observed between time of placement and site closure. This result cannot be accounted for simply by volume reductions that accompany decomposition. The explanation is more likely to be that no accurate, reproducible method exists for determining in-place density at a reasonable cost.

Permeability

The mean permeability of in-place refuse ranged from 1×10^{-2} to 4×10^{-2} cm/sec when measured at seven locations in the field. This value is somewhat higher than the actual value because of the difficulty in creating a complete seal of the permeameters to the refuse. Also, field permeameters yield values that are about 50 times those measured in the laboratory.

Pore Water

Chemical components were generally higher in the refuse pore water than in the leachate. Concentrations of constituents in the pore water generally increased with depth.

Microbial Assay

Soil samples of waste materials from TC-1 were assayed for microbial content. Levels of fecal coliforms in the waste were significant, indicating that the waste represents a source of potential disease transmission. Top soil was highly contaminated, possibly as a result of recent human or animal contact. The isolation of *Acinetobacter, Moraxella, Salmonella,* and *Klebsiella pneumoniae* is significant since these organisms were found only in the refuse samples. Methane-producing bacteria were present in greater numbers and at shallower depths within the solid waste than in the control soils.

Leachate Collection System

Leachate was drained from TC-1 through two collection pipes (Figure 3). The area around both pipes was backfilled with washed silica gravel. Gray clay from the liner and a light brown silty clay of unknown origin partially covered the top of the upper collector. The brown clay and the gravel were both mixed with refuse. The upper drain was typically 20 to 30 cm (8 to 12 in.) deep. The upper 10 cm (4 in.) of gravel backfill was moist and natural in color. The lower 10 cm (4 in.) was saturated with an odorous, dark black fluid. Gravel was stained with a thin, fine, black and rust-colored coating. Tiny particles of glass, metal, and sand partially filled voids in the gravel, and the bottom 0.3 cm (0.125 in.) contained a continuous gritty sand deposit. Gravel was generally subrounded in shape and accepted water at a rate greater than could practicably be applied through permeameters. A zone of cemented gravel was found in the bottom 1.3 cm (0.5 in.) of the upper collector. The cementing material consisted of a fine-grained mixture of quartz, rhodochrosite with a minor iron component, gypsum, and a small amount of illite. Evidence of seepage appeared along the bulked-clay interface and between drains. Gravel in the lower collector was low in moisture content and unstained throughout, reflecting minimal contact with leachate. No free fluids were found in the lower collector.

Liners

Chemical tests indicated that nearly all of the leachate was contained above the clay liner. No visual signs of cracking, channeling, or unusual changes in texture or consistency were noted in any of the excavations.

CSPE liner samples had been in contact with dilute leachate for 9 years; they had imprints of gravel and were swollen and soft. Substantial amounts of leachate had been absorbed by the CSPE samples. The physical properties of all these samples appeared to be approximately the same, and values all appeared to be relatively normal for a CSPE material. No significant differences were noted in the data among the different samples, indicating that sample location in the cell did not affect results and that all materials came from the same lot.

The LDPE film was clear after the surface stain was washed off, and it appeared to be unaffected by its 9 years of exposure to the full-strength leachate. The sample showed little swelling, and its properties were normal for a 6- to 7-mil LDPE. No punctures or tears of the material were observed during sample removal.

Subsoils

The subsoil in TC-1 consisted of a thin clay mantle overlying limestone bedrock. Immediately below the CSPE liner, the subsoil was a brown-gray for several millimeters, grading to a natural orange tan.

Test Cells 2A, 2B, and 2C

Test Cells 2A, 2B, and 2C consisted of refuse enclosed in identical steel cylindrical pipes 1.83 m (6 ft) in diameter and 3.66 m (12 ft) high (Figure 4). Refuse was placed in the pipes in 90 to 130-kg (200- to 300-lb) increments and compacted. Since all three cells were similar, TC-2B was judged to be representative and was excavated and examined in detail. The cover soil and shallow refuse in TC-2C were also investigated to confirm the assumed similarity. No study was made of TC-2A.

Soil Cover

Refuse in TC-2B was covered by a surficial layer of clean pea gravel underlain by a light brown clay of low plasticity. The gravel layer was moist below the upper few inches. No vegetation was established in the gravel or underlying clay soil. The clay layer was 28 cm (11 in.) thick, becoming gray within 8 cm (3 in.) of the refuse. The cover soil was very soft and moist to the touch.

Refuse

The physical appearance and composition of refuse in TC-2B after 9 years of exposure was similar to that of the other test cells. Newsprint was still quite legible, cardboard was very soft, metal cans were slightly rusty, painted labels were discolored but legible, and plastics were generally still pliable. A strong odor occurred when the cover was penetrated,

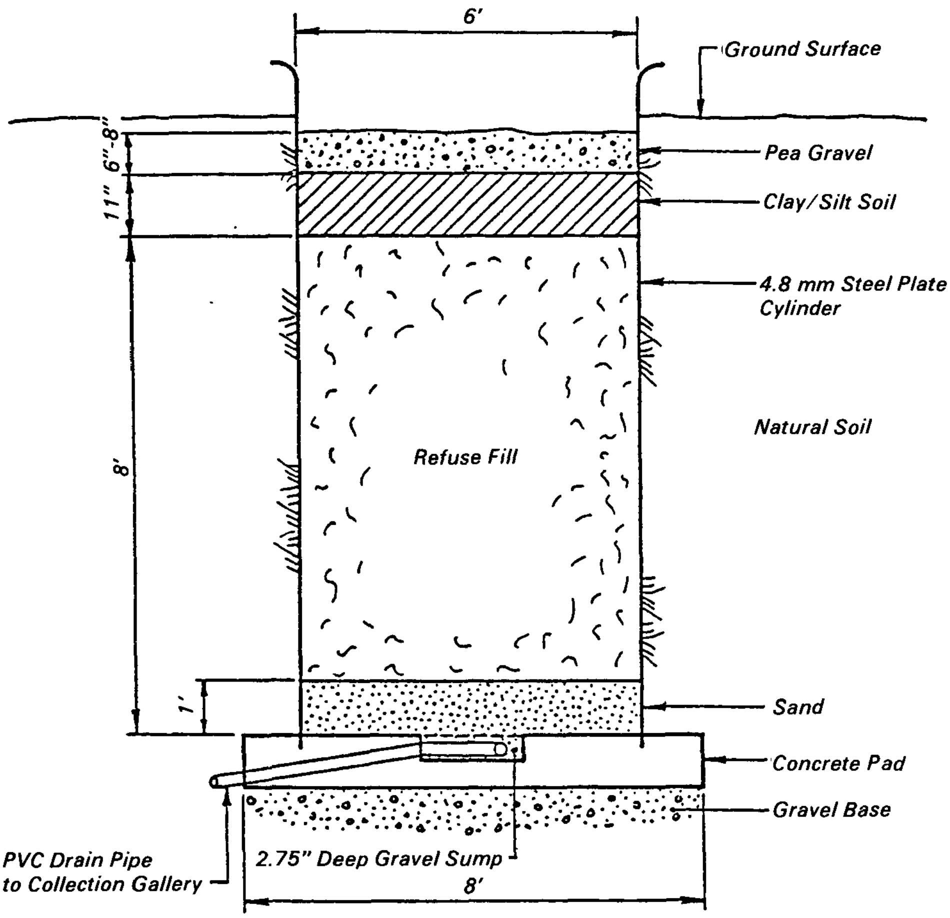


Figure 4. *Test cell construction details for TC-2A, 2B, and 2C.*

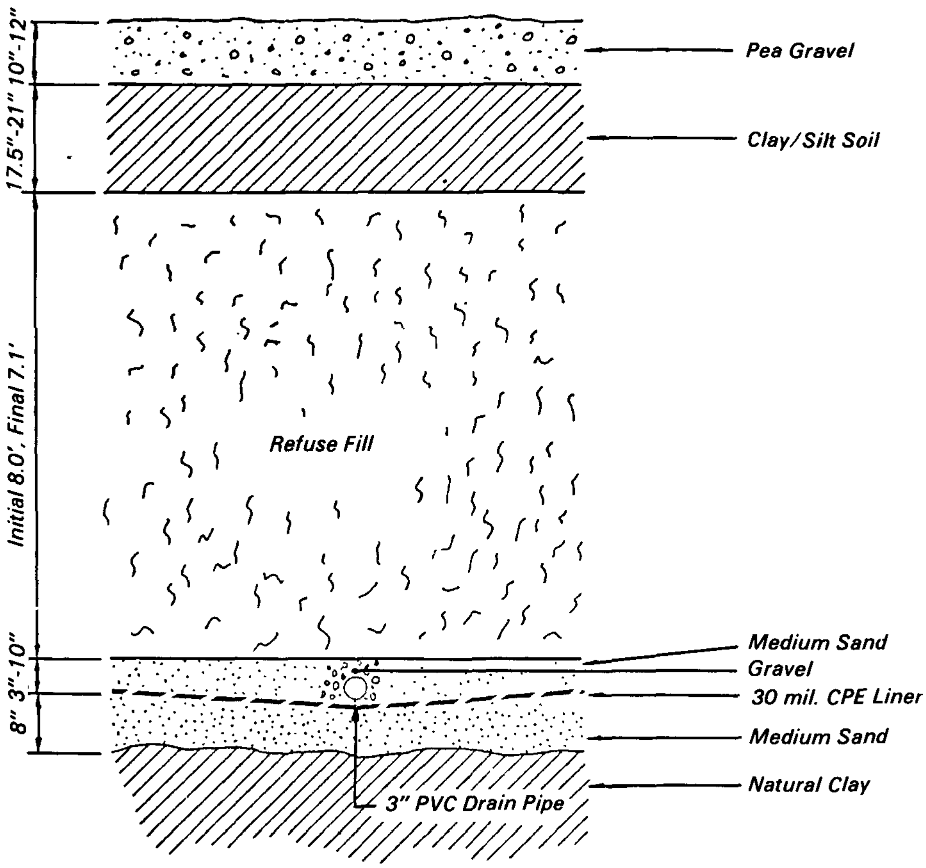


Figure 5. *Test cell construction details for TC-2D.*

but it quickly dissipated. The refuse was very moist to the touch. No free fluids were found anywhere in the refuse.

Chemical Analysis

Samples of refuse were obtained for chemical assay to determine vertical differentials in composition. Results presented no clearly defined trends for most assays, but potassium did exhibit a weak trend of decreasing concentration with depth.

Pore Water

The results for TC-2B contradict those for all the other test cells. Contaminant levels in the pore water were lower than those in the leachate, except for total solids, total volatile solids, TKN, Zn, As, and Ba. Errors in sampling and analytical procedures may account for these results.

Test Cell 2D

TC-2D was constructed in an excavation 2.6 m^2 (28 ft^2) by 3 m (10 ft) deep to provide a large-scale comparison for the three smaller test cells. The base of the cell was shaped with sand and a 7.6-mm (0.30-in.) thick, reinforced chlorinated polyethylene (CPE) liner was placed along the cell sidewalls and over the base (Figure 5). Refuse was added by a crane and compacted by a bulldozer. The cell was explored through three excavations that penetrated through the cell into the underlying subsoils.

Cover Soil

TC-2D was capped by a surficial layer of clean pea gravel overlying a clay cover soil. The gravel was dry near the surface, but very moist below the upper 8 to 10 cm (3 to 4 in.). No vegetation was established in the gravel. The clay cover was easily excavated by shovel and felt moist to the touch, unlike the dry, hard texture of the cover soil in TC-1. Permeabilities were about one order of magnitude smaller than in TC-1, reflecting an increased clay content and greater plasticity.

Refuse

Three trenches were dug to expose a cross section of the refuse pile in TC-2D. The refuse was more odorous than in TC-1, and it had a higher moisture content throughout (49% to 65% on a wet-weight basis). As in TC-1, the degree of refuse degradation was low. Newsprint was very legible, cardboard was still intact, metals had little rust or corrosion, labels were only slightly discolored, grass clippings were bright green, and plastics were still pliable. As with the other test cells, food wastes were not observed except for isolated bones, corn cobs, etc.

Chemical Analysis

Samples taken at two locations in TC-2D generally showed a trend of decreasing concentrations of chemical constituents with increasing depth. The same trend was found for SO_4, Na, K, and Mg. These findings do not support the concepts generally associated with single-pass systems, but the mode of operation of these test cells may have led to the results.

Pore Water

Concentrations of most contaminants were greater in pore water than in leachate. Fe, Cl, K, and Ca were approximately equal in both, however. Contaminant concentrations generally increased with depth, except for Ca and Fe. Such exceptions may have been the result of sampling errors

Moisture Content

The refuse pile was generally well drained, and no zones of perched fluids were encountered. Trenches remained dry until saturated drain soils were exposed.

Density

In-place mean wet density of the refuse was 1,327 kg/m^3 (2,237 lb/yd^3). Mean dry density was 848 kg/m^3 (1,430 lb/yd^3).

Permeability

The mean permeability determined in the field was 5×10^{-2} cm/sec. These results are somewhat high because it was impossible to seal the permeameters completely within the refuse. Results were comparable with those of TC-1.

Drainage Soil

A sand collector blanket separating the refuse from the CPE liner was very moist to wet. The lower several inches of the sand blanket were typically saturated and black in scattered areas. A slotted PVC pipe was placed along the transverse center line of the cell for leachate collection and gravity drainage. Silica gravel was then placed on the top and sides of the collection pipe. Some staining of the gravel was noted. The drain system was moist, but no free fluids were encountered in Trench B, and only a very slow seepage was noted in Trench A.

Liner

Analysis of the layers of sand above and below the liner indicated that the liner had contained the leachate. The CPE liner samples were stiff and leathery and showed significant adsorption of leachate. Nonetheless, their properties were relatively good. Two samples of CPE liner that had been exposed only to weather and not to leachate were significantly higher in tensile strength, moduli, and puncture resistance compared with the leachate-exposed samples.

Subsoils

An excavation was made into a layer of sand and a section of clay underlying the CPE liner in TC-2D. Water beneath the CPE liner contained no leachate and was believed to be the surface runoff into the sand surrounding the sides of the cell. The upper 2.5 to 5 cm (1 to 2 in.) of the clay layer had been reduced to a mottled gray-green. The remainder of the exposed clay was a natural orange-tan.

Conclusions

Soil structuring of cover soils are subject to cracking, which can increase cover permeabilities even though the major portion remains tight

Both clay and synthetic liners in the test cells examined provided effective containment of leachate. Though many synthetic liner samples were considerably swollen, they retained reasonably good physical properties after their 9 years of leachate exposure. The leachate drainage system was still functional even though there was minimal plugging of gravel drains. One short section did undergo cementation but apparently did not completely block the leachate of the upper gravel drains of TC-1.

Very little degradation had occurred in the wastes uncovered during the investigation. Newspapers buried for 10 years were still legible, and grass clippings were still green. Food wastes were noticeably absent.

High microbial counts were found in the landfill leachate, and high fecal-indicator levels were present in the refuse. Microbes apparently can survive within a landfill for long periods—in this case, more than 9 years.

Recommendations

Liners that have been exposed to solid wastes over an extended period should be examined to determine long-term exposure effects. Determinations should also be made of the origins of the pathogens and fecal indicators, and of the mechanisms and dynamics of pathogen and fecal indicator survival.

The full report was submitted in fulfillment of Contract No. 68-03-2824/02 by EMCON Associates under the sponsorship of the U.S. Environmental Protection Agency.

This Project Summary was prepared by staff of EMCON Associates in San Jose, CA 95112.

***Dirk Brunner** is the EPA Project Officer (see below).*

The complete report, entitled "Field Assessment of Site Closure, Boone County, Kentucky," (Order No. PB 83-251 629; Cost: $10.00, subject to change) will be available only from:

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5285 Port Royal Road
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The EPA Project Officer can be contacted at:

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