MINING AND RECLAIMING EXISTING SANITARY LANDFILLS

CURTIS E. COBB AND KONRAD RUCKSTUHL
SPM GROUP, INC.
Aurora, Colorado

ABSTRACT

Practically every conceivable method of handling and processing municipal refuse has been devised, i.e. burning, pyrolyzing, composting, baling, and recycling, with the traditional method being to bury it. What has been missing in the total process is an effective method to reclaim refuse depositories, and their composted heterogeneous ingredients, by "mining" them. Machinery to do this was successfully tested on Key West and Naples, Florida, landfills in June 1987.

PURPOSE

Mining a landfill may have several purposes. While the following options exist, all are site-specific and not all are recommended for all landfills:

(a) Empty the depository to reclaim the land for reuse.

(b) Reclaim the components such as dirt, steel, aluminum and plastic.

(c) Remove undesirable components, which may be toxic or leachable.

(d) Eliminate having to close a landfill and incurring all the closing and monitoring costs.

(e) Recover plastic as a fuel or for recycling into other products.

GOALS

The goals of the Collier County (Naples) landfill mining experiment and demonstration were as follows:

(a) To provide a relatively simple, low cost, low maintenance, mechanical system by which the depository's ingredients could be separated into usable, marketable, and/or redisposable components.

(b) To see if an alternative processing method could be devised by which the high costs of properly closing a full landfill could be avoided. A recent study conducted by the University of Florida estimated closure costs to be from $110,000 to $155,000 per acre, plus annual maintenance expenses of $2000 to $13,000 per acre.(see Table 1).

(c) To develop basic equipment performance data for ultimately designing and manufacturing a multipurpose waste handling system for processing both fresh municipal solid waste (MSW) and landfilled material.

PROBLEM AREAS

(a) Perhaps the most formidable barrier to mining landfills is overcoming the idea that it cannot be done safely and economically. Public fears emerge concerning air pollution from odors, explosions from methane emissions, soil contamination from chemicals, asbestos,

TABLE 1 ESTIMATED LANDFILL CLOSING COSTS AS PREPARED IN 1987 BY THE UNIVERSITY OF FLORIDA, GAINESVILLE

MAJOR COMPONENT	SMALL LANDFILL 10 TPD OR 6 ACRES	MEDIUM LANDFILL 100 TPD OR 28 ACRES	LARGE LANDFILL 300 TPD OR 75 ACRES	VERY LARGE LANDFILL 160 ACRES
1. MONITORING WELLS	$ 4,125	$ 8,250	$ 12,375	$ 16,500
2. FINAL COVER				
A.SLOPE & FILL	73,710	743,020	3,258,146	10,151,468
B.CLAY ADMIXTURE	117,612	548,856	1,470,150	3,136,320
C.TOPSOIL	188,760	880,880	2,359,500	5,033,600
3. CONTOUR GRADING AND SURFACE WATER DIVERSION	36,978	172,562	462,220	986,069
4. GAS MIGRATION CONTROL	70,877	156,626	240,656	389,843
5. REVEGETATION	4,050	18,900	50,625	108,000
6. SECURITY SYSTEMS	18,632	40,832	66,732	97,812
7. CERTIFICATION OF CLOSURE	10,000	10,000	10,000	10,000
8. 25% CONTINGENCY FEE	131,186	605,825	1,982,601	4,982,403
TOTAL CLOSURE COSTS	$655,930	$3,029,125	$9,913,000	$24,912,015
AVERAGE COST/ACRE	$109,322	$108,183	$132,173	$155,700
9.OPTIONAL: FINAL COVER COSTS WHEN SUBSTITUTED FOR 2B ABOVE.				
A.30 MIL PVC	$699,724	$3,020,655	$9,890,317	$24,863,615
B.ON-SITE CLAY	707,355	3,269,109	10,555,818	26,283,349
C.OFF-SITE CLAY	962,181	4,458,296	13,741,143	33,078,709
10.POST CLOSURE COSTS-20 YEARS				
A.GROUNDWATER QUALITY CONTAMINATION DETECTION,ANALYSIS, SAMPLING	$230,400	$460,800	$691,200	$921,600
B.GAS MONITORING	2,700	12,600	33,750	72,000
C.INSPECTION AND MAINTENANCE				
1.PUMPS & WELLS	1,255	2,510	3,765	5,020
2.BENCHMARKS	308	330	355	385
3.LANDSCAPING	31,980	141,956	376,906	795,085
D.15% CONTINGENCY FEE	39,996	92,729	165,896	269,113
POST CLOSURE COSTS	$306,639	$710,925	$1,271,872	$2,063,203

TABLE 2 COMPARISON OF AVERAGE VALUES OF DECOMPOSED MATERIAL EXTRACTED FROM COLLIER COUNTY, FLORIDA, SANITARY LANDFILL COMPARED TO FRESH MUNICIPAL SOLID WASTE

PARAMETERS	AVERAGE OF DECOMPOSED LANDFILL MINING SAMPLES	AVERAGE OF DECOMPOSED 50 CORE SAMPLES	AVERAGE OF FRESH MSW SAMPLES
TOTAL SOLIDS (% WET WT.)	75.7%	70.26%	75.0%*
TOTAL VOLATILE SOLIDS (% WET WT.)	24.2%	29.31%	50.0%*
ASH (% WET WT.)	59.3%	40.95%	25.0%*
MOISTURE (% WET WT.)	32.9%	29.74%	25.0%*
BTU/LB (WET WT.)	5,616	3,042	6,210+
BTU/LB (TS)	7,708	4,423	8,280+
BTU/LB (TVS)	49,839	10,744	12,420+

* Kispert, R.G.;Sadek,S.E.; and Wise,D.L.;1975. An Economic Analysis of Fuel Gas Production from Solid Waste. Resource Recovery and Conservation,1:95.

\+ Emcon Associates,1980. Methane Generation and Recovery from Landfills. Ann Arbor Science Publishers,Inc.,Ann Arbor,MI.

heavy metals, leachable toxins, hazardous materials, and disposal of undecomposed plastics.

(b) EPA regulations basically encourage only one method of handling a full landfill, i.e., cover it with more dirt, monitor the ground water for contaminants, and hope that nothing adverse happens.

(c) Instead of recapturing refuse disposal space, municipal officials have been heavily oriented toward the mass-burning of refuse as the most desireable solution to waste elimination; despite the capital costs and emerging ash disposal issues.

(d) Consulting engineers, upon whose advice communities strongly rely, are often obliged to comply with standard regulations and solutions, rather than be innovative. Most technical firms are not paid to do research or to even suggest relatively untried solutions. Like many other professions, liability considerations and fear of law suits can greatly curtail both creativity and innovation.

DISCUSSION

History

Collier County (near Naples in southwest Florida) chose to experiment with mining its landfill, primarily to recapture the ground cover for reuse in burying fresh refuse. In this region, cover dirt is becoming increasingly scarce and expensive. Creating additional depository space was of secondary importance to this County, whereas for other areas of the country, it may be primary.

Feasibility Study

To support the mining feasibility test and study, a $20,000 Exxon Fund grant was secured by the County and a portion was spent drilling fifty, 30 ft deep cores. Residue from these cores was chemically analyzed for heat value, ash and moisture content. The analyses of this 3-year old to 8-year old material are listed in Table 2.

It can be observed that the average heating value of the mined material significantly exceeded that of the core samples. This is because the core samples contained a large quantity of cover dirt. The mined plastic values included mostly residual dirt which clung to the surface.

Landfill Composition

Data on the quantities of residential, light commercial, vegetative matter and wooden building debris deposited in this landfill from 1980 to 1985 are listed in Table 3.

Estimated Closing Costs

Collier County has an existing 60 acre, 25-ft high landfill. If this were closed using EPA designated methods and covered with a clay admixture and topsoil, of which there is little in southern Florida, total expenditures are projected at $8 million plus annual monitoring costs of $63,000 per year (See Table 1). Alternately, using landfill mining techniques, this 60-acre area can be reclaimed for a cost of $2,600,000 plus saving the County an additional $2,100,000 in the cost of cover dirt over 11 years.

EQUIPMENT AND FEASIBILITY TEST

Impact Separator

The first equipment demonstration involved using a newly devised machine called an "Impact Separator" or "Impactor" for separating and fine screening highly decomposed landfill material. This machine was mounted inside a 22-ft long (6.7 m) truck and consisted of a 16-ft (4.9 m) long box-like trough, containing, first, a 4-ft (1.2 m) long beater/hopper section followed by three 4-ft (1.2 m) long sections of 18 in. (46 cm) diameter, 180 deg., half-round screens. The first two steel screen sections were perforated with ½ in. (1.3 cm) holes. The third and final screen had 1 in. (2.5 cm) holes. A center positioned, 70 rpm rotating shaft (Fig. 3) with closely spaced, specially designed paddles provided the beating, separating, and conveying action of the raw material over the screens. The first two screens allowed nearly refuse-free dirt to fall out of the processed material stream. The third screen, having the larger holes, allowed most of the remaining dirt and the small pieces of wood, glass and some stones to drop out. The residual material, being mostly plastic, was further conveyed into a small, double rotor hammermill located at the end of the trough. Any glass, ceramics, aluminum or other breakables were pulverized and plastic was shredded into 2–6-in. (5–15 cm) flakes. A minimum of steel items went through because these were handsorted out at the input hopper. A full production unit would contain a magnetic separator for ferrous removal.

Note that if only a coarse separation of the decomposed items is desired, then an impact separator is not necessary. However, if a highly refuse-free dirt is desired, then the final impact separation process is necessary to obtain the desired refinement.

When the residual plastic was chemically analyzed, the actual ash content of this sandy, highly moist and elastic material varied from 38% to 61% and averaged 51.1% on a wet basis. On a dry basis, it measured 70%. Moisture ranged from 19% to 30%, averaging 22%. Were the plastic air-dried and tumbled for dirt removal, the ash content would have been substantially reduced. The heating value for all ten samples averaged 5616 Btu/lb.

For final disposal, the plastic was hauled to the Key West mass-burn resource recovery plant where it burned with no detectable unsatisfactory side effects.

On a steady basis, the throughput of this experimental separating machine was 3 tons per hour. By using a primary coarse separation method, such as a vibrating screen or cam-screen separator, plus a high speed hammermill for material disintegration, the throughput for this or a larger machine could have been increased noticeably.

Raw Feedstock Preparation

During one of the 5 days of testing with the impact separator, a shear shredder was used to do a size reduction on the raw, mined refuse prior to processing it through the impactor. While this assisted in reducing the size of some items, it also left plastic bags in long

TABLE 3 TYPES OF WASTE RECEIVED AT NAPLES LANDFILL 1980 TO 1985, TONS PER YEAR

COLLIER COUNTY(NAPLES,FLORIDA) PUBLIC WORKS DIVISION
SOLID WASTE DIVISION

TYPE OF WASTE	1980	1981	1982	1983	1984	1985
HOUSEHOLD	38,073	42,131,	42,356	40,331	43,713	43,458
COMMERCIAL	24,096	29,415	33,445	37,028	40,786	44,253
YARD WASTE	8,659	6,267	5,893	4,018	4,303	4,076
LAND CLEARING	25,567	35,000	26,586	3,749	4,999	33,791
CONSTRUCTION	37,529	51,505	41,114	20,846	23,521	38,579
DEMOLITION	2,095	8,676	2,907	207	920	718
CONCRETE	10,512	6,983	7,478	3,144	6,382	4,471
DIRT & SAND	13,600	13,097	10,274	1,857	4,018	8,379
WOOD	4,877	3,379	2,744	1,607	1,838	1,772
PAPER	1,562	1,345	1,472	1,240	1,506	1,345
METAL	614	451	531	297	885	365
WHITE GOODS	156	134	250	201	265	255
GLASS	154	34	44	222	1,013	22
RUBBER	353	238	264	67	152	255
OTHER	77	400	963	119	873	2
TOTAL TONNAGE	167,924	199,055	176,321	114,933	135,174	181,741

strips, and the glass, wood and rocks in sizes too large for the Impactor to handle comfortably.

Vibrating Screen Separator

In late 1987, a second test and demonstration was performed using a conveyor-fed flat vibrating screen with 2-in. openings (5.1 cm). Its specific purpose was to perform a coarse separation and recapture cover soil from the fully decomposed landfill for use in burying fresh incoming refuse. This production method has allowed for a 60 tons per hour throughput, with noticeable inclusions of wood, metal, glass and stones in the resulting dirt. These inclusions are acceptable when the dirt is to be used on a landfill, but may prove unacceptable for dirt which is to be sold on the commercial market.

The oversized residue, mostly plastic, combined with wood, metal, leather, rubber, and fabric poses another disposal problem. While it comprises only 15% of the total weight of the excavated material, it is about 20% to 30% of the volume. This must be further separated into those items which are either recyclable or require reburial or incineration.

System Costs

For coarse separation using the simplest process, capital costs for a 400 tons per day system can be as low as $80,000. For 900 tons per day, the estimated cost is $160,000. As additional screening, separating, shredding and milling equipment and capacity is added, the cost of a fully automated system can escalate to over $1 million. Additional equipment to provide recycling and composting of fresh refuse will add even more.

Processing Costs

Based on operations to date, it is estimated that a coarse screening system operated by three workers can process as much as 120 tons per hour of raw landfill, with total production costs of approximately $1.85 per ton. The mining test showed that there was 85% composted earth in the landfill.

Thus, the average cost per ton of reuseable dirt is $2.18. With newly purchased dirt costing $3.70 per ton, the net saving to the County is $1.52 per ton. The total annual savings, based on the annual dirt requirement of 125,000 tons per year, will be $190,000.

Without landfill recovery, the County's 1988 budget for cover dirt is $462,000.

In this particular case, the screening system can process material at nearly twice the rate at which it is reused as landfill cover. Consequently, the recaptured earth is stockpiled and spread, as needed, using a pan-type road grader.

Odor Emissions

As the bulldozer tore open the 3-year and 8-year old sections, a momentary, "garbagy" odor filled the surrounding atmosphere. Most close observers were surprised at how quickly this dissipated and, within minutes, only a faint odor was detectable, even in the 90°F (32°C) heat. Once again, this can be expected only from a fully cured landfill. Landfills with high anerobic decomposition, can be expected to generate noticeably more odor.

Methane Emissions

Collier County landfill managers had previously installed methane gas vent pipes to release any ongoing gas production to the atmosphere. The normal output of these vents exceeds the meter reading of 30% of the Lower Explosion Level (LEL). In contrast, as the ground was removed for the mining activity, only a 5% LEL, maximum was detected. This meant that 0.25% of the volume of atmospheric air was methane, a condition far below the explosion level. Within 1 min, the LEL fell to only 1%. After 5 min, there was no measurable emission of methane.

Note that this condition can be expected from 3–5 year old landfills only in warm, moist climates where decomposition is nearly complete. Dryer northern regions cannot expect such methane-free conditions in young landfills.

Heavy Metals

Trace quantities of arsenic, cadmium, lead, chromium, mercury and selenium were detected by chemists using the EP-Toxicity testing procedure. Both the actual toxicity and leachable level were below the level of standard contamination and the threshold of the test apparatus.

RESULTS

Both the Collier County and Key West landfills were tested using the same impact separator. In each case, the recovered dirt showed that an excellent separation of the cover dirt and the undecomposed refuse could be obtained. The original refuse had highly decomposed and, along with the cover material, had formed a good grade of top soil, especially since most of the cover material was sand or a coral-based rock called marl.

In each case, about 85% by weight was the composted cover dirt, 10% was plastic, and 5% was mostly ferrous metal with some wood. The Separator proved that even under highly wet conditions [1 in.–3 in. of rain (2.5–8 cm) fell almost every evening], it could operate effectively. A self-cleaning feature added to the system would improve performance under all conditions.

A thorough chemical analysis proved that the soil was highly flexible, and contained no toxins of consequence.

CONCLUSIONS

(a) Solid waste in existing sanitary landfills can be mined in a safe, economical and environmentally sound manner.

(b) The mined material was tested and found free of dangerous chemicals or asbestos.

(c) The mining operation did not endanger the health or safety of the operating personnel.

(d) Using relatively simple machinery, the mined material can be easily separated into a dirt or cover material fraction and a secondary plastic fuel fraction.

(e) The plastic fuel fraction is combustible in a mass-burn type incinerator, as was demonstracted in Key West's resource recovery plant. The heat value of the recovered plastic exceeded 5600 Btu/lb on a wet basis. On a dry basis, it was 7400 Btu/lb (mass refuse is normally rated at 4500 Btu/lb).

(f) A sanitary landfill acts as a slow speed composting machine. Over time, chemical, biological and physical change occurs, breaking down organic materials, through the decomposition of starches, proteins and carbohydrates, into methane and other organic materials. Stable substances like metals, plastics, rubber and wood, can be incinerated, recycled or reburied.

(g) In this particular landfill test area, 85% of the material recovered could be considered reusable soil.

(h) Extensive chemical analysis and physical testing indicated that the recovered Collier landfill dirt had an average pH of 7.4, was 3% to 10% organics, and had a high calcium content of 73%. It was also free of asbestos and toxins.

(i) The exact performance of the recovered soil as an agricultural growing medium must still be tested.

(j) Compared to the costs of totally closing a landfill using EPA standards, mining a landfill can be a desireable, cost-effective, safe alternative.

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