Managed Fermentation and Leaching: An Alternative to MSW Landfills

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The current approach for landfilling of municipal solid wastes (MSW) is to try to design and construct "tombs" consisting of liners and caps to keep buried wastes dry (US EPA, 1988). Keeping the waste dry will prevent the decomposition of the wastes and the production of leachate; prevention of leachate formation will prevent pollution of groundwaters. While such a system, if properly designed, constructed, and maintained, should, in theory, keep the wastes dry as long as the engineered system maintains its integrity, this approach is not without significant deficiencies that will ultimately threaten public health and environmental quality. First, experience has shown that theoretical integrity of liner construction, placement, and endurance is not achieved in MSW landfills. Manufacturing defects and installation imperfections breach integrity from the out set; the materials used for liners will eventually deteriorate. Liner materials are typically warranted for about 20 years. These deficiencies and failure will promote leachate generation and transport to groundwaters. Second, even if the integrity of the system could be ensured and maintained until materials failure, the contents of the "dry tomb" would. at that time, be largely the same as they were when placed: thus the leachate formation and transport from the landfill is simply being delayed until the liner and cap materials fail. Proper maintenance and remediation would involve vigilant monitoring and preparedness for exhumation forever, since the materials in the "dry tomb" landfill would represent a threat to groundwater quality forever.

Being advanced herein is a system for MSW handling that would ferment and leach the wastes prior to final disposal of residues. The leachates generated in the process would be treated as wastewaters. The stabilized, leached residues would be buried. Since those residues would have already been fermented and leached, they would not represent the perpetual, significant threat to groundwater quality and public health that they would in a conventional MSW landfill. Harper and Pohland (1988) have also been critical of the US EPA's proposed approach for municipal solid waste management involving the attempt to create "dry tombs." They have also advocated a fermentation leaching approach.

Treatment Approach

The authors feel that consideration should be given to an alternative approach for landfilling of municipal solid wastes. Rather than trying to keep the wastes dry forever and not succeeding, a waste disposal area/cell should be used as a treatment reactor in which the wastes are actively fermented and leached. This process would stabilize the decomposable organic matter by providing the needed moist anaerobic environment and would generate methane and carbon dioxide. By following approaches similar to those typically used for stabilization of municipal wastewater sludges, it should be possible to ferment MSW's to a near-maximum extent within a few years. This process would also be designed to leach the wastes, removing chemicals that would be expected to eventually leak out of a conventional MSW landfill.

It is well known that the moisture content in a landfill is a key to optimizing the rate of "stabilization" of decomposable organics. Much of the moisture that would be needed to stabilize wastes can, in many parts of the US, be derived from the precipitation on the landfill surface and through the recycle of leachate through the landfill. Where necessary, those sources could be supplemented.

Since the success of this system will depend in large part on the even distribution of moisture within the wastes, several changes would have to be made in the design and operation of landfills if this rapid stabilization and leaching is to be achieved. First, the daily cover used in many sanitary landfills does not necessarily result in even distribution of moisture within a landfill. This means that some parts of the landfill stabilize at a slower rate than others. The placement of wastes, addition of water, and application of daily cover should be done in a manner to allow all parts of the landfill cell to contain an amount of moisture to bring about fermentation of the waste at an optimum rate. Second, even distribution of water will likely require that the wastes be shredded before placement in the treatment cell. Robert Ham of the University of Wisconsin, Madison has shown that shredding of municipal solid waste significantly improved its stabilization as measured by methane and carbon dioxide production. The cost of shredding municipal solid waste would be expected to add a few cents per person per day to the cost of solid waste disposal and would significantly improve waste handling, fermentation, and leaching. It may be necessary to install a header system at various depths in the waste to ensure that all parts of the landfill are receiving optimum moisture. Third, some changes will also likely have to be made in the way landfill cells are constructed to optimize rates of methane generation.

Because liquids would be added to and would need to be retained within the system, attention must be given to liquid containment during treatment. For this purpose double-composite-lined cells are recommended. Each composite liner should be composed of a high-density polyethylene (HDPE) flexible membrane liner (FML) at least 100 mil thick, underlain by and in intimate contact with a 3-ft compacted clay layer having a field-measured permeability no greater than 1×10^{-7} cm/sec. It may be desirable to admix polymers or polymer/bentonite mixtures with the clay to further improve its structural integrity and reduce its permeability. There should be a leachate collection and removal system above the upper liner and a leachate detection system between the liners. It would be important not to allow the leachate head on the upper liner to build up to the point at which it would create a significant additional potential for passage of liquid through the upper composite liner into the leachate detection system Significant leachate in the detection system would indicate that the upper composite liner system has been breached and the cell should be taken out of service for repair.

Because of the difficulties of siting MSW landfills, this system should be established at existing landfills. While with MSW landfills being designed today with liner systems there is concern about the long-term threat to public health and groundwater quality because of the eventual degeneration of the engineered systems; this is not a problem with the proposed system. This is because the cycle of fermentation and leaching would be expected to be on the order of 5 to 10 years. Thus the liner system would be accessible for inspection, and repair or replacement periodically during its expected lifetime, and, importantly, in response to detection of leachate generation.

The recommended approach will result in the leaching and removal for treatment of materials from the waste that would otherwise eventually leak into groundwaters. Leachate recycle through the system during the fermentation/leaching process will promote the leaching of those materials that would be expected to be readily leachable under the conditions that exist in a landfill. It has been known (as discussed by Lee *et al.* (1986)), that leachate recycle at sanitary landfills tends to improve the character of the leachate. Additional research needs to be done to understand how the composition of the recirculating leachate and water added to the landfill affects the leaching of wastes. Little is known about the conditions that would be needed to optimize leaching of wastes to maximize removal of materials that are potentially leachable under landfill conditions.

Residues

Once the waste has been stabilized and leached, it can be removed from the treatment cell. The residue can be sorted and classified by particle size/density. The "soil-like" residue can be evaluated to determine if, based on the heavy metal and other contaminant characteristics, it is suitable for use as a soil conditioner/humus. While the wastes would have been leached extensively, the non-usable residues still should be fixed with cement/silicates or other reagent and buried in a permanent, lined landfill. The amount of material that would have to be landfilled would be substantially less than that originally fermented and leached. The leachate would have to be treated as a wastewater and discharged to surface waters.

Basically, this approach is similar to that being used by some municipalities for mining of existing landfills. Important differences are that the stabilization process would be greatly accelerated in the proposed system and the wastes would be extensively leached to remove solubilized contaminants.

The proposed approach is in many respects similar to composting of municipal solid wastes, except that it would be done under anaerobic rather than aerobic conditions. The purpose of composting is to produce a "stabilized" residue that will not be "offensive" to the public. That residue, however, is not leached. That is a major and significant difference between the two approaches. Waste that has been composted will likely leach contaminants that can have an adverse effect on surface and groundwater quality. Care must be exercised in using residues from MSW and wastewater sludge composting because of potential problems of this type. Epstein and Epstein (1989) recently discussed public health issues associated with composting of solid waste.

Active Management

The approach outlined herein is active management rather than the traditional, passive approach used today in which moisture addition is not controlled, or the "dry tomb" approach advocated by the US EPA (1988) and some states. By actively managing the fermentation and leaching, many of the problems being encountered today with sanitary landfills and those that threaten public health and groundwater quality forever should be greatly minimized and possibly even eliminated.

Another advantage of using a fermentation/leaching approach is the increased safety of the facility. The production of gases, methane in particular, is of concern in sanitary landfills because of the potential for explosion upon ignition when the methane exceeds a few percent of the landfill gas/air mixture. While gas production problems can be controlled at sanitary landfills, the control of gas formation and gas recovery/utilization could be more readily done with the proposed approach because fermentation would be controlled and optimized. For any given treatment cell, the duration of gas production would be significantly less than that typically encountered in a MSW landfill.

Finally, the advantages to long-term protection of public health and groundwater quality of this approach are significant. The long-term problems of groundwater contamination by MSW landfill leachate are difficult, if not impossible, to control. The proposed approach would generate residues that would pose a significantly smaller threat to public health and groundwater quality because of their treatment.

References

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AN ALTERNATIVE TO MSW LANDFILLS

Instead of leaving a legacy of garbage "dry tombs" for future generations, say the authors, MSW should be fermented and leached to produce stable residues that will not threaten public health, the environment, or groundwater quality.

G. Fred Lee and R. Anne Jones

THE CURRENT APPROACH for landfilling of municipal solid wastes (MSW) is to try to design and construct "tombs" consisting of liners and caps to keep buried wastes dry (US EPA, 1988). Keeping the waste dry will prevent the decomposition of the wastes and the production of leachate; prevention of leachate formation will prevent pollution of groundwaters. While such a system, if properly designed, constructed, and maintained, should, in theory, keep the wastes dry as long as the engineered system maintains its integrity, this approach is not without significant deficiencies that will ultimately threaten public health and environmental quality. First, experience has shown that theoretical integrity of liner construction, placement, and endurance is not achieved in MSW landfills. Manufacturing defects and installation imperfections breach integrity from the outset; the materials used for liners will eventually deteriorate. Liner materials are typically warranted for about 20 years. These deficiencies and failure will promote leachate generation and transport to groundwaters. Second, even if the integrity of the system could be ensured and maintained until materials failure, the contents of the "dry tomb" would, at that time, be largely the same as they were when placed; thus the leachate formation and transport from the landfill is simply being delayed until the liner and cap materials fail. Proper maintenance and remediation would involve vigilant monitoring and preparedness for exhumation forever, since the materials in the "dry tomb" landfill would represent a threat to groundwater quality forever.

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TREATMENT APPROACH

The authors feel that consideration should be given to an alternative approach for landfilling of municipal solid wastes. Rather than trying to keep the wastes dry *forever* and not succeeding, a waste disposal area/cell should be used as a treatment reactor in which the wastes are actively fermented and leached. This process would stabilize the decomposable organic matter by providing the needed moist anaerobic environment and would generate methane and carbon dioxide. By following approaches similar to those typically used for stabilization of municipal wastewater sludges, it should be possible to ferment MSW's to a near-maximum extent within a few years. This process would also be designed to leach the wastes, removing chemicals that would be expected to eventually leak out of a conventional MSW landfill.

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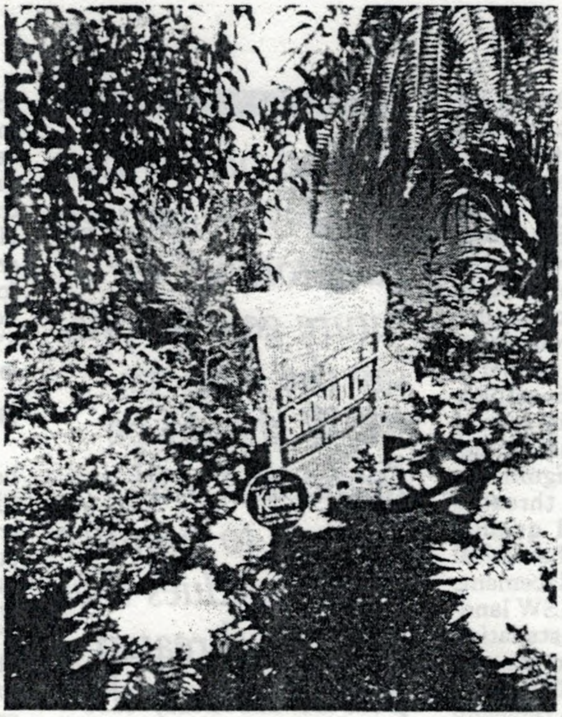
Since the success of this system will depend in large part on the even distribution of moisture within the wastes, several changes would have to be made in the design and operation of landfills if this rapid stabilization

Early users sent photos of crops grown using Kellogg's product.

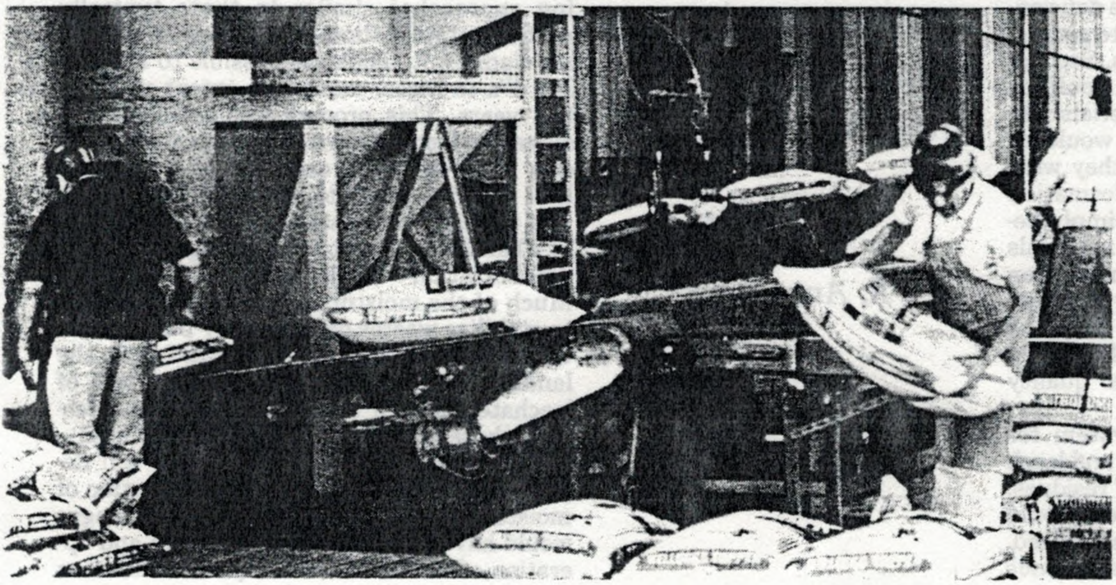
the Santa Ana River bottom awash with murky material and noted the plentiful plant growth. He scooped some of the muddy substance into a shoebox and experimented with it in his orange groves. The first crop grown with sludge yielded four times the quantity of any of his neighboring farmers. Other farmers wanted to know how Kellogg achieved these yields, and my grandfather knew he was onto something—and that something was Nitrohumus.

In 1925, my grandfather organized Kellogg Supply, Inc. after entering into a contract with the Los Angeles County Sanitation District to purchase and remove material from its lagoon drying beds. The Sanitation District is one of the largest in the world, serving over 78 cities and 4.7 million people, generating half a billion gallons of wastewater every day. It composts 300 wet tons/day of sewage sludge utilizing the windrow method. Together with the District, we have been one of the largest beneficial reusers of sewage sludge in the United States.

In those days, when the lagooned sludge was dry enough to handle, it



Today Nitrohumus is blended into a variety of products form a planter mix (right) to top dressing for lawns (below). (Photos courtesy of Kellogg Supply, Inc.)



was picked up with pitchforks by hand, loaded onto wagons pulled by horses, and taken to a screen and grinder. This was all the processing needed to bring the material to the agricultural market. As the years passed and the post war boom hit Southern California, many rural areas became urban. It was then necessary for Kellogg to seek the additional homeowner markets. My father, Hi Kellogg, developed a complete line of fertilizers and organic soil conditioners using Nitrohumus as the base—but not without a family struggle.

My father believed the path to success was to grow and diversify with the home gardening industry; my grandfather felt that sticking with what had been successful was the only way to go. When Grandpa was out on a trip, Dad mixed Nitrohumus with wood to enhance its ability to perform as a topdressing—and called it Topper. Because dichondra lawns were the rage in the 1950s, Topper was a smashing success. Today the company markets a wide variety of blends for plant mixes and mulches.

In marketing recycled wastes, the key is quality. Consistent supply, consistent particle size, overall consistent quality. You can't market to the homeowner without it.

And at our operation, it all starts with delivery of 300 to 400 tons of sludge every day, six days a week. We also use 1,000 to 1,400 cubic yards of wood waste daily—mixed in windrows and turned every other day. Through this kind of large scale recycling, we create 300,000 cubic yards of organic humus to put back into soils every day. With every bag opening, the consumer can expect to smell a fresh earthy odor and see even color and particle size. It's humus in their eyes, and it's still bread and butter to us.

—Kathryn L. Kellogg

and leaching is to be achieved. First, the daily cover used in many sanitary landfills does not necessarily result in even distribution of moisture within a landfill. This means that some parts of the landfill stabilize at a slower rate than others. The placement of wastes, addition of water, and application of daily cover should be done in a manner to allow all parts of the landfill cell to contain an amount of moisture to bring about fermentation of the waste at an optimum rate. Second, even distribution of water will likely require that the wastes be shredded before placement in the treatment cell. Robert Ham of the University of Wisconsin, Madison has shown that shredding of municipal solid waste significantly improved its stabilization as measured by methane and carbon dioxide production. The cost of shredding municipal solid waste would be expected to add a few cents per person per day to the cost of solid waste disposal and would significantly improve waste handling, fermentation, and leaching. It may be necessary to install a header system at various depths in the waste to ensure that all parts of the landfill are receiving optimum moisture. Third, some changes will also likely have to be made in the way landfill cells are constructed to optimize rates of methane generation.

> With MSW fermentation controlled and optimized, gas formation and recovery/utilization can be accomplished more readily.

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ALTERNATIVES TO MSW LANDFILLS

(Continued from page 80)

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These observations are derived from a review paper by Drs. Fred Lee and Anne Jones, entitled "Municipal Solid Waste Management: Long-Term Public Health and Environmental Quality Protection." The paper is available for $5 to cover costs, from G. Fred Lee & Associates, 970 East El Macero Drive, El Macero, CA 95618. The authors welcome comments on this approach and are interested in developing cooperative demonstration projects.

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