"Dry Tomb" Landfills

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Municipal solid waste (MSW) management has evolved in the USA from open dumps through classical sanitary landfills to "dry tomb" sanitary landfills. The "dry tomb" sanitary landfilling approach is basically an open dump in which each day's wastes are covered by a few inches of soil (classical sanitary landfill) where compacted soil (clay) and plastic sheeting (flexible membrane liners - FML's) are used to try to isolate the untreated municipal solid waste from moisture. Also, this containment system is designed to try to collect and manage the leachate (garbage juice) generated within the "dry tomb" that results from the entrance of moisture into the "tomb." Other countries and geographical areas in some parts of Canada and western Europe have chosen not to adopt the "dry tomb" method of MSW landfilling typically because of the likelihood of the ultimate failure of the "dry tomb" containment (liner) system to prevent moisture from entering the landfill and to collect all leachate generated in the landfill. This paper reviews the major deficiencies of "dry tomb" landfilling and presents alternative approaches for managing MSW that will provide for far greater protection of public health, groundwater resources and the environment.

Deficiencies in Subtitle D Landfills

The US EPA (1988a), as part of developing Subtitle D regulations, stated in the August 1988 Federal Register,

"First, even the best liner and leachate collection system will ultimately fail due to natural deterioration, and recent improvements in MSWLF (municipal solid waste landfill) containment technologies suggest that releases may be delayed by many decades at some landfills."

The US EPA Criteria for Municipal Solid Waste Landfills (US EPA, 1988b) state:

"Once the unit is closed, the bottom layer of the landfill will deteriorate over time and, consequently, will not prevent leachate transport out of the unit."

The situation today is no different than it was in 1988. There is no doubt that a composite liner, including a double composite liner system composed of plastic sheeting and compacted soil conforming to minimum Subtitle D requirements, will not prevent landfill leachate from passing through the liner system into the aquifer system associated with the landfill for as long as the wastes in the landfill represent a threat. This will eventually lead to pollution of the groundwaters hydraulically connected to the landfill.

30-Year Post-Closure Maintenance Myth

Commenters on the US EPA proposed Subtitle D landfill regulations (Lee and Jones 1988 and others)

discussed the ability of the then-proposed "dry tomb" landfilling approach to protect public health, groundwater quality and the environment from adverse impacts of the wastes for as long as the municipal solid wastes in the "tomb" would be a threat. While RCRA and the US EPA Subtitle C and D mandated a minimum 30-year post-closure maintenance and monitoring period, the Agency did recognize that this period may need to be expanded where it specifies that the regional administrator may extend the post-closure maintenance monitoring period beyond the minimum 30 years.

It is obvious, considering the characteristics of municipal solid waste and the processes that take place in "dry tomb" landfills that MSW in a "dry tomb" sanitary landfill will be a threat to public health, groundwater resources and the environment for as long as the landfill exists (Lee and Jones-Lee 1992, 1993). The inorganics (metals, salts) and many organics will be a threat, effectively, forever. Lee and Jones-Lee (1994b) have recommended that the minimum 30-year post-closure maintenance and monitoring period should be abandoned in favor of an expanded, perpetual, ad infinitum funded maintenance and monitoring. Hickman (1992, 1995) has urged that a dedicated trust fund be developed for all landfills to meet contingencies that may be encountered in the future.

Inadequate Post-Closure Care Funding

Lee and Jones-Lee recommend that the post-closure maintenance and monitoring funding be developed from additional disposal fees that are placed in a dedicated trust that can only be used to meet the closure/post-closure maintenance and monitoring needs. They recommend the magnitude of the trust fund be sufficient to eventually exhume (mine) the wastes in the landfill and properly manage these wastes so they do not represent threats to public health, groundwater resources and the environment. Lee and Jones-Lee (1995a) have recently reviewed the problems with current "dry tomb" landfill closure and post-closure maintenance and monitoring approaches and have recommended approaches for closure and post-closure maintenance for classical sanitary and "dry tomb" Subtitle D landfills.

Since, with few exceptions, both of the types of landfills (classical and "dry tomb" sanitary landfills) will pollute groundwaters and the aquifer system hydraulically connected to the landfill, the key to public health and environmental protection is the establishment of a leak-detectable cover that prevents moisture from entering the landfill after closure of the landfill. The current Subtitle D regulations allowed the closure of a "dry tomb" sanitary landfill with a cover that does not necessarily keep the wastes dry so that the landfill does not generate leachate that can penetrate the landfill liners and pollute the groundwaters associated with the landfill. Leak-detectable covers are now available from Gundle Lining Systems, Inc. of Houston, TX, and Robertson Barrier Systems Corps of Vancouver, BC. The development of the funding necessary to operate and maintain the leak-detectable cover is also a key component of proper closure of "dry tomb" sanitary landfills.

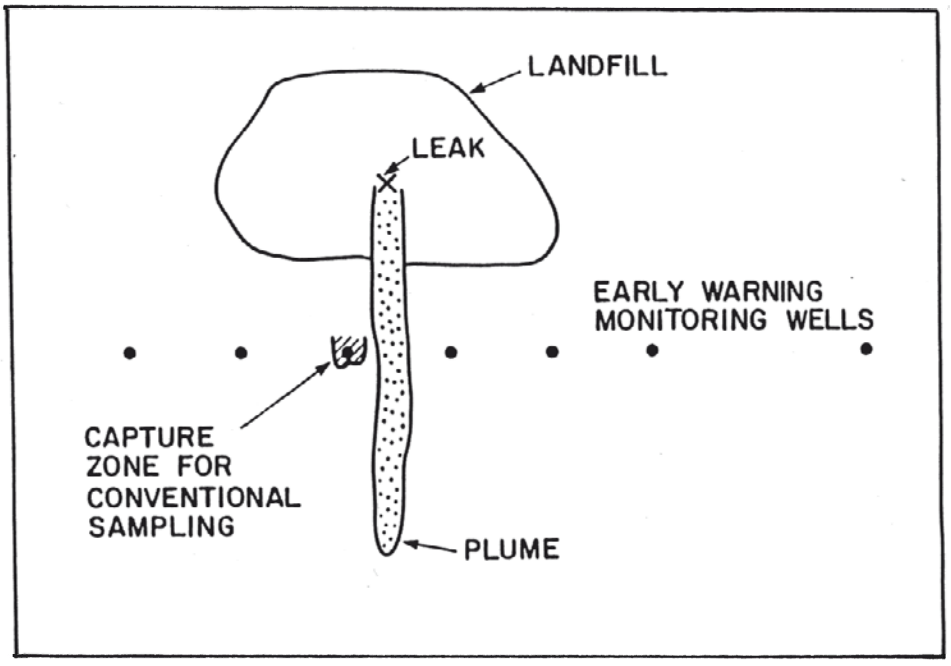
Inadequate Groundwater Monitoring

One of the most significant deficiencies with US EPA Subtitle D sanitary landfills is the unreliability of the groundwater monitoring system typically allowed to detect when liner leakage occurs. Subtitle D regulations require that the groundwaters at the point of compliance, which is equal to or less than 150 meters downstream from the waste management unit, meet drinking water MCLs. The typical groundwater monitoring approach at the point of compliance involves placing vertical monitoring wells spaced hundreds to a thousand or more feet apart. Cherry (1989) and, more recently, Lee and Jones-Lee

(1994a) have discussed the inability of this monitoring well array to reliably detect groundwater pollution by landfill leachate before widespread groundwater pollution occurs beyond the point of compliance.

As shown in Figure 1, the narrow plumes produced by initial leaks of the Subtitle D single composite liner system will readily pass between the vertical monitoring wells that are used to monitor leachate-polluted groundwater at the point of compliance. These wells have zones of capture of approximately one foot around the well. In order to be effective, such monitoring wells would have to spaced about 10 feet apart. The state of Michigan's Department of Natural Resources, through the development of the state's Rule 641 governing MSW landfilling, recognized the deficiencies in the US EPA Subtitle D groundwater monitoring approach and adopted double-composite-lined MSW landfills where the lower composite liner is a leak detection system for the upper Subtitle D composite liner. There is a leak detection layer between the upper liner and the lower liner. The collection of leachate in the leak detection system between the two liners is a clear indication that the upper liner has failed.

Figure 1. Pattern of landfill leakage groundwater - contamination from lined landfills (after Cherry, 1990).



At this time, however, Michigan does not require that adequate funding be made available to take action to either stop the leachate production which is passing into the leak detection system between the two composite liners or, if this cannot be stopped, remove the wastes from the landfill. Lee and Jones-Lee (1994a) recommend that a trust fund be developed from disposal fees to be able to take action when needed to prevent leachate from passing through the lower composite liner and polluting the groundwaters near the landfill. This dedicated trust would ensure that funds are available whenever they are needed at any time in the future to address the inevitable failure of the composite liner to prevent leachate generated in the landfill from eventually polluting groundwaters in the vicinity of the landfill.

Alternative Landfilling Approaches

At this time the USA is the only country that has adopted the "dry tomb" sanitary landfilling approach. Several states such as New York, New Jersey and Pennsylvania determined in the 1980's that a single-composite liner of the type adopted by the US EPA in 1991 as Subtitle D minimum requirements would not be adequate to protect groundwater resources from pollution by landfill leachate in "dry tomb" landfills. Since the promulgation of these regulations by the US EPA in 1991 a number of other states such as Arizona, Michigan, Kentucky and Oregon have adopted double composite liners for municipal solid waste landfills. As the significant deficiencies in minimum Subtitle D landfill liner and cover systems are becoming more widely recognized, it is likely that many other states will adopt double-composite lined MSW landfills as the minimum needed for protecting groundwater resources from pollution by landfill leachate. It is important, however, in adopting double composite liners not to try to rely on the lower composite liner as a containment liner. Instead, it should be part of a leak detection system for the upper composite liner.

"Wet Cell" Approach and Leachate Recycle

Municipal solid waste leachate recycle in which leachate is introduced back into the landfill has been found to potentially greatly accelerate the "stabilization" of the landfill. This so-called stabilization is the conversion of fermentable organics in the wastes into carbon dioxide and methane (landfill gas). EMCON (1975, 1976) conducted one of the most definitive demonstration projects on the value of MSW leachate recycle. In that study it was found that landfill gas production processes that normally take 30 to 50 years in a conventional sanitary landfill could be accelerated to take place in 4 to 5 years under field conditions.

Recently, considerable attention has been given to leachate recycle in Subtitle D landfills. Much of this attention arises from the fact that leachate disposal is expensive at some landfills. Recycling leachate back into the landfill at some locations is initially at least an inexpensive way to dispose of leachate. Lee et al. (1986) have discussed the importance of shredding MSW as part of any leachate recycle project to break up the plastic bags that are used for home and commercial solid waste disposal. Failure to shred the waste could readily hinder the accelerated stabilization of the fermentable components of MSW.

Lee et al. (1985) conducted a comprehensive review of the advantages and disadvantages of MSW leachate recycle. As they point out, some states at that time prohibited leachate recycle due to the potential for increased groundwater pollution associated with the increased hydraulic loading on the landfill. This problem can be especially important in Subtitle D landfills where the single composite liner FML makes the groundwater monitoring system particularly ineffective in detecting leachate pollution of groundwater by leakage through the liner. Lee and Jones-Lee (1995b) recommend that MSW leachate recycle should only be conducted in double composite lined landfills where the MSW is shredded.

While MSW leachate recycle is well-known to cause accelerated rates of conversion of fermentable organics to landfill gas, the so-called landfill stabilization that occurs in this process does not address the leaching of chemical constituents in the waste. Well-stabilized MSW with respect to gas production still is a significant threat to groundwater pollution. Lee and Jones (1990) and Lee and Jones-Lee (1993) recommend that, following a 4 to 5-year MSW leachate recycle period at the closure of the landfill, a 10

to 15-year clean water leaching of the fermented waste residues be practiced. This "wet cell" approach not only converts the fermentable organics in the landfill to CO_2 and CH_4 but also leaches the waste to remove those components of the waste that represent long-term threats to groundwater quality through passage of the leachate through the liners.

This "wet cell" approach should be conducted in double composite-lined landfills using shredded wastes in which the lower composite liner is a leak detection system for the upper composite liner. If during the leachate recycle or leaching of the waste with clean water it is found that leachate is detected in the leak detection system between the two composite liners, then the leachate recycle or clean water leaching should be stopped and the waste exhumed from the landfill.

There is need to change Subtitle D regulations to permit the managed leaching of the wastes with clean water during the time that the landfill liners are expected to be effective in order that the clean water washing of the wastes can be accomplished.

Conclusions

The US EPA Subtitle D "dry tomb" landfilling approach as adopted in 1991 at best only postpones groundwater pollution by a few decades from what would have occurred in the classical unlined sanitary landfill. Further, the FML in the single composite liner makes monitoring of liner leakage and groundwater pollution highly unreliable.

Alternative approaches to the "dry tomb" sanitary landfill include double composite liners where the lower composite liner is part of a leachate detection system for leakage of the Subtitle D liner. The cover used to close a "dry tomb" sanitary landfill should include a leak detectable cover that is effectively operated and maintained forever. Adopting this approach should enable the development of "dry tomb" sanitary landfills that will be protective of public health, groundwater resources and the environment for as long as the wastes represent a threat.

The "wet cell" landfilling approach in which a landfill is operated as a biological and chemical reactor to ferment and leach the components of the wastes (gas and leachate) that represent long-term threats to public health and the environment is a method of choice for MSW management. While somewhat more expensive initially, in the long term, it would be a far cheaper method of MSW management as a result of removing those components of MSW that represent long-term threats to public health, groundwater resources and the environment.

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