MSW Landfill Leachate Recycle and Groundwater Quality Protection

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Abstract

The recycle of municipal solid waste (MSW) landfill leachate can enhance the rate of waste stabilization with respect to landfill gas formation. Landfill gas production that would normally take place over 30 to 50 years in a conventional sanitary landfill can be accomplished in 5 to 10 years. Typically today, however, MSW landfill leachate recycle is used as a method of leachate disposal in order to reduce the operating cost of the landfill. The large numbers of plastic bags within landfills severely restrict the opportunity for the recycled leachate to interact with the solid waste to enhance gas formation and fermentable organic matter stabilization. MSW landfill leachate recycle however does not address the leaching of contaminants from the solid waste that can lead to groundwater pollution. Leachate recycle in a landfill can readily lead to increased groundwater pollution. Landfill leachate recycle should be practiced with landfills with at least a double composite liner on shredded MSW. The leachate recycle should be followed by single pass water washing (leaching) of the waste to remove leachable components.

Key Words - municipal solid waste, leachate recycle, groundwater pollution, landfill gas formation

Introduction

The US Environmental Protection Agency's (US EPA) Resource Conservation and Recovery Act (RCRA) Subtitle D requirements for municipal solid waste (MSW) landfilling basically prescribe the placement of MSW in a "dry tomb" landfill. In concept, it is intended that such systems keep the buried wastes dry; as long as the wastes are kept dry, they will not ferment and produce landfill gas, or generate leachate. However, the buried wastes remain a threat to groundwater quality for as long as they are in the "dry tomb."

Lee and Jones-Lee (1993a,b) discussed the problems with the "dry tomb" landfilling approach that preclude its ensuring protection of groundwater quality for as long as the wastes represent a threat. They noted among other problems that liners of the type currently used leak from the time a landfill is placed in service and deteriorate over time; the leachate collection and removal systems depend on the integrity of the liner system and are subject to biological fouling; groundwater monitoring programs typically used are inadequate to detect incipient liner leakage or incipient groundwater pollution by landfill leachate; inadequate attention is given to sufficiently funding the post-closure care of landfill covers that will be required in perpetuity. At best, "dry tomb" landfills postpone groundwater pollution and pass the costs for corrective action, proper waste handling, and lost groundwater resources on to future generations (See Lee and Jones-Lee, 1993c).

There is growing consensus that the "dry tomb" storage of MSW should be abandoned in favor of *in situ* treatment of MSW so as to remove at the outset, components that could otherwise eventually leak from the landfill to pollute groundwater. The "fermentation/leaching wet cell" (F/L wet cell) shows considerable promise for achieving such treatment in a cost-effective manner. In that system, moisture is introduced into the buried wastes to enhance the stabilization of fermentable organics (those that undergo anaerobic bacteriological transformation to methane and carbon dioxide), and to leach the leachable chemicals from the wastes that could otherwise escape the landfill to adversely affect the beneficial uses of groundwater. A potential source of moisture for the fermentation is leachate generated in the landfill. While recycling leachate through the wastes can aid in waste "stabilization," there is considerable misinformation being advanced today about the role of leachate recycle in the "treatment" of MSW to reduce the potential for the leachate to pollute groundwater. Presented below is a discussion of potential benefits of leachate recycle with particular reference to its potential use in protecting groundwater from pollution by landfill leachate.

Leachate Recycle in MSW Management

Lee *et al*. (1985; 1986), Pohland and Harper (1987) and Otieno (1994) noted that leachate recycle has been used for many years as a means of "disposing" of MSW landfill leachate and to enhance "stabilization" of fermentable organics in MSW. The rate of methane generation is controlled by the amount of moisture present in the waste. In the classical sanitary landfill where no attempt is made to restrict entrance of moisture, landfill gas formation typically takes place for 30 to 50 years. As additional moisture is added to the waste, the rate of methane formation increases. It has been well-documented in the literature that by adding moisture through leachate recycle the period during which methane is generated under ideal conditions in a sanitary landfill can be reduced to 5 to 10 years.

Christensen and Kjeldsen (1989) conducted a study of the impact of the moisture content of MSW on gas production rate. They reported that gas production essentially ceased when the percent moisture in the waste is less than about 20%. The rate of gas production increased with moisture content up to the maximum moisture content evaluated, about 60%. It is possible, although not investigated by them, that higher rates of gas production could have occurred with higher moisture content.

In cooperation with the Sonoma County (CA) Department of Public Works, EMCON (1975; 1976) conducted one of the most comprehensive and definitive studies of the impact of leachate recycle on the chemical characteristics of MSW landfill leachate. A set of landfill test cells (measuring 18x18x2.4m (60x60x8ft)-deep) was developed; each cell was filled with about 477 mtons (525 tons), about 909 m^3 (1000 yd^3) of MSW. Each cell received leachate that had been produced within the cell, or clean water, or no supplemental moisture, or one of various other treatments. The chemical characteristics of the leachate were determined periodically over a 4-year period. It was found that during the test period, the test cell that received recycled leachate produced methane at the greatest rate; by the end of the test, the rate of methane formation had been significantly reduced. The test cell that received only clean water, with no recirculated leachate, also produced methane at a rapid rate, but the rate was initially somewhat slower than that of the cell that received recycled leachate. Methane formation from stabilization of the fermentable organics in the waste in that test cell was also almost completed during the 4-year period. By contrast, the test cell that received no moisture other than atmospheric precipitation that penetrated the clay cover (which was not designed to be a "low-permeability" cover of the type being developed today for "dry tomb" landfills), produced very little methane by the end of the 4-year test period.

As might be expected, the groundwater pollution potential of the leachate produced in each of the three test cells at the end of the 4-year test period was different. The leachate from the test cell that had received only precipitation that naturally penetrated the cover had characteristics similar to those of classical MSW sanitary landfill leachate; it contained a wide variety of chemical contaminants in concentrations that would represent a significant threat to beneficial uses of groundwater. At the end of the 4-year test period, the leachate from the test cell that had received recycled leachate also still contained a wide variety of chemicals in concentrations that would represent a significant potential to pollute groundwater. The leachate from the test cell that had received clean water during the test period had somewhat less potential to pollute groundwater than that from the cell that had received recycled leachate. It was evident that the clean-water washing (leaching) of the wastes effected the lowering of concentrations of constituents that represented a significant potential for groundwater pollution. That was not accomplished in the test cell that received recycled leachate.

The Sonoma County studies further demonstrated that recycling of leachate in an MSW landfill does significantly enhance the rate of landfill gas production and stabilization of the fermentable components of the MSW. The stabilized MSW residues developed after leachate recycle, however, were still a significant threat to groundwater quality. These authors (Lee and Jones-Lee) conclude from the Sonoma County studies, as well as the information in the literature, that leachate recycle as it has been practiced will not produce MSW residues that are no longer a significant threat to groundwater quality.

While it is evident from the literature that leachate recycle can significantly hasten the rate of stabilization of fermentable components of MSW, there are significant amounts of material in normal MSW that are not converted to methane and carbon dioxide under anaerobic conditions (i.e., are not fermentable). It is also clear that some of the fermentation residues, as well as non-fermentable materials in typical MSW contain readily leachable components; because of those components, leachate developed has a significant potential to pollute groundwater hydraulically connected to the landfill area. Therefore, leachate recycle *per se* does not address the primary concern about the landfilling of municipal solid wastes, namely groundwater pollution by leachate-derived constituents. This was demonstrated in the Sonoma County study discussed above.

Some landfill owners/operators practice leachate recycle as a means of reducing the costs of leachate treatment. By recycling the leachate back into the landfill, the amount of leachate that must be treated by other means can be lessened. This is especially effective when the leachate is sprayed over the surface of the landfill and given significant opportunity to undergo evaporation and evapotranspiration. However, that approach does not remove many of the contaminants in MSW landfill leachate; re-introduction of the leachate into the landfill replaces the chemical contaminants in the landfill or at its surface where they remain subject to leaching and transport to the surface waters and groundwaters of the region.

Another significant factor that must be considered today in assessing the utility and effectiveness of MSW leachate recycle is the fact that much of the garbage received by MSW landfills is in plastic bags. Such bags significantly obstruct the contact between the recycled leachate and the fermentable components of the solid waste. This would detract from the appearance of accelerated fermentation noted with leachate recycle. The results of the laboratory studies by various investigators, as well as the Sonoma County studies, would be expected to be significantly different if significant amounts of the waste were contained in plastic bags that inhibited contact between the recycled leachate and the waste.

Fermentation/Leaching Wet-Cell Approach

Lee and Jones (1990) and Lee and Jones-Lee (1993b) described an *in situ* fermentation/leaching wet-cell treatment approach by which it should be possible to treat MSW to produce a residue that represents little long-term threat to groundwater quality. The concept is to stabilize the fermentable components of MSW employing leachate recycle, and then to actively leach the residues to remove and treat those components that would otherwise eventually leak from the landfill and pollute groundwater. Wastes would be shredded prior to placement to reduce impediments to contact of the liquid with the waste components. A double-composite-lined landfill with appropriate liner leak detection systems would be used; a reverse groundwater gradient liner system (hydraulic trap) may be employed where indicated to provide additional protection against groundwater pollution. It is expected that leachate would be recycled through the landfill for a period of 3 to 5 years; that should provide sufficient time for the fermentation of those components that are subject to anaerobic fermentation to methane and carbon dioxide. At the end of the leachate recycle period, clean water would be added to leach the waste; leaching should be practiced until the leachate produced no longer represents a significant threat to groundwater quality. Depending on the design of the landfill cells and the hydraulic loading, it is estimated that a leaching period of 15 to 20 years should be sufficient to produce MSW residues that are no longer a significant threat to groundwater quality. If during the course of the leaching period, leachate were to pass through the upper-composite liner, it would be necessary to stop the leaching process, exhume the wastes, and treat them to produce non-polluting residues.

The fermentation/leaching wet-cell approach for *in situ* treatment will initially be more expensive than the conventional "dry tomb" landfilling owing to the additional costs of treating the leachate produced in the clean-water washing of the garbage. The magnitude of the increased cost is highly site specific and depends on the methods used for leachate management. However, in the long term, the F/L wet-cell approach would be less expensive since it has the potential to eliminate the need for, and very high cost of, providing landfill cover maintenance *ad infinitum*, and since it would significantly reduce the potential for having to spend funds to try to clean up leachate-contaminated groundwaters near the landfill, and replace lost groundwater resources.

It is important to distinguish the "fermentation/leaching wet-cell" approach discussed by Lee and Jones-Lee (1993b) and briefly described above, from what some refer to as a "wet cell" landfill that only incorporates leachate recycle. As noted above, thorough leaching of the wastes with clean water is essential to reducing the pollution potential of MSW landfill leachate.

Permitting of Leachate Recycle

In the review conducted by Lee *et al*. (1985) it was found that a number of states, such as New Jersey, prohibited leachate recycle because of the increased potential for groundwater pollution associated with the increased hydraulic loading on the landfill. As discussed by Lee *et al*. (1985) the more rapid onset of groundwater pollution is a real, potentially significant problem that needs to be properly addressed if leachate recycle is to be practiced. It is clear that leachate recycle should not be practiced in an unlined landfill or a landfill that does not have a highly reliable liner leak detection system.

Lee and Jones-Lee (1993d, 1994) discussed problems inherent in trying to use conventional groundwater monitoring systems, with vertical monitoring wells spaced hundreds to a thousand or so feet apart, for the detection of incipient liner leakage or incipient groundwater pollution from a lined MSW landfill. Based on the manner in which lined landfills leak from point sources in the liners, and the manner in which leachate moves in groundwater systems in "finger" plumes, such conventional monitoring systems have a very low probability of detecting incipient groundwater pollution by landfill leachate at the point of compliance before widespread groundwater pollution has occurred.

Because of the inherent unreliability of single-composite liner systems that depend on the monitoring of groundwater to detect liner-leakage of landfill leachate, the authors strongly recommend against the practice of leachate recycle in a single-composite-lined landfill of the type prescribed as the US EPA Subtitle D minimum prescriptive standards.

Leachate recycle should only be allowed at those landfills sited where groundwater pollution by leachate is considered to be of no consequence, or that incorporate a double-composite liner system in which the lower-composite liner is part of a leak detection system designed to determine when the upper-composite liner fails to prevent leachate transport through it. Further, as described by Lee and Jones-Lee (1993a), sufficient funds must be available in a dedicated trust fund derived from waste disposal fees to exhume the wastes and treat them to produce non-polluting residues that may be safely buried in a landfill, when the upper-composite liner fails to prevent leachate transport through it. As a stop-gap approach, a landfill owner/operator may try to prevent further passage of leachate through the upper-composite liner once it is detected in the liner leak detection system, by immediately ceasing leachate recycle and trying to prevent entrance of moisture into the landfill through the cover. While costing more than the amount of money typically provided for landfill cover maintenance during the post-closure care period, it may be possible to isolate MSW from moisture that can generate leachate for those landfills sited above the watertable by using appropriate leak detection systems in the cover and aggressive maintenance *ad infinitum* as discussed by Lee and Jones-Lee (1993d). It is clear that any leachate recycle project must plan for the inevitable failure of the liner system to manage leachate and have the funds available in a dedicated trust fund to address the failure when it occurs.

It is in the best interest of protecting groundwater resources for future generations to allow properly conducted leachate recycle as part of fermentation/leaching treatment of wastes. As part of revisions of solid waste management regulations provisions should be included for leachate recycle in double-composite-lined landfills in which the lower composite liner is part of a liner leakage monitoring system, and where adequate funds have been set aside in a dedicated trust fund to properly address all plausible worst case scenarios for liner failure, *ad infinitum*, including waste exhumation and treatment. Leachate recycle should not be allowed in single-composite-lined landfills. Further, leachate recycle should be recognized as only providing stop-gap relief from leachate treatment costs; it will not eliminate or even significantly reduce the potential for groundwater pollution by solid waste components. Regulations prohibiting the *in situ* treatment of MSW should be amended to allow fermentation/leaching wet-cell treatment in properly designed and constructed double-composite-lined landfills of the type recommended in this discussion.

Conclusion

As it has been practiced, leachate recycle does not produce MSW residues that are not significant threats to groundwater pollution. Leachate recycle should not be practiced in a single-composite-lined landfill that relies on groundwater monitoring to detect the failure of the composite liner to prevent significant transport of leachate through it. Leachate recycle can and should be practiced in appropriately designed and constructed double-composite-lined landfills in which the lower-composite liner serves as a leak detection system for the upper-composite liner. Leachate recycle must be followed by clean-water leaching (washing) of the fermented solid waste residues in order to remove those components of MSW that represent threats to groundwater quality by their presence in leachate.

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