1st Intercontinental Landfill Research Symposium

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Session: Defining Landfill Stability and the End of the Post-Closure Monitoring Period

Session chair report by Morton Barlaz*

Background and Aims

The objective of the session on landfill stability was to evaluate potential criteria that could be used to determine when a landfill can safely be considered stable. In the US, regulations require that a municipal waste landfill be monitored for 30 years after placement of the final cover. This 30-year period is referred to as the post-closure monitoring period. At the end of 30 years, the site is assumed to be stable and post-closure monitoring ends unless it is extended by the regulatory agency. However, agencies have no technical criteria on which to base decisions to either decrease or extend the monitoring period. With the increasing interest in bioreactor landfills, requests to shorten the post-closure monitoring period are anticipated, which further highlights the need to develop technical criteria. In addition to the US regulatory framework, the question of landfill stability has been recognized throughout Europe as an issue that requires the development of technical criteria.

Landfill stability must be determined in consideration of all aspects of a landfill including the composition and quantity of leachate produced, the extent to which the solid waste mass is thoroughly decomposed, residual or long-term gas production and the geotechnical stability of the waste mass and final cover. The general theme for the session was to try to identify characteristics of a landfill that would suggest that further leachate or gas production do not represent a threat to the environment if released without treatment.

Session Participants

Morton Barlaz	Closing the Gaps in the Regulation of Municipal Solid Waste Landfills: Defining the End of the Post-Closure Monitoring Period
Peter Kjeldsen	MSW Landfill Leachate: Present and Future Composition
Ena Smidt	Organic Matter Stability After Mechanical-Biological Pretreatment of MSW

Session Content

After presentation of some background information on landfill stability and the session objectives, Dr. Peter Kjeldsen presented a paper on leachate composition. The focus of this paper was on the composition of leachate from well decomposed refuse because until such time as refuse is well decomposed, it is unlikely that a landfill could be considered stable. There is a wide body of literature on the composition of leachate from older landfills that are known to have produced methane. These data consistently show very low concentrations of biodegradable organic matter as measured by the biological oxygen demand (BOD) test. Leachate produced from well decomposed refuse will contain some additional organic matter, which is measured as chemical oxygen demand (COD), that is not degradable. This non-degradable COD consists of humic matter that forms as the lignocellulosic components of refuse decompose. Well decomposed refuse is characterized by a BOD/COD that is typically below 0.1. However, a low ratio is not, by itself, a certain indication of stable refuse because leachate composition will generally reflect the decomposition state of the bottom most layer of refuse in a landfill. For example, if leachate associated with the acid phase of decomposition were to percolate through a layer of well decomposed refuse at the bottom of a landfill, then the composition of leachate percolating below the bottom layer would likely have a low BOD/COD, despite the fact that at least some of the refuse was not stable.

Other components of the leachate to be considered include ammonia-nitrogen, metals and trace organic chemicals. The ammonia concentration in the leachate from well decomposed refuse varies widely but is often elevated, e.g. 200 to 1000 mg NH_3-N/L. Ammonia accumulates in leachate because under anaerobic conditions there is no mechanism by which its concentration can be expected to decrease. Leachate with elevated ammonia concentrations would typically exceed criteria governing effluent releases to the environment. There was a consensus that strategies to reduce the ammonia concentration of leachate were required and in the absence of low ammonia concentrations, leachate could not be considered stable.

The metals concentrations in landfill leachate were shown to be quite low, often below US drinking water standards. Nonetheless, questions were raised about whether metals concentrations could increase as the refuse in landfills became well decomposed. Dr. Kjeldsen introduced the concept of a humification phase to represent refuse that is so well decomposed that the oxygen demand of the refuse is less than the rate of oxygen diffusion into the landfill. At this point in the decomposition cycle, a landfill can be expected to become aerobic. Under aerobic conditions, there are several factors that could result in a pH decrease and theoretically, an increase in metals concentrations. First, increased CO_2 production associated with aerobic metabolism could result in a pH decrease which would increase the solubility of metals. Second, as oxygen enters a landfill, metal sulfide precipitates could be oxidized to metal sulfates that are considerably more soluble than the metal sulfides. It is not known whether landfills will reach an aerobic state over hundreds of years or even geologic time. Further study of the potential for metals mobilization under aerobic conditions was identified as a research need.

The concentrations of trace organics in landfill leachate are generally low and it was generally assumed that concentrations would continue to decrease through the combined effects of sorption, biodegradation and volatilization. While some participants in the session did not think that trace organics would limit the time for leachate to be declared safe, others thought that more data on trace organics was required, particularly data on large organic molecules such as polynuclear aromatic hydrocarbons and pesticides.

Dr. Barlaz presented a summary of data on the quantity of leachate that could be expected from landfills after installation of a final cover. The final cover for a regulated landfill in the US generally consists of a layer of low permeability soil and a flexible membrane liner overlain by a drainage layer and finally a vegetative layer. Data were available from a field study of US landfills as well as operating data from landfills in New York State. The field data suggested a range of 5-200 L/(ha-day) of leachate produced after installation of a final cover. Data from New York were unique because municipal waste landfills in New York are required to have a double composite liner. As such, leachate flow data in both the leachate collection and leachate detection systems were available and were used to calculate the efficiency of the leachate collection systems. For the 19 landfills studied, the average leachate collection efficiency was 99.1%. The efficiency was calculated as:

Collection Efficiency (%) = (1- detection system flowrate/collection system flowrate) * 100

Dr. Barlaz proposed that one way to assess landfill stability, with respect to leachate, was to evaluate the impact of a leachate release to the environment. A hypothetical case study was developed based on a landfill of a specified footprint (40 ha), with a specified leachate release rate (3.78 m^3/day) and an assumed composition (BOD-100 mg/L, NH_3N-250 mg/L). The Streeter-Phelps Model for calculation of dissolved oxygen consumption was illustrated based on the hypothetical release of leachate to a stream. A term to account for oxygen consumption due to ammonia oxidation was added to the model. The methodology was illustrative but can only be applied on a site-specific basis given the widely varying characteristics of surface water bodies to which leachate could be released. Participants suggested that a parallel methodology should be developed to evaluate a hypothetical leachate release to groundwater.

There was also some discussion of concerns regarding gas release. Ultimately, there may be a question of when it is acceptable to terminate operation of a landfill gas collection system Three issues were identified for consideration: (1) the potential for the released gas to create a nuisance due to odors, (2) potential explosion hazards and (3) the need to identify an acceptable gas release in consideration of atmospheric climate change.

Dr. Smidt presented a technique that could be used to assess the extent to which a solid waste sample has decomposed. FTIR-spectroscopy can be used to characterize the predominant chemical functional groups on solids. The interaction of IR-light with matter is used to identify the presence of distinct bands and peaks that can be correlated with the maturity or immaturity of the organic matter present in refuse. Due to their characteristics in the "fingerprint" region (wavenumber: 1500-1000/cm), different input materials can be distinguished. FTIR can be used for the identification of specific chemicals. However, its more likely application to solid waste will be to document changes in FTIR spectra during waste decomposition and to compare the spectra of well decomposed refuse to samples of well decomposed organic matter in other ecosystems. Changes are noted as the appearance or disappearance, or increase or decrease, of peaks and bands assigned to certain functional groups of chemical compounds. Two bands are particularly useful for quantification, a band at 2925/cm attributed to methyl- and methylene groups of aliphatics and the silica band at 1030/cm.

FTIR spectra can show when a sample has reached a certain stage of decomposition. However, we must still develop a definition for solids stability that might be based on (1) a comparison of refuse organic matter to soil organic matter, (2) a certain ratio of organic/inorganic components, or (3) the presence of stable substances like humic acids or organo-mineral complexes. While the FTIR method cannot provide a definition of stability, it does provide a technique for the analysis of the organic matter in a sample, providing a lot of information in one spectrum. One limitation to the assessment of solids stability is the ability to obtain representative samples from a landfill.

Summary

There was broad agreement on the need to develop criteria for landfill stability and there was significant discussion on the topics presented in each paper. There was a general consensus on the need to:

1. conclusively demonstrate that there is not a risk of metals remobilization in very well decomposed refuse.
2. further develop a methodology to assess the potential impact of a leachate release on groundwater and surface water
3. develop strategies for the long-term management of nitrogen in landfills
4. develop strategies to determine when solids were stable.

Unfortunately, while there was recognition of the need to consider geotechnical aspects of landfill stability, there was not a presentation from a geotechnical engineer which should be a goal for future discussions.

*Affiliation of Dr Morton Barlaz:

Department of Civil Engineering, Campus Box 7908, North Carolina State University, Raleigh, NC 27695-7908, USA. E-mail: barlaz@eos.ncsu.edu