Monday 3/13/2017

9:45–11:15 a.m.

Heat Generation at Solid Waste Landfills

Chairs: Morton Barlaz, North Carolina State University; Craig Benson, University of Virginia

A Model to Describe Heat Generation and Accumulation at Municipal Solid Waste Landfills

Morton Barlaz, Zisu Hao and Joel Ducoste, North Carolina State University

There have been reports of landfills in North America that are experiencing elevated temperatures that are resulting in challenging issues for landfill management. The objective of this study is to develop a box model to describe the generation, consumption and release of heat in landfills and subsequently to predict temperature profiles. Initially, a box model was developed that treats the landfill as a completely mixed system in which all relevant reactions are described. This model will make it possible to identify processes and reactions that are most significant. The model is based on thermodynamic principles and accounts for all significant heat sources and sinks in landfills. Heat sources include energy from biotic and abiotic reactions and condensation. Heat removal processes include convection of methane and carbon dioxide, infiltration, leachate collection and evaporation. The model was used to evaluate the heat generation performance of aerobic and anaerobic biodegradation of waste with and without the presence of ash (from coal or municipal solid waste). The model analysis showed that the hydration of ash can increase landfill temperature above that predicted for the disposal of municipal solid waste alone.

Landfill Operational Techniques in Presence of Elevated Temperatures

Timothy D. Stark, University of Illinois at Urbana-Champaign; Navid H. Jafari, Louisiana State University

Elevated temperatures in municipal solid waste landfills can produce obnoxious odors, toxic gases, and aggressive leachates, as well as damage gas extraction, leachate collection, interim cover, and composite liner systems. They also can result in expensive remedial measures and warrant permanent closure of the facility. Several factors can lead to elevated landfill temperatures, including air ingress, partially extinguished surface fires, reactive wastes, and spontaneous oxidation. Landfills typically experience changes to gas composition and flow, leachate chemistry and volume generation, and surface movement. Based on observed management, operation, and maintenance of elevated temperature facilities, various operational techniques are proposed for isolating and containing the elevated temperatures in a landfill.

Field Investigation of an Elevated Temperature Florida Landfill

Sam Levin and Robert Mackey, S2Li; Ryan Joslyn and Amir Motlagh, University of Central Florida

For reasons that are not entirely clear, incidents of elevated temperatures in landfills are occurring at increasing frequency in the US. A Florida landfill has experienced temperatures that well exceed the tolerable range for microorganisms and permit standards set by the Florida Department of Environmental Protection. The landfill has experienced elevated temperatures in gas wells on the west side of the active cell. These wells were installed in 2010 in an area that received biosolids treated with incinerator fly and bottom ash. These biosolids may have caused an exothermic reaction that has interrupted methane generation. In addition to elevated temperatures (as high as 175oF), smoke, odors, hydrogen in the landfill gas, leachate color darkening, and decreased leachate generation have been observed. However, abnormal settlement has not been observed in the landfill. Preliminary data analysis of gas temperatures suggests that 20% of the wells at the landfill are impacted. Waste samples have been collected and are being analyzed. Results of waste characterization support the presence of ash in areas of elevated temperature.

Temperature Effect on Transport of VOCs in Co-extruded EVOH Geomembrane

Jongwan Eun, New York University Abu Dhabi; Mehmet Yilmaz and James Tinjum, University of Wisconsin-Madison; Craig H. Benson, University of Virginia

Partition and diffusion coefficients for phenol, methylene chloride, toluene, and TCE for a co-extruded geomembrane (inner EVOH layer, HDPE outer layer) were measured using batch tests at 23 °C (room temperature), 38 °C (intermediate temperature), and 75 °C (high temperature). The partition coefficients for EVOH increased by as much as 36% as the temperature increased from 23 to 35 °C and 79% for 23 to 75 °C. The diffusion coefficients increased by as much as 82% and 200% over the same ranges of temperature. However, for HDPE, the increase in the partition and diffusion coefficients with increase in temperature was less than half that observed for the EVOH. For HDPE, the partition coefficient increased by as much as 18% and 46% for temperature increases from 23 to 35 °C and 23 to 75 °C, respectively. The diffusion coefficients increased by as much as 22% and 53% over the same ranges of temperature. Thus, temperature sensitivity of partition and diffusion coefficients for EVOH is significantly higher than for HDPE.

Characteristics of Gas and Leachate at an Elevated Temperature Landfill

Craig H. Benson, University of Virginia

Data from a municipal solid waste (MSW) landfill with elevated temperatures are evaluated to assess how characteristics of landfill gas and leachate evolved as the landfill temperature increased from ranges typically associated with methanogenic decomposition (40 – 50 oC) to more than 100 oC. The MSW landfill was deep (~ 100 m), unlined, and most of the waste was saturated and below the water table. Temporal trends in landfill gas temperature measured at the wellhead indicate that the gas temperatures increased abruptly and systematically following a shutdown to address a concern about the potential for subsurface combustion. Temperature profiles collected subsequently indicated that the highest temperatures were substantially below the leachate level, making combustion an unlikely mechanism for the elevated temperatures. Temporal trend analysis indicated that the primary gas ratio (CH4:CO2) decreased systematically and substantially when the gas temperature increased abruptly. Leachate chemistry also changed significantly after the gas temperature increased abruptly, with BOD, COD, and the BOD:COD ratio increasing rapidly, pH dropping more than one unit, and total suspended solids increasing more than two orders of magnitude.

Pyrolytic Reaction in MSW Landfills: Experiment and theory

Swanand Tupsakhare, The City College of New York; Marco Castaldi, The City College of New York; Morton Barlaz, North Carolina State University; Craig Benson, University of Virginia; Scott Luettich, Geosyntec Consultants; Joel Ducoste, North Carolina State University

The complex reaction sequence occurring within the landfill environment is affected by multiple factors ranging from heterogeneity of the waste mass to changing conditions within the landfill. While the major chemical species and their concentrations in this sequence can be determined for equilibrium conditions using thermodynamic considerations, this approach typically is inadequate to predict overall waste behavior. The time dependent evolution of intermediates and some non-equilibrated final products must be known, and can only be properly modeled using a kinetic reaction sequence. The question then becomes: how detailed a reaction sequence is required to enable accurate representation of events occurring without unnecessary acquisition of large and detailed data sets? To answer this question we began to investigate the likely reactions that will occur in an oxygen deficient environment (i.e. pyrolysis) and couple the results to the overall fluid and heat flow throughout the landfill. A laboratory scale reactor unit capable of replicating the temperature and pressure ranges measured in landfills has been assembled and charged with simulated MSW and different moisture amounts. Temperature, pressure and gas emissions have been continuously monitored over the course of six months. In addition, periodic measurements of the produced liquid material has been sampled and analyzed for organics.

This paper will primarily discuss the results of the testing and attempt to correlate the findings to measured data in the open literature. In addition some discussion will be given on the chemical reactions that contribute to heat accumulation in the temperature regime above which biological reactions contribute heat. Since cellulose is the dominant organic compound by mass in landfills, an understanding of reactions based on biomass will be used as the starting point for describing thermal reactions in landfills.