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Field-Scale Evaluation of Landfill Gas Emissions from an Instrumented Landfill Bioreactor Cell

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A 1.2 acre municipal solid waste (MSW) bioreactor cell located in central Michigan, U.S.A. has been instrumented to measure water content, temperature, landfill gas and leachate quality at over 60 locations in the cell. The final cap of this cell has also been instrumented to measure water content, landfill gas concentration, and flux of landfill gases emitted to the atmosphere from the cap. CO_2 and CH_4 are greenhouse gases emitted by MSW landfills. The final cap has been instrumented at three locations to make such measurements (Figure 1). These locations are spaced at about 15 m from each other. The configuration of the final cap varies at each location.

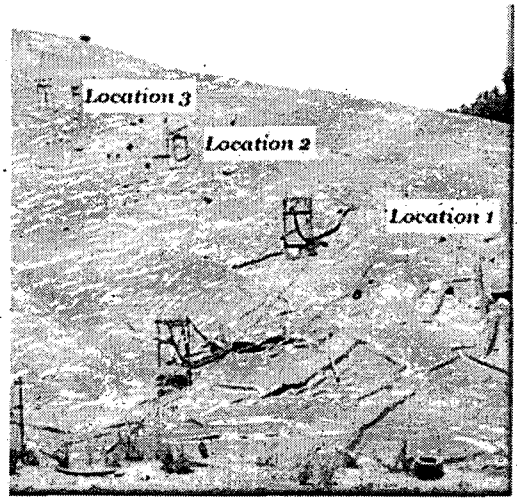

Figure 1: Locations 1, 2 and 3 where gas probes and the flux chambers were installed.

At Location 1, the final cap consists of, from top to bottom, a 400-mm-thick layer of loosely placed fine sand, a 1.5-mm-thick HDPE geomembrane (GM), and a 500-mm-thick layer of compacted clay. At Location 2 and 3, the final cap consists of, from top to bottom, a 450-mm-thick layer of loosely placed fine sand, a 1.5-mm-thick HDPE GM, and 450 to 650-mm-thick dense sand layer. At Locations 1 and 3, a 2 m by 2 m square window has been cut in the GM to simulate an earthen cap (Figure 2). At Location 2, a 10 mm by 10 mm square hole has been cut in the GM to simulate a composite cap with a defect. A flux box made of stainless steel is installed in the cap at these three locations above the openings created in the GM (Figure 3). Landfill gas concentration profile in the cap is measured using gas sampling ports consisting of hollow stainless steel tubes installed below and above the GM. Water content of the cap is measured using TDR probes.

Based on the four rounds of sampling conducted since summer of 2003, key observations include that the concentration of methane below GM at all locations has increased from about 10% during Summer 2003 to about 30% during Winter 2004. Above GM, where GM is not breached, the concentration has stayed below 3%. The methane flux during the period from September to December 2003 has ranged from about 1 to 100 g/m^2/day for Location 1, 150 to 9,200 g/m^2/day for Location 2, and

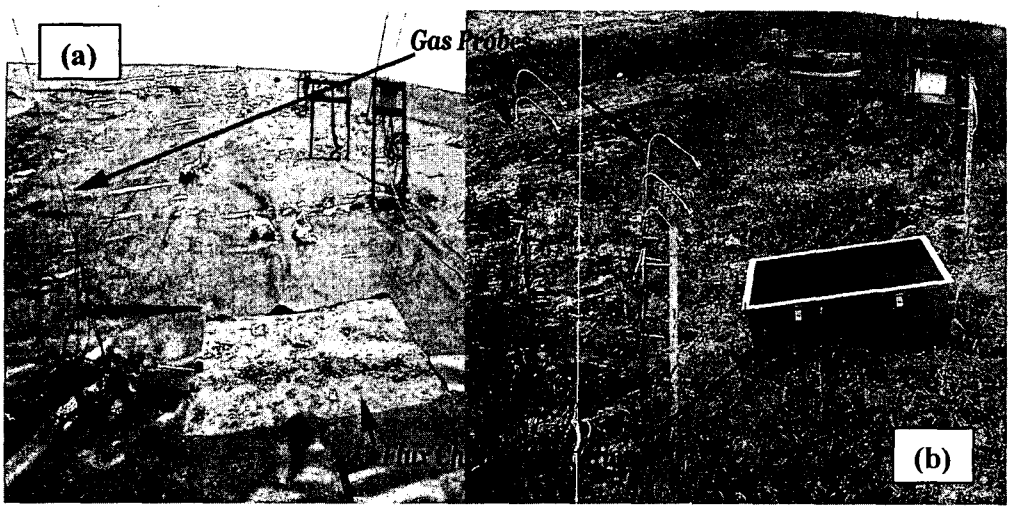

Figure 2: Nest of five gas probes next to the flux chamber: (a) before; and (b) after the GM was covered with topsoil.

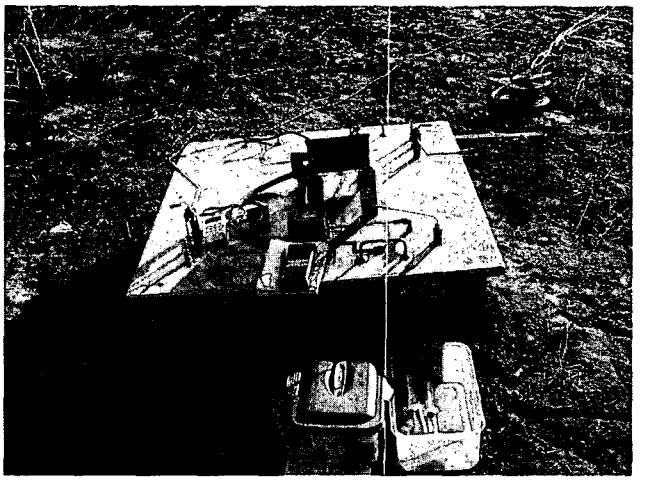

Figure 3: Stainless steel flux chamber.

30 to 60 g/m^2/day for Location 3. Highest flux has been observed for Location 2 where the 1 sq. cm hole has been cut in the GM. Gas flux at Location 1 where clay layer is present is almost equal to gas flux at Location 3 where only sand is used. Gas flux from all locations has been close to zero since the surface of the landfill cap is covered with snow since January 2004. Over 20 VOCs including butane, dichlorofluoro methane, pentane, and propane have been observed in the gas samples collected from the gas ports. Currently we are evaluating the flux of VOCs and methane as a function of water content of the cap, barometric pressure variation, and boundary conditions (snow, precipitation, evaporation, etc.).

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