Measuring Water Within Landfills

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Background

One means of stabilizing landfills is by ensuring that enough moisture exists for biodegradation of organic wastes in all regions of the landfill. Organic material will then degrade quickly, and risks associated with future breaks in the landfill cap are significantly reduced. Typically, leachate collected from the bottom of the landfill is recirculated to modify the moisture conditions and enhance biodegradation within the landfill. However, knowing how much leachate to recirculate and where to add it is problematic. Also, the process of adding a wide range of materials and daily cover to the landfill results in significant layering and heterogeneity. This heterogeneity in turn causes water to short circuit and move preferentially in a landfill, a process that has been virtually impossible to measure or model. Accurate methods for measuring the amount of water in situ would enable better implementation of leachate recirculation systems.

Unfortunately, current methods for measuring the amount of water in landfills are often inadequate, since they provide point measurements and are frequently affected by waste compaction and heterogeneity of the solid waste composition. While it may be reasonable to assume near saturated conditions in the lower portions of the landfill where water enters gravity collection systems, preferential water movement in upper landfill sections reduces the value of point measurements. Spatially integrated measures of the volumetric water content would overcome problems associated with point measurements in a system where water flows along preferential flow paths. Such measures would be of tremendous benefit to landfill operators and regulatory officials.

Research Hypothesis

In this research we are testing and evaluating a promising technology, recently developed by soil scientists, to characterize the volumetric water content within landfills, the amount of free water in solid waste divided by the system volume. In this methodology two gas tracers are injected into a landfill. One tracer is nonreactive with landfill materials, while the second partitions into and out of free water trapped within the pore space of the solid waste. Chromatographic separation of the tracers occurs between the point of tracer injection and tracer extraction because the second partitioning tracer is retarded due to water in the landfill. The degree of tracer retardation can be used to determine the average volumetric water content between the injection and extraction points. This partitioning gas tracer test yields a large-scale estimate of the volumetric water content, is not affected by solid waste compaction or heterogeneity in the composition of the solid waste, and has been successfully tested in a recent field experiment in soils.

Experimental Methodology and Results

To investigate this technology in solid waste, we conducted a series of gas tracer tests in laboratory columns containing various trash mixtures. Both the trash composition and the amount of water contained in the trash were varied to mimic the range of conditions that might exist within municipal landfills. Two gas tracers were flushed through the trash columns: helium, which is conservative and nonreactive with trash or water; and difluoromethane, which partitions into the water but is not reactive with other trash components. Difluoromethane was retarded with respect to helium transport, and moment analysis of the tracer breakthrough curves was used to determine the mean travel time of the tracers and the amount of free water in the system.

Figure 1 illustrates the results from a recent series of experiments: volumetric water contents measured with the partitioning gas tracer test are plotted versus independently measured values. The data represent 11 water content measurements in five different trash columns, where both water content and trash composition were varied. Measured volumetric water contents were typically within 12% of actual values. In addition, the slope of the line fitted to the data is 1.01, implying that any systematic error in these partitioning gas tracer tests was small.

We will discuss these data in more detail and will describe environmental conditions (e.g., temperature variations) that may affect the partitioning gas tracer test. We will also discuss our planned field tests of this technology.

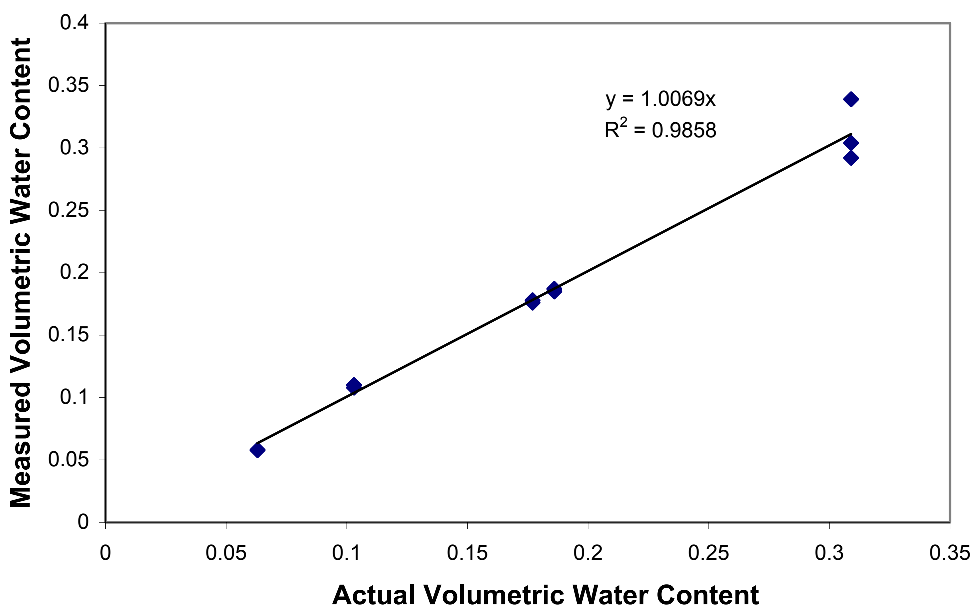

Figure 1. Measured versus actual volumetric water content in trash columns.