Hydrologic Properties of Municipal Solid Waste

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Motivation and Objectives

- Landfills are typical end-state of municipal solid waste (MSW) in North America
- Bioreactor landfills *enhance* waste degradation and stabilization, *increase* waste settlement, *treat* leachate in situ, and *reduce* post-closure monitoring
- Waste degradation is enhanced by increasing moisture content through liquid addition or leachate recirculation
- Predicting liquid movement through MSW is important for efficient design of liquid distribution infrastructure

Objective: Develop laboratory tests to accurately parameterize MSW for hydrologic models to be used in bioreactor design

Hypotheses

1) MSW hydrology can be modeled using correctly parameterized soil-water flow models
2) Adequate parameterization of flow models can be achieved through laboratory test is lab- to field-scaling effects are understood
3) Hydrologic parameters are scale dependent and sensitive to testing procedure and specimen preparation

Background

- MSW hydrology typically modeled using unsaturated soil flow theory-i.e. Richard's Equation

$$\frac{\partial\left(K(\psi)_x \frac{\partial\varphi}{\partial x}\right)}{\partial x}+\frac{\partial\left(K(\psi)_y \frac{\partial\varphi}{\partial y}\right)}{\partial y}+\frac{\partial\left(K(\psi)_z\left(\frac{\partial\varphi}{\partial z}+1\right)\right)}{\partial z}=\frac{d\theta}{dt}$$

- Two main pieces of information are required for hydrologic model parameterization
  - Saturated Hydraulic Conductivity (K)
  - Water Retention Curve (WRC)
- Saturated hydraulic conductivity in MSW is dependent on waste density which varies depending on stress and compaction condition
- The Water Retention Curve for MSW is dependent on waste density (stress) and waste composition

Acknowledgements

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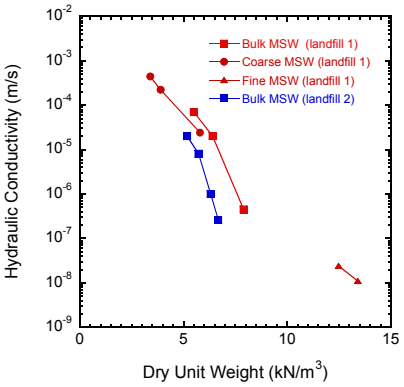
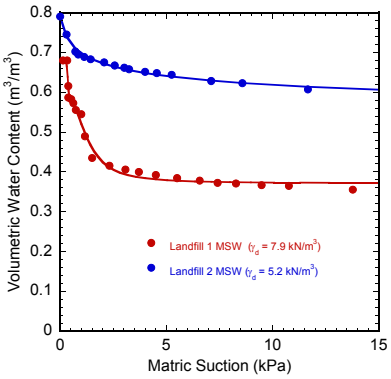
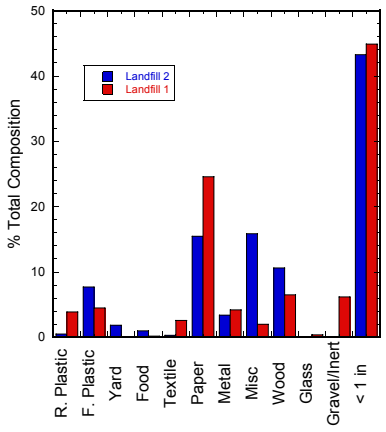
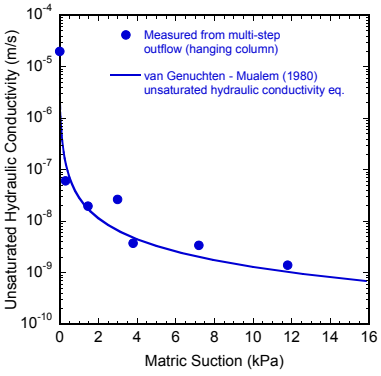
Preliminary Laboratory Testing

- Hydraulic conductivity of compacted shredded MSW from 2 sites
  - Compacted specimens with 0 applied stress (red)
  - Compacted specimen with 0, 60, 120, 180 kPa applied stress (blue)
- Water Retention Curve for 2 MSW specimens (0 applied stress for all specimens)
- Unsaturated Hydraulic Conductivity (from water retention curve data)









- Observations (1) Hydraulic conductivities were similar for different compositions at similar densities (2) Denser specimen has slightly higher air entry pressure in water retention curve (3) overall shape of water retention curve is similar between MSW with different composition (4) van Genucthen-Mualem Hydraulic conductivity model can be used to model unsaturated hydraulic conductivity in MSW

Future Work

- Laboratory experiments at varying scale on "synthetic" waste to assess the effects of material processing, scale and specimen preparation
- Wet-dry cycling tests to assess hysteresis in the water retention curve and further measure unsaturated hydraulic conductivity