Factors Controlling Alkylbenzene Sorption and Desorption in Municipal Solid Waste

Bingyan Wu, Department of Civil Engineering, North Carolina State University, Campus Box 7908, NC 27695, U.S.A, bwu@unity.ncsu.edu.
Detlef R. Knappe, Department of Civil Engineering, North Carolina State University, Campus Box 7908, NC 27695, U.S.A, knappe@unity.ncsu.edu.
Morton A. Barlaz, Department of Civil Engineering, North Carolina State University, Campus Box 7908, NC 27695, U.S.A, barlaz@unity.ncsu.edu.

The sorption and desorption of toluene and *o*-xylene from individual municipal solid waste (MSW) constituents [office paper, newsprint, rabbit food as a model food and yard waste, high density polyethylene (HDPE), and poly(vinyl chloride) (PVC)] were evaluated. Effects of sorbent decomposition and solvent composition on alkylbenzene sorption and desorption were studied by evaluating biodegradable sorbents in both fresh and anaerobically decomposed form and by conducting single-solute sorption isotherm tests and batch desorption tests in acidogenic and methanogenic leachate. To determine the effects of aging on alkylbenzene desorption rates, desorption tests were performed for samples that were contacted with toluene for 30 and 250 days. Selected samples containing *o*-xylene were analyzed after an aging time of 250 days.

Alkylbenzene sorption to plastics was greater than to biopolymer composites, and differences in sorbate/sorbent solubility parameter compatibility explained this observation. Alkylbenzene sorption to biopolymer composites yielded linear isotherms, and sorption capacities [log (K_{oc}/K_{ow})] decreased linearly with increasing sorbent polarity as expressed by the O-alkyl/alkyl ratio. Leachate composition had little effect on alkylbenzene sorption with one exception, volatile fatty acids in acidogenic leachate appeared to convert PVC from a glassy to a rubbery polymer. The results of this study showed that sorbent organic matter affinity for hydrophobic organic contaminants (HOCs) increased with increasing extent of MSW decomposition because of the recalcitrance of plastics and the preferential degradation of polar biopolymers. Furthermore, the plasticizing effect of volatile fatty acids in acidogenic leachate may enhance the bioavailability of HOCs sorbed to glassy organic matter in MSW or in soils contaminated with acidogenic leachate.

Desorption tests showed that alkylbenzene desorption rates were slowest for PVC and fastest for fresh rabbit food and newsprint. For the biopolymer composites, desorption rates decreased as aging time increased, suggesting that the bioavailability of HOCs in landfills decreases over time as HOCs are physically sequestered or undergo humification. Consistent with its larger molecular size, *o*-xylene desorption rates were slower than those of toluene. A single-parameter polymer diffusion model successfully described PVC and HDPE desorption data, but it failed to simulate desorption rate data for biopolymer composites such as rabbit food, newsprint, and office paper. Therefore, a three-parameter biphasic polymer diffusion model was applied to describe desorption rate data from biopolymer composites. Toluene desorption rates from mixed MSW were predicted for two landfill scenarios. Model results showed that 50% of the initially sorbed toluene desorbed in 5.83 days for an old landfill containing little plastic waste (0.72%, 1960 MSW composition) and in 3.97 years for a new landfill containing

more plastics (20%, 1997 MSW composition). Consequently, the mineralization rate of toluene is likely controlled by biological processes in old landfills but by desorption in new landfills.

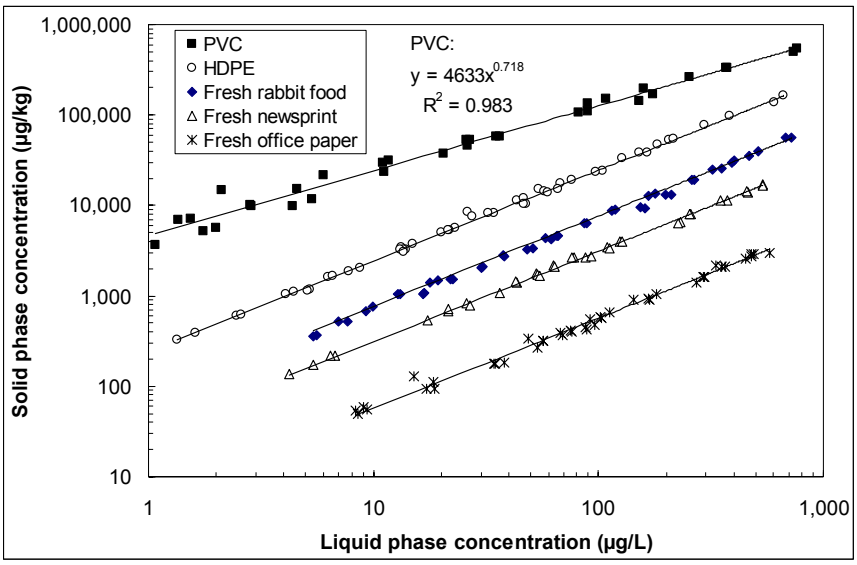

Figure 1. Single-solute *o*-xylene isotherms for model MSW components. Solid line through PVC data indicates the best fit of the Freundlich isotherm quation.

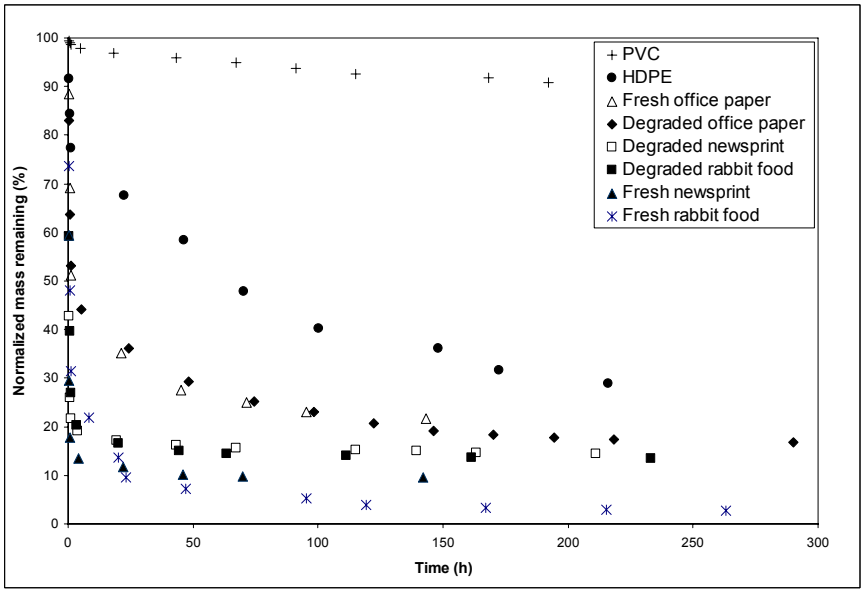

Figure 2. Experimentally determined toluene desorption rates from MSW components after aging of 30 days in acidogenic leachate

Reference

Wu, B., Taylor, C.M., Knappe, D.R.U., Nanny, M.A., Barlaz, M.A., "Factors controlling alkylbenzene sorption to municipal solid waste", Environ. Sci. Technol., Vol. 35, pp. 4569-4576, 2001.