Time & Location: March 30, 2012 at 11:30 AM in HEC 101
Title: Fate of Coated Zinc Oxide Nanoparticles in Landfill Leachate

Given the increase in nanomaterial (NM) use in consumer products and the large fraction of waste placed in landfills worldwide, the probability of these products reaching municipal solid waste (MSW) landfills at the end of their useful life is high. Since nanotechnology use is still in its early stages, there are currently no regulations pertaining to the disposal of NMs and their fate in MSW landfills is still unknown. Understanding the fate of NMs in MSW landfills is vital to ensure the proper handling of these novel materials from cradle to grave; such research will provide information on how these NMs can be safely introduced into the environment.

This research seeks to understand the fate of NMs within waste environments by examining the interactions between NMs and landfill leachate components. The primary focus of this thesis is the effect of Zinc Oxide (ZnO) on biological landfill processes, solids aggregation, and chemical speciation of Zn in landfill leachate following the addition of crystalline, nano-sized ZnO coated with triethoxycaprylylsilane. This research (1) observed the effects of coated ZnO on five-day biochemical oxygen demand and biochemical methane potential, (2) examined effects of solids aggregation on the fate of ZnO, (3) quantified the concentration of Zn by size fractions, and (4) modeled the chemical speciation of Zn in landfill leachate using Visual MINTEQ.

No change in dissolved Zn was observed after coated ZnO was exposed to “middle-aged” leachate. Upon exposure to “mature” leachate there was an increase in dissolved Zn assumed to be a result of the dissociation of ZnO. Solids data supported the aggregation of particles in both middle aged and mature leachate. There was an increase in the Zn concentration in leachate fractions greater than 1500 nm presumably due to the dispersion of normally insoluble ZnO nanoparticles (NPs) following the interaction with humic acids. ZnO did not inhibit anaerobic or aerobic processes in either middle aged or mature leachate, presumably due to the low concentration of dissolved ionic Zn. Despite the observation of increased dissociation upon exposure to mature leachate, the presence of DOM may have hindered the ability for dissolved ionized Zn to become bioavailable.

Fractionation, five-day BOD and BMP tests, and chemical speciation modeling provided insight on the mobility of ZnO in landfills and the absence of inhibitory effects on landfill processes. Aggregation of ZnO NPs may prevent movement through traditional containment systems (i.e. geomembrane liners) due to the increased particle size. However, the increased dispersion suggests that ZnO NPs will be transported out of the landfill in the leachate, however biological treatment of leachate should be unaffected in the presence of ZnO. The bioavailability of Zn was not substantially affected by the presence of ZnO due to affinity of dissolved Zn for DOM. However, due to the heterogeneity of landfill leachate and the utilization of different NM coatings, it is challenging to predict the overall mobility of other NMs in a landfill.

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Approved for distribution by Dr. Debra R. Reinhart, P.E., BCEE, Committee Chair, on March 10, 2012.
The public is welcome to attend.