Huntsman Environmental Research Center

BIENNIAL REPORT 2008-2009

PROJECTS AND PRODUCTS

Summary. During the years 2008-2009, HERC projects included the biodegradation of toxic chemicals known as polycyclic aromatic hydrocarbons (PAH) in wood preservative and petroleum wastes of interest to the U.S. Department of Energy, the Electric Power Research Institute, and the U.S. Environmental Protection Agency. In addition, the Huntsman On-Site Wastewater Treatment Training and Demonstration Site was expanded with additional demonstration units for training and certification about biodegradation for protection of ground water resources.

2008

Project: Biodegradation of Toxic Chemicals in Soil Systems at Hazardous Waste Sites

HERC Theme: Biodegradation

Collaborators: U.S. Department of Energy (Inland Northwest Research Alliance)

Students Supported: Yana Liang (PhD)

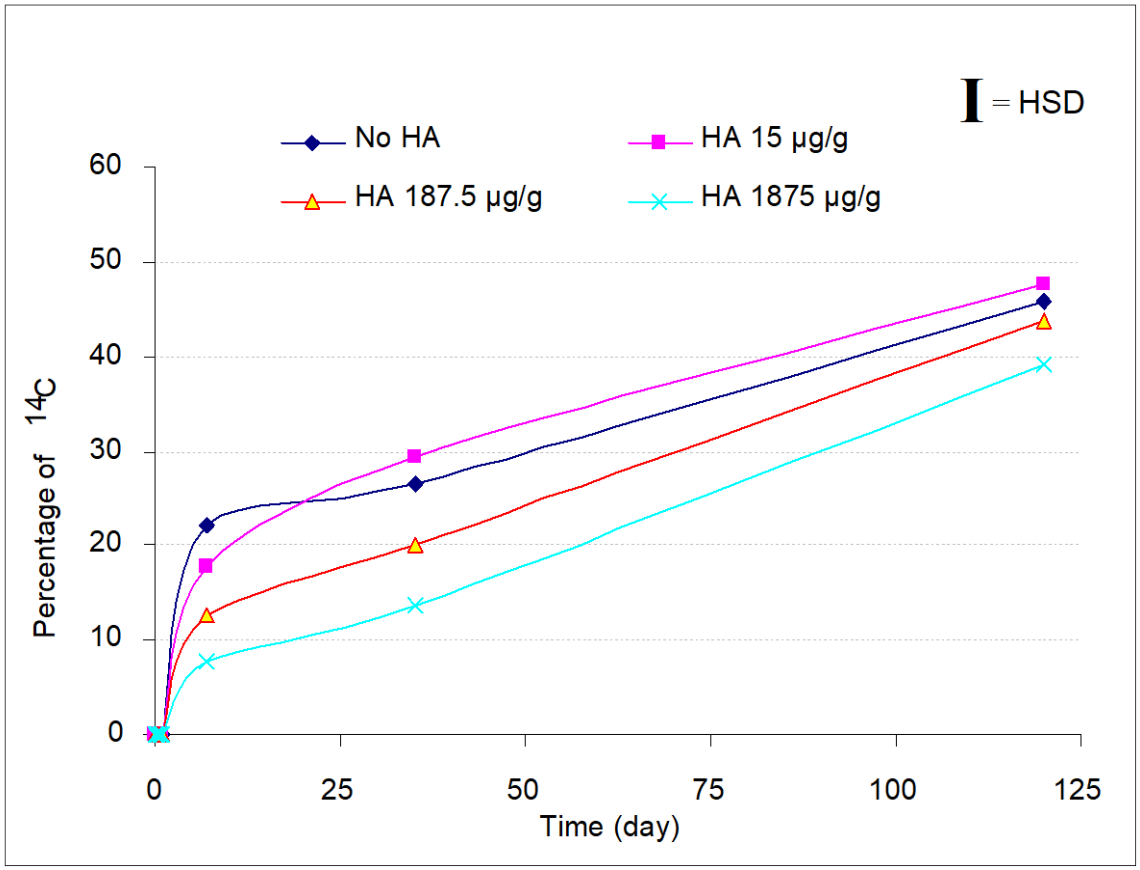
Results/Products/Outcomes:

Toxic and carcinogenic chemicals in wood preserving and petroleum wastes, referred to as polycyclic aromatic hydrocarbons (PAH), have contaminated soil and groundwater environments in the United States at multiple hazardous waste sites. Humic acid (HA), which is naturally present in a majority of contaminated soil and water environments, has been hypothesized to affect the biodegradation of PAHs. However, little information is available in the literature on the biodegradation of PAHs in the presence of humic matter, which is also present in land application systems for waste treatment at different concentrations in almost all naturally occurring soil systems. The U.S. Department of Energy and the Electric Power Research Institute are interested in understanding the fate, behavior, and potential treatment of PAH in subsurface environments using biodegradation.

Pyrene represents a PAH that is similar to other carcinogenic PAH in chemical characteristics but can be used as a surrogate carcinogen, and was selected for this project. Pyrene was added to soil slurry systems as radiolabeled ^{14}C-pyrene to simulate wet soils and groundwater environments, and biodegradation was measured as the percent (amount) of carbon dioxide produced over a 4-month test period as the pyrene was transformed by soil microorganisms.

The presence or addition of humic acid in soil and/or groundwater systems was found to significantly reduce complete biodegradation to carbon dioxide, referred to as mineralization. Statistical analysis of the results (shown in the figure below) showed that the two higher doses of humic acid (187.5 micrograms per gram of soil and 1875 micrograms per gram of soil) significantly inhibited biodegradation compared with the lowest amount of humic acid (15 micrograms/gram soil and also the control with no humic acid added).

However, biodegradation was found to bind the pyrene so that it was not available to the water. This process is referred to organic matter-bound formation. Overall, this project demonstrated a practical approach for decontamination of PAH contaminated soil through the addition of humic acid that will result in the binding of the PAH to the soil and prevention of contamination of groundwater.



Pyrene biodegradation measured as percent of biodegraded to carbon dioxide (^{14}C) with time (days).

Dissemination of Results:

Pyrene Fate Affected by Humic Acid Amendment in Soil Slurry Systems. 2008. Jour. Biological Engineering, 2:11. Liang, Yana., Darwin Sorensen, Joan McLean, and R.C. Sims https://doi.org/10.1186/1754-1611-2-11

2009

Project: Biodegradation for Bioremediation of Contaminated Soils

HERC Theme: Biodegradation

Collaborators: U.S. Environmental Protection Agency

Student Supported: Yanna Liang (PhD), Karl Nieman (PhD), Keith Albretsen (BS)

Results/Products/Outcomes: Consideration of bioremediation for remediation of a site contaminated with organic constituents requires a detailed site, soil, and waste characterization that must be conducted in order to evaluate the potential application of the technology at the site and to demonstrate the feasibility of the approach. A sound and thorough engineering remediation plan developed at the on-set of the project will allow cost-effective and efficient use of resources for implementation of site clean-up. The use of treatability studies and simulation modeling are also necessary components of the bioremediation plan so that necessary data to evaluate potential use and to identify pathways of migration are collected in a cost- effective manner. Bioremediation of sites contaminated with organic chemicals is a promising technology, especially if it is incorporated in a remediation plan that uses an integrated approach to the cleanup of the complete site, i.e., a plan that involves the concept of a "treatment train" of physical, chemical, and/or biological processes to address remediation of all sources of contaminants at the site.

Biodegradation of Polycyclic Aromatic Hydrocarbons in Soil at 30ºC

PAH Compound	Biodegradation Half-life (Days)
Phenanthrene	less than 60
Anthracene	200
Fluoranthene	140
Pyrene	210
Benz(a)anthracene	240
Chrysene	730
Benzo(a)pyrene	220
Dibenz(a,h)anthracene	940
Indeno(1,2,3-cd)pyrene	630

Dissemination of Results:

Approach to Bioremediation of Contaminated Soils. 2009. Hazardous Waste and Hazardous Materials. 7:2, 117-149. Sims, J.L, Sims, R.C, Matthews, J.E.