Fate of Polycyclic Aromatic Hydrocarbons Bound to Asphalt, Charcoal, Coal-Tar Pitch, and Soot in Urban Lake Sediments

Victoria H. Boyd (vhboyd@gsi-net.com) (GSI Environmental, Austin, TX, USA)
Somayeh G. Esfahani and Charles J. Werth (University of Texas at Austin, Austin, TX, USA)

Background/Objectives. The concentrations of polycyclic aromatic hydrocarbons (PAH) in urban lake sediments have been increasing for several decades. PAHs sorbed to carbonaceous materials (CM) such as asphalt and coal tar sealcoat, charcoal, and soot have been shown to contribute to PAH loading in urban lake sediments. The redistribution of PAHs between these materials was investigated in order to better understand the fate of PAHs sorbed to CMs and the risks presented to aquatic life. The objectives of this study were: 1) determine if PAHs are redistributed to strongly sorbing CMs or to the water column, 2) determine the rates of PAH redistribution between CMs and sediment, and 3) determine the relative importance of kinetic and thermodynamic sorption to PAH redistribution in CMs and sediment.

Approach/Activities. The redistribution of PAHs was measured in controlled, well-mixed laboratory experiments as well as a two-year in situ field study. CM particles were created from coal-tar pitch, asphalt binder, charcoal and soot and loaded with deuterated PAHs (dPAH) as tracers. Each material was loaded with a unique combination of dPAHs with varying molecular weights and Kow. In the laboratory experiments, particles were mixed with sediment for 90 days and samples were collected at designated intervals to measure dPAH redistribution over time. In the field study, particles were mixed with sediment, loaded into sample cores, pushed into the top layer of lake sediment, and allowed to age. Sample cores were retrieved over a two-year period and dPAH redistribution between sediment and CMs was measured. A PAH redistribution model was created that incorporated both mass transfer kinetics and thermodynamic equilibrium sorption. The data from the laboratory experiments was used to fit the model.

Results/Lessons Learned. There was substantial redistribution of dPAHs from all CMs to sediment in both the laboratory and field experiments. There was also redistribution of dPAHs among CMs. Low molecular weight dPAHs originally bound to asphalt and coal-tar pitch were the most mobile dPAHs and accounted for the majority of dPAH redistribution between materials. The results of the model indicated that PAH sorption trends at early times can vary from the trends at equilibrium. The faster mass transfer kinetics of less strongly sorbing materials, such as asphalt and sediment, resulted in greater redistribution at early times compared to more strongly sorbing materials such as charcoal and soot. From a risk perspective, PAHs with faster mass transfer are likely to be more bioavailable to aquatic life. Therefore, these results show the importance of considering mass transfer kinetics when assessing the risks of PAHs sorbed to materials such as asphalt and sediment at early times.