

Using a Risk-Based Approach to Guide Remedial Goals: Oral Relative Bioavailability of PAHs at Formerly Used Defense Sites

Norman D. Forsberg (norman.forsberg@arcadis.com) and Brian H. Magee
(Arcadis U.S., Inc., Chelmsford, MA, USA)

Anita K. Meyer (United States Army Corps of Engineers, Omaha, NE, USA)

Glenn C. Hoeger (Carollo Engineers, Inc., Tucson, AZ, USA)

Carlos M. Duarte (United States Army Corps of Engineers, Fort Worth, TX, USA)

Background/Objectives. The U.S. Department of Defense is responsible for the environmental restoration of properties that were formerly used for military training and weapons testing. The former Foster Air Force Base (FAFB) and Laredo Air Force Base (LAFB), both located in Texas, are two such sites that operated firearm training ranges in the World War II-time period. Remnants of spent skeet targets were determined to be a source of polycyclic aromatic hydrocarbons (PAHs) at these sites based on results from surface soil analyses and historical information demonstrating that skeet targets were commonly prepared using coal tar pitch as a binding agent. It was hypothesized that the nature of the coal tar pitch/limestone matrix of the skeet fragments reduces the oral bioavailability of PAHs compared to that seen in animal studies using pure benzo(a)pyrene in solvents. The bioavailability studies were performed to support site-specific cleanup goals.

Approach/Activities. In vivo oral bioavailability studies were performed using soils collected from the sites to determine the relative bioavailability of PAHs from the target fragments. Soils were collected to provide a range of PAH concentrations. The oral bioavailability study was performed using female B6C3F1 mice fed diets amended with soils or soil extracts at a rate of 5% in the diet for fourteen days. The test soils showed benzo(a)pyrene (BaP) concentrations ranging over 4-orders of magnitude, from 0.01 to over 100 mg/kg. A high-resolution mass spectrometry method was developed to detect low levels of several hydroxylated PAH metabolites in mouse urine to a reporting limit of 10 ng/L or lower. The fraction of total PAH dose excreted in the urine (FUE) was determined for the soil and soil extract amended treatment groups using linear regression of metabolite excretion rates versus daily dosing rates. The relative bioavailability of PAHs was then determined as the ratio of the soil and soil extract FUEs.

Results/Lessons Learned. The FUEs produced coefficients of determination (r^2) that were all greater than 0.83 and typically greater than 0.95, showing that the rate of urinary BaP metabolite excretion was directly proportional to oral daily dose rate of BaP in the soils evaluated. A Relative Bioavailability Factor (RBAF) for use in risk assessment was calculated using Monte Carlo simulations as the 95% upper confidence limit on the ratio of the soil and soil extract FUEs and was equal to 20% for BaP. RBAFs for the other potentially carcinogenic PAHs ranged from 20 to 28%. When taken together with results from site-specific dermal bioavailability testing, soil clean-up goals for potentially carcinogenic PAHs increased 4 to 5-fold and 2.5 to 5-fold for residential and commercial land uses, respectively, which is expected to reduce remedial activities by over 65% at each site. Regulatory approval is expected in the next few weeks.