#76188

Shaw Environmental & Infrastructure, Inc.

Shaw The Shaw Group Inc.™

5301 Central Avenue NE
Albuquerque, NM 87108-1513
505-262-8800
Fax: 505-262-8855

Memorandum

Date: **February 26, 2003**

To: **John Pietz**

From: **Jonathan Myers**

RE: **Sorption Coefficients for RDX and Barium at Los Alamos**

This memo provides the results of a literature review of RDX and barium sorption coefficients for use at Los Alamos.

RDX Sorption

RDX has a strong affinity for sorption on organic carbon, which is why the standard treatment process for contaminated waste water is sorption on granular activated carbon. Some organic carbon partition coefficients (K_{oc}) cited in the literature are as follows:

Koc (mL/g)	Reference
100	Rosenblatt,1986
135	Tucker et al., 1985
7.8 to 269	Sikka et al.,1980
42 to 126	Spanggord et al., 1980

The affinity for sorption of RDX on low-carbon soils, sediment, and specific soil-forming minerals is considerably less than that of organic carbon. The sorption of RDX on soils has been studied by several researchers (Sikka et al. 1980; Leggett 1985; Ainsworth et al. 1993; Selim and Iskandar 1994; Townsend and Myers, 1996). Each of these researchers found that RDX was extremely mobile and could be described well using a linear equilibrium approach. Leggett (1985) noted that sorption values for RDX on bentonite drilling muds were similar to sorption values for RDX on natural sediments, suggesting that the clay content of natural soils and sediments is important to the sorption of RDX. Reported linear equilibrium distribution coefficients for RDX on natural soils and sediments range from <1 to 7.8 mL/g (Townsend and Myers 1996).

Ainsworth et al. (1993) performed batch and column tests with RDX. In both the batch and column tests, RDX sorption fit a linear model, and was found to be reversible.

3633

Townsend et al. (1996) performed column flow-through sorption experiments on three soils: Tunica silt from Vicksburg, MS, Yokem clay from Vicksburg, MS, and Ottawa sand obtained from U.S. Silica Company, Ottawa, IL. Linear equilibrium distribution coefficients (K_d) for RDX were 2.5, 5.7, and 1.35 mL/g for the Tunica silt, Yokena clay, and Ottawa sand, respectively, and scale with increasing clay content. These coefficients are in good agreement with those reported in previous works (Townsend and Myers 1996, McGrath 1995).

Zakikhani et al., 2002 evaluated the sorption of explosives including RDX at the Louisiana Army Ammunition Plant (LAAP). Aquifer soils from LAAP were generally high in sand, ranging from 65.0 to 92.5 percent sand. Silt and clay were present in all samples in lower amounts. Total organic carbon content was low, ranging from 0.015 to 0.162 percent. Cation exchange capacity (CEC) was also low, ranging from 3.5 to 8.1 Meq 100 g^{-1}. Soil pH was acidic and relatively consistent for all soil types (average of 5.55). Permeabilities of the soils ranged from 10^{-4} to 10^{-9} cm sec^{-1}.

Adsorption of explosives from groundwater by the LAAP aquifer soils was limited. The measured values of K_d were below 1mL/ g for all soils and contaminants, ranging from no significant adsorption to a high value of 0.84 mL/g. The highest degree of sorption was associated with the soils highest in clay and CEC. They concluded that mass transport limitations other than sorption (such as low permeability) are limiting factors for transport of HE at LAAP.

Some additional experimentally determined K_d values for RDX are as follows:

K_d (mL/g)	**Reference**
0.2 to 7.8	Hale, et al., 1979
0.8 to 4.15	Sikka et al.,1980
1.4 to 4.2	Spanggord et al., 1980
4.92 to6.75	Leggett, 1985
<1	Ainsworth et al., 1993
0.0 to 0.8	Myers et al. (in preparation)

Barium Sorption

Barium has an affinity for adsorption on clays, oxides, and hydrous oxides in soil. The relative affinity of alkaline earth cations for cation exchange and specific adsorption sites on clays and oxides decreases in the order Ba > Sr > Ca > Mg (EPRI, 1984). Barium would thus be expected to displace Ca and Mg from sorption sites. Surface complexation by soil organic matter also occurs to a limited extent. Adsorption coefficients for barium are provided in the following table.

	Adsorption Coefficients (mL/g)	Substrate	Source	Range (mL/g)
Barium	K_d = 66 K_d = 128 K_d = 2,800	Unweathered glacial till Weathered glacial till Sediment/ River water	IT, 1993 IT, 1993 Li and Chan, 1979	K_d = 66 to 2,800

References

Ainsworth, C. C., Harvey, S. D., Szecsody, J. E., Simmons, M. A., Cullinan, V. I., Resch, C. T., and Mong, G. H. (1993). "Relationship between the leachability characteristics of unique energetic compounds and soil properties, " Final Report, Project Order No. 91PP1800, U.S. Army Biomedical Research and Development Laboratory, Fort Detrick, Frederick, MD.

EPRI, 1984, Chemical Attenuation Rates, Coefficients, and Constants in Leachate Migration, Volume 1: A Critical Review, EPRI EA-3356, Electric Power Research Institute, Palo Alto, California.

Hale, et al., 1979, Evaluation of the environmental fate of munition compounds in soil. Contract no. DAMD17-76-C-6065. Frederick, MD: U.S. Army Medical Research and Development Command, Fort Detrick. Document no. AD A082874.

IT Corporation, 1993, "Adsorption of Select Metals and Radionuclides on Glacial Overburden Present at the Fernald Environmental Management Project Site," FERMCO Restoration Management Corporation, Task Order No. 027, Subcontract No. 236552, Fernald, OH.

Leggett, D. C. (1985). "Sorption of military explosive contaminants on bentonite drilling muds," CRREL Report 85-18, U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH.

Li, Y. and L. Chan, 1979, "Desorption of Ba and Ra-226 from River-Borne Sediments in the Hudson Estuary," Earth and Planetary Science Letters, v 43, pp 343-350.

McGrath, C. J. (1995). "Review of formulations for processes affecting the subsurface transport of explosives, " Technical Report IRRP-95-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Myers, T. E., Brannon, J. M., Pennington, J. C., Townsend, D. M., Davis, W. M., Ochrnan, M. K., Hayes, C. A., and Myers, K. F. "Laboratory studies of soil sorption and transformation kinetics for explosives, " Technical Report (in preparation), U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Selim, H. M., and Iskandar, I. K. (1994). "Sorption-desorption and transport of TNT and RDX in soils, " CRREL Report 94-7, U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH.

Sikka, H. C., Banerjee, S., Pack, E. J., and Appleton, H. T. (1980). "Environmental fate of RDX and TNT, " Technical Report 81538, U.S. Army Medical Research and Development Command, Ft. Detrick, Frederick, MD.

Spanggord et al., 1980, Environmental fate studies on certain munition wastewater constituents: Phase II--Laboratory studies, Contract no. DAMD17-78-8081, Frederick, MD: U.S. Army Medical Research and Development Command, Fort Detrick. Document no. AD A099256.

Townsend, D. M., and Myers, T. E. (1996). "Recent developments in formulating model descriptors for subsurface transformation and sorption of TNT, RDX, and HMX, " Technical Report IRRP-96-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Townsend, D. M., Myers, T. E., and Adrian, D. D. (1995). "2,4,6- trinitrotoluene (TNT) transformation/sorption in thin-disk soil columns, " Technical Report IRRP-95-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Townsend, D.M, D. D. Adrian, T. E. Myers, , "RDX and HMX Sorption in Thin Disk Soil Columns,", US Army Corps of Engineers, Waterways Experiment Station WES Technical Report IRRP-96-8 November 1996.

Zakikhani, M., D. W. Harrelson, J. C. Pennington, J. M. Brannon, M. K. Corcoran, J.Clark, W. A. Sniffen, 2002, "Environmental Monitoring and Remediation Analysis of Explosives," U.S. Army Engineer Research and Development Center, Vicksburg, MS.