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**Bioavailability of Mercury
in East Fork Poplar Creek Soils**

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Energy Systems Environmental Restoration Program
Y-12 Environmental Restoration Program

**Bioavailability of Mercury
in East Fork Poplar Creek Soils**

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PREFACE

This report summarizes an investigation of the bioavailability of mercury in Lower East Fork Poplar Creek (EFPC) floodplain soils as part of the remedial efforts pursuant to the Comprehensive Environment Response, Compensation and Liability Act (CERCLA) of 1980 as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 and the Federal Facility Agreement (FFA). This work was performed under Work Breakdown Structure 1.4.12.3.1.04.41, Activity Data Sheet 9304, "Lower East Fork Poplar Creek." An abbreviated version of this report appeared in the Addendum to the East Fork Poplar Creek - Sewer Line Beltway Remedial Investigation Report (DOE/OR/02-1119&D2/A1/R1). The information presented in this report was used in deriving the Remediation Goal Option (RGO) for EFPC soil.

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SUMMARY

The initial risk assessment for the East Fork Poplar Creek (EFPC) floodplain in Oak Ridge, Tennessee, a superfund site heavily contaminated with mercury, was based upon a reference dose for mercuric chloride, a soluble mercury compound not expected to be present in the floodplain, which is frequently saturated with water. Previous investigations had suggested mercury in the EFPC floodplain was less soluble and therefore less bioavailable than mercuric chloride, possibly making the results of the risk assessment unduly conservative. A bioavailability study, designed to measure the amount of mercury available for absorption in a child's digestive tract, the most critical risk endpoint and pathway, was performed on twenty soils from the EFPC floodplain. The average percentage of mercury released during the study for the twenty soils was 5.3%, compared to 100% of the compound mercuric chloride subjected to the same conditions. Alteration of the procedure to test additional conditions possible during soil digestion did not appreciably alter the results. Therefore, use of a reference dose for mercuric chloride in the EFPC risk assessment without inclusion of a corresponding bioavailability factor may be unduly conservative.

INTRODUCTION

The floodplain of East Fork Poplar Creek (EFPC) in Oak Ridge, Tennessee is contaminated with mercury from historic releases from the Department of Energy Oak Ridge Y-12 Plant located at the headwaters. The floodplain is currently being investigated as a superfund site (Department of Energy, 1994). The initial risk assessment dose calculations for mercury were based on the compound mercuric chloride, a soluble form of mercury not expected to exist in the environment. Several investigations have suggested the mercury in EFPC soils may be less soluble and therefore less bioavailable than mercuric chloride (e.g. Revis, et al, 1990), making the results of the risk assessment unduly conservative.

A bioavailability study was conducted to determine the fraction of mercury in EFPC soils potentially available for absorption in the human digestive system, the critical pathway of human exposure in this system. The bioavailability study attempted to simulate the human digestive system. The study was adapted from a protocol used in another risk assessment conducted on an old mercury mine (Camp, Dresser & McKee, 1992), which was designed to mimic the conditions encountered in the human digestive tract (e.g. pH, residence time, solid/solution ratio, etc.). The study was conducted on a suite of soils from the floodplain as well as some pure mercury compounds for comparison purposes.

EXPERIMENTAL METHODS

SAMPLE COLLECTION AND PROCESSING

In January 1994, soil samples were collected at two depths from ten sites (for a total of twenty samples) to represent a range of environmental conditions in the floodplain (Fig. 1). Surface samples were collected within three inches of the surface. Deeper samples were collected in layers historically associated with the highest concentration of mercury in the floodplain. The sample designation, soil description and sample depth are shown in Table 1.

Samples were collected by channel sampling with a stainless steel spatula and spoon, composited by mixing in stainless steel bowls, placed in glass jars, transported back to the laboratory and refrigerated until processing. In the laboratory, samples were air dried in aluminum foil trays, lightly crushed with a clean mortar and pestle and sieved to 2 mm to remove rocks, roots, etc. The < 2 mm material was ground in a clean mortar and pestle and sieved to < 180 μ m. Subsamples of the <180 μ m material were analyzed for total mercury by SW-846 Method 7471 and total carbon and total sulfur with a LECO carbon/sulfur analyzer.

LEACHING

One liter polypropylene containers were washed with 2 N nitric acid, and rinsed with distilled, deionized water. A 0.74 g portion of each air dried, <180 μ m soil was added to one liter of distilled, deionized water adjusted to pH 2.5 with 16 N hydrochloric acid in the cleaned containers. The samples were shaken continuously. The pH was rechecked after ten minutes and again after one hour. No pH readjustment was required for any of the samples at pH 2.5. After four hours of leaching, the pH of each sample was measured and recorded and the samples were allowed to settle. All samples had a final pH of 2.5 ± 0.2 . After twenty-five minutes, 250 ml of the supernatant was poured into cleaned, disposable 0.2 μ m filter units and filtered. The filtrate was preserved with potassium dichromate in nitric acid prior to analysis for total mercury by SW-846 Method 7470. This treatment simulates the stomach.

The remaining 750 ml of suspension was combined with 250 ml distilled, deionized water to restore the original solid/solution ratio and the pH was adjusted to 6.5 with 5 and 0.5 N sodium hydroxide. The samples were shaken while rechecking and readjusting pH as necessary at ten minutes and one hour. After four hours, the sample pH was checked and recorded, and the samples were filtered as described above. There were some problems with pH drifting from 6.5 (particularly down) during the procedure. Of the 46 leachates at pH 6.5, 25 had a final pH of 6.5 ± 0.2 , 39 had a final pH of 6.5 ± 0.5 and all

Table 1. Sample Identification, Depths and Description

Sample No.	Depth (in)	Description
ZN3210115	0-3	Grayish-Brown, Medium Texture
ZN3210127	13-19	Brownish-Gray, Medium Texture
ZN3340211	0-3	Grayish-Brown, Medium Texture
ZN3340223	5-16	Brownish-Gray, Medium Texture
ZN3340312	0-3	Grayish-Brown, Medium Texture, Wetland
ZN3340324	3-9	Dark Gray, Medium Texture
ZE5470412	0-3	Dark Brown, Medium Texture
ZE5470424	10-20	Dark Gray, Medium Texture
ZE5380512	0-3	Brown, Fine Texture, Clay, Wetland
ZE5380524	10-14	Dark Gray, Medium Texture, Clay
ZE5340619	0-3	Dark Brown, Medium Texture
ZE5340621	10-16	Dark Brownish-Gray, Medium Texture
ZE5150717	0-3	Dark Brown, Medium Texture
ZE5150729	5-8	Dark Gray, Medium Texture
ZE3770810	0-3	Dark Brown, Medium Texture
ZE3770822	10-16	Light Brown, Medium Texture
ZE3740918	0-3	Dark Brown, Medium Texture
ZE3740920	8-12	Dark Brown, Medium Texture
ZE3181013	0-3	Dark Brown, Medium Texture
ZE3181025	16-32	Reddish Brown, Fine Texture, Clay

46 had a pH of 6.5 ± 1.0 . This treatment simulates the remainder of the gastrointestinal tract.

In order to more closely replicate the conditions of actual soil ingestion, the leaching procedure was also repeated for a few samples of unprocessed field moist soil, soil at body temperature (37°C), and with 10 mg/l deoxycholic acid, a common constituent of the human digestive system. Mercuric chloride and two forms of mercuric sulfide, cinnabar and metacinnabar, were also run as controls. The mercuric chloride (Mallinckrodt) and cinnabar were reagent grade (EM Science). The metacinnabar was synthesized in the laboratory, and confirmed by x-ray diffraction.

QUALITY ASSURANCE

Two of the soil samples were submitted in triplicate to measure variability in mercury, sulfur and carbon analysis. Method 7471 also specifies that three 0.2 g aliquots of each soil be taken for total mercury analysis and thus considerable information on sample homogeneity and analytical precision was obtained. Replicate NIST standard reference material (NIST SRM 2710) soil was also submitted blind to the laboratory for analysis of mercury, sulfur and carbon. Distilled, deionized water and process blanks (distilled, deionized water carried through the leaching procedure) were analyzed for mercury. Three soils were leached in triplicate to measure variability in mercury concentrations in the leachate.

RESULTS AND DISCUSSION

The results of total mercury, sulfur and carbon analysis on the dry soil are shown in Tables 2 and 3. Mercury concentrations ranged from 15 - 2630 mg/kg and, as expected, were higher for deeper samples in nine of the ten sites. The anomalous site (E-37728) was located near the creek and field observations indicated this site had recently been eroded removing the surface soil and exposing the underlying more highly contaminated soil at the surface.

The predominant form of mercury in EFPC soils has been suggested previously as mercuric sulfide (Revis, et al., 1989 a,b). The association of elemental mercury and sulfur in individual soil particles has also been noted (K-25 Technical Division, 1993). The results of the present study further indicate the association between mercury and sulfur in the soils of EFPC, which may influence mercury solubility and bioavailability. As shown in Fig. 2, mercury was significantly correlated ($r=0.84$) with sulfur in the twenty samples (as discussed below, this correlation was due predominately to the deeper samples). In nineteen of the twenty samples, sufficient sulfur was present to bind all of the mercury as mercuric sulfide, with an average of almost seven times as much sulfur as mercury on a molar basis. In one sample, the concentration of mercury exceeded the concentration of sulfur on a molar basis by approximately 20%, indicating all the mercury in this sample can not be mercuric sulfide. One other sample (ZN3210127) clearly deviated from the mercury-sulfur relationship exhibited by the other samples. By removing this sample from the regression, the mercury-sulfur correlation improves significantly ($r=0.92$) for the other nineteen soils. This sample, the most upstream sample taken (i.e. closest to the source), was apparently geochemically different from the other samples, containing the highest concentration of mercury, and leaching significantly more mercury than the other samples. Carbon has also been shown to be strongly associated with mercury in the environment (Andren and Harriss, 1975). However, the correlation between carbon and mercury in EFPC soils is weak ($r=0.59$).

There was a significant difference between the association of mercury and sulfur in the surface samples compared to the samples taken at depth. As shown in Fig. 3, total mercury was well correlated ($r=0.945$) with total sulfur in the deep samples. The correlation ($r=0.528$) was not as good in the surface samples as shown in Fig. 4. In analyzing the surface and deep samples, the sample which clearly deviated from the mercury-sulfur relationship was not included, and the surface sample from the area where the original surface had been eroded (site E-37728) was included in the deep samples. Several geochemical reasons for the better mercury-sulfur correlation at depth can be postulated. The formation and stability of mercuric sulfide is favored in reducing environments which may occur more favorably in the deeper soils. Alternatively, the deeper mercury concentration peaks are co-depositional with the early operation of the Y-12 plant. Other sulfur rich materials may have been deposited during this same time frame, and coal fragments and fly ash are readily visible in the deeper soils.

Table 2. Mercury, Sulfur and Carbon Concentrations in EFPC Soils

Sample No.	Hg (mg/kg)	S (mg/kg)	C (mg/kg)
ZN3210115	260	150	65000
ZN3210127	2630	683	44300
ZN3340211	270	300	59000
ZN3340223	1900	900	68000
ZN3340312	230	350	93000
ZN3340324	2100	1600	110000
ZE5470412	85	140	40000
ZE5470424	1300	650	81000
ZE5380512	67	110	23000
ZE5380524	2100	1700	120000
ZE5340619	140	30	35000
ZE5340621	1200	490	69000
ZE5150717	230	150	33000
ZE5150729	900	320	50000
ZE3770810	480	200	30000
ZE3770822	15.3	26.7	13600
Z43740918	55	120	25000
ZE3740920	780	220	23000
ZE3181013	28	150	38000
ZE3181025	390	50	12000
mean	758	417	51600

Table 3. Mercury, Sulfur and Carbon Molar Concentrations in EFPC Soils

Sample No.	Hg (mmol/kg)	S (mmol/kg)	C (mol/kg)	S/Hg (mol/mol)
ZN3210115	1.3	4.7	5.4	3.6
ZN3210127	13.1	21.3	3.7	1.6
ZN3340211	1.3	9.4	4.9	7.0
ZN3340223	9.5	28.1	5.7	3.0
ZN3340312	1.1	10.9	7.8	9.5
ZN3340324	10.5	49.9	9.2	4.8
ZE5470412	0.4	4.4	3.3	10.3
ZE5470424	6.5	20.3	6.8	3.1
ZE5380512	0.3	3.4	1.9	10.3
ZE5380524	10.5	53.0	10.0	5.1
ZE5340619	0.7	0.9	2.9	1.3
ZE5340621	6.0	15.3	5.8	2.6
ZE5150717	1.1	4.7	2.8	4.1
ZE5150729	4.5	10.0	4.2	2.2
ZE3770810	2.4	6.2	2.5	2.6
ZE3770822	0.1	0.8	1.1	10.9
Z43740918	0.3	3.7	2.1	13.7
ZE3740920	3.9	6.9	1.9	1.8
ZE3181013	0.1	4.7	3.2	33.5
ZE3181025	1.9	1.6	1.0	0.8
mean	3.8	13.0	4.3	6.6

Fig. 2. Mercury versus Sulfur in EFPC Soils.

Fig. 3. Mercury versus Sulfur in Deep Soils.

Fig. 4. Mercury versus Sulfur in Surface Soils.

The results of the leaching study for the twenty soil samples are shown in Table 4. The percentage leached at pH 6.5 is corrected for the soluble mercury lost from the sample when decanting the supernatant for filtration at pH 2.5. The total percent soluble mercury is simply the sum of the percent soluble at both pH values and represents a worst case scenario, since some of the mercury in the soil is undoubtedly soluble at both pH values and is double counted in the simple summation.

In nineteen of the twenty samples, the mercury was not significantly (as a percentage) extracted at either pH. The maximum concentration of mercury in the leachates was 77 $\mu\text{g/l}$. Less than 5% of the mercury was solubilized in fifteen of the samples. Total soluble mercury in the nineteen samples ranged from 0.3 - 14.2% with an average of 3.2%. For sample ZN3210127, the soluble mercury concentration was 570 and 300 $\mu\text{g/l}$ at pH 2.5 and 6.5 respectively for a total of 45.9% soluble mercury. The high leachate concentrations for the sample are thought to reflect differences in the form of mercury in the sample. As noted earlier, this sample was an outlier with respect to the otherwise good correlation between total mercury and total sulfur. In addition, this was the only sample among twenty which exhibited detectable mercury vapor in the sample headspace. Including this sample, the average percent mercury leached from the twenty samples was 5.3%.

The presence of mercuric sulfide or a mercury-sulfur association in the soils may be a reason for the low solubility and bioavailability of mercury in the EFPC soils, since the one sample which did not readily conform to the mercury-sulfur correlation was also the sample which had the highest mercury concentrations in the leachate. However, the average percentage leached for the deep samples (3.6%) was higher than for the surface samples (1.6%), though the deep samples exhibited a better mercury-sulfur correlation. However, this be indicative of the more water soluble mercury forms being preferentially removed in the surface soils by water infiltration.

The leaching procedure was also conducted for five samples at body temperature (37 °C), four field moist soils and two samples with 10 mg/l deoxycholic acid, a common constituent of the human digestive tract. The samples were selected to more realistically simulate uptake via soil ingestion and to measure the variability of the results above in conditions more representative of the digestive tract. The results are shown in Table 5. The change in percent solubility for the samples (percent leached minus percent leached from dry soil at 25 °C from Table 4) ranged from -7.7 to +1.8%. The differences appear to be within the average experimental error, as discussed later.

Mercuric chloride and mercuric sulfide (cinnabar and metacinnabar) were also subjected to the leaching procedure and the results are shown in Table 5. The entire mercuric chloride sample dissolved and the leachate concentrations (540 and 450 mg/l) were much higher than the soil leachates, almost one thousand times higher than the highest soil leachate. The concentration of mercury in the metacinnabar sample was 0.05 and 0.5 $\mu\text{g/l}$ and was 97 $\mu\text{g/l}$ and 42.0 $\mu\text{g/l}$ in the cinnabar sample at pH 2.5 and 6.5 respectively. The fraction of the sample dissolved was much less than 1% for both cinnabar and metacinnabar. The cinnabar sample was reagent grade and may have

Table 4. Leachate Results for Dry Soils

Sample	Soil Hg (mg/kg)	Leachate Hg (µg/l) pH 2.5	Leachate Hg (µg/l) pH 6.5	% Soluble pH 2.5	% Soluble pH 6.5	% Soluble Total ^a
ZN3210115	260	0.70	1.00	0.4	0.5	0.9
ZN3210127	2630	570.00	300.00	29.3	16.6	45.9
ZN3340211	270	0.80	0.80	0.4	0.4	0.8
ZN3340223	1900	77.00	20.00	5.5	1.4	6.9
ZN3340312	230	0.20	1.80	0.1	1.1	1.2
ZN3340324	2100	30.00	11.00	1.9	0.7	2.6
ZE5470412	85	0.20	0.40	0.3	0.6	1.0
ZE5470424	1300	73.00	14.00	7.6	1.5	9.1
ZE5380512	67	1.60	1.10	3.2	2.2	5.5
ZE5380524	2100	26.00	8.20	1.7	0.5	2.2
ZE5340619	140	0.10	0.20	0.1	0.2	0.3
ZE5340621	1200	10.50	4.90	1.2	0.6	1.7
ZE5150717	230	1.80	2.60	1.1	1.5	2.6
ZE5150729	900	13.00	3.20	2.0	0.5	2.4
ZE3770810	480	2.40	1.50	0.7	0.4	1.1
ZE3770822	15.3	1.10	0.50	9.7	4.5	14.2
Z43740918	55	0.20	0.20	0.5	0.5	1.0
ZE3740920	780	14.00	5.80	2.4	1.0	3.4
ZE3181013	28	0.03	0.20	0.1	1.0	1.1
ZE3181025	390	6.30	1.90	2.2	0.7	2.8
mean	740	41.4	19.0	3.5	1.8	5.3

a (% soluble pH 2.5) + (% soluble pH 6.5)

Table 5. Leachate Results for Field Moist Soils, Soils at Body Temperature, Soils with Deoxycholic Acid and Mercuric Chloride and Sulfide

Sample ^a	Hg (mg/kg)	Hg (µg/l) pH 2.5	Hg (µg/l) pH 6.5	% Soluble pH 2.5	% Soluble pH 6.5	% Soluble Total	% Change in Solubility ^b
ZN3210127-37	2630	580.00	170.00	29.0	9.2	38.2	-7.7
ZN3210115-37	260	0.72	1.10	0.4	0.6	0.9	0.1
ZN3340223-37	1900	97.00	14.00	6.9	1.0	7.9	1.0
ZE3740918-37	55	0.06	0.80	0.1	2.0	2.1	1.3
ZE5470424-37	1300	88.00	16.00	9.1	1.7	10.8	1.8
ZE5470424-W	1300	110.00	27.00	8.1	2.0	10.1	1.0
ZE3740918-W	55	0.10	0.87	0.2	1.4	1.6	0.7
ZE3770810-W	480	1.20	7.90	0.2	1.5	1.8	0.7
ZE3740920-W	780	7.80	13.00	0.9	1.5	2.4	-1.0
ZE3740918-C	55	0.07	0.80	0.2	2.0	2.1	1.3
ZE3740920-C	780	6.50	1.10	1.1	0.2	1.3	-2.1
HgCl ₂		540,000.00	450,000.00	98.8	109.3	100.0	
cinnabar		97.00	42.00	0.0	0.0	0.0	
metacinnabar		0.05	0.50	0.0	0.0	0.0	

a. 37 represents sample leached at 37 °C, W represents field moist soil and C represents with 10 mg/l deoxycholic acid.

b. Total % leached - Total % leached from dry soil at 25 °C from Table 4.

contained other more soluble mercury phases (such as an oxidized surface coating) whereas the metacinnabar had been recently precipitated and washed with distilled water.

QUALITY ASSURANCE

The quality assurance data for soil analysis are shown in Table 6. Three replicates each were analyzed for two of the soils. The coefficient of variation (COV), the ratio of the standard error to the mean expressed as a percentage, for the two soils were 3.8 and 2.2% for total mercury indicating excellent precision. Note that EPA Method 7471 requires solids to be analyzed in triplicate and thus all the values for all twenty soils are the mean of these measurements. The COV for two soil total carbon analyses were 4.2 and 3.4% also indicating excellent precision. The precision for the total sulfur analysis was not as good, with COV for two samples of 53.9 and 21.9%. The mercury values reported for two blind NIST standard reference materials agreed within -1.8 and -14.1% of the reference value indicating acceptable accuracy (the results of all twenty soils agreed within approximately 1% with the mercury results for the same soils analyzed for the EMSL speciation study (Dobb, et al, 1994). The reported values for carbon agreed with the NIST SRM within -3.3 and 0% indicating excellent accuracy. The reported values for sulfur, however, only agreed with the NIST SRM within -45.8 and -92.5%.

The quality assurance data for the aqueous leachate samples are shown in Table 7. All source water and process blanks had mercury concentrations less than the minimum detectable concentration of 0.2 µg/l (not shown). The precision of the leachate mercury concentrations based on three replicates each for five samples varied with COV ranging from 0 - 48.1%. The larger COV could have probably been reduced by rejection of one outlier.

The quality assurance data for all analyses was acceptable to excellent, with the exception of the analysis of total sulfur in soils, which did not have ideal accuracy nor precision. The LECO sulfur analyzer measures the amount of sulfur by conversion to sulfur dioxide during high temperature combustion with oxygen. However, the extent of conversion to sulfur dioxide is dependent on the soil matrix (Huffman and Stuber, 1985). In addition, sulfur is apparently a problematic element to measure in environmental samples. Measurement of the amount of sulfur in three humic substances (a common component of natural samples) by four different laboratories consistently produced COV of greater than 50% (Huffman and Stuber, 1985). The absolute values (accuracy) of sulfur measured in the soil samples are suspect. However, since the measurements were conducted on twenty soils, precision errors would tend to cancel out in examining trends. Therefore, although the sulfur content of individual soils are suspect, the trends identified (i.e. increasing sulfur content with mercury content) are valid.

Table 6. Quality Assurance Data for Solid Samples

Sample	Element-Replicate	Concentration (mg/kg)	Mean (mg/kg)	COV %
ZE3770822	Hg-1	15	15.3	3.8
	Hg-2	16		
	Hg-3	15		
	S-1	16	26.7	53.9
	S-2	43		
	S-3	21		
	C-1	13,000	13,700	4.2
	C-2	14,000		
	C-3	14,000		
ZN3210127	Hg-1	2700	2630	2.2
	Hg-2	2600		
	Hg-3	2600		
	S-1	560	683	21.9
	S-2	850		
	S-3	640		
	C-1	43,000	44,300	3.4
	C-2	46,000		
	C-3	44,000		
NIST SRM	Element	Concentration (mg/kg)	Standard Value (mg/kg)	% difference
Replicate 1	Hg	28	32.6	-14.1
	S	1,300	2,400	-45.8
	C	29,000	30,000	-3.3
Replicate 2	Hg	32	32.6	-1.8
	S	180	2,400	-92.5
	C	30,000	30,000	0

Table 7. Quality Assurance Data for Leachate Samples

Sample No.	Replicate No.	Hg ($\mu\text{g/l}$)	Mean($\mu\text{g/l}$)	COV (%)
ZE5380619 pH 2.5	1	< 0.2	< 0.2	0
	2	< 0.2		
	3	< 0.2		
ZE5380619 pH 6.5	1	< 0.2	< 0.2	0
	2	< 0.2		
	3	< 0.2		
ZE5340621 pH 2.5	1	12.0	10.5	17.2
	2	11.0		
	3	8.5		
ZE5340621 pH 6.5	1	5.0	4.87	26.8
	2	6.1		
	3	3.5		
ZE3770822 pH 2.5	1	1.7	1.1	48.1
	2	0.9		
	3	0.7		
ZE3770822 pH 6.5	1	0.4	.53	28.6
	2	0.5		
	3	0.7		

SUMMARY AND CONCLUSIONS

Twenty soil samples were collected from the EFPC floodplain to represent a range of biogeochemical environments and mercury contamination levels (15 - 2630 mg/kg). Total mercury was correlated ($r=0.84$) with total sulfur in the twenty soils, possibly indicative of the presence of mercuric sulfide in the soils as suggested by other investigations. The soils were subjected to a leaching procedure designed to simulate the human digestive system. One of the twenty soils (ZN3210127) leached approximately 45.9% of total soil mercury while the remainder leached at most 14.2%, with only five soils leaching greater than 5%. The average total percent leached from the twenty soils was 5.3%.

The leaching procedure was repeated for several soils at body temperature, with deoxycholic acid, a common constituent of the digestive system, and on field moist soils. The changes in percentage leached (percent leached minus percent leached at 25 °C) were within experimental error. Therefore, the results of the study may be extended to conditions more representative of the actual digestive system.

Less than 1% of the mercuric sulfide samples, both cinnabar and metacinnabar, leached in the procedure. In contrast, all of the mercuric chloride sample dissolved, producing leachate concentrations almost one thousand times higher than the highest soil leachate. Although the procedure is a simple representation of a complex system such as the human digestive system, the solubility and hence bioavailability of mercury in EFPC soils is obviously substantially less than pure mercuric chloride. Use of a reference dose for mercuric chloride in the EFPC risk assessment without incorporating a corresponding bioavailability factor may be unduly conservative.

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Enclosed please find a report entitled *Bioavailability of Mercury in East Fork Poplar Creek Soils*. The data presented in this report were used to derive a bioavailability factor and human health remediation goal option (RGO) for mercury in LEFPC soils. An abbreviated version of this report was included in the addendum to the LEFPC Remedial Investigative Report (DOE/OR/02-11198DE/A1/R1).

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