Summary Report of Washed and Unwashed Mine Tailings (Chat) from the Tar Creek Superfund Site Area

TAR CREEK SUPERFUND SITE

OTTAWA COUNTY, OKLAHOMA

May, 2000

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Introduction

The Site Remediation Section of the Waste Management Division of the Department of Environmental Quality sampled two mining waste (chat) piles that are used for commercial purposes. These piles are located near Picher, Oklahoma which is in the Tar Creek Superfund Area. The purpose of this sampling was to provide information concerning the analytical and physical characteristics of the chat. Analyses of chat before and after washing will also provide data on the contaminants in the wash water.

Additionally, two used asphalt piles were sampled. The used asphalt came from the Will Rogers Turnpike. It was assumed that mining waste (chat) was used in the construction of this highway. The purpose of this test was to determine the metal content after the mining waste was used in asphalt. The two piles were located near Quapaw, Oklahoma.

Background

The Tar Creek site encompasses 40 square miles in far northeastern Oklahoma and affects the towns of Quapaw, Commerce, Picher, North Miami, and Cardin. The site is part of the former Tri-state Mining Area that extended from northeastern Oklahoma, through southeast Kansas, and into southwest Missouri. Extensive lead and zinc mining during the early 1900's through the 1960's resulted in the formation of acid mine water that has contaminated the shallow ground water and surface water with iron, sulfate, zinc, lead, and cadmium at the Tar Creek site.

Mine tailings (chat) are comprised of mostly angular chert fragments and contain residual amounts of lead sulfide (galena). Chat is the waste product derived from jigging operations to recover lead and zinc and consists of material typically ranging in diameter from 5/8 inch to less than No. 200 seive. Chat has been used for many purposes including aggregate for asphalt used in roads and as gravel for county roads and driveways. The use of chat in driveways and as fill material has contributed to lead contamination of soils in residential property that has caused elevated blood lead concentrations in area children. The Environmental Protection Agency (EPA) is now conducting soil remediation work in the cities in this area. The purpose of this study is to see what effect washing has on the lead content of chat. This will help determine appropriate management of chat prior to its use.

Sampling and Sample Analysis

The DEQ Site Remediation personnel collected samples in November, 1999, from raw mining waste (chat) piles, washed mining waste (chat), and water used in the washing operation. The Oklahoma State Environmental Laboratory (SEL) analyzed the samples for total lead, cadmium, arsenic, and zinc on the washed and unwashed chat. For the washed and unwashed chat the toxicity characteristic leaching procedure (TCLP) was run for the lead and cadmium. Standard Engineering and Testing, a geotechnical laboratory, ran the particle size gradation. The sieve sizes used were the U.S. Standard Inch/Sieve# of 1/2, 3/8, #10, #40, #80, and #200. The material collected from each of the sieve sizes was analyzed for total lead, cadmium, arsenic, and zinc. The material was also analyzed using toxicity characteristic leaching procedure (TCLP) which were run for the lead and cadmium. The water samples were analyzed for lead, cadmium, zinc, arsenic, iron, calcium, magnesium, sodium, potassium, alkalinity, chloride, sulfate, total dissolve solids, and total suspended solids.

Additionally, the DEQ Site Remediation personnel collected samples from the asphalt piles that had been removed from the Will Rogers Turnpike in February 2000. The Oklahoma State Environmental Laboratory (SEL) analyzed the samples for total lead, cadmium, and zinc. Then the toxicity characteristic leaching procedure (TCLP) was run for the lead and cadmium.

Summary

Twelve mining waste (chat) samples were taken from the Ottawa and Atlas mining waste (chat) piles along with two duplicates. Twelve sieve samples were also analyzed with one duplicate. Nine water samples were collected from the wash water along with a field blank and equipment blank.

The total concentration values for lead, cadmium, zinc, and arsenic of the washed, raw, and dry screen mining waste (chat) generally increased as the particle size decreased. The arsenic results were non-detect for totals with the detection limit being 40 mg/kg. The TCLP was run for the lead and cadmium and generally increased as the particle size decreased. The Ottawa Mining Waste (Chat) Pile had higher values than the Atlas Mining Waste (Chat) Pile. This could be due to several reasons such as the number of time the chat pile was milled. The data for the totals and TCLP are given in Table 1. The values of the process water or wash water are given in Table 2.

The range of values for total lead for each of the sieved samples from the Ottawa Mining Waste (Chat) Pile is 70 to 6,668 mg/kg and for the Atlas Mining Waste (Chat) Pile the range is 25 to 1789 mg/kg. The range of values for the TCLP lead for each of the sieved samples for the Ottawa Mining Waste (Chat) Pile is 2.872 to116.560 mg/l and for the Atlas Mining Waste (Chat) Pile is 1.241 to 15.57 mg/l. For the sieved sample, as the particle size decreases the lead content increased. These sieved values are given in Table 3. It should be noted that a liquid did not decontaminate the sieves. Instead they were shaken by hand and brushed with any particles stuck in the mesh being removed by hand.

A remedial investigation was done for both the Kansas and Missouri portion of the mining area. The total lead concentration in Kansas (Dames & Moore, 1993) for the bulk chat ranged from 100 to 1,660 mg/kg with an average of 750 mg/kg for 16 samples. The total lead concentration in Kansas (Dames & Moore, 1993) for the tailings ranged from 56 to 13,000 mg/kg with an average of 3,790 mg/kg for 12 samples. The total lead concentration in Missouri (Dames & Moore, 1995) for the bulk chat ranged from 22 to 6000 mg/kg with a mean value of 608 mg/kg for 97 samples. The total lead mean concentration in Missouri (Dames & Moore, 1995) for the tailings was 3,963 mg/kg for 156 samples. These data sets also show that the metal content increased as the particle size of the chat decreases.

The United States Department of Interior (DOI) took 30 samples from 13 chat piles located on Indian Lands (CCJM, 1999). The total lead results for the whole raw chat ranged from 78 mg/kg to 2289 mg/kg with a mean of 830 mg/kg (CCJM, 1999). The samples were also sieved into different particle sizes. The total lead concentrations for the sieved particles ranged from 11,700 mg/kg for the < 250 microns to 566 mg/kg for the > 4.75 mm. The averaged total lead ranged from 2794 mg/kg for < 250 microns to 160 mg/kg for > 4.75mm. Leachable lead was also run. These values ranged from 0.659 mg/l to nondetect (C. C. Johnson et al, 1996). This data is consistent with the other tests that have been run.

A thesis prepared by K. David Drake (Drake 1999) studied the leachability of size-fractionated mine tailings in Kansas. The chat was sieved into different particle sizes ranging from -200 to +4 (<0.075 mm to 4.76 mm). The TCLP concentrations of lead from pile TC-3 for the different sizes ranged from 118 mg/l for the -200 size fraction (<0.075 mm) to 0.450 mg/l for the +4 size fraction (4.76 mm). The TCLP concentrations of lead from pile TC-16 for the different sizes ranged from 10.5 mg/l for the -100 size fraction to not detected (detection limit of 2.6 ppb) for the +4 and +8 size fraction.

Drake (Drake 1999) also tested some tailing impoundments. The TCLP concentrations of lead from pile TT-11 for the different sizes ranged from 5.4 mg/l for the -200 size fraction to 7.1 mg/l for the +4, +8, and +16 (4.76 mm to 1.19 mm) size fraction. The TCLP concentrations of lead from pile TT-22N for the different sizes ranged from 62.8 mg/l for the -200 size fraction (<0.075 mm) to 25.8 mg/l for the +4 to +30 (4.76 mm to 0.595 mm) size fraction.

Six used asphalt samples were taken from two piles named the Battie Asphalt Pile and the DeHorn Asphalt Pile along with one duplicate. These piles are located near Quapaw, Oklahoma and came from the Will Rogers Turnpike. The total concentration values for lead, cadmium, and zinc are less than the values for the raw and washed chat except for one anomaly where the value is 2228 mg/kg. The values for the total metal content ranged from 141 to 252 mg/kg for lead, 12 to 35 mg/kg for cadmium, and 1,761 to 5,104 mg/kg for zinc. The TCLP was run for the lead and cadmium with the values being lower than for the raw and washed chat. The values for the TCLP ranged from < 0.050 to 0.221 mg/l for lead and 0.005 to 0.014 mg/l for cadmium. The data is given in Table 4.

Conclusion

Compared to total metals analysis, the TCLP analysis is thought to be more representative of metal content in chat samples because of the larger sample size used in the analysis. The TCLP uses 100 gram of solution compared to 0.5 gram of solution for the total metal.

The remedial action value set for lead in the residential soil cleanup at the Tar Creek Superfund Site is 500 mg/kg (EPA, 1997). All but one of the samples of the washed and unwashed chat at the Atlas Chat Pile had lead concentrations below the 500 mg/kg value. All but one of the samples of the Ottawa Chat Pile had lead concentrations above the 500 mg/kg value. One reason that each chat pile has different levels of metals is because some piles were run through the milling process one, two, or three times to recover additional lead. Only one set of composite samples was taken from each pile. Even though the total lead concentrations at the Atlas Pile were low, the sediment from the washing operations (fines) tested in excess of 1500 mg/kg for lead. This means that "clean" chat contains some elevated concentrations of material.

Other residential lead cleanup numbers used in Oklahoma ranged from 750 mg/kg at Blackwell (DEQ, 1996), 925 mg/kg at Bartlesville (DEQ, 1994), and 1000 mg/kg at Sand Springs (DEQ, 1997). One of the reasons for a difference in the cleanup levels is the bioavailability of the lead or how the body absorbs the lead.

Commercial levels have not been determined for the chat at the Tar Creek Superfund Site but in other locations such as Bartlesville and Blackwell, Oklahoma, the commercial cleanup numbers for lead were 2000 mg/kg (DEQ, 1994 and DEQ, 1996).

The use of mining waste (chat) in highway construction has been occuring for many years. A study was done by the U.S. Army Corps of Engineers (Corps, 2000) to determine the lead content of roadside soils where chat was used in the asphalt matrix or other components of the road building. This study showed that the use of chat in the sampled roads did not pose a problem for commercial/industrial exposures. The average soil lead levels for the chat roads were 266 mg/kg and 233 mg/kg while the average for the control road is 54 mg/kg. The maximum values were 886 mg/kg and 1,090 mg/kg for the chat roads and 189 mg/kg for the control road. Only nine samples were above the residential cleanup value of 500 mg/kg with none above the potential commercial level.

The limited test results from the used asphalt indicate that chat coated with asphalt ties up the metals. The results for total lead content ranged from 141 mg/kg to 2228 mg/kg with mean being 469 mg/kg. Only the 2228 mg/kg level was above the next high of 252 mg/kg. The one result is high but when the TCLP value of 0.155 is considered for that sample, then it is within the range of the other values (<0.050 to 0.221 mg/l). This test indicates that the chat used in asphalt can be stabilized. Additional testing and sampling need to be done to determine the longterm effects of using chat-containing asphalt.

List of Acronyms

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, also known as Superfund: Amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA).
DEQ	Oklahoma Department Of Environmental Quality
DOI	The United States Department of Interior
EPA	United States Environmental Protection Agency
ROD	Record of Decision: Documents selection of cost-effective Superfund financed remedy.
SEL	The Oklahoma State Environmental Laboratory
TCLP	Toxicity Characteristic Leaching Procedure
USACE	United States Army Corps of Engineer

REFERENCES

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2. "Final Remedial Investigation Neck/ALBA, Snap, Oronogo/duenweg, Joplin, Thoms, Carl Junction, and Waco Designated Areas, Jasper County Site, Jasper County, Missouri" Volumes I and II, Dames and Moore, 633 Seventeenth Street, Denver, Colorado 80202-3625, October 31, 1995.

3. "Final Additional Site Characterization Report" for the Tar Creek NPL Site, U.S. Department of Interior, Bureau of Land Management, BLM Oklahoma City Field Area, CCJM, C. C. Johnson & Malthotra, P.C., Environmental Engineers and Scientists, January 14, 1999.

4. Drake, K. David, "Leachability of Size-Fractionated Mine Tailings from the Kansas Portion of the Tri-Mining District," Master of Science Thesis, University of Missouri, Kansas City, Missouri, 1999.

5. "Record of Decision for Residential Areas Operable Unit 2" for the Tar Creek Superfund Site, Ottawa County, Oklahoma, U. S. Environmental Protection Agency, Region 6, 1445 Ross Avenue, Dallas, Texas 75202, August 1997.

6. "Record of Decision for Operable Unit One" of the National Zinc Site, Bartlesville, Oklahoma, Oklahoma Department of Environmental Quality, State of Oklahoma, Oklahoma City, Oklahoma, December 13, 1994.

7. "Record of Decision for Soil Remediation Unit" of the Blackwell Zinc Site, Bartlesville, Oklahoma, Oklahoma Department of Environmental Quality, State of Oklahoma, Oklahoma City, Oklahoma, April 4, 1996.

8. "Record of Decision" for the Federated Metals Site, Sand Springs, Oklahoma, Oklahoma Department of Environmental Quality, State of Oklahoma, Oklahoma City, Oklahoma, May 5, 1997.

9. "Final Summary Report Chat-Asphalt Paved Road Study, Tar Creek Superfund Site, Ottawa County, Oklahoma," U. S. Army Corps of Engineers - Tulsa District, Tulsa, Oklahoma, February 2000.

TABLES

TABLE 1. DATA RESULTS FOR THE CHAT WASHING						
Collected by The Oklahoma Department of Environmental Quality on November 23, 1999						
CHAT SAMPLES		**TOTAL METALS**			**TCLP RESULTS**	
PROCESS	**IDENTIFICATION**	**Lead**	**Cadmium**	**Zinc**	**Lead**	**Cadmium**
OTTAWA CHAT	**NUMBER**	(mg/kg)	(mg/kg)	(mg/kg)	(mg/l)	(mg/l)
Raw Chat	OTRC-2	732	57	11,086	18.020	0.792
Wet Screen Coarse	OTWSC-1	642	94	15,638	1.487	0.137
Wet Screen Sand Screw Fines	OTWSSSF-1	384	35	5,996	3.938	0.310
Type 2 Slurry Seals Dry Screen Fines (Harp Screen #6 mm)	OTT2SS-1	1,594	67	13,504	17.810	0.742
Type 2 Slurry Seals Dry Screen Coarse (Harp Screen #5 mm)	OTT2SSC-1	910	45	9,600	8.406	0.462
Wet Sieving Screen Sediment 1	OTWSSED-1	2,014	64	11,742	21.310	0.693
Wet Sieving Screen Sediment 2	OTWSSED-2	1,582	50	8,966	19.830	0.643
ATLAS CHAT						
Raw Chat 2	ATRC-2	358	41	8,266	2.750	0.403
Raw Chat 3	ATRC-3	270	46	9,486	6.238	0.769
Wet Screen Coarse	ATWSC-1	116	50	8,728	1.028	0.154
Wet Screen Sand Screw Fines	ATWSSF-1	285	96	16,612	1.540	0.229
Type 2 Slurry Seals Dry Screen Fines	ATT2SS-2	269	18	3,766	1.720	0.305
Type 2 Slurry Seals Dry Screen Coarse	ATT2SSC-1	368	38	6,332	1.926	0.252
Wet Sieving Screen Sediment	ATWSSED-1	1,899	97	19,882	26.590	1.640
NOTE: The total for arsenic was also run and was less than the detection limit of 40 mg/kg.						
TCLP = Toxicity Characteristic Leaching Procedure						

TABLE 2. PROCESS WATER SAMPLES										
Collected by The Oklahoma Department of Environmental Quality on November 23, 1999.										
WATER SAMPLES	**CONCENTRATIONS**									
PROCESS	**Pb**	**Cd**	**Zn**	**As**	**Fe**	**Ca**	**Mg**	**Na**	**K**	**Alk**
OTTAWA PROCESS WATER	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
										CaCO3
Process Water Input	0.423	0.140	9.876	<0.200	0.875	566	42	126	6	188
Process Water Output	210.880	6.658	1605	<3.2	275.200	2342	277	<160	44	379
Filtered Process Water Output	0.147	0.225	7.072	<0.200	0.056	596	44	125	5	n.a.
Makeup Water (Mine Shaft)	0.088	0.042	9.404	<0.200	26.520	511	48	57	4	232
Makeup Water (Pond)	0.090	0.037	9.876	<0.200	1.618	464	51	845	12	199
Equipment Blank	<0.050	0.007	0.169	<0.200	0.050	18	1	<10	<1	n.a.
ITEM	**Pb**	**Cd**	**Zn**	**As**	**Fe**	**Ca**	**Mg**	**Na**	**K**	**Alk**
ATLAS PROCESS WATER	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
										CaCO3
Process Water Input	0.056	0.007	3.439	<0.200	0.381	623	21	46	4	214
Process Water Input	<0.050	0.006	3.278	<0.200	0.297	625	21	47	4	n.a.
Process Water Output	35.540	1.871	37.120	<0.800	134.720	1866	212	54	33	307
Filtered Process Water Output	0.230	0.024	5.196	<0.200	0.454	604	21	46	4	n.a.
Field Blank										

NOTE: n.a. = not available

TABLE 2 CONTINUED. PROCESS WATER SAMPLES				
Collected by The Oklahoma Department of Environmental Quality on November 23, 1999.				
WATER SAMPLES	**CONCENTRATIONS**			
PROCESS	**Cl**	**SO4**	**TDS**	**TSS**
OTTAWA PROCESS WATER	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Process Water Input	207	161	2569	42
Process Water Output	15.6	1620	2572	1872
Filtered Process Water Output	n.a.	n.a.	n.a.	n.a.
Makeup Water (Mine Shaft)	33.9	146	2187	52
Makeup Water (Pond)	1740	1020	4118	18
Equipment Blank	n.a.	n.a.	n.a.	n.a.
PROCESS	**Cl**	**SO4**	**TDS**	**TSS**
ATLAS PROCESS WATER	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Process Water Input	81	156	2395	9
Process Water Input	n.a.	n.a.	n.a.	n.a.
Process Water Output	72.2	155	2248	10364
Filtered Process Water Output	n.a.	n.a.	n.a.	n.a.
Field Blank				

NOTE: n.a. = not available

TABLE 3. DATA RESULTS FOR SIEVING THE RAW UNWASHED CHAT

Collected by The Oklahoma Department of Environmental Quality on November 23, 1999 and sieved on December 21, 1999.

ATLAS RAW CHAT PILE (ATRC)

				TOTAL METALS			TCLP	
SIEVE SIZE/NUMBER	**% PASSING**	**% RETAINED**	**RETENTION SIZE**	**LEAD**	**CADMIUM**	**ZINC**	**LEAD**	**CADMIUM**
				(mg/kg)	(mg/kg)	(mg/kg)	(mg/l)	(mg/l)
1/2 INCH SIEVE (medium size gravel)	100.0	0.0	0.500 inch (12.70 mm)	NA	NA	NA	NA	NA
3/8 INCH SIEVE (medium size gravel)	99.9	0.1	0.375 inch (9.53 mm)	NA	NA	NA	NA	NA
ATRC-4 (fine size gravel)	80.4	19.5	0.187 inch (4.75 mm)	25	ND	251	1.241	0.113
ATRC-10 (very coarse sand or very fine gravel)	52.7	27.7	0.079 inch (2.00 mm)	47	7	2,738	1.418	0.184
ATRC-40 (medium size sand)	22.6	30.1	0.017 inch (420 um)	198 [225]	41 [32]	7892 [520]	1.812 [1.700]	0.251 [0.252]
ATRC-80 (fine size sand)	14.3	8.3	0.007 inch (177 um)	324	61	11,110	2.082	0.391
ATRC-200 (clay size particles)	7.4	6.9	0.003 inch (75 um)	671	82	14,772	3.212	0.646
ATRC-PAN (clay size particles)		7.4		1789	128	24840	15.57	1.625

NOTES:

NA = Data not available to run test
ND = Non-detect
Data was collected on November 23, 1999
Data was sieved on December 21, 1999
Duplicate run on ATRC-40 with result in [ ]
ATRC means Atlas Raw Chat
The total for arsenic was also run and was less than the detection limit of 40 mg/kg.
TCLP = Toxicity Characteristic Leaching Procedure

TABLE 3 CONTINUED. DATA RESULTS FOR SIEVING OF THE RAW UNWASHED CHAT

Collected by The Oklahoma Department of Environmental Quality on November 23, 1999 and sieved on December 21, 1999.

OTTAWA RAW CHAT PILE (OTRC)

				TOTAL METALS			TCLP	
SIEVE SIZE/NUMBER	**% PASSING**	**% RETAINED**	**RETENTION SIZE**	**LEAD**	**CADMIUM**	**ZINC**	**LEAD**	**CADMIUM**
				(mg/kg)	(mg/kg)	(mg/kg)	(mg/l)	(mg/l)
1/2 INCH SIEVE (medium size gravel)	100	0.0	0.500 inch (12.70 mm)	NA	NA	NA	NA	NA
3/8 INCH SIEVE (medium size gravel)	99.9	0.1	0.375 inch (9.53 mm)	NA	NA	NA	NA	NA
OTRC-4 (fine size gravel)	82.0	17.9	0.187 inch (4.75 mm)	70	2	260	2.8720	0.130
OTRC-10 (very coarse sand or very fine gravel)	50.1	31.9	0.079 inch (2.00 mm)	238	303	47,940	2.8730	0.308
OTRC-40 (medium size sand)	18.7	31.4	0.017 inch (420 um)	319	25	4,580	4.5550	0.360
OTRC-80 (fine size sand)	10.3	8.4	0.007 inch (177 um)	884	54	9,738	16.7400	0.965
OTRC-200 (clay size particles)	5.6	4.7	0.003 inch (75 um)	2,704	100	20,340	34.5500	1.726
OTRC-PAN (clay size particles)		5.6		6,668	170	39,780	116.5600	4.444

NOTES:

NA = No data to run test
Data was collected on November 23, 1999
Data was sieved on December 21, 1999
OTRC means Ottawa Raw Chat
The total for arsenic was also run and was less than the detection limit of 40 mg/kg.
TCLP = Toxicity Characteristic Leaching Procedure

TABLE 4. TESTING OF ASPHALT REMOVED FROM THE WILL ROGERS TURNPIKE LOCATED NEAR QUAPAW OKLAHOMA Asphalt contained mining waste (chat) of unknown levels for metals. Collected on February 25, 2000					
	TOTALS			TCLP	
LOCATION	LEAD	CADMIUM	ZINC	LEAD	CADMIUM
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/l)	(mg/l)
BAPNORTH-1	158	17	2,718	0.065	0.013
BAPMIDDLE-1	141	15	1,761	< 0.050	0.009
BAPSOUTH-1	179	35	5,104	0.067	0.011
DAPNORTH-1	2,228	12	1,934	0.155	0.014
DAPMIDDLE-1	168	18	2,594	0.166	0.006
DAPMIDDLE-2 (DUPLICATE OF 1)	160	17	2,708	0.115	0.005
DAPSOUTH-1	252	20	2,808	0.221	0.015

BAP = BATTIE ASPHALT PILE
DAP = DEHORN ASPHALT PILE
TCLP = Toxicity Characteristic Leaching Procedure