Proceedings of the Annual International Conference on Soils, Sediments, Water and Energy

Volume 11 Article 22

January 2010

Use Of A Bench-Scale Treatability Study To Determine Cost-Effective Disposal Methods For Contaminated Sediments

M.T Balba
CONESTOGA-ROVERS & ASSOCIATES

S. Dore
CONESTOGA-ROVERS & ASSOCIATES

D. Pope
CONESTOGA-ROVERS & ASSOCIATES

J. Smith
CONESTOGA-ROVERS & ASSOCIATES

A.F. Weston
CONESTOGA-ROVERS & ASSOCIATES

Chapter 21

USE OF A BENCH-SCALE TREATABILITY STUDY TO DETERMINE COST-EFFECTIVE DISPOSAL METHODS FOR CONTAMINATED SEDIMENTS

M.T Balba, S. Dore, D. Pope, J. Smith, and A.F. Weston
CONESTOGA-ROVERS & ASSOCIATES

Abstract: Cost-effective disposal is a major concern for sediment remediation projects that require removal of sediments. To meet landfill criteria sediments must pass tests for hazardous waste content, hazardous waste leachability and residual moisture content. Knowledge of these parameters is essential before the cost of the remediation can be estimated. CRA has developed a laboratory treatability study procedure to obtain the required information rapidly. An example of the application of this procedure is a treatability study that was conducted on heavy metal contaminated dredged sediment from a site in Michigan

Three sediment samples were obtained and composited to form a sample that would be representative of site conditions. To be acceptable for disposal at a non-hazardous waste landfill the sediment samples must pass TCLP, stability criteria, and the paint filter test. Sediment leachate data showed that the sediment met only TCLP criteria, therefore stabilization was necessary. Ten polymers were evaluated for their effect on solids settling. A sediment slurry was settled with and without polymer treatment and the supernatant and settled solids were collected. A filter press was used to dewater the settled solids to produce a filter cake, which was tested for water content, TCLP metals, and the paint filter test. The effects of solidification agents on the settled solids were also evaluated. The agents tested were Portland cement, fly ash, and cement kiln dust. The results showed that untreated settled solids did not meet landfill stability requirements. The ability of polymer treatment, solidification and filter cake from dewatering using a filter press to meet the landfill stability requirements will be described. Based on the results of the treatability study a cost-effective technique for sediment treatment and disposal was determined.

Key words: Treatability study; sediments; heavy metals; disposal method; contamination

1. INTRODUCTION

In Michigan, lake sediment was contaminated with heavy metals such as arsenic, cadmium, chromium, lead and mercury. It was determined that the sediment would be dredged and safely disposed of in a landfill. A treatability study was conducted to determine a cost-effective disposal method for the dredged sediment.

2. MATERIALS AND METHODS

2.1 Task #1 Sample Characterization

One water sample and three sediment samples were obtained. In order to form a representative sample, a composite was formed from the three sediment samples. The tests performed on the composite include:

Target Analyte List (TAL) metals (SW-846 Method 6010B/747 IA);

- TCLP Metals;
- Water content (USEPA 160.3);
- Grain-size distribution (from Sieve Analysis, ASTM D422);
- Grain-size distribution for finer fraction (from Hydrometer Analysis, ASTM Dl 140);
- Paint Filter Test; and
- Visual observation during sample collection.

The water sample was analyzed for:

- Turbidity (USEPA 180.1);
- TOC;
- TAL metals (USEPA 200.7/245.1); and
- Visual observation during sample collection.

2.2 Task #2 Polymer addition

After sample characterization, polymers were added to observe the effect of polymer treatment on the settling of the solids. Ten polymers were evaluated at the recommended dose rates.

2.3 Task #3 Column Settling

A column settling test was conducted on the sediment slurry. Supernatant was collected at 2, 8, and 24 hours. The height of the sediment-water interface was recorded. Percent moisture of the settled solids and metal content were also analyzed.

2.4 Task #4 Filter press efficiency

The efficiency of using a filter press to dewater the solids was evaluated. Sediments that are hydraulically dredged require mechanical dewatering and polymer conditioning. A bench scale filter press apparatus was used for solid dewater. The sediment was pressed in a circular mold between two plates for 45 minutes, producing a filter cake.

The filter cake samples were tested for:

- Water content (USEPA 160.3);
- TCLP metals; and
- Paint Filter Test.

The dewatering filtrate was tested for:

- TSS (USEPA 160.2);
- Visual observation during sample collection; and
- Total Metals.

2.5 Task #5 Evaluation Solidification Agents on Raw Slurries and Filter Cake

Solidification and stabilization tests were conducted on the sediment slurries. The reagents used were Portland cement, fly ash and cement kiln dust.

The following treatments were tested:

i). 2.5% Portland Cement
ii). 5% Portland Cement
iii). 2.5% Portland Cement and 2.5% Fly Ash
iv). 2.5% Fly Ash and 2.5% Cement Kiln Dust
v). Control (no additions)

2.6 Task #6 Evaluation of Treatment Requirements for Water

Water discharged from settling tanks or filter press treatments must meet the NPDES permit limits. The total metal data from the initial water sample, supernatant, and filtrate will be examined and compared to the expected NPDES permit limits.

3. RESULTS

3.1 Task #1 Sample Characterization

Soil analysis indicated that the soil contained arsenic, cadmium, chromium, lead and mercury. The highest concentration was chromium present at 9700 mg/kg. Hexavalent chromium was not detected in the samples. Chromium was the only metal detected in the water sample at a concentration of 0.0057 mg/L. Hexavalent chromium was not detected. The water sample was clear with no measurable turbidity.

The analysis of grain size indicated that the sediment samples consisted of mainly sand and silt with very little gravel or clay. Tables 1 and 2 show the results of the sample characterizations.

Table 1. Initial Characterization of Sediment

	Composite Sediment	**Landfill Acceptance Levels**
Water Content (%)	79.2	
Total Metals (mg/kg)		
Arsenic	9.4	
Cadmium	6.4	
Chromium	9700	
Lead	115	
Mercury	0.86	
Hexavalent chromium	ND	
TCLP (mg/L)		

	Composite Sediment	Landfill Acceptance Levels
Arsenic	ND	5
Cadmium	0.011	1
Chromium	0.63	5
Lead	ND	5
Mercury	ND	0.2
Grain Size Distribution (%)		
Gravel	0.4	
Sand	54.4	
Silt	43.8	
Clay	1.4	
Paint filter test (pass/fail)	fail	

Table 2. Initial Characterization of Water

	Concentration
Total Metals (mg/L)	
Arsenic	ND
Cadmium	ND
Chromium	0.0057
Lead	ND
Mercury	ND
Hexavalent chromium	ND
Total Organic Carbon (mg/L)	3
Turbidity (NTU)	ND

3.2 Task #2 Polymer Addition

The settling test indicated that the addition of the polymers produced a clear supernatant, but did not enhance the settling of the sediment after the treatment therefore treatment with the polymer was discontinued.

3.3 Task #3 Column Settling

The sediment-water interface increased after two, eight, and twenty-four hours. After twenty-four hours, sediment settling was not observed.

Metals analysis results for the supernatant water and TCLP analysis results for the settled solids indicated that chromium was the only metal detected in the supernatant water at a level of 0.18 mg/L. Cadmium was the only metal detected in the leachate from the settled solids at a level of 0.011 mg/L. This value is below the allowable cadmium leachate value for landfill acceptance. The column settling results appear in Table3.

Table 3. Column Settling Test

Time Parameter	2 hours	8 hours	24 hours	Landfill acceptance levels
Distance of sediment-water interface from column top (mm)	8	22	48	
Turbidity of supernatant (NTU)	1080	720	122	
Metals in Supernatant (mg/L)				
Arsenic	---	---	ND	
Cadmium	---	---	ND	
Chromium	---	---	0.18	
Lead	---	---	ND	
Mercury	---	---	ND	
TCLP Metals for Settled Solids (mg/L)				
Arsenic	---	---	ND	5
Cadmium	---	---	0.011	1
Chromium	---	---	ND	5
Lead	---	---	ND	5
Mercury	---	---	ND	0.2

3.4 Task #4 Filter Press Efficiency

The pressing process produced a solid free-standing filter cake. The filter papers that had been used to press the cake released cleanly. The filter press results appear in Table 4.

Table 4. Filter Press Test

Parameter	Sample	Landfill Acceptance Levels
Filter cake water content (%)	53.1	
Paint filter test on cake	pass	
Unconfined compressive strength of cake (psi)	5	
Total suspended solids in filtrate (mg/L)	110	
Metals in filtrate (mg/L)		
Arsenic	ND	
Cadmium	0.00079	
Chromium	0.48	
Lead	ND	
Mercury	ND	
TCLP metals for filter cake (mg/L)		
Arsenic	ND	5
Cadmium	0.025	1
Chromium	ND	5
Lead	ND	5
Mercury	ND	0.2

The water content of the filter cake was 53.1%. The cake passed the paint filter test and had an unconfined compressive strength of 5 psi. TCLP results indicated that cadmium was the only metal detected in the leachate from the filter cake at a level of 0.025 mg/L, which is well below the level required for landfill acceptance.

The dewatering filtrate was a clear straw-colored liquid. TSS and total metals results indicated that cadmium and chromium were detected in the filtrate water.

3.5 Task #5 Evaluation of Solidification Agents on Raw Slurries and Filter cake

The effect of the solidification agent was conducted on the on the raw slurries only since the filter cakes passed the paint filter test. The treatments set up were 10% PC, 15%PC, 20%PC, 5%PC-5%CKD, 7.5%PC-7.5% CKD, and 10%PC-10% CKD. The samples cured for 28 days and were monitored using a pocket penetrometer.

After curing, the samples were tested for unconfined comprehensive strength, total metals, and TCLP metals. The results of the penetrometer readings appear in Table 5.

Table 5. Solidification Tests-pocket penetrometer readings

Parameter	**control**	**10% PC**	**15% PC**	**20% PC**	**5%PC 5% CKD**	**7.5%PC 7.5%CKD**	**10%PC 10% CKD**
Penetrometer reading (psi)	<0.22	0.43	0.87	2.4	0.43	2.3	3.9

3.6 Task #6 Evaluation of Treatment Requirements for Water

The original water sample and all water generated by the treatments in this study met the NPDES permit limits.

The samples contained chromium, but there is no permit level for chromium.

The pH of the supernatant and the filter press filtrate were above 7.0, which is acceptable.

4. DISCUSSION

Initial analysis indicated that the metal content of the sediment samples did not leach at levels that exceed the landfill acceptance criteria, so the stability requirement will determine whether the sediments can be accepted at a landfill. The stability requirement is 150 pounds per square foot (1.04psi). The addition of polymers did not assist in the stability of the sediments.

Settlings of the sediments removed some of the water, but since the sediment consisted mostly of silt, significant dewatering through settling alone was not attainable. Filter press treatment of the settled solids would achieve landfill stability acceptance criteria. The filter cakes had an unconfined stability of 5 psi, which is acceptable.

Based on results from the original water and the water generated from the treatments, the water does not need treatment to meet the NPDES permit limits.

Stabilization of the sediment using stabilizing agents is more cost effective than filter press treatments. The 7.5% Portland cement and 7.5.5 cement kiln dust allowed the sediment to meet landfill requirements.

5. CONCLUSIONS

- Leaching of metals from the sediment was not a concern;
- Polymer treatment was not effective;
- Untreated settled solids did not meet landfill stability requirements;
- Filter press treated yielded a filter cake that met landfill stability criteria;
- Solidification using Portland cement and cement kiln dust was more cost effective than filter press treatment; and
- All treated waters met expected NPDES requirements, therefore no further was required treatment.