GREAT LAKES ACTION PLAN

Great Lakes Environment Office
Environment Canada
Ontario Region

CLEANUP FUND FACT SHEET

CONTAMINATED SEDIMENT TREATMENT TECHNOLOGY DEMONSTRATION SERIES

NUMBER 4

ARC/EPRI Clean Soil Process Bench Scale Demonstration

Contaminated Sediment Treatment Technology Program

The Great Lakes Cleanup Fund is a $55 million component of the Federal Great Lakes Action Plan. Started in 1991, the Cleanup Fund focuses on the development and implementation of cleanup technologies for contaminated sediments, urban runoff and rehabilitation of fish and wildlife habitats. The Cleanup Fund also focuses on Canada's 17 Areas of Concern identified by the International Joint Commission for priority clean-up

The Contaminated Sediment Treatment Technology Program (COSTTEP) was set up to demonstrate new and innovative technologies for treating contaminated sediments. It is also COSTTEP's mandate to communicate results of demonstrations to the Canada/Ontario Remedial Action Plan (RAP) teams and other agencies involved in RAP implementation. The initial focus of the contaminated sediment treatment program has been on demonstrating technologies at laboratory or bench scale. Future priorities will centre on pilot and full scale demonstrations.

This series of Fact Sheets is intended to summarize the demonstration work of COSTTEP. Fact Sheet Number 1 gives an overview of the Great Lakes Cleanup Fund, COSTTEP and the sediment contamination problems in the Great Lakes. All other Fact Sheets are specific to a technology demonstration project. Fact Sheets are available from Environment Canada's Great Lakes Environment Office, Toronto, Ontario.

Clean Soil Process

The Alberta Research Council (ARC) and the United States Electric Power Research Institute (EPRI) developed the Clean Soil Process from a coal cleaning technology based on the principle of coal agglomeration. In coal agglomeration, oil added to a slurry of coal and soil fines preferentially wets the coal fines. When mixed, the coal particles contact one another and the oil forms "bridges" between the coal particles, creating coal agglomerates which are readily separated from the mixture.

The Clean Soil Process takes advantage of the preference of organic contaminants to bond to coal rather than mineral matter (soil/sediment particles). The hydrocarbons/contaminants can be equated to the oil and the coal or other similar non-extractable organics to the coal in the coal agglomeration technology. The process is shown schematically in *figure 1*. The two main unit processes are the mixing/cleaning and separation steps.

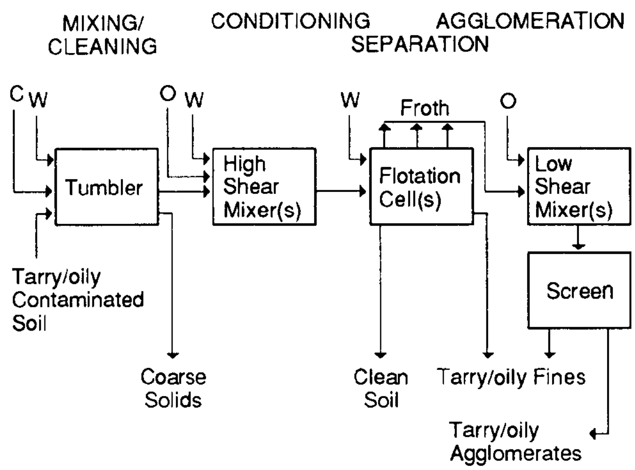

FIGURE 1: Block diagram of the pilot scale process.

In mixing/cleaning, a slurry of screened soil and fine coal is vigorously agitated in order to scrub contaminants from the soil particles and transfer them to the coal. Heat may be applied to the slurry to enhance the transfer process. Note that coal addition may not be necessary as the natural content of coal or similar organic matter within the soil matrix may be sufficient to bind all the hydrocarbons associated with the soil.

After the mixing/cleaning step, froth flotation is used to separate the contaminated coal and clean soil particles. Conditioning additives are used to enhance the separation. The underflow (tailings) and overflow from the flotation unit are a slurry of "clean" soil and a froth of

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contaminated coal respectively. The coal froth may be agglomerated and dried, potentially for use as fuel. Depending on the planned end-use, the "clean" soil may require post-treatment, such as thermal desorption, to reduce residual contamination further.

The parameters that determine process performance are slurry concentration, mixing intensity, residence time, cleaning temperature, coal addition and froth collector addition. The latter three are closely associated with the composition of the contaminated material and require investigation in each case. The process performance is measured by the recovery of solids as tailings and the level of contamination of these tailings.

The principal benefit of the process is a reduction of the volume and mass of contaminated material requiring treatment for a relatively low cost.

Many batch bench-scale tests have been conducted using a variety of soils. The process has also been tested with soils using a 250 kg/hr pilot plant.

Bench Scale Demonstration Project

The bench scale study was performed at the ARC facilities in Devon, Alberta using sediments from Hamilton Harbour. The study consisted of comprehensive sediment characterization (physical and chemical) followed by treatability tests.

This bench scale test represented the first application of the Clean Soil Process to the very fine solids generally associated with sediments. Because of the novel application, process optimization was not performed as part of the study.

The sediment was separated into a number of size fractions and characterized for a set of parameters used by ARC to determine initial processing parameters, efficiency and minimum health and safety measures. These parameters included the volatility of the sediment contamination and the quantity of non-extractable organics. In addition the list of USEPA priority polynuclear aromatic hydrocarbons (PAHs) and heavy metals were determined for the bulk sediment. The PAHs were considered as the contaminant of concern for the Hamilton Harbour sediment.

The treatability testing involved three batch processes - mixing/cleaning with the addition of a variety of conditioning materials, flotation and thermal desorption. Three experimental process trains were tested. The first involved a single conditioning and flotation step, the second, sequential conditioning and flotation steps and the third included thermal desorption of the tailings as shown in *figure 2*.

The analyses associated with each experiment performed are presented in *table 1*.

Results and Discussion

The characterization testing indicated that "large" organic material retained on a screen with a 150 micron mesh was highly contaminated with oil and grease. Although 85% of the sediment passed such a screen, approximately 30% of the oil and grease in the sediment was retained. The screen could be used as a cheap, simple technique to reduce the cost of following processes. Note that the finer fraction was also associated with higher metals concentrations which may potentially off-set any advantage gained by screening.

The recovery of solids in the tailings and the residual concentrations of contaminants in the tailings are presented in *table 1*.

The non-extractable organics content of the sample suggested that the indigenous "coal" content was sufficient for "coal cleaning." This was confirmed in the treatability testing. No benefit was realized by adding ground coal to the Hamilton Harbour sediment sample.

In the initial experiments *(table 1, runs 1 to 9)*, the sediment remaining in suspension (neither floated nor settled) was significant and undesirable. The net effect of this was to create a third process stream - high solids contaminated water.

The experimental process was redesigned to emphasize the flotation step (as opposed to the mixing/cleaning). As shown in *figure 2* two varieties of conditioners/ promoters were applied in series, targeting organic matter and metals respectively. The concentration of solids remaining in suspension was substantially reduced and the tailings yield was increased significantly.

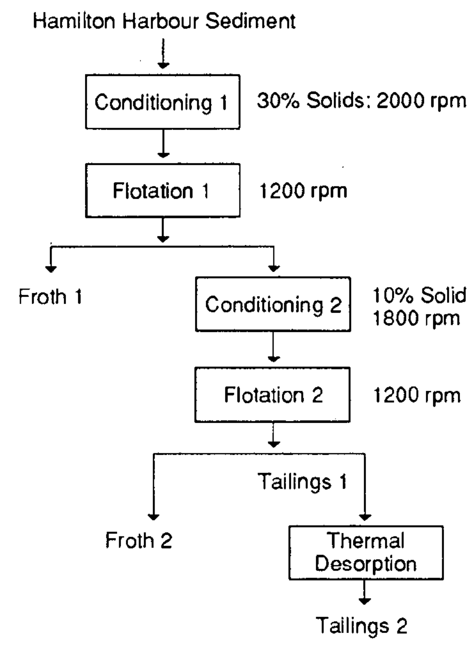

FIGURE 2: Redesigned experimental process.

Although the PAH concentration associated with the tailings was significantly decreased by floatation, the concentration of PAHs remained unacceptably high. Thermal desorption was demonstrated to readily reduce these levels to close to non-detect limits.

Conclusions

In their final report ARC staff made the following conclusion and recommendations:

1. The ARC/EPRI Clean Soil Process technology is technically capable of treating sediments to remove contaminating hydrocarbons and macro-organics;
2. Hamilton Harbour sediment may be treated for organic contamination (including PAHs) as well as sulfur and nitrogen bearing compounds by floatation; and,
3. Depending upon the residual concentration of PAHs in the tailings and the proposed end use for the tailings, floatation may be followed by thermal desorption.

As the auditing agency for the project, the WTC also had conclusions about the project. In summary these are:

1. The ARC conclusions were valid;
2. The ARC staff were very knowledgeable of the factors most pertinent to the treatment of contaminated sediment using the ARC/EPRI Clean Soil Process. All work was performed professionally and according to specifications; and,
3. The ARC/EPRI Clean Soil Process has shown the potential for application to Hamilton Harbour sediment. Depending upon the economics of the process, it could be implemented as a first step in an overall sediment clean-up process.

Future Directions

ARC, EPRI and their industrial clients are interested in demonstrating the Clean Soil Process at pilot-scale for treatment of Hamilton Harbour Sediment.

The ARC/EPRI Clean Soil Process will be rated against all other technologies demonstrated in COSTTEP and those demonstrated by other programs such as the U.S. Assessment and Remediation of Contaminated Sediments (ARCS) Program at the conclusion of the demonstration phase. This rating will be published in the final report expected in 1995.

More Information

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TABLE 1: Demonstration and analytical program and results

Run #	Coal Addition[1]	Percentage of Initial Solids Cleaned[2] (%)	Tailings Concentrations[3] (dry wt. basis)		Experimental Process[4]
			O&G (%)	PAH (ppm)	
1	H	19[5]	0.34	NA	A
2	H	33[5]	0.40	NA	A
3	H	20[5]	0.36	NA	A
4	L	42[5]	0.91	NA	A
5	0	25	0.46	NA	A
6	0	22	0.39	NA	A
7	0	16	0.25	NA	A
8	0	9	0.31	NA	A
9	0	21	0.36	NA	A
10	0	52.5	1.47	NA	B
11	0	49.7	1.38	NA	B
12	0	51.3	1.49	NA	B
13[6]	0	50.0	1.45	819	B
13[6] (200)	NA	NA	0.555[7]	NA	NA
13[6] (250)	NA	NA	0.014[7]	1.9[7]	NA
13[6] (300)	NA	NA	0.016[7]	NA	NA

1. H – High; L– Low; 0 – Zero
2. Percentage of initial solids recovered in the tailings, the "clean" product of the process
3. O&G – Toluene extractables; PAHs – Sum of the concentrations of the USEPA 16 priority PAHs
4. As per figure 1 (A) or figure 2 (B)
5. Assumes all added coal recovered in the froth
6. Composited from 5 experiments under identical conditions. Samples were split with the Wastewater Technology Centre for analysis (O&G, 16 PAHs, 17 metal scan)
7. After the tailings from experiment 13 had been thermally desorbed at the temperature indicated in the brackets (degrees Celsius) for 10 minutes

NA Not applicable

Note: The initial Hamilton Harbour sediment had a total PAH concentration of 4009 ppm and O&G concentration of 3.55%, dry basis.