GREAT LAKES ACTION PLAN

Great Lakes Environment Office
Environment Canada
Ontario Region

CLEANUP FUND
FACT SHEET

CONTAMINATED SEDIMENT TREATMENT TECHNOLOGY DEMONSTRATION SERIES

NUMBER 1

Contaminated Sediment Treatment Technology Program Overview

Summary

Environment Canada's Great Lakes Cleanup Fund, one component of the federal Great Lakes Action Plan was initiated in 1991. The program focuses on Canada's 17 Areas of Concern identified by the International Joint Commission. The Cleanup Fund is designed to help meet federal commitments in the development and implementation of cleanup options. One priority of the program is to develop and demonstrate new and innovative technology on the safe removal and treatment of contaminated sediments. To evaluate sediment treatment technologies the Contaminated Sediment Treatment Technology Program (COSTTEP) was initiated.

The mandate of COSTTEP is to foster the development and demonstration of technologies to remediate contaminated sediment and to communicate the results of the program to persons involved with Great Lakes remediation projects. Funds are provided to COSTTEP by the Cleanup Fund and are used to sponsor technology demonstration projects. Any technology is eligible for funding provided it has excellent technical merit, is innovative and has the potential to treat Great Lakes sediment in a cost-effective manner.

The program has three levels of projects which it will fund: bench scale, pilot scale and full scale. In general the program is to progress from bench through to pilot and then full scale projects. The program has been advertised nationally and internationally resulting in a very large response from technology developers and vendors. A database of technologies has been created based on the initial data submitted by these firms.

Background

The 1972 Great Lakes Water Quality Agreement signed by the United States and Canada commits both countries to cleaning up the Great Lakes by controlling point and non-point sources of pollution and by remediating those areas with in-place pollutants. The two countries have identified 42 Areas of Concern (AOCs) which are either badly polluted or are major sources of pollution. Seventeen of these AOCs are on the Canadian side of the Great Lakes. For each of these seventeen areas the Canadian Government and the government of the Province of Ontario under the Canada-Ontario Agreement have initiated a Remedial Action Plan (RAP) process to deal with the site-specific problems. Each RAP is being prepared in consultation with local government officials, industry representatives and citizens. Most of the RAP Teams have now completed Stage One of the process which is to *assess* their AOC. With a completed assessment document the RAP Team will know where the pollution problems are and what level of cleanup is necessary to provide the desired environmental recovery.

The RAP Teams are now moving into Stage Two of the process which is to *investigate remedial options*. Stage Three will be to actually implement the action plan. To assist RAP Teams with the Stage Two evaluation process the Great Lakes Environment Office of Environment Canada has channelled the current funds from the Cleanup Fund into a number of technology and cleanup strategy assessment programs. The programs are being carried out in partnership with the Province of Ontario, industry and municipal governments.

Approximately one-third of the Cleanup Fund budget is being directed towards contaminated sediment remediation. There are two reasons why the cleaning of sediments has been given such a high priority. The first is that pollutants in the sediment are absorbed into or ingested by organisms and plants which live in or on sediment. These benthic organisms are either directly impaired (killed by toxic effects, deformed at birth, caused to develop cancer) or pass the toxins up through the food chain (bioaccumulation, biomagnification) where toxic effects can show up at the higher trophic levels including humans. The second reason sediment remediation is a priority is that sediments have now been identified as a major *source* of pollution to the water column above. During past years of heavy industrial and municipal pollution, sediments absorbed a great deal of pollution from the water column. Now, however, industrial and municipal discharges have been greatly reduced so that the water is generally cleaner than the sediment in a relative sense. Thus the pollutants stored in the sediments are now diffusing back into the water. This is a major obstacle to improving Great Lakes water quality since it could take hundreds of years for all of the pollutants to diffuse out of the sediment.

Great Lakes Cleanup Fund Sediment Programs

In 1990, when the Cleanup Fund was initiated, three distinct sediment programs were created. The three programs created are the Contaminated Sediment *Removal* Technology Program, the Contaminated Sediment *Treatment* Technology Program and the Contaminated Sediment *Assessment* Program. Projects initiated deal with innovative dredging technologies, specialized bioassays of treated and untreated sediment, enhanced natural sediment remediation processes, chemical treatment of in place sediments, physical barriers to pollutant diffusion from sediment and a variety of others. This Fact Sheet describes the Contaminated Sediment Treatment Technology Program (COSTTEP). For more information on the other programs and projects contact Environment Canada, Great Lakes Environment Office, Toronto, Ontario.

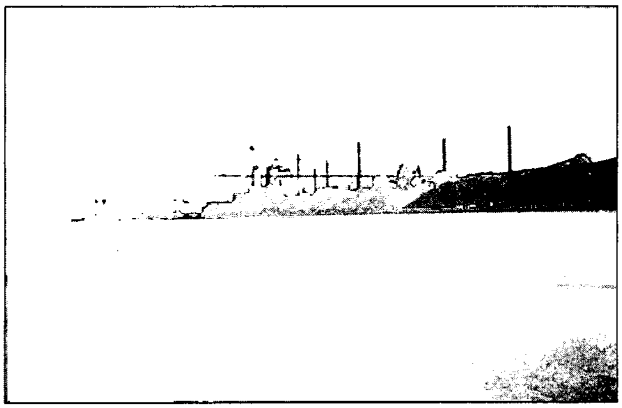

FIGURE 1: View of Hamilton Harbour. This harbour has one of the most serious sediment contamination problems of all Canadian AOCs.

Mandate and Coordination of the Contaminated Sediment Treatment Technology Program

The Great Lakes Environment Office has contracted with the Wastewater Technology Centre to administer COSTTEP. The Wastewater Technology Centre (WTC) is a federal government owned, privately operated institution dedicated to developing and commercializing promising technologies for wastewater treatment and environmental protection.

The principle mandate of COSTTEP is to encourage the development of new technologies to remediate contaminated sediment by funding the demonstration of selected technologies at bench, pilot and full scale. The program will move from bench scale demonstrations in the first two years to pilot scale demonstrations to full scale demonstrations. A full scale demonstration would not necessarily clean up an entire sediment "hotspot", but would process enough sediment to prove that the technology is technically and economically viable. To fund these demonstrations the program has been allocated a total budget of almost six million dollars. The projected year by year budget for the first four years of the program is shown in *Table 1*.

TABLE 1
Program Budget

FISCAL YEAR	PROGRAM STORAGE	BUDGET (000s)
1990/91	Bench scale	$ 450
1991/92	Bench/Pilot	$1300
1992/93	Bench/Pilot/Full	$2100
1993/94	Full scale	$2100
TOTAL		**$5950**

The second part of the program's mandate is to communicate the nature of the program and the results of demonstrations to as wide an audience as possible with particular attention to the RAP groups and the environmental authorities of the U.S.A. To address this part of the mandate a number of actions have been initiated.

The program was widely advertised in the fall of 1990 in Canadian and international publications. A very large number of technology "vendors" responded and the technologies were evaluated. Some of these technologies have now been funded under the program. All of the technologies meeting the minimum criteria have now been entered into a computerized database. This is currently one of the only such databases in North America. The database is available to anyone for a moderate fee.

The program is also communicating through a number of other channels. This Fact Sheet is one channel. A Fact Sheet will be produced for each funded demonstration. Copies of the final reports of funded projects will also be available. Program staff also actively participate in a number of key committees including the U.S. Assessment and Remediation of Contaminated Sediment Committee, several site specific cleanup committees and the Remedial Action Plan Program Sediment Subcommittee. A slide presentation has been prepared and has been given at a number of conferences and RAP workshops. The program will also host a series of workshops on sediment treatment technologies.

Selection for Funding Under COSTTEP

To be considered for funding under COSTTEP, technologies must meet certain criteria: The technology must either remove, segregate or destroy contaminants in sediment or the pore water associated with wet sediment; must have at least one innovative feature; must be at least at the bench scale stage (ie. the program will not fund research leading to technology creation); and, must appear to be economically feasible.

To be *selected* for funding a technology must be rated superior to other technologies in the same category. The criteria used to evaluate technologies are:

CONTAMINATED SEDIMENT TREATMENT TECHNOLOGY DEMONSTRATION SERIES

NUMBER 5

Ecologic Waste Destructor Pilot 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.

EcoLogic Technology

EcoLogic, a Canadian company based in Rockwood, Ontario, was formed in 1986 to develop a means to safely and economically destroy hazardous wastes. Using chemical theory that, at elevated temperatures hydrogen in the gas phase reacts with organic molecules to produce smaller, lighter and less toxic molecules, EcoLogic developed the EcoLogic Waste Destructor (the Destructor). The technology is designed to have very high destruction efficiencies; to have no production of dioxins or furans; to have continuous monitoring and process control; to be suitable for aqueous wastes; to be mobile; and to be moderately priced.

A simplified process schematic is displayed in *Figure 1.* Waste, diluted with water or solvents if too viscous to be pumped, is preheated (to 150 °C) and then injected into the reactor vessel through atomizing nozzles. Hydrogen gas and nitrogen gas are also injected into the reactor. Nitrogen is needed to purge the unit of all oxygen.

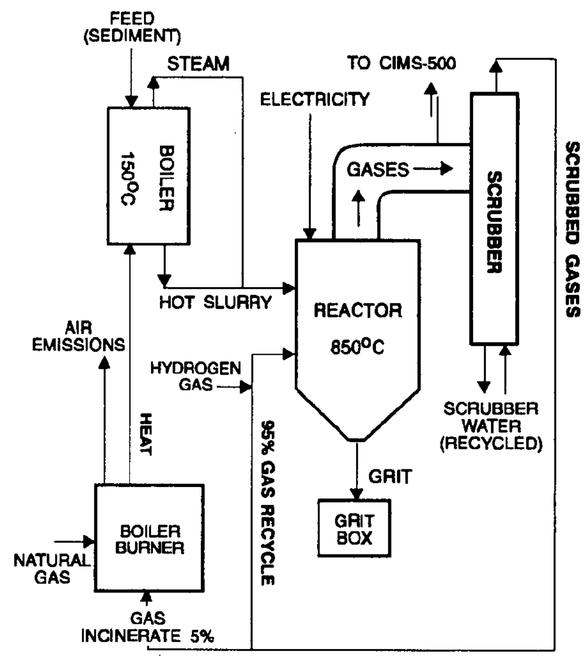

FIGURE 1: EcoLogic destructor schematic.

Recirculating off-gases are also re-injected into the reactor. The waste and gases "swirl" through the reactor until they exit at the bottom. The waste stream within the reactor is kept above 850 °C by "Glo Bar" heaters. Solids exit downwards and are captured in a quenching tank. Gases rise up through the central ceramic tube where further reduction reactions occur. The gases then exit through the top of the reactor and enter the scrubber unit where they are quenched with water and scrubbed with carbon steel and polypropylene filter material. The scrubbed gas, containing very light hydrocarbons, is recirculated except for roughly 5% which is diverted to the boiler burner and used as a supplementary fuel. Scrubber water is recirculated until it is too 'dirty' for use. The process gas is continuously monitored for ten chemicals in near real time by sampling just prior to the gas scrubber and analyzing the sample with an on-line chemical ionization mass spectrometer (CIMS-500).

Pilot Scale Demonstration Background

The EcoLogic demonstration followed the successful completion of a bench scale demonstration for the COSTTEP (see Fact Sheet No. 2). It was the first pilot scale project completed under the COSTTEP and the first pilot demonstration of the EcoLogic unit anywhere. Financing was shared by the COSTTEP, the Ontario Ministry of the Environment and EcoLogic.

Hamilton Harbour, Ontario was chosen for the demonstration location. Approximately 12 m^3 of contaminated sediment was removed from the Harbour floor using a CABLE-ARM modified clamshell bucket. The primary organic contaminants of concern within the sediment were considered to be polynuclear aromatic hydrocarbons (PAHs).

Pilot Scale Demonstration Project

The pilot scale EcoLogic unit was set up and commissioned on Hamilton Harbour Commission property adjacent to one of the most contaminated parts of the Harbour and tested over a period of 5 months from April to August, 1991. The unit is shown in *figure 2.*

The unit was set up on two 15 m drop deck trailers, and a third trailer contained the process control systems and other analysis equipment. Also located on site were propane and nitrogen gas tanks, a diesel generator, a water tank and a hydrogen gas supply.

EcoLogic divided the overall testing program into twelve short "characterization" runs and three "performance" runs. The conditions and selected results for the demonstration program are summarized in *table 1.*

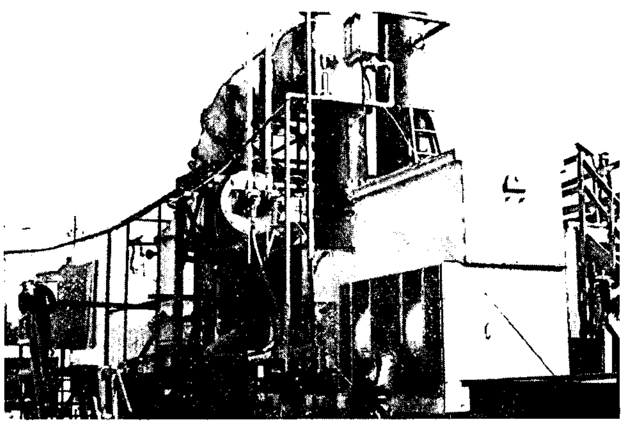

FIGURE 2: Photograph of the pilot unit.

The characterization runs enabled the EcoLogic personnel to gain experience in operating the equipment, allowed process problems to be identified (and if possible corrected) and allowed process parameters to by optimized for the sediment sample.

The performance runs were undertaken to demonstrate the ability of the EcoLogic unit to run for extended periods of time and to measure a wider range of emissions for longer periods of time. In addition, a single performance run was run with a sediment sample spiked to 110 ppm polychlorinated biphenyls (PCBs).

Personnel from the Wastewater Technology Centre (WTC) audited all characterization and performance tests. Split samples were taken for analysis by the WTC laboratories for some runs, as indicated in *table 1.*

Results and Discussion

The pilot scale project was very successful, demonstrating EcoLogic's ability to coordinate the various phases of a pilot scale demonstration, providing confirmation that the EcoLogic Waste Destructor will successfully destroy hazardous organics and yielding useful information to further refine the Destructor.

Although the EcoLogic Waste Destructor is promoted as an alternative to incineration for PCB destruction, the primary organic contaminant of concern for this demonstration was PAHs. The Hamilton Harbour sediment is a difficult matrix to process with a heat based process as the concentration of heavy ringed hydrocarbons is high, and upon heating tends to break down creating lighter compounds such as PAHs. Nevertheless the Destructor proved to be successful in destroying PAHs (and PCBs in performance run 3). A destruction and removal efficiency (DRE) of better than 99.9% was achieved for total PAH destruction assuming that the initial PAH concentration was equal to the sum of the 16 US EPA priority PAHs.

The stack gas emissions for all air quality parameters assessed (most importantly PCBs, PAHs, dioxins, furans, metals and particulates) were well below the ambient air quality guidelines as prescribed by the Ontario Clean Air Program. The scrubber decant water was clean enough to be disposed of directly to the municipal sewers. The scrubber sludge contained moderate concentrations of total PAHs, but very low metals and PCBs. Although clean enough for landfilling, the analytical cost to establish this was not considered economical, so the small quantities of sludge generated were recycled through the Destructor. The last effluent, the grit, contained very high concentrations of metals (approximately 15% Fe, 1% Mg and 0.5% Zn) and moderate concentrations of total PAHs.

Although the destructive capabilities of the system was established, a number of processing problems were identified. These problems were either rectified on site or noted for further pilot development. None of the problems presented an obvious threat to either human health and safety or the environment.

Difficulty was encountered in feed preparation and injection into the Destructor as indicated in *table 1* by notes

4, 6 and 8 and the low solids content of the feed. Some problems were encountered with regard to plugging of the feed system and erosion of the flow measurement and control elements. Redesign of the feed piping overcame these problems.

The Destructor required a large amount of electrical power, which was supplied by a rented diesel generator. The generator broke down on a number of occasions and ultimately the rental company was changed after which the generator operation was uninterrupted.

Reactor pressure control problems were encountered and diagnosed to be due to the injection of "cold" waste into the hot vapourizer. This problem was corrected by modifying the feed protocol to more frequent, smaller doses.

One problem not corrected on site occurred due to grit melting within the reactor and accumulating around the Glo Bars and the grit exit. The former caused the Glo Bars to break between some runs as the grit cooled and solidified (table 1, note 4). The latter resulted in the base of the reactor plugging, preventing the grit from escaping and causing interruptions in processing.

The initial grit sampling technique was poorly designed, and resulted in samples consisting mainly of water. The method was altered after characterization run 7; however the representative nature of the samples was still questionable due to the grit exit plugging problems.

A final comment was that the sampling program conducted by EcoLogic was not sufficient to be able to calculate mass balances for the system. This should be corrected for any future operation, as the mass balance allows an overall destruction efficiency for a contaminant to be assessed.

The use of the V&F CIMS-500 to monitor trace organic compounds on a continuous basis as an indicator of destruction efficiency made the system more environmentally acceptable to the public and to regulators.

Conclusions

In their final report EcoLogic staff drew several conclusions. In summary these are:

1. The EcoLogic process can be used successfully to eliminate organic contamination (particularly PAHs and PCBs) from harbour sediment;
2. Levels of hazardous air emissions were well below ambient air quality guidelines;
3. The CIMS-500 on-line mass spectrometer system was a valuable component of the process control system;
4. The test program was successful in demonstrating the ability of the pilot system to process liquids and sludges up to 10% solids;
5. Design modifications are required to handle grit from the reactor; and,
6. The cost of a 100 tonne/day operation for a similar system is projected to be $325 per tonne.

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

1. The EcoLogic conclusions as found in their final report are correct in a general sense;
2. The WTC laboratory audit confirmed the EcoLogic analytical results except for certain test results. Results for these discrepancies were rechecked by both laboratories but no errors were found. The difference in results is attributed to poorly mixed samples;
3. The EcoLogic staff made every effort to complete the project according to the terms of reference; and,
4. The EcoLogic process has excellent potential, especially if the identified problems are corrected.

Future Directions

Since the Hamilton project was completed EcoLogic has modified a number of features of the Destructor. The most important change is in the feed system. A thermal desorber for separating volatile compounds from solids has been added so that solids will no longer be fed to the reactor. This will improve the efficiency and reduce the waste flow problems.

EcoLogic has been included in the USEPA Superfund Innovative Technology Evaluation (SITE) Program and are to begin a demonstration processing PCB contaminated landfill leachate and soils at Bay City, Michigan. A number of process improvements will be demonstrated during this program, including the soil desorption module for pre-processing solids.

The EcoLogic 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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For more information on the Great Lakes Cleanup Fund or more Factsheets contact:

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TABLE 1: Demonstration and analytical program and results

Test[1]	Mass Processed kg	Solids Concentration %	Target Contaminant	Influent Concentration of PAHs[2] µg/L	Influent Concentration of Organics[3] %	DRE[2] %
C1	200	5	PAHs	6 663	1.5	99.98
C2[4]	250	5	PAHs	NA	1.5	
C3	350	5	PAHs	3 079	1.5	99.992
C4	400	5	PAHs	4 991	1.4	99.98
C5	250	6	PAHs	3 517	1.92	99.996
C6[5]	350	6	PAHs	NA	1.92	
C7[6]	300	9	PAHs	12 119	2.52	99.998
C8[7]	300	8	PAHs	11 689	2.24	99.995
C9[8]	300	8	PAHs	NA	2.24	
C10[9]	350	8	PAHs	11 063	2.24	99.998
C11[5]	350	9	PAHs	4 322	2.61	99.994
C12	450	6	PAHs	3 267	1.92	99.989
P1	850	7	PAHs	6 107	2.1	99.996
P2	900	10	PAHs	7 307	3	99.997
P3[10,11]	600	10	PAHs	3 064	3	99.995
			PCBs	110 000		>99.9996

1. C: Characterization Test; P: Performance Test
2. The sum of the 16 US EPA priority PAHs
3. Organics were characterized as Total Organic Carbon (TOC)
4. Turbotak nozzle removed after this run due to plugging problems. A vibrating screen was added to screen the feed
5. Globars were replaced after this run
6. Liquid and solids were pumped from two different drums to alleviate plugging problems at the base of the vapourizer
7. **WTC sample audits:** air train extracts were re-analyzed by the WTC laboratories. The extract preparation was audited by an expert in this field
8. Peristaltic pump was used for liquid feed for this and the following runs to increase the flow rate of the liquid
9. **WTC sample audits:** as for 7 and non-gaseous feed and effluent split samples were analyzed by WTC laboratories. Scrubber tower and "ambient" air samples were analyzed by the WTC laboratories
10. The feed was spiked to 110 ppm PCBs
11. Non-gaseous feed and effluent split samples were analyzed by WTC laboratories

NA Not analyzed