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Project Summary

Pilot Study on Demonstration of Remedial Action Technologies for Contaminated Land and Groundwater Volumes 1 and 2

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This two-volume report* presents information on a 5-yr pilot study (1986-1991) sponsored by the North Atlantic Treaty Organization's (NATO) Committee on the Challenges of Modern Society (CCMS) entitled "Demonstration of Remedial Action Technologies for Contaminated Land and Groundwater." Volume 1 discusses the findings, conclusions, and recommendations produced by the study—a study proposed by the U.S. Environmental Protection Agency (EPA) in May 1986 and accepted by NATO member countries in November 1986. Volume 2, in two parts, contains the appendices: The final Project Reports, NATO's CCMS final Fellow Reports, invited expert speaker contributions, representatives' discussions of their country's national regulatory and research and development programs and other overview topics, detailed information on specific case studies, and a listing of all participants.

The study's purpose was to identify and evaluate innovative, emerging, and alternative remediation technologies and to transfer technical performance and economic information to potential users. Twenty-nine remediation technology projects that treat, recycle, separate, or concentrate contaminants in soil, sludges, and groundwater were examined. The seven technology areas studied were chemical treatment of contaminated soils, microbial treatment, physical/chemical extraction, pump and treat groundwater, soil vapor extraction, stabilization/solidification, and thermal treatment.

The detailed CCMS report of the findings, conclusions, and recommendations is intended to serve as a reference to the state-of-the-technologies examined by the participants and as a guide to the potential application of different technologies to various types of soil and groundwater contamination. Conclusions from the study reveal both the strengths and weaknesses of current technologies and identify efforts needed to increase their application and effectiveness.

This Project Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of this CCMS Pilot Study that is fully documented in a separate report (Volume 1) and in two appendices (Volume 2) of the same title (see Project Report ordering information at back).

Introduction

Land and groundwater contamination from improper handling and disposal of hazardous materials/waste is an international concern and is among the most complex and challenging environmental problems faced by most countries. The complex geochemical, physical, and biological nature of contaminated subsurface soils and groundwater coupled with limited knowledge of the behavior and interaction of pollutants in these matrices and

* The documents described are not publications by the United States Environmental Protection Agency nor of any agency or department of any other country.

the magnitude of the contamination adds to the challenge. Reliable, cost-effective technologies are needed to remediate sites contaminated with complex hazardous wastes.

Governmental and private organizations in many countries have committed resources to developing and evaluating, under field conditions, advanced, innovative remediation technologies to solve problems associated with hazardous waste sites. These organizations require a conduit through which information concerning technology advancements can be effectively transferred to decision makers responsible for implementing remedial actions.

This CCMS pilot study maximized the member country technology demonstrations' results and utility through effective technology transfer. The purpose of this study was to identify, discuss, evaluate, and transfer technical performance and economic information concerning innovative, emerging, and alternative treatment technologies for remediating contaminated land and groundwater. A specific study objective was to identify "lessons learned" from the demonstrations, including both successes and failures or limitations. Although failures or limitations or both are rarely presented in conferences or discussed in the technical literature, they are important for making informed decisions that involve critical time and monetary requirements.

Pilot Study Structure

During the 5-yr study, 29 different remediation technology projects conducted by non-NATO-sponsored organizations within member countries were described. Table 1 lists the projects accepted by the study and their country of origin. Three categories of technologies (alternative, innovative, and emerging) were examined. Technologies where barrier walls and containment were the primary techniques were specifically excluded from the study. The remediation technology projects were the primary source for discussion and final report information. This project-specific information was supplemented by reports of scientists supported by the NATO/CCMS Fellowship Program, guest expert speakers, and the knowledge and experience of the individual chapter authors.

Projects were selected during an annual spring administrative meeting. Presentation and in-depth discussions of technical and cost data contained in the interim and final reports of the demonstration projects were the key aspects of annual fall international conferences.

The study conducted under the joint leadership of the United States, the Federal Republic of Germany, and the Netherlands was directed by Donald E. Sanning of the EPA. Canada, France, and Denmark were also active participants; Norway was an "observer" country; and the United Kingdom Department of the Environment was represented at the nine conference and workshop meetings hosted by the participating countries. Japan was represented at the First International Conference, and Hungary and Austria attended the Fifth.

Results of the pilot study are presented by technology area in Volume 1, Chapters 2 through 8. Technology areas included are Thermal, Soil Vapor Extraction, Stabilization/Solidification, Physical Chemical Extraction, Pump and Treat Groundwater, Chemical Treatment of Contaminated Soil: APEG, and Microbial Treatment. These reports are reproduced as submitted, along with summaries and detailed information, when available, on specific case studies of projects examined, in the appendices (Volume 2).

Of the 12 CCMS Fellows associated with the pilot study, 9 conducted related studies and submitted reports on their research; the other 3 contributed to preparing the Final Report. The fellows represented private, university, and governmental organizations in Germany, Italy, The Netherlands, Turkey, the United Kingdom, and the United States.

Pilot Study Accomplishments

Project Reports revealed an evolution of innovative and advanced technologies. The pilot study was instrumental in facilitating development of these technologies, stimulated significant exchange of experts and their knowledge, and provided opportunity for collaborative projects among the represented countries.

Technology transfer of pilot study information was accomplished through frequent involvement of members in conferences, symposia, journal article authorship, and reports of pilot study meetings. Understanding policy differences and management strategies of the various representative countries was promoted through the "tour de table" statements.

Technology-Based Conclusions

Thermal Technologies

- Existing high-temperature incineration (onsite and offsite) successfully destroys organic contamination; however, not all nations allow its use for chlorinated compounds.
- Low-temperature thermal desorption is a successful technology for treating volatile and semivolatile wastes.

Stabilization/Solidification (S/S) Technologies

- S/S can immobilize most inorganics but not materials containing organic chemicals.
- Scientifically based S/S leaching tests would provide a more easily comparable data base than that available today.

Soil Vapor Extraction (SVE) Technologies

- SVE is a viable technology for unsaturated zone remediation of volatile and semi-volatile contaminants.
- Off-gases can be treated by conventional technologies including activated carbon, condensation, and thermal destruction processes.

Physical/Chemical Extraction Technologies

- Conventional extractive techniques have limited *in situ* applications because of their limited applicability to soils with high permeability.

Table 1. *Review of Pilot Study Projects by Treatment and Country of Origin*

Type of Project	*CAN*	*DEN*	*FRG*	*FN*	*JPN*	*NETH*	*USA*	*Total*
Thermal treatment			*2*		*1*	*1*	*1*	*5*
Solidification/stabilization				*1*			*1*	*2*
Volatilization						*1*	*2*	*3*
Physical/chemical treatment			*3*			*2*	*3*	*8*
Microbial treatment		*2*				*3*	*1*	*6*
Pump and treatment	*1*	*1*		*2*			*1*	*5*
Total	*1*	*3*	*5*	*3*	*1*	*7*	*9*	*29*

CAN = Canada
DEN = Denmark
FRG = The Federal Republic of Germany
FN = France
JPN = Japan
NETH = The Netherlands
USA = The United States of America

- Conventional, above-ground extraction methods are powerful techniques for a large range of soils containing heavy metals and organic contaminants; they are limited, however in the soil size fraction they can effectively clean. A major drawback is the production of sludge.
- Electroreclamation is a promising new technology for the *in situ* cleanup of clayey soils contaminated with heavy metals.

Pump and Treat Groundwater

- Groundwater extraction and treatment is not an effective stand-alone approach for the ultimate remediation of aquifers to health-based cleanup concentrations.
- Treatment by air stripping and activated carbon, as illustrated in the Canadian Ville Mercier Case study, was only partially effective. A subsequent pilot-scale study, using an alternative iron-removal process involving diffused air combined with sand filtration, effectively removed iron to acceptable levels. This approach combined with an alternative air stripping system designed to remove the most difficult contaminant, rather than volatile contaminants generally, effectively reduced the organics to acceptable levels.
- An ultraviolet radiation/oxidation process (Ultrox™)* was effective in reducing the concentration of volatile organics in groundwater to acceptable levels.
- A precipitation process involving the use of lime and sodium sulfide effectively reduced the concentrations of zinc and cadmium to acceptable levels.

Chemical Treatment of Contaminated Soils: Alkaline Polyethylene Glycol (APEG)

- Long-term stability and behavior of products of partial dechlorination in APEG processes require investigation.
- The combination of thermal pyrolysis and APEG treatment successfully reduced PCB concentrations to below target cleanup levels.

Microbial Treatment Technologies

- Bioremediation process scale-up from laboratory to the field is difficult. Generally, either bench and/or pilot-scale studies in the laboratory need to be followed by pilot- and/or full-scale testing (treatability studies) in the field.
- Both data on oxygen behavior in the subsurface and improved methods of providing it are needed for *in situ* bioremediation. One promising technique is the use of soil vapor extraction methods. The combined effect of vapor extraction and biodegradation appears to provide a method for achieving remediation of a wide range of organic contaminants.
- Further research is needed on bioavailability and achievable residual concentrations.
- Soil inoculation of artificially supplied microorganisms has not been proven to enhance *in situ* bioremediation.
- Permeability is the key parameter that determines the applicability of *in situ* biorestoration.

General Conclusions

Remediation efforts should strive for a complete solution to the hazardous waste problem.

Treatability studies must be conducted early for effective remedy selection, and technologies should be judged on their overall performance.

Vitrification is a promising technique for treating mixed organic and inorganic waste.

Energy efficiency practices influence plant design and, therefore, processing costs differently.

Treatment technologies and permanent solutions are preferred to containment.

Modular-designed, integrated, technology treatment systems are needed for site remediation.

Field treatability/pilot studies should be conducted for each candidate technology, under the range of potentially applicable site field conditions.

Technology scale-up problems need to be addressed during the design and testing phase.

A mass balance approach to remediation is desirable.

Technology remedies that transfer contaminants from one media to another should be avoided if possible.

All remediations require proper operation and management.

Long-term monitoring of permanent remediation activities may be necessary to ensure that cleanup goals are met.

Basic records of site investigations and associated remediation actions should be preserved for future reference and evaluation.

Collection of uniform data is needed.

Independent technology evaluations are needed for effective technology transfer.

The CCMS network is an important source of information about the successes and failures of technologies used within the hazardous waste treatment arena.

There is a continuing need to develop new technologies and use common research protocols.

Scientific understanding of processes is essential to ensure against formation of harmful end products.

Standardized analytical methods are needed within the worldwide hazardous waste community as well as within countries.

Techniques are needed to remove contamination beneath urban structures without significantly disturbing activities within the structures.

Recommendations

This CCMS pilot study should be continued to report results of technology field demonstrations and information on new and emerging technologies including cleanup criteria, project design methodologies, and documentation of completed remediations.

Participation of NATO and non-NATO countries in the continuation study should be encouraged.

CCMS should encourage more active participation by all member countries.

The NATO Science Committee is encouraged to establish a special scientific program and advance study institute for soil and groundwater contamination issues.

CCMS should support the transfer/application of results of the current study through workshops and seminars within NATO and non-NATO countries.

CCMS should encourage annual technology transfer reports from each of its individual pilot studies.

A more formal interface of the continued pilot study with the Office of Economic Community Development (OECD), the European Community (EC), and other international groups should be created.

CCMS should establish a budget for writing the final report to encourage its timely preparation.

The full report was submitted in fulfillment of Contract No. 68-C8-0062 by Science Applications International Corporation under the sponsorship of the U.S. Environmental Protection Agency.

* Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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Naomi P. Barkley *is the Project Summary author and EPA Project Officer (see below).*

The complete NATO/CCMS report, entitled "Pilot Study on Demonstration of Remedial Action Technologies for Contaminated Land and Groundwater," consists of the following volumes:

"Volume 1" (Order No. PB93-218238, Cost: $27.00, subject to change) reports on the results of the CCMS Pilot Study.

"Volume 2, Appendices, Part 1": Pages 1 through 662 (Order No. PB93-218246, Cost: $77.00, subject to change) contains overviews of national environmental regulations, and guest speakers' presentations.

"Volume 2, Appendices, Part 2": pages 663 through 1389 (Order No. PB93-218253, Cost: $84.00, subject to change) contains final project reports and CCMS Fellow reports.

The volumes of this report will be available only from:

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