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ALCAN INTERNATIONAL LIMITED

TECOSOL INC.

DEMONSTRATION OF THE SOLTEC PROCESS FOR THE *IN-SITU* PHYSICO-CHEMICAL TREATMENT OF A DIESEL-OIL CONTAMINATED SITE

EXECUTIVE SUMMARY

PRESENTED TO

ENVIRONMENT CANADA (QUÉBEC REGION)
ECO-TECHNOLOGY INNOVATION SECTION
ENVIRONMENT PROTECTION

MARCH 1997

This document has been published by authority of the Minister of the Environment.

Minister of Public Works and Government Services Canada 1997
Cat. No. : En40-542/4-1997-1
ISBN : 0-662-63198-6

MANAGEMENT PERSPECTIVE

This summary of the final report is published as part of the « Technology Development and Demonstration Program » of Environment Canada, which promotes private sector initiatives in the development and demonstration of innovative environmental technologies. This program is also associated with the Federal Office of Regional Development -Quebec region (FORD-Q) and is a part of the St.Lawrence Vision 2000 action plan from Environment Canada.

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File: 4954-19/A-226-1 (EC)
3332.52.93.11 (MEF)

Executive Summary

(Activity No.: 31654)

Promoters: Alcan International Limited
Tecosol Inc.

Financial participation

⇒ Environment Research and Technical Development Funds
Ministère de l'Environnement et de la Faune du Québec

⇒ Technology Development and Demonstration Program
Environment Canada

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Direction de l'information environnementale et de la recherche

AR-97/0006 March 1997

TABLE OF CONTENTS

EXECUTIVE SUMMARY

During a project aimed at choosing a restoration technology for an industrial site, Alcan contributed to the development and demonstration of a treatment process for soil contaminated by different hydrocarbons.

In-situ treatment tests using physico-chemical or biological means proved fruitless. The soils contaminated by diesel oils were mainly located around and under buildings with equipment in use or which were in the course of being dismantled.

The Problem

At the site of one of the plants, a diesel oil leak from an underground reservoir had contributed to contamination of the soil around and under the buildings. A bowl of permeable sand confined by an underlying siltic-clay formation was impregnated with hydrocarbons. Part of the hydrocarbons had spread to the surface of the underground water for a distance of almost 150 metres in a south-easterly direction. The affected site was located 1 mile from a river.

Project Objective

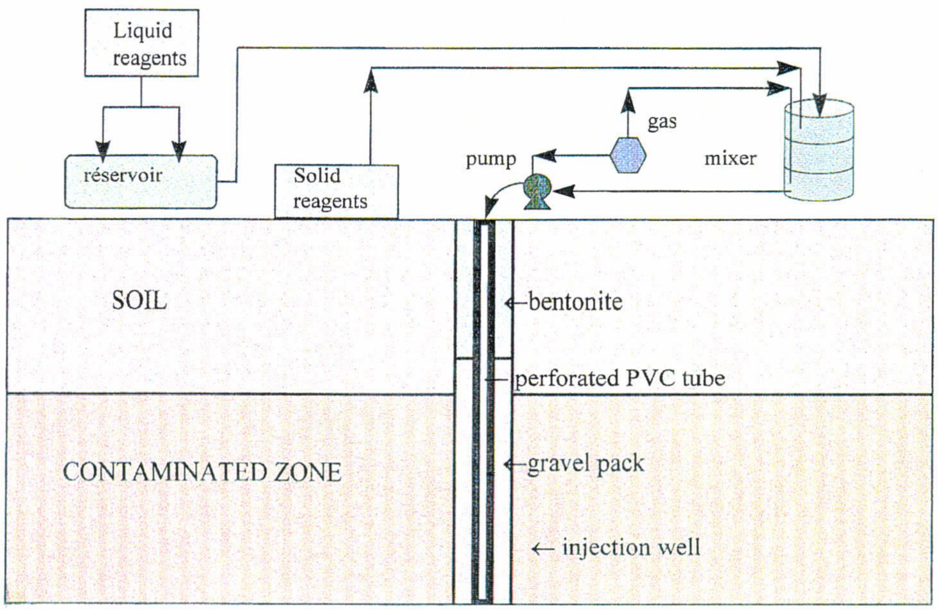
The project carried out by Alcan in 1995 and 1996 aimed at demonstrating that the SOLTEC® process proposed to Quebec by Tecosol was acceptable from the technical, economic, social and environmental points of view for the treatment of soils contaminated with diesel type hydrocarbons.

This physico-chemical technology proposes to treat oil permeated soil by *in-situ* injection of solid, liquid and gaseous reagents which will degrade the hydrocarbons physico-chemically. This process, recently developed in Europe *for ex-situ* treatment of soil contaminated with light hydrocarbons, has not yet been demonstrated in Quebec for *in-situ* treatment of soil contaminated with diesel oil.

The Technology

The SOLTEC® process oxidises the hydrocarbons in the soil without forming by-products harmful to the environment. The physico-chemical reaction, which is carried out in less than 48 hours, allows rapid reuse of the decontaminated soil as fill. This reaction is brought about by using injection to make contact between the solid reactants based on calcium and liquid and gaseous oxidising agents and the hydrocarbons. The proposed physico-chemical technology offers a valid alternative to other treatment methods. It may be applied *in-situ* or *ex-situ* and the treatment is rapid and may be performed at all times of the year.

SOLTEC® PROCESS
IN SITU APPLICATION



Description of the Work

In order to demonstrate the environmental, technical and economic efficiency of the SOLTEC® technology, the project was divided into four phases:

1. To measure in the laboratory, by tests on samples of contaminated soil, the treatment efficiency and the toxicity level before and after treatment characterised by the addition of the SOLTEC® reagents. In parallel, to perform laboratory tests on underground water treatment.

2. To perform a treatment test *in-situ*, on the site at the pilot scale, requiring the drilling of two (2) injection wells in the contaminated soil zone.

3. To perform a full-scale demonstration of the contaminated soil treatment technology by constructing a network of injection wells spread throughout the contaminated sector.

4. To carry out, for a period of one year, environmental control and monitoring of the soil quality and underground water, by means of a dozen drillings or observation wells.

In addition, to define the reaction mechanisms between the reagent mix and the hydrocarbons in the soil, and to evaluate what becomes of the contaminants, tests were performed during Phases 1 and 2 in the laboratories of the Chemistry Department of Sherbrooke University.

Analytical Programme

The analytical programme proposed during the presentation of the project is shown in the following table:

Analyses envisioned for the whole project

Phases/steps	Parameters Analysed	Soil/water quantities	Location (1)	Stage (2)	Analytical methods	Detection limit
Phase 1: Pilot plant scale tests (laboratory)	Lettuce germination	water 4	Zo	Av - Ap	EPA 89	< 1 u.t.
		soil 4	Zo	Av - Ap	BNQ 1987	< 2 u.t.
Toxicity tests	Microtex/biolumin-escence	soil 4	Zo	Av - Ap	Agdex 533	
Step 2		water 4	Zo	Av - Ap		
		soil 8	Zo	Av - Ap		
	pH	water 8	Zo	Av - Ap		
Step 3: Reaction mechanisms			Zo	Av - Ap	STM 5520	
	O&G				C & F	
	Organic C					0,1
	Particle size				EPA 624	
	BTEX					
	pH					
	Leaching					
Phase 2: pilot scale soil tests (field)						
Step 1	Particle size	soil (7)	Zo	Av	BNQ	N.A.
Step 3	T oil & grease	soil (7)	Zo	Av	2560-040	
	Leachable O & G	soil (7)	Zo	Ap	STM 5520	
		leachate	Zo	Ap	C & F	
	BTEX (T)	(3)	Zo	Av		
	BTEX (leachable)	soil (7)	Zo	Ap	EPA 624	
	pH	soil (7)	Zo	Av - Ap		0,1 (u)
	conductivity	soil (6)	Zo	Av - Ap	Agdex 533	
		water (6)				
Underground water treatment tests						
Step 3	Oil and grease	water (11)	Av	Av	STM 5520	
		water (11)	Av	Ap	C & F	
	BTEX	water (11)	Av	Av	EPA 624	
		water (11)	Av	Ap		

Phases/steps	Parameters analysed	Soil/water quantities	Location (1)	Stage (2)	Analytical methods	Detection limit
Phase 3: Full scale field test	Particle size	soil (40)	Zo	Du	Agdex 533	0,1
Step 1	pH conductivity	water (40)	Av	Ap		
Step 2	Total Oil & Grease	soil (16)	Am	Ap		
		soil (4)	Zo	Ap		
		soil (2)			STM 5520	0,1
	Oil & Grease	leachate (3)	Zo	Ap	C & F	
			Av	Ap		
	Total BTEX	soil (16)	Am	Ap	EPA 624	0,1
		soil (4)	Zo	Ap		
		soil (2)				
	Leachable BTEX	leachate (3)				
Step 3	See agreement with the University, Item 2,0					
Phase 4: Environmental control and monitoring after treatment						
Step 1	Total Oil & Grease	soil (22)	Zo	Ap	STM 5520 C & F	0,1
	Leachable Oil & Grease	leachate (3)	Zo	Ap		
					EPA 624	0,1
	Total BTEX	soil (22)	Zo	Ap		
	Leachable BTEX	leachate (3)	Zo	Ap		
						0,1
	Oil & grease	water (132)	Av, Am, Zo	Ap	Agdex 533	
Step 2	pH	water (132)	Av, Am, Zo			0,1
	BTEX	water (132)	Av, Am, Zo	Ap		

(1) Av = Downstream zone Am = Upstream zone Zo = Soil treatment zone (Figure 3)
(2) Av = Before treatment Ap = After treatment Du = During treatment

Note: The number of analyses includes control analyses which represent 10 % of the analyses envisaged in the framework of the quality assurance programme. Lab. used: Eco-CNFS, Control Lab: SEDAC

Phase 1 - Laboratory Pilot Scale Test

The soil

The main steps consist of sampling the contaminated soil from three surveys, preparing and adding the reagents, injecting the reagent mix into the soils in the laboratory and analysing the contaminant concentrations before and after treatment. Analyses allowing the reaction mechanisms to be identified were carried out. The parameters analysed were BTEX, oil &

grease, particle size and pH. GC-MS's were performed on different samples in order to determine the reaction mechanisms.

Results of laboratory tests performed at Sherbrooke University demonstrated a reduction in hydrocarbons by a factor of 20. From GC-MS it was determined that no significant new product appeared and that, for oil and grease, we have a destruction mechanism which uses a chemical reaction.

Results of the toxicity studies performed by the Institute of Biological Research (IBR) of the National Council of Canada, showed that the SOLTEC® technology:

- significantly reduces the cyctotoxicity induced by diesel oil as well as the phytotoxicity extracted from soil samples, using solvents;
- reduces the phytotoxicity induced by diesel oil in the soil samples;
- causes complete elimination of the mutagenicity measured in extracts from soil contaminated with diesel oil.

Underground water

The principal steps consist of sampling the underground water using three piezometers, preparing and adding the reagents, injecting the reagent mix into the water in the laboratory and analysing the concentrations before and after treatment. The parameters analysed were BTEX, oil & grease and pH.

The results of laboratory tests performed at Sherbrooke University, showed a reduction of 50 to 65% of hydrocarbons in the underground water without reducing the concentration below the criterion « C » after treatment. These tests did not demonstrate that the technology could be applied to underground water and further work with a much wider scope will be necessary to optimise the proportions of the products and to evaluate the full scale feasibility.

Phase 2 - Pilot Scale Tests in the Field

The positive results from the laboratory phase allowed the pilot stage to be continued in the field. Two injection wells were drilled, to obtain soil samples, and the liquid reagents were injected into each of the wells. Six (6) sampling wells were drilled around the injection wells in order to obtain control samples after treatment.

During this phase, eight (8) soil samples were taken from the injection wells before treatment and twenty (20) after treatment samples were taken from the sampling wells. On the twenty-eight (28) a series of analyses were performed by Sherbrooke University for O&G, BTEX and pH parameters.

The results

The results obtained showed that the reduction of O&G in the samples after *in-situ* treatment was similar if not better than those from the laboratory tests. Before treatment the measured concentrations varied between 42 900 and 63 500 mg/kg and after treatment the measured levels varied between 1 100 and 2 700 mg/kg which is lower than the « C » criterion of the MEW. For the BTEX's, reductions attaining the « C » criterion were also obtained. The pH of the soil in the levels treated was of the order of 12.

The work on reaction mechanisms showed that the presence of oxidation reactions results in the creation of calcium carbonates. GC-MS analysis showed that there was no formation of secondary products nor heavier hydrocarbons.

Phase 3 - Full Scale Demonstration

The objective of this phase was to demonstrate the efficiency of the technology in a volume of almost 3 000 m^3 of soil contaminated with diesel type hydrocarbons. The work of *in-situ* treatment was performed for a period of four months. The area of contaminated soil was divided into four zones for reagent injection.

The work

Zone « A », the farthest upstream from the residual polluting enclave, was covered by ten (10) injection wells into which almost 4 000 litres of reagents were injected. Zone « B » situated under the building had eleven (11) wells; injection was at an angle to each side of the building. A total of more than 10 000 litres of reagents were injected there. Zone « C », the farthest downstream from the residual polluting enclave, needed twenty-four (24) injection wells arranged uniformly over the test zone. Zone « D » situated under two buildings required four (4) injection wells inside the buildings. During drilling, no contamination was detected in this zone and the soil found was silty-clay. Injection was not carried out in this zone.

During drilling of the forty-seven (47) injection wells, composite soil samples were taken from each well for particle size analysis. Two weeks after the end of the injections, ten (10) sampling wells were drilled throughout the injection zones. Eighteen (18) samples were taken for O&G, BTEX and pH analysis.

The results

From the particle size analysis it was concluded that in the fine sand soils, the quantities of reagents needed were much lower than when the sand was larger. The treatment efficiency is shown in the following table:

O&G ANALYSIS BEFORE AND AFTER TREATMENT

	Before treatment	After treatment	% destruction
Number of samples	13	36	
Average mg/kg	41 615	1 582,8	> 95
Standard deviation	23 447	796,5	
Number of samples < 1000 mg/kg	0	10	

Criteria: A - 100, B - 1000, C - 5000, mg/kg

With a reduction from over 41 615 to 1 583 mg/kg, an average destruction efficiency of over 95 % was obtained.

Of a total of forty-seven (47) injection wells spread over an area of 1 500 m^2, almost a third were drilled at 45° with the aim of injecting under the industrial buildings. The results obtained in these areas compare with those obtained in the vertical injection wells of the whole treated site.

The changes made to well drilling and the injection technique during the demonstration project permitted significant improvement to be made in the treatment efficiency. Also, the results obtained in the last sectors allowed the MEW criterion « B » of the policy of rehabilitation of contaminated ground (Reference: Quebec National Library) to be attained.

Phase 4 - Environmental Monitoring

Environmental monitoring of the underground water quality for a period of a year demonstrated that the decontaminated soil did not act as a source of contamination for underground water and that, up to the present time, the area of the contamination enclave has been reduced by more than 95%.

Evaluation of costs

Depending on the nature of the soil, the volume to be treated, congestion, infrastructures and the contamination level, the range of costs varies between 60,00 $/m³ for a gravelly soil having no major infrastructure to 150,00 $/m³ for a silty soil under operational buildings.

Conclusions and recommendations

The work carried out in the different phases of testing the SOLTEC® process have demonstrated that in full scale situations, the technology can attain the MEW criterion « C » and even the criterion « B » under certain conditions.

RESULTS OF TREATMENT TESTS IN THE LABORATORY, ON A PILOT SCALE AND FULL SCALE IN THE FIELD

Phases	Parameters mg/kg	Before treatment	After treatment	Destruction Efficiency
Laboratory	O&G BTEX	84 700 700	4 300 80	95 % 89 %
Pilot	O&G BTEX	44 000 752	1 860 5,3	96 % 99 %
Full scale	O&G BTEX	41 615 75	1 583 2	96 % 97 %

Hydrocarbons in the soil which are contacted with the reagent mix, are destroyed by oxidation giving rise to the formation of water (H_2O) and gaseous carbon dioxide (CO_2).

The series of chemical analyses and biotests, carried out in the laboratory, demonstrated that the reaction with the hydrocarbons does not generate environmentally harmful by-products.

The technology could be improved, i.e. by the method for constructing the injection wells and prior imperviousness of the soil to be treated.

Potential and limits

The main limit of the technology for *in-situ* treatment is the soil permeability; thus the presence of silt and clay may limit the area being influenced by the reagents to the point where the technology may become more expensive.

The technology may be evaluated in the framework of treatments for soil contaminated with transformer oil and/or PCB's.

DISTRIBUTION LIST

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March 1997

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