



St. Lawrence TECHNOLOGIES

ABSTRACT

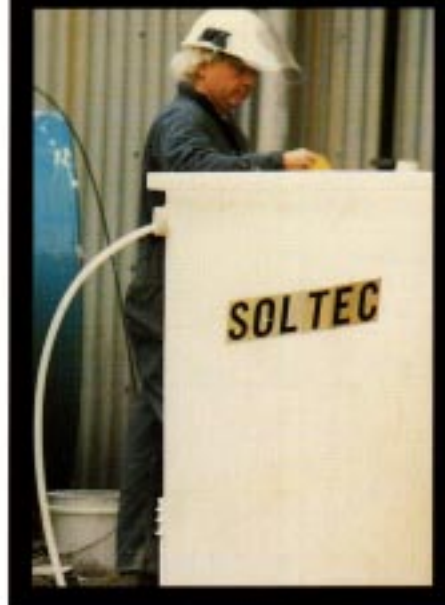
Alcan and the firm Tecosol Inc. undertook an industrial-sites restoration project to develop and demonstrate a technology for the treatment of contaminated soil by oxidation.

In situ treatment tests were carried out in 1995 on 3000 m³ of diesel-oil-contaminated soil and, in 1996, *in situ* and *ex situ* tests were done on 200 m³ of soil contaminated with transformer oil. Treatment efficiency was demonstrated on mineral oil and grease, petroleum hydrocarbons, benzene, toluene, ethylene and xylene (BTEX), polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). Laboratory studies on toxicity and reaction mechanisms were also part of the project.



CONTAMINATED SOIL

DEVELOPMENT OF THE SOLTEC™ PROCESS FOR THE PHYSICO-CHEMICAL TREATMENT OF SOIL CONTAMINATED WITH HYDROCARBONS



MAIN FEATURES

- **Technology**
 - Simple equipment, easy to install
 - Process applicable year-round, *in situ* and *ex situ*
 - Quick and efficient treatment.
- **Environment**
 - Destruction of more than 90% of petroleum hydrocarbons, BTEX, PAHs and PCBs
 - No environmentally harmful by-products.
- **Cost**
 - No excavation, transportation or landfill costs
 - Reuse of treated soil as backfill
 - Competitive treatment cost.



Environment
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Québec Region

Environnement
Canada

Protection

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Gouvernement du Québec
Ministère de l'Environnement
et de la Faune

TECOSOL



Federal Office of
Regional Development
(Québec)

Bureau fédéral de
Développement régional
(Québec)

PROJECT OBJECTIVES

The projects carried out by Alcan were aimed at demonstrating that the SOLTEC™ process, introduced to Quebec by Tecosol Inc., is technically, economically, socially and environmentally viable for the *in situ* and *ex situ* treatment of soil contaminated with hydrocarbons or transformer oil.

PHASES

1. Laboratory treatability tests and measurement of soil toxicity before and after treatment.
2. Pilot-scale *in situ* treatment tests (injection wells) and *ex situ* tests (in containers).
3. Full-scale, on-site demonstration.
4. Year-long environmental control and monitoring of soil and groundwater quality in the areas treated.

Analyses were also carried out in the laboratories of Sherbrooke University's chemistry department and at the Institute of Biotechnology Research (IBR) of the Canadian National Research Council to define reaction mechanisms between the mixture of reagents and soil contaminants and to assess treatment efficiency and changes in the contaminants.

BACKGROUND

Industrial activities can sometimes lead to incidental soil contamination problems.

The SOLTEC™ process physically and chemically degrades hydrocarbons through the injection of environmentally-friendly reagents, *in situ* or *ex situ*. This process is promising for use where buildings or underground infrastructure hamper or make impossible the excavation of soil contaminated with hydrocarbons or transformer oil.

TECHNOLOGY

The SOLTEC™ process allows for the *in situ* or *ex situ* treatment of soil contaminated with hydrocarbons. It consists of placing a mixture of calcium-based solid reagents and liquid and gaseous oxidizing agents in contact with the hydrocarbons in the soil. The physico-chemical reaction occurs in less than 48 hours.

The reagent mixture is introduced into the soil *in situ* using small-diameter wells located at strategic points. For the *ex situ* treatment, the soil is excavated and mixed with the reagents in a container.

RESULTS OF LABORATORY, PILOT AND FULL SCALE ON SITE TESTING

Contaminant	Parameters	Laboratory			Pilot scale			Full scale		
		Before (mg/kg)	After (mg/kg)	Destruction efficiency	Before (mg/kg)	After (mg/kg)	Destruction efficiency	Before (mg/kg)	After (mg/kg)	Destruction efficiency
Diesel oil	MOG				43 000	1 100		25 000	700	
	- range	-	-	-	to 64 000	to 2700	-	to 64 000	to 2800	-
	- average	84 700	4 300	95%	44 000	1860	96%	44 000	1580	96%
	BTEX									
	- range	-	-	-	26 to 98	1 to 17	-	20 to 100	< 2	-
	- average	700	80	89%	752	5.3	99%	75	2	97%
Transformer oil	C ₁₀ -C ₅₀	28 000	490		7600	400		To be completed 1997-98		
	- range	to 32 000	to 580	-	to 17 000	to 1 900	-			
	- average	29 766	527	98%	9 000	725	92%			
	PAHs									
	- range	28 to 34	< 1	-	12 to 95	1 to 4	-			
	- average	31	< 1	> 97%	6.0 41 (*)	< 1.0 2.5	> 83% 94%			
PCBs										
- range	60	8	87%	8 to 9	1 to 2	-				
- average	200	30	85%	8.6 2.4 (*)	1.3 0.25	85% 90%				

(*) *Ex situ* treatment.

RESULTS

Reaction mechanisms and toxicity

Laboratory research demonstrated that, on contact with the reagents, the hydrocarbons in the soil are destroyed by oxidation, forming water vapour and carbon dioxide gas. Moreover, a battery of tests performed by the IBR showed that no environmentally harmful by-products are formed by this reaction.

Effectiveness in treating diesel oil

During three months of treatment, almost 3000 m³

of soil was treated *in situ*. Pretreatment mineral oil and grease concentrations (MOG) were situated at a depth of 3 to 5 m and ranged from 25 000 to 64 000 mg/kg. After treatment, concentrations of MOG and BTEX measured in the observation wells showed average reductions of more than 95%.

Effectiveness in treating transformer oil

Pilot-scale treatment tests conducted *in situ* on the soil beneath the buildings confirmed the process' effectiveness in treating

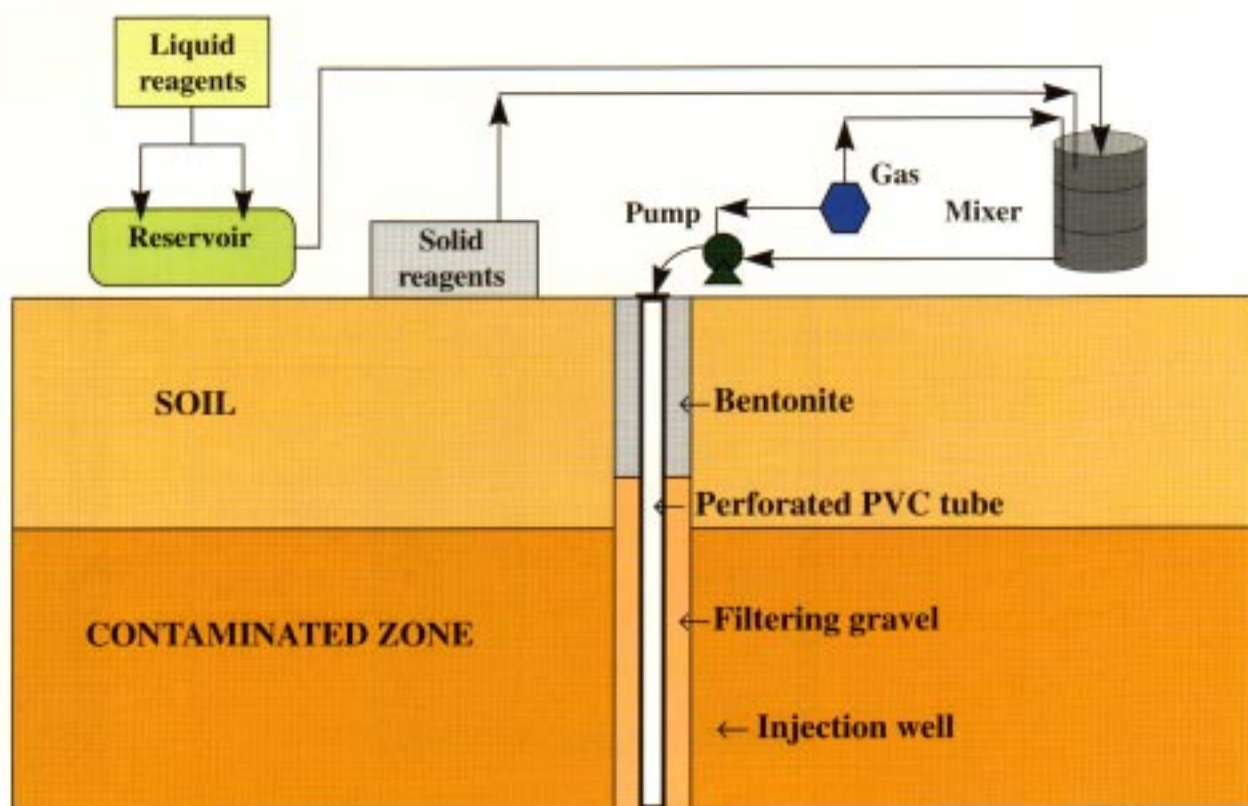
soil contaminated with transformer oil, as did the *ex situ* treatment of over 200 m³ of excavated soil. Non-treated soil was found to contain concentrations of petroleum hydrocarbons ranging from 7600 to 32 000 mg/kg. At the pilot scale, an average reduction of more than 90% was obtained. Reductions of PAHs and PCBs were on the same order of magnitude.

Environmental monitoring

Environmental monitoring of the soil and groundwater quality over a one-year

period showed that the treated soils no longer constitute a source of contamination for groundwater and that, to date, the size of the contaminated enclave had diminished by more than 95%.

SOLTEC™ PROCESS *IN SITU* APPLICATION



POTENTIAL AND LIMITATIONS

Potential

The SOLTEC™ process can treat soil contaminated with light or heavy, difficult-to-biodegrade hydrocarbons in a few days.

The presence of heavy metals does not affect treatment efficiency; European experience demonstrates that they are stabilized by the reagents used.

The reagents injected into the soil may form a hydraulic barrier preventing hydrocarbon dispersion.

Limitations

A soil's permeability and heterogeneity may be an obstacle to *in situ* treatment. Soil with a high concentration of organic matter, certain other types of

soil or particular site conditions may also restrict contact between the reagents and contaminants and thus reduce the efficiency of the process.

INFORMATION

This technology data sheet is based on the results of two development and demonstration projects carried out jointly by Alcan's Arvida Research and Development Center and the firm Tecosol Inc., with the technical and financial assistance of Environment Canada. One of the projects also received the support of the ministère de l'Environnement et de la Faune du Québec.

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physico-chimique de sols contaminés par des hydrocarbures

Canada 

ADDENDUM

Abstract

The SOLTEC™ process combining in situ and ex situ treatment was developed and demonstrated on 1380 cubic metres of soil contaminated by transformer oils and polychlorinated biphenyls (PCBs), and also on 30 m³ of PCB-contaminated soil.

Results

Laboratory research showed that transformer oil reacted to the treatment by oxidizing, and that no environmentally harmful by-products were generated by such reactions. As for PCBs, the Biotechnology Research Institute (BRI) was able to confirm that no dioxins or furans were formed during treatment, and that the absence of degradation by-products suggests that the reaction mechanism is also oxidation.

Treatment Efficiency

Full scale testing of the ex situ and in situ treatment of soil contaminated with transformer oils demonstrated a destruction efficiency of 85–95% for C₁₀–C₅₀ hydrocarbons, and 75–90% for PCBs, thereby attaining the MEF's C criterion.

The ex situ treatment of PCB-contaminated soil in the laboratory and on-site pilot-scale testing demonstrated treatment efficiency rates of 85% for pre-treatment concentrations on the order of 200–230 mg/kg of PCBs reaching 30 mg/kg following treatment. This post-treatment concentration was adequate for the safe landfill disposal of soil contaminated with PCBs.

Environmental Monitoring

Area groundwater was monitored over the course of the year following treatment. Hydrocarbons were found at concentrations below the MEF's C criterion, while the water's pH level returned to normal between six and twelve months after the treatment of contaminated soil.

RESULTS OF FULL SCALE, ON SITE TESTING OF THE SOLTEC PROCESS ON SOIL CONTAMINATED BY TRANSFORMER OILS

Phase	Parameters mg/kg	Mean concentration (mg/kg)		Destruction Efficiency
		Before Treatment	After Treatment	
Full scale, indoor in situ	C ₁₀ - C ₅₀	9 930	1 567	> 85%
	Total PCBs	1.6	0.36	> 75%
Full scale outdoor in situ	C ₁₀ - C ₅₀	18 400	1 100	> 94%
	Total PCBs	5.3	0.27	> 90%
Full scale ex situ	C ₁₀ - C ₅₀	21 800	2 194	> 90%
	Total PCBs	8.1	<0.1	> 90%

RESULTS OF EX SITU TREATMENT TESTS ON PCB-CONTAMINATED SOIL

Phase	Parameters mg/kg	Mean concentration (mg/kg)		Destruction Efficiency
		Before Treatment	After Treatment	
Laboratory	Total PCBs	200	30	85%
Pilot	Total PCBs	230	29.2	> 85%