Dutch Advanced In Situ Remediation Technologies in Canada

A “success” story on Canadian-Dutch co-operation in Canada between private Solution Providers supported by both Canadian and Dutch Governments

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Introduction

Topics
1. Canadian Perspective
2. Dutch Perspective
3. Business Perspective
4. Cases
Canadian Perspective

Canadian Governmental institutions involved:
• Provincial Governments (AB, ON, QU)
• Local (City) Governments
• Support from National Government
• Support from Centers of Excellence (e.g. OCE, MCEBR)

Scientific Institutions and private businesses

Missions & meetings
Dutch Governmental institutions involved:
• Dutch ministry of Housing, Spatial Planning and Environment (VROM);
• Ministry of Agriculture, Nature and Food Quality (LNV)
• Ministry of Economic Affairs (EZ).

Scientific Institutions (e.g. Deltares) and private businesses (e.g. Groundwater Technology)

Under 2g@there/NSP support for network/business development and demonstration projects; missions, meetings & conferences
NSP is financially supported by its participants and the Dutch government through the 2g@there program administered by the EVD office for the Dutch ministry of Economic Affairs.

NSP is a collective network, introducing Dutch state-of-art technologies and sustainable integrated solutions to its partner countries. It offers participants a platform to:

- Exchange information about the international soil market
- Create opportunities to access the international soil market
- Organize workshops or seminars to promote Dutch solutions
- Organize incoming missions and outgoing missions
- Obtain reports about the development of international markets
Economies comparable, land use pressure vastly different
Netherlands: accustomed to high pressure on land use
Canada: increasing pressure on land use through legislation
Business culture: compatible

<table>
<thead>
<tr>
<th>Market</th>
<th>Canada</th>
<th>Europe</th>
<th>Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>People</td>
<td>33.487.208</td>
<td>491.582.852</td>
<td>16.715.999</td>
</tr>
<tr>
<td>Size (land) (km2)</td>
<td>9.093.507</td>
<td>4.324.782</td>
<td>33.893</td>
</tr>
<tr>
<td>people/km2</td>
<td>4</td>
<td>114</td>
<td>493</td>
</tr>
<tr>
<td>Economy (GDP in 2008 US$)</td>
<td>1,30E+12</td>
<td>14,9E+12</td>
<td>0,67E+12</td>
</tr>
<tr>
<td>Economy per capita</td>
<td>38.821</td>
<td>30.310</td>
<td>40.081</td>
</tr>
</tbody>
</table>
Therefore: mutual business opportunities:

- Bring Dutch experience & know how to Canadian Market
- Bring Canadian experience & know how to Dutch Market
Case 1

Province of Quebec, Major City

- Down town site, ex service station
- Prime real-estate, in use as day care centre
- Contaminated, free product, migrating towards river
Case 1
Case 1
Case 1
Case 1

Solutions:

• Excavation impossible (building & too deep)
• Complicated geology & high concentrations
• Consultant interested in innovation
• Client (Municipality) interested in new technologies to remediate while minimising nuisance
Case 1

Co-operation between

Technorem, Inc (Quebec)

Groundwater Technology BV (The Netherlands)

Deploy a train of in situ technologies to optimise remediation

• Heat enhanced recovery (Steam injection) for high mass removal, mobilisation and precursor to next step

• In Situ Chemical Oxidation in hot soil after steam injection

• Evaluation of effectiveness
Case 1
Case 1 Status

B2B matters: contracts in place

B2B plans (implementation, action plan etc): complete

Governmental positions: Positive view

Financial issues (government support, grants) developing

Start-up: awaiting final green light on government financing
Case 2: ISMP

Former metal factory, soil and groundwater contaminated by heavy metals and Chlorinated Hydrocarbons
Site in urban redevelopment area

Development consortium handles redevelopment and source zone excavation

GT requested to address deep & off-site plume
Case 2: Site Overview

- Site
- Plume

Presentation RemTech, Banff, October 2009
Case 2: First Phase

1. Demolish buildings and foundations
2. Excavation of the contaminated soil
Case 2: Second Phase

Direct injection of a mixture of methanol, lactate and protamylasse leads to biodegradation of the Chlorinateds

Low redox levels lead to sulphate reduction

Sulphate reduces to Sulphite

Sulphite & nickel bond to form NiS

NiS has very low solubility => NiS precipitates
Case 2: Second Phase

Bacteria
Substrate

DOC bron (substraat) + bacterie

Degradation sequence

Afbraak Per tot etheen
\[\text{Per, Tri, Cis, Etene, VC}\]

Nieuwe cellen

koolstof, energie, elektronen

Elektronen-acceptor (VOC verontreiniging)

Carbon
New cells
Energy
Electrons
Electron acceptor (chlorinated contaminants)
Case 2: Conceptual model

Basic model:
• Topsoil, very fine sand, slightly permeable; 0-2.5 m
• Clay 2–6 m
• Clay & peat layers 6–7 m
• Deeper than 7m: Aquifer (7 – 10 m: fine sand)
Case 2: Lab testing

- Biodegradation of the VOCl’s takes place
- Immobilisation of the Ni takes place
- Extra addition of sulphates has a positive effect on the immobilisation of Ni
Case 2: Implementation (1)

Phase 1: Application of 2.5 tons sulphates (solid form) in excavation
Case 2: Implementation (2)

- Phase 2: Direct injection;
- After backfilling: in total 254 injections
- 127 m³ substrate mixture injected
Case 2: Monitoring (3)

Monitoring during 5 years
• 3 & 6 months,
• 1, 2, 3 and 5 years after the injections)
Case 2: Monitoring (3)

First results after 3 months:
• Ni concentrations dropped,
• DOC up to 1.000 mg/l
• PER/TRI/CIS concentrations decreasing
• VC, ethene, ethane increasing
### Case 2: Costs / duration

<table>
<thead>
<tr>
<th>Phase</th>
<th>Duration</th>
<th>Cost estimate (euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab testing</td>
<td>3 months</td>
<td>€ 25.000</td>
</tr>
<tr>
<td>Sulphates application</td>
<td>1 week;</td>
<td>€ 5.000</td>
</tr>
<tr>
<td>Injection (substrate) first round</td>
<td>3 weeks</td>
<td>€ 80.000</td>
</tr>
<tr>
<td>Injection (substrate) second round</td>
<td>3 weeks</td>
<td>€ 40.000</td>
</tr>
<tr>
<td>Monitoring</td>
<td>5 years</td>
<td>€ 30.000</td>
</tr>
<tr>
<td>Lump sum risk</td>
<td>-</td>
<td>€ 100.000</td>
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</tbody>
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*Presentation RemTech, Banff, October 2009*
Case 3: Issue

- Ex dry-cleaners facility in 16th century building. Designated monument & on cultural heritage list; part of old city centre Weesp on water front
- Volatile chlorinated ethenes, degading
- Low permeability soil
- Highly susceptible to subsidence
- Transfer of ownership: future liability is an issue
Case 3: Situation

• Contamination extends over 150 m² (source: 60 m²) ; vertical extent > 7 m (deeper unknown)

• Migration appears to be minimal

• Typical approach: ‘monitored natural attenuation’
1. What GT can provide to avoid ‘perpetual’ monitoring
2. Perpetual monitoring is unwanted burden
3. Perpetual monitoring decreases value of site
Case 3: Site Overview

Site

Plume
Case 3: Conceptual model

Basic model:
• Topsoil, very fine sand, slightly permeable; 0-2.5 m
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Case 3: GT Solutions

Ruled out:
• Standard approach is most cost-effective. (Costs of active measures will not be off-set by savings on monitoring)
• Pump & treat, sparge & vent ruled out (subsidence)
• ISCO ruled out (presence of peat)
• In Situ Anaerobic Biodegradation (monitoring phase too long)

Ruled in:
• In Situ chemical reduction
• In Situ stabilization
Case 3: GT approach

Intensive mass reduction followed by in situ stabilization

Intensive step:
In Situ chemical reduction: inject nano-iron slurry in vegetable oil
Inject substrate & nutrients to promote in situ biodegradation

Polishing step:
Reduce permeability to stop migration
Two injection zones:
1. In front of premises
   First round: 20 injection points, some oblique underneath building, to 7 m – grade: nano-iron & substrate
   Second round: 20 injection points, some oblique underneath building, to 7 m – grade: to reduce permeability
2. At waterfront
   15 injection points (vertical) as precaution ('just in case')
Case 3: Conceptual model

Approx. 20 injections, 2 m interval

Approx. 15 injections, 2.5 m interval
## Case 3: Costs / duration

<table>
<thead>
<tr>
<th>Option</th>
<th>Duration</th>
<th>Cost estimate (euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>monitoring</td>
<td>perpetual</td>
<td>€1500 per annum</td>
</tr>
<tr>
<td>Basic injection (nano-iron)</td>
<td>Per injection event: 1 week; Total: 1-2 years</td>
<td>€35K</td>
</tr>
<tr>
<td>Additional injection (substrate)</td>
<td>No additional time; May save one basic injection round</td>
<td>€17K</td>
</tr>
<tr>
<td>In Situ Fixation</td>
<td>No additional time; May save one basic injection round</td>
<td>€16K</td>
</tr>
</tbody>
</table>
Thank You

For Your Attention