

Successful 12-Month Pilot Trial of Enhanced Reductive Dechlorination

First use of 3DMe® in Finland yields a 99% reduction of cis-1,2-DCE

With RGS Nordic and Nordic Envicon



Introduction

REGENESIS were approached by RGS Nordic and Nordic Envicon to form part of a specialist team to design a remedial scheme for a former aerospace factory in Finland. An area of over 100,000m² is impacted by a chlorinated solvent plume in the groundwater, comprising predominantly cis-1,2-dichloroethylene (DCE) contamination. The first phase of these works comprised a pilot trial, to demonstrate the applicability and efficacy of the suggested treatment method ahead of full-scale deployment.

Remediation Approach

The site had many challenges that needed to be overcome in order to deliver a cost-effective scheme of works:

- Complex heterogeneous formation, comprising sands, gravels, silts and crystalline bedrock;
- Extremely large plume (>100,000m² of which 60,000m² requires treatment);
- Conflicting seasonal groundwater flow directions;
- Full-scale works will be required to deliver a fully remediated site within two years.

After completing an in-situ remediation option appraisal the team agreed that the full-scale strategy should comprise a series of 'barriers' (treatment zones through which groundwater would continue to flow, but in which the contamination would be degraded) perpendicular to groundwater flow.

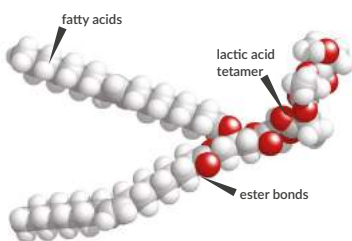


Fig. 1 - The molecular structure of 3-D Microemulsion

This configuration would minimize the number of injection points, reducing application costs, without compromising treatment efficiency. The electron donor which was suggested was 3-D Microemulsion® (3DMe).

Remediation Details

Site Type:

Derelict site

Project Driver:

Redevelopment

Remediation Approach:

Enhanced Reductive Dechlorination (ERD)

Technologies:

3-D Microemulsion (3DMe)®

Geology

	Bedrock
X	Gravel
X	Sand
X	Silt
X	Clay

Medium

X	Groundwater
	Saturated Soil
	Vadose Zone

COC

	Petroleum Hydrocarbons
X	Chlorinated VOCs
	Free Phase
	Metals

COC Concentration Levels:

1,100µg/L

Treatment Level:

4-10m BGL

Treatment Area:

20m Barrier

Remediation Cost:

€50k

3DMe provides three stages of electron donor release from a single concentrate of specially designed polar molecules. When mixed with water on site, 3DMe forms a high-volume microemulsion, without the requirement of emulsifiers.

Upon injection into the groundwater, 3DMe initially moves out into the formation and adsorbs to the soil particles. As the molecule is designed to be appropriately soluble, it then gradually dissolves back into the groundwater, where it ferments to drive enhanced reductive dechlorination (ERD), but also reaches its critical micelle concentration (300 ppm), reforms as a microemulsion and moves further out from the injection point.

This process repeats to 'self-distribute' the 3DMe over large distances within the subsurface, without it washing away. This mechanism allows for wider injection spacing which reduced the number of injection locations.

Pilot Trial Application

Prior to a full-scale application being completed, it was determined that a pilot test should be completed. The intention was to determine how well the heterogeneous formation would accept the application, verify the injection spacing and confirm the efficacy of the treatment. A 20m wide barrier was installed perpendicular to groundwater flow. This consists of 5 injection points, forming two rows with 10m spacing within the rows and 4.5m in between rows (see fig. 4) This created an effective injection spacing of 5m perpendicular to groundwater flow.

Direct push injection was used, with the requisite dose of 3DMe injected at each location from 4m BGL (groundwater level) to 10m BGL (top of the competent bedrock).



Fig. 2 - The 3 Stage Release profile of 3DMe

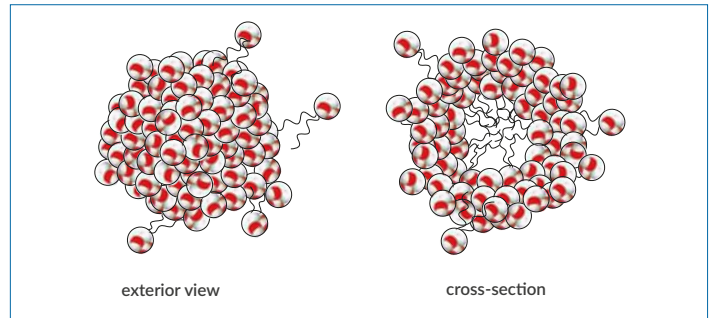


Fig. 3 - 3DMe micelle representation

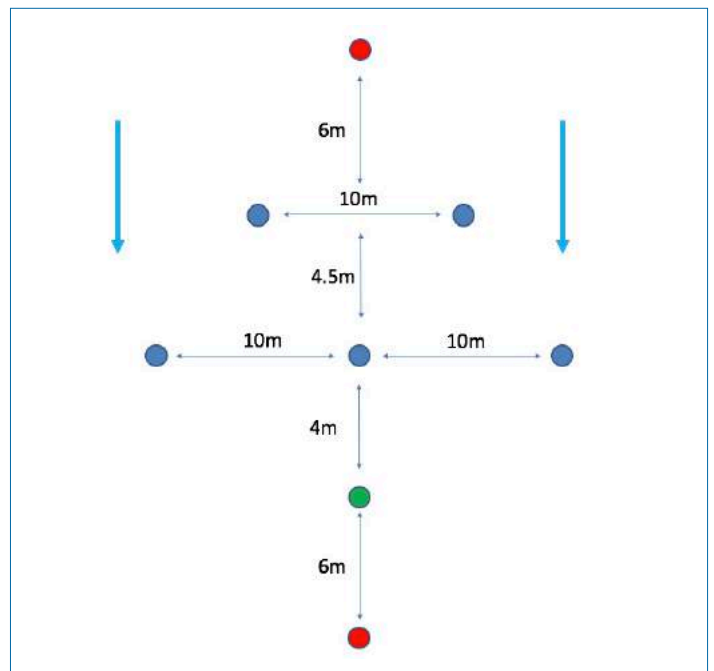


Fig. 4 - Injection configuration



Fig. 5 and 6 - Injection works on site

Results

Validation was completed over 12 months following application. During this period the small amounts of PCE and TCE were reduced in the groundwater to below detection limit. The main cis-1,2-DCE contamination was reduced by 99% to 13µg/L, well below the remedial target of 500µg/L. Sequential production and degradation of daughter products showed that full reductive dechlorination was achieved, with vinyl chloride (VC) concentrations peaking at 280µg/L, but then quickly decreasing to 12µg/L by the end of the validation period. Full reductive dechlorination was also evidenced by the production of ethene throughout the treatment.

Table 1 - Contaminant concentrations over time in µg/L

	Aug-16	Oct-16	Dec-16	Mar-17	May-17	Aug-17
	0	2	4	7	9	12
PCE	6	BDL	BDL	BDL	BDL	BDL
TCE	6	BDL	BDL	BDL	BDL	BDL
cis-DCE	1,100	1,100	210	68	10	13
VC	84	250	280	63	120	12
ethene	6	10	9	BDL	BDL	62

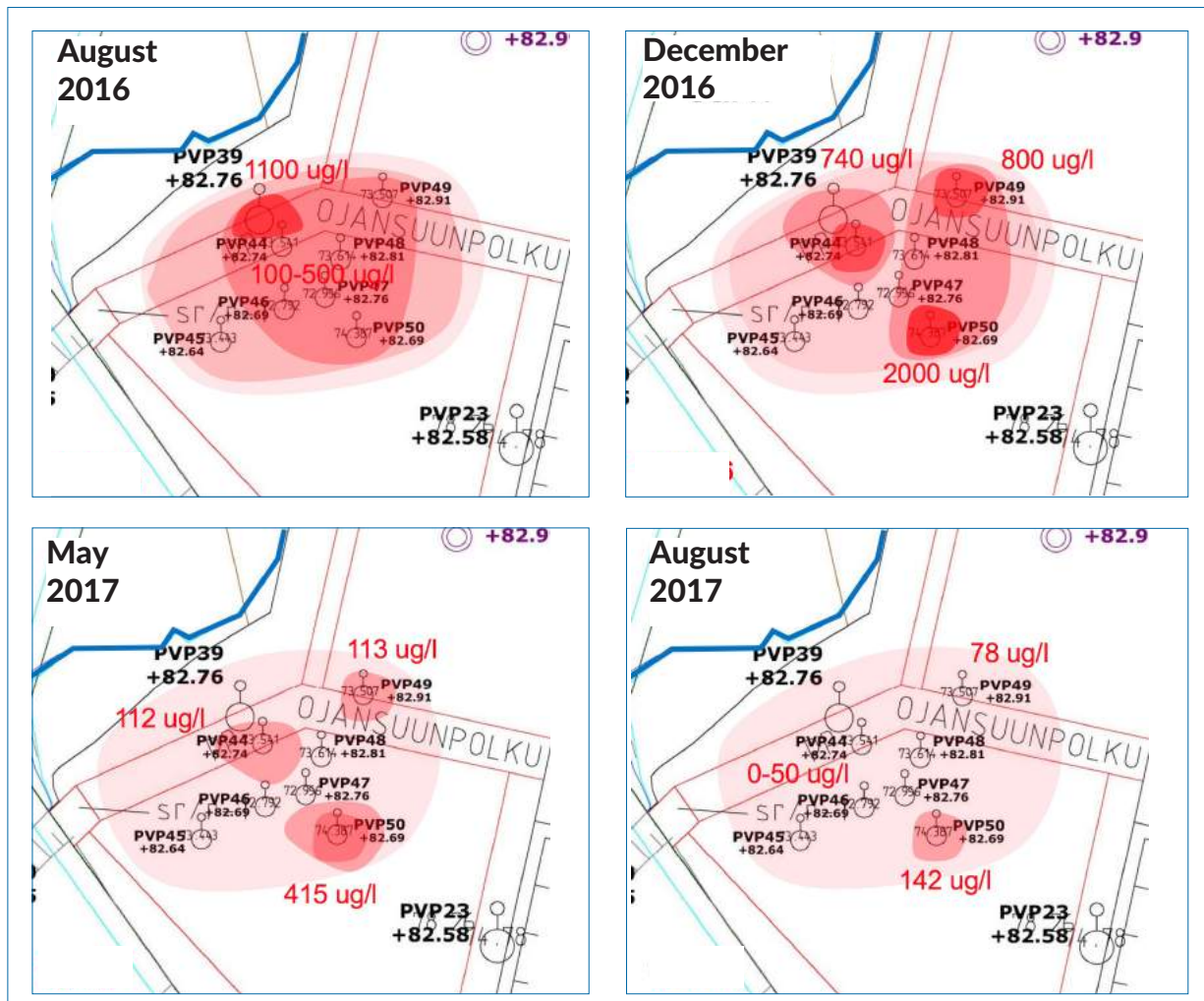


Figure 7 - Contaminant concentrations plots in target area over time

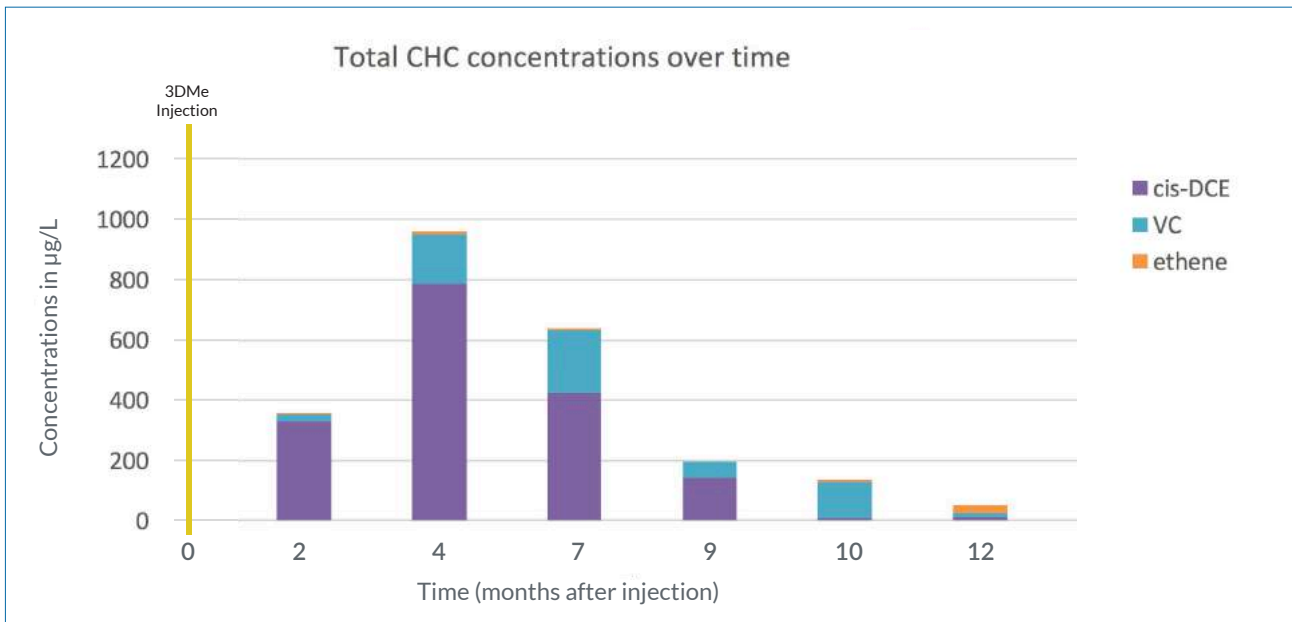


Fig 8 - Total CHC concentrations over time

Conclusions

- The pilot trial demonstrated the ability to apply 3DMe on a wide grid in a heterogeneous formation.
- The treatment successfully reduced the contaminant of concern by 98%, well below the remedial target values.
- Full reductive dechlorination of the contaminant was achieved.
- The pilot trial allows for the full scale treatment to be accurately designed and programmed.

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