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Reduction of the environmental load by determination of remediation goals

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Possible ways to reduce the environmental load

1. By choosing remediation method
2. By calculation of the remediation effect to reduce the remediation needed to a minimum

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Reduction of the environmental load by choosing remediation method

Remediation Methods	Geology			Target Source Zone			Function			Environmental Load		
	Sand	Clay	Chalk	Unsatu-rated	Satu-rated	Aquifer	Rem. Effec-tiveness	Relia-bility	Site condi-tions	Environ-mental	Energy	Work environ-ment
Excavation												
Thermal remediation	X	X	X	X	X	X	3	3	3	2	3	1
Soil Vapor Extraction												
GW extraction												
Chemical oxidation												
Air-sparging												

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Reduction of the environmental load by choosing remediation method

Preconditions

- The method can satisfy the necessary remediation degree
- Reliable
- Cost effective

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If we look at chlorinated solvents in clayey till

- These requirements limit the number of methods to two, i.e.
  - Excavation and thermal remediation
  - Other methods are speculative or, at best, unreliable

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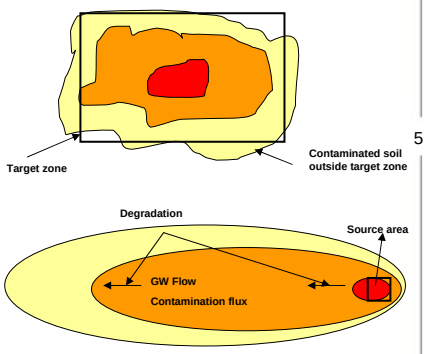
Calculation of the remediation effect

Presuppositions

- The extension, distribution and mass of contamination in the source zone is completely outlined
- Outlined so precisely that we can determinate the share of contamination outside the target zone and be able to establish if it is 1, 2 or 5% of the total amount
- The plume is determined with great accuracy, including determination of gw flow and the flux of contaminants
- Degradation in the plume is well determined



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Calculation of the remediation effect

Determination of the necessary and sufficient remediation degree

Achievements

- Calculate the remediation effect on the contamination in the plume
- Evaluate whether the examined remediation methods will satisfy our remediation goal
- Allow us on a qualified basis – to decide to stop e.g. a thermal remediation before we have achieved the remediation degree, which the method makes possible

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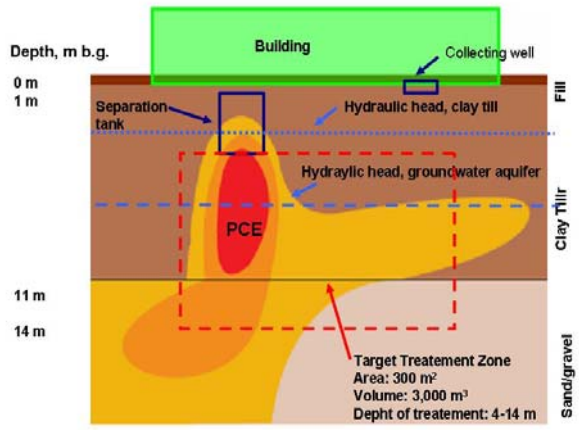
Calculation of the remediation effect

Example - Remediation of PCE contamination, Knullen 8

Contamination distribution



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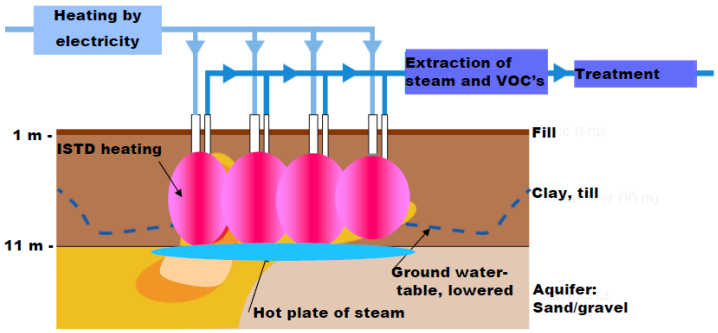
Calculation of the remediation effect

Scenario 1 Thermal remediation

Remediation method



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Calculation of the remediation effect

Scenario 1 Thermal remediation

Goal and remediation results

Goal

The remediation degrees, which the methods were expected to provide, i.e. 99 % in the clay and 95 % in the sand layer.

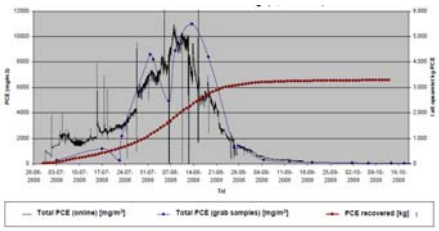
Plume shrinks to less than 300 m

Achieved

Remediation degree of 99,7% in the clay and more than 95% in the sand layer.

Removed more than 3500 kg PCE

Remains in the target zone were estimated to 10 kg.



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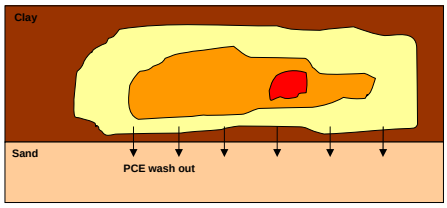
Calculation of the remediation effect

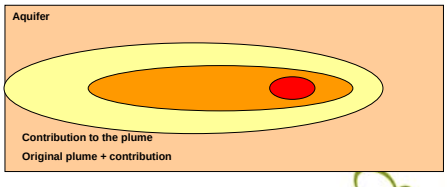
Determination of the necessary and sufficient remediation degree

Calculation concept

The calculations were carried out in 2 steps

1. The percolation of contaminants from the clay soil to the groundwater aquifer is calculated.
2. The wash out contribution to the plume as well as the wash out contribution including contribution from the original plume is calculated by a contaminant transport model.





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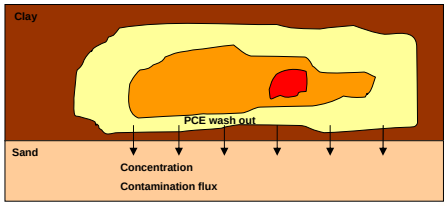
Calculation of the remediation effect

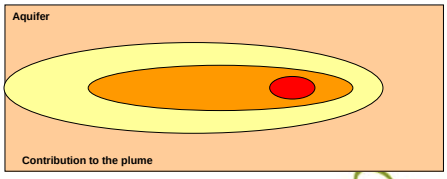
Determination of the necessary and sufficient remediation degree

Verification
scenario without remediation

1. The calculated percolation of PCE to the aquifer. Concentrations and contamination flux in the aquifer was compared to the amounts found in the investigations

2. The initial calculations were made with 2 degradation rates for PCE, a high rate and a low rate. The calculations with both rates were compared to the actually observed contamination distribution in the plume.





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Calculation of the remediation effect

Determination of the necessary and sufficient remediation degree

Verification – low degradation rate

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Calculation of the remediation effect

Case – Remediation of PCE contamination, Knullen 8

The possibilities to reduce the environmental load will be illustrated through 3 scenarios

1. Describes the remediation carried out. A 99% remediation degree was achieved.
2. The possibilities of reducing the environmental load. The effect of shortening the heating period by 30 days was simulated. The shortening of the heating period corresponds to a 94% remediation degree.
3. Describes remediation by means of excavation in the most contaminated part of the source zone. The excavation scenario corresponds to a 85% remediation degree.

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Calculation of the remediation effect

Scenario 1 Thermal remediation

Contamination distribution 50 years after the 99% remediation

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Calculation of the remediation effect

Scenario 2 Thermal remediation, reduced heating period

Contamination distribution 50 years after the 94% remediation

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Calculation of the remediation effect

Possible reduction of the environmental load – scenario 2

Reduction of environmental load

- A reduction of the heating period by 30 days would have resulted in a saved amount of energy of 410 MWh
- This corresponds to a reduction of 20% of the total energy consumption
- Saved costs is only about 7%

Remediation effect

- 210 kg PCE remains in source zone
- The contribution to the plume from the remaning contaminants will for many years be smaller than the contibution from remains in the plume
- The objective of a plume length less than 300 meters not fulfilled
- Maximum plume length will be approx. 700 meters

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Calculation of the remediation effect

Scenario 3 excavation and reductive dechlorination

Contamination distribution 50 years after remediation

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Calculation of the remediation effect

Possible reduction of the environmental load – scenario 3

Reduction in environmental load

- Energy consumption only approx. 50 MWh
- This corresponds to a reduction of 95% the total energy consumption
- Must be combined with a long term In Situ treatment effort.

Remediation effect

- 500 kg remains in source zone
- The recontaminating contribution to the plume will largely correspond to the condition without remediation
- The objective of a plume length less than 300 meters not fulfilled
- Maximum plume length will be approx. 900 meters

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CONCLUSION AND PERSPECTIVE

Remediation degree	Reduction in wash out contribution	Reduction in plume lenght (without remediation > 1000 m)	Reduction in energy consumption
Thermal 99% degree rem.	99%	Reduced to approx. 400 meters	-
Thermal 94% degree rem.	94%	Reduced to approx. 700 meters	20%
Excavation	85%	Reduced to approx. 900 meters	95%

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- **Define the contamination conditions**
- **Determine exactly how much contamination to remove**

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CONCLUSION AND PERSPECTIVE

- Calculation of the remediation effect at least improves our ability to choose the best remediation method.
- In remediation with thermal methods there seem to be relatively great possibilities of reducing the energy consumption and consequently the environmental load on the climate.
- In this case it seems that it could have been possibly to reduce the energy consumption by 20 %.
- On the other hand, when looking at the durability of the 94% scenario as well as risks and economy, not only advantages were achieved. Reducing the heating period causes that you either must be willing to extend the treatment zone of the plume or carry out long-term remediation in the plume.
- With the present conditions, the excavation scenario cannot meet the remediation goal. Therefore, the solution must be combined with long-term remediation in the source area or in the plume. Although this method has a very low energy consumption, the method is not to be recommended in cases like this.

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Thank you for your attention

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