Aspects of investigation and remediation of ground water contamination in connection with brownfield revitalization

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Structure

• Short presentation of Dr Eisele group of companies
• Methods of ground water investigation
• Examples (case studies) for hydraulic remediation in connection with brownfield revitalization
Dr Eisele group of companies (1)

Operating and holding company
Dr. Eisele mbH & Co. KG

Environmental and construction engineering consultants
Dr. Eisele mbH

Planning and project development company
Dr. Eisele mbH

Dr Eisele group of companies (1)
• A lot of large-scale brownfields can not be decontaminated completely due to costs
• The revitalization of such brownfields can be achieved if the remediation measures are limited to the prevention of hazards
In the majority of contamination cases, ground water pollution causes the need for action.

The prevention of hazards concerning the ground water only is achievable if the transport mechanisms and the distribution of contaminants in the water logged zone is clarified.
This presentation deals with methods of ground water investigation and the implementation of hydraulic remediation methods (safeguarding and decontamination) in connection with brownfield remediation.
Investigation steps (1)

• Detailed investigation of the aquifer
  – aquifer structure
  – aquifer boundaries
  – hydraulic parameters

• Detailed investigation of groundwater contamination
  – contaminant concentration distribution
Investigation steps (2)

• Validation by numerical groundwater flow and transport modeling
  – verified information of groundwater contamination (immission)
  – verified information of contaminant mass fluxes (emission)
  – base for the calculation of hydraulic remediation scenarios
Hydraulic tests like

• pumping tests
• injection tests
• slug & bail tests
• borehole tests with packers (slug-, drill-stem- or pulse-tests)
Aquifer diagnostics by interpreting the test draw-down or build-up data using the most modern methods of oil industry

- plot of draw-down or build-up data within double logarithmic scale
- identification of the aquifer model using the typical gradient of the first derivative
- accurate determination of hydraulic parameters by type curve fitting
- determination of well quantities (well bore, storage, Skin)
- determination of aquifer boundaries
Principle of aquifer diagnostics (1)

Horizontal line indicates infinite acting radial flow in an ideal aquifer

draw-down data

first derivative
The typical slope in late time data with the gradient of -1 indicates the influence of a recharge boundary like a river or lake.
Typical slopes in late time data with the gradients up to +1 indicate barrier boundaries, parallel barrier boundaries (like channels) or closed groundwater reservoirs.
Variants for a detailed investigation of groundwater contamination (1)

Classical approach: groundwater samples out of observation wells

advantages: - fast, direct
disadvantages: - many observation wells needed
- for the gaps between wells only interpolation possible
Variants for a detailed investigation of groundwater contamination (2)

Modern approach: determination of contaminant mass fluxes by integral pumping test analysis

advantages:
- total mass flux and concentration distribution can be obtained
- no interpolation of point scale concentration measurements is needed
- fewer observation wells necessary

disadvantages:
- pumping tests and - if necessary -
- cleaning of the discharge needed
Principle of integral pumping tests

- well
- catchment area
- plume

Graph showing concentration ($C_p$) over time (days) for a pumping test.
Principle of analytical inversion

Analytical inversion for infinite radial flow, groundwater velocity negligible, after TEUTSCH et al. (2000)

\[
Cx_i = \frac{\pi Cp_i - 2 \sum_{k=1}^{i-1} Cx_k \left[ \arccos \left( \frac{r(t_{k-1})}{r(t_i)} \right) - \arccos \left( \frac{r(t_k)}{r(t_i)} \right) \right]}{2 \arccos \left( \frac{r(t_{i-1})}{r(t_i)} \right)};
\]

Result: plume with a concentration of 90 in a distance 5-8 m form the pumped well

\[
r(t) = \sqrt{\frac{Qt}{\pi bn_e}}
\]
Principle of source detection

control plane 1

well 1

well 2

well 3

well 4

control plane 2

Groundwater flow

Integral pumping tests

Plume

Source

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Investigation of groundwater contamination
Case study: integral groundwater investigation Ravensburg (SW-Germany) (1)

Project data

- 1,000,000 m² area, recently or formerly used by industry (engine construction industry, gas plant, metal working, chemical industry), gas stations, dry-cleanings, disposal sites, residential areas
- known and assumed ground water contamination by HVHH, PAH, HC, BTEX, phenol, cyanide and heavy metals
Case study: integral groundwater investigation Ravensburg (SW-Germany) (2)

Tasks

• detection and assessment of ground water contamination in connection with urban planning and site revitalization
• evaluation of contaminant emission (ground water)
• discrimination of contaminant plumes
• allocation of plumes to potential impact-areas and pollution emitters
• identification of areas without ground water impact
Methods

• numerical ground water flow and transport model for planning the investigations, validation of the results and backtracking the determined groundwater pollution to emitters

• integral pumping tests and test analysis tools
Engine construction industry (known pollution)

Chemicals stock (unknown pollution)
Case study: revitalization of a former industrial site in Romania (1)

- 197,000 m²
- Former use as fuel storage site
- Located in the northern part of Bucharest
- Close to lakes
- Close to the Airports
- Future development area
Case study: revitalization of a former industrial site in Romania (2)
Case study: revitalization of a former industrial site in Romania (3)

Bombardment 1944 during World War II
Case study: revitalization of a former industrial site in Romania (3)

Grid of ground water model

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Case study: revitalization of a former industrial site in Romania (4)
Case study: revitalization of a former industrial site in Romania (5)

- Infiltration of cleaned water into inflow for enhancement of biological degradation
- Air-injection to provide enough oxygen to enhance naturally existing biological degradation
- Pump-and-treat system: prevention of contaminant movement off BANEASA-site
- Installation of pump system in at least 15 wells in the ground water run-off
Case study: revitalization of a former industrial site in Romania (6)

mode of operation of withdrawal (blue dots) and infiltration (red dots) of ground water (particle tracking)
Case study: revitalization of a former industrial site in Romania (7)

Petrom City – Draft

The closed oval solitaire buildings group themselves radial around the Petrom Plaza. The Solution Center is divided in two connected solitaires.
Case study: revitalization of a former industrial site in SW-Germany (1)

former KIENZLE-site, Schwenningen
former fabrication of watches
area: 47,000 m²
location: city center
not used for 18 years
Case study: revitalization of a former industrial site in SW-Germany (2)

landfill with radioactive components

HVHH contamination

ground water flow

max. conc.: > 20 mg/l HVHH
mass flux: > 2.5 kg/d
Case study: revitalization of a former industrial site in SW-Germany (3)

removal of contaminant sources

technical safeguarding of disposal site

hydraulic ground water safeguarding

(pump and treat)
Case study: revitalization of a former industrial site in SW-Germany (5)
Eu agradeço pela atenção!