

TRANSNATIONAL TRAINING ON SUSTAINABLE REMEDIATION

TRAINING MATERIALS

Bydgoszcz, 10 May 2017



Venue

Idea Space for Business in Bydgoszcz Industrial and Technological Park
Bydgoskich Przemysłowców 6, 85-862 Bydgoszcz





The Transnational training on sustainable remediation is organized within the Interreg Central Europe project ReSites - Environmental Rehabilitation of Brownfield Sites in Central Europe.

ReSites is a transnational cooperation project that seeks to improve the environmental management of unused or underused industrial areas. The project aims to achieve this through the definition of strategies and tools that are based on a sustainable, integrated approach to make functional urban areas (FUAs) cleaner, healthier and more liveable places. ReSites partnership is made of 11 partners from 5 central Europe countries working together to share and enhance knowledge on integrated environmental management of brownfields. The project started in June 2016 and will end in May 2019.

ReSites aims at providing the public sector with new skills and know-how on brownfield regeneration in order to improve the sites' environmental conditions producing a positive impact on the surrounding inhabited areas. Therefore partners will organize 2 transnational trainings, 9 local trainings and 8 site visits for public employees and stakeholders to increase their capacity to effectively manage brownfield regeneration in a sustainable way.

The first transnational training is organized in Bydgoszcz and will tackle the subjects of sustainability measures in remediation. The knowledge gained will support partners in the implementation of their pilot activities and will favour the exchange of know-how to better deal with the management of brownfields. The training takes place on the area of the former chemical factory which is also the subject of project work for the Bydgoszcz partner.

The training materials include abstracts from the training experts' presentations

- ✓ Nicole's position paper on sustainable remediation
- ✓ green remediation techniques (reducing the carbon footprint)
- ✓ sustainable remediation (stakeholder involvement, broadening the scope and using time)
- ✓ practical examples of sustainable brownfield remediation
- ✓ challenges for brownfield site owners
- ✓ sustainable management aspects of the remediation process
- ✓ methodology for assessment of sustainable remediation solutions, selection of most appropriate approaches
- ✓ aspects of cost-efficiency in remediation
- ✓ innovative monitoring techniques
- ✓ introducing Bydgoszcz pilot site
- ✓ hydrogeological modelling of contamination



Training agenda

Morning session: Sustainable remediation approaches

8.00	Meeting at the hotel, Hotel pod Orłem (bus trip to meeting venue)
8.30 - 8.45	Registration
8.45 - 9.00	Welcome speech
9.00 - 9.45	Erwin van de Pol - European network NICOLE <ul style="list-style-type: none"> ✓ <i>short introduction Nicole's position paper on sustainable remediation;</i> ✓ <i>green remediation techniques (reducing the carbon footprint)</i> ✓ <i>sustainable remediation (stakeholder involvement, broadening the scope and using time)</i>
9.45 - 10.30	Klaus Heise, Harald Zauter - Brownfield Authority (DE) <ul style="list-style-type: none"> ✓ <i>practical examples of sustainable brownfield remediation</i> ✓ <i>challenges for brownfield site owners</i>
10.30 - 10.45	Coffee break
10.45 - 11.30	Thomas Ertel - et environment and technology (DE) <ul style="list-style-type: none"> ✓ <i>sustainable management aspect of remediation process.</i> ✓ <i>methodology for assessment of sustainable remediation solutions, selection of most appropriate approaches.</i> ✓ <i>aspects of cost-efficiency in remediation</i>
11.30 - 12.15	Wojciech Irmiński (PL) <ul style="list-style-type: none"> ✓ <i>innovative monitoring techniques</i>
12.15	Press conference
12.15 - 13.15	Lunch

Afternoon session: Pilot site visit and practical implementation of methods

13.15 - 13.30	Trip to Exploseum
13.30 - 14.00	Exploseum, example of industrial heritage of brownfield area
14.15 - 14.45	Dorota Pierri, Mariusz Czop - AGH University of Science and Technology (PL) <ul style="list-style-type: none"> ✓ <i>introducing Bydgoszcz pilot site in Exploseum movie room</i>
14.45 - 16.15	Dorota Pierri, Mariusz Czop - AGH University of Science and Technology (PL) <ul style="list-style-type: none"> ✓ <i>pilot site visit - former Zachem and Łęgnowo</i>
16.15- 16.45	Coffee break - Idea building
16.45 - 18.00	Parallel sessions <ol style="list-style-type: none"> 1. Hydro geological modelling of contamination plumes - presentation of IT programme and testing by participants - Dorota Pierri, Mariusz Czop 2. Speed dating with experts 3. Poster Session: Pilot Sites, LUMAT, UTP
20.00	Dinner



Experts introduction:



MR. ERVIN VAN DE POL has been working as consultant for 20 years on projects related to soil remediation, redevelopment and sustainability at Witteveen+Bos consulting engineers. As part of his employment at Witteveen+Bos, Mr. Van de Pol is very active in the Dutch Sustainable Remediation Forum (SURF-NL) and in the Sustainable Remediation working group of Nicole. Nicole is the Network for Industrially Co-ordinated Sustainable Land Management in Europe. In his presentation Mr. Van de Pol will represent Nicole and demonstrate how the industry in Europe is involved in sustainable remediation and sustainable land management.



DR. THOMAS ERTEL is owner of the company et environment and technology with key competences as a project manager in environment and landfill issues as well as brownfield redevelopment. Key qualifications of Dr. Thomas Ertel are investigation and remediation of contaminations of groundwater and soil, waste management, brownfield redevelopment project management. In recent years he was main expert for the assessment of soil and groundwater contamination and landfills at the industrial sites Bussi and Spinetta and technical expert to clarify liabilities for groundwater pollution caused by an ancient landfill site. Experienced in many European projects dealing with brownfields.



MR. KLAUS HEISE is team leader in the Brownfield Authority of Saxony Anhalt (Landesanstalt für Altlastenfreistellung Sachsen-Anhalt). After some years of experience in the field of remediation of contaminated sites in a consulting agency, he joined the Brownfield Authority in 2000. As one of his tasks he was involved in the remediation of former heavy metal mining and smelting sites in the Mansfelder Land. Presently Mr. Heise is responsible for the clean-up activities in the megasites Magdeburg-Rothensee (industrial area of the port of Magdeburg) and the Natural Gas Field "Altmark". Additionally he is representing the Brownfield Authority in the WFD working groups of Saxony-Anhalt and compiling brownfield related contributions to the WFD reporting system



MR. HARALD ZAUTER has been working as hydrogeologist in several companies and in the international co-operation with developing countries. Since 2010, he is project officer in the Brownfield Authority of Saxony Anhalt (Landesanstalt für Altlastenfreistellung Sachsen-Anhalt). Presently his focus is the remediation of contaminated groundwater at the former chemical plant Bitterfeld-Wolfen in Saxony Anhalt. The principal activity at this megasite is the extraction of about 2 million cubic meters of groundwater containing chlorinated solvents, pesticides, remains from insecticide production and various contaminants and a complex water treatment system



DR. WOJCIECH IRMIŃSKI is geologist and since 1989 works on the environmental protection projects. Till 2008 was employed by Polish Geological Institute (national geological survey). 2010 established the entity Geo-Logik Wojciech Irmiński, which main goal are investigation and evaluation of soil-groundwater system quality as well as remediation and monitoring. Since 2004 he is certified specialist for soil- and groundwater sampling on the brownfield areas. He was partner or subcontractor by a few EU brownfield projects. Each year he elaborate a lot of brownfield expertise and remediation plans. Many of accepted plans were successful introduced and finalized. His challenge are cases of heavy contamination with common opinion “hopeless case”.



MARIUSZ CZOP PhD Eng. is an assistant (adjunct) professor at AGH University of Science and Technology in the Department of Hydrogeology and Engineering Geology. He is a specialist in hydrogeochemical and hydrodynamical modelling of physical and chemical processes in the groundwater environment, including reactive and multiphase transport of mass and water-rock-gas interactions. Author and co-author of about 120 scientific papers and about 350 research reports in practically all aspects of hydrogeology. Principal manager in the project of the remediation planning for the industrial waste site ‘Zielona’ in the former ‘Zachem’ Chemical Plant in Bydgoszcz and in the other projects related to the restoration of contaminated brownfield areas



DOROTA PIERRI PhD Eng. is a research - teaching assistant at AGH University of Science and Technology in the Department of Hydrogeology and Engineering Geology. She has 8-years’ experience in hydrogeological modelling, hydrogeochemistry of organic pollutants and groundwater and soil contamination. She is an author and co-author of about 20 scientific papers and about 35 research reports in the field of applied hydrogeology, especially related to the groundwater and soil remediation and brownfields regeneration. Leader expert in the groundwater and soil pollution in the area of the former ‘Zachem’ Chemical Plant in Bydgoszcz and remediation planning for the industrial waste site ‘Zielona’

NICOLE
Network for Industrially Co-ordinated Sustainable Land Management in Europe



Best Practices on Sustainable Remediation of contaminated land

Bydgoszcz, May 10th 2017
Erwin van de Pol

About myself




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Content

Content of this presentation:

- About Nicole
- Green Remediation
- Sustainable Remediation



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What is NICOLE?

NICOLE is

- A network in Europe, linking professionals from the industry, service providers and academics in the field of contaminated land management
- a leading organisation in the development and promotion of state-of-the-art solutions for contaminated land management

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Nicole's members

NICOLE's members

- 23 industrial companies
- 50 service providing / technology developing companies
- 32 academic members from universities and research organisations, other (funding organisations, other networks, governmental organisations)
- Total 105 (2015)

From Sweden, Poland, Germany, UK, France, Belgium, Spain, Greece, Ireland, Luxembourg, Norway, Czech Republic, Romania, Austria, Switzerland, USA, Finland, Bulgaria, Denmark, Netherlands, Italy

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NICOLE'S Activities

Nicole's Activities:

- **Two workshops per year** on all aspects of contaminated land management
- **Working Group meetings:** Sustainable Remediation, Emerging Contaminants, Regulatory Issues
- Yearly **Technology Award**
- Publications, (joint) position papers and reports

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Position Paper SR

Risk-Informed and Sustainable Remediation

Joint Position Paper with Common Forum
On Risk-Informed and Sustainable Remediation

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Position Paper SR

Key points of the position paper:

1. Agree on the necessity for protecting population and the environment against contaminated media
2. SR involves the assessment of risks and benefits
3. More sustainable use of resources
4. Sustainability can not be quantified in absolute terms : stakeholder engagement is crucial
5. Integration of the elements of sustainability at the early beginning but also throughout the life of the project
6. Nicole's Road Map (2010) and the Claire (2010) document on SR are considered as Good Practice

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Nicole's vision on SR

Nicole's vision on SR:

- The earlier in the process the more sustainability gain
- Communication is the number one barrier and enabler
- Green remediation vs. Sustainable

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Green Remediation

Why green remediation?

- a Quick Win: You can start today
- More sustainable use of resources
- Unique Selling Point in Tendering



[Example SBNS-remediation Bilthoven](#)

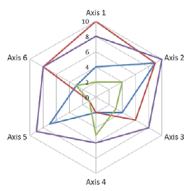
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Examples of green remediation

- Examples:

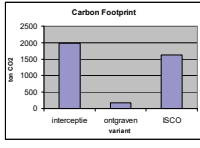
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Green Remediation



NICOLE does not prescribe Tools!
... but there is a lot available:

- Qualitative: narrative analysis or ranking
- Semi quantitative
 - Multi-criteria analysis, weightings and scores
 - Pairwise comparison (Weighing of benefits and burdens)
- Quantitative
 - Cost Benefit Analysis
 - Life Cycle Assessment
 - Etc.



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Green Remediation

Green Remediation is a good starting point, however:

- Considers only Environmental impact
- End of Pipe methodology

So we need there is more...

The Venn diagram shows three overlapping circles: Social (top), Environmental (left), and Economic (right). The intersection of Social and Environmental is labeled 'Biodiversity', the intersection of Social and Economic is 'Quality', and the intersection of Environmental and Economic is 'Value'. The center intersection of all three is 'Sustainability'. Below the Venn diagram is a bar chart with 'SUSTAINABILITY BENEFIT' on the y-axis and 'PROJECT STAGE' on the x-axis. Two bars are shown: the first is taller and labeled 'Setting the remediation specification and strategy', the second is shorter and labeled 'Setting the remediation technical approach'.

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Sustainable Soil Remediation

The flowchart shows a process starting with 'APPLICATION' leading to 'IMPLEMENTATION'. The implementation phase is divided into 'REALISING' and 'SUPPORT'. 'REALISING' includes 'Review opportunities & objectives', 'Review options', 'Review parties involved', and 'Agree objectives & options'. 'SUPPORT' includes 'Agree indicators/metrics', 'Assign weighting (eg. importance)', 'Define boundaries', and 'Agree tools/techniques'. This leads to 'AGREED APPROACH', which then leads to 'AGREED FINDINGS'. 'AGREED FINDINGS' leads to 'DESIGN VERIFICATION'. A vertical dashed line on the right is labeled 'INDICATED SUSTAINABILITY CRITERIA'. A box on the left is labeled 'SUSTAINABILITY APPRAISAL' and includes 'Sustainability appraisal', 'Uncertainty to appraisal', and 'Findings/conclusions'.

The Road Map of Nicole:

1. Identify and review parties
2. Review objectives and starting points
3. Agree on conceptual site model (source-path-receptor linkage)
4. Explore options
5. Agree on sustainability indicators
6. Agree on tools/methodology e.g. Sustainability appraisal based on decisive benefits and burdens
7. Assign priorities or weightings
8. Technical detailing of options
9. Agree on findings (Justification rule)

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Sustainable Soil Remediation

How to use the roadmap for sustainable remediation of Brownfields?

The images show: A-site: A large circular structure under construction in an open field. B-site: A large open field with a sign in the foreground. C-site: A large area of land with a complex network of paths or roads, possibly a remediation site.

A-site B-site C-site



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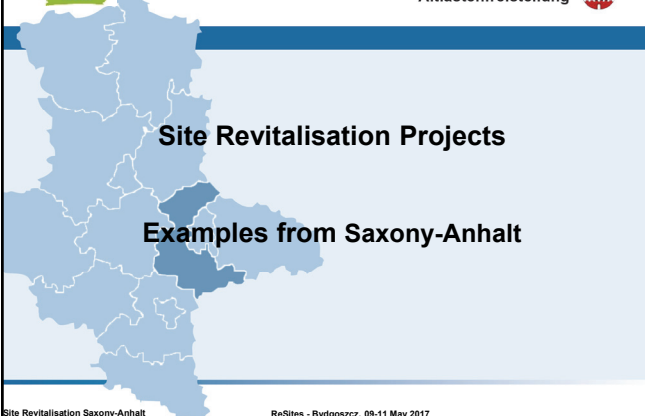
Thank you for your attention

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Landesanstalt für Altlastenfreistellung 

Site Revitalisation Projects

Examples from Saxony-Anhalt





Site Revitalisation Saxony-Anhalt ReSites - Bydgoszcz, 09-11 May 2017


Landesanstalt für Altlastenfreistellung 

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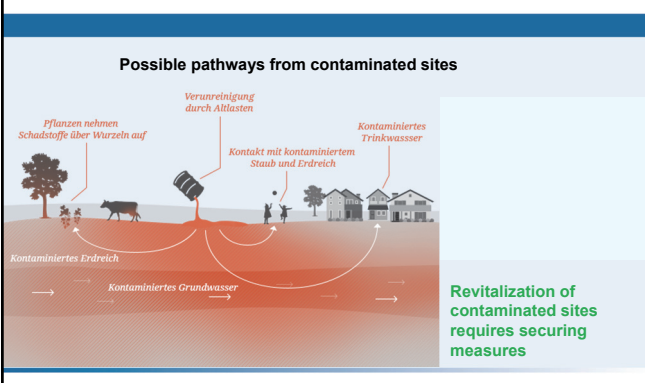
1. Introduction
2. Magdeburg Rothensee
3. Messma Magdeburg
4. Weissandt-Görlzau
5. Megasite Bitterfeld
6. RESITES TOOL

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Introduction

Possible pathways from contaminated sites



Revitalization of contaminated sites requires securing measures



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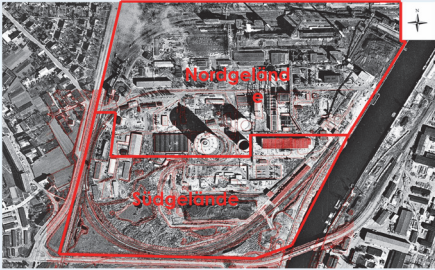
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Megasite Magdeburg-Rothensee

Former Main Gas Works





Subjects of protection according to planned use:
 - Health of employees
 - Buildings

Hazards from:
 - Tar
 - Benzene

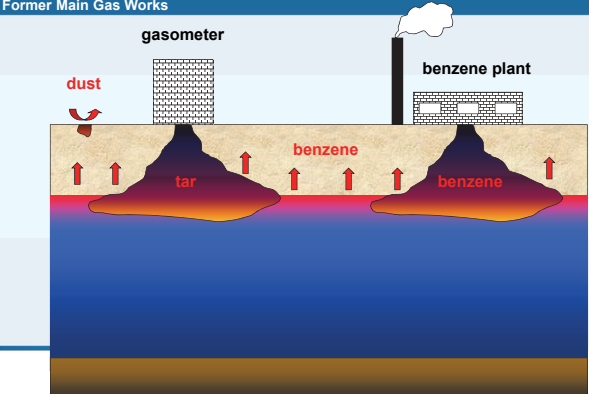
- Northern part of former main gas works, operational from 1930 to 1993
- The aim is to build the production facilities for the laminated wood producer (Nordlam)

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Megasite Magdeburg-Rothensee

Former Main Gas Works



gasometer benzene plant

dust tar benzene benzene

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Interreg CENTRAL EUROPE ReSites

Megasite Magdeburg-Rothensee Landesanstalt für Altlastenfreistellung

Former Main Gas Works

Securing measure: interruption of exposure pathways

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Interreg CENTRAL EUROPE ReSites

Megasite Magdeburg-Rothensee Landesanstalt für Altlastenfreistellung

Former Main Gas Works

Securing measure: interruption of exposure pathways using plastic sealing

Revitalisation possible with partly remaining contamination in the soil and in the groundwater!

Site Re

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Megasite Magdeburg-Rothensee Landesanstalt für Altlastenfreistellung

Former Main Gas Works

- Located NE of Magdeburg, at the port of Magdeburg
- Size approx. 10 km² with 96 old industrial locations
- Today increasingly used by industry, trading and service companies

Subarea TF12 former main gas production site

- Strongly contaminated with PAH, BTEX, NSO heterocyclic compounds, cyanide, ammonia, phenols
- remedial actions in planning stage → partial groundwater containment → inflow reduced by 80%
- remaining 20% inflow: EMNA treatment (Enhanced Monitored Natural Attenuation)

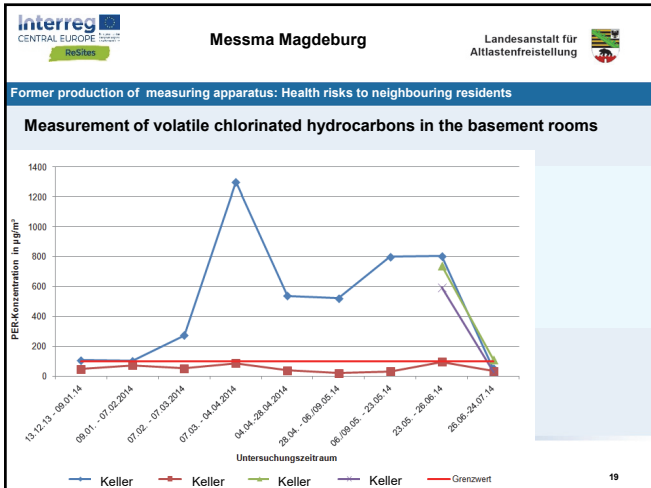
Field test site for EMNA

- Stage 1: off site
Batch tests and column experiments
- Stage 2: on site
Infiltration of H₂O₂ subs. technical oxygen
- Stage 3: on site
Infiltration of airborne oxygen

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Messma Magdeburg Landesanstalt für Altlastenfreistellung

Former production of measuring apparatus: Health risks to neighbouring residents



Remediation targets ?

Tetrachloroethene 100 µg/m³
Limit value according to German law (2. BImSchV) for residential rooms next to dry cleaning, 7-days-mean value

Tetrachloroethene 250 µg/m³
WHO

Tetrachloroethene 10 µg/m³
Recommended by German expert committee for immission control (Länderausschuss), annual mean value 1997

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- Magdeburg Rothensee
- Messma Magdeburg
- **Weissandt-Gölsau**
- Megasite Bitterfeld
- RESITES TOOL

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Weissandt-Gölsau

Former carbonize plant

Industrial park with 1.500 employees

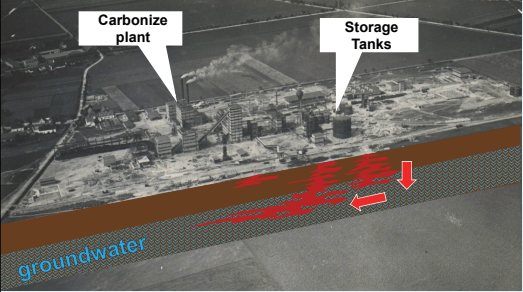


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Weissandt-Gölsau

Former carbonize plant



1876 – startup of lignite mining 1928 – startup of carbonize plant
 1965 – shutdown of carbonize plant 1965 – VEB Orbitaplast: production of polyethylene products

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Former carbonize plant

pollutant soil gas groundwater groundwater run-off

Hazards for buildings, infrastructure and employees as a result of gas formation (methane) due to microbiological degradation processes!

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Former carbonize plant

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Former carbonize plant

Carried out securing measure



Pressure relief through natural degradation in the biological filter

Use of microbiological processes

Well head gas-proof sealed


Microbiological oxidation of methane and aromatic hydrocarbons in the biofilter

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Weissandt-Görlau




Former carbonize plant

Carried out securing measure



Biofilter at several places in the industrial park

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Weissandt-Görlau


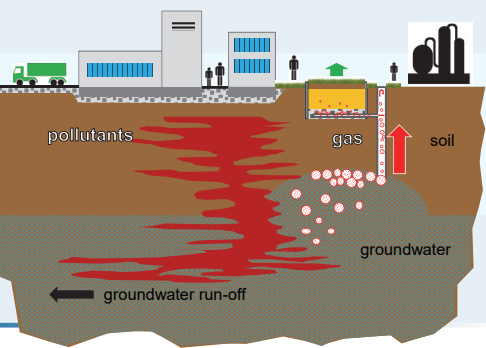
Former carbonize plant

Modern infrastructure



8.2 million EUR spent for hazard protection

1.500 jobs

MNA- concept agreed with relevant authorities



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- Messma Magdeburg
- Weissandt-Görlau
- **Megasite Bitterfeld**
- RESITES TOOL

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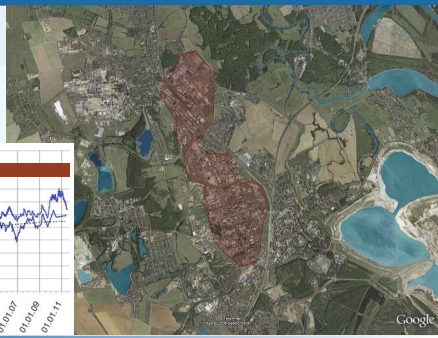
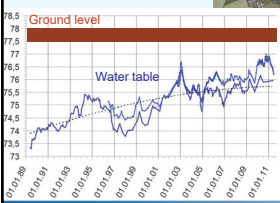
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Megasite Bitterfeld

Landesanstalt für Altlastenfreistellung

Rising of groundwater in the Bitterfeld area

open pit lignite mining
operational 1839 – 1992
flooding of Goitsche Lake in 2002

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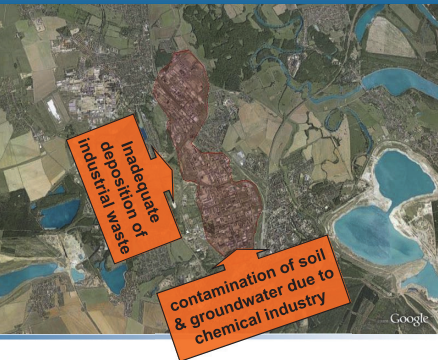
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Megasite Bitterfeld

Landesanstalt für Altlastenfreistellung

Rising of groundwater in the Bitterfeld area

Chemical production as from 1893
Major European centre of chlorine chemistry
Today: wide spread contamination of soil and groundwater (chlorinated organic compounds)



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Megasite Bitterfeld

Landesanstalt für Altlastenfreistellung

Remediation measures for groundwater contamination



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Megasite Bitterfeld


High groundwater level threatens buildings and workers



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Megasite Bitterfeld


High groundwater level threatens buildings and workers



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Megasite Bitterfeld


High groundwater level threatens infrastructure



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Megasite Bitterfeld


Example No 3 – sewer rehabilitation





Replacing old sewer pipes in Hauptstrasse area

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- Messma Magdeburg
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- **RESITES TOOL**

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RESITES TOOL


Requirements to provide information

Main targets of the RESITES - Tool

- ReSites Tool is planned as a site information system for online collaboration of public authorities that are concerned with brownfield rehabilitation.
- It will be an easy to use Web GIS tool including only the most essential maps and data.
- Sensitive data are included as metadata describing the content and providing information about the location of the original data.

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RESITES TOOL


Requirements to provide information

Main information for brownfield evaluation:

- Maps showing use-related needs of remediation, distinguished in industrial use, agricultural purpose, residential use
- Maps showing the environmental medias affected by pollutants: soil, soil gas, groundwater, surface water, atmospheric air
- Risk maps showing active exposure pathways & exposure pathways to be interrupted (related to future use options)
- Maps showing depth to groundwater table (important for the issues of hydrostatic uplift and wet basement walls)
- More information → RESITES TOOL QUESTIONNAIRE

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**Many thanks
for
your attention**

We are looking forward to a good cooperation

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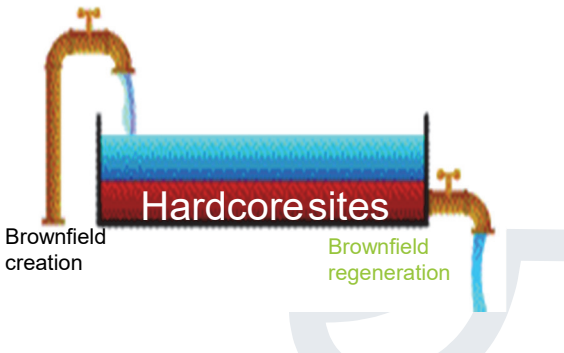


environment and technology
berät und betreut Wirtschaft,
Institutionen und Kommunen

Brownfield Regeneration Management – sustainable and cost-efficient

Dr. Thomas Ertel, et environment and technology
ReSites – Transnational Training on Sustainable
Remediation, Bydgoszcz, 10 May 2017

Brownfield Regeneration - an ongoing process

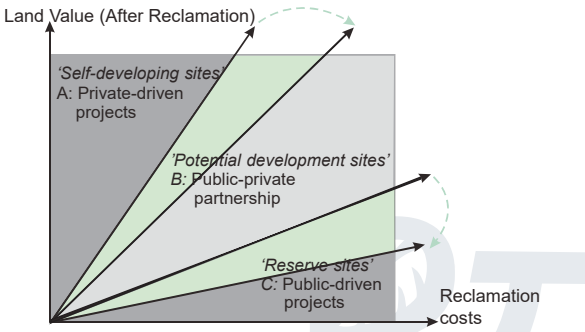


Brownfield creation

Hardcore sites

Brownfield regeneration

Cabernet A-B-C model



Land Value (After Reclamation)

Reclamation costs


'Self-developing sites'
A: Private-driven projects

'Potential development sites'
B: Public-private partnership

'Reserve sites'
C: Public-driven projects

REVIT puzzle

What is obvious: Brownfield revitalisation is a long term and complex process and a wide range of professional disciplines has to be involved.



REVIT

Marketing Stakeholder engagement Contamination Natural assets Industrial Heritage Sustainable planning Finance Water Management Politics

What we have learned.....

Prepare the ground – environmental remediation



2017-09-19 13:33

Industrial Heritage



Hengelo
Hart van Zuid

COBRAMAN environment and technology CENTRAL EUROPE EUROPEAN UNION EUROPEAN REGIONAL DEVELOPMENT FUND

What we have learned.....

Stakeholder engagement



What we have learned.....

Financing – a miracle?

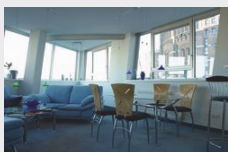


Private **Public Partners** Pays



What we have learned.....

Marketing brownfield sites most important



MARKETING



What we have learned.....

Managing the process!!!

CABERNET's "Football" Conceptual Model.

The Most Significant Driver Drags The Football Down

CABERNET
www.cabernet.org.uk

Go Back!!

What we have learned.....

We do need a professional brownfield manager, well educated and well situated in the administrative structure of the municipality.

Politicians

pot. Investors

Journalists

Neighbours/ other interest groups

other stakeholders

IWG with brownfield manager

Brownfield Manager - BM
A new professional discipline

- Drafting a detailed job description
- Developing a training program with accompanying training materials
- Compiling effective management tools
- Doing training on the job with selected staff of the partner cities
- Giving recommendations on optimised municipal management structures in course of brownfield redevelopment projects

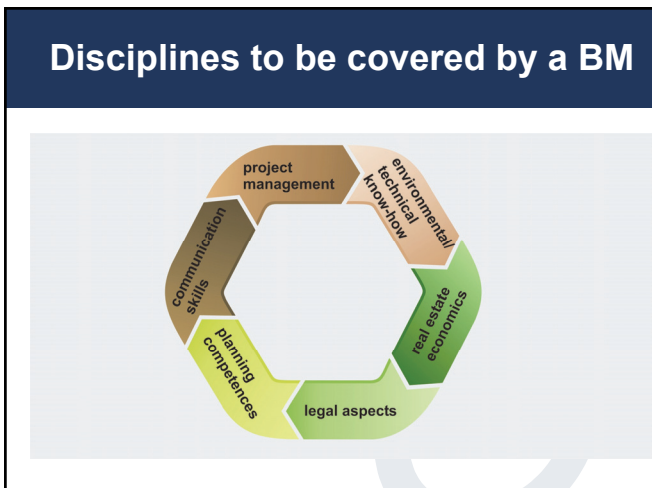
COBRAMAN

BM's tasks and responsibilities

Tasks	Responsibilities
<ul style="list-style-type: none"> Provision of relevant and well targeted information for specific groups Identification and involvement of community/neighborhood and other stakeholders in redevelopment process 	<ul style="list-style-type: none"> "one stop shop" for internal and external stakeholders (e.g. investors as well as for site owners) Initiator and moderator of the stakeholder engagement process
<ul style="list-style-type: none"> Internal communication in the municipality, short and direct channels enable short time project results Set-up and steering a project-specific interdisciplinary working group 	<ul style="list-style-type: none"> acting as interface between policy makers, administration and the technical specialists coordinating information flow and work at any step in the development process
<ul style="list-style-type: none"> developing the visions/development plans which recognize existing policy, and needs. Preparation of political decisions, financial and institutional framework 	<ul style="list-style-type: none"> Triggering the regeneration process

BM's tasks and responsibilities

Tasks	Responsibilities
<ul style="list-style-type: none"> To facilitate efficient project delivery coordination of revitalization process including time schedule and cost management quality and risk management 	<ul style="list-style-type: none"> Project manager
<ul style="list-style-type: none"> Branding – building a positive image for the area under regeneration Marketing – initiating target group specific marketing activities 	<ul style="list-style-type: none"> Initiator and coordinator of public relations and marketing activities



Required skills (1)

project management



- General project management
- Conceptual and visionary thinking
- Leadership - strong team player
- Organizational skills

environmental/technical know-how



- Civil and construction engineering
- Environmental engineering, geotechnics
- Health and safety measures

Required skills (2)

real estate economics



- Basic knowledge in project financing and calculation
- Market mechanisms and trends
- Life cycle considerations of real estate investments

legal aspects



- Basic knowledge in all related legal areas
- Municipal administration and structures
- Understanding of decision making processes and a sense of political feasibilities

Required skills (3)

planning competences

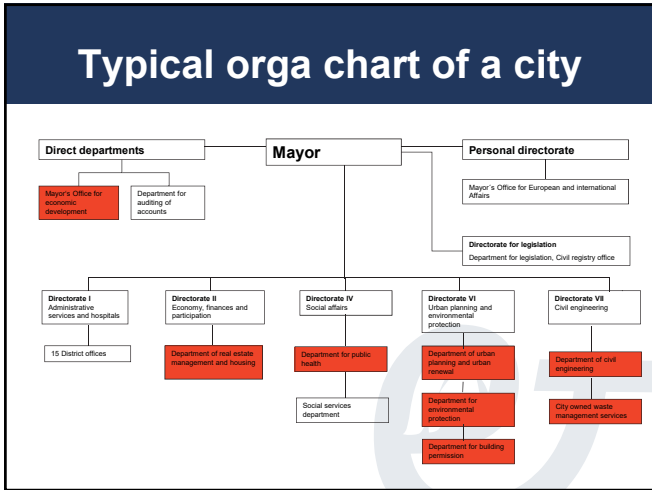


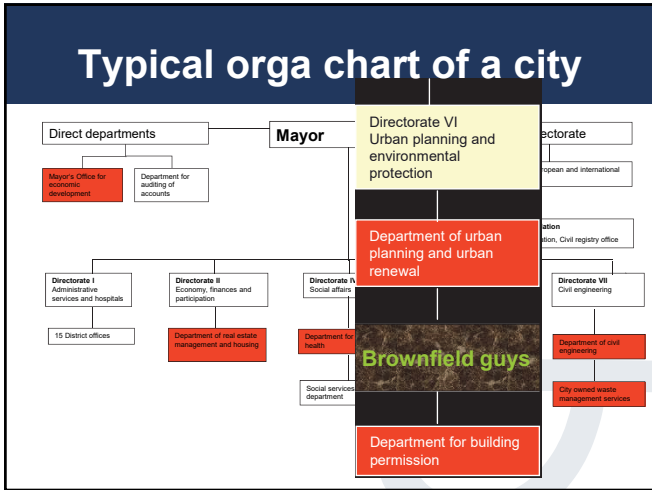
- Landscape and urban planning
- Architecture
- Socio-economic dimension of urban development

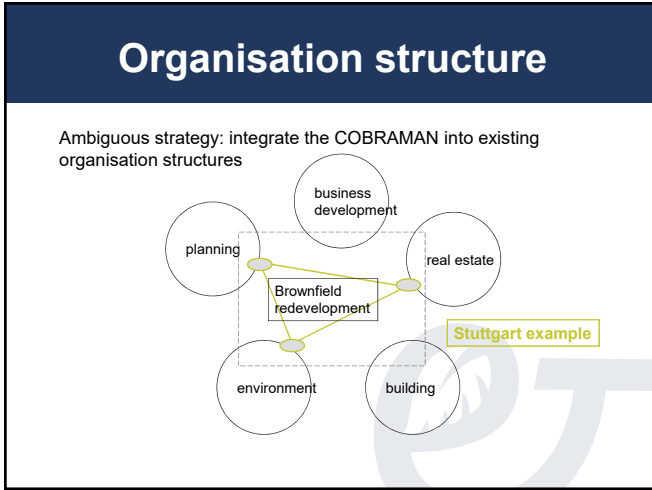
communication



- Communication management
- Moderation, negotiation, mediation
- Ability to describe even complex issues in illustrative and simple words - spokesman qualities
- Marketing and campaigning





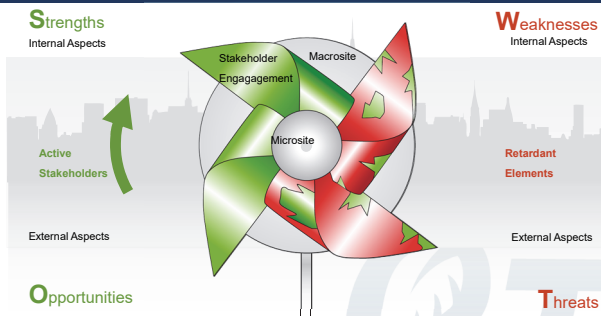


4 Key Management Tools

- the interdisciplinary working group
- the site review
- the brownfield SWOT
- the brownfield regeneration management plan



Stakeholders as key drivers



Brownfield Regeneration Management Plan

Category	Management tasks	Subsidiary management plans & tools
Basic	Project description / approach	IWG
	Project description / overview	Site review Brownfield SWOT
Target & Strategy	Project scope	Scope management plan WBS work breakdown structure Milestone list
	Communication	Communication management plan
	Time resources	Schedule management plan
Resources	Human resources	Cost management plan
	Financial management	
	Procurement management	
Quality & Evaluation	Quality management	Risk register
	Risk management	
	Change control & reporting	

Selection of cost-efficient technologies – Operating Windows Concept

Key challenges in technology selection

1. Site specific feasibility
 - Exact knowledge about mode of operation, pros and cons of all available technologies
2. Costs
 - Remediation design
 - Cost risks and main influencing factors
 - Time required for remediation

Selection of cost-efficient technologies – Operating Windows Concept

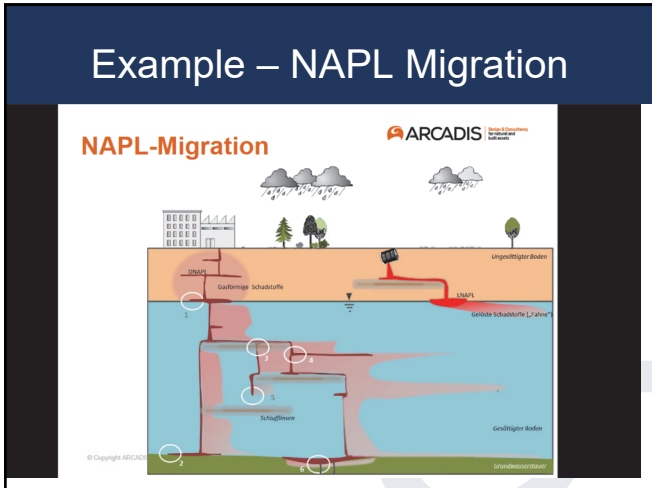
Key challenges in technology selection

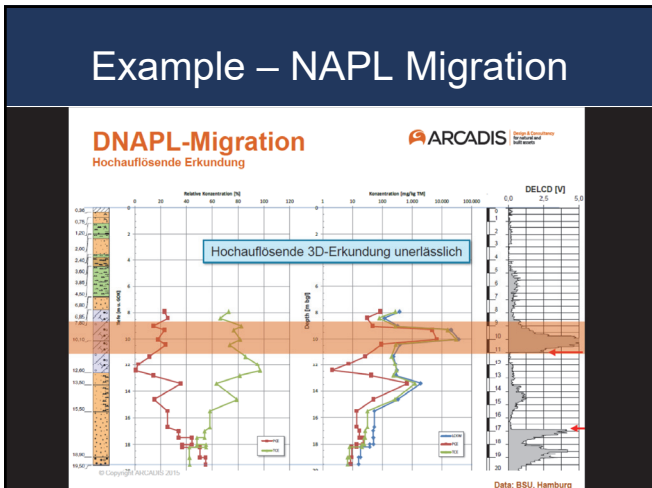
3. Fate and transport of contaminants
 - Dissolved, adsorbed
 - Free phase, residual or mobil
 - Precursors
 - Redox-Characterisation
4. Heterogeneity affecting storage and back diffusion

Operating Windows

(ref. T. Held, Arcadis)

- Compilation of all critical parameters and their ranges of values as a basis for assessment of effectiveness of a remediation activity
- Strict consideration of quantitative methods and quantified boundary conditions
- Consistent decision making tools for design phase instead of trial & error in remediation phase





Operating Windows

- Data mining of successful remediation projects
- Lab experiments and pre-tests
- Application of conceptual remediation models

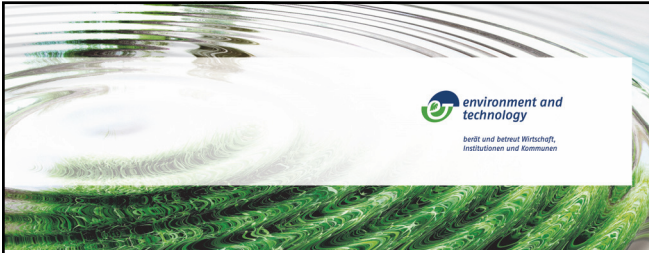
Will enable

- Knowledge based selection of technologies
- Optimised prognosis of effectiveness
- Reduced costs with more reliable estimations

But do require

- More quantitative characterisation results

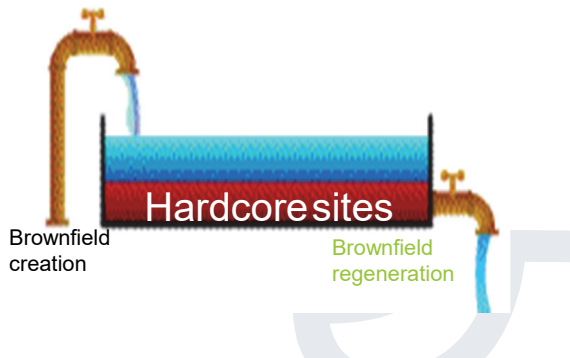
= > a new generation in site characterisation



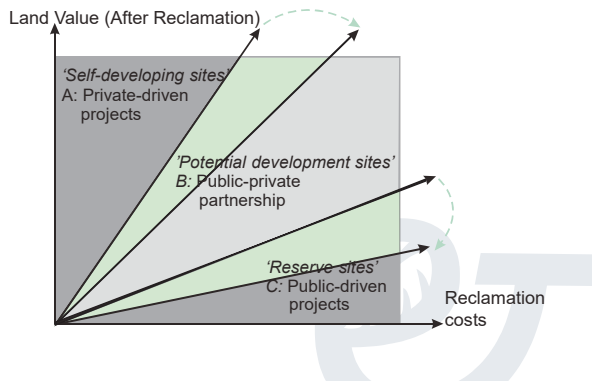
Brownfield Regeneration Management – sustainable and cost-efficient

Dr. Thomas Ertel, et environment and technology
ReSites – Transnational Training on Sustainable
Remediation, Bydgoszcz, 10 May 2017

Brownfield Regeneration - an ongoing process



Cabernet A-B-C model



REVIT puzzle



What is obvious:
Brownfield revitalisation
is a long term and
complex process and
a wide range of
professional
disciplines has to be
involved.

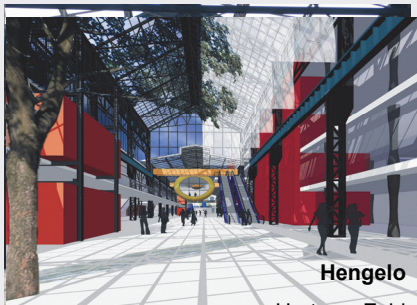


What we have learned.....

Prepare the
ground –
environmental
remediation



Industrial
Heritage



COBRAMAN

environment and
technology

CENTRAL
EUROPE

EUROPEAN UNION
EUROPEAN REGIONAL
DEVELOPMENT FUND

What we have learned.....

Stakeholder engagement



What we have learned.....

Financing – a miracle?



Private **Public Partners** Pays



What we have learned.....

Marketing brownfield sites most important



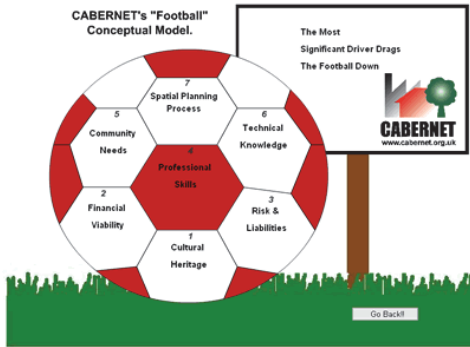
Gasometer Vienna, AUSTRIA

MARKETING



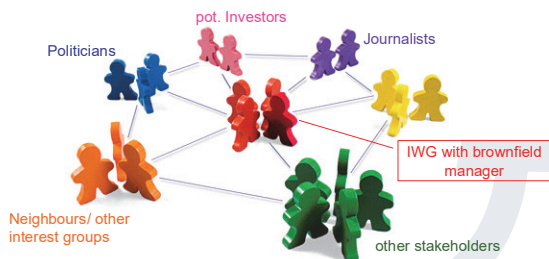
What we have learned.....

Managing the process!!!



What we have learned.....

We do need a professional brownfield manager, well educated and well situated in the administrative structure of the municipality.



Brownfield Manager - BM A new professional discipline

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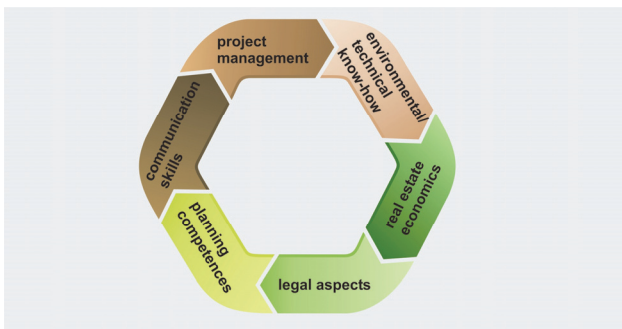
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Disciplines to be covered by a BM



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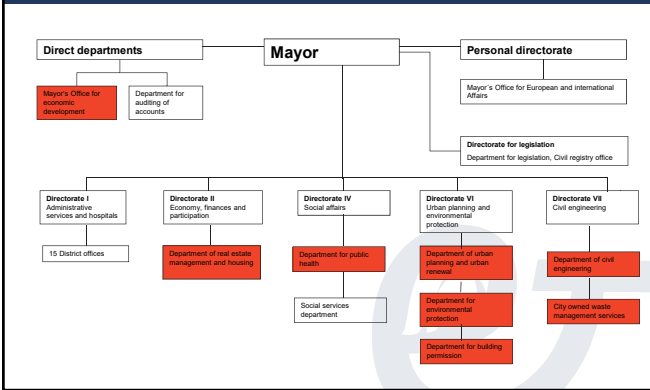
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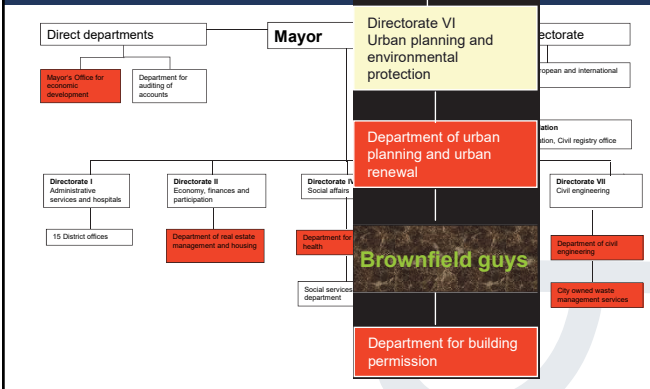


- Communication management
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Typical orga chart of a city

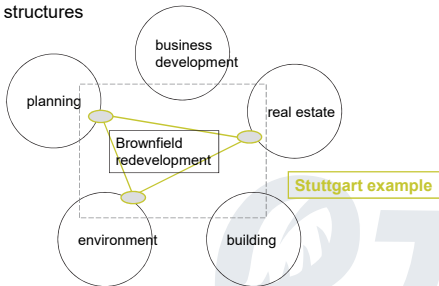


Typical orga chart of a city



Organisation structure

Ambiguous strategy: integrate the COBRAMAN into existing organisation structures

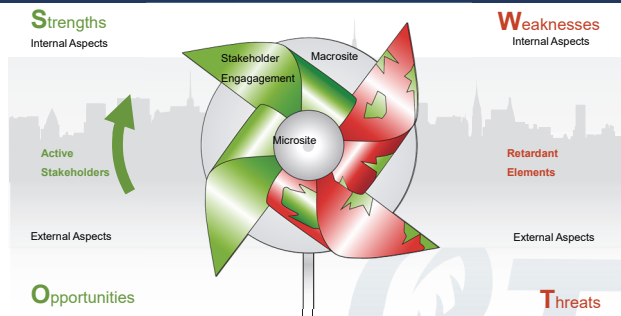


4 Key Management Tools

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Selection of cost-efficient technologies – Operating Windows Concept

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Selection of cost-efficient technologies – Operating Windows Concept

Key challenges in technology selection

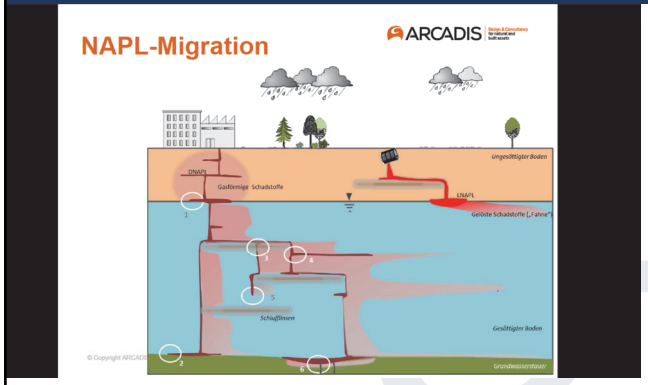
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Operating Windows

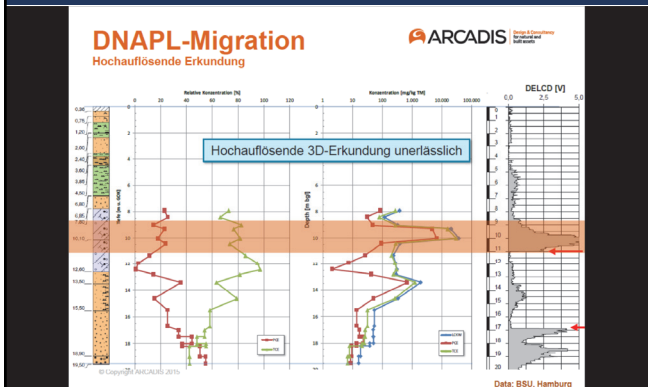
(ref. T. Held, Arcadis)

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- Strict consideration of quantitative methods and quantified boundary conditions
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Example – NAPL Migration



Example – NAPL Migration



Operating Windows

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 - Lab experiments and pre-tests
 - Application of conceptual remediation models
- Will enable**
- Knowledge based selection of technologies
 - Optimised prognosis of effectiveness
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- But do require**
- More quantitative characterisation results
- = > a new generation in site characterisation**

BROWNFIELD REGENERATION MANAGEMENT
- sustainable and cost-efficient

Dr. Thomas Ertel, et environment and technology, Boschstr. 10, 73734 Esslingen Germany	05-2017
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MANAGEMENT OF BROWNFIELD REGENERATION PROCESSES

All over Europe revitalisation of brownfield sites plays an important role in avoiding urban sprawl and improving the quality of urban environment, thereby helping to create the conditions necessary for sustainable development. Brownfield land endangers public health and creates environmental risks. Moreover it strives to combat related social and spatial segregation threatening the competitiveness of European cities. Rehabilitation will be of growing importance in the EU member states, which requires large investments.

It is one of the most important lessons learnt from previous European activities in the brownfield sector, that professional process management is a key factor for successful brownfield regeneration. Accordingly it was the basic approach of the COBRAMAN project to introduce a new professional discipline: **the brownfield regeneration manager**. The successful implementation of brownfield regeneration managers within European cities enables effective and successful renewal and conversion processes.

Brownfield regeneration processes are often long term, complex and involve a wide range of professional disciplines as well as political actors and different stakeholder groups. Co-ordination and communication are essential to sustain complex projects. The management of the process as such is more evident to facilitate the redevelopment than sole technical aspects. Key tasks for professional regeneration managers are to develop and deliver opportunity plans and to steer revitalization processes. The responsibilities of the brownfield manager comprise further community involvement and marketing activities.

4 KEY MANAGEMENT TOOLS

The management of regeneration processes requires the application of established management tools. There is a wealth of existing instruments and tools to be used in process and project management. Those which proved to be the most important have been specifically adapted by the COBRAMAN partnership to the regeneration business.

Coordination – the interdisciplinary working group

There might be many ideas about the best name to be assigned to a project specific working group – but it is consensus that such a working group with all actors represented is a must for coordinating the manifold activities around the brownfield regeneration process. The term “interdisciplinary working group” reflects the composition of this group comprising various departments and specialists involved. The working group structure will depend on the specifics of each case, and it might vary during the subsequent phases of project implementation. It is recommendable to set up a formal statute for the working group, outlining:

- Aims and objectives, lifetime, meeting schedule
- Membership, representation and participation
- Competences and duties of the members
- Rules for decision making
- Chair and secretariat.

The more responsibilities and decision making power can be assigned from the different departments to such a group, the more effective will be their work. Taking over the chair or secretariat is a key role for the regeneration manager.



Information and communication – the site review

From the beginning of a project a multitude of information, planning documents, technical reports etc. will be produced from various actors involved. Keeping the overview, structuring and filing, assessing according to relevance and target groups as well as drawing appropriate conclusions are fundamental tasks to ensure the information flow within the project and its environment.

The site review is the mother document, outlining and summarising all relevant aspects, and linking to the wealth of existing specific documents. It is an internal working document continuously updated, collecting information from all members of the working group. It helps to bring all working group members to the same level of knowledge; it should be easily accessible for them. It should not be focusing on different target groups, but to be considered as the source for specific documents (e.g. SWOT) and target group related information as e.g. marketing communication activities.

As many cities are already operating brownfield registers similar information systems, it has to be decided

- which parts of information,
- to which level of detail and
- in which time intervals

the transfer of updated content will be done from the site review to these public info systems.

Strategy and marketing – the brownfield SWOT

SWOT Analysis is a strategic planning method used to evaluate the Strengths, Weaknesses, Opportunities, and Threats involved in a project or in a business venture.

SWOT stands for:

- Strengths: attributes of items that are helpful to achieving the objective.
Weaknesses: attributes of the items that are harmful to achieving the objective.
Opportunities: external conditions, which are helpful to achieving the objective.
Threats: external conditions, which could do damage to the objective.

In SWOT analysis a careful identification of individual SWOT items is essential because subsequent steps in the process of planning for achievement of the selected objective may be derived from the SWOT. For a brownfield regeneration specific SWOT these items have been categorised into:

- microsite aspects, e.g. current and future use, ecological aspects, financial issues, social and cultural aspects etc.
- macrosite aspects, e.g. neighbourhood uses, infrastructure / transport situation, market situation & competitors etc.
- stakeholder engagement, e.g. owners, investors, citizens in neighbourhood, politicians etc.

This third category is considered to be the key function driving or blocking development.

Project management – the brownfield regeneration management plan

This plan is similar to a classical project management plan. It is a formal, approved document that defines how the redevelopment project is executed, monitored and controlled. Depending on the complexity of the site it may be summary or detailed and may be composed of one or more subsidiary management plans and other planning documents.

It is like a roadmap for all project team members but especially dedicated to the BM. It explains how the intended project scope will be reached, guides through the stations from initiating, planning, executing, monitoring and closing the redevelopment project and helps to take care of various project constraints like



scope, quality, schedule, budget, resources and risks. Once agreed and approved by at least the project team and its key stakeholders the plan is the binding framework for all activities during the redevelopment process. What makes the difference? As in general project management matters it is all about persons, their aims & goals, the financial framework, the time planning, public relation and documentation. But the special situation in a redevelopment projects even enlarge the complexity of a project. This complicates the definition of clear and broadly accepted objectives, structures and main work flows and subsequently setting up of subsidiary plans for schedule, cost, risk and quality management as well as stakeholder engagement plans.

Although at project start the urban development framework and targets seem to be well defined, the longevity of the processes or technical risks and related modifications may imply changing boundary conditions, entrance of new stakeholders or substantial shifts in stakeholder's attitude towards the development.

These unknowns hamper the set-up of well-defined management plans. On the other hand they underline the particular importance of their strict application.

The general structure is divided in 4 categories (see respective slide in ppt) and helps to keep the overview. The structure is as simple as possible but as complex as needed to cover all aspects of the redevelopment project in an adequate way. The importance of the single elements may vary from case to case but the general structure can be applied to all kind of redevelopment projects. The number of categories is NOT indicating the importance of the elements but is reflecting the logical and partly chronological sequence or a redevelopment process.

Selection of cost-efficient technologies - Operating Windows Concept

The success of characterisation and remediation activities strongly depends on the application of the most appropriate technologies and their combination. To date selection of these technologies is still based more on qualitative experience of the experts involved than on quantitative, scientific sound decision making processes. This is due to strong effects of site specific parameters and subsurface heterogeneity on characterisation results as well as on the data quality and information value of remediation reports of completed projects.

Key challenges in technology selection

1. Site specific feasibility
 - Exact knowledge about mode of operation, pros and cons of all available technologies
2. Costs
 - Remediation design
 - Cost risks and main influencing factors
 - Time required for remediation
3. Fate and transport of contaminants
 - Dissolved, adsorbed
 - Free phase, residual or mobil
 - Precursors
 - Redox-Characterisation
4. Heterogeneity affecting storage and back diffusion



The strict application of quantitative methods and considerations will enable the development of proper consistent decision making tools for the design phase instead the widespread application of trial & error in the remediation phase.

In order to achieve significant progress in the application of the operating windows approach, it is required to enlarge the data basis on operational aspects. Hence a stringent data mining of successful remediation projects is inevitable. Further a wider application of lab experiments and pre-tests in the design phase as well as the application of conceptual and mathematical remediation models will be needed.

Doing so this will enable a proper knowledge based selection of technologies in combination with optimised prognosis of effectiveness. This will lead to reduced costs with more reliable estimations, but requires more quantitative characterisation results, to be achieved through a new generation in site characterisation.

LIST OF REFERENCES

COBRAMAN final brochure: Brownfield regeneration management, from education to practice.

T. Held, Arcadis : Operating windows – Auswahl von Sanierungsverfahren. Presentation held at Seminar 03/2017 – Sanierungspraxis 2017 – Stuttgart, 06.April 2017




TAKING COOPERATION FORWARD

TRANSNATIONAL TRAINING ON SUSTAINABLE REMEDIATION

📍 Bydgoszcz 10.05.2017

🗨️ Optymalizacja badań i monitoringu skażeń środowiska na terenach przemysłowych

👤 Wojciech Irmiński, Geo-Logik Wojciech Irmiński






Greenfields czy brownfields ?
Oto jest pytanie.

Być czy nie być ?
Oto jest pytanie.

TAKING COOPERATION FORWARD 2



Brownfields - oznacza nie tylko tereny przemysłowe, ale także wszelkie obszary zdegradowane, potencjalnie zanieczyszczone, a nawet obszary „umierające”, których funkcja uległa wyczerpaniu.

Projekt UE HOMBRE - m.in. Solec Kujawski jako partner stowarzyszony - konferencje i seminaria na temat, jak hamować procesy i zapobiegać powstawaniu brownfields. Idea „zerobrownfield”.

BROWNFIELDS
"Brownfields are real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant."
 U.S. Environmental Protection Agency

TAKING COOPERATION FORWARD 3



 ReSites


Mimo obecności Polski w Unii od 2004 r. wciąż w wolnym tempie odrabiamy zaległości:
 Koniec lat 80. XX w. - w Niemczech sortowano odpady na plastik, metal, a szkło dzielono według koloru.
 W Polsce zachwyliśmy się kolorami i mnogością opakowań z plastiku.
 Wprowadzano jednorazowe butelki PET do napojów.



Obecnie mamy gotowe rozporządzenie w sprawie sposobu prowadzenia oceny zanieczyszczenia powierzchni ziemi (od 1.IX.2016). W metodyce Atlasten w Niemczech podano to i wprowadzono w życie już w 1989 r. (Badenia-Wirtembergia).


Gdy tam mówiono o sanacji, my walczyliśmy z powszechną koncepcją rekultywacji zamykanych składowisk.

TAKING COOPERATION FORWARD 4

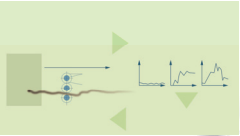


 ReSites


Tworzenie dobrego prawa jest opóźnione
 Metody innowacyjne i prośrodowiskowe nie są w porę stosowane, bo brak zachęt i wymogów.
 W Polsce nadal panuje model trzech piezometrów o średnicy 100 mm dla składowiska odpadów średniej wielkości.



Liczne badania i przypadki pokazują, że pomiędzy dwoma otworami migrują niebezpieczne substancje organiczne
 Związki hydrofobowe tworzą smugę („plume”)
 badania typu IPT (np. projekty INCORE, MAGIC - stare gazownie, projekt Ostrów Mazowiecka, projekt FOKS w Jaworznie)



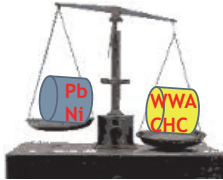
TAKING COOPERATION FORWARD 5



 ReSites

Zmiana ciężaru problemu

Metale ciężkie a substancje organiczne (pierścieniowe, chlorowane)



TAKING COOPERATION FORWARD 6




 ReSites

Postęp w technikach analitycznych

- Próbki mogą być niewielkie, czyli
- Musimy lepiej zadbać o reprezentatywność
- Możemy stosować tańsze i mniej inwazyjne metody próbkobiorcze
- Możemy stosować skutecznie innowacyjne techniki pobierania próbek, które mniej szkodzą środowisku


 7



 ReSites

Podwójne Eko:
efektywnie i prośrodowiskowo


Ekonomizacja badań

Tańsze metody i mniej energii
Lepsze rozpoznawanie historyczne
Mniej zaangażowanych osób

Ekologizacja badań

Mniej odpadów podczas badań i monitoringu
Mniej inwazji w środowisku
Lepsza ocena zagrożenia dla ludzi

Standard podwójne eko



 8



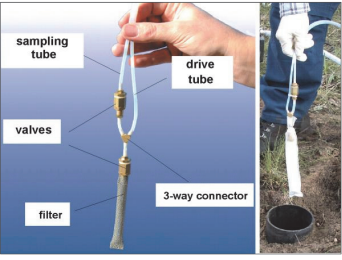
 ReSites




 9


 ReSites


Pompa miniciśnieniowa (mini-pompa dwuzaworowa) - imw dr H.Weiss



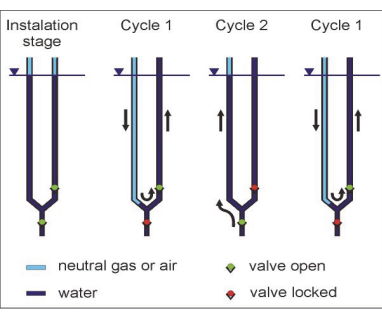
Otwór 20 mm
 Niewielka ilość energii
 Brak turbulencji
 Bez podciśnienia
 Teflon i PE
 Minimalny kontakt z O₂
 Minimalna ilość wody odpadowej

Jako pompa gubiona
 Jako pompa w zestawach wielopoziomowych - MLPS
 Idealna do poboru wody z rozpuszczonymi gazami

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Zasada działania MPP



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Napęd: azot lub powietrze






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Próbniki pasywne dla wód (podziemnych)
 - Dozymetr ceramiczny (imw dr H. Weiss)

Patent: prof. P. Grathwohl, 2003




Test ETV - projekt PROMOTE
 Bydgoszcz 2007,

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 ReSites


Długookresowy monitoring jakości wód
 Różne substancje adsorbujące,
 różne zestawy wykrywanych zanieczyszczeń

Wysoka pojemność adsorpcyjna, a jednocześnie
 Dobra ekstrakcja i wysoki współczynnik odzysku

Nie jest wskazany do monitoringu krótszego niż 1 miesiąc
 - to zależy od rodzaju substancji

Przykładowo: stężenie naftalenu rzędu 1 µg/L wymaga 33 dni do osiągnięcia limitu detekcji; przy stężeniu 0,1 µg/L potrzeba 330 dni, ale tylko 0,3 dnia przy stężeniu 100 µg/L .
 Dla stężenia toluenu = 1 µg/L dozometr potrzebuje 1,1 roku aby osiągnąć limit detekcji, gdy stężenie wynosi 0,1 µg/L trzeba na to 11 lat, ale przy stężeniu 100 µg/L wystarczy 4,1 dnia.

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 ReSites

Dwa przykłady ze standardu podwójnie eko:
 Rekomendowane
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- ekonomicznych (mobilność, niskie koszty pobierania próbek) oraz
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The presentation is based on:

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TRANSNATIONAL TRAINING ON SUSTAINABLE REMEDIATION

Bydgoszcz 10.05.2017

Optymalizacja badań i monitoringu skażeń środowiska na terenach przemysłowych

Optimization of testing and monitoring of environmental contamination in post-industrial areas

Wojciech Irmiński, Geo-Logik Wojciech Irmiński



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Greenfields czy brownfields ?
 Oto jest pytanie.




Być czy nie być ?
 Oto jest pytanie.

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Brownfields - oznacza nie tylko tereny przemysłowe, ale także wszelkie obszary zdegradowane, potencjalnie zanieczyszczone, a nawet obszary „umierające”, których funkcja uległa wyczerpaniu.

Projekt UE HOMBRE - m.in. Solec Kujawski jako partner stowarzyszony - konferencje i seminaria na temat, jak hamować procesy i zapobiegać powstawaniu brownfields.

Idea „zerobrownfield”.

BROWNFIELDS

"Brownfields are real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant."

U.S. Environmental Protection Agency

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Mimo obecności Polski w Unii od 2004 r. wciąż w wolnym tempie odrabiamy zaległości:
Koniec lat 80. XX w. - w Niemczech sortowano odpady na plastik, metal, a szkło dzielono według koloru.
W Polsce zachwycaliśmy się kolorami i mnogością opakowań z plastiku. Wprowadzano jednorazowe butelki PET do napojów.



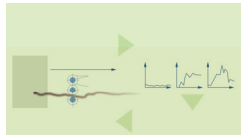
Obecnie mamy gotowe rozporządzenie w sprawie sposobu prowadzenia oceny zanieczyszczenia powierzchni ziemi (od 1.IX.2016). W metodyce Altlasten w Niemczech podano to i wprowadzono w życie już w 1989 r. (Badenia-Wirtembergia).

Gdy tam mówiono o sanacji, my walczyliśmy z powszechną koncepcją rekultywacji zamykanych składowisk.

Tworzenie dobrego prawa jest opóźnione
Metody innowacyjne i prośrodowiskowe nie są w porę stosowane, bo brak zachęt i wymogów.
W Polsce nadal panuje model trzech piezometrów o średnicy 100 mm dla składowiska odpadów średniej wielkości.



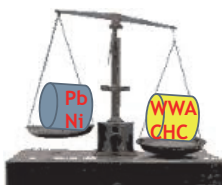
Liczne badania i przypadki pokazują, że pomiędzy dwoma otworami migrują niebezpieczne substancje organiczne
Związki hydrofobowe tworzą smugę („plume”)



badania typu IPT (np. projekty INCORE, MAGIC - stare gazownie, projekt Ostrów Mazowiecka, projekt FOKS w Jaworznie)

Zmiana ciężaru problemu

Metale ciężkie a substancje organiczne (pierścieniowe, chlorowane)



Postęp w technikach analitycznych

- Próbki mogą być niewielkie, czyli
- Musimy lepiej zadbać o reprezentatywność
- Możemy stosować tańsze i mniej inwazyjne metody próbkobiorcze
- Możemy stosować skutecznie innowacyjne techniki pobierania próbek, które mniej szkodzą środowisku



Podwójne Eko:
efektywnie i prośrodowiskowo

Ekonomizacja
badań

Tańsze metody i mniej energii
Lepsze rozpoznawanie historyczne
Mniej zaangażowanych osób

Ekologizacja
badań

Mniej odpadów podczas badań i monitoringu
Mniej inwazji w środowisku
Lepsza ocena zagrożenia dla ludzi

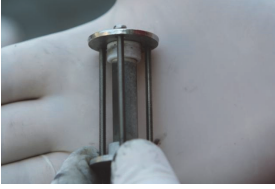
Standard
podwójne
eko





Próbniki pasywne dla wód (podziemnych) - Dozymetr ceramiczny (imw dr H. Weiss)

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Test ETV - projekt PROMOTE
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OPTIMIZATION OF TESTING AND MONITORING OF ENVIRONMENTAL CONTAMINATION IN POST-INDUSTRIAL AREAS

Wojciech Irmiński

05-2017





INTRODUCTION

Contamination testing in post-industrial areas has already a long history in Europe. It is evident that in the late 80s of the last century there was an unusual revival in this topic in some of the countries (Germany, the Netherlands, Denmark). Increase in funding in this area of environmental research was a result of not only constant increase of ecological awareness and society's expectations, what was brought by e.g. advances in science, but also invaluable "greenfields" areas started to be saved in developed countries. Thus, the interest shifted towards areas called "brownfields" – the name refers not only to post-industrial areas but also to all areas which were degraded, potentially contaminated and lately even "dying" areas which functions have been exhausted. Land recycling became gradually a notion as standard as paper or scrap recycling.

Regardless of this, scientific advances in medicine, ecotoxicology and development of analytical methods in laboratories have shown that focus of environmental studies should be shifted from problems of heavy metals contamination towards organic compounds.

The economic crisis and collapse in 1990s did not facilitate implementation of current knowledge into practice. Also, regulation of contamination prevention law was not an easy process. For example, in Poland, the State Inspectorate for Environmental Protection by the Ministry of the Environmental Protection (former name of the Ministry of the Environment) published in 1996 *Handbook on the research of old landfills - assessment, research bases* (original title: *Podręcznik badań starych składowisk – ocena, podstawy badawcze*, 1996). This was done thanks to the initiative of the Polish Geological Institute within the framework of the Environmental Monitoring Library series. It was a translation of the German textbook *Altlastenhandbuch* (source: Landesanstalt für Umweltschutz Karlsruhe, Baden-Württemberg) adapted to Polish realities. Some time later Agricultural University of Wrocław (nowadays Wrocław University of Environmental and Life Sciences) gradually published a similar translation of the same methodology (Old Landfill, volume I - Recognition and Evaluation - Part 1, 1997; volume I - Recognition and Evaluation - Part 2, 1999; volume II – Reform and control, 2000). These actions did not bring the expected result and brownfield areas had not been perceived as good places for new investments for a long time. Local authorities vied with each other to attract Polish and foreign investors by offering them attractive land plots in the special economic zones, equipped with new infrastructure and long-term tax relief.

Currently, the trend to move post-industrial areas outside of the city still lasts, however now, especially in bigger cities, post-industrial areas became an interesting part for investors and developers because of their good location and big land plots with clear ownership status. Local spatial planning undergoes changes and it is allowed now to build apartments, offices and shops. For several years now, cautious investors and buyers ask about the environmental state of their potential investment. They learned to do that after many cases when there occurred problems with heavily contaminated land from excavations, that no one wanted to receive and quite often did not know how to manage. Also, legal regulations had to keep up with the dynamic situation in economy – building permits started to be accompanied with recultivation decisions and from year 2016 we can talk about remediation in Poland.

Both the detection of contamination, its right assessment needed for remediation plan and the monitoring of the environment also require changes. In Europe these are not new methods at all, however in the context of the new approach to the principles of environmental conservation and economization of testing these are innovative methods (certainly they have been used in Poland very rarely so far).

What should therefore be the optimization of testing and monitoring of the environment?



In simple terms, the optimal operation to control the state of the environment is:

- efficiency – gaining knowledge at a relatively low financial cost; and -
- pro-environmental approach – minimization of any negative impact on the environment caused by research testing and monitoring.

In other words, we can define this attitude as a double "Eco" - that is, "Economization & Ecologization" (Eco-Eco Standards).

ECONOMIZATION

The issue of financial effectiveness does not require a broader comment. This action is the result of a compromise between the need to acquire the necessary information and the budget. In practice, this is the result of the arrangements between the investigator and the funding body.

Arising question - what exactly is the needed information?

The principle of historical query research, for many years preferred in the German methodology "Altlasten" and American methodology "superfunds", finally is in Poland also legally bound. Methods of proper investigation of contaminated areas are formulated in the decree of the Minister of the Environment dated from 1 September 2016, which treats on the method of conducting assessment of surface contamination. Unfortunately, it means that we still have a delay: in Poland we are 20-30 years behind the method makers. It is a sad reflection.

The first element of the needed information is the accuracy of the historical query. It is particularly important in post-industrial areas as the effects of different technological processes overlap most often there. The second element is the quantity and type of samples. The aforementioned regulation defined, e.g. research stages of contaminated sites, as well as a minimum number of samples, on the basis of which the geochemical quality of the soil can be characterized. An important factor in planning research testing is the need to divide the space into research sections. The number and minimum area of a section depends on the land's category – it is similar for lands belonging to group I (residential land) and group IV (industrial land), and it is different for land belonging to groups II and III (cultivated land and forest areas respectively).

For post-industrial area, that is assessed in respect of land contamination and ultimately human health risks, the actual number of sections to divide the tested area should be determined based on historical query. This is a first point of misunderstanding between a contracting entity and a contractor, because it has clear financial consequences - as the number of sections grows, the number of samples grows.

The third element of the needed information is a type and scope of chemical analyzes. It also generates significant costs and often raises doubts on the customer's side. At the exploratory stage, a broad but justified analyzes spectrum should be used. At the monitoring stage, it is worth pointing out key substances (indicators), in order to aim at economic efficiency.

Economization of the study also includes other factors, such as the number of people involved, the type of drilling equipment used, the hole diameters, the amount of energy needed, work intensity, waste disposal costs and other.

ECOLOGIZATION

Improvement of analytical methods in laboratories lead to a situation, when smaller volumes of material need to be tested. Following this trend of miniaturization it cannot be forgotten, however, that a sample must be representative. Hence the role of the sample-collector (sampler), the choice of surveying site, the sampling area, the sampling method and the preparation of samples for surveying.



In post-industrial areas soil, subsoil (ground) and water contamination can have very high levels. Therefore, the optimum method of making test holes are drillings of a small diameter or testing with penetrometer or rotary hammer. This limits the amount of excavated material to a minimum, which can be surprising and dangerous even for the drilling team. Leaving outside the extracted soil, which emits, for example, volatile organic compounds, is not a solution at all. However, it often happens even in companies that specialize in environmental protection, and geotechnical drilling companies do it quite regularly without paying attention to the fatal environmental effects.

The problem is most apparent when the subject of the study is the strongly contaminated groundwater. Traditional piezometers with a diameter of 4 inches and a depth of e.g. 14 meters need a complete extraction and removal of 1 m³ of ground before embedding the pipe column. Then the piezometer passes the pumping cleaning phase (sic!), and before collecting each sample it is advised to pump 3 times the volume of water column in the piezometric tube (another method recommends removing even 3 times the volume of water from the filter tube and surrounding artificial sand zone). Assuming that in "our" piezometer the water mirror is at a depth of 4 meters, we need to develop or spill over 300 litres of water, which is often heavily contaminated.

What solution would be optimal from the point of view of ecologization of research testing and monitoring?

The following two methods are suggested by the German company Innovative Messtechnik Dr. Weiss (imw) and they were tested also in Bydgoszcz as a part of the international project PROMOTE in 2007 (6th EU Framework Program). Both methods have successfully passed tests in Europe's new Environmental Technology Verification (ETV) system. Therefore they are not completely new, but still not very popular. They contribute greatly to the ecologization of research testing and monitoring. Both methods require only piezometric holes of 1-2 inches in diameter. If there is no need to study soil samples, these holes can be done using the direct-push technique (for many years this technique has been used and disseminated, e.g. within the framework of the TIMBRE project, 7th EU Framework Program).

MINI PRESSURE PUMP, imw, GERMANY

This type of pump offers low-flow sampling of water without gaseous losses of volatile compounds or contamination with atmospheric oxygen.

Compressed air from a cylinder or compressor can be used as a drive, or in special cases compressed nitrogen can be used. The pump itself consists of two valves, which regulate the push of the subsequent portions of water through the pipe to the surface. Outflow takes place through the supply pipe as a result of momentary gas pressure (e.g. nitrogen). Adjustment of operation – with a pneumatic controller (pressure, frequency, cycles' length) takes place in the control box with a small battery.

Water sampling requires little energy, it causes no hypotension or turbulence, which minimizes the release and escape of VOCs (Volatile Organic Compounds). Pipes with a diameter of 4 mm are made of PE or Teflon. The double valve mini pump is fit to the tube with 20 mm (< 1 inch diameter).

The structure and actions are shown in the figures 1 and 2.

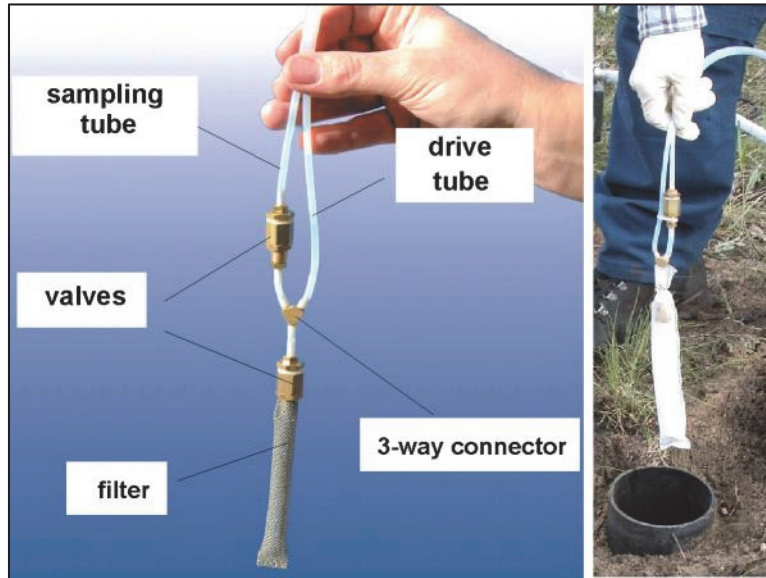


Fig. 1. Structure of MPP (mini pressure pump) made by imw dr Weiss

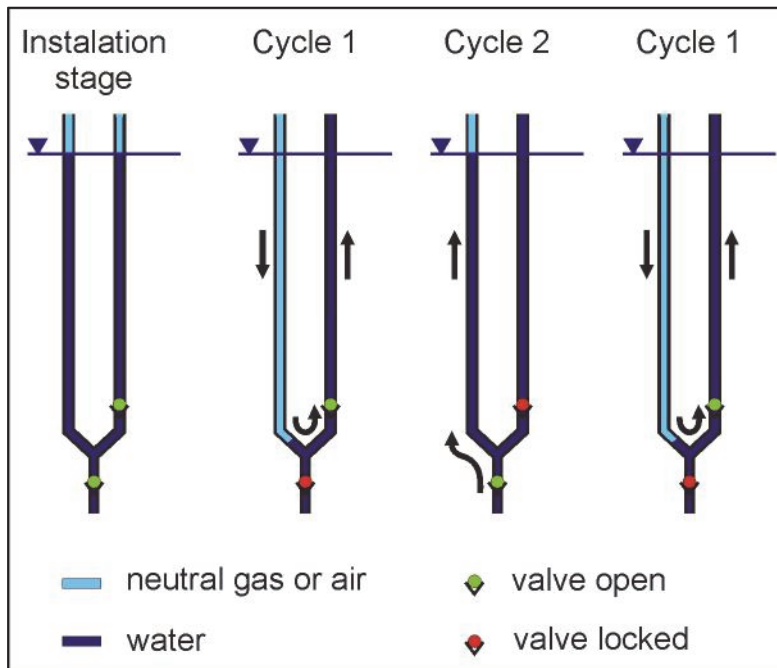


Fig. 2. Operation principle of MPP

The mini pressure pump can be used also in holes with a large diameter, preferably with packer systems it can be used as so-called daughter-pump. This method is used in many countries in Europe, also in Poland. It is very successful in detection of all compounds – inorganic and organic – in water, but particularly of volatile and semi-volatile hydrocarbons. Thanks to this technique it was repeatedly possible to detect the presence of BTEX and PAH, but also the presence of such chlorinated hydrocarbons as highly carcinogenic and volatile vinyl chloride (CV). CV is basically impossible to detect in soil samples, because it quickly leaks from the drilled material. This compound may indicate the presence of PCE and TCE in deep aquifers, but it is



impossible to be collected with the traditional technique (rotor pump) because it does not actually reach the sample.

Case 1. Site of a pre-war chemical factory with numerous scattered centres of soil contamination at different depths. Phenols, cresols, PAH, BTEX and many of their chlorinated variants were detected (October 2015). CHC source is hard to detect. Assessment of actual emissions from the DNAPL phase is necessary. The rotor dynamic pumps used in a 4 inch piezometers show concentration of VC: P4 - 72,7 µg/L, P1- <1 µg/L.

The use of a mini pressure pump in P4 shows 35 µg/L for VC and in P1 1,2 µg/L. MPP in a 2 inch piezometer (Pz19 close to P4) shows for VC 108 µg/L.

Case 2. Old brownfield site. Historical factory buildings. Low concentrations of chloroform were detected in the soil samples from the embankments. Cause unknown. In the aeration zone in the native soil (sands) chloroform and other chlorinated compounds are absent. Low-cost piezometers of a small diameter and water samples collected using the mini pressure pump have shown (for example): Chloroform 195 µg/L, TCE 21,2 µg/L, PCE 5,02 µg/L.

An elegant solution: low-cost drilling and pump operation, precise data, no waste-water in environment.

When using a mini pressure pump in holes of a small diameter, pumping is not necessary. And if the water is severely contaminated, the water collected from the pump during the flow rate adjustment can be accommodated in one litre bottle.

PASSIVE SAMPLERS - CERAMIC DOSIMETER

The ceramic dosimeter takes shape of a ceramic tube with nanopores (membrane) and a sorbing material. The tube diameter is 1 cm, the wall thickness 1,5 mm and the pore size is 5 nm. The tube is filled with sorbent and closed with PTFE caps. In application of the ceramic dosimeter in the field the tube should be covered with a stainless steel cage.

The figure 3 and 4 show the applications of ceramic dosimeter set during the PROMOTE Project test in Bydgoszcz in 2007 and groundwater monitoring project in Ostrów Mazowiecka (2008).

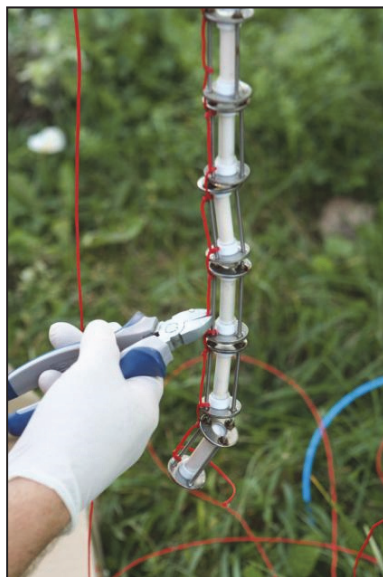


Fig. 3. The ceramic dosimeter set in Bydgoszcz (PROMOTE, 2007)

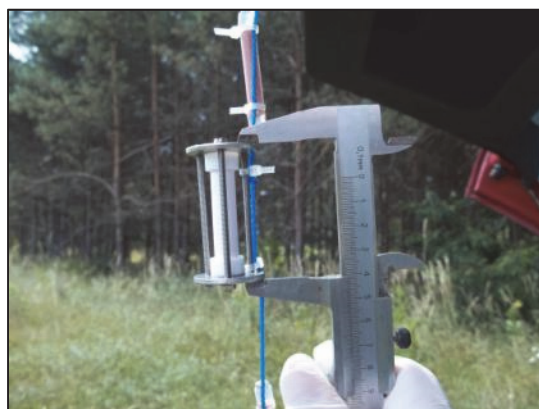


Fig. 4. Groundwater long-term monitoring in Ostrów Mazowiecka using passive samplers (2008)

The idea of the ceramic dosimeter was elaborated by prof. P. Grathwohl in 2003 and is patented. The use of ceramic dosimeters in water monitoring was mainly described by scientists from the University in Tübingen (e.g. Grathwohl, Pipenbrink, Martin), but for this short review the paper of Weiß et al. (2006) was selected. A number of experiments in the lab scale and field tests and works show the suitability of ceramic dosimeters for time-integrated, long-term monitoring of groundwater quality. Using different, dedicated sorbents sampling of polycyclic aromatic hydrocarbons (PAHs) as well as sampling of benzene, toluene, ethylbenzenes, and xylenes (BTEX) and chlorinated hydrocarbons (CHCs) is possible. An additional application of ceramic dosimeters is the basis for the development of the Toximeter, the first passive sampler directly compatible with toxicological tests.

The sorbents are required to have a high affinity and capacity for the uptake of the tested chemicals combined with an easy extraction at high analytic recovery rates.

Ceramic membrane, small size and diffusion process generate low sampling rates. This guarantees appropriate time for delivery of chemicals (mass) from the surrounding water. This is particularly important for low-flow sampling and generally ceramic dosimeters are not well suited for sampling periods of less than 1 month in a low concentration environment (depending on the compounds to be assessed), where the collected mass for testing would be below the detection limit.



For example: with assumed concentration of Naphthalene of 1 µg/L the device needs 33 days to reach a detection limit, of 0,1 µg/L needs 330 days and of 100 µg/L 0,3 day respectively. With assumed concentration of Toluene of 1 µg/L the dosimeter needs 1,1 year to reach a detection limit, of 0,1 µg/L needs 11 years and of 100 µg/L 4,1 days respectively.

The accumulated mass can be measured in longer periods by using sets of ceramic dosimeters. This shows trends of contamination or decontamination of the groundwater in long-term monitoring. According to the EU Groundwater Directive this method can be used as the Eco&Eco standards.

SUMMARY

Presented examples of modern, however still not very popular sampling techniques aim to detect many problematic substances. Their use for investigating the state and monitoring of the environment in post-industrial areas is recommended due to research reasons (good accuracy and validity), economic (mobility, low sampling costs) and ecological reasons (minimum environmental stresses, observation of actual trends of increase or decrease of contamination levels).

The presentation is based on: PROMOTE project's materials available on the website www.promote-etv.org; materials available thanks to the author's cooperation with imw Weiss company and the results of the author's own research performed for the assessment of heavily contaminated post-industrial sites in Warsaw.

LIST OF REFERENCES

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TAKING COOPERATION FORWARD

TRANSNATIONAL TRAINING ON SUSTAINABLE REMEDIATION

ReSites Meeting, Bydgoszcz 10 May 2017

COMPREHENSIVE ASSESSMENT OF THE SOIL AND WATER ENVIRONMENT IN THE AREA OF THE FORMER 'ZACHEM' CHEMICAL PLANT IN BYDGOSZCZ

Dorota Pierri, Mariusz Czop - AGH University of Science and Technology in Krakow Prelegent, afiliacja

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GENERAL DESCRIPTION OF THE 'ZACHEM'

„Zachem” Chemical Plant JSC in Bydgoszcz city

occupies an area of strong anthropogenic transformation which constitutes over 11% of the city

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HISTORICAL BACKGROUND OF THE 'ZACHEM'

- from 1945 - DAG Fabrik Bromberg
- 1945-1948 - State Gunpowder Factory in Legnowo
- 1948-1951 - NitroFactory Label Legnowo
- 1951-1959 - Chemical Plant No. 9 in Legnowo
- 1959-1971 - Chemical Plant in Bydgoszcz
- 1971-1976 - Chemical Plant 'Zachem' in Bydgoszcz
- 1976-2003 - Chemical Plant 'Organika-Zachem' in Bydgoszcz
- 2003-2012 - Chemical Plant 'Zachem' JSC in Bydgoszcz
- 2012-2014 - Kapuściska Infrastructure JSC

TAKING COOPERATION FORWARD 3

CURRENT STATE OF THE ENVIRONMENT

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TAKING COOPERATION FORWARD 7

CURRENT STATE OF THE ENVIRONMENT

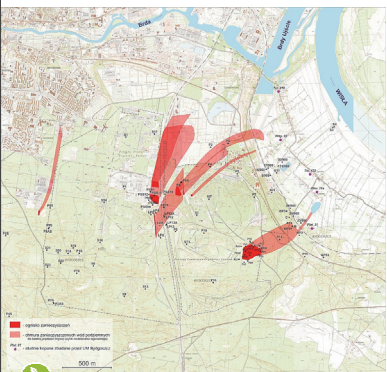
Interreg CENTRAL EUROPE ReSites



TAKING COOPERATION FORWARD 8

CURRENT STATE OF THE ENVIRONMENT

Interreg CENTRAL EUROPE ReSites



- 1) Large area of Chemical Plants (about 1600 ha)
- 2) Long history of activity
- 3) Accumulation of technical infrastructure components
- 4) „Hazardous” for human production profile
- 5) Identification of the most severe contamination sources

TAKING COOPERATION FORWARD 9

PRIORITY LIST OF CONTAMINATION SOURCES

Interreg CENTRAL EUROPE ReSites

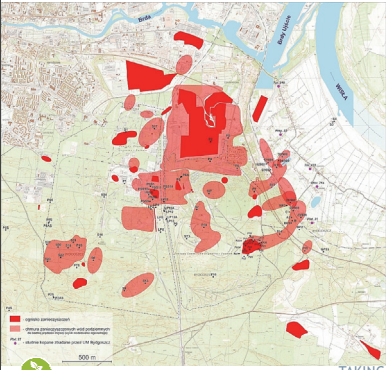
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PHENOL, NITRO-ORGANIC COMPOUNDS, INORGANIC CONSTITUENTS, PRODUCTION WASTES, SLUDGES AND ASHES FROM POWER PLANT
- 4) OTHER OBJECTS

TAKING COOPERATION FORWARD 10

HISTORICAL ENVIRONMENTAL RESEARCH

Interreg CENTRAL EUROPE ReSites

ENVIRONMENTAL RESEARCH FROM 80S



HEAVY METALS:
CR, HG, MN, AS, PB, ZN

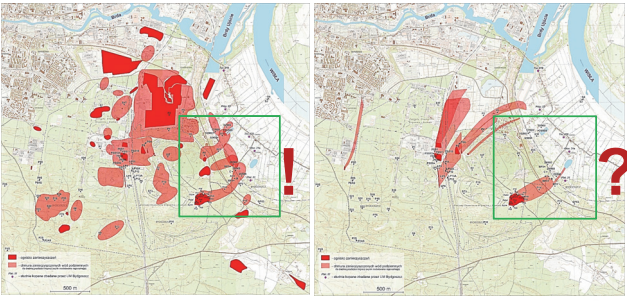
INORGANIC COMPOUNDS:
CL⁻, SO₄²⁻, NA⁺, B³⁺, CYANIDES

ORGANIC COMPOUNDS:
PHENOL, ANILINE, NITROBENZENE

TAKING COOPERATION FORWARD 11

COMPARISON OF ENVIRONMENTAL RESEARCH

Interreg CENTRAL EUROPE ReSites



STATE OF THE ENVIRONMENT 80S STATE OF THE ENVIRONMENT AFTER 2010

Surprising disappearance of contamination?

TAKING COOPERATION FORWARD 12

INDUSTRIAL WASTE SITE 'ZIELONA'

składowisko ogólnostanowiskowych odpadów innych niż niebezpieczne
 chlorofenole (związki gryfobójcze)
 glikole (odpady surowicze produkcyjny) i olej z syntezatorów ciepła
 odpady innych podmiotów niż ZOZ "Zielona"
 odpady z produkcji w skali półprzemysłowej
 odpady z dwóch stacji spalania
 odpady z sortowania odpadów (RSC)

składowisko odpadów niebezpiecznych
 pak (t), bezpostaciowy odpad z produkcji fenolu
 stacjonary i mobilny stacjonaryzowany fenol
 odpady z produkcji fenolu i kleju Rzeszki (zycia fenolowa - formaldehydowa)
 odpady z produkcji benzenu
 gładz budowlany
 odpady smolisty, mączki, emulsje produkcyjne
 plac spalania odpadów innych niż niebezpieczne
 plac spalania odpadów niebezpiecznych z produkcji specjalnych
 odpadów nitrowodni
 wypalanie urządzeń i lampek wygaszanych
 odpady inne niż niebezpieczne

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 odpadów nitrowodni
 wypalanie urządzeń i lampek wygaszanych
 odpady inne niż niebezpieczne

HYDROGEOLOGICAL NUMERICAL MODELLING

Contaminated area more than
15 times bigger than the Main Square!

TAKING COOPERATION FORWARD 14

POLLUTANTS

phenol C_6H_5OH (hydroxybenzene)

aniline $C_6H_5NH_2$ (phenylamine)

toluidine $CH_3C_6H_4NH_2$ (methylaniline)

chloroaniline $ClC_6H_4NH_2$

octylphenol $CH_3(CH_2)_7C_6H_4OH$
 and ethoxylated octylphenol esters
 $CH_3(CH_2)_6CH_2$

hydroxybiphenyl $C_{12}H_{10}O$ (phenylphenol)

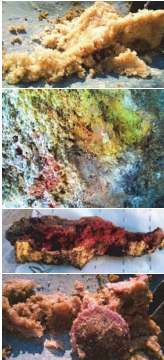

diphenyl sulfone $C_{12}H_{10}O_2S$

TAKING COOPERATION FORWARD 15

CURRENT STATE OF THE ENVIRONMENT

The use and production of various substances both organic and inorganic ones was not without the effect on the condition of soil and water environment. The pollutants were detected in the past and are now being detected within all of the components of natural environment - particularly in soils and groundwater.

Conditions of contamination of the natural environment with toxic substances (often mutagenic and carcinogenic) are particularly significant in relation to the potential impact on the natural heritage in the area of Plant, ie. the Backwoods of Bydgoszcz "Valley of the Lower Vistula" Nature 2000.

TAKING COOPERATION FORWARD 16

PRIORITY LIST OF THE ACTIONS

- 1) STARTING THE BARRIER
LIMITING MIGRATION OF POLLUTION FROM INDUSTRIAL WASTE SITE 'ZIELONA' INTO INHABITED AREAS (ŁĘGNOWO, OTOROWO, PŁĄTNOWO)
- 2) CREATING AND CURRENT SERVICE OF THE INTEGRATED MONITORING NETWORK OF SOIL AND WATER ENVIRONMENT IN THE AREA OF THE 'ZACHEM' CHEMICAL PLANT IN BYDGOSZCZ
- 3) IMPLEMENTATION OF EFFECTIVE REMEDIATION OF THE SOIL AND WATER ENVIRONMENT IN THE AREA OF 'ZIELONA' INDUSTRIAL WASTE SITE ALONG WITH A CONTAMINATION PLUME
- 4) DETAILED RESEARCH FOR DIFFERENT SOURCES OF POLLUTION AND THEN PERFORMANCE OF THEIR REMEDIATION PROJECTS

TAKING COOPERATION FORWARD 17

REAL THREAT TO LIFE AND HEALTH

ŁĘGNOWO

ŁĘGNOWO I
founded in 1954
1 985 inhabitants


ŁĘGNOWO II
founded in 1977
814 inhabitants


STRONG CONTAMINATION OF SHALLOW GROUNDWATER:
Total organic carbon (TOC): 32,6 mg/dm³
Organic compounds: phenol, anilinae, Toluidine, phenanthrene (PAHs)




TAKING COOPERATION FORWARD


REAL THREAT TO LIFE AND HEALTH






Inhabitants of BRDYUJŚCIE

Inhabitants of ŁĘGNOWO




Inhabitants of HUTNICZA St.

Inhabitants of OTOROWO




Inhabitants of PŁĄTNOWO


Inhabitants of AWARYJNE Hous. Est.

TAKING COOPERATION FORWARD  19

SUMMARY



1. OCCURRENCE OF EXTREMELY HAZARDOUS ORGANIC POLLUTANTS (CARCINOGENIC AND MUTAGENIC) WITH RELATIVELY VERY HIGH CONCENTRATIONS (INDUSTRIAL WASTEWATER LEVELS)
2. HIGH NUMBER OF THE SUPPOSED POLLUTANTS SOURCES (27 OBJECTS IN „ZACHEM” CHEMICAL PLANT ONLY)
3. DEFICIENCIES IN THE POLLUTION STUDIES FOR THE ENVIRONMENTAL COMPONENTS (ESPECIALLY RISKS FOR HUMAN HEALTH AND BIOTA)
4. IDENTIFICATION OF THE 7 PLUMES OF POLLUTANTS IN GROUNDWATER FROM POLLUTION SOURCES (MAINLY INDUSTRIAL WASTE SITES)
5. SERIOUS HAZARD FOR INHABITANTS DUE TO POLLUTION OF SHALLOW GROUNDWATER (DUG WELLS) AND SURFACE WATER
6. EXTREMELY HIGH COSTS OF THE REMEDIATION (UP TO 500 MLN EUR)

TAKING COOPERATION FORWARD  20

CONTACT




Dorota Pierri, PhD Eng.
 Mariusz Czop, PhD Eng.


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 Faculty of Geology, Geophysics and Environmental Protection
 AGH University of Science and Technology in Krakow



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TAKING COOPERATION FORWARD

TRANSNATIONAL TRAINING ON SUSTAINABLE REMEDIATION

ReSites Meeting, Bydgoszcz 10 May 2017

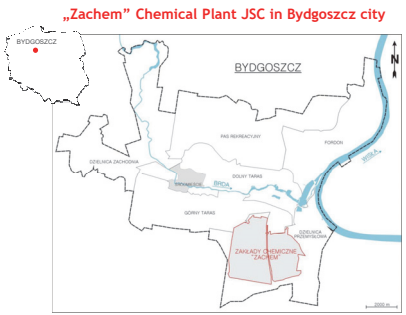
COMPREHENSIVE ASSESSMENT OF THE SOIL AND WATER ENVIRONMENT IN THE AREA OF THE FORMER 'ZACHEM' CHEMICAL PLANT IN BYDGOSZCZ


Dorota Pierri, Mariusz Czop - AGH University of Science and Technology in Krakow Prelegent, afiliacja





GENERAL DESCRIPTION OF THE 'ZACHEM'

„Zachem” Chemical Plant JSC in Bydgoszcz city










occupies an area of strong anthropogenic transformation which constitutes over 11% of the city

TAKING COOPERATION FORWARD 2



HISTORICAL BACKGROUND OF THE 'ZACHEM'



- from 1945 - DAG Fabrik Bromberg
- 1945-1948 - State Gunpowder Factory in Legnowo
- 1948-1951 - NitroFactory LabelLegnowo
- 1951-1959 - Chemical Plant No. 9 in Legnowo
- 1959-1971 - Chemical Plant in Bydgoszcz
- 1971-1976 - Chemical Plant 'Zachem' in Bydgoszcz
- 1976-2003 - Chemical Plant 'Organika-Zachem' in Bydgoszcz
- 2003-2012 - Chemical Plant 'Zachem' JSC in Bydgoszcz
- 2012-2014 - Kapuściska Infrastructure JSC

TAKING COOPERATION FORWARD 3

HISTORICAL BACKGROUND OF THE 'ZACHEM'



Dynamit - Aktien Gesellschaft Fabrik Bromberg

included nitrocellulose ($C_6H_7N_2O_5$), smokeless powder and nitroglycerin ($C_3H_5N_3O_9$), TNT ($C_7H_5N_3O_6$), dinitrobenzene ($C_6H_4N_2O_4$), V1 missiles, as well as aerial bombs, artillery shells and powder charges

Polish plant produced for the military and civil needs (after 1948)

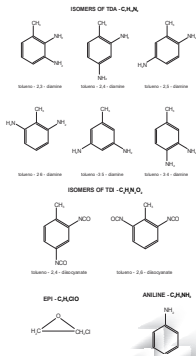
TNT ($C_7H_5N_3O_6$), pentaerythritol tetranitrate ($C_{12}H_8N_{10}O_{22}$) and tetryl ($C_7H_5N_3O_8$) for the military and civil needs. It also produced dyes, dyeing intermediates, pigments and phenol (C_6H_6O), as well as dinitrotoluene (DNT $C_7H_5N_2O_4$), nitrobenzene ($C_6H_5NO_2$), aniline (C_6H_5N) and products from the recycled PVC

Chemical Plant in Bydgoszcz (from the 60s)

the production of isocyanates, dienes and polycarbonates, the polyurethane complex; flexible polyurethane foams, the electrolysis of brine, phosgene ($COCl_2$), dinitrotoluene (DNT $C_7H_5N_2O_4$), toluene diamine (TDA $C_7H_8N_2$), toluene diisocyanate (TDI $C_9H_{10}N_2O_2$) and epichlorohydrin (EPI C_2H_4ClO) as well as rigid polyurethane foams

Basic and most important products manufactured in the Plant

toluene diisocyanate (TDI), allyl chloride (C_3H_5Cl), epichlorohydrin (EPI), hydrochloric acid (HCl), sodium hydroxide (NaOH) and sodium hypochlorite (NaClO)



TAKING COOPERATION FORWARD

4

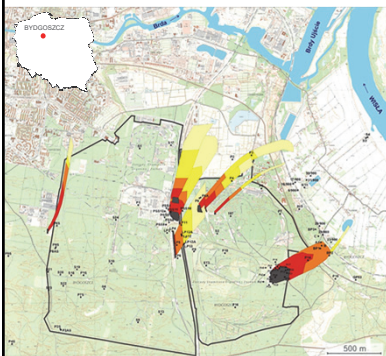
CURRENT STATE OF THE ENVIRONMENT



TAKING COOPERATION FORWARD

5

CURRENT STATE OF THE ENVIRONMENT



The quality of groundwater has a mosaic character

in the area of the Chemical Plant are zones of clean water but also zones of groundwater highly contaminated as a result of industrial activities.

Zones of strongly contaminated groundwater by coexisting organic and inorganic substances occur within contaminant plumes which are genetically assigned to the surface sources of contamination.

Main inorganic contaminants: Cl⁻ and Na⁺.

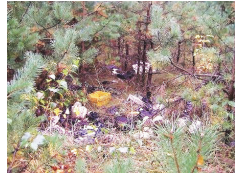
Main organic contaminants: phenol, AOX substances, diphenyl sulfone, hydroxybiphenyl, octylphenol and ethoxylated octylphenol esters and chlorinated ethenes and methanes.



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6

CURRENT STATE OF THE ENVIRONMENT



TAKING COOPERATION FORWARD

7

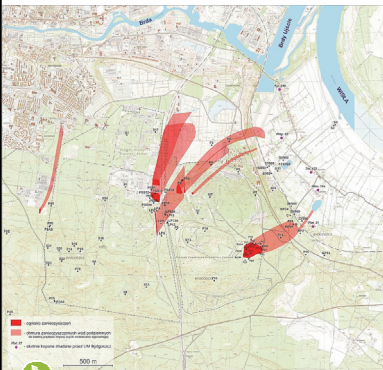
CURRENT STATE OF THE ENVIRONMENT



TAKING COOPERATION FORWARD

8

CURRENT STATE OF THE ENVIRONMENT



- 1) Large area of Chemical Plants (about 1600 ha)
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- 5) Identification of the most severe contamination sources



TAKING COOPERATION FORWARD

9

PRIORITY LIST OF CONTAMINATION SOURCES



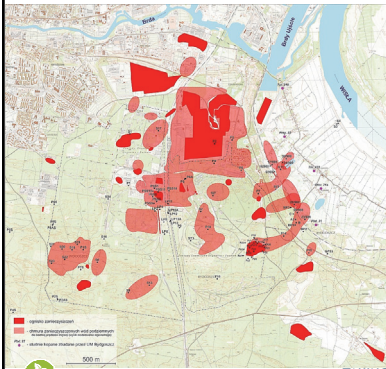
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TAKING COOPERATION FORWARD

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HISTORICAL ENVIRONMENTAL RESEARCH



ENVIRONMENTAL RESEARCH FROM 80S



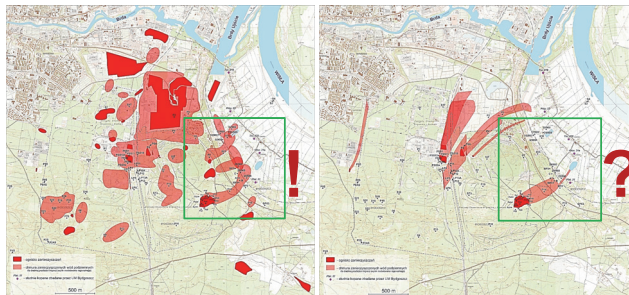
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- INORGANIC COMPOUNDS:
CL⁻, SO₄²⁻, NA⁺, B³⁺, CYANIDES
- ORGANIC COMPOUNDS:
PHENOL, ANILINE, NITROBENZENE



TAKING COOPERATION FORWARD

11

COMPARISON OF ENVIRONMENTAL RESEARCH



STATE OF THE ENVIRONMENT 80S

STATE OF THE ENVIRONMENT AFTER 2010

Surprising disappearance of contamination?



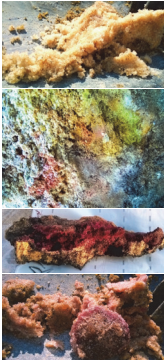

TAKING COOPERATION FORWARD

12

CURRENT STATE OF THE ENVIRONMENT

The use and production of various substances both organic and inorganic ones was not without the effect on the condition of soil and water environment. The pollutants were detected in the past and are now being detected within all of the components of natural environment - particularly in soils and groundwater.

Conditions of contamination of the natural environment with toxic substances (often mutagenic and carcinogenic) are particularly significant in relation to the potential impact on the natural heritage in the area of Plant, ie. the Backwoods of Bydgoszcz "Valley of the Lower Vistula" Nature 2000.

TAKING COOPERATION FORWARD 16

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TAKING COOPERATION FORWARD 17

REAL THREAT TO LIFE AND HEALTH

ŁĘGNOWO

ŁĘGNOWO I
founded in 1954
1 985 inhabitants

ŁĘGNOWO II
founded in 1977
814 inhabitants

STRONG CONTAMINATION OF SHALLOW GROUNDWATER:
Total organic carbon (TOC): 32,6 mg/dm³
Organic compounds: phenol, anilinae, Toluidine, phenanthrene (PAHs)




TAKING COOPERATION FORWARD

REAL THREAT TO LIFE AND HEALTH



Inhabitants of BRDYUJŚCIE

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Inhabitants of OTOROWO



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Inhabitants of AWARYJNE Hous. Est.



TAKING COOPERATION FORWARD

19

SUMMARY



- 1. OCCURRENCE OF EXTREMELY HAZARDOUS ORGANIC POLLUTANTS (CARCINOGENIC AND MUTAGENIC) WITH RELATIVELY VERY HIGH CONCENTRATIONS (INDUSTRIAL WASTEWATER LEVELS)**
- 2. HIGH NUMBER OF THE SUPPOSED POLLUTANTS SOURCES (27 OBJECTS IN „ZACHEM” CHEMICAL PLANT ONLY)**
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- 6. EXTREMELY HIGH COSTS OF THE REMEDIATION (UP TO 500 MLN EUR)**



TAKING COOPERATION FORWARD

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CONTACT



Dorota Pierri, PhD Eng.

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TAKING COOPERATION FORWARD

21

MODELLING OF CHEMICAL MIGRATION UNDER
THE OVERLAPPING IMPACT OF MULTIPLE AND
DIVERSE POLLUTION SOURCES IN THE AREA OF
THE „ZACHEM” CHEMICAL PLANT
(BYDGOSZCZ, NORTHERN POLAND)

Dorota Pierri, Mariusz Czop

05-2017





Abstract: Modeling studies of chemical migration in the area of the “Zachem” Chemical Plant in Bydgoszcz started from the analyses of the production profile. Those studies were conducted to investigate the potential contamination. Organic compounds still represent a substantial concentration in soil and water environment, including total organic carbon (TOC) reaching values above 1600 mg/L, aniline, nitrobenzene and phenol (up to 500-800 mg/L), organochloride and organometallic compounds, as well as hydrocarbons, such as benzene, toluene and PAHs. Groundwater contains most of the major ions (chlorides, sulphates and bicarbonates, sodium and calcium) and trace elements (Al, Co, Cr and Ni).

A reliable conceptual model of the geological structure was constructed for 3 continuous layers with variable bottom morphology. This model represents the complex structure containing permeable and impermeable Quaternary and Neogene deposits. A hydrogeological numerical model was created for the area of the “Zachem” Chemical Plant using the Visual MODFLOW program. Low values of two key statistical measures confirm a good model fit to the measured data: root mean square (RMS) amounts to only about 1.5 m and normalized RMS reaches only about 4.4%. The differences between measured and calculated values are normally distributed. A Modpath module was used to analyze the potential extent of contaminant plume. Accurate hydrogeological 3D sampling was conducted using a “low flow” technique.

The results of full and reliable modeling of the chemical migration under the overlapping impact of multiple and diverse pollution sources in the area of the “Zachem” Chemical Plant are essential for further planning of remedial strategies.

Key words: groundwater pollution, “Zachem” Chemical Plant, organic and inorganic contamination, pollution migration, numerical model

AGH University of Science and Technology, Kraków, Poland

Correspondence: Dorota Pierri, Department of Hydrogeology and Engineering Geology, Faculty of Geology, Geophysics and Environmental Protection, AGH University of Science and Technology, Mickiewicza 30 Av., 30-059 Kraków, Poland. E-mail: pietruc@agh.edu.pl



INTRODUCTION

Chemical plants are objects of potentially high risk to the soil and water environment. Production of chemical substances with a high potential for toxicity, both organic and inorganic ones, poses high risk of pollutant infiltration into the soil and groundwater. These substances do not occur in natural conditions and are strongly related to the specificity of the manufacturing industry.

Modeling of chemical migration in industrial areas, heavily modified by human activity, is a relatively difficult task. One of the particularly characteristic features of such industrial areas is having a number of pollution sources, often extremely varied in terms of the type of chemical substances hazardous to soil and water environment and/or migrating within. In addition to typical pollution sources (industrial waste dumps), industrial areas are characterized by technological infrastructure of high density, including pipelines, technological ponds, pools and sewage systems. In case of accident, all these elements can negatively affect the environment, which cannot be avoided even in a perfectly functioning plant (Witkowski et al. 2008; Weingran, Meiners 2015).

Until recently (year 2013) the “Zachem” Chemical Plant in Bydgoszcz was the largest producer of organic chemicals for the Polish market. Hydrogeological studies revealed a significant environmental contamination by both organic and inorganic substances within the area of the plant.

This paper presents methodological solution to the problem of migration modeling, emphasizing the importance of the field work and sampling stages, described in this paper. Credible hydrogeological model is not restricted only to computing. The entire study consists of: laborious and detailed fieldwork, understanding and accurate mapping of the geological structure of the area as well as hydrogeochemical processes occurring in the aquifer. Only consideration of all stages of research allows to create a correct and reliable model.

PRECEDING STUDIES

The modeling of chemical migration should always begin with a detailed analysis of the plant’s production profile in order to identify the expected pollutants (Figure 1). Initially, the “Zachem” Chemical Plant in Bydgoszcz produced explosive materials for the mining industry. Then the production was adapted to both military and civilian needs, producing trinitrotoluene $C_7H_5N_3O_6$, PENT $C_5H_8N_4O_{12}$ or tetryl $C_7H_5N_5O_8$. It also produced dinitrotoluene $C_7H_6N_2O_4$, nitrobenzene $C_6H_5NO_2$, aniline $C_6H_5NH_2$, products from recycled PVC (mer structure $-CH_2CHCl-$), dyeing intermediates, dyes, pigments and phenol C_6H_6O . Experimental isocyanate systems (isocyanate group $-N=C=O-$), diene (chemical bonds $-CH=C=CH-$ or $-CH=CH-CH=CH-$) and polycarbonates were tested in the plant in the early 60’s of the last century. Studies on the construction of polyurethane complex were also conducted. Allyl chloride C_3H_5Cl , dinitrotoluene $C_7H_5N_2O_4$, epichlorohydrin C_3H_5ClO , phosgene CCl_2O , hydrochloric acid HCl , sodium hypochlorite $NaClO$, toluenediamine $C_7H_{10}N_2$, toluene diisocyanate $C_9H_6N_2O_2$ and sodium hydroxide $NaOH$ were also produced from the 70’s until 2013. Polyurethane, rigid foams and polyurethane foam fittings for the automotive industry were also among the products manufactured in the “Zachem” Chemical Plant (Pietrucin 2013).

The use and production of various substances, both organic and inorganic, in the “Zachem” Chemical Plant had an impact on the conditions of adjacent soil and water environment. Contaminants have been reported in the past and currently detected within all components of the natural environment, particularly in soil and groundwater. Identification of all substances used in production processes of the plant is the most important task to recognize the type of soil and water pollution.

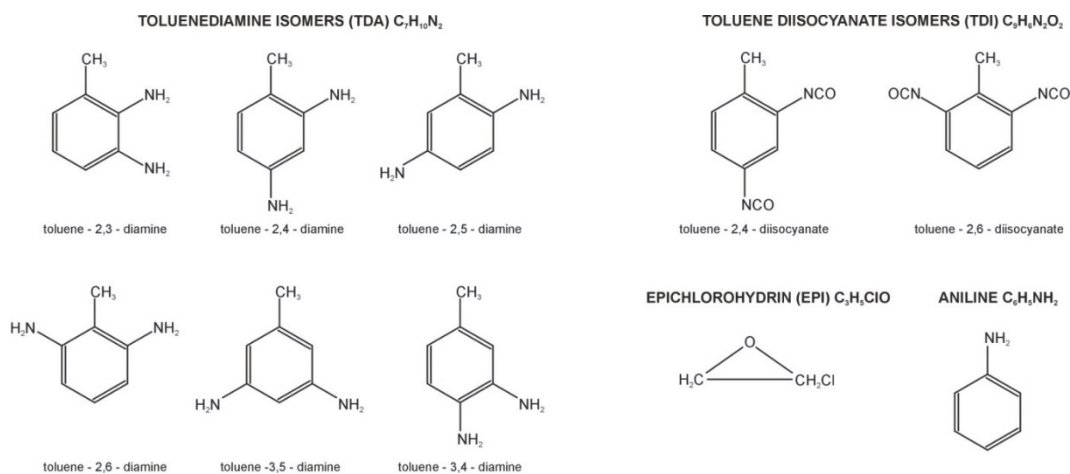


Fig. 1. 'Zachem' Chemical Plant production profile - selected chemical compounds

Very high concentration of organic compounds is one of characteristic features of groundwater polluted by chemical plants. It is manifested by an extremely high concentration of total organic carbon (TOC), reaching values above 1600 mg/L. The identified organic substances in groundwater included aniline, nitrobenzene and phenol (with determined concentrations up to 500-800 mg/L). Groundwater contains also organochloride and organometallic compounds as well as hydrocarbons, including benzene, toluene and PAHs.

Among inorganic components found in groundwater in the vicinity of the chemical plants there were very high concentrations of most of the major ions (chlorides, sulphates, bicarbonates, sodium and calcium) and trace elements, including those of high toxicity to living organisms and humans (Al, Co, Cr and Ni).

CONCEPTUAL MODEL

The development of a conceptual model is the second key step in understanding the migration of pollutants in groundwater. It is the basis and foundation for any further action. This includes understanding of the system layout and structure together with the development of its objectives. Errors made at this stage are of fundamental importance for the adequacy of hydrogeological model. Computer modeling from this point of view, is a verification or confirmation of the author's understanding of the analyzed aquifer system (Woessner 1995).

Organic and inorganic substances originating from different sources of pollution after infiltrating into the soil, migrate with the direction of groundwater flow (Pietrucin 2013). In general, in the area of the former "Zachem" Chemical Plant groundwater flows to the north and north-east to the rivers Vistula and Brda. The most important factors affecting the direction of groundwater flow include simultaneous occurrence of permeable sands and gravels together with impermeable boulder clays, buried valleys and hydrogeological windows constituting contact zone between aquifers. Groundwater flowing from the High Plane towards the Vistula Valley emerges at the surface in the form of leaks and wetlands. Precise recognition and understanding of the geological structure is the key element of credible mapping of the geological structure and hydrogeological conditions of the model, leading to the solution of the problem of chemical migration in groundwater. Emphasis should be put on the precise recognition of the location of any elements disturbing groundwater flow directions (boulder lenses and buried valleys) and bottom morphology of the aquifer. All these aspects allow to conclude that the geological structure of the area of the former "Zachem" Chemical Plant is highly complex (Czop 2010).



A numerical model was prepared based on lithological profiles of approximately 90 boreholes (wells and piezometers). The conceptual model of geological structure is composed of 3 layers which reflect lithological separations. This is the key of the description of hydrogeological conditions within the “Zachem” Chemical Plant area. Model layers were created taking into consideration their morphology and variable thickness (Figures 2, 3). The numerical model includes:

- 1st layer – Quaternary deposits predominantly present in the form of sand and locally boulder clay,
- 2nd layer – Pliocene clays and silts in the area of the moraine upland and Quaternary sands in the area of the Vistula River Valley,
- 3rd layer – Miocene sandy deposits (isolated from Quaternary aquifer in the area of High Plane and connected with them in the area of Vistula and Brda Rivers Valleys).

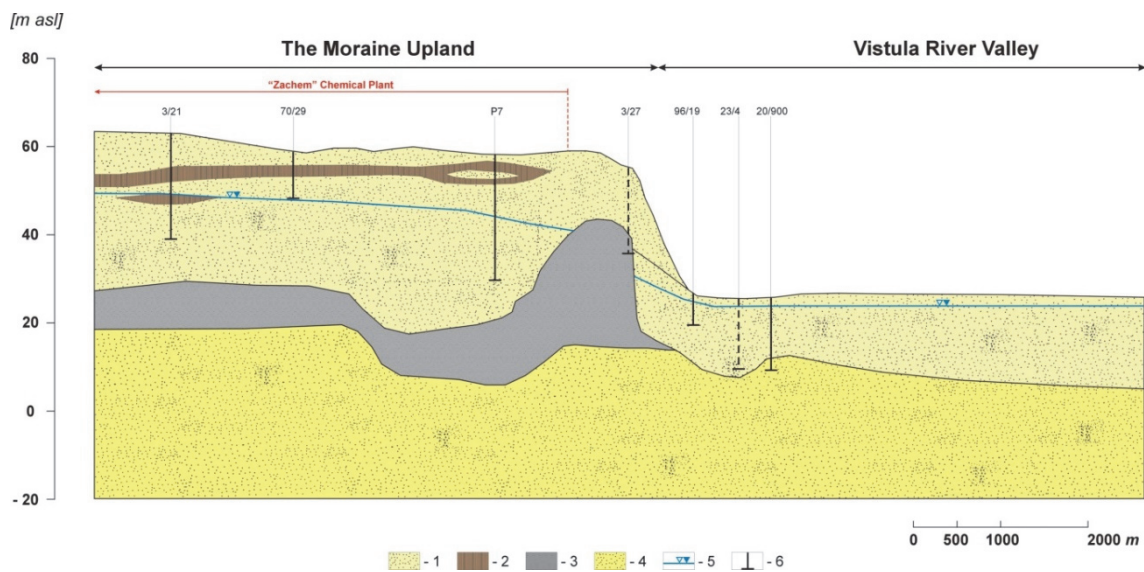


Fig 2. Geological cross-section of “Zachem” Chemical Plant in Bydgoszcz (based on Narwojsz 1987)

Legend: 1 – Quaternary sands, 2 – Quaternary boulder clay, 3 – Pliocene clay and silts, 4 – Miocene sands, 5 – groundwater table, 6 – borehole(well, piezometer)

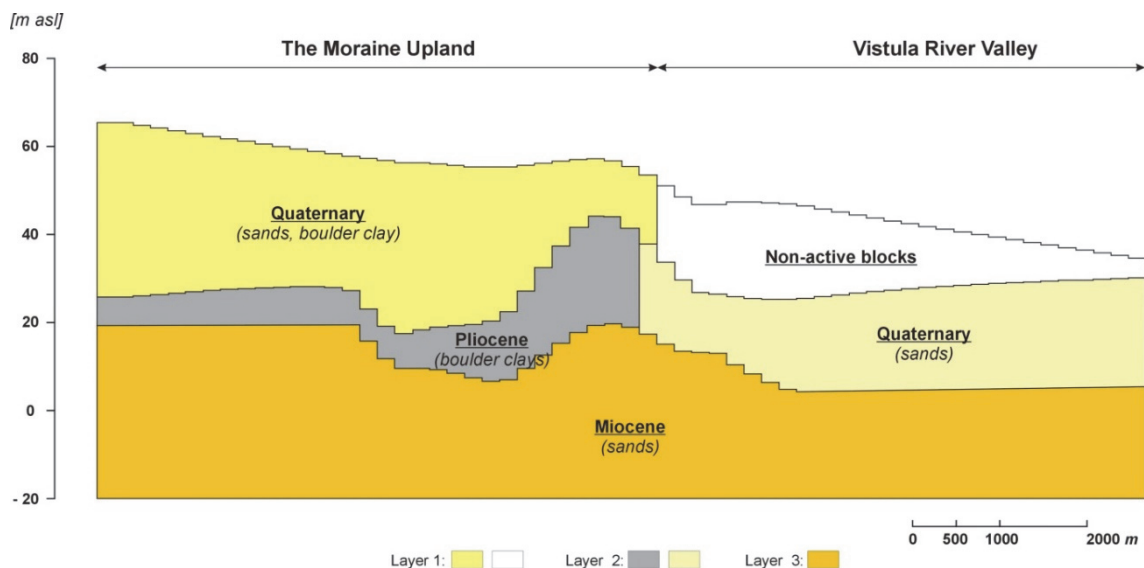


Fig. 3. Conceptual model of geological structure



Such detailed mapping of the geological structure based on a conceptual model allows to create a precise hydrogeological numerical model and to investigate the migration of chemical substances. From the viewpoint of the accuracy of modeling studies this methodology is more appropriate than the application of flat layers with constant thickness.

NUMERICAL MODEL

The hydrological model was created using the Visual MODFLOW program for the purpose of mapping the migration of chemical substances from the area of the “Zachem” Chemical Plant. Visual MODFLOW is currently the most popular and most widely used program for modeling in hydrogeology. It was developed by Schlumberger Water Services (formerly Waterloo Hydrogeologic). The creation of the numerical model is therefore the third and fundamental stage of modeling of chemical migration in industrial areas.

The model domain covers the area of a significant size of 8 km × 12 km, i.e. 96 km². The study area comprises both the chemical plant in Bydgoszcz and the land up to the Vistula and Brda riverbeds – this is the direction of pollution migration in groundwater from the above chemical plant. Discretization of model domain was conducted. The size of square calculation blocks is 200 meters. In total, there are 2400 blocks in one layer of the model area (60 columns and 40 lines) including the majority of active blocks.

The hydrogeological model of the analyzed area very well reflects the actual condition of hydrodynamic field, which was achieved based on field measurements of about 90 piezometers and wells. With respect to the measurement from December 2009 the differences between the actual and calculated elevations of groundwater table fall within ± 2 m for the vast majority of study sites. Larger differences occur only in about 15% of the boreholes, mainly in the area of very sharp decrease of the groundwater table at the border of the High Plane and Vistula River Valley. It is very difficult to show the accurate reflection of groundwater table morphology in this area, because a slight change in the location of a borehole gives a significant difference in the level of the groundwater table. Low values of two key statistical measures confirm good model fitness to the measured conditions: root mean square (RMS) amounts to only about 1.5 m and normalized RMS is only about 4.4%. The differences between the measured and calculated values are normally distributed (Czop 2010, Pietrucin 2013).

The main aim of creating a prognostic model was to map the directions of contaminant migration from the pollution sources in the area of the “Zachem” Chemical Plant in Bydgoszcz. Due to the complex hydrogeological conditions within this area and coexistence of both organic and inorganic chemical substances, the discussed problem is very difficult to resolve.

The simulation was performed by assuming a worst-case scenario of non-reactive pollutants’ migration with the groundwater flow, i.e. no chemical reactions with the liquid (water) and solid (soil) phase. This approach to the problem allows to use the Modpath module. It was used to visualize the flow directions of contaminants and the maximal possible range of contaminant plume in groundwater (Figure 4).

The predicted ranges of contaminant plumes according to both organic and inorganic pollution migration in “Zachem” Chemical Plant should be regarded as preliminary and require further detailed studies.

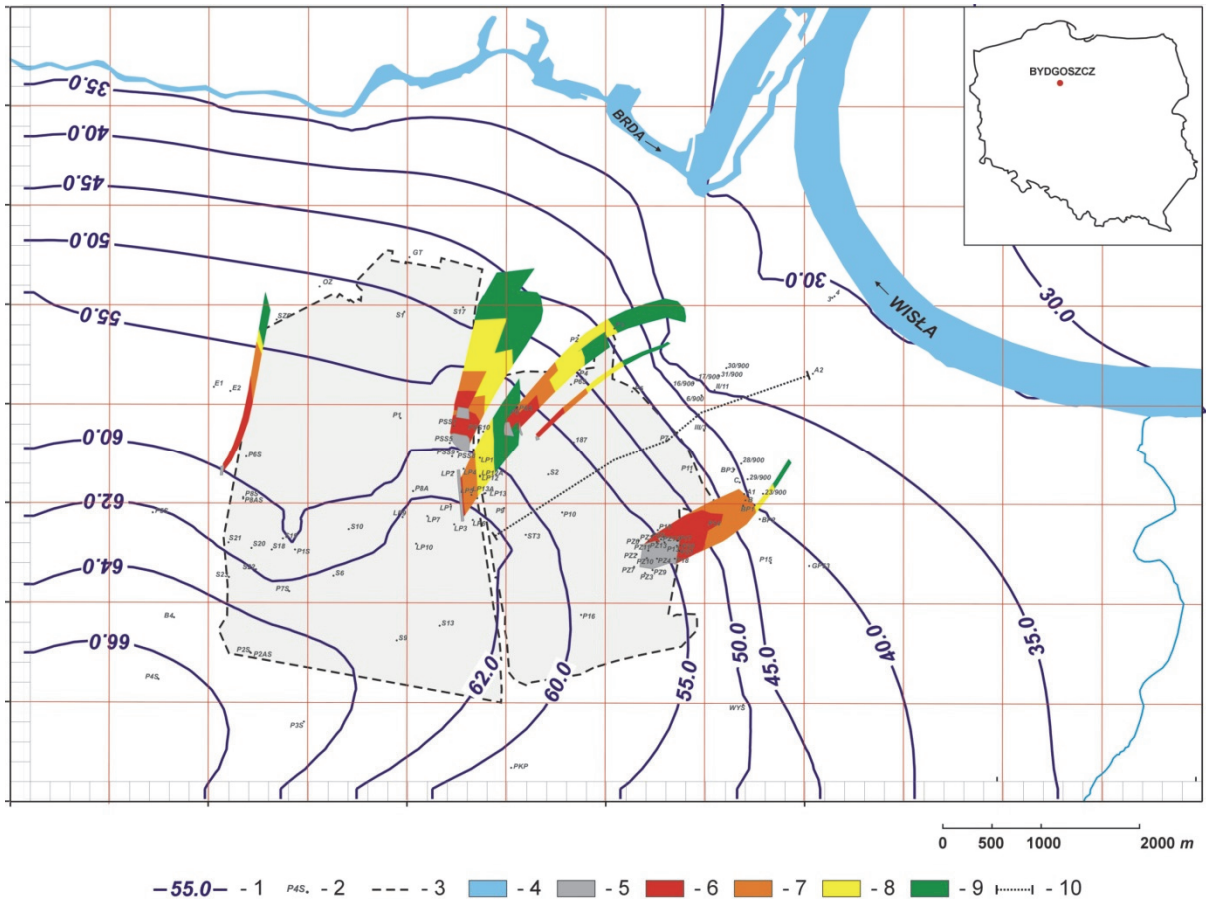


Fig. 4. Predicted ranges of contaminant plumes from pollution sources identified in the "Zachem" Chemical Plant in Bydgoszcz
 Legend: 1 – groundwater table contour [m asl], 2 – hydrogeological borehole (well, piezometer), 3 – border of the "Zachem" Chemical Plant, 4 – surface water, 5- source of pollution, 6 – range of contaminant plume after 25 years, 7 – range of contaminant plume after 50 years, 8 – range of contaminant plume after 75 years, 9 – range of contaminant plume after 100 years, 10 – geological cross-section line (Fig. 3)

DETAILED STUDIES

The visualization of the contaminant flow directions and range of contaminant plume in groundwater is often mistakenly considered as the final stage of the modeling process. Authors take for granted that the border of the range is accurate and precisely mapped. After completion of a reliable conceptual and numerical models, the verification of the results should always require detailed research. Understanding of the research study area, geological structure and hydrogeochemical processes allows the authors to clarify the range of contamination. This task is relatively simple for one source of pollution and one contaminant plume but complicated and interesting conditions exist in mixing zones.

Organic substances originating from the identified sources of pollution in the area of the chemical plant (primary substance) migrate in groundwater in unchanged form or can be transformed by chemical reactions with other compounds (organic and inorganic) occurring within the contaminant plume, but new organic compounds (secondary substances) may therefore be formed in the contaminated groundwater. Because of diverse chemical composition of individual streams of contaminated



groundwater and different Eh-pH conditions, chemical reactions (both degradation and the formation of new compounds) may occur in different directions. According to the world literature (Eisenhauer, 1968; Kuo et. al., 1977; Montgomery, 2000), soil and water pollutants in the area of chemical plants decompose into dozens of various substances (Figure 5). All of these transformations, due to their high complexity, are difficult to describe. Cross-reactions occur between organic and inorganic compounds and between a wide range of new products.

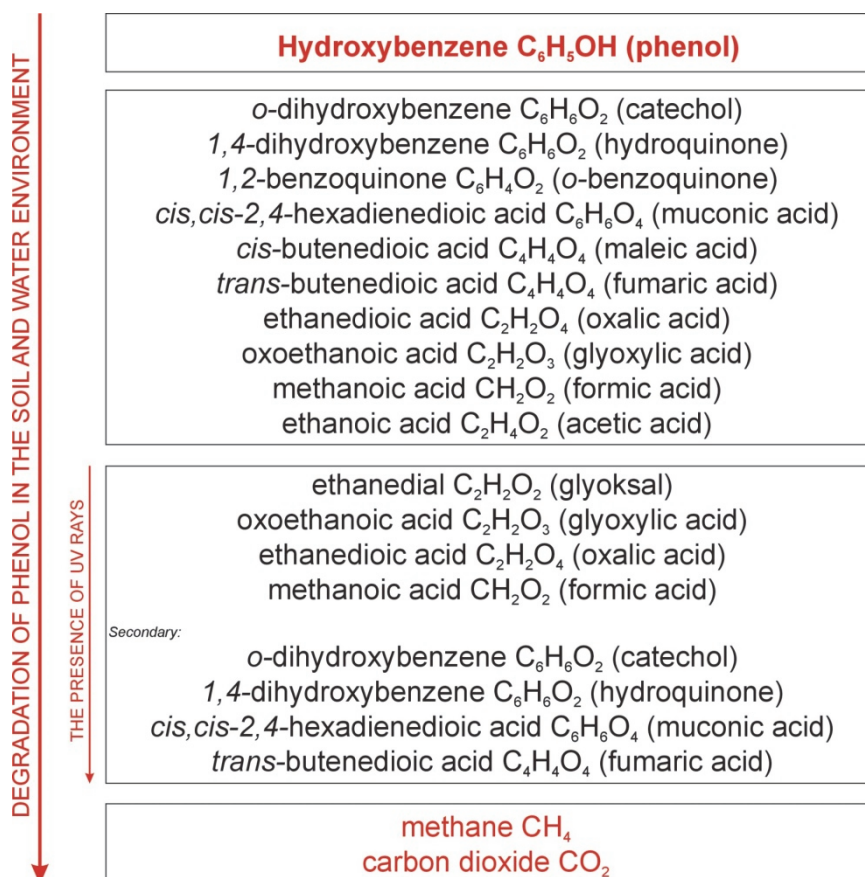


Fig. 5. Phenol degradation scheme in the soil and water environment

In the context of the contaminant plume there is also an important issue of determining the chemical composition of groundwater, taking into account the stratification of pollutants in the vertical profile of the aquifer. Such studies have been carried out at the "Zachem" Chemical Plant in the period from 2012 to 2013. Those studies were carried out under conditions of "low flow" sampling technique. Continuous measurements of variation in physicochemical parameters such as temperature, electrical conductivity, pH value, redox potential and dissolved oxygen were performed at the same time within the columns of individual boreholes (Witkowski 2009).

This technique allows for the spatial sampling of contaminant plume taking into account the stratification of the concentration of pollutants in the studied borehole: (x) samples along the length of contaminant plume from the pollution source in the direction of its drainage zone, (y) variation in the concentration from the center to the edge of plume and (z) vertical stratification in piezometer. These



three monitoring directions of contamination spread in the aquifer are the most significant and allow for complete analysis and subsequent control of the contaminant plume propagation (Pietrucin 2013).

SUMMARY

Modeling of the chemical migration in groundwater in industrial, highly urbanized areas is very complicated. It also applies to the area of the discussed “Zachem” Chemical Plant in Bydgoszcz. This problem is even more complex under the conditions of overlapping impact of multiple and diverse pollution sources. Coexistence of organic and inorganic substances together with chemical reactions occurring in the aquifer in the vicinity of the studied chemical plant also cause a number of problems in this context. The only reasonable solution to this complex task is to broaden the numerical model with thorough research including accurate identification of the potential contamination. Then it is necessary to understand and map the geological structure which allows to create a target numerical model. Interpretation and critical assessment of the results justifies undertaking detailed studies. Those studies will verify ranges of contaminant plumes.

Modeling of chemical migration in the “Zachem” Chemical Plant in Bydgoszcz is one of the elements that allow for the development of an environmental reclamation plan. It is essential to purify the soil and water environment due to the real threat to the health and life of local inhabitants of Bydgoszcz and its nearby areas - Otorowo, Płątnowo, Łęgowo. Due to very complex geology and hydrogeological conditions as well as extreme organic and inorganic contamination of groundwater, specialized remediation methods should be used in this area. These methods are designed for specific chemical compounds and individual contaminant plume.

Based on detailed analysis of chemical composition of groundwater in the context of inorganic substances and a wide range of organic compounds, particularly including the stratification of the water column in boreholes, it is planned to calculate subsequent numerical models of migration for reactive contaminants. The regional model allows to trace the directions of pollution spread in groundwater. In order to obtain a detailed analysis of the site, local models should be developed for each of the industrial waste dumps (e.g. “Zielona” industrial waste dump) or when their effects overlap - for their groups. The development and design of the optimum scenario for soil and water remediation can be based only on a reliable model. Preliminary costs of land restoration are estimated to be at least several hundred million PLN.

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