Management of the remediation and re-use of contaminated industrial sites in the Czech Republic—Karolina site, Ostrava

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Abstract The approach to soil pollution remediation based on the legislation of the Czech Republic is explained here using the Karolina site as a case study. Karolina site is an area in the town of Ostrava that has been heavily contaminated due to past industrial activities. This project responds to the plans of the City of Ostrava to restore the Karolina site to make it a new administrative and business centre of the town. The project will be one of the biggest cleanup actions in the Czech Republic and the first example of such a site being converted for non-industrial purposes.

REMITIATION IN THE CZECH REPUBLIC—A FRAMEWORK

An impressive remediation programme was started in the Czech Republic after the end of the communist regime as a consequence of the industrial privatization process. The government declared its responsibility for environmental pollution that had been caused by previously state-owned industry. Old pollution was excluded from other liabilities that were generally transferred with privatized properties to new owners. In total, US$3 × 10⁹ are allocated for spending on soil and groundwater cleanup.

An environmental audit, which must also contain a preliminary assessment of soil and groundwater pollution, is an obligatory part of any privatization project. New owners of privatized enterprises may apply for a refund of the remediation expenses by the National Property Fund. It is their last and only chance to be exempted from remediation costs and future liability for the pollution of their sites. Access to funds is bound to the condition that further soil and groundwater pollution ceases.

A risk analysis is a basic obligatory tool for allocation of funding, selection of priorities, establishing remediation goals and criteria with respect to the character and extent of pollution and with respect to the site to be used in future.

The Government, the National Property Fund, the Ministry of Finance and the Ministry of Environment are involved in the decision-making process at the end of which a remediation order for the site in question is issued by the State.
Environmental Inspection. Local authorities are involved by presenting their plans concerning the future land-use of a site and of its surroundings which may be influenced by pollution.

THE KAROLINA SITE

Ostrava is the third biggest town and one of the most important industrial centres of the Czech Republic. For more than a century, its development was tied with mining, steelworks and a chemical industry that have negatively influenced the environment and the quality of urban areas.

There is now an ambitious plan to reconstruct the central part of the City of Ostrava, which comprises a large vacant area, called the Karolina site. It arose from demolition of an industrial complex of 36 ha extent dominated by a coking plant and an associated chemical plant where mainly coking by-products were processed.

According to the City Master Plan, various commercial and institutional objects, and residences, as well as public greenery, have been designed for the Karolina site to integrate it into the active city organism.

The flat, mostly open, terrain of the site is found adjacent to the Ostrava city centre, at a distance of 350 m from the Ostravice River. The industrial activity definitely ceased here in the eighties. Demolition of industrial objects followed, during which just superficial parts of the buildings were removed. The foundations and underground objects, along with a large amount of demolition debris and probably also various tanks and collectors with some liquid fillings, were left mostly buried under the terrain. Most of the land still has no purpose today.

SITE POLLUTION

Investigations confirmed widespread massive soil pollution on the Karolina site, originating from 150 years of industrial usage. This is manifested, first of all, by the huge body of tar substances in a free phase (DNAPL), filling a Quaternary gravel aquifer to depths of 4 to 11 m over an area of 8 ha. In places where original pollution sources were located, massive tar impregnation occurs in upper soils of the vadose zone just near the surface (Fig. 1). It appears that tar and other liquid were deliberately disposed to gravels through infiltration wells. An aureole of high groundwater contamination is associated with the DNAPL/tar body in gravels. Polyaromates, aromates and phenols are dominant organic contaminants. At some spots, increased concentrations of inorganic pollutants (As, Hg) were also identified in the soil.

Pollution in the aquifer spreads from the site at a migration velocity which results in several metres being polluted each year. In some places, it has crossed the site perimeter and borders on to an urbanized area of the city centre. Buried demolition debris and some wastes from the former industrial activities form very unsuitable soil for construction activities from the geotechnical point of view, and should also be taken into account as one aspect of the soil environment deterioration.
RISK ASSESSMENT

The quantitative risk analysis (Voltaggio et al., 1995; Vit, 1996) based on a pollution investigation (Kofroň & Šmit, 1995) confirmed high and unacceptable human risk levels for all scenarios with respect to the planned site use. In hot spots, even short-term visitors could be unacceptably exposed. The crucial exposure pathways are:
- inhalation of organic volatiles (VOCs) emitted from the tar/DNAPL contamination of soil and groundwater (with benzene as a dominant pollutant),
- inadvertent ingestion of the contaminated topsoil (PAHs, arsenic).

The population exposed to the inhalation risk would gradually enlarge as the contamination plume slowly spreads from the site to urbanized surroundings. In a long-term perspective, the Karolina site contamination could also significantly affect water quality in the Ostravice River flowing close to the site.

Risk analysis was used as a tool to formulate remediation goals for the site as follows:
- further migration of the contamination from the site had to cease, regardless of the future land use of the site,
- any use of the Karolina site itself would only be possible on the condition that on-site risks from VOCs inhalation and from inadvertent soil ingestion were reduced.

Finally, remediation criteria, $ILCR \leq 1 \times 10^{-4}$ or $HQ \leq 1$ (individual life time cancer risk or hazard quotient) respectively, were derived from the accepted level of the on-site residual human risk for impacts from VOC inhalation, and from inadvertent soil ingestion for long-term employees and residents. Cost–benefit analysis revealed that remediation

![Fig. 1 Karolina site—schematic cross-section.](image-url)
costs would substantially increase if a residual risk level of $\text{ILCR} \leq 1 \times 10^6$ is required.

As for the Ostravice River, the official Czech river water quality limits were decisive to deriving acceptable residual contamination of groundwater flowing from the site.

**FEASIBILITY STUDY**

Risk assessment was the base for the feasibility study which proposed and assessed remediation options for the site. In principle, seven possible approaches to site remediation were developed for two different residual risk levels; three of them were focused on removing the sources of the risks, and four of them on interrupting the path of exposure by pollution containment.

Each of the approaches was also evaluated from the economic point of view with respect to expected results in risk reduction. Possible changes in the Karolina land-use plan were considered to decrease remediation costs by excluding residential zones from areas with the highest risk on the site. Technical details were not specified by the feasibility study; these were decided later according to accepted levels of residual risk and to the economic and technical site-specific feasibility of the remediation technologies concerned. Room for initiatives from contractors competing for a remediation project performance was also allowed in this manner.

**PROJECT MANAGEMENT**

The complex ownership and responsibility had to be settled with the active involvement of many state and municipal authorities before access to public monetary sources for the remediation could be arranged (there were 16 owners of the site).

It was City of Ostrava, as one of the important land-owners of the site interested in its future development, which initiated the “Karolina Coordination Committee” in 1993. Representatives of all the Karolina site land-owners involved in the Committee agreed to cooperate closely during phases of the site investigation and in a subsequent effort to mobilize financial sources necessary for its remediation and development as well. The Committee accepted an offer presented by the Ministry of the Environment of the Czech Republic for arranging international technical assistance aimed at human health and ecological risk assessment that was provided by US EPA and by INERIS from France.

The Ostrava-Karviná Coal Mine Company (OKD), as the owner of the most seriously polluted area at the Karolina site and the main polluter of it in the past, submitted an application to the National Property Fund (NPF) for reimbursement of the costs of the site remediation. The application had to be supported by a comprehensive report containing results of the site investigation and its risk analysis along with proposed remedial options (Tylčer & Vallíček, 1996).

After approval of all submitted documents by appropriate state authorities, the Government authorized NPF to sign a reimbursement contract with OKD. The Czech
Environmental Inspection then issued an official remediation order for the Karolina site. It paved the way for OKD to advertise a public competition in which NPF, the Ministry of Environment and OKD had decisive votes in selecting a remediation contractor. Subsequently, NPF established a supervising consulting firm to look after the total remediation project on its behalf.

**SITE REMEDIATION**

The offer proposing a removal of the risk source was finally chosen as a traditional, quicker and less risky approach to other offers proposing *in situ* cleanup methods. There was a general resistance to the containment option. The winning proposal is based on the excavation and consecutive *ex situ* treatment of polluted soil from the site encircled by a temporary sheet piling (Figs 2 and 3). Only small peripheral areas which are inaccessible to excavation will be treated by a combination of *in situ* methods (enhanced pump-and-treat, venting).

Special attention must be paid to health protection for the remediation workers and to reducing impacts of site remediation work on surroundings of the Karolina site. surroundings.

The remediation started in autumn 1997 and is supposed to be finished in 2004.

![Diagram](image)

**Fig. 2** Karolina site—first stage of the implemented remediation.
CONCLUSION

The procedure used in the Karolina Project has been accepted by the Czech Ministry of the Environment and the NPF as an example of how the past environmental damage, caused by industry before its privatization, can be solved. Procedures described above proved to be viable and effective. The project will be one of the biggest cleanup actions in the Czech Republic and the first case of such a site being converted for non-industrial purposes. The Karolina Project can also be taken as a stimulating example of a productive and fruitful cooperation between state authorities, municipal elected representatives and industrial managers, significantly supported by the excellent international cooperation of Czech, American and French experts.

REFERENCES


