Application and Development of the Technologies for Contaminated Sites Remediation in the Czech Republic

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Abstract: The Czech Republic is a country of extremely high soil contamination due especially to the vast industrial and military activities in the past. The soil remediation program has therefore the utmost priority in the state environmental policy. Successfully applied remediation technologies are especially represented by:
- venting and bioventing with the purpose of removal of light petroleum products from the former military areas (airfields),
- desorption technologies, such as thermal desorption aimed at removing organic compounds (including PCB´s) and the so-called solidification-evaporation process (applied successfully for example in a treatment of neutralization sludge containing volatile chlorinated compounds),
- bioremediation technologies applied above all during elimination of hydrocarbon contamination but successfully field tested also for treatment of PCB contamination,
- solidification of soil contaminated by petroleum products, which is based on mixing or homogenization of the waste products with active calcium oxide.
The research and development in this field are focused especially on the:
- removal of metals and other compounds by electrokinetic decontamination,
- mathematical modelling enabling us to describe equilibrium and kinetic effects taking place when air is passed through porous materials contaminated by volatile compounds,
- phytoremediation - investigation of the ability of selected plant cultures to accumulate toxic metals from contaminated media.

In greater detail, following processes successfully applied for the remediation of contaminated soils in large-scale operation are discussed:
- thermal desorption
- venting
As examples of application of the thermal desorption technique, the results of two decontamination processes are presented:
Large scale industrial plant (one of the biggest in Europe) for desorption of coal tar and other organic substances from polluted soil (Karolina locality, Ostrava, Northern Moravia).
The soil is excavated in a former industrial zone having an area of about 26 hectares. Due to the many industrial activities in the past (coking, iron processing) both soil and ground waters are significantly contaminated. The polluted soil is heated for 8 minutes to achieve the target temperature within a range of 350^{o}C and 600^{o}C, which is sufficient for the removal of all organic contaminants. In the following step the soil is cooled down to about 90^{o} C and placed into an intermediate storage. Waste gases pass through a cyclone and a filter and are directed to the incineration chamber and exposed to the temperature of between 850^{o}C - 1000^{o}C for two seconds.

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The large-scale unit operation started in 1999. In total the amount of heavily polluted soil excavated in the area by the end of the year 2000 reached 300 000 tons. 155 tons of free product (coal tar) were separated from this soil. 116 000 tons of the soil were treated by the thermal desorption process.

Pilot-scale and large-scale unit for decontamination of soils and other solid materials contaminated by organic substances, especially by PCB (inert nitrogen atmosphere, temperature from 100°C to 480°C).
This thermal desorption unit is installed in the Innovation Center of Environmental Technologies of the company IDOS Praha, Ltd. Process efficiency was verified on the semipilot-scale installation with the capacity of approx. 30 kg per one charge.

Table 1 Efficiency of the desorption process (semipilot-scale unit)

Sample	State	Sum of 6 PCB congeners (mg per kg of dry matter)	Separation efficiency (%)
1	before desorption after desorption	455.85 1.23	99.77
2	before desorption after desorption	1163.84 1.028	99.91
3	before desorption after desorption	114.951 0.295	99.74

The layer of soil in a chamber of a large-scale thermal desorption unit is 400 mm. The capacity of one load is approx. 20 tons of soil. The whole procedure takes approx. 96 hours. The purified soils do not require any further operations before final handling. The possibility of recycling the decontaminated soil into the standard environment, for example as a sub-topsoil layer for covering former landfills, may even be considered in the future.

The venting technology has successfully been applied on many different sites in the Czech Republic. The largest venting system was installed at a former military airbase in Hradčany (Northern Bohemia) where massive soil and groundwater contamination was detected covering an area of about 50 hectares. Jet-engine fuels and chlorinated solvents are the main pollutants in the airfield area. Based on the preliminary monitoring, the presence of more than 10 000 tons of pollutants was estimated at this locality. The remediation process consisted of three steps:
- removal of free product floating at the surface of groundwater
- installation and operation of the venting system (while simultaneously pumping out polluted groundwater)
- transformation of the venting system into a bio-venting system after removing the more volatile parts of contaminants.

The remediation process at this site was started in 1993. Approx. 270 wells were installed and now form the venting system. In five years of operation 800 tons of fuel and chlorinated hydrocarbons were recovered from the soil and groundwater.

Laboratory-scale or pilot-scale testing is now examining many other methods of commercial applicability. Most of these researches are performed in the Institute of Chemical Technology Prague. Examples of the developed remediation techniques are shown as follows:

The phytoremediation technique is systematically studied under both well-defined laboratory conditions and field conditions. For the laboratory tests the plants were grown on the artificially polluted porous soil systems and their cumulating abilities and mechanisms were studied. In the field-tests the plants exhibiting good cumulative efficiency and fast growth were exposed to real soil contamination. As of May 2001 a field-scale phytoremediation test will be started on locality, where wastewater sludge polluted by heavy metals is discharged.

The research on electrokinetic remediation started in the Czech Republic in 1994. The laboratory experiments performed during the first part of this research were followed by a field-scale application working with 10 m^3 of sediments polluted by heavy metals (industrial locality near Prague heavily contaminated by cadmium). The results obtained proved the potential of this process for commercial application. Further laboratory-scale research has been directed to soils polluted by persistent organic pollutants, such as polychlorinated biphenyl. Another field-scale experiment is supposed to start at the end of 2001 in a petroleum refinery near Prague where heavy pollution of soil by organic lead compounds was detected.

To study the possibility of the effectivity increase of the installed venting systems a special laboratory-scale apparatus was constructed enabling the simulation of transport of media through soil porous matrices by a standard mathematical model. This laboratory-scale apparatus has successfully been used to study the influence of different process conditions (such as temperature, soil moisture content, and others).
The results of these experiments enable us to:
- determine the real reachable remediation limits,
- optimize the process parameters of the remediation,
- reach the significant financial savings due to the elimination of unrealistic remediation requirements.

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