ConSoil 2008 - *Abstract form*

Title of abstract	**Verification tool for in situ soil remediation technologies**		
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Most appropriate theme (see Call: theme A-G)	Between E and F	**ORAL presentation** (type O) **or POSTER** (type P)	O

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Enhanced in situ bioremediation, cyclodextrin treatment for enhancing biodegradation, combined chemical and phytostabilisation, in situ bioremediation, integrated bioremediation, technology verification, technology monitoring, technology evaluation, environmental efficiency of remediation

Abstract

With the increasing number of innovative remediation technologies, decision makers, owners and other stakeholders should be guided by useful information related to the quality, applicability, efficiency and risks of environmental technologies. Especially the in situ technologies based on natural biological processes are mistrusted and suffer from lack of confidence, due to missing information, objective evaluation and transparent verification.

An engineering tool has been developed for the evaluation of in situ soil remediation technologies. The complex verification methodology includes 1. material balance, that is the mass flow balance of the soil phases and the modified or eliminated pollutant amount, 2. quantitative characterisation of the environmental risk before, during and after the remediation, including emission and local, regional, or global environmental risk elements, 3. cost-efficiency or if necessary and possible, cost-benefit assessment and 4. SWOT analysis.

The engineering tool for the verification of in situ bioremediation was applied for the characterisation of two remediation technologies based on enhanced natural processes of biodegradation and phytostabilisation.

1. The "cyclodextrin technology" (CDT), which is an innovative bioremediation developed and used for soils contaminated with hydrocarbons of low bioavailability was applied for three cases in Hungary for engine oil and for transformer oil contaminated sites. The risk reduction was based on enhanced biodegradation and the decrease of the concentration of the contaminant under the acceptable risk represented by the site specific target value. The randomly methylated ß-cyclodextrin (RAMEB) was found to significantly enhance the bioremediation and detoxification of the transformer oil-contaminated soil increasing the bioavailability of the pollutants and the activity of indigenous microorganisms to 150–200%. The feasibility of the innovative cyclodextrin-enhanced bioremediation (CDT) was demonstrated also in field applications. The technology-monitoring was designed for the control of the process and for proper data acquisition in aid of the verification procedure. Mass balance was calculated on the basis of CO_2 production and O_2 consumption and validated by the amount of the residual contaminant. The risk of the technology application was evaluated by sampling and testing the surrounding monitoring wells. The cost of the CDT was evaluated in comparison with traditional bioventing and pump and treat technologies. Time-spare resulted not only in cost decrease but depending on the future land use, in higher benefit. SWOT analyses was converted into marks by a uniform scoring-system. It was also able to show the advantages of CDT compared to alternative options. The verification of the CDT using the developed innovative tool-box proved the efficiency and the competitiveness of the CDT and the

applicability and usefulness of the verification tool.

2. The combined chemical and phytostabilisation (CCP) applied in situ for point and diffuse sources contaminated by toxic metals is based on the concept of reducing risk by making the metals irreversibly immobile, as well as stopping runoff and soil erosion. The results of the stabilisation microcosm experiments indicate that it is possible to reduce the mobility of toxic metals such as Cd, Zn, Pb, Cu and As by soil treatment with chemical stabilizers. The first field applications at two different sites proved the microcosm results: chemical stabiliser decreased the mobility of Zn and Cd with 99,9 %, erosion-prevention by phytostabilisation reduced As and Pb emission by 90%. The complex technology-monitoring of the CCP enabled to calculate the mass balance of mobile and immobile metal forms from seepage and leachates from the experimental plots as well as the plant uptake by test-plants and by real plants grown on the site. By an integrated soil monitoring methodology we were able to differentiate between extractability (water-, acidic leachate), bioavailability (by toxicity) and accessibility of metals for plant uptake by measuring bioaccumulation. The risk of the site before and after the technology application was followed by measuring the adverse effects. The long-term effect was estimated on the basis of 3 years long microcosm experiments. Cost of the PPC was evaluated in comparison with alternative solutions, like dig and dump, soil washing and phytoextraction. PPT was verified as the most environmentally efficient solution for metal-polluted soil and diffusely polluted large areas.

The development and application of a uniform remediation technology-verification system makes possible better understanding and evaluation of the remediation technologies and is able to increase trust in remediation, including in situ biotechnologies. The introduced field applications of two innovative in situ bioremediation combined with chemical treatment technologies made the evaluation of the verification system itself possible. Many innovative soil and groundwater remediation technologies have been developed and are ready for application throughout Europe, and some of them have proven their applicability and performance in demonstrations, but the market uptake and widespread practical implementation of these innovative remediation technologies is very slow, still not realised. A well established, uniform verification procedure with objective engineering tools would improve the situation and help a more efficient management of the environment.