InnoBLA II: New design of a planning tool for heating soils using electrically heated heat sources

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Introduction

The newly development planning tool enables the design and a better estimation of the operating time of thermal soil treatment projects. Two of the main considerations of the tool are the ease of use by a graphical user interface and short calculation times. The tool should provide sufficiently accurate results for the planning of thermal soil treatment and uses just as much computing resources as necessary. To achieve this, simplified approaches for the mass and heat transport are implemented. For the development of these approaches, a detailed understanding of the physical and chemical processes in detail is necessary. To obtain this detailed understanding, a detailed model was created, which was evaluated via laboratory experiments.

Detailed model

To model the experimental setup a multi-region model based on OpenFOAM was developed. In the solid region which covers the refractory lining and the steel shell, only the transient Fourier equation is solved. The soil region is modelled by two Eulerian phases. The solid-soil phase includes the water, organic and inert components. To describe this phase, the transient conservation equations for species and energy are solved. The gas-soil phase describes the soil air with the components N_2, O_2, $H_2O(g)$, CH_4 and CO_2. To obtain the flow field, the transient 3D Darcy equation is solved in combination with mass conservation. Also, species and energy conservation equations were solved. The drying/condensation and pyrolysis is implemented kinetically.

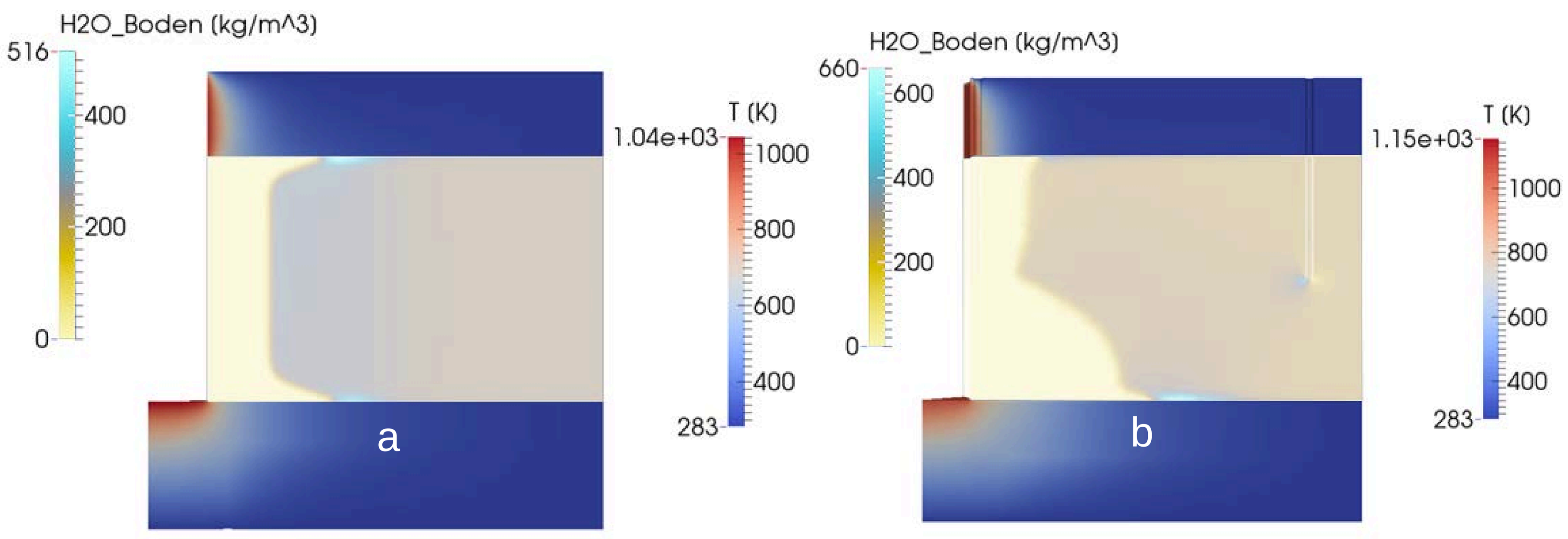

Fig. 1: Temperature profile of the refractory and water content of the soil (a) without extraction of soil air, (b) with extraction of soil air.

If there is no extraction of the soil air (Fig. 1a), the heat transport via conduction dominates. The soil is heated in the proximity of the heating lance, and the water evaporates in the process. The thermal conductivity of the dry soil is only one third of the soil of the initial moisture. As a result, the heat flow into the soil decreases. With targeted air guidance (Fig. 1b), the heat transport via convection is used, which allows a faster heating of the soil.

Experimental setup

The aim of the experimental setup is to investigate the thermal phenomena and to evaluate the simulation models. Analogous to the simulation, the experiment also shows the significantly faster heating of the soil due to the targeted air guidance (Fig. 2)

Fig. 2: Surface area of the soil (a) without extraction of soil air, (b) with extraction of soil air.

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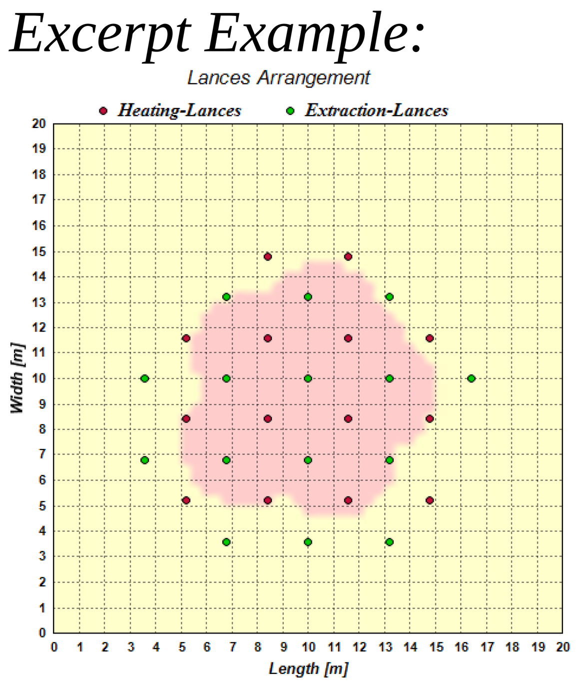
Planning Tool

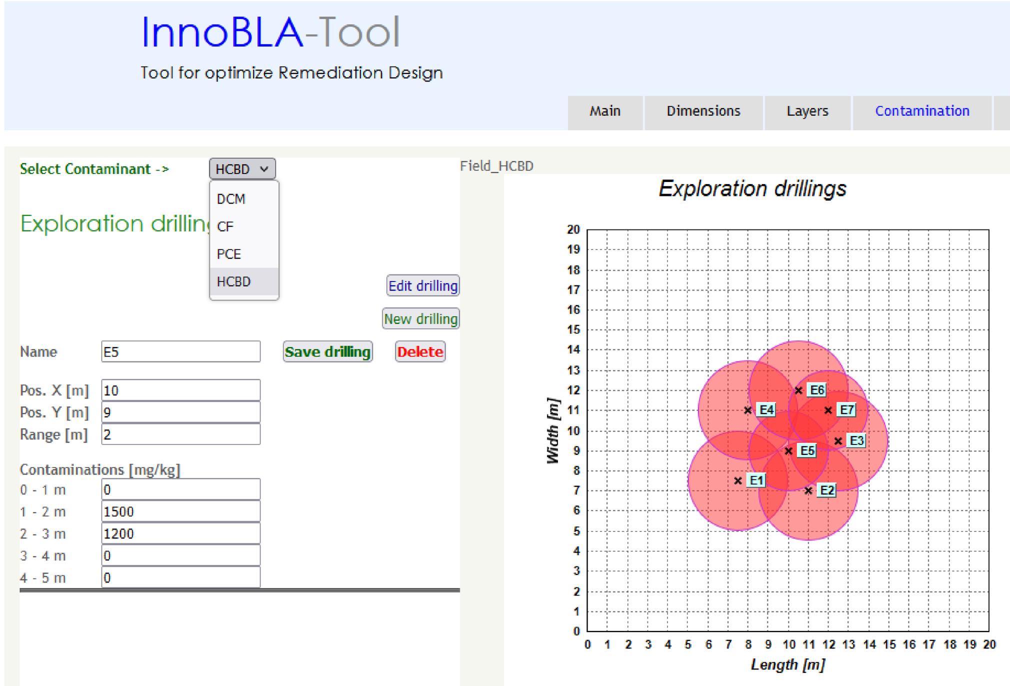
The Tool bases on calculations of heat- and mass transfer and serves remediation results for different arrangements of heating- and extraction lances. With the results of the calculations the optimum distance for a heating lance arrangement can be found.

Input and setup are:

- Input field dimensions (length, width and depth)
- Input different kind of soil types over depth
- Input contaminations via data from exploration drillings
- Automatically estimate contamination distribution over the field
- Automatically set heat- and extraction lance arrangements
- Input lance parameters (max. heat rate , max. temperature,…)

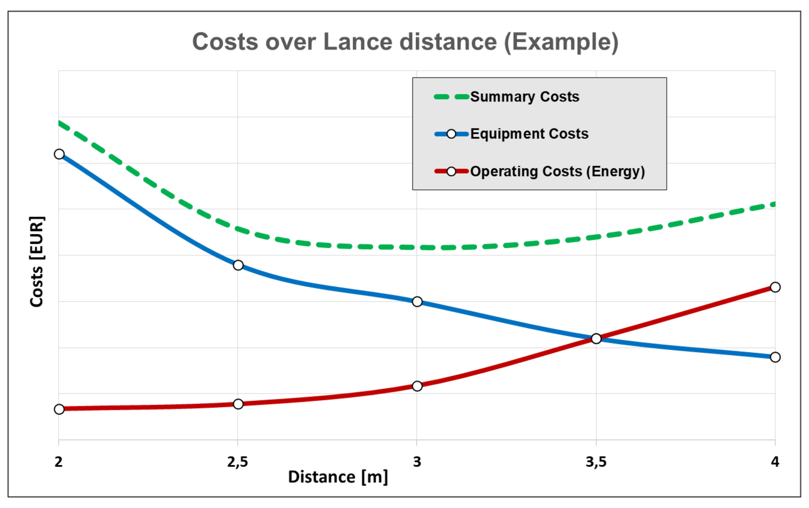
Excerpt Example:





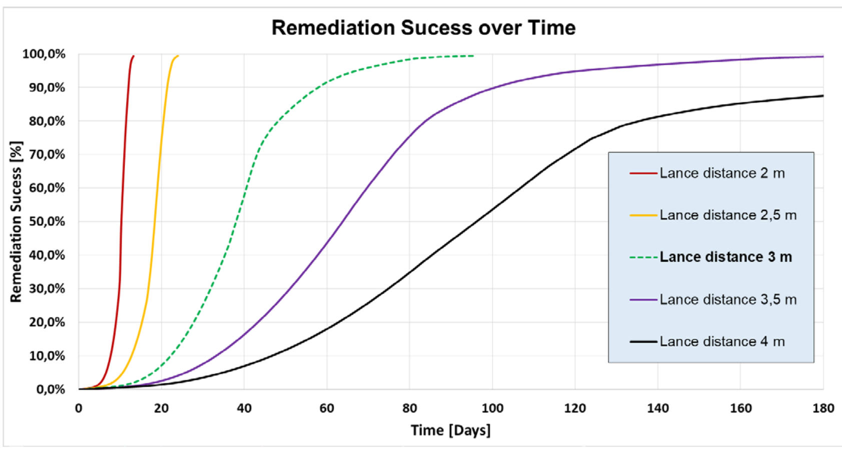
Results individual for:

- Soil types
- Type of contaminant
- Severity of contamination
- Max. heat power of heat lances
- Max. temperature of heat lances
- Costs of equipment and energy

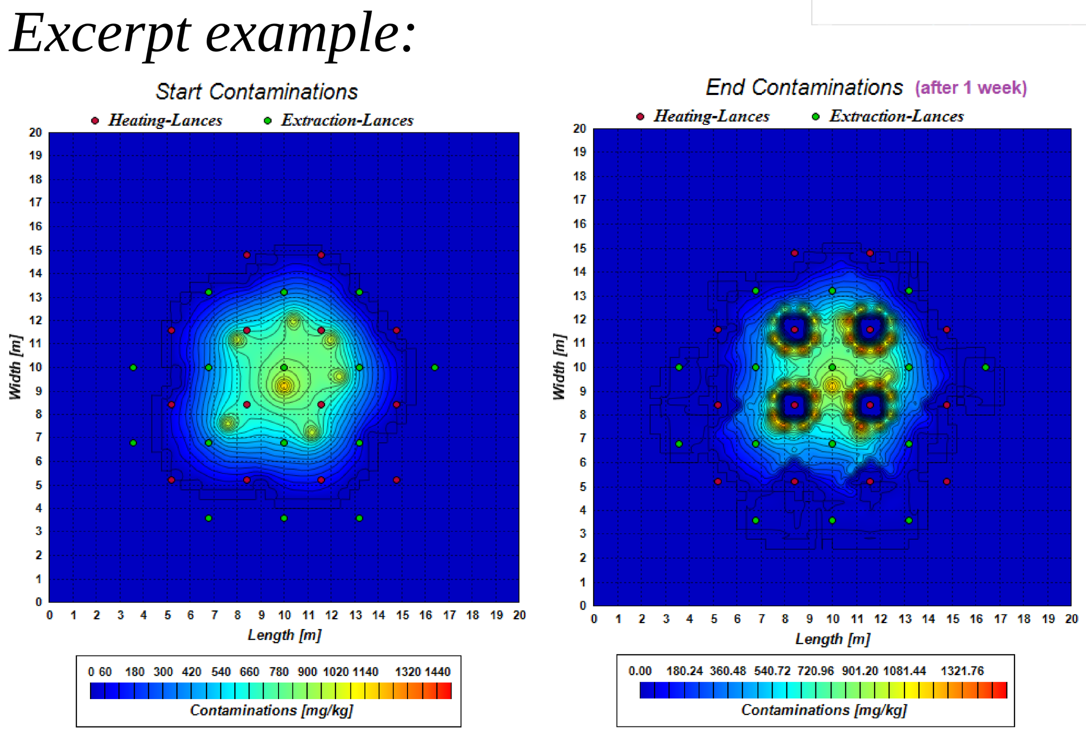


Optimum remediation design with estimated data for:

- Remediation costs
- Remediation process
- Heating process
- Temperature distribution
- Contaminant distribution



Excerpt example:



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