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RELIABILITY OF MODELING RESULTS OF FUTURE FINAL COVER PERFORMANCE

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ABSTRACT

Sound quantitative methods for supporting the engineering work are essential for successful designing of future objects. As such methods are ever more available with the use of computers a question of their reliability arises. An evaluation of future final cover hydrological performance was done for mill tailing landfill Boršt, Žirovski vrh. Two different models (HELP and HYDRUS-2D) were used in order to give an insight with respect to the governing processes and to increase the reliability of conceptual model quantification.

Key words: final covers, modeling, model comparison, Boršt.

INTRODUCTION

One of the most important questions in modeling of natural processes is to what extent our model reflects the actual field conditions and what is the reliability of its results. Uncertainty arises from a series of assumptions, simplifications, estimations and interpretations of measurements used in attempts of predicting future states. Calibration of models of existent objects is done by fitting model results on measured data, and the model is verified when its predicting ability is confirmed. However, in optimization of future objects these confidence building methods are inapplicable, so the reliability of the model has to be ascertained by other means.

One of the ways to do this is the intercode comparison where results of two mathematical representations of the same conceptual model are critically reviewed and compared. Differences between the models have to be taken into account although in theory any two different models representing a concept should give the same results. In this way, the discrepancies between the results can be divided in those that are consequence of an insufficient mathematical definition of physical problems and those that arise due to the differences between the codes. Such study was done in the case of future final cover performance assessment in mill tailing landfill Boršt, Žirovski vrh.

METHODOLOGY

Evaluation of the final cover performance was performed with water balance analysis with two commercial tools, namely HELP model (Schroeder, 1994), and HYDRUS-2D (Šimunek et al, 1999). The former is a standard tool for hydrogeological evaluation of landfill performance and the latter is a numerical tool for calculating groundwater flow and transport in unsaturated and saturated zone. In order to plan a top cover that would reduce the infiltration in the waste body of the landfill, the study was carried out in three stages: cover design evaluation, optimal material selection, and sensitivity analysis.
Final cover was initially planned with a five-layer system design, but later three other variations of the design were proposed by independent investigators to enable the comparison of several possibilities for the installation (Figure 1). A set of some local materials and some other materials were used in the modeling. Since the transport cost was also an important aspect of the problem, the study was also set in the way to evaluate autochthon materials vs. non-autochthon ones. In addition, a sensitivity analysis was performed to investigate the partial impacts of the thickness and saturated hydraulic conductivity of barrier layer on the performance of the cover.

LOCATION

Boršt mill tailing landfill is located near the recently closed uranium mine Žirovski vrh in a location which can hydrogeologically be characterized as low permeable. However, that doesn't exclude the possibility of occurrence of groundwater, which could especially be seen in 1995, when groundwater triggered a landslide of the landfill and parts of its surroundings. Since then, several hydrogeological studies were carried out on the site.

RESULTS AND DISCUSSION

Top cover design

As can be seen in Figure 1, four variants named VAR A thru VAR D were studied.

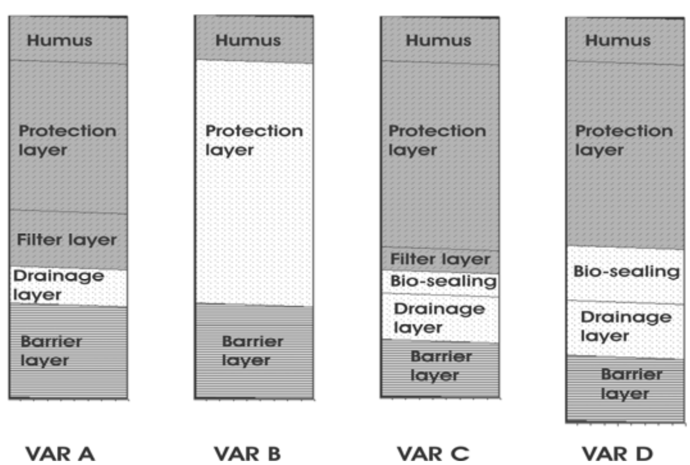

Figure 1.: Four studied top cover designs of the final cover installation in Boršt, Žirovski vrh.

The main interest in evaluating final cover performance is the division of water among different cover outlets, and among those the routes of the infiltrated portion of are especially decisive. Therefore, ratio between percolation and infiltrated water is used as the comparing factor between different variants to reflect the performance in terms of diversion of subsurface water away from the landfill body.
Percolation was normally found to be considerably bigger through covers on plateau than on slope as a consequence of smaller lateral drainage potential.

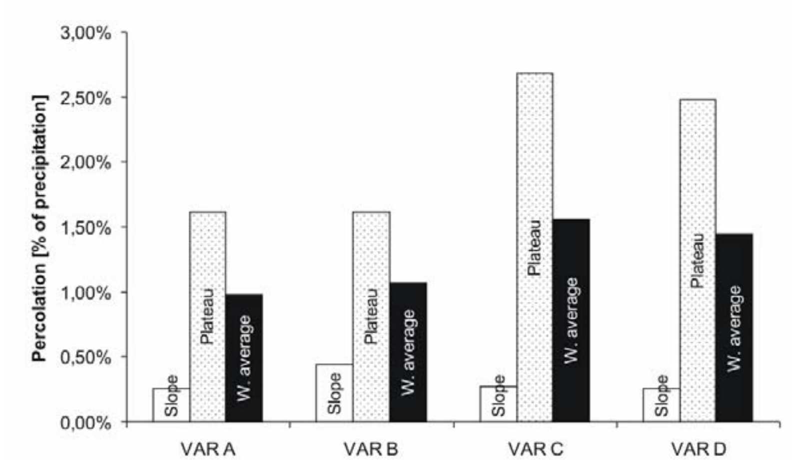

Figure 2.: Percentage of percolation through final top cover on slope and on plateau, and the area weighted average percolation.

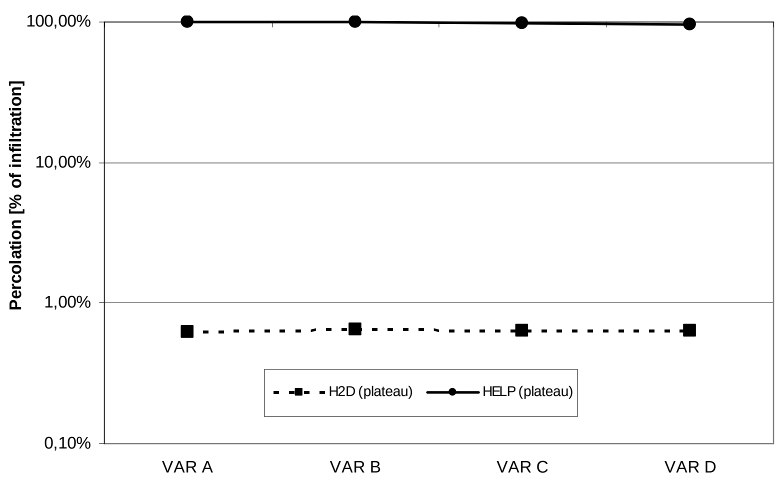

Figure 3.: Percolation on the plateau expressed as percent of the infiltrated water with respect to different top cover design variants calculated with HELP and HYDRUS-2D.

The hydraulic conductivity and layer thickness of the barrier layer controls the percolation on the plateau. Here, higher percolation is in variants C and D, which have thinner barrier layer. Looking only at the infiltrated portion of water, the two models show substantially

different results on plateau. HELP removes majority of the infiltrated water out of the system by percolation because of insignificant inclination, whereas HYDRUS-2D still promotes lateral drainage over percolation. This is a consequence of the fact that HELP does not account for capillary suction which is significant in fine grained sediments.
Protection layer seems to control the percolation on the slopes. Higher percolation on the slope in B is a consequence of lower permeability of the protection layer performing as a drainage layer.

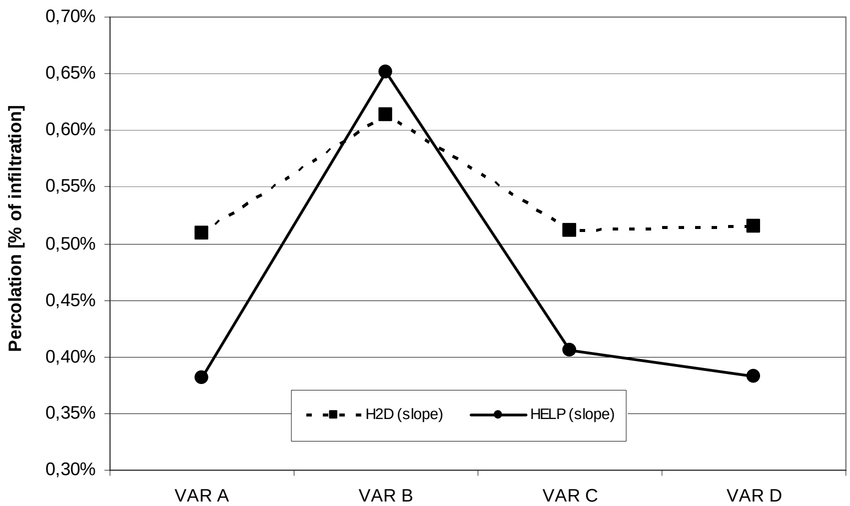

Figure 4.: Percolation on the slopes expressed as percent of the infiltrated water with respect to different top cover design variants calculated with HELP and HYDRUS-2D.

In the end, area weighted average percolation (Figure 2), which represents the percent of percolation through the entire area of the landfill in question, shows a half percent decrease in variants A and B as compared to variants C and D, suggesting that the optimal variant be chosen among the first two alternatives. Due to small difference in performance between variant A and B, a simpler version B was preferred over the five layer version B.

MATERIALS

Materials for protection and barrier layers (Table 1.) were chosen based on their performances in the sloped portion of the top cover variant B. The sloped portion was preferred due to the fact it shows greater dependency on the material selection as well as the fact it presents a bigger landslide risk building almost one half of total final cover area.

Table 1.: General properties of used material.

LAYER	POROSITY	K_s [m/s]
H (humus)	0,3464	7,07E-05
P-I	0,1597	7,07E-05
P-II	0,2000	1,56E-04

B-I	0,3386	1,10E-07
B-II	0,2962	5,65E-08
B-III	0,4650	2,24E-08
B-IV	0,3897	7,42E-09
B-V	0,4272	1,49E-08
B-VI	0,3044	5,42E-07

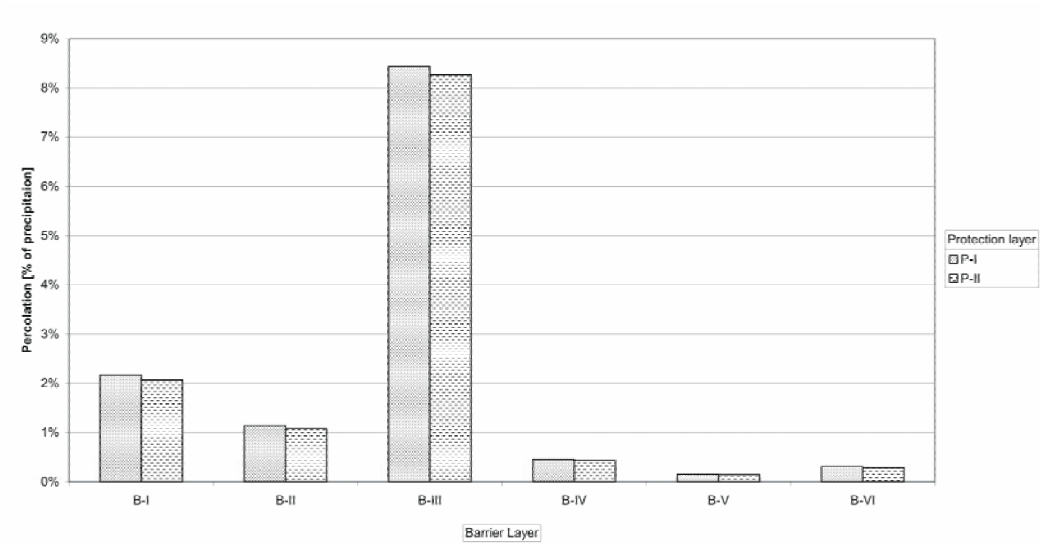

Figure 5.: Percentage of percolation through sloped final top cover (variant B) for different barrier layer and protection layer materials (6 materials for barrier layer are given by the position on the x-scale, while 2 protection layer materials are illustrated by different hatch patterns).

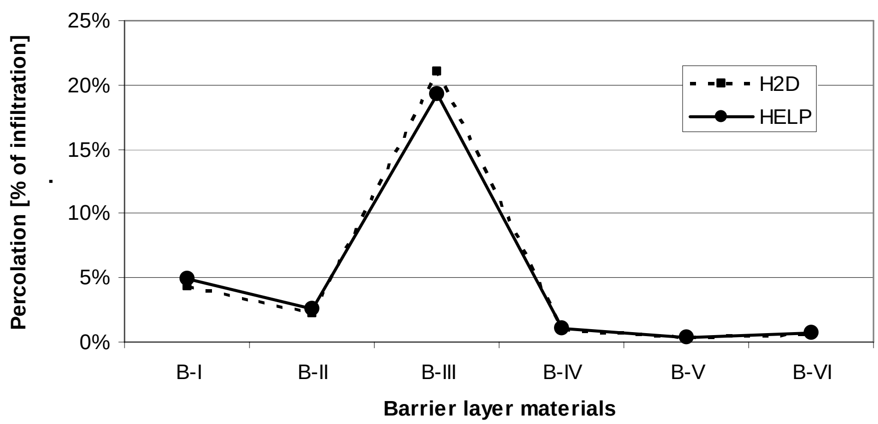

Figure 6.: Percolation expressed as percent of the infiltrated water with respect to different barrier materials calculated with HELP and HYDRUS-2D.

The controlling factor in improving the top cover performance with respect to its constructing materials is the selection of the barrier layer material prior to selection of protection layer material (Figure 5.). However, effects of lateral drainage layer must not be overlooked and the more permeable material that drains off water more easily must always be sought.

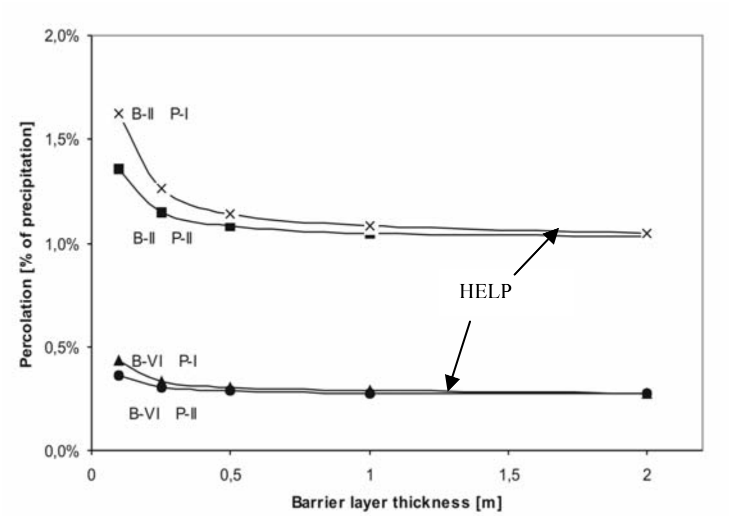

Figure 7.: Percolation through top cover with respect to barrier layer thickness for two barrier layer materials and two protection layer materials (all HELP).

SENSITIVITY ANALYSIS

Barrier layer thickness

A thicker barrier layer means better hydraulic performance of the cover. However, with increasing thickness of barrier layer, impact on percolation gradually diminishes and it becomes less important, which material was selected for protection layer, since the barrier layer takes on an increasingly bigger part in the process (even bigger in the case of lower Ks). HYDRUS-2D shows less influence of barrier layer thickness on percolation than HELP, which is possibly because HYDRUS-2D only considers the upper portion of the barrier layer as competent in dividing water in lateral drainage and percolation.

Saturated hydraulic conductivity of the barrier layer

Saturated hydraulic conductivity showed to be the most important (Figure 9.). Again, impact of decreasing Ks on percolation gradually diminishes as we approach lower values. In terms of infiltrated water flow, at some point in increasing Ks of the barrier layer in HYDRUS-2D, the cover looses all the ability to laterally drain the water, even at Ks lower than that of the percolation layer because of insufficient difference in capillary pressure. It shows better correlation with a more straightforward HELP model at lower values of Ks.

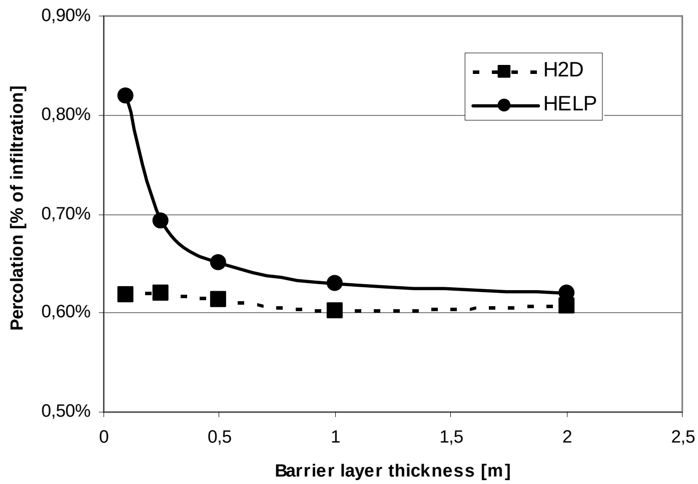

Figure 8.: Percolation expressed as percent of the infiltrated water with respect to barrier layer thickness calculated with HELP and HYDRUS-2D.

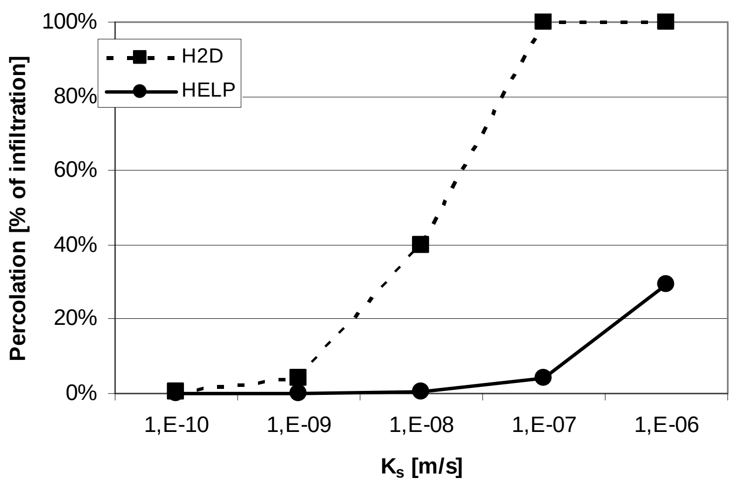

Figure 9.: Percolation expressed as percent of the infiltrated water with respect to saturated hydraulic conductivity of the barrier layer.

CONCLUSIONS

We showed that both models give mostly consistent results even though HELP and HYDRUS-2D use substantially different approach. The results of the two models are largely consistent on the relative scale where different designs and materials show same proportions, but they are also consistent in some parts on the absolute scale although to a bit lesser extent. Good agreement between the results and the completed sensitivity analysis give extra information on future final cover performance and add to reliability of the performed predictions.

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