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Development of a step by step geo-electrical methodology for landfill investigation

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Introduction

In this study we present research work aiming at evaluating the use of 3D geo-electrical resistivity to investigate landfills, with an overall objective to develop a methodology for a step by step approach for landfill characterisation. In the study extensive field experiments were conducted at the Filborna landfill site in Helsingborg, Sweden, in the summer of 2010 and 2011. In general, the resistivity measurements showed results corresponding to results reported from previous investigations at landfils, and the field experiments presented in this study also showed good correlation indicating the results to be robust and reliable. We present results showing internal structures, indication of groundwater levels, and the influence of rainfall events on the resistivity. The study presented here in gives emphasise to the temporal and spatial dependence of resistivity measurements.

Material and methods

The step by step approach aim at developing a time and cost effective methodology for investigation of landfills, starting at a large-scale with a rapid method and then gradually increase temporal and spatial resolutions. The first set of measurements, with an objective to give a rapid overview of the area, was performed in the spring of 2010 using an electromagnetic conductivity meter (CMD) 4 and 6.

In order to get more extensive geo-electrical information, large-scale resistivity measurements were performed after the CMD measurements. The resistivity measurements were performed using ABEM Terrameter LS with an electrode configuration as a gradient dipol-dipol with 5 meters electrode spacing. The raw data was processed and inverted initially in Res2Sinv (Geotomo Software) and was presented in 2D-profiles. Also a 3D-inversion in Res3Dinv (Geotomo Software), was performed for the production of 3D-volums of resistivity, based on the same data-set. Also interpretations based on the induced polarisation measurements were conducted but are not presented here in.

Based on the results from the CMD and large-scale resistivity measurements, small-scale resistivity measurements were designed for detailed time-lapse measurements. One year after the large-scale measurements were performed, the small-scale measurements were established at an sub-area of the large-scale measurements measuring 22 by 40 meter. The experimental set-up was based on 12 parallel lines with 21 electrodes in each line, and with a spacing of 2 meter. The electrode configuration was pol-dipol and the measurements were repeated each third hour using a ABEM Terrameter LS 12-channel instrument.

Results

When the results of the CMD measurement and the large-scale resistivity measurement were compared, high correlation in the uppermost layers was shown (Fig 1), indicating the both techniques to be robust and the results to be reliable. The results show large-scale features that could be detected, e.g., the low resistivity in the area whit inert waste deposited in an area of an old road (Fig. 1; North-west). Also the area with final soil cover showed the same magnitude in resistivity (Fig. 1; South-west).

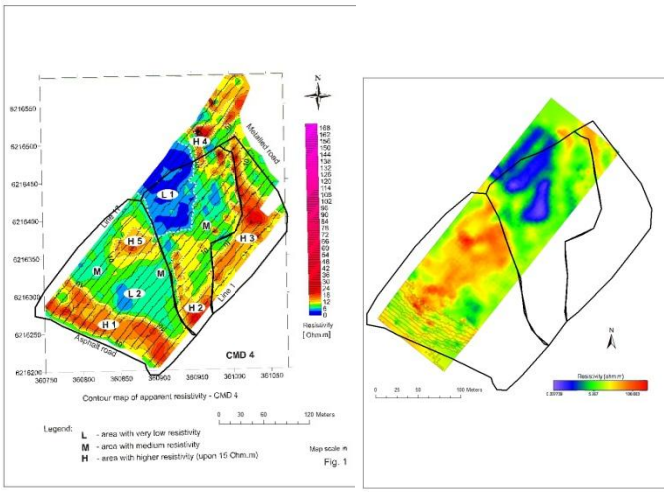

Figure 1. Results of CMD 4 (left) and large-scale resistivity (right) at the uppermost layers showed good correlation.

The 3D-models generated from the data obtained in the large-scale and small-scale resistivity measurements agreed with internal features that, could be explained (Fig. 2). For example, soil cover extensions, groundwater level, and natural soil and bedrock beneath the landfill. However, some features remain unexplained and future field campaigns will contain physical investigations and sampling for a better understanding of the possibilities and limitation for the use of geo-electrical measurements for characterisation of landfill bodies.

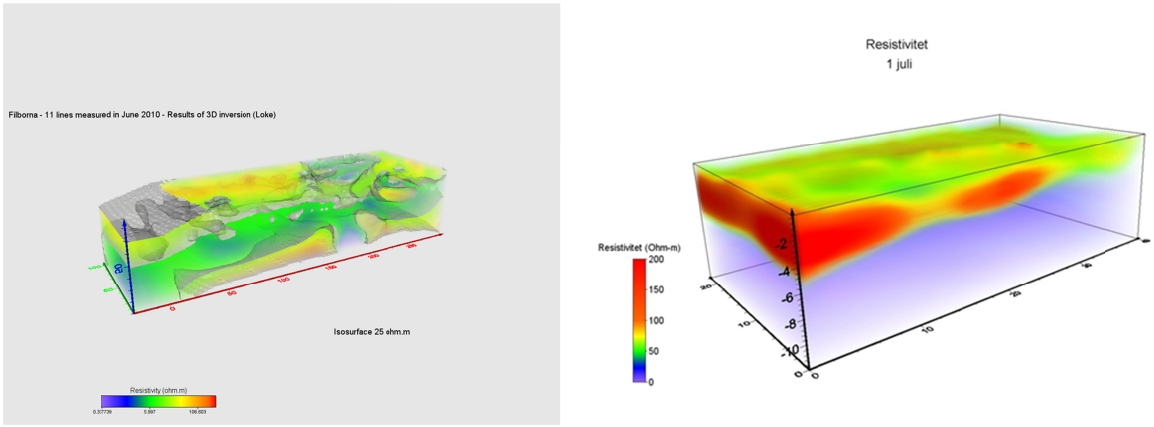

Figure 2. Results of large-scale (left) and small-scale (right) resistivity measurements showed correlation with expected internal features.