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An evaluation of the potential of the geoelectrical resistivity method for mapping gas migration in landfills

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Introduction

Methane is a powerful greenhouse gas and growing concern regarding global climate changes over the last years has pointed out that landfills are one important anthropogenic methane source among others, such as, rice paddies, biomass burning and domestic animals (Chapin et al. 2002). There are two major advantages in collecting landfill gas; the environmental benefit of reducing the amounts of methane emissions to the atmosphere and economical considerations, since landfill gas can be refined to fuel for vehicles and energy for heating buildings. In that respect landfill gas is regarded as being a renewable energy source.

Electrical resistivity is suitable for monitoring of water fluxes in landfills since it links with moisture content and ionic content in the water (e.g., Guérin et al., 2004). In recent years resistivity has been used at landfills for various applications like mapping landfill cover (e.g. Leroux et al., 2007), detecting and mapping pollution plumes (e.g. Rosqvist et al. 2003), and for studies of moisture migration processes during leachate recirculation at bioreactor landfills (e.g., Marcoux, et al., 2007, and Rosqvist et al, 2005, and 2007). Landfills are highly heterogeneous formations where the presence and migration of landfill gas can be expected to be highly non-uniform. In landfills, gas appears to be transported mainly horizontally due to the compaction of waste in layers. Gas flow follows the paths of highest permeability until the gas eventually finds its way into the atmosphere, generally through fissures and cracks. The rate of emission depends on several factors like the soil moisture content and the atmospheric pressure (O'Leary and Walsh, 2002). In experiments designed to map moisture migration also gas migration was indicated by zones with high, and highly variable, resistivity (Rosqvist et al, 2005, 2007). It is, however, also expected that the variations in resistivity will be related to soil temperature and moisture.

To recover the energy potential and to mitigate the environmental impact from methane, effective techniques for landfill gas collection are crucial. The location of wells for landfill gas collection is important, and there is therefore a need for development of techniques to detect the presence and migration of gas in landfills. In this study we present research work with the objective to evaluate the use of geoelectrical resistivity to detect zones in municipal solid waste landfills where gas migration occurs.

Material and methods

Resistivity is a geoelectrical imaging method which is based on measurement of the potential distribution arising when electric current is transmitted to the underground via electrodes. The electrical resistivity of soil materials generally depends on the moisture content,
temperature, porosity, and on the pore water salinity.

In this study resistivity measurements were monitored at four filed sites for several days using a remote controlled system. The area of the field plots varied between 300 and 1200 m^2, and the penetration depths varied between 13 and 35 meter, depending on the experimental set-up. All resistivity measurements were designed for 3D-measurements and 3D-inerpretation, using the ABEM-Lund imaging system and processed with Res3Dinv (see www.geoelectrical.com for information) to produce a 3D-model. Other data, such as soil temperature, climatic data and groundwater levels were recorded locally during the measurements. At one site also static chamber gas flow at the landfill surface was recorded using the static chamber method.

Results

The inverted resistivity data varied from very low (under 3 Ωm) to relatively high (over 500 Ωm) resistvity. However, most the resistivity data were in the same range as previous investigations have shown, that is, in general resistivity varies in MSW landfills between very low resistivity (under 3 Ωm) to approximately 50 Ωm.

As mentioned above, the main focus in the study was on the variability in the resistivity data, as it was assumed that large variability in the data could indicate gas migration in the waste mass. In Figure 1, the variation coefficient for the inverted resistivity data in the six uppermost layers is shown. The variation coefficient varies from very low values, below 0,01 (blue and green areas in Fig. 1) to high values (yellow and red areas in Fig. 1). There is a higher variability in the data in the uppermost layers and a clear decrease in variability with depth.

The results in this study indicate large variations in resistivity, which are not likely explained by only influence of changes in soil moisture content or temperature. We have therefore interpreted the variations as changes in gas pressure indicating gas migration in the landfill body.

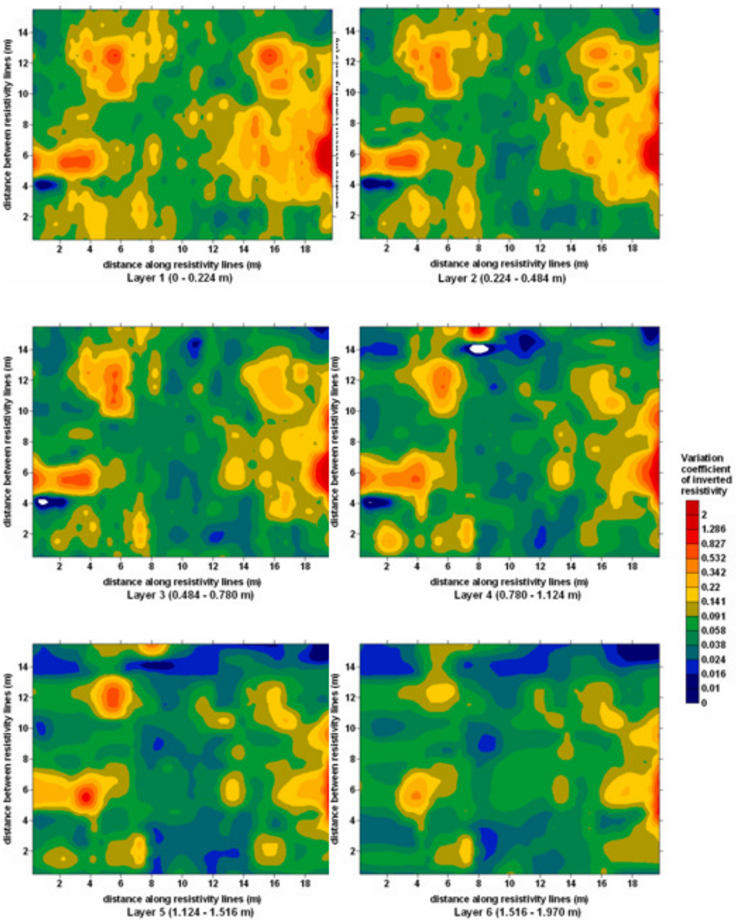

Figure 1. The variation coefficient of the inverted resistivity data at six layers from the surface to approximately 2 meter, at the Filborna landfill.

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