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DETECTION OF GAS IN LANDFILLS USING GEOPHYSICAL METHODS

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ABSTRACT

At NSR, Filborna landfill in Helsingborg, Sweden, a pilot test for detection of gas using the geophysical method resistivity profiling has shown promising results. Some of the results most likely showing trapped gas is shown. Due to the promising results two new separate tests are planned for 2008. The first test will focus on comparing gas leakage on the ground surface using laser technique and simultaneous resistivity monitoring. The second test is aiming to optimize the localisation of gas resources and monitoring the expected decrease of gas after the installation of gas wells. The set up for those tests will be presented and discussed.

KEYWORDS

Landfill, Filborna, gas detection, geophysical methods, resistivity, gas wells

1 INTRODUCTION

In energy terms waste deposits will most probably in the near future be treated as a resource, and since a number of years gases of slightly different varieties are produced from landfills. The common use of the gases is fuel for vehicles and heating of houses. However, the technique for location and production/gas outtake is not yet ideal. A few of the issues that should be further developed are detection of the gas resources and optimal location of the gas wells. If techniques of locating gas in landfills are found a better optimization of the location of the gas wells and the gas outtake will be enhanced, and hence resulting in a better economy and environment.

2 BACKGROUND

The use of geoelectrical imaging techniques is an established practice for environmental investigations and monitoring of various landfill processes [2, 3, 7] and in recent years also the bioreactor landfill concept has been emphasised [4, 5, 8]. In 2006 a pilot test at the NSR Filborna landfill, Sweden, was designed for monitoring moisture migration through a bioreactor landfill during leachate flushing and during a tracer test using the electrical resistivity technique. A second aim of that test was to find out if the technique also could be useful for biogas detection. The promising results will be shown below.

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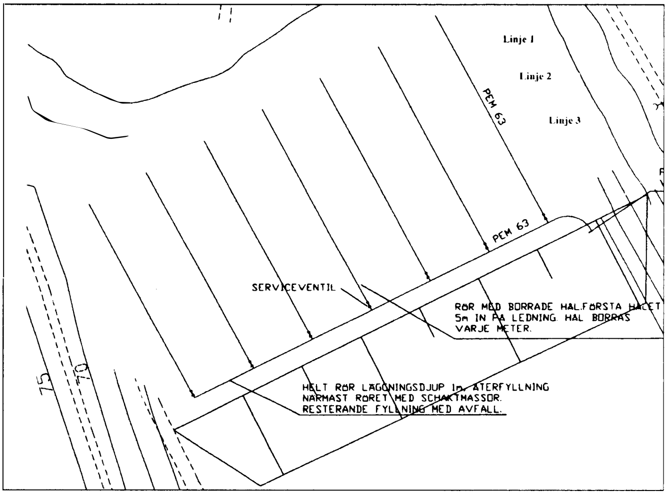

Figure 1. Plan of the bioreactor landfill showing the distribution pipes for leachate and the lines for resistivity measurements (Line 1 – 3).

2.1 The geoelectrical-imaging techniques

Geoelectrical imaging techniques are envisaged to have three major applications in connection with ground and groundwater contamination around landfills: mapping for identification and delineation of contaminants, quality control of soil stabilisation/contaminant immobilisation and long term monitoring. Leakage from municipal and mining waste deposits is generally associated with high ion concentrations and hence very low resistivities. This makes geoelectrical imaging techniques particularly interesting for leachate migration inside, and around, landfills. In the study presented here the use of geoelectrical imaging techniques for bioreactor landfill process monitoring have been addressed. The electrical resistivity is suitable for monitoring of water fluxes in landfills since it links with moisture content and ionic content in the water, as pointed out in [4]. The reasons explaining the promising results for gas detection are not yet fully understood.

The geoelectrical imaging method is based on measurement of the potential distribution arising when electric current is transmitted to the underground via electrodes. The data acquisition was done as two-dimensional (2D) resistivity imaging, using the ABEM Lund Imaging System. The system is computer controlled and consists of a resistivity-IP instrument, a relay-switching unit, four electrode cables, connectors and steel electrodes. The 2D imaging layouts used comprises around 80 electrodes, and measurement lines can be expanded via a roll-along technique. A multiple gradient array electrode configuration was used in order to get good resolution and fast data acquisition. The measured data was processed with inverse numerical modelling (inversion) to produce model cross-sections of the resistivity and chargeability distribution of the ground using the software Res2dinv.

2.2 The experimental set up

A 2-D resistivity and IP survey was performed in which three parallel lines, each 160 m long, were measured perpendicular to the leachate distribution pipes (see *Figure 1*). The electrode distance was 2 m and multiple current source gradient array was used. A number of resistivity and IP-surveys were carried out with the cable layout in fixed positions. In this paper only the resistivity measurements are shown.

A flushing experiment started in March 2006 and continued for 85 days. To get a picture of the bulk resistivity of the waste material in the bioreactor the fieldwork started with a set of background measurements. The irrigation system was started after the background measurements had been carried out, and seven further measurements were carried out during the experimental period. During the experiment, in all 922 m^3 of water was introduced to the bioreactor landfill, corresponding to less than 2 mm/day.

3 RESULTS

3.1 Flushing test

In *Figure 2* the resistivity measurements at line 1 from day no 8 to 85 are presented as the relative difference between the measurements at day one and the current day. The scale in *Figure 2* is –0.1 to 0.1 which stands for a 10% increase and decrease in resistivity, respectively. In *Figure 2* also the input of water to the bioreactor landfill are shown. In all, 922 m^3 of water was introduced to the bioreactor landfill during the experimental period.

In *Figure 2* the moisture migration in the waste is shown as a decrease in resistivity. It is shown that after 8 days the migrating water results in a scattered pattern of lowering of the resistivity (blue/dark) zones near the surface. These zones are interperted as a non-uniform water flow through the upper layer of the waste. As the water input continued, the zones with decreased resistivity showed a more uniform pattern, which is interpreted as higher moisture content. At the end of the experimental period (day 85), the low resistivity zone showed a relatively homogeneous pattern reaching to a depth of almost 10 meter.

In *Figure 2* also an increase in resistivity has been recorded in irregular zones at various locations during the experimental period. The appearance of high resistivity zones could not be experimentally evaluated. However, the most probable explanation for the irregular pattern of high resistivity zones is migration of gas in the bioreactor landfill.

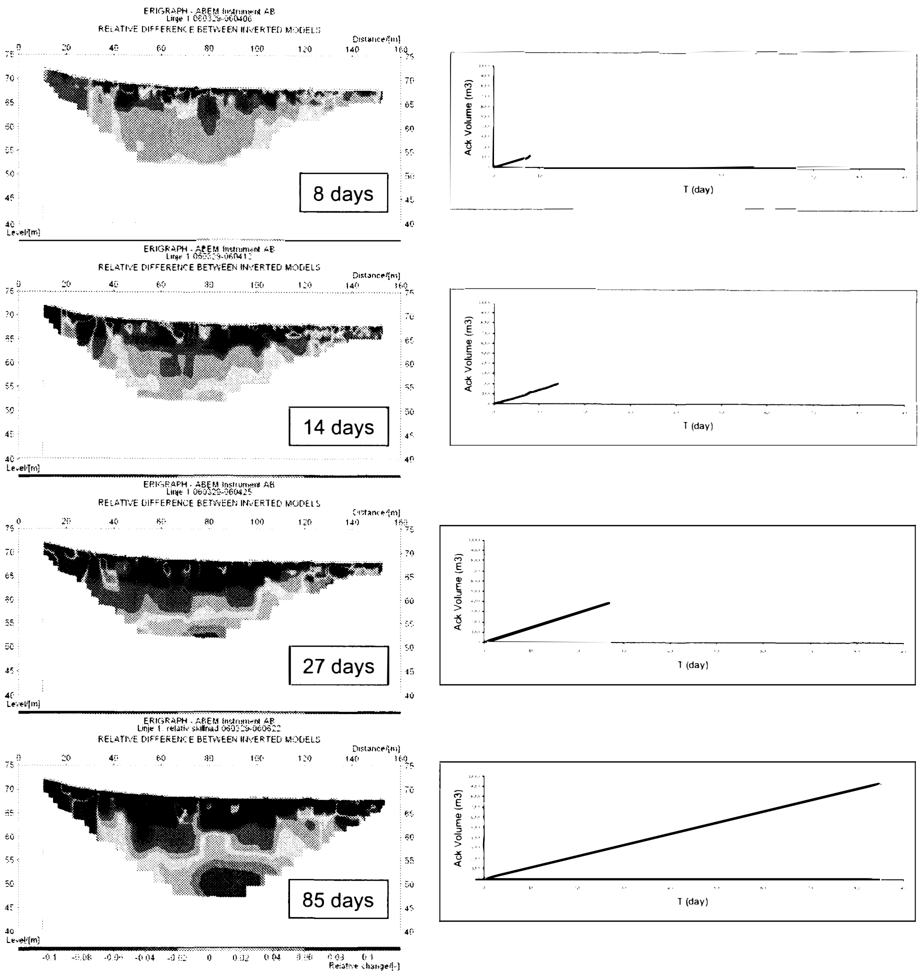

Figure 2. Inverted resistivity sections for line 1 presented as relative change from day no 8 to 85, and the accumulated input of water to the bioreactor landfill. Note the high resistivity zones around 20 m, interpreted as trapped gas.

4 DISCUSSION AND CONCLUSIONS OF 2006 TESTS

The fieldwork was performed under good conditions resulting in high quality field data showing a fairly consistent picture of the waste mass in the bioreactor landfill. In the bioreactor the resistivity of the relatively wet waste mass at depth was measured to be in the range of 3 to 30 Ωm, which is in the same range [4] or somewhat lower [2], than results presented elsewhere. High water content and ionic content, and high organic content in the bioreactor can partly explain the relatively low resistivity. Also the temperature may influence the outcome of the measurements [4].

The main objective with the study was to investigate the spatial distribution of recirculated leachate in a bioreactor landfill at field scale. It was concluded that the experiment could successfully detect the distribution of recirculated leachate through the waste mass by comparing interpretations of resistivity measurements at different time steps (i.e., relative differences) in 2-D resistivity sections.

In recent years a study addressing gas migration in landfills has been reported [5]. In [5] variation in electrical resistivity indicated biogas migration and an interpretation of leachate recirculation effects on biogas migration were proposed. In the study carried out here an increase in resistivity was recorded in irregular zones at various locations in the waste mass during the experimental period. The appearance of high resistivity zones could not be experimentally evaluated. However, the most probable explanation for the irregular pattern of high resistivity zones is migration of gas in the bioreactor landfill. Therefore it is concluded that that the resistivity measurement could be a viable method for detection of gas migration in landfills. It is therefore suggested that the use of resistivity should be further investigated in order to develop systems for landfill gas monitoring.

5 PLANNED TESTS FOR 2008

5.1 Combination of resistivity and laser technique

As has been shown above gas is likely to be detected using resistivity technique. However it has not been experimentally verified. In a related project laser technique has been used trying to localise methane leakage to the air from the same area as above. Preliminary results are promising, though indicating sometimes rather quick changes in the amount of leakage. The results are also indicating gas leakage limited to certain areas, sometimes from cracks in the top coverage or from the slopes bordering the landfill.
During 2008 therefore a project focusing on comparing gas leakage on the ground surface using laser technique and simultaneous resistivity monitoring is planned. The project will start with background measurements from both techniques aiming to find an area indicating both trapped gas and leakage of gas to the air. For the area selected simultaneous measurements will be carried out in different cycles, covering both continuous 24 hour monitoring and long time monitoring for both methods. A reference area will also be monitored.

5.2 Locating of gas wells

Today location of wells for gas outtake is based on vague ideas and experience, further than any measurements or solid theory, of where the most gas is found. Partly due to this the productive lifetime of each well also varies a lot. In order to optimise the location of new gas wells and to find a theory for estimating the rate of gas decrease during production or gas outtake a project focusing on those questions is planned for 2008.

The measurements will be carried out using resistivity technique and start with collecting data from a number of parallel lines, resulting in a semi 3D plot of the resistivities of the part of the landfill covered. Data will be collected following an only slightly modified scheme as for the results reported above. After decision of where to install the gas wells the installation will be carried out. Immediately after installation continuous resistivity monitoring will start in the close surroundings of the wells, and continue for approximately one week. After that less dense monitoring will be done, however carry on for approximately six months, optionally one year.

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