CHARACTERISATION OF LANDFILLS IN THE NETHERLANDS USING A MULTIDISCIPLINARY APPROACH

M.A.J. Bakker, N. Hoekstra & J. Oonk

Deltares, Unit Subsurface and Groundwater systems, P.O. Box 85467, 3508 AL Utrecht, the Netherlands

In the Netherlands about 3800 abandoned landfills are present with a total surface of about 9000 ha. As they are often located near urban areas and their influence extends into their surroundings they put pressure on available space. Most abandoned landfills were in use until the 1960's and 70's. Their precise geometry and composition are often unknown. The same can be said about the internal processes and resultant short- and long-term risks of the fills. As a result the average landfill is a black box, 'controlled' by monitoring of surrounding groundwater composition. TNO/Deltares and partners in the field of environmental engineering joined forces to develop a risk-evaluation method. A number of sites have been selected for geophysical assessments in combination with chemical characterization. The aim of this presentation is to share experiences from two sites; the Landgraaf site in inland, hilly terrain and the Bergen site situated in the coastal realm of the Netherlands.

The Landgraaf site is a bioreactor test-cell, located on top of an existing landfill and separated from the older waste with a HDPE-liner system. The test-cell has the form of a mound. The dump history (domestic waste) and composition has been recorded in detail and is known to be relatively homogeneous. The bioreactor-experiment with leachate recirculation is in progress since 2003. Fig. 1 demonstrates geo-electrical results (Wenner electrode array) in which the occurrence of preferential flow paths and stagnant zones are most prominent; despite the ongoing leachate recirculation program heterogeneities are still present. It can be concluded that high resistivity appears to correspond with low water content; intermediate resistivity seems to correspond with preferential flow paths containing low residual concentrations of chemical compounds and finally, low resistivity corresponds to stagnant zones containing high concentrations of chemicals

The Bergen landfill is situated in former sand pits and was actively in use between 1969 and 1974, mostly for poorly controlled dumping of municipal waste. After this period, until recently, building debris and (partly contaminated) soil has been dumped incidentally at the site. From the site a contaminant plume, with mainly benzene, originates. Fig. 2 presents EM-31 results at the Bergen site plotted on Google Earth where green and blue indicate low resistivity and yellow/red high resistivities. The results match very well with the anticipated position of the pits and also indicated the presence of a non-anticipated pit towards the northeast. Resistivity profiling using geo-electrical measurements was carried out here also to deduce characteristics within the landfill. Consequently, cone-penetration tests (CPT) where positioned on the basis of EM and resistivity. The Bergen landfill has a very specific CPT signature, with strong contrasts to its surroundings. At the CPT stations and additional selected locations samples were taken from the groundwater and leachate and analysed for aromatic and chemical characteristics. It turned out that within the landfill rather homogeneous values in terms of geochemistry and pollutants occur despite some differentiated patterns in the EM-31

and resistivity profiles. It appears that the highest concentrations occur outside the actual landfill in the surrounding substratum, well in agreement with the geophysical signature. Most notably this is the case for aromatic compounds such as benzene with concentrations of 6 – 50 mg/l in the leachate and 100 – 650 mg/l below and adjacent to the landfill. This observation is attributed to biological degradation processes using the irons from the waste leading to a decrease of contaminant concentrations within the fill. In conclusion, the Landgraaf landfill is still heterogeneous despite recirculation; flow paths are very persistent. This problem will have to be tackled by injection into stagnant zones, zones that can only be imaged by geophysics and verified by chemical analysis. Ongoing analysis on the Bergen data will have to shed light on the precise relationship between landfill composition and geophysical parameters, a goal to be achieved by including additional abandoned landfills in our study.

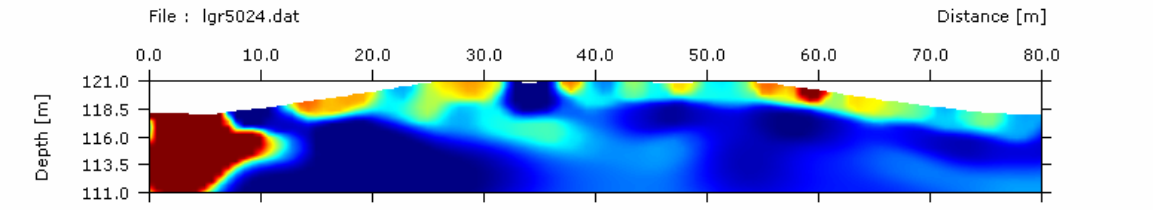
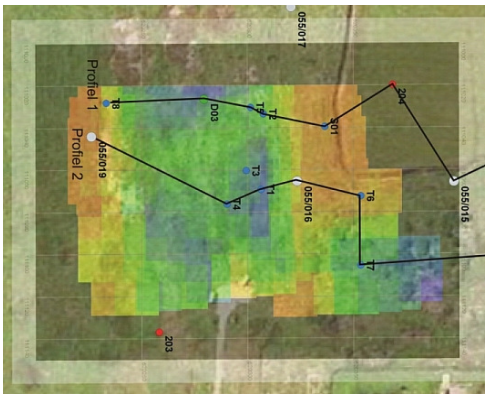


Fig. 1. Resistivity profile across Landgraaf landfill demonstrating preferential flow paths (green) and stagnant zones (blue). High resistivity (yellow to red) corresponds to low water content.



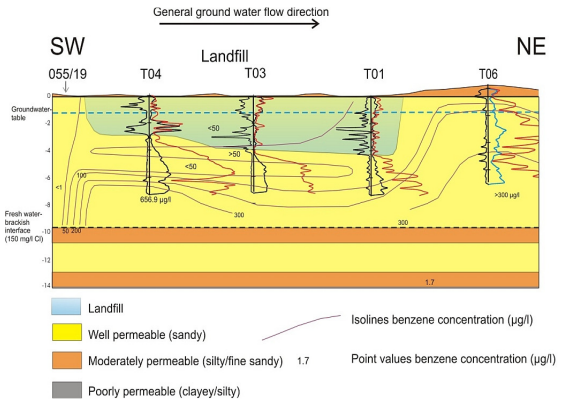


Fig. 2 (left). EM-31 survey imaged and cross sections on Google Earth indicating outline of landfill and distribution of resistivities within.

Fig. 3 (right). Cross section at Bergen showing lithology (based upon CPT) and benzene concentrations.