Characterization of a Landfill Using Geophysical Methods

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1. Acquisition

Seismics

We acquired seismic reflection and electrical resistivity (ER) data in the Wieringermeer landfill in the summer of 2013. We used shear-wave (S-wave) sources and receivers, with a source spacing of 1 m and a receiver spacing of 0.5 m over a line of 23.5 m length. The ER measurements had a 1 m electrode spacing covering a 60 m line; both Wenner and dipole-dipole arrays were used.

The goal of this study is to identify higher-density zones in the landfill. The zones act as a barrier for the leachate flow and thus affect the treatment procedure of the landfill. The landfill is a very heterogeneous subsurface and high-resolution measurements and precise processing steps are required for the identification of these possible stagnant zones.

2. Subsurface Images

The processing of the data for obtaining a subsurface image required special steps to account for the heterogeneous subsurface and the noisy environment. The recorded seismic data were first cleaned of the unwanted arrivals (noise from nearby gas pipe, refraction, direct arrivals and surface waves) by muting, leaving primarily the desired reflections.

Next, we performed velocity analysis iteratively to extract a velocity model of the subsurface. These velocities were then used in a prestack depth migration to better handle the heterogeneity of the subsurface. In Figure 1 the prestack depth-migrated result is depicted showing the main features of the landfill: the landfill bottom (yellow line) and several scatterers that correspond to higher-density areas inside the landfill (red ellipses).

3. Quantitative Characterization

The results shown in Figure 1 and 2 provide a good understanding of the subsurface; however, it is also important for the landfill operators to obtain values of the mechanical properties, especially density. Choudhury and Savoikar (2009) performed a literature study of over 30 published works that provided unit weight values and S-wave-velocity values for landfills and so derived an empirical relationship between unit weight and S-wave velocities specifically for landfills: \( V_s = 1/(0.0174 - 0.00978\gamma) \), where \( V_s \) is the S-wave velocity and \( \gamma \) the unit weight. Using the relation between unit weight and density \((\rho) = \gamma / \rho\), where \( g \) is the acceleration due to gravity (9.81 m/s²), we can calculate the density values of the subsurface, see Figure 3 (the different colors for the values are for visualization purposes).

Figure 4 shows the comparison of the study of Choudhury and Savoikar, and our results. Besides seismic reflection analysis we performed also multichannel analysis of surface waves (MASW). Both results show a good fit with the theory, giving confidence to our interpretation.

4. Next Steps

Besides S-wave and ER data, compressional-wave (P-wave) reflection data were acquired as well. Using the P- and S-wave data, the Poisson’s ratio can be calculated. In addition, the P/S ratio can provide another indication for the location of possible wet pockets. Using mixing rules, we will investigate the possibility to calculate the density of the subsurface to confirm our results. Finally, seismic interferometry will be applied to our data, which has shown to be promising for such a heterogeneous subsurface (Konstantaki et al., 2015).

References


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