ELECTROMAGNETIC MODELING OF LABORATORY-SCALE 2-D SOIL-BED SETUP

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ABSTRACT

There are different traditional approaches for locating and characterizing soil contaminated sites. Some of the most common contaminants found in the soil and groundwater are Dense Non-Aqueous Phase Liquids (DNAPLs); these can cause serious environmental harm and affect human health. Different techniques exist for detecting underground contaminants. Some are invasive techniques that require drilling, testing and sampling. These techniques can promote further spread of contaminants in polluted areas. On the other hand, non-invasive techniques offer rapid and relatively inexpensive characterization of soil without producing fractures and causing further downward migration of DNAPLs. Cross Well Radar (CWR) technologies form part of non-invasive techniques, which can detect and monitor DNAPLs contaminants in underground environments. A laboratory-scale 2-D SoilBED setup has been developed to study the detection of DNAPLs using CWR. An electromagnetic model of the experimental setup was developed, using Ansoft's HFSS, to simulate the electromagnetic fields in the SoilBED. The model will be used to evaluate electromagnetic measurements taken in the SoilBED and assess the behavior of the electromagnetic field in 2D SoilBED. The electromagnetic model does an analysis on different frequencies, changing the soil properties with combinations of dry sand, wet sand and saturated sand. Opportunities for Technology Transfer – The Department of Energy is looking in to different alternatives for the detection and monitoring of contaminants, specifically DNAPLs. This technology can provide a solution for this problem.

PROBLEM STATEMENT

Electromagnetic modeling of the SoilBED can be used for the understanding of wave propagation characteristics in underground environments. Specifically, electromagnetic models can be used to evaluate electromagnetic fields behavior in the presence of contrasting permittivities and conductivities. This contrasting provides the option of simulate the soil electrical properties, with combinations of dry sand, wet sand and saturated sand, and the placement of regions with contaminants. The system response is observed, by varying the excitation point, allowing us to obtain the network parameters that determine if it is possible to detect any pollution in soil, with greater space resolution, this process was madding consecutively for frequencies of 285 MHz, 515MHz and 1.5GHz with different alterations of the soil properties. The table 1 shown the different soil conditions with electrical properties.

<table>
<thead>
<tr>
<th>Soil conditions</th>
<th>Dielectric permittivity</th>
<th>Electrical conductivity (S/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Sand</td>
<td>2.55</td>
<td>0.003</td>
</tr>
<tr>
<td>Dry - Wet Sand</td>
<td>2.55 - 20</td>
<td>0.003 - 0.03</td>
</tr>
<tr>
<td>Wet Sand</td>
<td>20</td>
<td>0.03</td>
</tr>
<tr>
<td>Wet Sand - DNAPL</td>
<td>20 - 2.28</td>
<td>0.03 - 2.2e-5</td>
</tr>
</tbody>
</table>

Table 1. Different soil conditions with electrical properties [2, 3]

RESULTS

For the three different conditions, it is observed that the propagation of the wave depends on the electrical properties of the ground and of the position of wave port within the tank. In the case of wet sand, fig 2, a major attenuation of the electric field, independent of the excitation port is observed.

CONCLUSIONS

The variations in the amount of energy received at the ports for the different test conditions entail a possible detection of the polluting agent in the underground.

REFERENCES


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