Dielectric characterization in frequency domain of waste materials

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Abstract

This study is motivated by the need to develop a less destructive and an in situ monitoring of water content and hydraulic parameters of waste materials both prior to and after the land filling. In this respect along with other electromagnetic methods, Time Domain Refelctrometery (TDR) has been successfully used by Li and Ziess, (2001), and van Praagh et al., (2005), (2007) in this respect.

The apparent dielectric constant is a complex quantity which consists of two parts-real and complex. The real part represents the response of the medium to an external electric field and imaginary part represents processes other than energy storage i.e. relaxation-phase lag between applied field and material's response.

However it is not always possible to separate these two and, despite promising results, the application of TDR in highly conductive medium e.g., wastes, represents challenges due to signal attenuation. Unlike most soils waste materials exhibit different characteristic especially, organic matter, porosity, bulk density, and electrical conductivity. All of these have strong bearing on TDR waveforms through signal attenuation. This can be further complicated by internal system losses such as impedance mismatch, lossy connectors, and multiplexers.

In this back drop, the clear elucidation of different process that results in attenuation in lossy medium is highly important for accurate measurement with TDR. As frequency domain reflectometery (FDR), unlike TDR, allows simultaneous measurement of both slow and fast signals from materials over a specified frequency range. Thereby, allowing a clear separation of real and imaginary part of dielectric permittivity. FDR measures the frequency of reflected wave rather than its travel time therefore offers an alternative or compliment for TDR measurements. This ability to subject porous medium to varying stress of angular frequency can be important for quantification of losses (Jonscher 1999).

The prospects and problems associated with the use of TDR, on waste materials, have been demonstrated by van Praagh et al. (2007). Their study used upward flow experiments, in laboratory columns, and a field lysimeter to quantify hydraulic parameters of waste materials. Four different types of materials i.e. contaminated soil, stabilized industrial sludge, asphalt, and sorting rest were used in laboratory columns. The bulk densities of these materials ranged from 0.45 to 1.29 Kg/l.

The waste materials, despite being soil like, exhibited a different relation between dielectric permittivity and volumetric water content compared to Scanian sub and top soil. This could be due to high initial water content as samples were not oven dried. Similarly, the presence of

solid material was cited as main influence on dielectric permittivity. The later is important as it might affect the long term emission from wastes.

The results of water content measurement highlighted that TDR measurement was dependent on mineralogical content and bulk density of porous medium. It was suggested that several cores should be sampled from lysimeter and should be used in laboratory column to verify water content measurement. The bulk electrical conductivity was assumed to be dependent on pore water content as dissolution of salts from solids in porous medium is driven by water. The values of bulk electrical conductivity for up-ward flow experiments prove this assumption. However in order to clearly establish the impact of pore water on electrical conductivity under varying water content, it was suggested that a calibration of relation among different parameters should be included in future work.

The results from above study formed the basis for the present work as it intends to further extend work by van Praagh et al. (2007) with TDR in to the frequency domain. This objective will be realized by using FDR on same waste samples. The FDR instrument consists of a network analyzer, a measurement probe and a PC interface with analysis software. The probe will be calibrated, before each measurement, in air, water and a shortening block.

The samples were oven dried, at 105 C for 24 hours, and homogenized before the measurements. The water content of the samples varied in order to study electrical conductivity and hydraulic response of waste samples. The results show the potential of the FDR approach, especially since it is less affected by high electrical conductivities.

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