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Temperature and volumetric water content petrophysical relationships in municipal solid waste for the interpretation of bulk electrical resistivity data

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Landfills pose major environmental issues including long-term methane emissions, and local pollution of soil and aquifers but can also be seen as potential energy resources and mining opportunities. Water content in landfills determine whether solid fractions can be separated and recycled, and controls the existence and efficiency of natural or enhanced biodegradation. Geophysical techniques, such as electrical and electromagnetic methods have proven successful in the detection and qualitative investigation of sanitary landfills. However, their interpretation in terms of quantitative water content estimates makes it more challenging due to the influence of parameters such as temperature, compaction, waste composition or pore fluid. To improve the confidence given to bulk electrical resistivity data and to their interpretation, we established temperature and volumetric water content petrophysical relationships that we tested on field and laboratory electrical resistivity measurements.

We carried out two laboratory experiments on leachates and waste samples from a landfill located in Mont-Saint-Guibert, Belgium. We determined a first relationship between temperature and electrical resistivity with pure and diluted leachates by progressively increasing the temperature from 5°C to 65°C, and then cooling down to 5°C. The second relationship was obtained by measuring electrical resistivity on waste samples of different volumetric water contents. First, we used the correlations obtained from the experiments to compare electrical resistivity measurements performed in a landfill borehole and on reworked waste samples excavated at different depths. Electrical resistivities were measured every 20cm with an electromagnetic logging device (EM39) while a temperature profile was acquired with optic fibres. Waste samples were excavated every 2m in the same borehole. We filled experimental columns with these samples and measured electrical resistivities at laboratory temperature. We made corrections according to the temperature profile and to volumetric water contents obtained previously on undisturbed samples. Corrected values tended to be superimposed on those obtained in the field. Then, we calculated the water content of the different reworked waste samples using the correlation between volumetric water content correlation and electrical resistivity and we compared this value to the one measured at the laboratory. Both values were correlated satisfactorily.

In conclusion, we show that bulk electrical resistivity measurements are very promising to quantify water content in landfills if temperature can be estimated independently. In future applications, electrical resistivity tomography coupled with distributed temperature sensing could give important estimates of water content of the waste and thus helping in dealing with problematics such as boosting biodegradation and stabilization of the waste, reducing risks of soil and aquifers pollution, landfill mining, and controlled production of methane.