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Influence of soil water content, soil bulk density, soil solution composition on electrical resistivity measurements

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Since several years, interest in electrical resistivity methods has increased in the field of Soil Science because they are non destructive. They have been used to both discriminate between different soil types and monitor soil functioning, especially water transfers. Several characteristics of the soil influence the electrical resistivity measurements: soil constituents- especially clay type and content-, water content, temperature and composition of the soil solution are recognised as first order parameters. Some equations have been established to take into account these parameters: among others, the Kalinski & Kelly equation[1] enables to predict the electrical resistivity as a function of the water content; the Keller & Frischknecht equation[2] gives the evolution of electrical resistivity versus temperature. Nevertheless, these equations have been calculated for homogeneous materials for large ranges of variations of the cited parameters. Their application in heterogeneous and multi-scale materials like soil is still in discussion. We have also conducted laboratory experiments on disturbed and undisturbed soil cores to discuss the validity domain of these equations. Three parameters have been examined: the soil bulk density, the soil water content and the ionic strength of the soil solution.

Experiments have been conducted on a Haplic Luvisol (FAO Classification, 1998[3])

developed on loess with controlled bulk densities. As expected, the electrical resistivity decreases when the bulk density increases. In the range of usual variations in soil bulk densities, a linear relationship between soil resistivity and soil bulk density has been demonstrated. For two characteristics values of compacted and uncompacted agricultural soil, a significant 10 ohm.m difference in electrical resistivity has been evidenced. The water content has been shown to decrease the soil electrical resistivity but its influence is not linear and depends of the bulk density. Finally, the electrical resistivity increases with the ionic strength but this effect can been masked by the bulk density influence. As a conclusion, all the considered parameters have to be carefully taken into account to correctly interpret water infiltration experiments in the field.

[1] Kalinski R. J., Kelly W. E., 1993. Estimating water content of soils from electrical resistivity. Geotech. Test. J. 16, 323-329.

[2] Keller G., Frischknecht F.C., 1966. Electrical methods in geophysical prospecting. Pergamon Press.

[3] FAO, 1998. World Reference Base for soil resources. In: World Soil Resources Report n˚84. FAO, ISRIC, Rome, 91pp.