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# Derivation of soil texture and soil water content from electromagnetic induction measurements

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## Abstract

Surveying soils can be reduced by measuring the apparent soil electrical conductivity and converting the readings into textural parameters as well as soil water contents. The relationship between $EC_a$ and clay, silt, sand as well as water content at field capacity was investigated in representative soils of the 150 ha agroecosystem research study site Scheyern. Field wide distribution of these parameters were obtained with a sequence of calibrations. The spatial variability of soil texture and soil water as well as their boundaries could well be described.

**Keywords**: apparent soil conductivity, EM 38, topography, soil pattern

## Introduction

Site-specific agriculture requires detailed information about the spatial soil heterogeneity of fields. Earlier investigations have shown that the apparent electrical conductivity ($EC_a$) measured with EM38 represents the influence of several factors, including volumetric soil water content, gravimetric content of soil texture and further soil conditions like conductivity of the pore water, cation exchange capacity and organic matter. However, on the field/farm level simplified field wide derivations to predict soil texture and water content are not sufficiently developed. This study describes an approach to calculate these parameters with a sequence of multi-linear regressions.

## Materials and methods

The study was carried out on the experimental farm at Scheyern, located in the tertiary hill side, a hilly landscape where tertiary sediments are partly covered by Pleistocene loess. The study included 133 sites with a broad range in soil texture. For each site soil texture and water content were determined and weighted according to the characteristic EM 38 response with depth.

## Results and discussion

Field wide distribution of soil texture and water content at field capacity were obtained with the following steps: (i) Serial conductivity measurements with EM38 within a distance of 20 m; (ii) soil sampling on selected points and determination of the contents of clay, silt, sand and water (iii); classification of the data set according to different criterions (empirical derivation and statistical evaluation) e.g. content of soil texture and soil water, cultivation, topography, geology; (iv) derivation of soil texture by means of apparent electrical conductivity ($EC_a$) and topography (altitude, inclination, exposition) for every cluster with the purpose to obtain field wide contents of clay, silt and sand; (v) calculation of the water content by means of the apparent electrical conductivity, topography parameters and soil texture for every cluster with the aim to get field wide contents of soil water. The best results for the derivation of clay, silt and sand content were achieved with a segmentation of the data set into five different groups: Miocene freshwater molasses and Pleistocene loess each with integrated and organic farming, and gleyic soils. The multi-linear regressions show adjusted $R^2$ between 0,62 and 0,86 in the vertical as well as in the horizontal mode (Tab. 1). Such a good representation of sand and silt content was not reported until now in the literature. This is due to the segmentation of the data set and further due to the inclusion of topography parameters in the equations. The greatest influence on $EC_a$ exerted the clay content at field capacity, but silt and sand should not be neglected, particularly if the target variable is the water content.

Table 1. Adjusted $R^2$ between soil texture and the independent variables $EC_a$ and topography parameters for the clusters Miocene freshwater molasse and Pleistocene loess each with integrated and organic farming, and gleyic soils at Scheyern.

Dependent variable: clay, silt, sand [g*g-1]
Independent variables: $EC_a$, topography

| | Geology: | Pleistocene loess | | | Miocene freshwater molasse | | |
|---|---|---|---|---|---|---|---|
| Cultivation | Mode | Clay | Silt | Sand | Clay | Silt | Sand |
| Integrated | vertical | 0,71 *** | 0,71 *** | 0,72*** | 0,72 *** | 0,63 *** | 0,77 *** |
| | horizontal | 0,68 *** | 0,82 *** | 0,74 *** | 0,79 ** | 0,62 * | 0,76 ** |
| | | n = 34 | | | n = 24 | | |
| Organic | vertical | 0,73 *** | 0,76 *** | 0,72 *** | 0,73*** | 0,70 *** | 0,66 *** |
| | horizontal | 0,72 *** | 0,82 *** | 0,76** | 0,78*** | 0,64*** | 0,86 *** |
| | | n = 14 | | | n = 54 | | |
| Gleyic soils | vertical | 0,67* | 0,72* | 0,79* | | | |
| | horizontal | 0,79* | 0,96** | 0,83* | | | |
| | | n = 7 | | | | | |

By means of discriminant analysis the partitioning into the geological substrates was calculated. The classification results show a predicted group membership of 88% (Pleistocene loess) and 83% (Miocene freshwater molasse), respectively, with a significant canonical correlation coefficient of 0,7. In contrast to the simulation of the soil texture, the estimation of the water content at field capacity requires only a segmentation into the groups hydromorphic and terrestrial soils. In both clusters, soil texture predominantly influences the soil water content. Adjusted $R^2$ of 0,99 (V-, H-mode) were achieved in the terrestrial soils and of 0,95 (V-mode) and 0,89 (H-mode), respectively, in the water influenced soils.

## Conclusion

Based on the delineation of more homogeneous entities the procedure described displays an effective method to derive the spatial variability of soil texture and soil water as well as their boundaries.

## References

Schmidhalter U., A. Zintel und E. Neudecker, 2001. Calibration of electromagnetic induction measurements to survey the spatial variability of soils. In "Proceedings of the 3rd European Conference on Precision Agriculture". Montpellier. (Eds. G. Grenier and S. Blackmore), 479-484.

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