Current challenges in application of Electromagnetic Induction method in monitoring soil salinity and sodicity in irrigated agricultural lands: Case studies from Portugal

Mohammad Farzamian[1,2], Nadia Castanheira[1], Ana Marta Paz[1], Tiago B. Ramos[3], Fernando A. Monteiro Santos[2], Maria Catarina Paz[2,4], Francisco José Martinez Moreno[2], Carlos A. Alexandre[5], Mario Ramos Rodríguez[6], Karl Vanderlinden [6], and Maria C. Gonçalves[1]*

[1][INIAV, Instituto Nacional de Investigação Agrária e Veterinária, Oeiras, Portugal]
[2][Instituto Dom Luiz, Universidade de Lisboa, Lisboa, Portugal]
[3][Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal]
[4][CIQuiBio, Barreiro School of Technology, Polytechnic Institute of Setúbal, Lavradio, Portugal]
[5][Universidade de Évora, institute of Mediterranean Agricultural and Environmental Sciences, Évora, Portugal]
[6][IFAPA Centro Alameda del Obispo, Córdoba, Spain]

* Corresponding author: mohammad.farzaian@iniav.pt

Keywords: Soil salinity and sodicity, Electromagnetic Induction, soil electrical conductivity, inversion, efficient field assessment

Introduction, scope and main objectives

Efficient field assessment methods are needed to monitor the dynamics of soil salinity and sodicity in salt-affected irrigated lands and evaluate the performance of management strategies (Farzamian et al. 2021). Our study aims to examine the ability of the electromagnetic induction (EMI) sensors and recently developed inversion techniques for field-scale monitoring of soil salinity and sodicity over several irrigated agriculture lands in Portugal and to address the challenges associated with the proposed methodology.

Methodology

The proposed methodology consists of 4 main steps: 1) use of time-lapse EMI surveys to measure the soil apparent electrical conductivity (EC_a) and its changes during the experiment period; 2) inversion of time-lapse EC_a data to assess the spatiotemporal distribution of the soil electrical conductivity (σ); 3) calibration process consisting of a regression between σ and the electrical conductivity of the saturated soil paste extract (EC_e), sodium adsorption ratio (SAR), exchangeable sodium percentage (ESP) used as proxies for soil salinity and sodicity and; 4) conversion of spatiotemporal distribution of σ into salinity and sodicity cross sections using the obtained calibration equations.

Results

Our results indicate that the ability of the proposed methodology depends on soil salinity level in the study area and spatial variability of other soil properties (e.g. clay fraction, moisture content - θ) which influences the EMI signal. It was possible to predict soil salinity and sodicity with good accuracy from EMI data in Lezíria de Vila Franca, located in Lisbon region (Paz et al. 2020a) due to high level of soil salinity in the south of the study area (ECe > 4 dS/m) and relatively small variability of soil texture in this region. In contrast, in the Roxo irrigation district in Alentejo region, we found a stronger correlation between σ and clay fraction due to large variability of soil texture and reduced level of salinity (ECe < 4 dS/m) which make it difficult to establish a regression model to predict soil salinity from σ.

Discussion

Predicting soil salinity changes from time-lapse EMI data over large areas is more challenging (Paz et al. 2020b). This is due to the large variability of other dynamic parameters including θ, soil temperature, level and salinity of groundwater which impact the EMI signal and make it more difficult to infer soil salinity changes. We found it particularly challenging to assess soil salinity changes in the root zone from EMI measurements, as θ and temperature vary more significantly in this zone due to different irrigation practices, root uptake of different crops, and evapotranspiration processes.

Conclusions

The EMI method provides enormous advantages over traditional methods of soil sampling because it allows in-depth and non-invasive analysis, covering large areas in less time and at a lower cost. However, a proper interpretation of the EMI inversion models in terms of soil salinity dynamics is usually difficult owing to the fact that σ is a complex function of several soil properties, which may vary significantly over space and time. Thus, retrieving soil salinity from EMI data requires an appropriate understanding of site-specific soil processes, EMI data, and inversion process. This fact highlights the necessity of collaboration of geophysicists, soil scientists and hydrologists to construct a conceptual model which can explain the salinity and water processes in the soil.

Acknowledgements

This work was developed in the scope of SOIL4EVER "Sustainable use of soil and water for improving crops productivity in irrigated areas" project supported by FCT, grant no. PTDC/ASPSOL/28796/2017.

References

Farzamian, M., Autovino, D., Basile, A., De Mascellis, R., Dragonetti, G., Monteiro Santos, F., Binley, A., and Coppola, A. 2021. Assessing the dynamics of soil salinity with time-lapse inversion of electromagnetic data guided by hydrological modelling, *Hydrol. Earth Syst. Sci*., 25, 1509–1527, https://doi.org/10.5194/hess-25-1509-2021.

Farzamian, M., Paz, M. C., Paz, A. M., Castanheira, N. L., Gonçalves, M. C., Monteiro Santos, F. A. and Triantafilis, J. 2019. Mapping soil salinity using electromagnetic conductivity imaging—A comparison of regional and location-specific calibrations, *L. Degrad. Dev., 30(12), 1393–1406,* doi:10.1002/ldr.3317.

Paz, A. M., Castanheira, N., Farzamian, M., Paz, M. C., Gonçalves, M. C., Monteiro Santos, F. A. and Triantafilis, J. 2020a. Prediction of soil salinity and sodicity using electromagnetic conductivity imaging, *Geoderma, 361(November), 114086*, doi:10.1016/j.geoderma.2019.114086.

Paz, M. C., Farzamian, M., Paz, A. M., Castanheira, N. L., Gonçalves, M. C. and Monteiro Santos, F. 2020b. Monitoring soil salinity using time-lapse electromagnetic conductivity imaging, *SOIL*, 6, 499-511, doi:10.5194/soil-2019-99.