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Spectral Induced Polarization: Laboratory measurements on artificial soils with varying water saturation, salinity and clay content

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Geoelectrical methods provide diverse toolsets to image the subsurface and monitor its water dynamics. These observations might be crucial in arid areas, where the structure and function of agricultural and natural ecosystems are dramatically determined by water availability. Dryland ecosystems can be characterized by heterogeneous soil cover, high salt content in upper soil layers and low levels of soil moisture. However, understanding the combined effect of soil water content, salinity and soil composition on the electrical signal remains a challenging issue. Recent studies demonstrated the sensitivity of the IP method to water content [1; 2], clay content [3] and salinity [4; 5]. [4] noted that the quadrature conductivity is weakly dependent on the pore fluid salinity, thus, it might be used to separate between pore water salinity and water content.

Here, in a laboratory experiment series, we conducted spectral measurements on artificial soils in small sample holders to observe under controlled conditions how the IP response is affected by water saturation and salinity. This laboratory setup with manipulated gradients of water content and salinity levels allowed to perform measurements with high accuracy, and establish relationships between the electrical and hydrological properties of unconsolidated deposits or soils. Sand-clay mixtures were used, consisting of very fine-coarse sand and clay powder (Ca-montmorillonite) which were mixed during multiple dry-wet mixing cycles with gradually growing clay content (0-8 %). The samples were packed under dry conditions and afterward saturated with tap water. The decreasing water content was obtained by air injection with growing pressure (0,05-2,5 bar). At the second phase of the experiment, the salinity was increased through the pore water (NaCl solution up to the electrical conductivity of 7000 µS/cm). Regression analysis is carried out on the obtained dataset to calibrate the sensitivity of the complex resistivity to the changing parameters at different frequencies. Based on the preliminary results, the method may have the potential for the construction of a pedophysical model, allowing the field application for water content monitoring in arid areas.

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