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Soil water-structure interaction in the tilled horizon as monitored in space and time by 2D Electrical Resistivity Tomography method

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The soil structure -i.e the spatial organisation of soil particles- changes in time and space at the decimetric scale under natural and anthropic pressures (climate, biological activity, tillage, compaction). Usual methods for characterising soil structure are destructive and time-consuming preventing spatial and temporal monitoring. New technological tools are then required. The Electrical Resistivity Tomography method (ERT), which is non-destructive and provides exhaustive description of the soil, has already been demonstrated to be useful for the description of the soil structure. However, the soil electrical resistivity is a physical parameter which depends not only on the soil structure but also on other soil characteristics, including soil water content. Changes in soil structure result in alterations of the soil water system and vice-versa by retroactions. These combined effects of soil properties on resistivity can restrict the interpretation of ERT in term of soil structure variability.
The objective of this study was to characterise the spatial and temporal variability of the soil structure by the ERT method from the analysis of soil water-structure interactions on resistivity measurements.
2D ERT time monitoring has been performed for one year, in field on a small plot located in Beauce region (France). The soil was locally compacted by in-field wheel traffic to create structural zones with different bulk densities: compacted zones vs porous zones. The studied area covered both a cultivated zone and a bare soil zone to study different dynamics of water content. ERT consisted in Wenner array which gathered 72 electrodes spaced 0.1m apart. The volumic water content was monitored by TDR probes installed at several depths along the soil profile and in the different soil structural units (compacted and porous). The spatial and temporal variability of the soil structure in the first layer was analysed by i) vertical visual morphological profiles realised at six dates during the electrical resistivity monitoring, and ii) measurements of the bulk density on undisturbed soil cores sampled on the morphological profiles. After a 2D inverse modelling, resistivities were corrected from temperature effect.
The analysis of ERT combined with bulk densities and morphological profiles showed relevant structural changes, especially in summer and winter. The porous zones were mainly affected by these changes in accordance with soil moisture variability in space and time. The electrical resistivity allowed to discriminate compacted zones which were less resistant than porous zones and to identify temporal changes in porous zones, especially the formation of cracks during summer. The compacted zones did not significantly evolve during the year, showing the slow resilience of the soil structure after compaction. Nevertheless, the electrical resistivity measurements demonstrated that cracking developed specifically at the contact between compacted clods and porous zones. As a consequence, the electrical resistivity increased in these cracking areas during the drying season due to their higher air content and decreased at the same locations due to preferential infiltration of water in the cracks. The 2D ERT allowed then us to describe the interactions between soil water content and structure.

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