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Passive acoustic emissions: a dynamic tool to monitor soil structure variations?

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The structure of soils, i.e. the macroscopic organization of aggregates and pores, conditions the storage and transport of water and gas in the soil, and strongly determines the physico-chemical environment of soil organisms (plants, micro and macro-organisms). The description of the soils structure dynamics constitutes a major issue in the current context of global change, at the scientific, environmental and agronomic level. However, few tools are available to monitor this dynamic non-destructively and in situ. We therefore propose to develop a new method based on the analysis of acoustic emissions (AE) spontaneously emitted by soils during the evolution of their structure. A laboratory feasibility study was conducted to explore the links between variations in soil structure and the AE emitted during soil desiccation.

Two undisturbed soil columns (8 cm in diameter, 5 cm high) were sampled in an agricultural field (near Chartres in France), in the surface horizon of a Glossic Retisol. These cylinders were air dried (20°C during 9 days), and the AE produced during drying were monitored using piezoelectric sensors place at the soil surface. The concomitant soil structure changes were followed through 3D images, acquired by X-ray tomography (CIRE platform, INRAE, Nouzilly) all along the experiment. These images, with a resolution of 168 µm, were used to characterize the pore network (porosity, surface density, connectivity, etc.).

The dynamics of the EAs recorded during the drying of the samples is comparable for the two samples: the AE rates are maximum at the start of the experiment and then reach a plateau. Changes in soil structure follow the same dynamics, e.g. considering porosity or surface density of the pores. If we analyze the relationship between the signals recorded by the surface sensors (EA rate) and the porosity, we observe a linear relationship (R^2 of 0.79). This relationship, although encouraging, remains to be consolidated by additional results.

To go further, it is also necessary to define the necessary conditions to perform such a measurement in situ, and to improve the acoustic signal processing to characterize the EA produced during soil desiccation. Indeed, a major objective of our work is to differentiate, thanks to EAs, the various factors responsible for the evolution of soil structure (physical and biological), by determining their "acoustic signature".