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Near infrared spectroscopy for identifying the earthworm's participation to soil macroaggregation

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As ecosystem engineers, earthworms are major actors of soil aggregation, a process that drives the delivery of ecosystem services by soils. However, our inability to identify the origins of different types of macroaggregates found in soils, the macroaggregates persistence in the soil matrix, their degradation rates, and their role in the dynamics of soil organic matter (SOM) and nutrients remain poorly known. Near Infrared Spectroscopy (NIRS) was tested as a tool to discriminate between origins of macroaggregates, collected in the field at the soil surface and in the 25 first cm of the soil. In parallel, NIR spectral signatures of earthworm casts were measured, during the ageing processes of the aggregates.
During the first experiment, earthworm casts of unknown origins, collected in the field, were identified by comparing their NIR spectral signatures to the signatures of macroaggregates produced by the same ecosystem engineers in laboratory conditions, living in the same soil. Principal component analysis of NIR spectra permitted us to characterize macroaggregates of each species by a specific spectral signature ($p<0.001$; total variance explained: 38.3%). The organic matters included in the soil macroaggregates present quantitative and qualitative differences according to the earthworm species that produced them.
During the second experiment, realized in laboratory conditions, NIR spectral signatures were measured in subterranean and surface casts of different earthworm species, incubated in controlled laboratory conditions for different periods of time. In parallel, dynamics of total amounts of C and N were assessed in ageing macroaggregates. As casts aged, NIR spectral signatures went through three main stages in the maturation process: (1) rapid changes in the NIR signal during the first 48 h, (2) a maturation period from days 3-30 with much slower change in NIR spectral signatures and (3) a further stage of maturation (days 45-90), where cast spectral signature and C and N contents converged towards those of the control soil. The first two axes of the PCA corresponded closely to the C and N content, respectively, of the casts.

These two complementary experiments demonstrate that NIRS allows identifying origins of macroaggregates produced by various earthworm species in different environments. Other complementary experiences we realized in laboratory conditions highlight that OM modifications, caused in aging casts, are large enough to be detected by NIRS in macroaggregates and to estimate a cast's age. We propose a new method to analyse soil macroaggregates origins, to quantify the relative contribution of ecosystem engineers to soil aggregation and to evaluate soil macroaggregates dynamics in the soil structure.