Analysis of Soils in Agriculture and Archaeology by NIR Hyperspectral Imaging

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Detection and quantification of materials incorporated in the soil, such as organic matter, crop residues, fragmented bones and ceramics becomes a priority in both agriculture and archaeology as they contain a large quantity of information that could prove to be valuable. In the case of agriculture, the monitoring of these materials will lead to sustainable agricultural practices by better understanding of the biochemical and physical processes of farming and soil tillage. In archaeology, the study of the condition and state of degradation of these materials can play an important role necessary in order to evaluate in situ preservation as a potential alternative to excavation or to analyze the impact of climate change on past human occupations.

Conventional soil chemical measurements are slow, costly and usually generate unwanted waste and destruction of original samples. A large number of papers have shown the advantage of using Near Infrared Spectroscopy combined with pedometrics or soil science, or the application of mathematical and statistical methods for the study of the distribution and genesis of soils, mainly for the quantification of soil parameters. However the diversity of mineral composition of the soils and the weak content level of organic matter make their detection and quantification by NIRS a real challenge.

NIR Hyperspectral Imaging is an exciting technique recently applied in the analysis of soils in both agriculture and archaeology. For agriculture, important research concerns the study of the effect of tillage and the management of crop residues (mainly organic matter) on soil. NIR Hyperspectral Imaging can be used to detect and quantify the presence of residues and roots from past crops. In the future, these techniques should allow monitoring the decomposition of crop residues in soils as well as the development of root systems. For archaeology, research is needed to study the different factors affecting conservation of different kinds of archaeological materials, including soil and bone analysis. NIR hyperspectral imaging has been applied to identify animal bone material in complex soil-sediment matrices from an archaeological excavation. In this context NIR Hyperspectral Imaging can rapidly and non-destructively screen soil samples to detect bone and (potentially) evaluate their degree of collagen preservation. This could be used as a preliminary analysis to select samples suitable for analysis requiring collagen (e.g., ancient DNA analysis).