Sorting of crop residues and fossil bones from soil by NIR Hyperspectral Imaging

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Introduction

NIR-HSI system (1100-2500 nm)

Soil is a complex matrix containing a wide variety of constituents of interest for disciplines like agronomy or archaeology; it could either be crop residues like roots and straws or bones and ceramics. Current challenges comprise the detection of these constituents as well as the assessment of their qualitative parameters by means of fast and non-destructive analytical methods.

The scope of this work is to present two applications using Near Infrared Hyperspectral Imaging (NIR-HSI) combined with chemometrics to sort constituents of soil and to assess their qualitative parameters. The first application concerns the feasibility study of using NIR-HSI to sort crop residues such as roots and straws in soil. The second application aim to develop a method to assess the level of collagen preservation in fossil bones.

APPLICATION 1

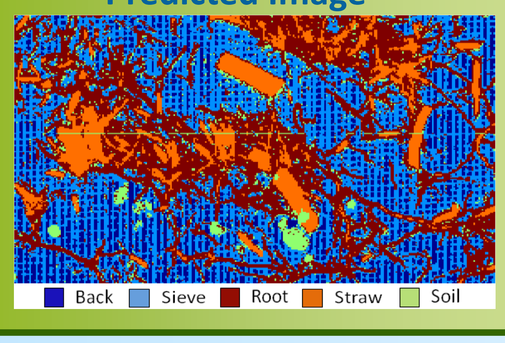
Sorting of crop residues from soil

Current challenges in agricultural research focus on the effect of tillage and the quantification of roots and straw residues in soil, which are key constituents for the monitoring of the development of the root systems and the decomposition of crop residues. In this context, a tentative study has been performed using NIR-HIS and chemometric tools to detect and quantify roots and straws.

A hierarchical classification tree based on four classes (support, soil, roots and straws) has been constructed by "successive exclusions steps" using binary PLS-DA models constructed on a spectral databank containing 1000 NIR spectra for each class. The first step of the classification tree used a model to remove spectra related to the support (conveyor belt and sieve); the second step separated soil from straws and roots and the last step discriminated 'straws' and 'roots' spectra. Depending on the model, between 75% and 99% of the spectra were well predicted. These preliminary results demonstrate the interest of this method to sort the different constituents (roots and straws) in a soil sample.

Original image

Predicted Image

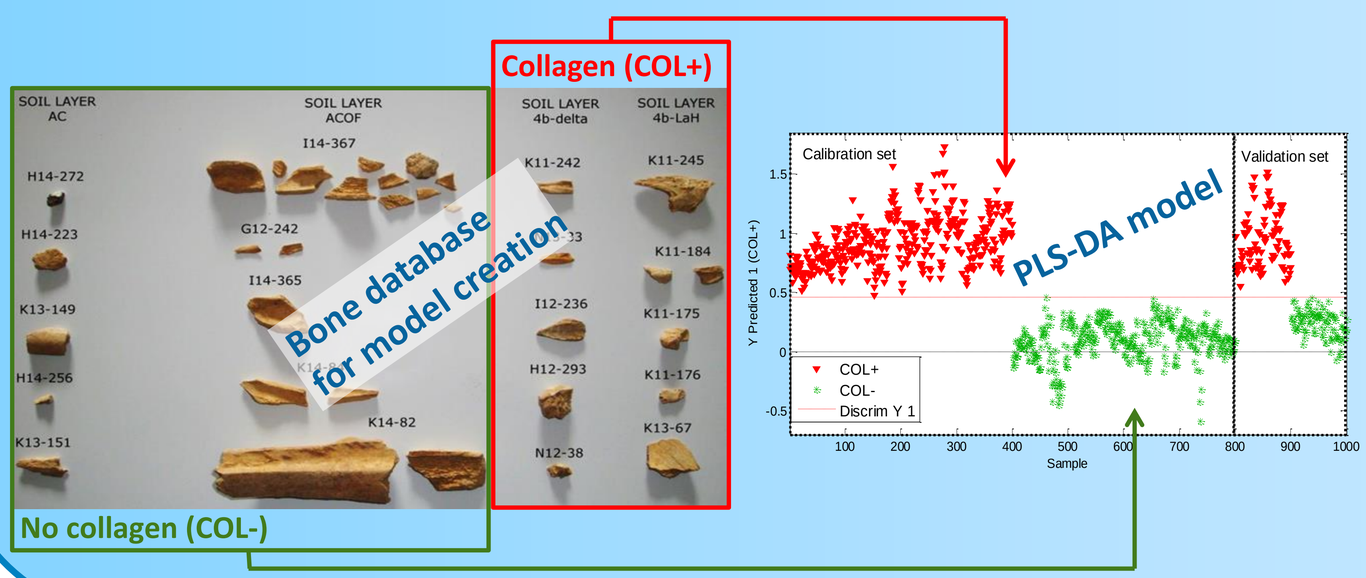


APPLICATION 2

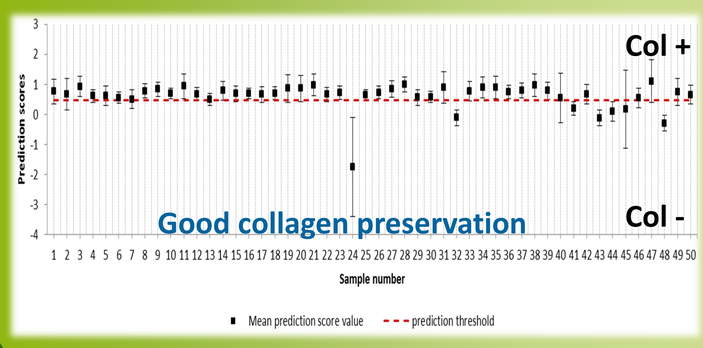
Evaluation of collagen preservation in fossil bones

In archaeology many analyses require the presence of collagen as the Zooarchaeology by Mass Spectrometry (ZooMS) technique, for taxonomic identification, the radiocarbon (AMS) dating and stable isotopic analyses to reconstruct past human and animal diets.

For these analyses, the challenge is to obtain bone samples with sufficient collagen content to get positive results. To date, there has been no protocol or analytic method capable of rapidly and non-destructively screen bones to detect and quantify collagen. In this context, the advantages of NIR-HSI represent a high potential for the development of a new analytical method.



A PLS-DA model has been developed to discriminate bones on the basis of their collagen content. Then, the model has been applied to 50 bones from a known archaeological layer. The results presented in the figure hereafter indicate that almost all the samples have been sorted above the dashed line meaning that collagen has been detected. This result is supported by the geological information indicating that this stratum was preserved from recurrent water flooding and it could be assumed that the collagen of these bones is preserved.



Conclusions

In the present work, two cases studies have been presented. The first one concerns a feasibility study where NIR-HSI combined with chemometrics has been proved to be a good alternative to classical methods for sorting the different constituents of soils like crop residues (roots and straws). In the second case study, the potential of the technique to assess the level of collagen preservation in fossil bones has been proved. In both cases, only qualitative results have been obtained. The future challenge will be the possible quantification of the constituents. In the case of the crop residues it will be to quantify the respective weights of each constituent (roots and straws) and in the case of the collagen in fossil bones, it will be the assessment of the amount of collagen present.

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"Analysis of collagen preservation in bones recovered in archaeological contexts at Trou Al'Wesse (Belgium) using NIR hyperspectral Imaging" 2014, Vincke D., Miller R., Stassart E., Otte M., Dardenne P., Collins M., Wilkinson K., Stewart J., Baeten V., Fernández Pierna J. A. Talanta, 125, pp. 181-188

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