Production of an innovative biowaste-derived fertilizer: rapid monitoring of physical-chemical parameters by hyperspectral imaging

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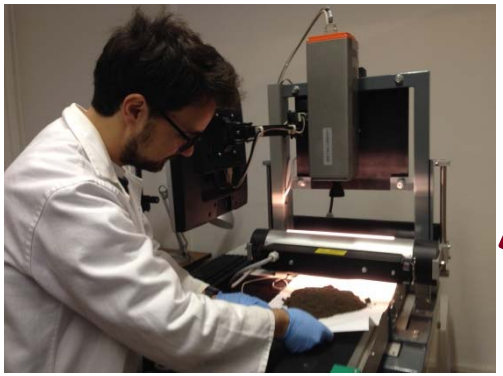
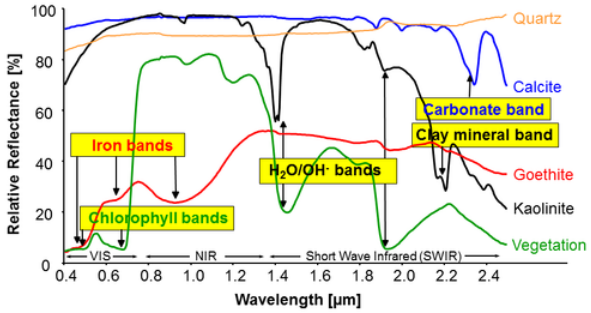
Aim of the study

In this study the possibility to apply *HyperSpectral Imaging (HSI)* as a fast and non-destructive technique for the characterization of an innovative biowaste-derived fertilizer was explored.



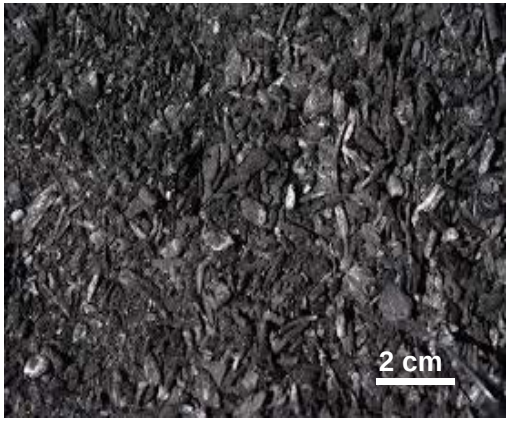


The work was carried out in the framework of the LIFE RESAFE Project (LIFE12 ENV/IT/000356).

The main objective of the RESAFE project was to demonstrate the production and use of a fertilizer obtained from Urban Organic Waste (UOW), Farm Organic Residues (FOR), Bio-Char (BC) mixed with Vegetable Active Principles (VAP).

UOW

FOR



BC

Expected benefits

For farmers and urban waste managers it will be possible to reduce costs and obtain environmental and economical advantages, such as:

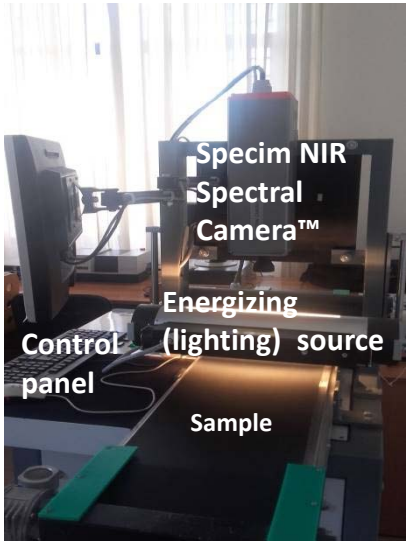
- **an important material recovery (e.g. reduced quantities of waste sent to landfill disposal and related costs saving) and**
- **a further economic benefit due to the obtained fertilizers.**

Expected results

The use of the innovative fertilizer will allow:

- **A significant reduction of chemical fertilizer**
- **A consistent improvement of soil health and fertility**

Actions and Means



During the project different actions have been carried out:

- **Pilot plant demonstration to show as from "different waste recipes", enriched with vegetable active principles, a new class of fertilizers will be obtained**

- **Utilisation of specific sensing device (hyperspectral imaging based) to follow the transformations of the complex material, during the different stages of the process**

Fertilizer recipe

Italy

45% UOW

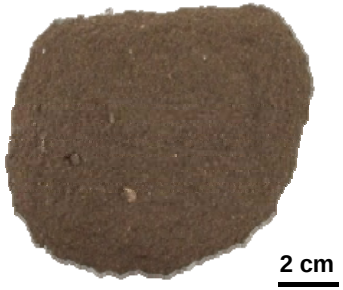
45% FOR

10% BC

+

VAP

Spain



55% UOW

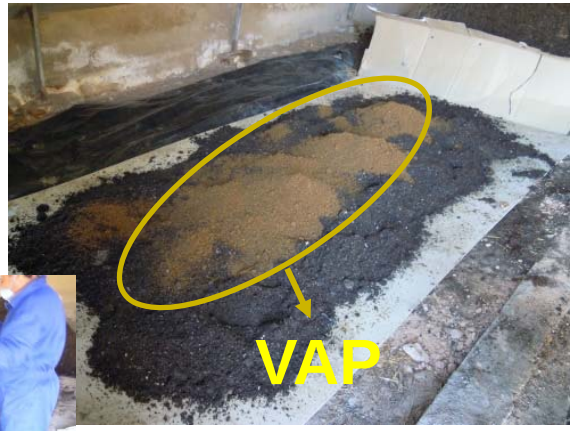
35% FOR

10% BC

+

VAP

Pilot plant

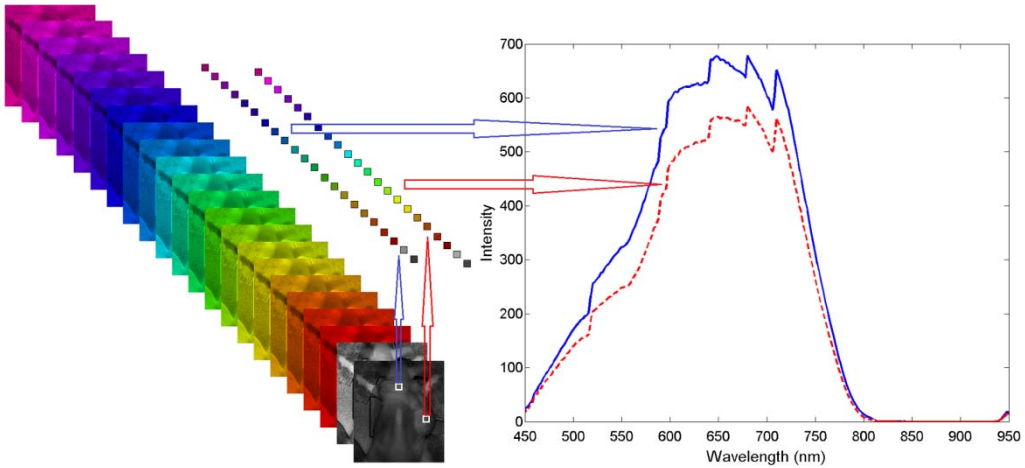


Investigated Samples

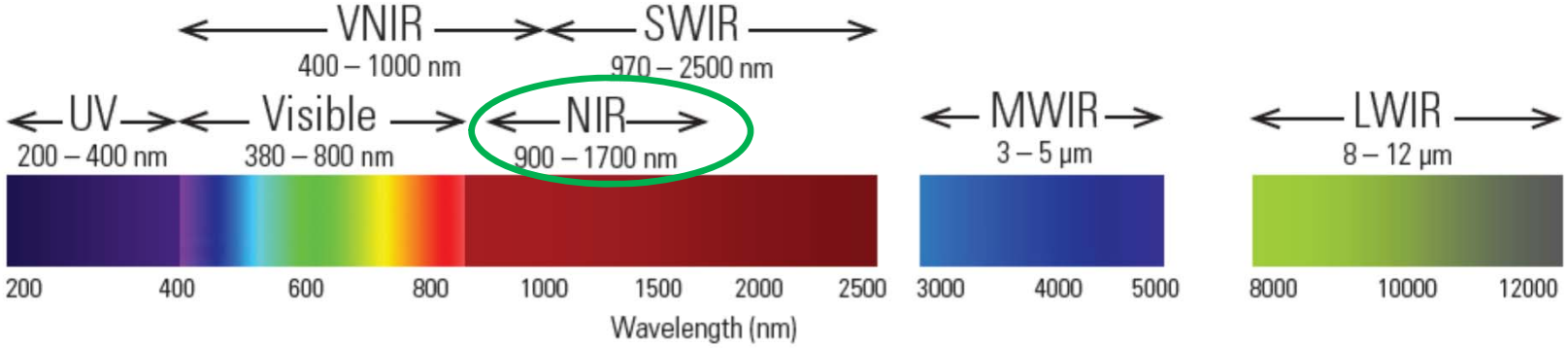
In order to produce the fertilizer at pilot scale plant, both in Italy and Spain, three different heaps were realized.

For each heap, three samples were collected at the beginning (T=0) and at the end (T=90 days) of the curing process, for a total of 18 samples in Italy and 18 samples in Spain.

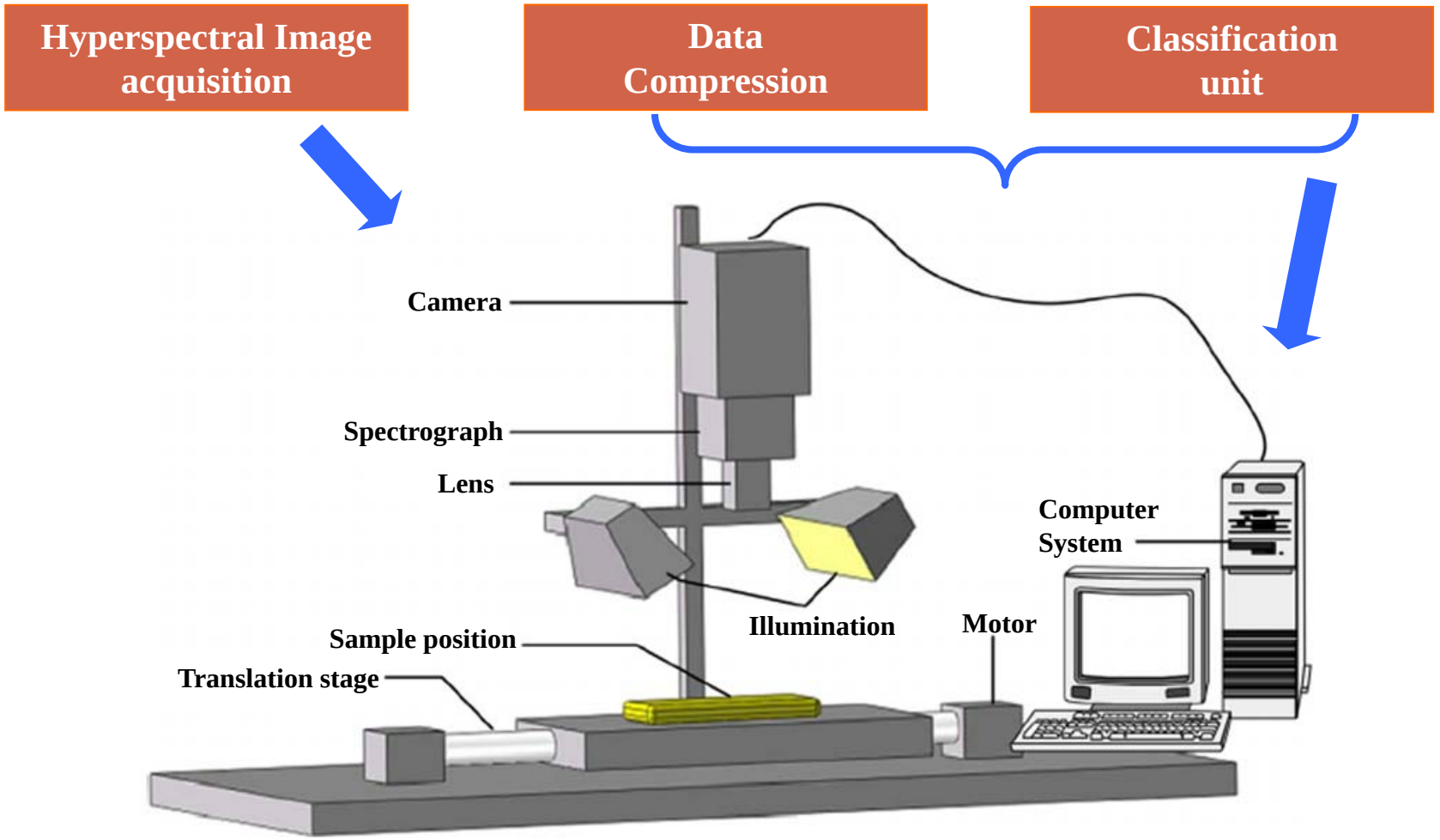
Hyperspectral imaging



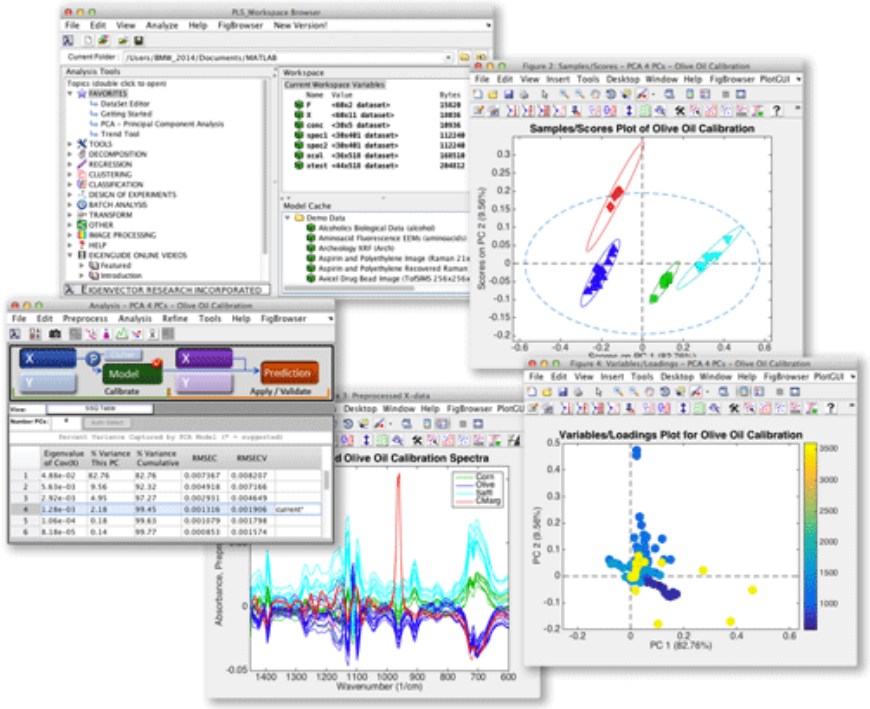
All individual spatial and spectral images could be picked up from the hypercube and the spectrum of each pixel of the image in a specific position can be extracted



HSI architecture set-up



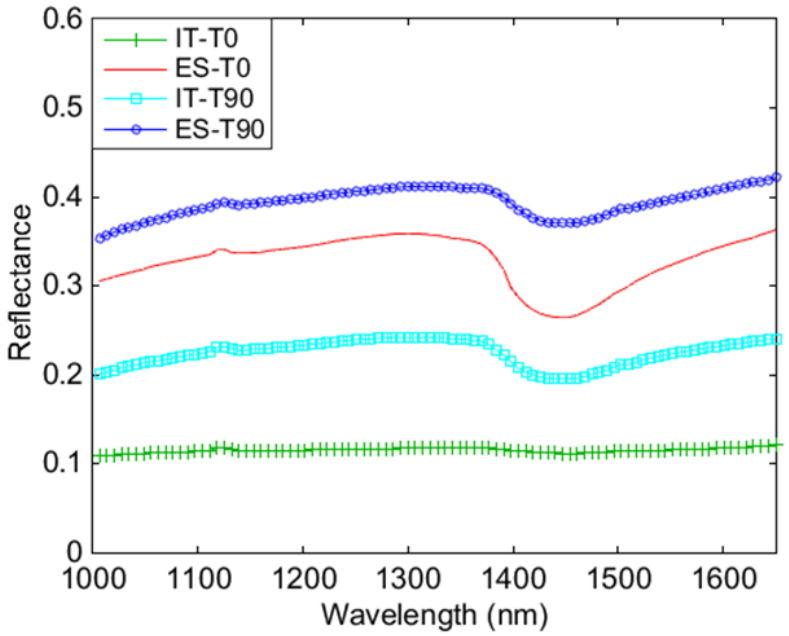
Hyperspectral data processing



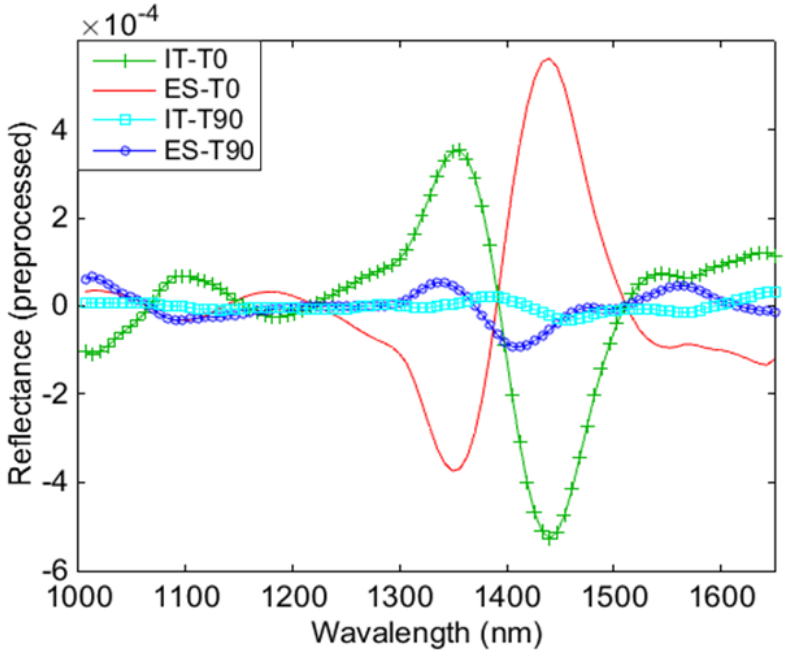
Spectral data have been analysed using the PLS_Toolbox 7.9.2 (Eigenvector Research Inc.) running inside Matlab™ environment (version 8.4.0).

- **Spectra preprocessing**
- **PCA applied for data exploration**
- **PLS applied for spectra correlation with pH, Soluble Total Organic Carbon, Soluble Total Nitrogen**

Experimental results: data preprocessing



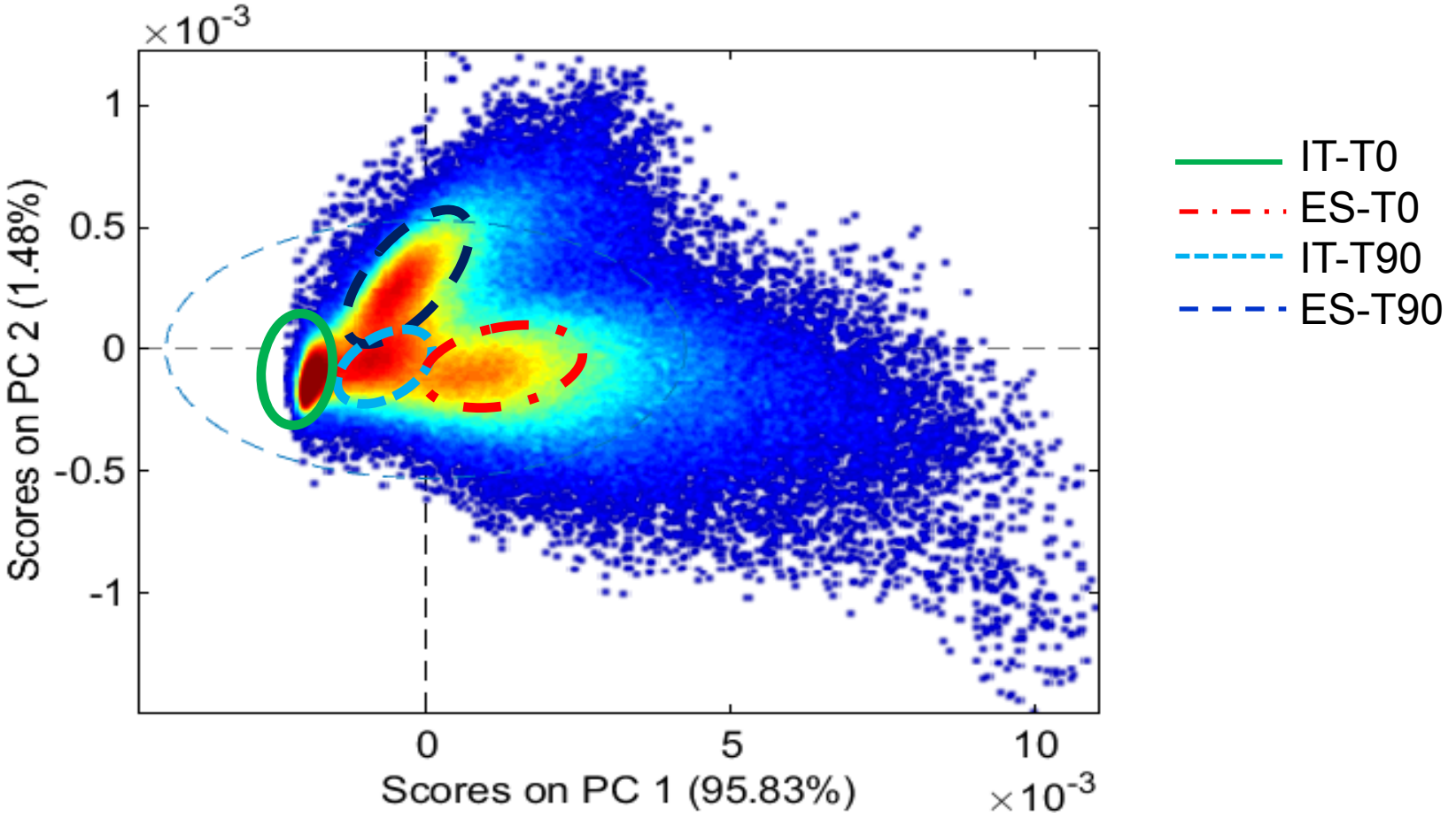
Smoothing
2nd Derivative
Mean Center



Average raw spectra

Pre-processed spectra

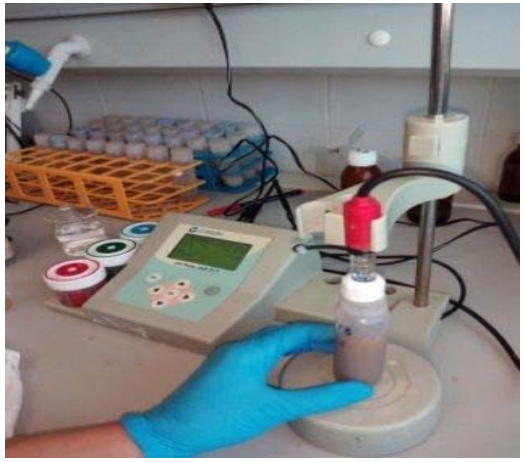
PCA results



PCA score plots (PC1 vs. PC2)

Chemical analyses

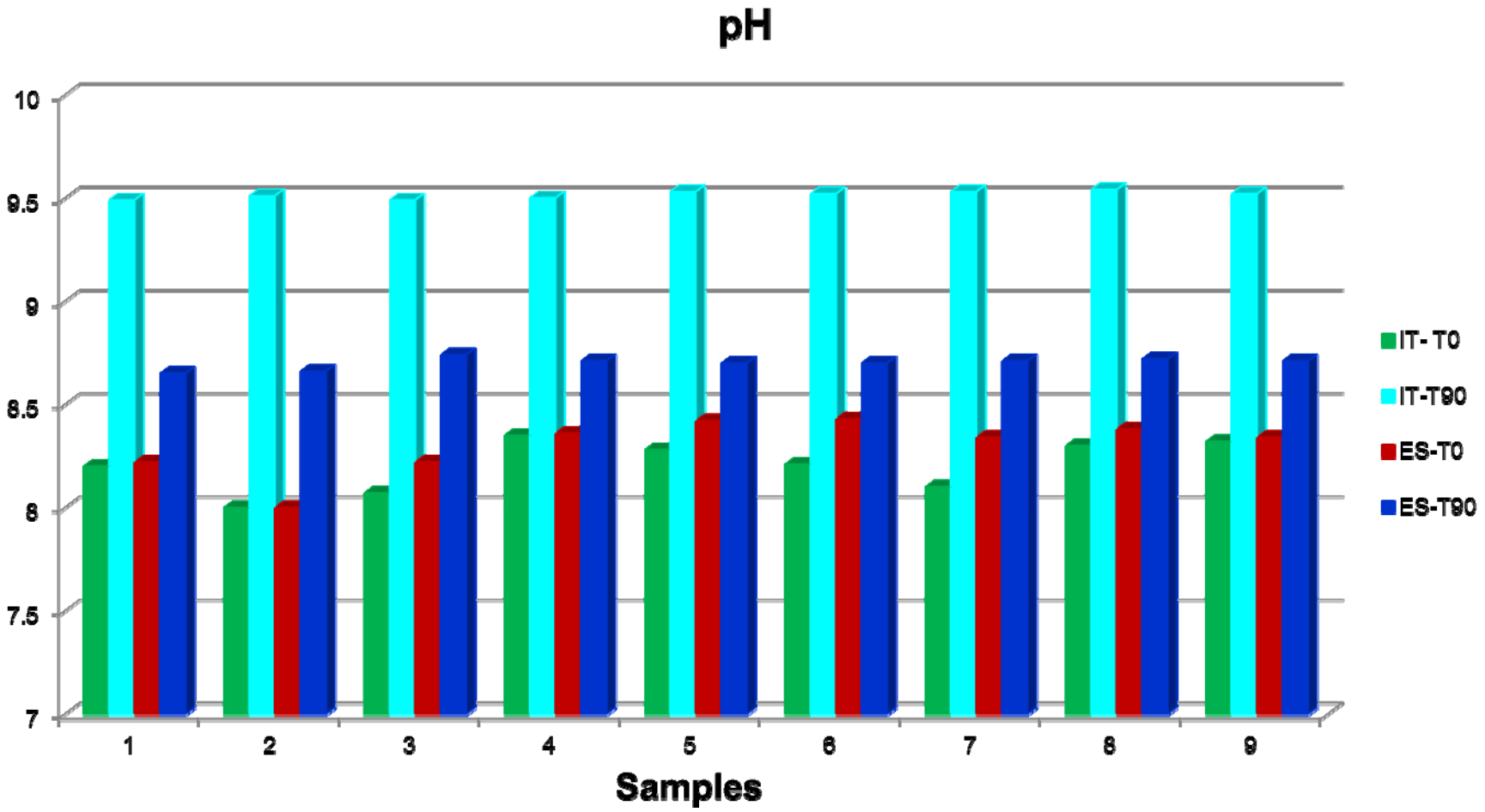
The measured parameters utilized to find correlation with the hyperspectral imaging data were pH, Soluble Total Organic Carbon (STOC) and Soluble Total Nitrogen (STN).



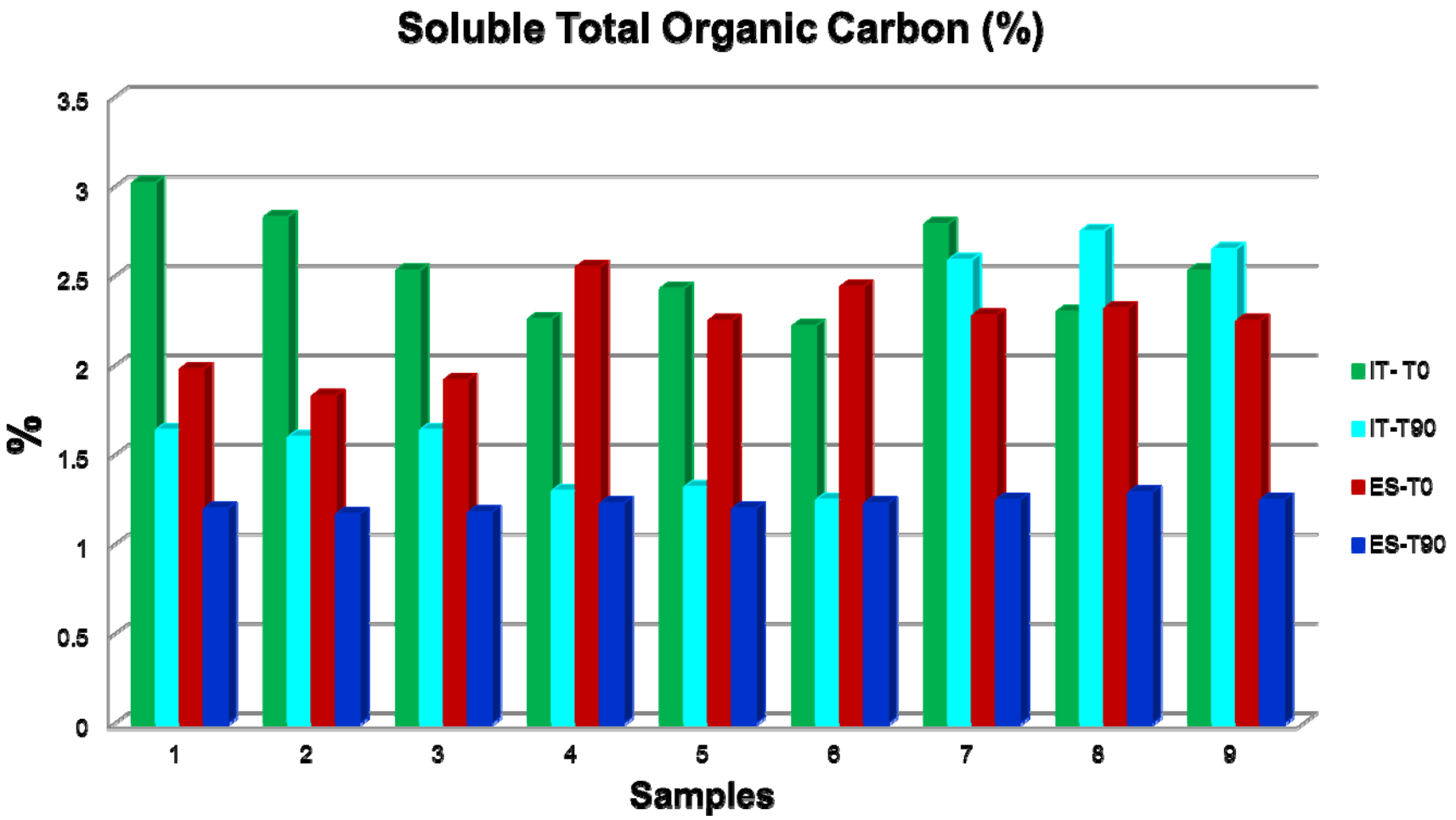
pH measurement

STOC and STN analyses performed by AnalitykJena Multi N/C Analyzer

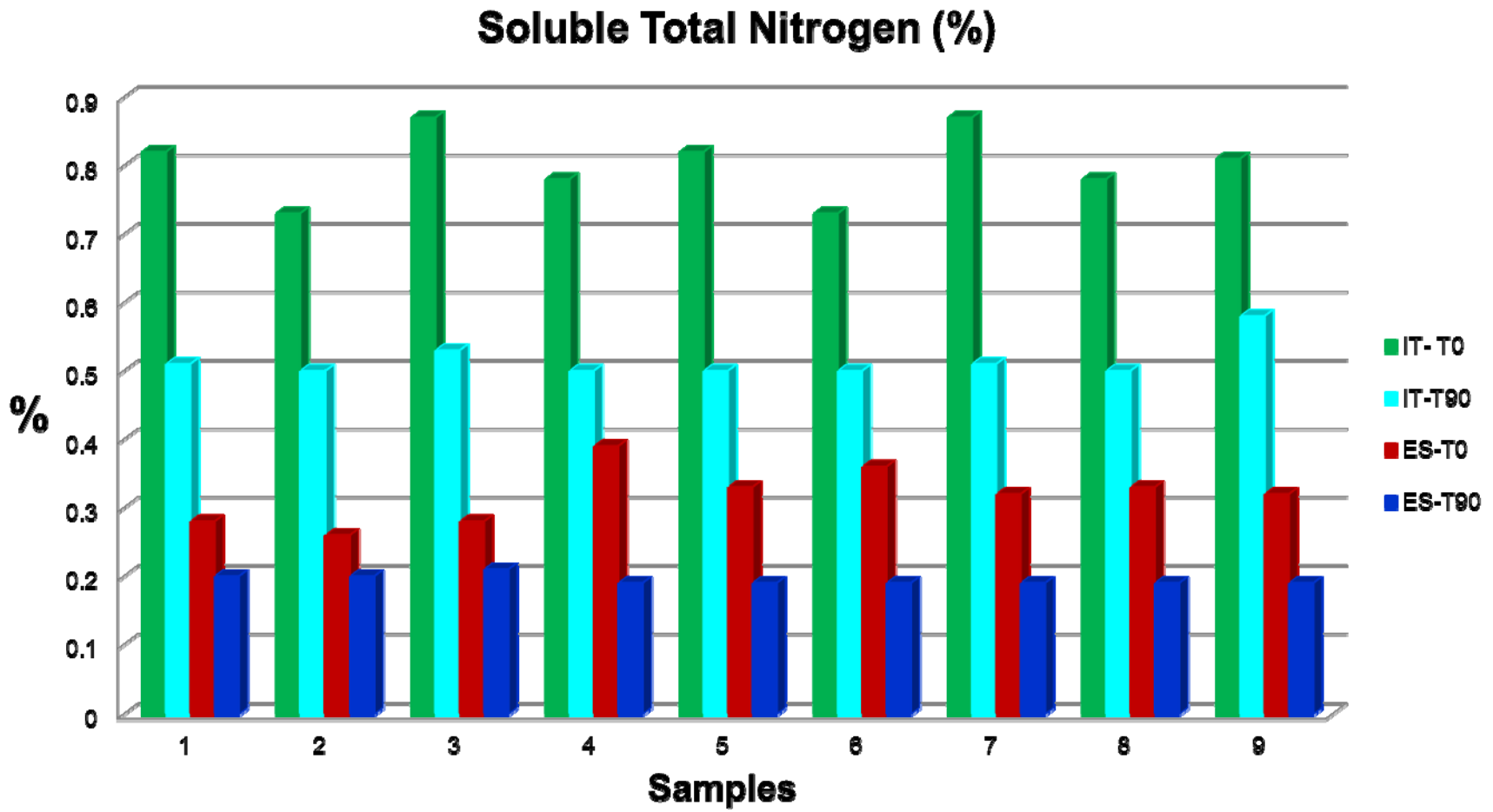
Chemical analyses results: pH



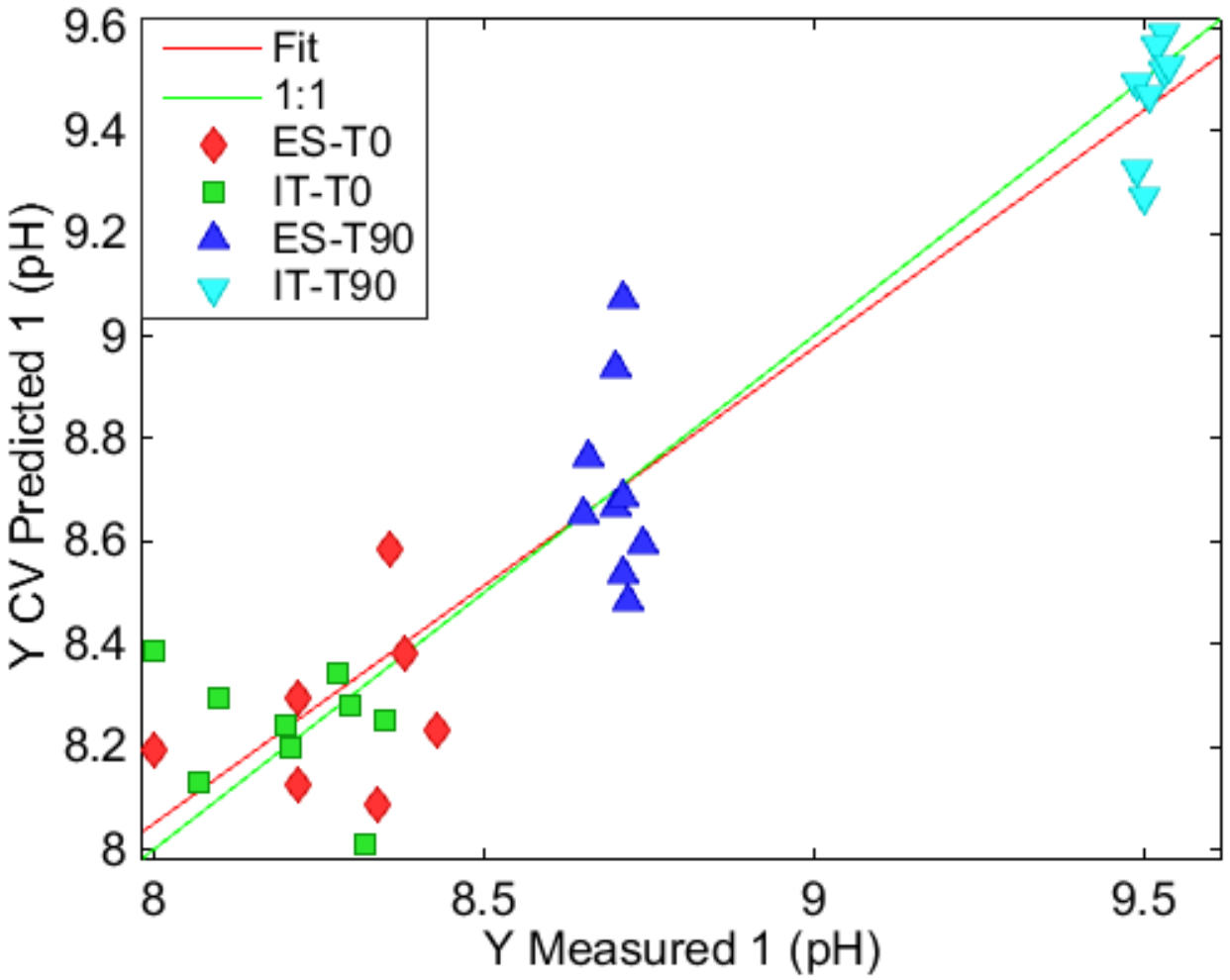
Chemical analyses results: Soluble Total Organic Carbon



Chemical analyses results: Soluble Total Nitrogen

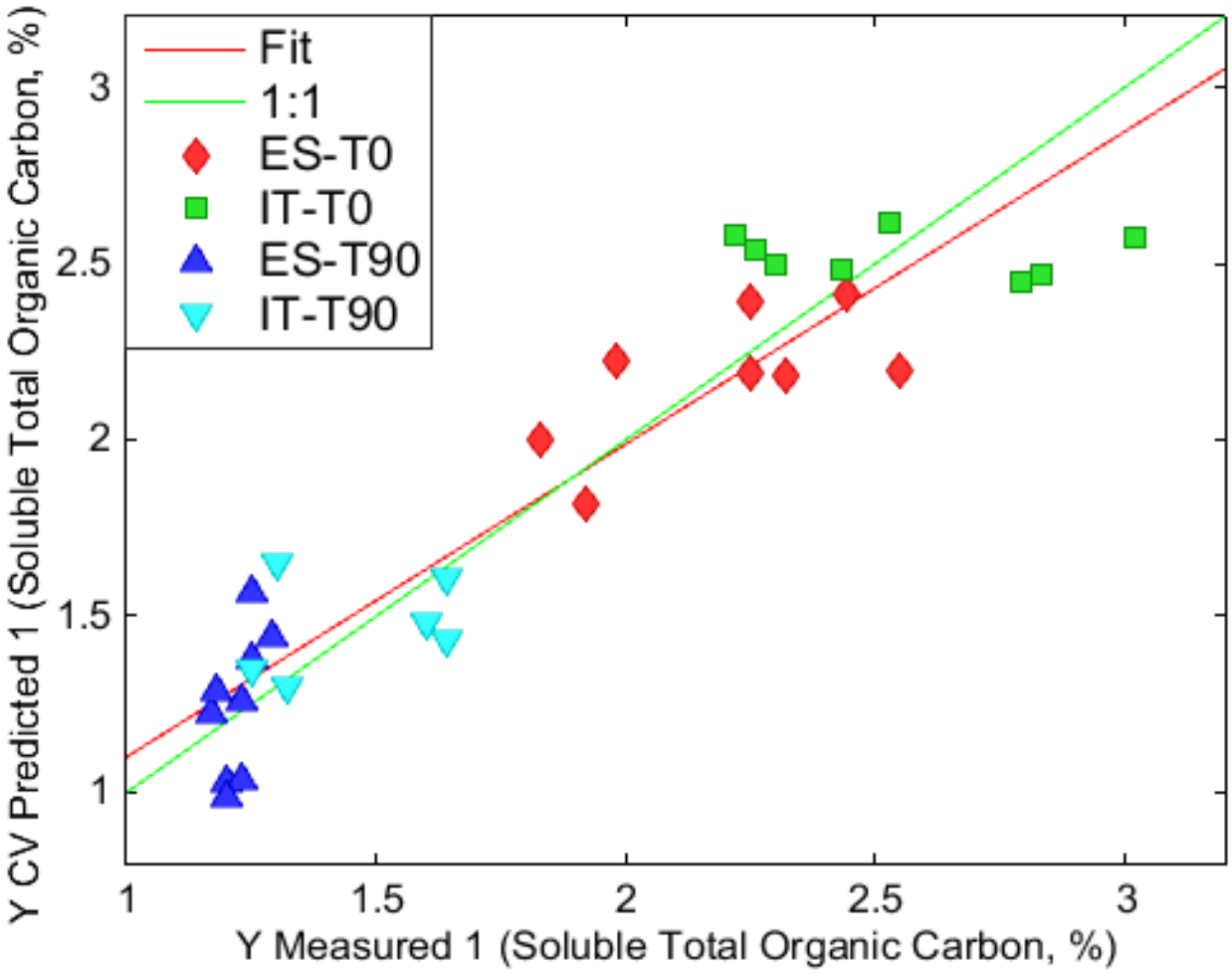


PLS results
Prediction of pH

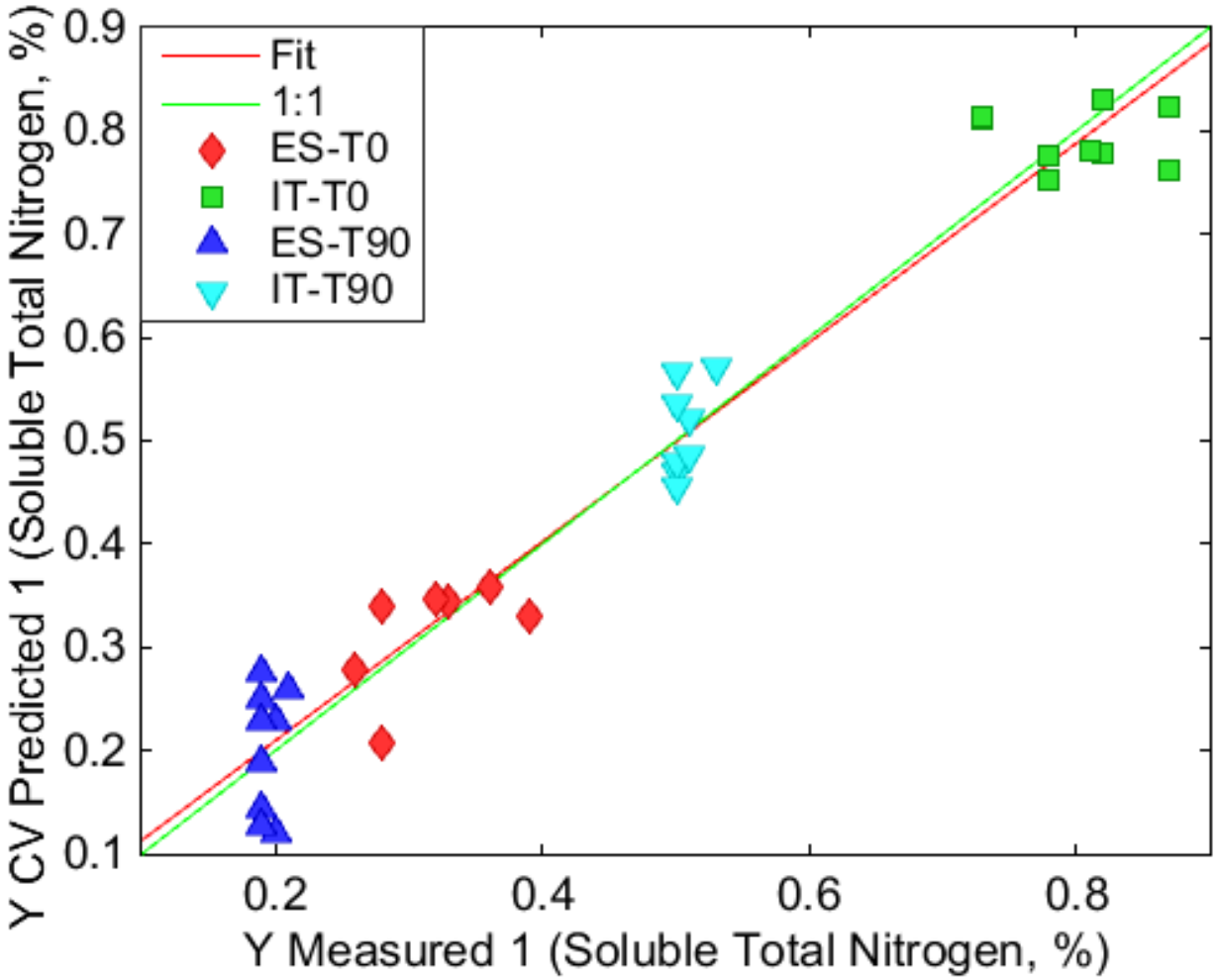


PLS results

Prediction of Soluble Total Organic Carbon



PLS results
Prediction of Soluble Total Nitrogen



Conclusions

- ✓ **The possibility to investigate the combined utilization of chemical analysis and chemical imaging based techniques to perform a characterization of a new fertilizer was explored.**

- ✓ **pH, Soluble Total Organic Carbon (STOC) and Soluble Total Nitrogen (STN) were investigated in order to find correlations with the acquired spectral signatures in the NIR wavelength range (1000-1700 nm).**

- ✓ **Good correlations were found between collected samples and classical laboratory measured parameters.**

- ✓ **Further studies will be addressed to improve the precision of calibration models through the acquisition and analysis of a larger number of samples.**

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Thank you!

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