

## Possible use of near infrared spectroscopy for management of the composting process

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### Introduction

A large range of organic residues can be transformed into valuable products by different types of composting processes. Several parameters describing compost have been previously assessed by near infrared (NIR) spectroscopy [1 - 4]. Composting agro-food wastes, according to industrial processes, can provide organic fertilisers with known quality levels, among which there are the potential of transformation for carbon and the potential of transformation for nitrogen [5, 6], as required by a future modification of the original French standard for organic soil improvers NFU 44-051 [7]. For the industrial manufacturer, it is important to control the quality of compost during its formation. A key of success is to respect the major composting stage; the thermophilic phase. The challenge is to complete this phase as quickly as possible.

A batch of compost prepared under industrial conditions may involve mixing up to 2,000 tonnes of material in several piles. As the thermophilic phase in each pile may take up to 12 weeks it is important know the stage of composting when combining piles.

The aim of this work was to explore the possibility of using NIR spectroscopy to predict composting age as an indicator of the degree of composting occurring under industrial conditions.

### Materials and methods

#### Compost material

The material that was examined consisted of composts made from sheep manure, coffee cakes, olive pulp and wool residues that complied with the French standard for organic soil improvers NFU 44-051 [7]. The material was sampled weekly during the early stage of development and the compost age of the sample recorded. On average the thermophilic phase lasted for 60 days between different piles. This study followed compost development in several piles.

#### Sample preparation and scanning

Due to the heterogeneity of fresh materials, samples were dried to constant weight at 40°C and ground to pass through a 1-mm sieve. Each sample was scanned on a NIRS 6500 (Foss NIRSystems, Silver Spring, MD, USA) in duplicate (two different cup fillings) in ring cups. Spectral data were collected every 2 nm from 400 to 2,498 nm. Each spectra, which consisted of 32 scans, was stored as log (1/R) using a ceramic standard reference spectrum.

#### Data analysis

Spectra were corrected with a standard normal variate and detrend 2,5,5 [8] (Win-ISI, Infrasoft International, Port Matilda, PA, USA) mathematical treatment. Visible wavelengths were discarded because they were shown to introduce instability in the models. Calibrations of estimating compost

age were performed using a multiple linear regression [9] (WIN-ISI, Infrasoft International, Port Matilda, PA, USA). The standard error of calibration, coefficient of determination of validation and the standard error of cross-validation were calculated. In order to minimize over-fitting of the equations, cross-validation was used as an internal validation during calibration development.

## Results and discussion

The compost age varied widely between 0 and 103 days (Table 1) as compost sub-piles were combined to form six series. A series corresponds to a unique pile sampled regularly along the thermophilic phase. The general across piles model developed to estimate compost age was reasonably accurate with a coefficient of determination close to 0.9. However, the ratio of the standard deviation to the standard error of cross-validation was under 3. The standard error of cross-validation was close to the corresponding standard error of calibration, indicating an acceptable robustness of the model.

Another calibration strategy was attempted using a linear multiple regression model for data from a single series of 22 samples coming from a unique pile, sampled along the thermophilic phase (Table 1).

**Table 1.** Performance of the general calibration model and the particular calibration model for composting age (days).

Multiple linear regression calibration	Population			Calibration			
	n	Mean	SD	SEC	R <sup>2</sup>	SECV	RPD
General (all piles)	83	32.4	23.5	9.35	0.84	9.80	2.4
Particular (one pile)	22	50.4	32.6	6.04	0.97	6.96	4.7

n: number of samples

SD: standard deviation

SEC: standard error of calibration

R<sup>2</sup>: coefficient of determination of calibration

SECV: standard error of cross-validation

RPD: ratio of performance to deviation ( $SD/SECV^{-1}$ )

As was seen for the general model, the population considered for the particular pile had a high variation in compost age. The model, which was developed from 22 samples, had a standard error of calibration that was a third of the value of that calculated for the general model. The coefficient of determination exceeded 0.95, and the standard error of cross-validation was less than seven days with the ratio of standard deviation to standard error of cross-validation being greater than 3.

## Conclusions

These preliminary results show that it seems possible to assess composting age within a series of piles being composted under commercial conditions. More effort will need to be devoted to decrease the standard error of cross-validation to a more acceptable level of less than four days and close to one day.

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