Non-destructive analysis for quality control of compost by near infrared spectroscopy

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Introduction

It is very important to know the chemical composition of Korean compost because of the amount being used and because of the influence of constituents such as nitrogen, phosphate, organic matter, and several metals on the quality in terms of its biological value. The amount of compost produced in Korea is up to two million tons per year. Currently, chemical methods of analysis are widely used for quality control, but these are expensive and time-consuming. We have attempted to address this problem by considering the possibility of alternative methods, which must be more rapid and less expensive. It might be possible to sacrifice some precision in the analysis, if we could find an alternative method that is rapid and inexpensive.

Near infrared (NIR) spectroscopy has been a valuable tool for the proximate analysis of many analytes for several decades.[1–4] We found many examples where NIR spectroscopy was successfully adopted for the quality control of processes in factories and it was decided that we should investigate the reliability of NIRin the evaluation of compost quality. Experiments have been conducted using compost produced by fermentation of swine excreta as the test system.

Materials and methods

Sample collection and chemical analysis

One hundred and thirty-five compost samples were collected, periodically, for a two years period, commencing in April 1997, from three compost plants in Korea. Among these samples 102 samples were used for calibration and 33 samples were used for prediction. The analytes determined were total nitrogen (TN), total phosphorus (TP), organic matter (OM), total carbon (TC), moisture, copper (Cu), potassium and sodium. All of these constituents are important for assessing compost quality. The analytical characteristics of the samples are given in Table 1.

NIR measurement

Samples were dried at room temperature and then ground by a mill with a 10-mesh sieve. NIR spectra of compost samples were measured in an InfraAnalyzer 500 (Bran+Luebbe Co.) diffuse reflectance NIR spectrophotometer from 1100 nm to 2500 nm at 2 nm interval. A rotating drawer with

Table 1. Statistical characteristics of calibration and prediction sets for MLR and PLSR.

Components	Calibration set				Prediction set			
	n	Range	Mean	*SD*	*n*	Range	Mean	*SD*
TN (%)	102	1.3–2.75	1.93	0.2	33	1.40–2.75	1.94	0.28
OM (%)	102	7.36–81.5	69	9.1	33	47.3–77.8	68.3	7.2
TP (%)	102	1.45–4.86	3.27	0.7	33	1.45–4.86	3.42	0.73
TC (%)	102	23.0–41.1	65.5	3.42	33	23.0–39.4	34.7	3.6
Cu (g kg^{-1})	102	0.11–0.6	0.42	0.14	33	0.14–0.59	0.44	0.14
Potassium (g kg^{-1})	102	0.92–3.09	2.22	0.53	33	0.96–3.09	2.27	0.55
Sodium (g kg^{-1})	102	0.41–0.98	0.66	0.11	33	0.49–0.98	0.67	0.11
Moisture (%)	102	4.29–10.1	7.28	1.52	33	4.39–9.62	7.46	1.51

n: number samples
SD: standard deviation

closed cup was used to minimise the effect of the heterogeneous particle size of the samples. Absorbance, as log1/*R* and 1st derivative spectra of compost are shown in Figure 1.

The Sesame-3 program, supplied by Bran+Luebbe, was used for multiple linear regression (MLR) and partial least square regression (PLSR) calibrations. MLR and PLSR were conducted between log1/*R* or first derivative data and the concentrations of each component in the compost.

Results and discussion

In order to correlate the NIR spectral data to the concentration obtained by the chemical methods, the partial least square regression (PLSR) algorithm was used for calibrations for total nitrogen, moisture, Cu, K and Na and MLR was used for the calibrations for the remaining analytes. The standard errors of prediction and the coefficients of variation are shown in Table 2.

The results of the present studies showed that NIR could be used for a non-destructive and rapid determination of many of the analytes used to evaluate the quality of compost samples in Korea. Additional research is required to find suitable calibrations for phosphate and some of the metals.

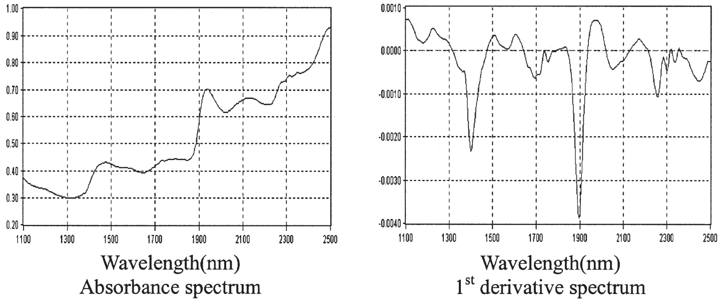

Figure 1. Near infrared spectra of compost, (a) absorbance and (b) 1st derivative.

Table 2. Statistical results of the prediction of the 33 compost selected samples.

Components	r^2	*SEP*[a]	*SD*[b]	Applied chemometrics	Data treatment
TN (%)	0.96	0.085	4.38	PLSR	1st derivative
OM (%)	0.76	3.76	5.5	MLR	1st derivative
TP (%)	0.88	0.4	11.6	MLR	Log1/*R*
TC (%)	0.95	1.12	3.2	PLSR	Log1/*R*
Cu (g kg^{-1})	0.96	0.048	10.9	PLSR	1st derivative
Potassium (g kg^{-1})	0.95	0.24	10.6	PLSR	1st derivative
Sodium (g kg^{-1})	0.79	0.08	11.9	PLSR	Log1/*R*
Moisture (%)	0.97	0.11	1.5	PLSR	Log1/*R*

[a]*SEP*: standard error of prediction
[b]*SD*: standard deviation (%)

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