Abstract

Prediction of biochemical methane potential of municipal solid wastes and understanding of their biodegradability by near infrared spectroscopy

M. Lesteur,[a,*] J.M. Roger,[b] E. Latrille,[a] G. Junqua,[c] J.P. Steyer,[a] C. Gonzalez[c] and V. Bellon-Maurel[b]

[a]*INRA, UR050, Laboratoire de Biotechnologie de l'Environnement, Avenue des Etangs, Narbonne F-11100 France. E-mail: lesteur@supagro.inra.fr*
[b]*Cemagref, UMR ITAP–Information and Technologies for AgroProcesess, BP 5095, 34033 Montpellier Cedex 1, France*
[c]*Laboratoire Génie de L'Environnement Industriel, Ecole des Mines d'Alès, 6 avenue de Clavières, 30319 Alès Cedex, France*

Introduction

Biochemical methane potential (BMP) is one of the most important criteria measured on solid waste before treatment in an anaerobic digester to produce biogas (methane and carbon dioxide). The BMP value shows the capacity of the waste to produce methane in anaerobic conditions, as an indicator of its anaerobic biodegradability. However, this measure, consisting of a fermentation of the waste by micro-organisms, is time consuming (about 30 days). A relationship exists between the BMP value and the quality and the quantity of organic matter. NIR spectra offer the possibility of supplying these two kinds of information. In this study, a prediction model, based on NIR measurement, was built in order to get information about the biodegradability of wastes, and to reduce the analysis time from several days to a few minutes.

Materials and methods

Sixty-six municipal solid waste samples were freeze-dried and ground to 1 mm. The composition and quantity of gas produced was analysed every two days with a micro-Gas Chromatography Varian CP-4900. The BMP value is the cumulative quantity of methane produced in 30 days.

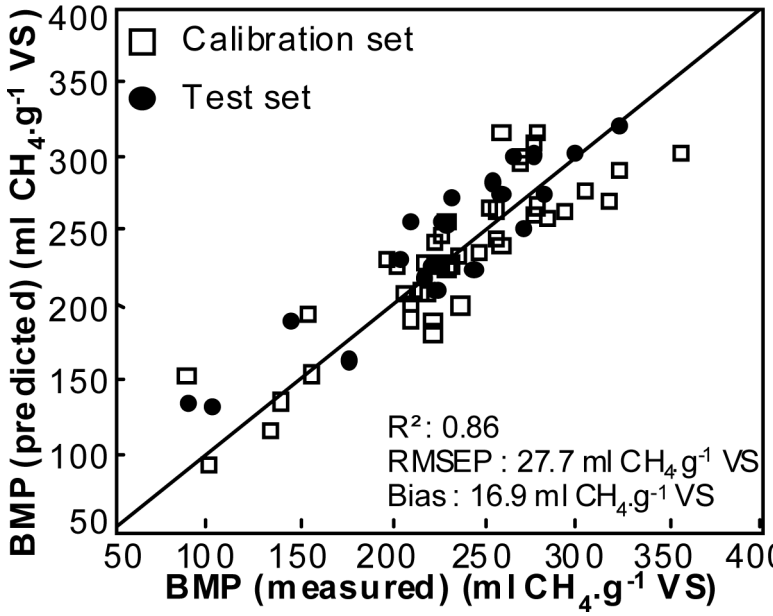

Figure 1. PLS regression (measured vs. predicted) of the calibration (square) and test (circle) set.

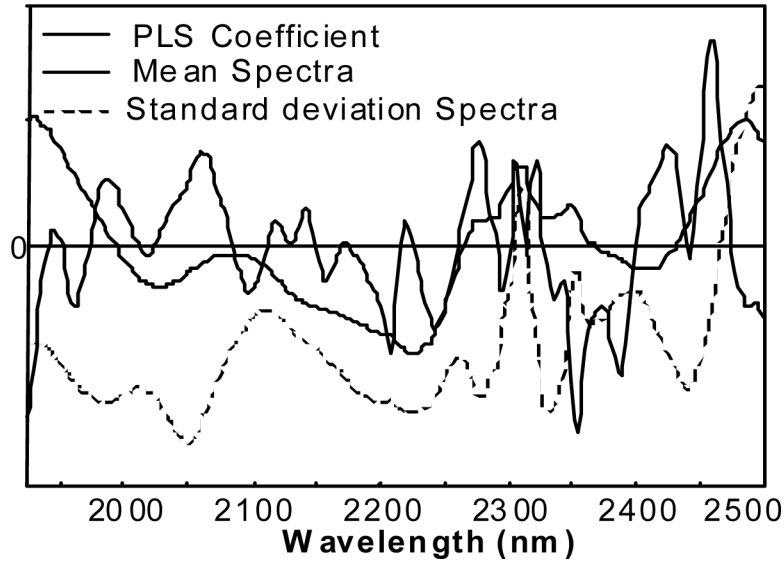

Figure 2. PLS coefficient (9th dimension), mean spectra, standard deviation spectra.

Three NIR spectra were realised for each sample, with sample homogenisation between each. Five hundred scans were measured per spectrum. NIR measurement was performed with the NIRFlex N-500 solids model, with the Petri dish add-on, in reflectance (R) mode in the NIR wavelength region (1000–2500 nm). Absorbance (log 1/R) was used for the prediction model. A calibration data set (44 samples) and a test set (22 samples) were built for calibration, and validation of the model. Several pretreatments were tested by leave-one-out cross-validation. Partial least squares (PLS) regression was used to predict the BMP of the test set. Data analysis were carried out by Matlab software using the PLS toolbox.

Results and discussion

The prediction of the BMP value on the calibration and test sets is shown in figure 1.

The best model was obtained with SNV and Detrend, applied on the variable selections (1925–2500 nm). *RMSEP* and bias were respectively 27.7 and 16.9 ml $CH_4.g^{-1}$ of Volatile Solid. Taking into account the variability that occurred in the BMP test, especially the inoculum activity, but also, the complexity of the matrix of solid waste, this *RMSEP* was considered as acceptable. The three predictions of each sample were very similar (not illustrated in Figure 1), showing the relatively good homogeneity of samples and the repeatability of the NIR method. A study of the regression coefficient (Figure 2) could help to the understanding of the waste biodegradability.

PLS coefficient values above zero indicate a positive relationship with the biodegradability. indicated by absorptions generally associated with proteins (1985 nm), lipids (2307 nm) and carbohydrates (2080 nm, 2277 nm). PLS coefficient values below zero indicate a negative relationship with the biodegradability, associated with fibre components (lignin: 1935 nm, 2388 nm).