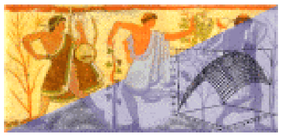

New Multivariate Approach for the Handling of Electronic Nose Data Applied to Composting Process

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Abstract

The aim of the present work is to assess the capability of an electronic nose (from now on EN) as a tool to study the composting process of fermentable residuals and organic wastes.

At the industrial level, the composting process is conducted with different techniques (biocells, bioreactors, aerated piles, etc.). Such a process was recreated on a laboratory scale by means of a small pilot project working in a batch mode. During the composting process the air from the different matrix treated in the pilot project was sampled on a daily basis. Each air sample has been analysed by the EN.

The EN showed to be able to distinguish the samples collected in different days and to identify a "path" (composting process) common to the different matrices if analytical data were treated with a multiway techniques (PARAFAC) [1].

This result is quite interesting because shows that EN can well be used as a tool for monitoring the composting process under appropriate data handling conditions.

Introduction

The composting process consists in the biologic stabilization of fermentable residuals and organic wastes. It is a bio-oxidative, aerobic, exothermic process promoted by micro-organisms, which performs a loss of putrescibility in a short time. At the industrial level, the composting process can be conducted in a variety of plants. Up to now there are no consolidated monitoring techniques that allows to quickly and efficiently determine the progress made of the composting process. Therefore it is not possible to control the process "on-line" and optimise the performances of the plant.

In order to pursue this study, the composting process was recreated on a laboratory scale (using 30 l aerobic bioreactors) and EN measurements were performed the on a daily basis.

Materials & Methods

The composting processes for 4 different matrices have been recreated on laboratory scale:

- matrix M1: commonly used waste fraction (fraction passing sieves between 20mm and 80mm) added with composting activators
- matrix M2: commonly used waste fraction
- matrix M3: commonly used waste fraction plus the under 20mm fraction (3:1 ratio)
- matrix M4: waste fraction under 20mm

The composting process experiment lasted 3 days: every day an air sample was collected from each matrix and subsequently analysed by the EN. The EN (PEN2 Airsense) was composed by 10 "MOS" thin layered, semi-conductive sensors, added with noble metals and heated between 423K and 773K degrees. They are based on the principle that there is a variation of the conductivity of the oxide in the presence of volatile compounds, compared to the conductivity value in standard conditions. The sensors have a different response to the same chemicals because of their different thermo-regulation and set-up. The measurements have been conducted performing cycles of three repetitions for each sample alternated with a cleaning cycle. Each measure gave about 1000 data, from the beginning of the acquisition (zero value) to the final value (reached after 100 seconds). A 36 x 10 x 100 data matrix has been obtained (objects x sensors x time). Because the dynamic response of EN sensors is related to the nature and amount of chemical substances in the air sample, the whole dataset has to be considered. This need suitable techniques to handle and interpret such amount of data. PEN2, as other commercial EN, are equipped only with conventional 2-way chemometrics tools, thus the collected data have been analysed by means of a freeware software (Sensable, KVL) [2] able to work also with the three-dimensional data matrices (samples x sensors x time) generated by such instrument. Sensable allows to operate either different signal and data pre-treatments, either statistical analysis such as PCA, PARAFAC, PARAFAC2, PLS e N-PLS.

Results

17 different models have been calculated by pre-treating the data in different ways, using either the whole signal or specific parts of it (absolute maximum or maximal slope of adsorption part). The chosen model, obtained by the whole signal, subtracting to the signal the baseline signal ($S\text{-}S_0$) and scaling the sensors mode (in order to give the same importance to al the sensors), has been used by means of PAFAFAC. This model provided the highest amount of explained variance (98.83% exp. var., 98.81% cross-validated exp. var.) and the most easily understandable disposition of the scores. For readability reason in figure 1 are represented only the centroids of each replicates (i.e. M1 stands for the centroid of the 3 replicates of M1). In such a figure it is possible to notice how the samples, which are initially well separated during the first sampling, become always more similar throughout the whole process up to finally cluster together. It could be said that the EN is able to read the evolving of the composting process. It is also possible to use the first component scores to build a simple model ($Y\ ?\ aX^{b}$) that well represents the studied phenomenon (i.e. for the commonly used waste fraction, R^2=0.9916).

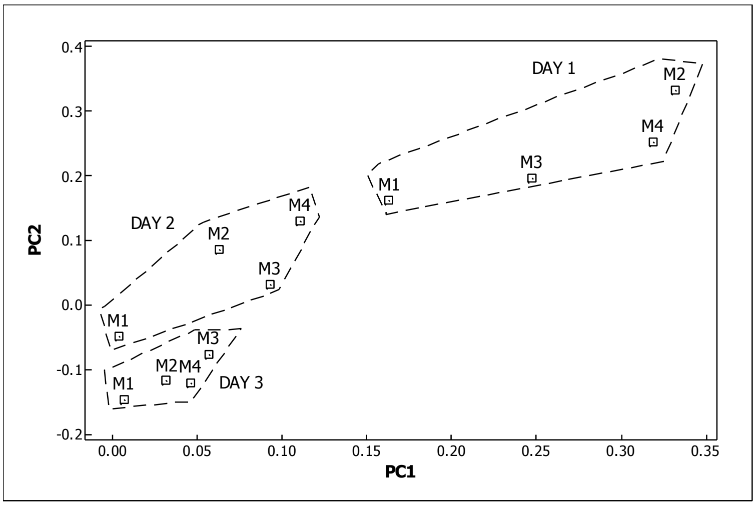

Fig. 1; Best model centroid scores plot

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Conclusions

The use of an instrument such as the EN could well constitute a valid opportunity to monitor a composting process, allowing a quick and optimised management of such process, especially if data were analysed by means of appropriate 3-way chemometric techniques. Further testing is currently being undertaken also for better understanding the relationship between EN response and the biochemical aspects of the composting process.

References

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2) T. Skov, R. Bro A new approach for modelling sensor based data. *Sensors and Actuators B: Chemical*, vol. 106 2 (2005), 719-729.