Application of Receptor Models to PM10 and PM2.5 Samples

G. de Gennaro, P. Ielpo, P. Bruno, M. Caselli, V. Paolillo, B. E. Daresta, C. M. Placentino, P. R. Dambruoso, L. Trizio

Department of Chemistry, University of Bari, Via E. Orabona 4, 70126 Bari, Italy

Abstract

The human activities in their various aspects cause a change in the natural air quality. This change results more marked in very populated areas and in that with high industrialization. Some pollutants emitted are typical of a particular activity. Each source of pollution is identified by its profile in the composition of the emissions in the environment. Multivariate receptor models can be used in order to apportion pollutants to the different sources assessing the contribution of each source to the total pollution.

This paper deals with the analysis, by Absolute Principal Component Scores (APCS) model, of PM10 and PM2.5 data collected during several projects (Comune di Bari project, SITECOS project, "Programma Triennale per la Tutela dell'Ambiente della Regione Puglia" project, etc.) carried out in Puglia Region during 2005-2006. In this paper a preliminary application of APCS model to a matrix of data collected in Bari during October 2005 is shown: it has been possible to identify five sources.

Moreover the APCS model has been compared with two other multivariate receptor models: TTFA and NMF with different sparseness levels. The error, calculated by Frobenius norm, on the reconstructed concentration matrix is less when the APCS model is used.

Introduction

In the environmental field the diffusional and receptor models are mostly used. Chemical Mass Balance (CMB), Absolute Principal Component Sores (APCS), Unmix, Non Negative Matrix Factorization (NMF), Target Transformation Factor Analysis (TTFA) are some of the most used models. From a mathematical point of view none of these models can give a unique solution but only solutions physically acceptable with different probability levels. These models therefore must be integrated by an at least indicative knowledge of the source profiles and/or by specific analyses such as the determination of the dimensional and morphological characterizations of the particulate matter.

Materials & Methods

Beginning from the data matrix X (samples x parameters) in the APCS method the first step is the search of the Eigenvalues and Eigenvectors of the data correlation matrix. Only the most significant p Eigenvectors are taken into account. The p Eigenvectors are then rotated by an orthogonal or oblique rotation, in order to transform them into values which have a physical meaning. An abstract image of the source contributions to the samples can be obtained by multivariate linear egression:

$Z = PCS * V^T$, where Z is the scaled data matrix, PCS is the principal component scores matrix, and V^T is the transposed rotated loading (Eigenvectors) matrix. The Z matrix is scaled by "zero sample" method proposed by Thurston and Spengler [1]. The matrix obtained in this way is referred to as Absolute Principal Component Scores (APCS) matrix. The APCS matrix can be identified with the estimated contribution matrix Fr. Then, a regression on the data matrix X allows to obtain the estimated source profiles matrix Ar [2, 3].

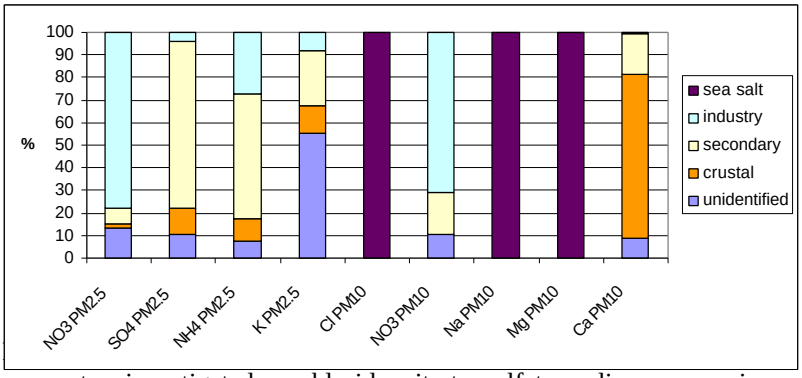
In order to calculate the reconstruction error on the data matrix the Frobenius norm equation:

$Er\ ?\ \frac{norm_f(X)\ ?\ norm_f(X_{calc})}{norm_f(X)}$ has been used as an objective error measure.

Results

A matrix constituted by the inorganic ion concentrations of PM10 and PM2.5 samples simultaneously collected in Bari during October 2005 has been processed by APCS model: it has been possible to identify five sources.

In figure 1 the distribution of the ionic parameters in the five sources is shown, while in table 1 the loadings rotated are presented.



parameters investigated are chloride, nitrate, sulfate, sodium, ammonium, potassium, magnesium and calcium both in PM10 and PM2.5 samples.

Table 1: Loadings rotated by Varimax. Fine and coarse indicates parameters contained in PM2.5 and PM10 respectively.

Parameters	Sea salt	industry	Secondary	crustal	unidentuifie d
NO3 fine		**0.65**			
SO4 fine			**0.85**		
NH4 fine		**0.33**	**0,55**		
K fine					**0.99**
Cl coarse	**0.56**	**0.13**		**0.12**	
NO3 coarse		**0.64**			
Na coarse	**0.54**				
Mg coarse	**0.62**				
Ca coarse				**0.98**	

Conclusions

In this preliminary analysis, performed on data collected in Bari during October 2005, five sources contribute to ionic fraction of PM10 and PM2.5: sea salt source, industry source, secondary particulate source, crustal source and unidentified source. Vehicular traffic is not present as source in the ionic fraction of particulate matter. The APCS method will be applied to all samples collected during 2005-2006 in order to increase the knowledge of the particulate matter (PM10 and PM2.5) and atmospheric pollutants of Puglia Region air.

References

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