Application of PCA and HCA to PM10 Data Collected by SEM/EDS in Three Site of Center Italy

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Abstract

Principal Component Analysis and Hierarchical and nonhierarchical Cluster Analysis were applied on PM10 particles data in order to: identify clusters of particles that can be differentiated on the bases of their chemical composition and morphology; investigate the relationship existing among the chemical and morphological parameters and evaluate the differences among the sampling sites. PM10 was collected in three different sites in central Italy and then analysed by scanning electron microscopy (SEM) coupled with microanalysis (EDS) and processed by a image analysis software.

Introduction

SEM/EDS was applied to study the chemical and morphological parameters of PM particles. Considering both the parameters, the study and evaluation of the effects of many processes can be adequately done, i.e. the absorption of volatile molecules present in atmosphere, chemical reactivity and not least the origin of the particles [1-5]. In particular, in literature some studies have been concerned to relate the composition and morphology of particulate highlighting the special relationship with atmospherical conditions [6]. Multivariate statistical analysis were applied on the particles morpho-chemical parameters that were analyzed and measured by SEM/EDS and Image Pro Analyzer software. Principal Component Analysis (PCA) and hierarchical and nonhierarchical Cluster Analysis (CA) let investigate the correlations among the identified variables and the set of particles.

Materials & Methods

The samples, collected by a low volume sequential sampling on polycarbonate membranes, belong to three sites characterized by different boundary conditions: a yard site, an urban site and a rural site. Morpho-chemical characterisation of particles was performed by ESEM Philips XL30 - EDS microanalysis: 20 chemical parameters (C, O, Na, Mg, Al, Si, P, Cd, Cl, K, Ca, Sn, Ti, Cr, Mn, Fe, Co, Ni, Cu, Zn) were determined and 7 morphological parameters (area, aspect ratio, roundness, fractal dimension, box width, box height, perimeter) were measured by Image Pro Analyzer 6.3. A set total of 1340 particles from three sites has provided three sets of structured data in a poly-dimensional matrix (27 variables x 1340 particles). PCA and hierarchical and nonhierarchical CA were performed on data set of each site using Statistica 6 software.

Results

The statistical analysis revealed the presence of different clusters of particles, differentiated on the bases of chemical composition and morphological parameters. They were: Aluminosilicate; particles rich in calcium; carbon particles of biological origin; soot; Cenosphere; Sodium Chloride;

Sulphates; metallic particles; spherical particles of iron. The statistical analysis showed a deep difference among particles, classified as crustal (aluminosilicates) and particles rich in calcium, in the different sites: particles of rural site and urban site show a similar nature due to a mainly natural origin, while those of the yard site show a more heterogeneous composition and morphology mainly related to human activity of the site.

Carbonaceous particles can be differentiated on the bases of their origin (biological particles and soot), essentially due to the higher loads of fractal dimension, which characterizes soot, and of Na, Mg, Ca, Cl and K which characterize the biological ones. Moreover, it was possible to observe that the soot belonging to the yard site and rural site showed a higher loads of Roundness and Fractal Dimension than the soot belonging to the urban site. The metal particles were characterized mainly by the higher load of iron, that is present in two morphologically distinguishable forms: sphere and angular particles. The spherical particles of iron are generated by fusion process at high temperature and then they due to metallurgical activity, while the other one metal particles can be characterized by a crustal origin, because enriched by many typical terrigenous elements as Si, Al, and K, but also by human origin, such as abrasion of metallic materials.

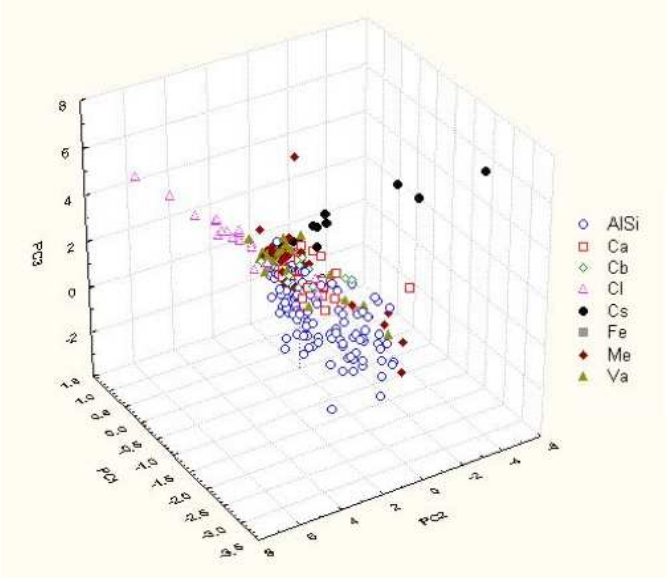

Fig. 1; Score analysis and PC loadings of characterized PM10 particles

Conclusions

Application of statistical methods permitted to investigate differentiation between families of particles, based on chemical and morphological parameters, and differentiation between the particles sample on the three sites investigated. This represents a study that can be implemented by applying the same methods to PM sampled during night time in order to highlight differences between the different sampling periods. It is also useful to develop a method for characterization of particulate matter that can provide important considerations regarding the source apportionment.

References

1) M. Ebert, M. Inerle-Hof, S. Weinbruch, Environmental scanning electron microscopy as a new technique to determine the hygroscopic behaviour of individual aerosol particles, *Atmos. Environ.*, 36(39-40), (**2002**), 5909-5916

2) M. Ebert, S. Weinbruch, P. Hoffmann, M. H. Ortner, The chemical composition and complex refractive index of rural and urban influenced aerosols determined by individual particle analysis, *Atmos. Environ.*, 38(38), (**2004**), 6531-6545

3) R. D. Willis, F. T. Blanchard, T. L. Conner, *Guidelines for the application of SEM/EDX analytical techniques to particulate matter samples*, EPA Report No. 600/R-02/070, (**2002**)

4) B. J. Krueger, V. H. Grassian, J. P. Cowin, A. Laskin, Heterogeneous chemistry of individual mineral dust particles from different dust source regions: the importance of particle mineralogy, *Atmos. Environ.*, 38(36), (**2004**), 6253-6261

5) B. Sitzmann, M. Kendall, J. Watt and I. Williams, Characterisation of airborne particles in London by computer-controlled scanning electron microscopy, *Sci. Total Environ.*, 241(1-3), (**1999**), 63-73

6) G. Pratesi, M. Zoppi, T. Vaiani, F. Calastrini, A morphometric and compositional approach to the study of ambient aerosol in a medium industrial town of Italy, *Water Air Soil Pollut.*, 179(1-4), (**2007**), 283-296