Ionic Components and Carbon Fractions of PM2.5 and PM10: Seasonal and Site-Specific Features

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Abstract

The PM2.5 and PM10 fractions were simultaneously collected in three sites of the Bari territory (South-East Italy) during winter and summer sampling campaigns.

The ionic components and the carbon fractions of the PM samples were determined.

The Principal Component Analysis and Absolute Principal Component Scores of the dataset allowed to identify similar PM sources in the two PM fractions: organic and inorganic secondary compounds, local and diffuse combustion processes, calcium carbonate, sea salt. While secondary and combustion compounds were mainly in PM2.5, primary and natural species were prevalent in coarse PM. Seasonal and site-specific differences were investigated.

Introduction

The application of receptor models to the PM samples allows the identification and quantitative apportionment of air pollutants to their sources. Different models including principal component analysis (PCA), absolute principal component scores (APCS), Unmix, chemical mass balance (CMB) are currently used [1,2].

In this paper PCA and APCS methods were applied to ionic components and carbon fractions of PM2,5 and PM10 in order to identify the different and common sources of the two fractions and estimate their contributions.

Materials & Methods

Two sampling campaigns were performed during the winter (from 10 to 27 March 2007) and the spring (from 14 June to 5 July 2007) in three sites of Bari territory: Pane e Pomodoro Beach (PP), S. Nicola sport stadium (SN) and Casamassima country (CS).

Low-volume particle samplers (FAI Instruments model Hydra Dual sampler, Roma, Italy) were used to collect PM2.5 and PM10 samples. PM2.5 samples were collected on quartz fiber filters while PM10 samples were collected on polycarbonate membranes. Both the filters were weighed, before and after the particulate sampling, by a microbalance with the smallest scale division of 0.0001 mg (Sartorius series Genius). The relative humidity (RH) and temperature in the weighing room were 44 ± 7 % and 22 ± 3 °C.

A quarter of each sample (PM2.5 and PM10) was extracted, in two step, with 10 ml of deionized water for 20 minutes using ultrasonic agitation. These solutions were analyzed by ion chromatography to obtain the following ions Cl^-, NO_3^-, SO_4^{2-}, $C_2O_4^{2-}$, Na^+, NH_4^+, K^+, Mg^{2+} and Ca^{2+}. OC, EC and CO_3^{2-} analysis were performed on rectangular punches of filter deposit of PM2.5 by a thermal optical method (Sunset Laboratory Inc, Tigard, OR, USA) [2]. The chemical data set was used for applying the PCA and APCS methods.

Results

The PCA was applied on dataset of 86 PM2.5 samples and 12 parameters. The first three Principal Components (PCs) explained 71% of data variance.

In figure 1 are reported average and percentage weight contributions, for the two seasons and the three sites; moreover percentage contributions of parameters to each source profile were showed. The first and second sources (73% of total PM mass), mainly constituted by OC and SO_4^{2-}, respectively, were identified with organic and inorganic secondary PM. They were almost constant in different seasons and sites. The third source showed summer levels nearly three times winter ones. It was constituted by calcium carbonate. The fourth source, more high in winter, may be due to point combustion sources. While the fifth source was difficult to assign (data not shown), the sixth ones might attributed to diffuse combustion sources. The comparison between sources in PM2.5 and PM10 showed similarities and differences. The source characterized by Ca^{2+} and CO_3^{2-} was found in both PM fractions: it constituted a percentage weight contribution of 29% for PM10, instead of 12% for PM2.5. On the contrary, both the source with prevalence of SO_4^{2-} and ones with high loading in OC contributed to PM2.5 more then in PM10. Finally in PM10 was identifiable a marine source (with high content in Cl^-, Na^+ and Mg^{2+}), while in PM2.5 Na^+ and Mg^{2+} were in the same source with SO_4^{2-}, without Cl^-.

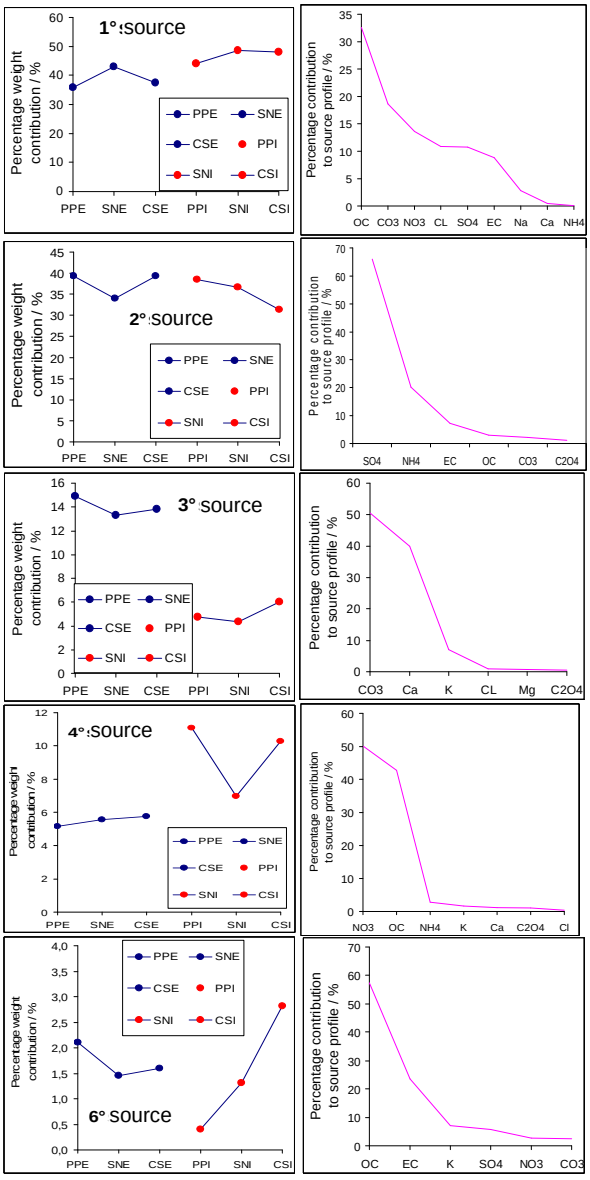

Fig. 1; Percentage weight contribution (on the left) and percentage contribution to source profile (on the right). Average winter samples are on right side; average summer samples are on left side.

Conclusions

The PCA and APCS on the main chemical constituents of PM2.5 and PM10 identified similar PM source: organic and inorganic secondary compounds, local and diffuse combustion processes, calcium carbonate, sea salt. Differences were observed in their distribution: secondary and combustion compounds were mainly in PM2.5, while primary and natural species were prevalent in coarse PM.

References

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