Application of CMB Model to PM10 Data Collected in a Site of South Italy: Preliminary Results and Comparison with APCS Model

E. Andriani[1], M. Caselli[1], G. de Gennaro[1], P. Ielpo[1], B.E. Daresta[1], P. Fermo[2], A. Genga[3], A. Piazzalunga[2], M. Placentino[1]

[1]Dipartimento di Chimica, University of Bari, via E. Orabona 4, 70126 Bari, Italy
[2]Dipartimento di Chimica Inorganica e Metallorganica e Analitica, 20133 Milano, Italy
[3]Dipartimento di Scienza dei Materiali, University of Salento, 73100 Lecce, Italy

Abstract

Chemical mass balance modeling (CMB) was applied to determine the PM10 sources and their contributions. PM10 samples were collected in Lecce (South Italy) during two monitoring campaigns performed in the months of July 2005 and February 2006. Nine source profiles and average mass concentration of the following chemical parameters: EC, OC, Cl^-, NO_3^- , SO_4^{2-}, Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}, Al, Si, Ti, V, Mn, Fe, Cu, Pb, and Zn were used to run the Chemical Mass Balance (CMB_8) model. The results obtained by application of $CMB_{8.2}$ to one sample data (L21) are shown. The contributions to PM10 show that dominant contributor was traffic with 37% followed by petroleum industry with 19% and field burning with 16%. Minor source contributions were marine aerosol (1%), ammonium sulfate production (4%), ammonium nitrate production (11%), oil-fired power plant (0.1%), gypsum handling (10%) and crustal (2%).

Introduction

The aim of the application of the receptor models is the apportionment of the pollutant's sources. The chemical mass balance (CMB) consists of a least squares solution to a set of linear equations that expresses each receptor concentration of a chemical species as a linear sum of products of source profile species and source contributions.

The source profile species abundances (i.e., the fractional amount of the species in the emissions from each source-type) and the receptor concentrations, with appropriate uncertainty estimates, serve as input data to the CMB model. The output consists of the amount contributed by each source-type to each chemical species. The model calculates values for the contributions from each source and the uncertainties of those values. Input data uncertainties are used both to weight the importance of input data values in the solution and to calculate the uncertainties of the source contributions.

Materials & Methods

CMB model

CMB proceeds as follows:

1. The number and the type of sources likely to be impacting the sampler are determined.
2. The sources composition is found. This can be either by actually measuring the composition of sources in the area or by looking up the composition of similar sources in literature.
3. The standard deviations of measurement errors in the concentrations are estimated. The analytical laboratory usually supplies these.
4. The standard deviations of the errors in the sources compositions are estimated.
5. Finally, the sources contributions are calculated by an iteratively reweighted least squares procedure.

PM10 sampling and analysis

The sampling of particulate was performed using a Graseby-Andersen (Smyrna, GA, USA) high volume sampler (mod. 1200), with a size selective inlet (SSI) which allows the collection of PM10 particles. Daily samplings were performed. The membranes were conditioned before each weighting using a system supplied with temperature and humidity control (20°C and 50 % RH) (Activa Climatic, Aquaria, Milano, Italy). The sensitivity of the analytical balance (Gibertini mod. E154, Milano, Italy) was 0.1 mg. OC (organic carbon) and EC (elemental carbon) were determined by Thermal-Optical-Trasmission (TOT) method using Sunset Laboratory instrumentation; anions (Cl-, NO_3^-, SO_4^{2}) analyses were performed using a Dionex DX120 Ion Chromatography system equipped with an electrical conductivity detector for and a Dionex DX600 Ion Chromatography system for cations (Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}). Metals were determined by IPC-OES.

Results

The CMB model was applied to PM_{10} samples collected in Lecce, a site of South Italy (Puglia). For L21 sample, collected in July 25th 2005 and here discussed, the results obtained are shown in Fig.1 and Fig.2.

In Figure 1 there is a comparison between calculated (by CMB model) results and measured values for some pollutants; as shown a good reconstruction was obtained.

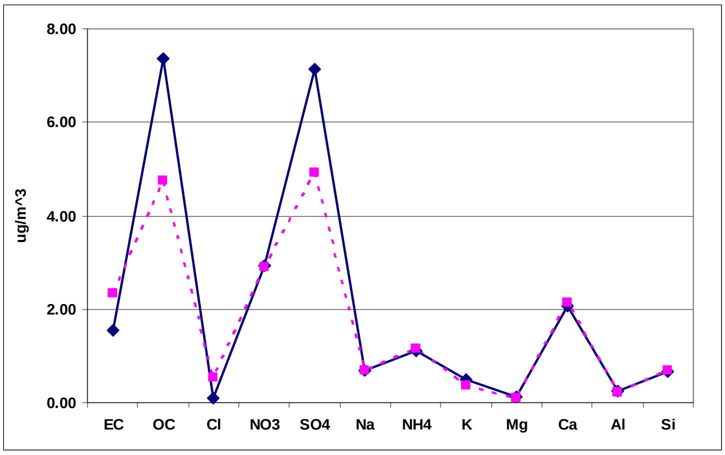

Fig. 1; Calculated results (dashed line) compared with measured values (continuous line).

In Figure 2 the sources contributions are shown. The contributions to PM10 show that dominant contributor was traffic followed by petroleum industry and field burning. Minor source contributions were marine aerosol, ammonium sulfate production, ammonium nitrate production, oil-fired power plant, gypsum handling and crustal .

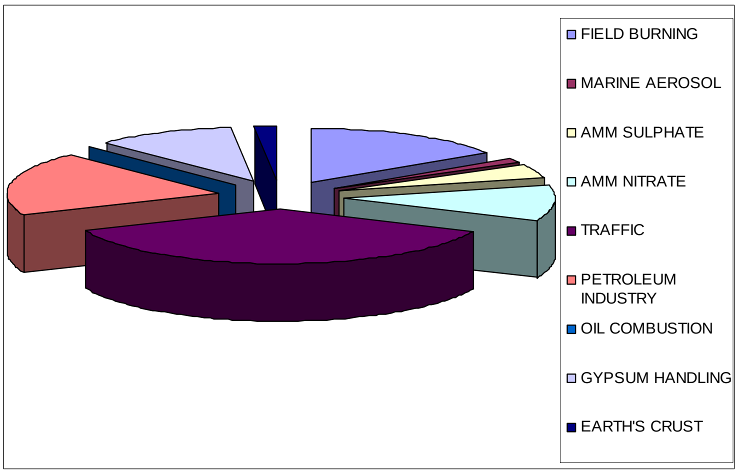

Fig. 2; Sources Contribution

Conclusions

This study investigated the contributions of different emission sources to PM10 in Lecce using CMB model. Result of CMB model showed that the major source for L21 sample was traffic with 37% followed by petroleum industry with 19% and field burning with 16%.

This represents a preliminary result: further investigations will be done and the results obtained will be compared with APCS (Absolute Principal Component Analysis) model ones.

References

1) R.C. Henry, C.W. Lewis, P.K. Hopke, H.J. Williamson, Review of receptor model fundamentals, Atmos. Environ., 18(8) (1984) 1507-1515
2) M. Caselli, G. de Gennaro, P. Ielpo, A comparison between two receptor models to determine the source apportionment of atmospheric pollutants, Environmetrics, 17(5) (2006) 507-516