Available online at www.sciencedirect.com
ScienceDirect
Atmospheric Environment 41 (2007) 7977–7986
ATMOSPHERIC ENVIRONMENT
www.elsevier.com/locate/atmosenv

Short communication

Mass levels, crustal component and trace elements in PM_{10} in Palermo, Italy

G. Dongarrà[a,*], E. Manno[a], D. Varrica[a], M. Vultaggio[b]

[a] *Dip. Chimica e Fisica della Terra (CFTA), via Archirafi 36, 90123 Palermo, Italy*
[b] *Azienda Municipalizzata Igiene Ambientale (AMIA), via Ingham. 27, 90124 Palermo, Italy*

Received 17 May 2007; received in revised form 6 September 2007; accepted 6 September 2007

Abstract

Results concerning the levels and elemental compositions of daily PM_{10} samples collected at four air quality monitoring sites in Palermo (Italy) are presented. The highest mean value of PM_{10} concentrations (46 $\mu g\,m^{-3}$, with a peak value of 158 $\mu g\,m^{-3}$) was recorded at the Di Blasi urban station, and the lowest at Boccadifalco station (25 $\mu g\,m^{-3}$), considered as a sub-urban background station. Seventeen elements (Al, As, Ba, Co, Cr, Cu, Fe, Li, Mn, Mo, Ni, Pb, Sb, Sr, U, V, Zn) were measured by ICP-MS. Al and Fe showed the highest concentrations, indicating the significant contribution of soil and resuspended mineral particles to atmospheric PM_{10}. Ba, Cr, Cu, Mn, Mo, Ni, Pb, Sb, V and Zn had higher concentrations at the three urban sampling sites than at the sub-urban background station. Besides soil-derived particles, an R-mode cluster analysis revealed a group of elements, Mo, Cu, Cr, Sb and Zn, probably related to non-exhaust vehicle emission, and another group, consisting of Ba, As and Ni, which seemed to be associated both with exhaust emissions from road traffic, and other combustion processes such as incinerators or domestic heating plants. The results also suggest that Sb, or the association Sb–Cu–Mo, offers a way of tracing road traffic emissions.

Keywords: PM_{10}; Heavy metals; Environmental geochemistry; Enrichment factors; Chemical tracers

1. Introduction

Epidemiological studies have shown that, in urban areas, the continuous exposure to particulate matter has the potential to affect the health of population, causing various pathologies of the respiratory tract (allergies, asthma, lung emphysema) and cardiopulmonary mortality (Stone, 2000; Brunekreef and Holgate, 2002; Donalson et al., 2002). When examining the health impact, at least two main characteristics of particulate matter need to be considered: the aerodynamic diameter of particles, and their trace elements content. These parameters appear to be correlated with each other.

The finest solid components of atmospheric particulate, the inhalable and respirable fractions ($PM < 10\,\mu m$ and $PM < 2.5\,\mu m$, respectively) have been better correlated to adverse health effects than total suspended PM (TSP). PM_{10} is a carrier of PAHs and heavy metals produced by human activities. Although many metals, including iron, and non-metal, may have adverse effects on human

*Corresponding author. Tel.: +39 91 6161574; fax: +39 91 6168376.
E-mail address: dongarra@unipa.it (G. Dongarrà).

1352-2310/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.atmosenv.2007.09.015

health because of their biochemical activity and production of free radicals (Smith and Aust, 1997; Lighty et al., 2000) a systematical PM_{10} chemical characterization program is not requested by the environmental standards. The present paper aims at covering the lack of information on the trace elements content of the PM_{10} fraction which is regularly monitored at Palermo. Here the results concerning the elemental composition of PM_{10} samples collected at three air quality monitoring sites within the urban area of Palermo (Italy), where the air pollution frequently reaches warning levels, leading to traffic restrictions, are presented and discussed. A fourth sampling site, a sub-urban background station, is located outside the urban area, although not far from it.

2. Materials and methods

2.1. Area description

Palermo is the largest urban area of Sicily with >850,000 inhabitants. The town is situated on the north-western coast of the island along the wide bay "Piana di Palermo" overlooked by Mt. Pellegrino (606 m above sea level). It is delimited at NE by the Tyrrhenian sea and it is surrounded by mountains (Monti di Palermo) elevated 500–1000 m above sea level. The study area is entirely covered by sedimentary rocks (limestones, clay, marly-clay and white or yellow quaternary biocalcarenites). The Monti di Palermo, of Mesozoic and Tertiary age, are essentially made up of limestone. Along the perimeter of the Piana di Palermo they overlay turbidite deposits, of Oligo-Miocene age, made up of clay, marly-clay and marls interlayered with quartz arenites (Numidian flysch). Some eastern sectors of the Piana di Palermo are covered by a bright red-coloured soil rich in Fe-oxides, known as Terra Rossa. Prevailing wind directions are from East and West. The movement of the local air masses are strictly linked to topography. Normally, during daytime sea breeze drives the pollutants produced in the city towards the surrounding mountains. During evening and night a reversal in the breeze takes place, which drives back the polluted air masses above the city. Thermal inversion are commonly observed phenomena and, in these periods, warning levels of air pollution may be reached. Potential local pollutants are limited to emission from vehicular traffic, house heating and small manufacturing industries.

2.2. Sampling

A total of 195 PM_{10} daily samples were collected from February to November 2005 (except during May and June), at four sampling stations belonging to the municipal air quality monitoring network (AMIA), characterized by varying traffic density. The four selected stations were:

- *Boccadifalco* (*BF*): a sub-urban background station, situated on the leeward of the sea breeze, without any direct influence of urban activities. This site was selected as a control, to monitor the hypothetical background level of pollution. Number of samples collected: 42.
- *Indipendenza* (*IND*): an urban site, characterized by lower traffic density than the other stations. Number of samples collected: 49.
- *Giulio Cesare* (*GC*): a large square in front of the railway station, exposed to heavy traffic, composed by cars and urban and extra-urban buses. Number of samples collected: 50.
- *Di Blasi* (*DB*): characterized by high traffic flow, located close to a crossroad with traffic lights at pedestrian crossings. Number of samples collected: 54.

To meet the requirements of the Directive 1999/30/CE, PM_{10} sampling was performed according to European Standard EN12341, using a low-volume system, equipped with a sampling inlet head (Zambelli), operating at a constant sampling rate of $38.3\,l\,m^{-1}$ ($2.3\,m^3\,h^{-1}$). Particles were collected on standard 47 mm Teflon filters with a pore size of 2 μm. The sampling time was 24 h, from midnight to midnight.

2.3. Analytical procedures

Initial and final weighing of filters were carried out in temperature and humidity controlled room ($T = 20 \pm 1\,^{\circ}C$, $RH = 50 \pm 5\%$), after having conditioned the filters for 48 h before and after sampling. Gravimetric determination of the mass was carried out by three consecutive weight measurements using an analytical microbalance Sartorius ME5-OCE.

To determine the bulk metal content in PM_{10} samples, each filter was digested with a mixture 3:1:1 of HNO_3–$HClO_4$–HF in teflon vessel and heated in microwave system (CEM). Seventeen elements (Al, As, Ba, Co, Cr, Cu, Fe, Li, Mn, Mo, Ni, Pb, Sb, Sr, U, V and Zn) were measured by