Atmospheric Environment 45 (2011) 7293–7300

Contents lists available at SciVerse ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Identification of sources and processes affecting particulate pollution in Thessaloniki, Greece

P.A. Kassomenos [a], A. Kelessis [b], A.K. Paschalidou [a,*], M. Petrakakis [b]

[a] Laboratory of Meteorology, Department of Physics, University of Ioannina, 451 10 Ioannina, Greece
[b] Environmental Department, Municipality of Thessaloniki, Paparigopoulou 7, Thessaloniki 54630, Greece

A R T I C L E   I N F O

Article history:
Received 14 June 2011
Received in revised form
25 July 2011
Accepted 10 August 2011

Keywords:
Particulate pollution
Urban background
Source identification
Source apportionment
Non-combustion sources

A B S T R A C T

The identification of local and remote particulate pollution sources, as well as the understanding of the factors determining the spatial and temporal variability of the particulate matter in urban areas is an issue of increasing public concern, since the above actions are absolutely essential for the design of effective particulate pollution control strategies. In the present study, the sources and the factors affecting the particulate pollution were studied in Thessaloniki, the second largest Greek city, in order to develop the necessary scientific framework for the subsequent development of integrated mitigation and control strategies and the design and implementation of effective environmental policies. Hourly PM_{10}, $PM_{2.5}$ and PM_c concentrations from two monitoring sites (the Egnatia-Dimarchio and the Eptapyrgio stations) were therefore correlated to gaseous pollutant concentrations (CO, NO, NO_2, NO_x, SO_2 and O_3) and meteorological parameters (temperature, wind speed and relative humidity) during the 2-year period between June 2006 and May 2008. The analysis revealed that both sites experienced poor air quality, while a large number of exceedances of the daily and annual EC objectives were observed, especially during the cold season. Positive correlation between particles and NO_x in DHM, provided evidence about higher combustion-related emissions during the cold season, whereas increased contribution of secondary particles was suggested during the warm season. In addition, Principal Component Analysis was used to identify the main particulate pollution sources, while the quantification of the combustion and the non-combustion-related fraction of particles was performed through Regression Analysis. Specifically, the non-combustion-related fraction ranged between 25.1 and 72.7%, depending on the site and the season. Finally, concentration roses were constructed in order to gain insight into the distribution of local emission sources around the monitoring sites.

© 2011 Elsevier Ltd. All rights reserved.

1. Introduction

The adverse effects of ambient particulate pollution on human health have been known since the early 1950s (Lippmann, 1989). During the last decades, a large number of epidemiological studies have been published around the world, establishing the association between human exposure to ambient particulate matter concentrations and daily excesses in mortality and morbidity (see, e.g. Dominici et al., 2006 and Cairncross et al., 2007). These studies have revealed that the adverse health effects of particulate pollution may be attributable to short or long-term exposure and to different exposure-response characteristics.

It is also well established (see e.g. Harrison et al., 1997) that airborne particulate matter can be classified in terms of its origin and size. Hence, particles can be either primary (i.e. emitted directly from the source, such as road traffic and resuspended dust), or secondary (i.e. formed within the atmosphere through chemical reactions). The latter are known as $PM_{2.5}$ and are mainly concentrated in the fine particle size fraction (<2.5 μm diameter). On the other hand, particles associated with natural sources (such as wind-blown soil and sea-spray) tend to be concentrated in the coarse particle fraction (>2.5 μm diameter). Various studies have revealed that the adverse health effects of particulate matter vary with several particle properties such as chemical composition and size, with the fine and ultrafine particles associated with the greatest health impact (see e.g. Harrison and Yin, 2000).

Reflecting these concerns, the European Union has legislated a series of limits and guidelines on controlling the mass concentration of particles in ambient air. Specifically, a 24-h mean concentration of 50 $\mu g\ m^{-3}$ not to be exceeded more than 35 times per year and an annual mean concentration of 40 $\mu g\ m^{-3}$ have been imposed for particles with aerodynamic diameter below 10 μm,

* Corresponding author. Tel.: +30 69740 77481; fax: +30 26510 08671.
E-mail address: apaschal@cc.uoi.gr (A.K. Paschalidou).

1352-2310/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.atmosenv.2011.08.034

PM_{10} (Council Directive 1999/30/EC). In addition, the recent directive on ambient air (Council Directive 2008/50/EC) has imposed an annual concentration cap of 25 μg m^{-3} for particles with diameter below 2.5 μm, while Member States are required to reduce exposure to $PM_{2.5}$ in urban areas by an average of 20% by 2020 based on 2010 levels. Local authorities and policy-makers throughout the European Union are therefore asked to perform the necessary monitoring and apply environmental policies, in order to comply with the above limits and objectives. Under this perspective, characterizing the physical and chemical properties of the particles, as well as identifying major particle sources and quantifying their contribution are some of the issues that need to be addressed in urban areas in the European Union (Chaloulakou et al., 2003).

In the recent past, several research efforts have been conducted on analyzing pollutant and meteorological datasets in European cities. For instance, Smith et al. (2001) analyzed 3-year PM_{10} data from three monitoring sites (Haringey, Kensington/Chelsea and Eltham), as well as meteorological data and air trajectory products, in order to identify the factors that control the particulate matter levels in London. The analysis revealed strong evidence of particle resuspension, as well as significant contribution of a remote south-easterly PM_{10} source in London. Lenschow et al. (2001) performed a comparison among the chemical composition of particles selected at urban, regional background and kerbside sites in Berlin, in order to achieve the desired source apportionment. The analysis revealed that almost 50% of the urban PM_{10} background was associated with long-range transport and natural sources. Querol et al. (2004) studied the origin of particulates in seven European regions and concluded that the ratio $PM_{2.5}/PM_{10}$ was highly dependent on the type of site and varied widely between different EU regions. Source apportionment results showed that, on an annual average, the natural contribution (mineral and marine) at EU regional sites was in the range of 4–8 μg m^{-3} for PM_{10}, but contributions up to 19 μg m^{-3} were reported for specific locations. Kukkonen et al. (2005) used PM_{10} and meteorological data to study selected PM_{10} episodes in four European cities (Oslo, Helsinki, London and Milan). It was concluded that the vast majority of episodes were mainly related to high atmospheric pressure systems and temperature inversions. Vardoulakis and Kassomenos (2008) used 3-year meteorological and pollutant data in order to identify the sources and factors that affect PM_{10} levels at urban and suburban background locations in Athens and Birmingham. In Birmingham high PM_{10} concentrations were generally associated with cold weather, anti-cyclonic conditions and easterly winds, providing clear evidence of long-range transport of particles from continental Europe, whereas in Athens strong local emissions sources in combination with stagnating or re-circulating air masses gave rise to a larger number of exceedances per year.

In the present work, the particulate pollution is studied in Thessaloniki, a Mediterranean city with more than a million inhabitants and significant industrial activity. Specifically, the study focuses on the identification and quantification of the factors that influence background PM_{10}, $PM_{2.5}$ and PM_c (i.e. the coarse fraction of particulate matter defined as $PM_{10-2.5}$) levels by (a) analyzing the seasonal variability of particle background levels, (b) estimating the combustion and non-combustion-related contributions to the total particulate pollution and (c) examining and evaluating local particle sources, through concentration roses.

2. Area description and data used

2.1. Area description

Thessaloniki covers an area of about 200 km^2 and hosts more than a million inhabitants with an average population density equal to 287.24 inhabitants per km^2. The mountain of Hortiatis, reaching 1200 m approximately, is located at the east of the area, while some more hills are located at the north. In the west, the area is flat and allows the connection of the city with the rest of the Macedonia mainland. Finally, the rather shallow gulf of Thermaikos is located in the south (Fig. 1).

Thessaloniki experiences a rather Mediterranean climate with mean temperatures during winter and summer at 7 and 25.3 °C respectively and mean annual rainfall at 445 mm. The highest frequency of air pollution episodes is associated with the presence of anti-cyclonic conditions over the Northern part of Greece, being characterized by weak or very weak surface pressure gradient intensity, depending on the position and extension of the anticyclone (Flocas et al., 2009). Additionally, the terrain complexity and the pronounced terrain features of the Greater Thessaloniki Area lead to the formation of local atmospheric circulations, such as sea-land breezes and drainage flows that affect the development, evolution and maintenance of air pollution levels (Helmis et al., 1997).

The main air pollution sources are the industrial activities taking place in the western part of the city and the automobiles, with more than 500,000 registered in the area (Petrakakis et al., 2008). The absence of a contemporary public transportation system forces people to overuse private cars and consequently leads to high emission regimes in the urban sites of the city. The central heating also plays a significant role during the cold period of the year (October–April). Fig. 2 summarizes the main sources of PM_{10} in the greater area of Thessaloniki.

2.2. Data sources

The air quality in Thessaloniki is monitored through a complete network of monitoring stations located in traffic and background sites and operated by the Environmental Department of the Municipality of Thessaloniki. Some of the main air pollutants routinely recorded are Particulate Matter (PM_{10}, $PM_{2.5}$), carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide (NO_2), ozone (O_3) and sulphur dioxide (SO_2). SO_2 and CO concentrations are measured through the UV-fluorescence principle and the infrared correlation photometry method respectively, while the Beta-gauge method is used to measure the particulate matter concentrations.

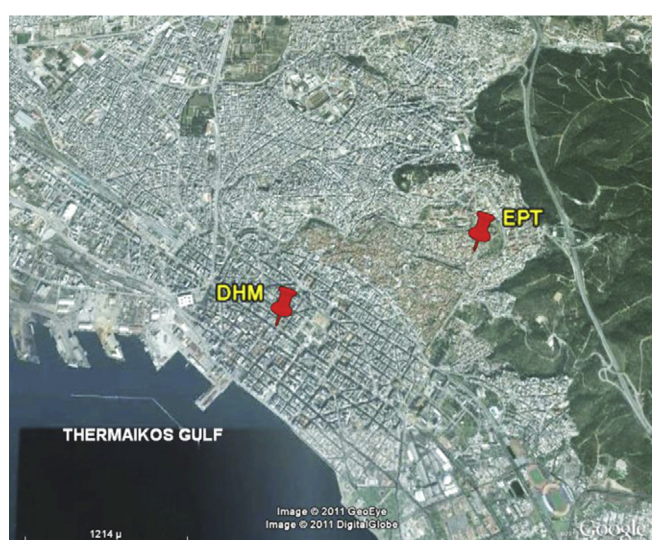

Fig. 1. Map of the Thessaloniki area showing the two measuring sites.

Download English Version:

https://daneshyari.com/en/article/4439168

Download Persian Version:

https://daneshyari.com/article/4439168

Daneshyari.com