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Statistical characterization of atmospheric PM_{10} and $PM_{2.5}$ concentrations at a non-impacted suburban site of Istanbul, Turkey

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Abstract

Inhalable particulate matter (PM_{10}) has been monitored at several stations by Istanbul Municipality. On the other hand, information about fine fraction aerosols ($PM_{2.5}$) in Istanbul atmosphere was not reported. In this study, 86 daily aerosol samples were collected between July 2002 and July 2003. The PM_{10} annual arithmetic mean value of 47.1 μg m^{-3}, was lower than the Turkish air quality standard of 60 μg m^{-3}. On the other hand, this value was found higher than the annual European Union air quality PM_{10} standard of 40 μg m^{-3}. Furthermore, the annual mean concentration of $PM_{2.5}$ 20.8 μg m^{-3} was found higher than The United States EPA standard of 15 μg m^{-3}. The statistics and relationships of fine, coarse, and inhalable particles were studied. Cyclic behavior of the monthly average concentrations of PM_{10} and $PM_{2.5}$ data were investigated. Several frequency distribution functions were used to fit the measured data. According to *Chi*-squared and Kolmogorov–Smirnov tests, the frequency distributions of $PM_{2.5}$ and PM_{10} data were found to fit Log-logistic functions.

Keywords: PM_{10}; $PM_{2.5}$; Statistical analysis; Frequency distribution; Air pollution

1. Introduction

Istanbul is the most populated city of Turkey and the fourth in Europe with nearly 12 million inhabitants and annual growth rate is about 4.5% (SIS, 2003). Air pollution is one of the challenging environmental problems in Istanbul. Some regions of Istanbul have been continuously exposed to high pollution levels during the heating season (November–March) (Gülsoy et al., 1999). Especially at the end of 1980s and the beginning of 1990s sulfur dioxide (SO_2) and particulate matter (PM) concentrations have exceeded the short-term air quality standards in many days (Tayanç, 2000). After 1966, PM_{10} have been monitored in several stations by Istanbul Municipality in Istanbul. Nevertheless, so far no $PM_{2.5}$ data for Istanbul has been published.

Epidemiological studies suggest that exposure to particles with an aerodynamic diameter <10 μm (PM_{10}), and most recently <2.5 μm ($PM_{2.5}$), induces adverse health effects. Evidence also suggests that in elderly people with pre-existing cardiopulmonary illness, such

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exposure may even lead to increased mortality and hospitalization rates (Pope et al., 1995; EPA, 1996; Chapman et al., 1997). $PM_{2.5}$ particles are likely to penetrate deep into alveolar sacks of the lung. These particles can accumulate in the respiratory system and are associated with numerous negative health effects (Vinitketkumnuen et al., 2002). Recently, it has been suggested that for every 10 μg m^{-3} increase of fine particles from automotive emissions show approximately a 3% of increase in the daily mortality rate, while fine coal combustion emissions only account for about 1% (Laden et al., 2000).

Frequency distribution is the tabulation of raw data obtained by dividing it into size ranges and computing the number of data elements (or their fraction out of the total) falling within each size range (Kenney and Keeping, 1962). The frequency distribution of air pollutant concentration data is useful in understanding the statistical characteristics of air quality. It is a very useful tool to estimate how frequently a critical concentration level is exceeded (Seinfeld and Pandis, 1998; Wilson et al., 2002). Knowledge of the frequency distribution is necessary for developing air pollutant control strategies (Lu and Fang, 2002). In some studies, some frequency distribution functions, such as Lognormal, Weibull distributions, were used to fit PM data (Law and Kelton, 1991; Stuart and Ord, 1991; Lu and Fang, 2002).

The purpose of this study is to explain the relationships between $PM_{2.5}$, $PM_{2.5-10}$ and PM_{10} data, and determine the frequency distribution characteristics of $PM_{2.5}$ and PM_{10}.

2. Experimental

2.1. Sampling site and period

In this work, 86 daily aerosol samples of fine (<2.5 μm) and coarse (2.5–10 μm) particles were collected at Istanbul Water and Wastewater Administration (ISKI) compound near the Büyükçekmece Lake. The samples were collected in random days during July 2002 to July 2003. By this manner, at least six samples were collected each month. The sampling site is located in a suburban area of Istanbul, approximately 5 km north from the town of Büyükçekmece, at a height of 10 m above sea level within the first zone of the watershed area of Büyükçekmece Lake. The sampling area is away from any direct stationary and mobile pollution sources (non-impacted suburban). The location of the sampling station is shown in Fig. 1.

There is no close residential or industrial area within 5 km around the sampling site. This place was chosen for sampling, for the reason that there is no direct impact of nearby stationary or mobile emission source.

2.2. Sampling method

A size segregation automatic dichotomous sampler (Anderson sampler) was used to collect two ranges of aerosol samples. It has an inlet with PM_{10} cut-off, which collects only particles smaller than 10 μm. The particles are then size-segregated by means of virtual impaction, into fine particles smaller than 2.5 μm and coarse particles between 2.5 and 10 μm ($PM_{2.5-10}$). The particles are

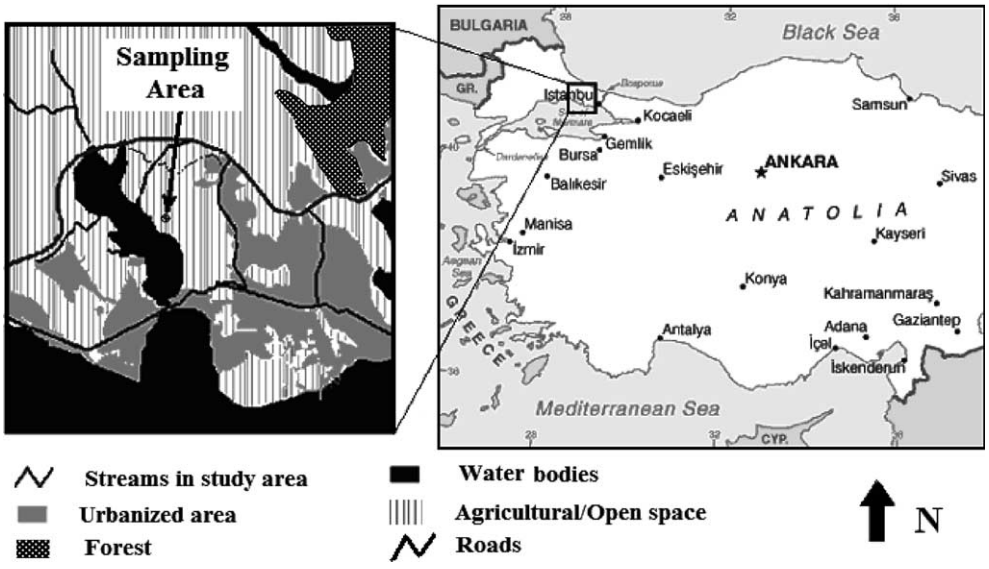

Fig. 1. The location of sampling site.