Lecture at
CMA4CH 2014, Mediterraneum Meeting
Employ the Multivariate Analysis and Chemometrics in Cultural Heritage and Environment Fields
5th ed., Rome, Italy, Europe, 14-17 December 2014

Submicrometer Aerosol Distribution in Urban Area

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Abstract

Many studies show that particle toxicity increases with decreasing their size. They emphasize the role of submicrometric particles, in particular of ultrafine particles (<100 nm), and have drawn the attention on particle surface area or number rather than mass. Given the paucity of data on size distributions of submicrometer particles, and in particular UltraFine Particles (UFPs), in downtown Rome, a study was undertaken from 2008.

Introduction

Epidemiological studies have correlated atmospheric particulate matter (PM) to increase of mortality and to adverse human health effects, such as lung cancer, respiratory and cardiovascular diseases. Hence, the importance of an effective control of the atmospheric concentrations of Particulate Matter (PM). PM is presently regulated throughout the European Community on a mass basis through the PM10 and PM2.5 conventions.

Many studies [1-3] have provided evidence that some particles become more toxic per unit mass as their size decreases and consequently have drawn the attention on particle surface area or number rather than mass, emphasizing the role of the submicrometer aerosol. While particles greater than 2.5 µm are quickly removed through dry and wet deposition on the time scale of hours, submicrometer particles may reside in atmosphere for weeks, penetrate in indoor environment [4] and be long-range transported.

Submicrometer particles emitted from road traffic are an important source of respiratory exposure for the population living in urban areas. In particular, many toxicological studies have evidenced the role of ultrafine particles (<100 nm), emphasizing the importance of airborne particle number rather than mass. Size resolution in aerosol measurements is required since the deposition efficiency in the respiratory system is strictly related to particle dimensions. Time resolution is another important requisite, given the fast evolution of atmospheric aerosol in urban areas. Starting from such considerations, time resolved aerosol particle number size distributions have been measured in downtown Rome

Materials & Methods

The aerosol measurements were carried out at the INAIL's Pilot Station, located in downtown Rome, in an area characterized by high density of autovehicular traffic.

Submicrometer aerosol and relative size distribution were measured using two instruments with different resolution times. The first, having a 5 min measuring-period, manages to measure particles in the range 3.5-117 nm, by means of a water-based ultrafine condensation particle counter (CPC 3786, TSI Inc., Shoreview, MN, USA) and a Scanning Mobility Particle Sizer (SMPS 3936, TSI), equipped with a Differential Mobility Analyzer (DMA 3085, TSI). The second one performs highly time resolved measurements (i.e., 1 s time resolution) of aerosol size number distributions: it is the Fast Mobility Particle Sizer (FMPS 3091, TSI) which allows to investigate the particle in the range 6-520 nm.

Results

The availability of such instrumentation has allowed us to investigate in details the issue regarding Ultrafine Particles. In fact, at the beginning the use of the CPC showed a variability of the dimensional spectra likely due to the different type of combustion sources related to motor/auto vehicle traffic. The subsequent measurements carried out by FMPS, have confirmed this interpretation, enabling to transient phenomena in the time interval of few seconds, time scale typically associated with the emission of gasoline and diesel.

The different size distributions measured very likely reflected the exhausts emitted by the

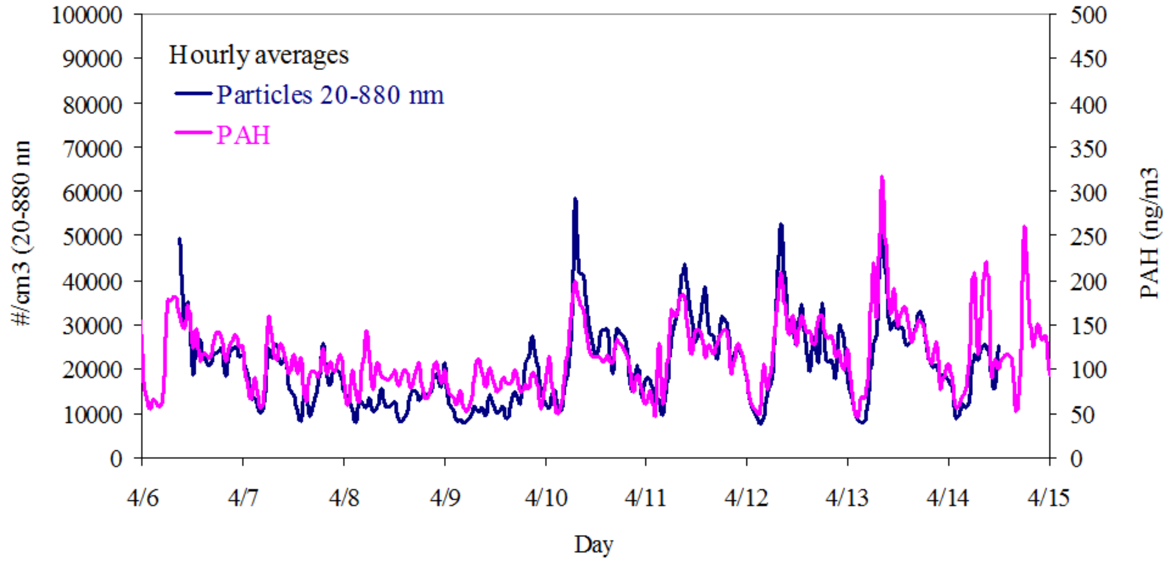

Fig. 1; Hourly trends of submicrometer particles (20-880 nm) and total PAHs.

different types of vehicle, passing within few metres from the measuring point. In Figure 1 it could be observed the hourly trends of the submicrometer particles (20-880 nm) and an anthropogenic pollutant related to combustion processes, such as Polycyclic Aromatic Hydrocarbons. The same modulation of these two pollutants suggests that the origin is substantially similar in downtown Rome due to autovehicular traffic. Furthermore, UFP number concentrations displayed similar patterns of variation as carbon monoxide, a typical primary pollutant associated to the autovehicular exhaust.

Conclusions

Autovehicular traffic is the main source of submicrometer particles in downtown Rome. The dilution process of the vehicle exhausts plays an important role in affecting the particle number distribution. Total particle concentration follows a daily trend governed by the evolution of the atmospheric mixing height and by the variation of the autovehicular traffic intensity. In downtown Rome the hourly-average size distribution is bimodal or trimodal with maxima at about 5-15 nm, 20-30 nm and 70-100 nm. Particle formation in the nucleation mode is favoured in periods with high radical oxidative activity.

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