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

Traffic Aerosol Deposited in the Human Respiratory System

M. Manigrasso, P. Avino
DIT, INAIL settore Ricerca, via IV Novembre 144, I-00187 Rome (Italy)

Abstract

This paper describes the aerosol regional doses deposited in the human respiratory system in a traffic environment. Cumulative and instant doses are calculated for submicrometric and ultrafine particles (UFPs) deposited in the lobes of the lung described by a stochastic model (60^{th} percentile). After 1 h exposure about 6.6×10^{10} particles, almost entirely UFPs, are deposited into the respiratory system. Particles are preferentially deposited in right than in left lung lobes.

Introduction

Aerosol pollution in urban environments has been recognized to be responsible of important pathologies of the cardiovascular and respiratory systems, it has also been associated to increased mortality and hospital admissions. Directive 2008/50/EC states that for fine particulate matter (PM2.5) there is as yet no identifiable threshold below which PM2.5 would not pose a risk. Therefore, a general reduction of its concentrations in the urban background should be pursued to ensure that large sections of the population benefit from improved air quality.

More recently the International Agency for Research on Cancer (IARC) has considered outdoor pollution as a leading environmental cause of cancer deaths. Furthermore, particulate matter has been classified as carcinogenic to humans (Group 1). Within this context, the importance of the measurements of aerosol size distribution resides in that the doses deposited in the human respiratory system strictly depend on the particle sizes.

In this perspective, great attention has been addressed to Ultra Fine Particles (UFPs < 100 nm) [1-3], since they efficiently penetrate into the respiratory system and are capable of traslocating from the airways into the blood circulation [4].

Materials & Methods

This work relies on aerosol measurements carried out on kerb side in downtown Rome in a street characterized by high density of autovehicular traffic. Aerosol number-size distributions were measured by means of a Fast Mobility Particle Sizer 3091 (by TSI, USA) in the range from 5.6 to 560 nm (electrical mobility diameter), in 32 size-channels (16 channels per decade), with 1 s time resolution.

An hour aerosol data collected during the morning traffic peak period has been selected to estimate the total dose of particles (5.6-560 nm) and of ultrafine particles deposited in the regions of the respiratory system: head (H), tracheobronchial (TB) and alveolar (AI). For the TB and AI region the left-upper (LU), left-lower (LL), right-upper (RU), right-middle (RM), right-lower (RL) lung lobes were considered. Dosimetry estimates were performed with the Multiple-Path Particle Dosimetry model (MPPD v.2.1, ARA 2009). Calculations were carried out by means of the stochastic lung model (60^{th} percentile), because it provides a more realistic lung geometry than symmetric models. Doses are reported both as number of particles deposited for each tidal volume of air inhaled (instant doses) and as number of particles deposited at the end of an exposure period (cumulative doses).

Results

Cumulative doses are reported in Figure 1. After 1 hour exposure in proximity of traffic 1.29×10^{10}, 1.88×10^{10} and 3.45×10^{10} particles are deposited in head, tracheobronchial and alveolar regions. More than 95 % of such doses are represented by UFPs. Both in tracheobronchial and alveolar regions doses in RU lobes are about twice as much as those in LU lobes, 24% and 31% more respectively in TBRL than in TBLL and in PRL than in PLL lobes.

Close to traffic, the exposure scenario is represented by a sequence of short-term peak

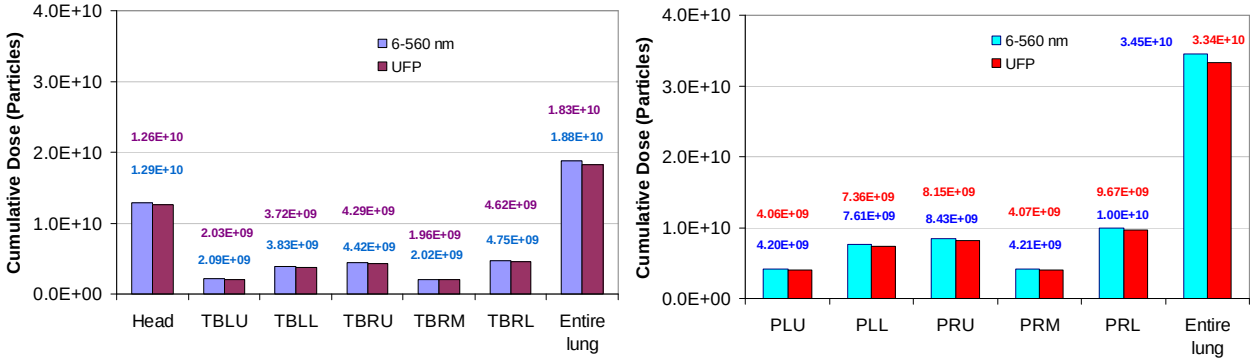

Fig. 1; Cumulative regional lobar doses after 1 h exposure in traffic proximity (TBLU tracheobronchial left-upper lobe; TBLL tracheobronchial left-lower lobe; TBRU tracheobronchial right-upper lobe; TBRM tracheobronchial right-middle lobe; TBRL tracheobronchial right-lower lobe; PLU alveolar left-upper lobe; PLL alveolar left-lower lobe; PRU alveolar right-upper lobe; PRM alveolar right-middle lobe; PRL alveolar right-lower lobe).

exposures, on the time scale of few tens of seconds, as shown in Figure 2, where instant regional doses are reported as a function of time.

Conclusions

This work discusses the aerosol doses deposited in the respiratory system of individuals exposed in proximity of traffic. During traffic peak hours about 6.6×10^{10} particles are deposited into the respiratory system. Such dose is almost entirely made of UFPs. According to the greater dose estimated, right lung lobes are expected to be more susceptible to respiratory pathologies than left lobes.

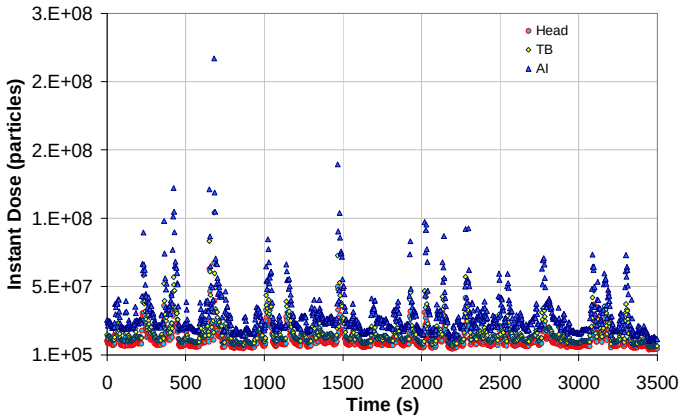

Fig. 2; Instant regional doses in traffic proximity.

References

1) P. Avino, S. Casciardi, C. Fanizza, M. Manigrasso, Deep investigation of ultrafine particles in urban air, *Aerosol Air Qual. Res.*, 11, (2011), 654-663

2) M. Manigrasso, P. Avino, Fast evolution of urban ultrafine particles: Implications for deposition doses in the human respiratory system, *Atmos. Environ.*, 51, (2012), 116-123

3) M. Manigrasso, L. Stabile, P. Avino, G. Buonanno, Influence of measurement frequency on the evaluation of short-term dose of sub-micrometric particles during indoor and outdoor generation events, *Atmos. Environ.*, 67, (2013), 130-142

4) G. Oberdörster, E. Oberdörster, J. Oberdörster, Nanotoxicology: an emerging discipline evolving from studies of ultrafine particles, *Environ. Health Perspect.*, 113(7), (2005), 823-839