Atmospheric Environment 102 (2015) 156–166

Contents lists available at ScienceDirect

Atmospheric Environment

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

Exposure and dose assessment to particle components among an elderly population

M. Almeida-Silva [a, b, *], S.M. Almeida [a], P.N. Pegas [c], T. Nunes [c], C.A. Alves [c], H.T. Wolterbeek [b]

[a] Centro de Ciências e Tecnologias Nucleares, Instituto Superior Técnico, Universidade de Lisboa, EN 10, km 139.7, 2695-066 Bobadela LRS, Portugal
[b] Faculty of Applied Sciences, Department of Radiation, Radionuclides and Reactors, Section RIH, Technical University of Delft, Delft, The Netherlands
[c] CESAM, Universidade de Aveiro, 3810-193 Aveiro, Portugal

HIGHLIGHTS

- Elderly spend 95% of their time indoors.
- Indoor air quality was closely linked to personal exposure.
- The exposure and the inhaled dose of the studied elders differed significantly.
- The contribution of each indoor micro-environment depended on the particle constituents and respective sources.

ARTICLE INFO

Article history:
Received 9 June 2014
Received in revised form
26 November 2014
Accepted 27 November 2014
Available online 28 November 2014

Keywords:
Elderly
Exposure
Dose
Particles
Carbonaceous components
Trace elements

ABSTRACT

People spend the majority of their time indoors and the composition and toxicity of indoor particles is very complex and present significant differences comparing with outdoor aerosols. Consequently, ambient particles cannot represent a real exposure. The aim of this work was to determine the daily exposure and the daily inhaled dose to particle components of elders living in Elderly Care Centers. A questionnaire was applied to 193 institutionalized elders in order to achieve their daily time pattern and to define the micro-environments where PM_{10} and its components (carbonaceous components and trace elements) were assessed. Daily exposure was calculated by integrating the elder's time spend in each micro-environment and the concentration of the pollutants for the period of interest. This parameter, together with the inhalation rate and the standard body weight, were used to calculate the daily inhaled dose. PM_{10} daily exposure and daily inhaled dose ranged between 11 – 16 μg m^{-3} and 20×10^{-3} – 28×10^{-3} μg kg^{-1}, respectively. This work not only allowed a fully quantification of the magnitude of the elders exposure, but also showed that the assessment of the integrated exposure to PM components is determinant to accomplish the dose inhaled by elders living in ECCs.

1. Introduction

The concerning about exposure to particulate air pollution and their possible human health effects is not a current problem. In 1875 arose the first legal document containing a section called "nuisances" where it was required the decrease of smoke pollution in urban areas (Public Health Act, 1875). Meanwhile, several epidemiological studies have established associations between exposure to Particulate Matter (PM) and adverse human health effects (Almeida et al., 2014a; Almeida-Silva et al., 2013; Pope et al., 2011, 2002). More recently, some researchers have investigated which properties of ambient aerosol are responsible for health effects; whether certain particulate chemical components are more harmful than others (Suh et al., 2011; Zanobetti et al., 2009); and the particle size as an important determinant of the site and efficiency of pulmonary deposition (Andersen et al., 2008).

However, epidemiological associations between PM and health outcomes are based predominantly on ambient air measurements where it is assumed that each person in a given region has the same exposure level, which is often obtained from a few air quality

* Corresponding author. Centro de Ciências e Tecnologias Nucleares, Instituto Superior Técnico, Universidade de Lisboa, EN 10, km 139.7, 2695-066 Bobadela LRS, Portugal.
E-mail address: marina@ctn.ist.utl.pt (M. Almeida-Silva).

http://dx.doi.org/10.1016/j.atmosenv.2014.11.063
1352-2310/

monitors and reflects the entire community (Almeida et al., 2009a; Freitas et al., 2009a,b; Sarmento et al., 2011). Nevertheless, poor correlations have been found between ambient PM concentrations and personal exposure to PM (Meng et al., 2005) because actual exposure is strongly related to the individual time activity patterns, followed by its distance from each particle source. Moreover, indoor environments has gain an increasing importance since in developed countries daily patterns had changed and people spend more than 80–90% of their time indoors (Zhao et al., 2009; Klepeis et al., 2001).

According to Morawska et al. (2013), up to 30% of the burden of disease from PM exposure can be attributed to indoor-generated particles, signifying that indoor environments are likely to be a dominant factor affecting human health. This initiated a debate as to whether ambient PM is a good surrogate for exposure to PM once the composition and toxicity of indoor PM is very complex, with similarities but also differences to outdoor aerosols. Therefore, personal integrated exposure to PM components is of considerable importance as it is the key determinant of the PM dose received by an individual and thus directly influences the health impacts.

These facts are particularly relevant when we are talking about institutionalized elderly people not only because they are consider a susceptible group but also because they spend the majority of their time indoors (Almeida-Silva et al., 2014a; Saksena et al., 2003). Besides the increasing number of studies reporting pollutant concentrations in different micro-environments, the integrated exposure or integrated dose of the people was not successfully estimated. Moreover, as far as we know the assessment of the daily exposure to PM components (trace elements and carbonaceous components) and the estimation of the daily dose was never done, even for children which are the most studied population's group.

Therefore, a monitoring programme was designed to evaluate not only the Elderly Care Centers (ECCs) chemical and biological contamination but also the elderly daily exposure and inhaled dose to different air pollutants. The project followed the Risk Assessment Paradigm that includes: 1) the evaluation of emission sources; 2) the identification and quantification of hazards; 3) the exposure assessment; 4) the quantification of the dose; and 5) the study of effects on human health (Fig. 1). Sampling campaigns were undertaken in 10 ECCs considering 384 old people living on these sites. Several results generated within this project were already reported and focused: 1) on the fungi contamination of ECCs (Viegas et al., 2014), 2) on the daily elders exposure to carbon dioxide, carbon monoxide, PM in different sizes fractions, total volatile organic compounds, ozone and formaldehyde (Almeida-Silva et al., 2014a) and 3) on the nanoparticles deposition into elderly lungs (Almeida-Silva et al., 2014b). The objective of the present work was to characterize the PM_{10} components measured in the indoor air of ECCs, in order to assess the daily exposure and the inhaled dose of institutionalized elders to air pollutants.

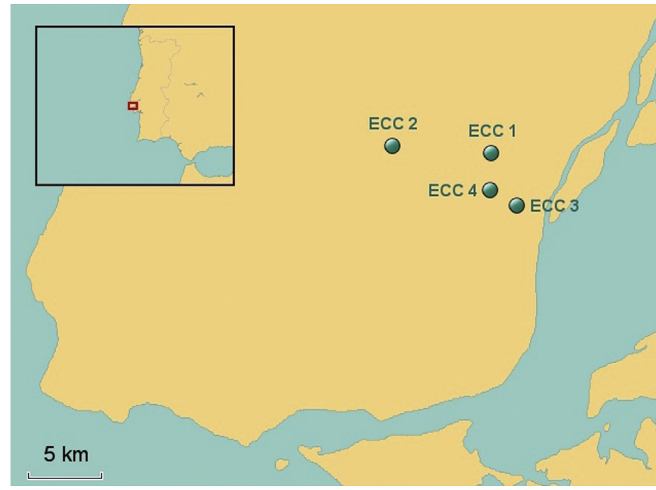

Fig. 2. Localization of the elderly Care centers.

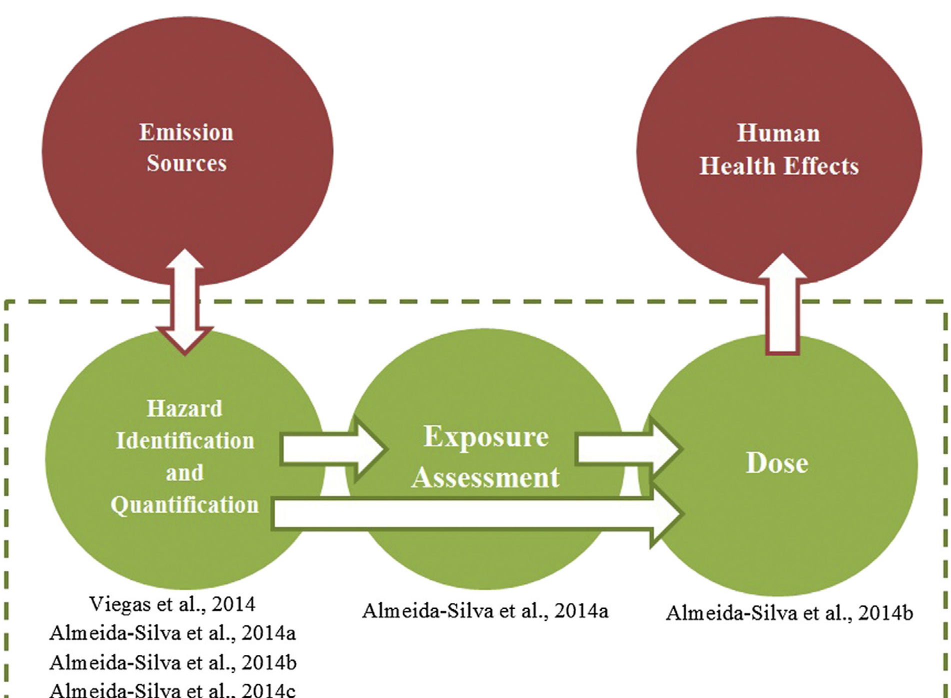

Fig. 1. Risk assessment paradigm applied in this work.