Ecotoxicology and Environmental Safety 72 (2009) 866–871

Contents lists available at ScienceDirect

Ecotoxicology and Environmental Safety

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

Review

Health risk by inhalation of $PM_{2.5}$ in the metropolitan zone of the City of Mexico ☆

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ARTICLE INFO

Article history:
Received 11 July 2008
Received in revised form
1 August 2008
Accepted 1 September 2008
Available online 7 November 2008

Keywords:
Health risk
Public health
Risk assessment
Risk characterization
Particulate matter
Atmospheric pollution
PIXE
Inhalation exposure
Mexico City
$PM_{2.5}$

ABSTRACT

The study assessed the risk to the health of the inhabitants of the metropolitan zone of the City of Mexico posed by the chemical elemental contamination present in $PM_{2.5}$ particles. PIXE (particle induced X-ray emission) analysis of particles identified 18 elements, thereby achieving an elemental characterization. In order to calculate the risk posed by each element, the dose of elemental exposure was considered in relation to the corresponding reference dose. This gave an elemental risk of less than 1 for the three age groups; however, when the additive risk is considered for each age group a value exceeding 1 is obtained. Hence, although no individual element represents a public health risk, a consideration of the total risk for each of the age groups shows that members of the population are at high risk of contracting any one of the diseases that can be caused by the elements present in $PM_{2.5}$.

Contents

☆ This paper was supported by Instituto Nacional de Investigaciones Nucleares of Mexico.
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doi:10.1016/j.ecoenv.2008.09.014

1. Introduction

Mexico has not escaped the environmental deterioration that is being experienced by this planet; the metropolitan zone of the City of Mexico (MZCM), among other places, has suffered from examples of this deterioration, and serious public health problems have arisen as a result of the contamination of the air by suspended particles (Rosales-Castillo et al., 2001; Ocaña et al., 2001; Rosas, 1996; Zapata et al., 2001; Rico et al., 2001; Ponciano and Rivero, 1996; Cicero, 1996).

The various contaminants that the US EPA (2006b) and SMA (2006b) have considered as assessment criteria include suspended particles. These particles have been classified according to their aerodynamic diameter and inside this classification have $PM_{2.5}$ (particles less than or equal to 2.5 μm). $PM_{2.5}$ particles are very light and remain in the air for days or weeks, sometimes traveling up to hundreds of kilometers. Respiration involves the inhalation of air together with whatever particulate matter this contains, and the air and the particles travel into the respiratory system as far as the pulmonary alveoli. On the way, the particles may adhere to the walls of the respiratory tract, or they may travel deep into the lungs. Respiration through the mouth allows the particles to penetrate more deeply within the lungs. Persons of advanced age respire less deeply, and so the particles do not penetrate so far. The lungs produce mucus to trap the particles, and there are mechanisms for transporting the mucus and the particles away from the lung; the mucus is expelled from the respiratory passages by coughing or by swallowing. However, these particles, being so small, can enter deeply into the lungs, where certain cells entrap them so that they can no longer be expelled; this can result in pulmonary disease, emphysema or pulmonary cancer. Exposure to these particles and the resultant damage leads to an increase in the use of therapeutic drugs and in visits to the doctor or attendance at an emergency clinic. The various effects on health include the following: coughing, difficulty in breathing, asthma, damage to the lung (including a decrease in pulmonary function and a life-long increase in respiratory diseases), and premature death in individuals with preexisting heart or lung disease (Pope III et al., 2002; Ocaña et al., 2001; Zapata et al., 2001). Other factors that adversely affect the health of the population of the MZCM are the geographical and climatic characteristics that govern the accumulation and dispersion of the contaminants.

Despite the importance for public health of constantly monitoring $PM_{2.5}$, the network for the monitoring of $PM_{2.5}$ in Mexico was initiated in Mexico City as recently as 2003, and lately the enforcement of an Official Mexican Norm is also being considered in order to protect the health of the population against exposure to $PM_{2.5}$ (SSA, 2005). This will be applied nationally and corresponds to the equivalent norm that is in effect in the USA EPA (2006b). The proposed values of the norm are 65 $\mu g/m^3$ (24 h mean) and 15 $\mu g/m^3$ (annual arithmetic mean).

However, this proposal for a norm refers only to the gravimetric concentration and does not consider the chemical elemental composition of this contaminant. For this reason, surveillance of $PM_{2.5}$ has been confined to gravimetric analysis, which means that assessment of the effects on health considers only this variable, even though the health risks calculated in terms of the gravimetric variable do not necessarily represent the real effects that can occur. Hence, it is important to determine the chemical elemental characterization of the particles less than 2.5 μm in diameter and from these data to deduce the public health risk.

The present study assesses the public health risk at a site in the MZCM caused by the chemical elemental composition of the suspended particles that are less that 2.5 μm in diameter.

2. Methods

2.1. Study site

The sampling site was selected with reference to the federal registers for environmental regulation by the US EPA (2006a). The site is at the western margin of the MZCM, as shown in Fig. 1. It was selected to represent the edge of this zone, at an altitude (2750 m asl) that is high in comparison with the mean altitude of the other parts of the MZCM, i.e., 2240 m asl (INEGI, 2004). Industrial activity is low, with only 324 diverse industrial establishments (INEGI, 2006). Because of the direction of the prevailing wind, there is no influence of contaminants from industrial zones such as that of Naucalpan and Xalostoc (SMA, 2004, 2005a–c). To date, there have been no studies at this site for $PM_{2.5}$ particles and there have only been measurements of meteorological parameters by SIMAT, the atmospheric monitoring system of the Government of the Federal District of Mexico.

The site is the Belisario Domínguez Primary School on Calle Monte Encino, Colonia Jesús del Monte, Cuajimalpa. This is an urban area, mainly residential, characterized by roofs constructed of sheets of asbestos. There is a moderate flow of traffic comprising private cars, taxis, minibuses, buses, and trucks. The land is urban, and the climate is subhumid temperate with rains in summer.

2.2. Collection of samples

Samples were collected on alternate days from 1 December 2004 to 31 March 2005, during the cold dry season, by methods described by Martínez and Romieu (1995), Korc (2001), and US EPA (1998). The apparatus was a Gent sampler as described by Maenhaut (1992). Nuclepore filters of 47 mm diameter were used, with 0.4 μm pores for $PM_{2.5}$ particles and with 8 μm pores for PM_{10} particles (particles with an aerodynamic diameter between 2.5 and 10 μm). Each collection was over a 24 h period and, in total, 60 samples were collected.

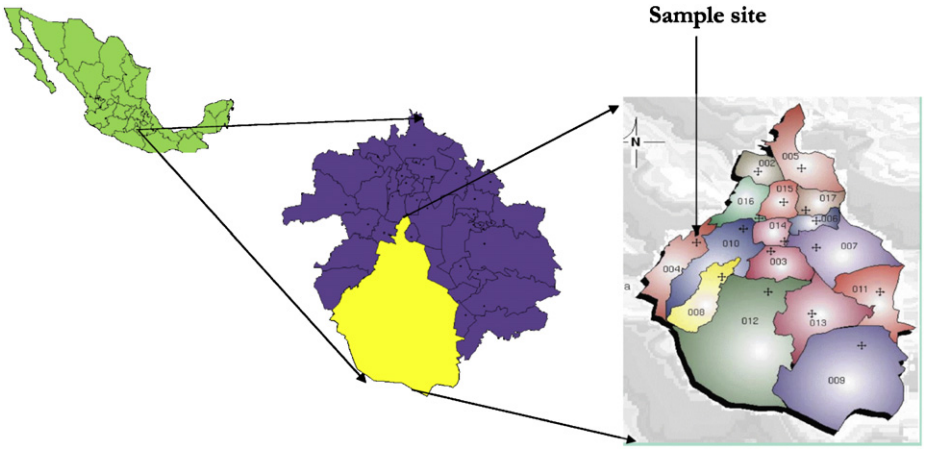

Fig. 1. Sample site, western edge of the MZCM.