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Ambient monitoring of airborne asbestos in non-occupational environments in Tehran, Iran

Hossein Kakooei [a,*], Mohsen Meshkani [a], Kamal Azam [b]

[a] Department of Occupational Health, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran
[b] Department of Biostatistics, School of Public health, Tehran University of Medical Sciences, Tehran, Iran

HIGHLIGHTS

- We examine the airborne asbestos fiber concentrations of 110 air samples in non-occupational environments in Tehran, Iran.
- The asbestos fiber type and concentrations were studied by SEM, PCM and PLM.
- The concentrations of chrysotile fibers obtained by SEM were 14–15 times higher than those by PCM.
- Increasing information about urban asbestos exposure will decrease or ban of asbestos consumption.
- Increasing information of PLM will increase rapid and inexpensive asbestos fibers type detection method.

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ABSTRACT

Airborne asbestos fiber concentrations were monitored in the urban areas of Tehran, Iran during the period of 23 August to 21 September 2012. The airborne fiber concentrations of 110 air samples collected from 15 different sites in five regions of Tehran. The monitoring sites were located 2.5 m above ground nearby the main street and heavy traffic jam. The ambient air samples were analyzed using scanning electron microscopy (SEM), with energy-dispersive X-ray analysis and phase-contrast optical microscopy (PCM). The geometric means of the airborne asbestos fiber concentrations in the outdoor living areas was 1.6×10^{-2} SEM f ml^{-1} (1.18×10^{-3} PCM f ml^{-1}). This criteria is considerably higher than those reported for the levels of asbestos in outdoor living areas in the Europe and the non-occupational environment of the Korea. No clear correlation was found between asbestos fiber concentration and the relative humidity and temperature. The SEM and PLM analysis revealed that all samples examined contained only chrysotile asbestos. It can be concluded that several factor such as heavy traffic, cement sheet and pipe consumption of asbestos, and geographical conditions play an important role for the high airborne asbestos levels in the non-occupational environments.

1. Introduction

Asbestos is a commercial term for two family of fibrous silicate minerals that are easily separated into long and very thin fibrils when crushed or processed. According to the domestic regulation, the fibrous–asbestiform are included under the definition of asbestos: chrysotile (serpentine asbestos), amosite, crocidolite, tremolite, actinolite and anthophyllite (amphibole asbestos). Due to its unique physical and chemical characteristics (strength, flexibility, low electrical conductivity, and resistance to heat and chemicals), it has been used extensively for instance in asbestos cement products, automobile brakes and clutches, insulation and gasket materials, cements, bitumen products, glues, vinyl asbestos floors, coating, asbestos panels and gypsum board (Walton, 1982; Kakooei et al., 2009, 2011). It has been scientifically proven that the inhalation of all type of asbestos can cause a variety of malignant diseases such as lung cancer and mesothelioma (Nicholson and Lanndrigan, 1994; McDonald et al., 1989; Hillerdal, 1999; Panahi et al., 2011). Presently, some developed countries have banned using all types of asbestos (Richardson, 2009; Maryoryad, 2010). However, wide spread manufacturing and consumption of asbestos products continues in Asia (Kakooei et al., 2009). Despite the fact that in Iran the production of asbestos and industrial use of asbestos in friction materials were ignored with current legislation, it is estimated that there are still a total of 11 asbestos cement sheet and pipe manufacturing plants are producing cement products with asbestos (Mrioryad et al., 2011). The use of

* Corresponding author. Tel.: +98 21 88951390.
E-mail address: hkakooei@sina.tums.ac.ir (H. Kakooei).

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Table 1
Airborne asbestos fiber concentrations by areas.

Area	Number of samples	Asbestos fiber concentration (fiber ml^{-1})	
		SEM f ml^{-1}	PCM f ml^{-1}
North	36	0.0186 (0.015)	0.0013 (0.001)
South	18	0.0159 (0.012)	0.0011 (0.0008)
East	25	0.0137 (0.008)	0.0009 (0.0006)
West	8	0.0166 (0.021)	0.0011 (0.0015)
Center	22	0.0168 (0.009)	0.0012 (0.0006)
Total	110	0.016 (0.013)	0.0011 (0.0009)

asbestos in Iran has not declined, and the asbestos cement (AC) plants such as asbestos cement roof slates contribute nearly 94% of the total national usage (Panahi et al., 2011; Mrioryad et al., 2011). Asbestos containing materials such as AC sheets, friction materials and joints, tend to degrade and release into ambient air. Asbestos fiber concentrations and length during various mechanical operations such as crushing of whole roof slates ranged from 0.36 to 0.012 f ml^{-1} and 30.34–17.78 μm, respectively (Tadas et al., 2011). Although there have been a few studies on occupational exposure to asbestos (Marioryad et al., 2012), there is only one report of asbestos at exposure levels in ambient air (Kakooei et al., 2009). Therefore, the results of this study can provide environmental information for the general population risk assessment of asbestos-related diseases in Iran. Currently there are no specific criteria for respirable asbestos and synthetic vitreous fibers in ambient air. This directly related to the public health risk of asbestos exposure. Additionally, there are no relevant international threshold limit values (TLV) for environmental asbestos exposure (WHO, 1998; Kakooei et al., 2009).

The objective of this study were to determine airborne asbestos fiber concentrations by quantitative electron microscopy (SEM) and polarized light optical microscopy (PLM) in Tehran non-occupational areas and to compare the concentrations of asbestos fibers by season, and between five main areas in Tehran. The results will provide a clue to obtain data for contribution of establishment background exposure to asbestos fiber in the non-occupational exposure.

2. Materials and methods

2.1. Monitoring strategy and areas

Ambient air samples were performed during the period of 23 August to 21 September 2012. The investigated sites are placed in the residential and commercial areas of Tehran the capital city of Iran. The urban areas were divided into five large regions: (1) the north, (2) south, (3) east, (4) west, and (5) center. A total of 15 sites were selected in five areas from each category. The sampling sites, were designated also to collect samples to evaluate seasonal variations. In addition, a few representative bulk samples (ten samples) such as asbestos cement sheet and automobile brake were collected randomly from different residential areas.

2.2. Sample preparation and analytical method

During the study period, 110 ambient air samples were collected from 15 different sites distributed in the five areas of Tehran. A high-volume flow sampling systems was used to collect the particulate on mixed cellulose ester (MCE) filter membranes (Millipore type AA; 0.45 μm pore size; 47 mm diameter) using an open-face filter holder (model FP050/2; Schleicher and Schuell, Dassel, Germany). Sampling was carried out for 10 h, at a flow rate of 10 L min^{-1} using an environment suction pump (model IP 30L; Sibata Scientific Technology, Tokyo, Japan). Sampler inlets were located 2.5 m above ground. One-half of each filter was prepared by the method of BS ISO 14966 (BS ISO, 2005). All the prepared samples were scanned at a magnification of 2000. Elemental compositions of detected fibers were determined using a SEM (model WEGA/TESCAN, Czech Republic) with an energy dispersive X-ray analyzer (EDXA). It is important to note that the method detection limit using SEM is estimated to be at around 0.0001 f ml^{-1} (Steen et al., 1983). Another portion of the 47 mm diameter filter was analyzed according to PCM by National Institute for Occupational Safety and Health (NIOSH) method 7400 (NIOSH, 1989). The PCM method detection limit was about 0.01 f ml^{-1} when the sample volume was 480 L. Particle with a length >5 μm, diameter <3 μm, and having at least a 3:1 aspect ratio considered to be fibers. The analysis procedure of the matrix particulate included polarized light microscopy (PLM) and quantitative electron microscopy (SEM).

2.3. Data analysis

Descriptive statistics were used for both SEM and PCM measurements of airborne asbestos concentrations using SPSS software for windows version 18. The mean asbestos fiber concentrations are presented as geometric means. The asbestos fiber concentrations of the ambient air samples between areas, and seasons were compared by one-way analysis of variance (ANOVA) and Post Hock

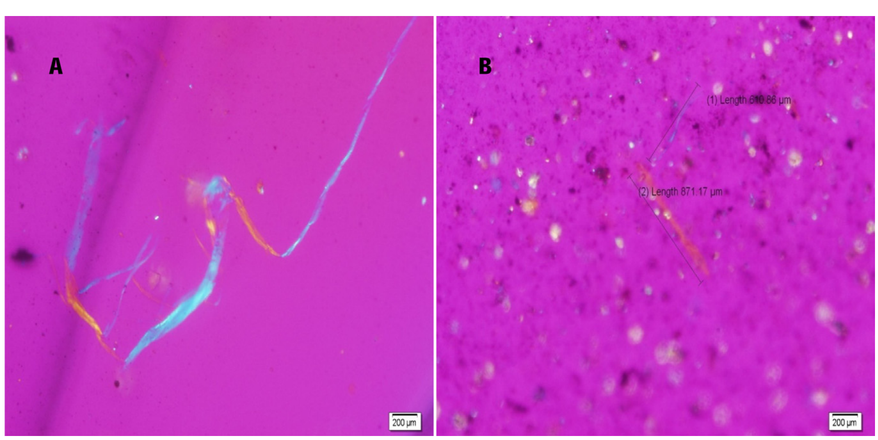

Fig. 1. (A) PLM micrograph of airborne chrysotile fibers in the sample relative to site north; (B) PLM micrograph of airborne chrysotile fibers in the sample relative to site east. Chrysotile fiber has a positive sign of elongation and will show yellow fibers oriented in the NW–SE direction, while they are blue in the NE–SE. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)