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Original

Determination of Airborne Concentration and Type of Asbestos Fibers in High-Traffic Areas of Zahedan City

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Abstract

Background: Asbestos fibers are one of the hazardous air pollutants in high-traffic areas of cities. This study was conducted during summer 2016 with the aim of determining the concentration and type of asbestos fibers in the air of high-traffic areas of Zahedan, Iran. **Methods:** In this descriptive, cross-sectional study, 4 high-traffic and 2 traffic-free areas of Zahedan were chosen. Ambient air samples were collected according to the NIOSH 7400 method, with a flow rate of 2 l/m and 4 hours per day. The asbestos fiber in the samples were analyzed with the use of Phase-Contrast optical Microscopy (PCM) and Scanning Electronic Microscopy (SEM). **Results:**The mean and standard deviation of asbestos contamination density in high-traffic areas were 0.0012 (0.0004) f/cc and 0.0012, respectively, which were higher than the threshold limit value (TLV). In traffic-free areas with mean and standard deviation of 0.0003 ± 0.0003 f/cc the asbestos concentration was lower than the allowed limits. To check the normality of data Kolmogorov-Smirnov test was used ($p< 0.05$). The results of Kruskal-Wallis test showed that there is a meaningful difference between the means of the two measured groups ($p< 0.001$). The types of asbestos fibers based on EDS spectrums and electron microscope images were actinolite, tremolite, and chrysotile. **Conclusion:** The findings of the present study indicated that the concentration of asbestos fibers in the sampleswas higher than the WHO standards for ambient air (0.00005 PCM f/ml). The use of asbestos fibers in car brake and clutch, as well as in asbestos cement sheet and insulation in buildings are among the most important sources of air pollution in the city.

Keywords: Airborne asbestos; Zahedan; Air pollution

Introduction

Asbestos is a term referred to a group of six different types of mineral fibers (amosite, chrysotile, crocidolite, tremolite, actinolite, and anthophyllite) which are naturally found in the environment. Chrysotile is one of the members of the Serpentine family, and other types of asbestos are subgroups of amphiboles.[1] All types of asbestos are dangerous and can cause cancer; however, more

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attention is paid to amphiboles in comparison to chrysotile in terms of health risks.[2] Health risks of amphiboles are proven to be three times more than chrysotile.[3] Crocidolite (the blue asbestos), is more dangerous than other types of asbestos.[4] Chrysotile, which is known as the white asbestos, is the major commercial type of asbestos. For several years, it was believed that chrysotile doesn't cause any diseases, yet the IARC (International Agency for Research on Cancer) put it in the list of carcinogenic substances in 2009. Unique features of asbestos fibers provide the opportunity to make use of it in various industries such as military,[5] shipbuilding,[6] insulation,[7] construction,[8] automobile brake pads manufacturing,[9] and mines.[10] Numerous clinical and epidemiological findings have shown that asbestos fiber is capable of creating diseases in many body parts like skin (blisters), lungs (asbestosis, cancer, mesothelioma, liquid discharge in the pleural cavity, and benign plaques of the pleural cavity), and probably digestion system cancer,[11] larynx cancer,[12] thyroid,[13] and nerves system disorders.[14]

Public health services of the United States offered the first occupational guide in 1938 to asbestos exposure, and the relationship between lung cancer and asbestos among asbestos textile workers in the United Kingdom was confirmed in 1995.[15] Silicosis and asbestosis were two types of the first diseases spread among the world laborers (6-7). 70 to 80 percent of mesothelioma cases, which is a rare and scarce kind of cancer, is due to occupational exposure to asbestos.[16] Considering the fact that there is 30 to 60 percent of asbestos fibers used in automobile brake pads and clutches,[17] they are regarded as an air pollution source in cities.[18-20] Environmental Protection Agency of the United States has estimated that every year 32 million kilograms of asbestosare scattered in the environment as a result of the attrition of brake pads.[18] It was in 1960 that asbestos was utilized in Iran, the most consumption of which was in the construction of asbestos-cement pipes and sheets[21] and the amount of asbestos importing to Iran is 55000 tons in a year.[22] The asbestos usage has been forbidden in Iran since July 23, 2007. However, it has a lot of usages in many industries due to its unique features.[23]

The results of a study by Saleh pour on 64 people of 78-80 ages with malignant pleural mesothelioma showed that 17.2% of these cases were in the construction of asbestos-cement pipes and sheets, 9.4% were in the industry of insulation, 9.4% were in the construction, 4.7% were in the asbestos storage, 3.1% were in the digging/ drilling of oil and gas wells, and 3.1% were in brake pad manufacture industry.[24] Population growth in metropolises, old architecture of streets, inversely proportional, lack of public transportation vehicles, and many other parameters cause heavy traffic in the metropolises of Iran. One of the most important ways of asbestos release into the air in big cities is through the attrition of automobile brake pads. In traffic, drivers have to repeatedly use brake and clutch. Every time they use brakes, some of the brake pad is eroded and the asbestos in that is released and scattered in the air and due to surface air flows near the asphalt, which multiples car movements, asbestos is scattered in the city environment. Owing to increase in population, the number of motor vehicles and usage of asbestos construction products, this study was done with the aim of determining the type and concentration of asbestos fibers in the air of high-traffic areas of Zahedan city in the summer of 2015 to define asbestos pollution in this city.

Methods

Selecting the sampling location

This cross-sectional study was conducted in the summer in five high-traffic areas Table 1 with permissions from the traffic police of Zahedan city. After determining the traffic load of the mentioned areas, for each area 4 samples in 4 successive non-holiday/ business days were selected; 8 samples from traffic-free areas (2 areas which were free from

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commuting vehicles) and 2 samples as field controls (control filter was a filter which was put inside the holder, but the sampling was not done).

Sampling and sample analysis

asbestos sampling was done with MCE (Millipore thickness of 25 mm, poor size of 0.8 micrometer) and an open-face cylinder holder in the flow rate of 2 liters per minute. First, the flow rate of the sampling pump was calibrated by an electronic calibrator and then the sampling was done for 240 minutes in the selected locations. In order to correct the volume of sampled air, barometric temperature and pressure were recorded during the sampling time. Traffic load of the location two of sampling (Amir-El-Momenin/ Sa'di crossroad) was more than the other 3 selected crossroads in the time of sampling (in traffic jams). After the sampling, the samples were transmitted to laboratory and were analyzed based on the NIOSH 7400 technique.[25]

In this technique, the filter is divided into 2 parts. Half of the filter is prepared on a microscope lam to determine the density of asbestos and is clarified by acetone vapor (with acetone vaporizer). In order to increase the reflexivity coefficient, tri-acetone is used. Afterward, they were analyzed with phase-contrast microscopy (PCM) (AXIOM; Germany) and Walton-Beckett graticule (type G-22) to reach the utmost of 100 fibers or the least amount of 20 fibers and the utmost of 100 fields. Although this technique is a relatively fast and simple technique, and fibers with a length of more than 5 microns are counted in, it is not possible to distinguish asbestos fibers from non-asbestos ones. To this end, the other half of the 25-mm-filter was prepared to determine the type of fibers with Scanning electron microscope and Energy-dispersive X-ray spectroscopy spectrum. After counting asbestos fibers with a phase-contrast microscope (PCM), the density of fibers on the filter was first calculated by the number of fibers on millimeter through the following formula.

Formula 1: $E\left(\frac{Fiber}{mm^2}\right) = \frac{(\frac{F}{n_f} - \frac{B}{n_b})}{A_f}$

F: Total number of fibers on the sample filter

nf: Total number of the counted fields

B: Total number of the counted fibers on the control filter

nb: Total counted fields

Af: The surface of the field of Walton-Beckett Graticule (Af = 0.00785 mm^2)

And then the concentration of asbestos fibers in sampling locations was calculated by f/cm^3 through the following formula.

Formula 2: $C(\frac{fiber}{cm^3}) = \frac{E \times A_c}{V \times 10^3}$

E: Fiber density (fiber/ mm^2)

Ac: the effective level of collecting a 25-mm filter (Ac = 385 mm^2)

V: the volume of the sampling air (L)

Data analysis

The data were inserted into SPSS software for Windows ver. 18 and mean and standard deviation of the fibers were calculated in fiber/ml. To identify and determine the fiber types, the EDS spectrum, and SEM images were used. Determining the type of asbestos is possible by comparing fiber components with asbestos components. Each type of asbestos has a defined spectrum of EDS with elements like magnesium, silicone, Fe, and Oxygen. The relative ratio of elements such as Aluminum and Potassium is used for distinguishing asbestos from other mineral elements.[21]

Results

Qualitative analysis of samples with the use of SEM technique showed that by average 50 percent of the collected fibers on the filters were asbestos. This ratio was applied in the quantitative estimation of asbestos fibers density. Based on the sampling results, mean, standard deviation, minimum and maximum

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amounts of asbestos fibers have been reported in table 1.The ratio of average exposure to asbestos fibers in all the crossroads was higher than the limits (0.00005 fiber in ml of air) and the highest level of asbestos concentration was at Imam Khomeini-Azadi and Ami-El-Momenin-Sa'di crossroads. The concentration in the area with no vehicles was also higher than limits and the amount of exposure load at Bazaar Moshtarak crossroad was the least in comparison to the other measured places. To check the normality of variables, Kolmogorov-Smirnov test was used ($p< 0.05$).

The total mean of pollution load in all the sampled locations demonstrated that the mean, standard deviation, and median of pollution load in the areas with less traffic are 0.0003 (0.0003) f/ml and 0.0001; however, in high-traffic areas the counterpart amounts were 0.0012 (0.0004) f/ml and 0.0012 Figer 2. Based on Kruskal-Wallis, the difference between the means of the two measured groups became meaningful with the significance level of $p < 0.001$. Moreover, in the comparison of all the measured samples (28 samples) with the standard amount (0.00005), the Kruskal-Wallis test revealed that average pollution to asbestos in the samples from all the sampled crossroads was meaningfully higher than the standard level ($p = 0.001$).

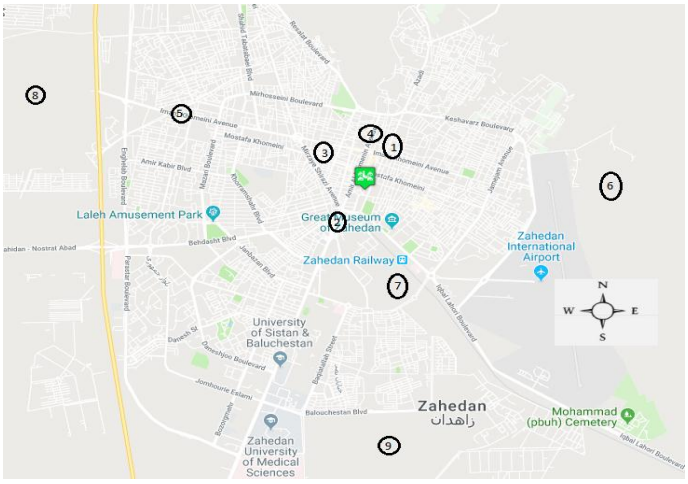

Figure 1. Map of Zahedan, showing the sampling points with high traffic area (1–5), sampling points with the traffic-free area (6-9)

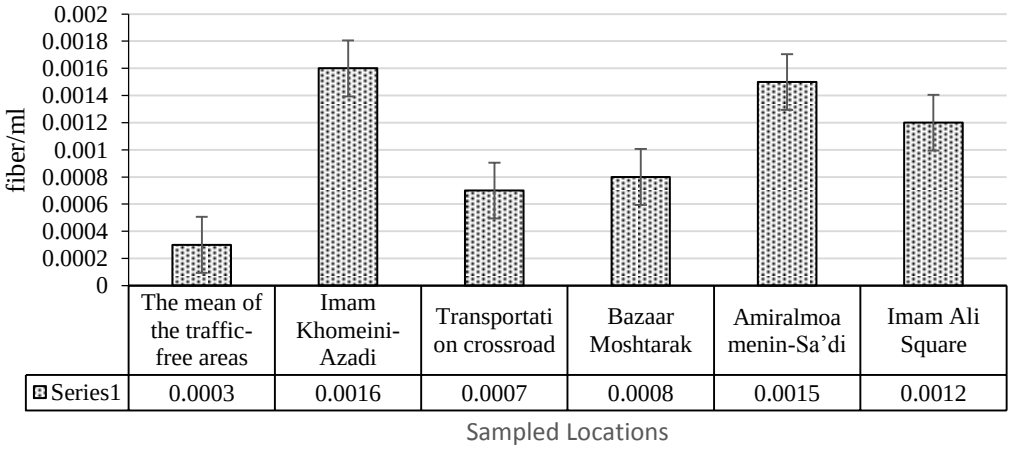

Figure 2. Asbestos fibers concentration in traffic areas of Zahedan

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For determining the elements and types of the fibers, the EDS spectrum and SEM images were utilized. Figures 2 and 3 are the images of fibers that were taken from some raw samples by SEM with fiber EDS spectrum. The results of sample identification with SEM and EDS indicated that fibers present in samples in classification of amphiboles are of actinolite and tremolite types. However, the observed fiber in most of the samples is of chrysotile type.

Table 1. Asbestos fibers concentration in high-traffic areas of Zahedan (f/ml)

Sampling location	Sample number	Geometric mean (SD) f/ml	Minimum f/ml	Maximum f/ml
Imam Ali Square	4	0.0012(0.0004)	0.0009	0.0017
Amir-Sa'di	4	0.0015(0.0005)	0.0011	0.0022
Bazaar Moshtarak	4	0.0008(0.0003)	0.0006	0.0012
Transportation crossroad	4	0.0007(0.0002)	0.0006	0.0011
Imam Khomeini-Azadi	4	0.0016(0.0002)	0.0013	0.0018
The mean of the free traffic areas	4	0.0003(0.0003)	0.00	0.0007

Standard : 0.00005 f/ml

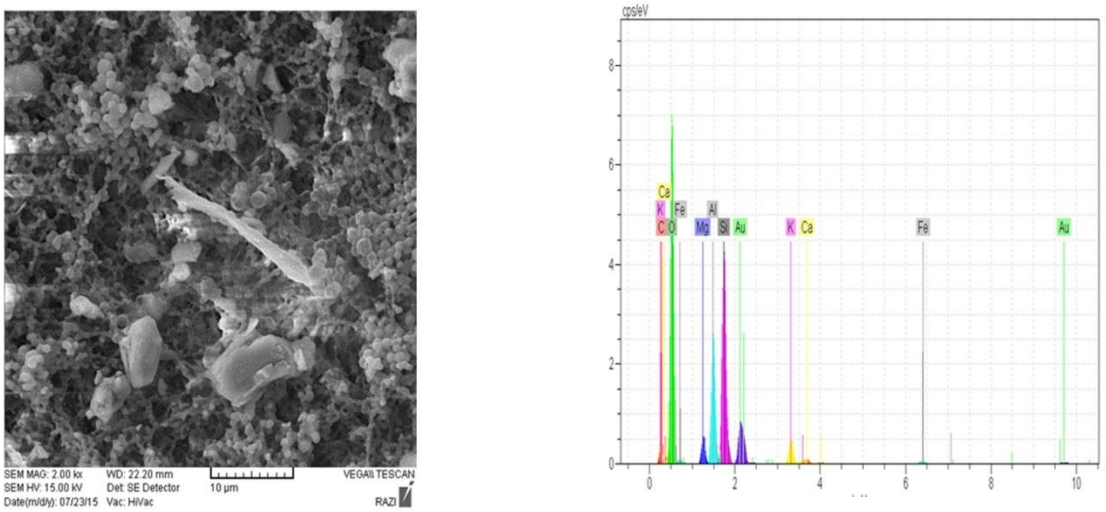

Figure 3. SEM image and EDS spectrum collected from the air tremolite fiber in airborne samples

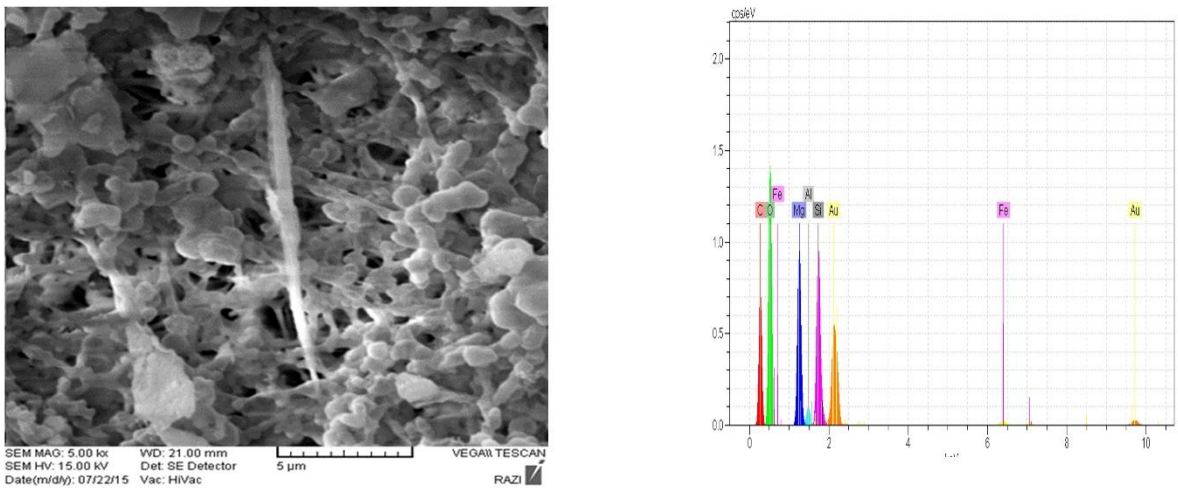

Figure 4. SEM image and EDS spectrum collected from the air chrysotile fiber in airborne samples

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Discussion

As the findings of the present study indicate, asbestos fibers concentration in high-traffic areas of Zahedan was higher than the standard limit (0.00005f/ml) while in traffic-free areas was lower than the standard limits. These results suggest that the main sources of these fibers in high-traffic areas are automobile brake pads and clutches. The highest concentration was at the crossroad of Amir-El-Momenin/ Sa'di (0.0015 f/ml) and Imam Khomeini street (0.0016 f/ml) which suffer from the most traffic load and are the most crowded parts of the city. However, it should be mentioned that using asbestos in different parts of buildings such as insulation and asbestos-cement sheets scatters these fibers in the air at the time of building destruction. The results of a study by Kakooei and his colleague for evaluating the exposure of construction workers in Tehran showed that the highest level of fiber concentration was due to the destruction of buildings having asbestos-cement sheets.[26] Furthermore, a study by Krakowiak for determining the fiber concentration in populous areas of Poland showed that the highest amount of asbestos fiber concentration was near big buildings that had broken or damaged asbestos components. It should be mentioned that the concentration of asbestos fibers inside the buildings was much more than the outside concentration. Another study for this aim done in Moscow demonstrated that when the concentration of asbestos fibers outside the building is 0.009 f/ml, at the same time the concentration inside the building is 0.049 f/ml which shows that the people living in the populous places of the city are in danger of asbestosis diseases.[27,28]

The concentration of airborne asbestos fibers has already been measured in populous cities of Iran including Tehran,[1] Tabriz,[23] Shiraz,[4] Isfahan,[29] and Yazd. [30] The results of the studies show that the concentration of airborne asbestos fibers in the air of these cities was higher than the allowed limit (0.00005 f/ml). These results were similar to the findings of the present study. In a research conducted by Bologna for evaluating the exposure to asbestos near to the asbestos production units in Milan, Italy, the mean of asbestos fibers concentration became lower than 0.001 f/ml, which was lower than the results of the present study.[31]Finxelstein conducted a study on death and mortality among 328 of factory workers of an asbestos-cement factory. The death rate due to malignant tumors was 5 times and the death rate due to lung cancer was 8 times more than the expected limit and out of 58 death cases, 10 cases were due to mesothelioma and 20 cases were due to lung cancer. The outcomes of this review showed a clear relationship among the contact with asbestos fibers, mesothelioma disease, and lung cancer.[32]

Chemical charactristics of asbestos fibers are related to the nature of them since fibers with different element compositions function differently inside the body. The main difference is between chemical structures of chrysotile and amphiboles. Desolation level of chrysotile is more than amphiboles; in addition, it is divided into smaller parts inside the body and cleared from lungs because of its smaller dimensions.[33, 34] SEM image and EDS spectrum of tremolite which has been shown in figure 3; in fact, considering MG and SI and Calcium, it is understood that the fiber is of tremolite type. In a study by Ghorbani which was done in Isfahan, the observed fibers were of chrysotile and tremolite types.[29] Moreover, Kakooei et al. in a research on automobile repair shops in Zahedan came to this conclusion that more than 90 % of the observed fibers were of chrysotile type; tremolite and actinolite from amphibole family were seen in the samples as well.[35]

Conclusion

These findings illustrate that perhaps the main sources of airborne chrysotile and tremolite in cities are brake pads and other automobile parts.

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