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Total Dust and Asbestos Concentrations during Asbestos-Containing Materials Abatement in Korea

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ABSTRACT: This study was performed during the abatement of two asbestos-containing materials (ACM): baumlite board (cement flat board) and ceiling textile. The concentrations of total dust for personal sampling were 0.28 and 1.70 mg/m^3 during baumlite board and ceiling textile abatements, respectively, when calculated with 8-hr time-weighted average (TWA). The geometric mean (GM) asbestos concentrations were 0.005±1.9 and 0.007±1.6 f/cc for personal sampling and 0.004±1.1 and 0.008±1.6 f/cc for area sampling with 8-hr TWA, respectively. Asbestos exposure concentrations were not significantly different during abatement of the two materials ($p>0.05$). Further, no statistical difference existed between personal and area samples during the two abatements ($p>0.05$). The concentrations of personal and area samples during both abatements were below the occupational exposure limit (OEL: 0.1 f/cc) of the Korean Ministry of Employment and Labor (MOEL). The correlation between total dust and asbestos concentrations was low throughout both abatements.

Key words: Abatement,Asbestos,Indoor,Interior materials,Ceiling textile,Baumlite board

INTRODUCTION

Physico-chemical parameters which are contributed to urban indoor and ambient air pollution have been widely studied during recent years (Sekhavatjou and Zangeneh, 2011, Zou *et al.*, 2011, Montero Lorenzo *et al.*, 2011, Alipour *et al.*, 2011, Wang *et al.*, 2011, Cui *et al.*, 2011, Chianese *et al.*, 2012, Barrera *et al.*, 2012, Nejadkoorki and Baroutian, 2012). The use of asbestos rapidly increased in Korea during the latter part of the 20th century due to rapid economic development. An average of about 70,980 tons of raw asbestos was imported annually between 1980 and 1995(Kim, 2009, KITA, 2009). Imported asbestos began to be used in construction materials in the 1960s, which surpassed 82 % of all of them. Specifically, asbestos was most commonly used in slate roof tiles (containing 8~14 % asbestos) as a building exterior material. Baumlite board materials contained about 10 % asbestos as an interior material and ceiling textile materials contained about 3~6 % asbestos. Several asbestos contained materials have been produced and used in Korea, but their production has banned in 2006(Kim and Hoskins, 2010). In these applications, asbestos has since been replaced by substitutes such as wollastonite and sepiolite(MOE, 2006). As the average life expectancy of building construction materials in Korea is 20~30 years, it is necessary to perform reconstruction and repairs to prevent building deterioration. The disassembling and abatement of buildings containing asbestos has increased in frequency every year: from eight places in 2004, to 115 in 2005, and 749 in 2006 (MOE, 2006). The abatement of buildings containing asbestos in 2020 is expected to be four times higher than that in 2007. Although removal of asbestos-containing buildings is increasing, workers do not have a clear understanding about the danger of asbestos. Numerous studies have been performed on the concentrations of airborne asbestos during building abatement(Choi, 2002, Kim, 2009, Lange *et al.*, 2006, Lange *et al.*, 2005b), from man-made mineral fibers (Krewski and Rainham, 2007, Lim *et al.*, 2004) and on the relationship between area and personal samples (Dufresne *et al.*, 2009, Lange *et al.*, 2005a).

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The notification (No. 2009-32) of the Ministry of Employment and Labor (MOEL) of guidelines related with asbestos abatement was legislated in August, 2009 in Korea. According to the new act, asbestos analysis should be carried out by designated agencies, and abatement should be performed by an expert company. Further, the airborne asbestos concentration should be lower than 0.01 f/cc after the abatement(MOEL, 2009). However, the measurement of airborne asbestos concentration during the abatement is not mandated and the asbestos concentration during abatement has not investigated. It is needed whether the asbestos concentration during abatement should be measured and controlled in the abatement worksite. Further, there is limited information on the exposure of workers conducting various types of asbestos abatement (Lange *et al*., 2006). Previous studies never compared the correlation between total dust and asbestos concentrations during asbestos contained interior building materials removal work in Korea. This study was performed to the exposure assessment of workers for total dust and asbestos during baumlite board and ceiling textile abatements that were the majority of removal work of asbestos containing interior materials in Korea.

MATERIALS & METHODS

This study was performed from February to April of 2010. The asbestos abatement of four office buildings with baumlite board and ceiling textile was investigated. The baumlite board abatements consisted of removing toilet partitions and the ceiling textile abatements were replacing the corridor and ceiling of the offices. Fifty-six samples were taken with personal sampling: 30 for total dust and 26 for asbestos. Average working (sampling) times for asbestos abatement were about 90 minutes (range: 63~234). Area samples were collected using an air sampler (AirLite Pump. SKC Ltd. U.S.A.) at a flow rate of 1.9~2.2 liter/min, whereas the personal samples were collected from the breathing zone (Lange *et al*., 2000). The cassette holder and filter were replaced with cassette cowl holders (diameter 25 mm, length 50 mm) with a mixed cellulose esters filter (MCE, diameter 25 mm, pore size 0.8μ3). DryCal™ (BIOSINT. Co. U.S.A.) was used to calibrate the flow rate of the pumps by calculating the air volume sampled. Sampling and fiber counting of asbestos were carried out according to the NIOSH method 7400 using phase contrast microscopy (Nikon, Japan) at 400X following method A rule. To investigate concentration of asbestos in total dust and exposure concentration of workers, total dust sample was taken as follows. Mixed Cellulose Esters filter (MCE) which was used in sampling asbestos in cassette before collecting asbestos sample was put in desiccator for 48 hours. Then it was weighed by Electronic Analytical Balance (OHAUS, Switzerland) and taken by assembling it to cassette. As MCE filter was hygroscopic after taking sample, it was desiccated for about 48 hours again and we analyzed it by gravimetric analysis method. We sampled by using area and personal method. First, when doing personal sampling, we opened sampler of which the air inhaled in breath zone of the worker and installed it open-face. When doing area sampling, we installed sampler of 1.2~1.5 meters over the floor on which asbestos were removed and dismantled following official test method of Ministry of Labor. Exposure data were calculated as non and 8-hr time weighted average (non-TWA and 8hr-TWA). The Wilcoxon Rank Sum test was used to compare the average concentrations in the personal and area samples. Spearman Rank correlation coefficient was used to evaluate the correlation between total dust and asbestos concentrations. All statistical analyses were performed with SPSS statistical package version 12.0 (SPSS Inc., Chicago, IL, USA).

RESULTS & DISCUSSION

The asbestos removal procedures in this study involved the removal of baumlite board and ceiling textile in the offices. As shown in Table 1, the geometric mean (GM) airborne concentration of total dust for personal sampling was 2.46 mg/m^3 and was 0.54 mg/m^3 for area sampling during baumlite board removal. The GM was 10.66 mg/m^3 for personal sampling and was 10.49 mg/m^3 for area sampling during ceiling textile removal, when calculated with non-TWA. The concentration of some samples exceeded over the OEL (10 mg/m^3) during abatement. The GM of total dusts was 0.28 mg/m^3 for personal sampling and 0.06 mg/m^3 for area sampling during baumlite board removal when calculated with 8-hr TWA. The GM was 1.70 mg/m^3 for personal sampling and was 1.47 mg/m^3 for area sampling during ceiling textile removal. Although the concentrations of personal sampling were slightly higher than those of area sampling, the difference was not significantly different ($p>0.05$).The GM concentration of asbestos was 0.044 f/cc (geometric standard deviation: GSD = 2.0) for personal sampling and 0.033 f/cc (GSD = 1.1) for area sampling during baumlite board abatement when calculated with non-TWA. The GM concentration of asbestos was 0.054 f/cc (GSD = 1.6) for the personal samples and 0.067 f/cc (GSD = 1.4) for the area samples during ceiling textile abatement. But the concentration of some samples exceeded over OEL (0.1 f/cc) from the range (0.014~0.114 f/cc) for personal sampling and it (0.031~0.106 f/cc) for area sampling during ceiling textile abatement when calculated with non-TWA. The GM concentration of asbestos was 0.005 f/cc (GSD = 1.9) for personal sampling and 0.004 f/cc (GSD = 1.1) for area sampling during baumlite board abatement when calculated with 8-hr TWA. The GM concentration of asbestos was 0.007 f/cc (GSD = 1.6) for the personal samples and 0.008 f/cc (GSD = 1.6) for the area samples during ceiling textile abatement. The concentration of all samples did not exceed over OEL (0.1 f/cc) from the range (0.002~0.009 f/cc) for personal sampling and it (0.003~0.014 f/cc) for area sampling during ceiling textile abatement when calculated with 8-hr TWA (Table 1). The differences of GM concentration between personal and area sampling were not significant ($p>0.05$). These results were consistent with those of

Table 1. Total dust and asbestos concentrations during asbestos-containing materials (ACM) abatement

Material		Type of Sampling	Number of Samples	non-TWA GM(±GSD)	non-TWA Range	8-hr TWA GM(±GSD)	8-hr TWA Range
Total dust (mg/m^3)	Baumlite Board	Personal	8	2.46(±1.4)	1.71~3.37	0.28(±1.4)	0.18~0.45
		Area	4	0.54(±2.8)	0.19~1.71	0.06(±2.9)	0.2~0.21
	Ceiling Textile	Personal	22	10.66(±2.1)	1.37~33.28	1.70(±3.0)	0.39~16.15
		Area	23	10.49(±2.3)	1.15~40.82	1.47(±2.8)	0.18~5.36
Asbestos (fiber/cc)	Baumlite Board	Personal	8	0.044(±2.0)	0.014~0.082	0.005(±1.9)	0.002~0.009
		Area	4	0.033(±1.1)	0.029~0.036	0.004(±1.1)	0.003~0.004
	Ceiling Textile	Personal	18	0.054(±1.6)	0.014~0.114	0.007(±1.6)	0.003~0.014
		Area	15	0.067(±1.4)	0.031~0.106	0.008(±1.6)	0.004~0.013

*TWA = time weighted average
*GM = geometric mean
*GSD = geometric standard deviation

Kim *et al*. (Kim *et al*., 2009) who reported an airborne asbestos concentration (GM) at asbestos abatement sites in Korea of around 0.007 f/cc (0.001~0.34 f/cc).

Asbestos exposure concentrations did not differ significantly between baumlite board and ceiling textile abatements ($p>0.05$). Further, no statistical difference was observed between the area and personal samples during the two abatements ($p>0.05$). Other studies also reported an absence of any statistical difference in airborne asbestos concentration between the area and personal measurements (Lange, 2005, Lange *et al*., 1996). However, some other studies (Dufresne *et al*., 2009, Lange and Thomulka, 2000) reported that personal samples contained statistically higher concentrations of asbestos than area samples. Personal and area samples were simultaneously collected in this study. Area sampling is often used rather than personal sampling due to convenience (Niven *et al*., 1992). Generally, area samples are used for environmental and public health protection and for evaluation of emission controls and general concentrations of fibers at the work location, including inside and outside of the regulated area, i.e., the containment area (Lange *et al*., 2000, Lange *et al*., 1995). Personal samples can also be used for decision criteria beside those of occupational exposure (Lange, 1999, Lange *et al*., 1996). The GSD values for the area and personal data suggested a relatively high variation, but still within the range of variation reported for occupational exposure (Lange *et al*., 1996). The occupational exposure limit (OEL) as designated by the MOEL of Korea is 0.1 f/cc TWA for any type of asbestos. The concentrations of the personal and area samples in the two abatements were below the OEL (0.1 f/cc) of MOEL, as the time required for baumlite board and ceiling textile removal was mostly less than 4 hours.

The correlation coefficient (r) of the total dust and asbestos in baumlite board removal working places was 0.119 for personal sampling and 0.600 for area sampling. Despite being higher for area sampling, the difference was not significant because of the small samples ($p>0.05$). The r-value of the total dust and asbestos in ceiling textile removal working places was 0.024 for personal sampling and 0.202 for area sampling ($p>0.05$). The correlation of total dust and asbestos concentrations was low throughout both abatements. Because when the long deposited dusts were shattered in removal working place, they were weakly the correlation of total dust and asbestos. Another study reported that they had not expected any relationship between fiber concentrations and total dust because of the low correlation (Lange *et al*., 2000). This study showed the same results that the correlation between total dust and asbestos concentrations during asbestos abatement work in Korea was low.

The study limitation was the small sample sizes because of the difficulty in getting permission to investigate the workplaces. Also we didn't analyze an electronic microscope like scanning electron microscope (SEM) and transmission electron microscope (TEM) for more accurate analysis.

CONCLUSION

The concentrations of personal and area samples during both abatements were below the OEL (0.1 f/cc) of MOEL. And the correlation of total dust and asbestos concentrations was low throughout both abatements. Although total and asbestos concentration did not exceed the OEL when calculated with 8-hr TWA, some sample concentrations during abatements did exceed the OEL when calculated with non-TWA.

Therefore, further exposure assessment needs to be conducted during asbestos abatement in Korea due to the carcinogenicity of asbestos (A1).

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