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Project Summary

Airborne Asbestos Concentrations During Buffing of Resilient Floor Tile

A study was conducted to determine the level of airborne asbestos concentrations during routine spray-buffing of asbestos-containing floor tiles at 17 schools in northern, central, and southern New Jersey. Although the schools selected do not represent a statistical random sample, they do represent a cross section of floor conditions and floor-care maintenance practices. Increased airborne asbestos levels during spray-buffing were measured at 12 of the 17 schools. The increase was statistically significant at 7 of the 17 schools. Overall, the mean relative increase in airborne asbestos concentrations during spray-buffing with the high-speed machines (1000 to 1500 rpm) was statistically significantly higher than that during buffing with low-speed machines (175 to 330 rpm). Machine speed appeared to have a significant effect on the structure morphology of the airborne asbestos structures generated during spray-buffing. Results of the study indicate that spray-buffing can generate asbestos-containing particles from the surface of asbestos-containing resilient floor tile. The estimated 8-hr time-weighted average (TWA) of total fiber concentrations (0.093 f/cm^2 maximum) in the breathing zone of the machine operators (as determined by phase contrast microscopy [PCM]) did not exceed the Occupational Safety and Health Administration (OSHA) action level of 0.1 fibers per cubic centimeter (f/cm^3), 8-hr TWA.

This Project Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Although no longer manufactured in the United States, asbestos-containing resilient floor tiles are installed in residential dwellings, institutions, commercial and public office buildings, and industrial facilities. The organic matrix in floor tiles may be either asphalt or polyvinyl chloride, and their dimensions are either 9 in. by 9 in. or 12 in. by 12 in. The asbestos in nearly all floor tiles is chrysotile, which is dispersed throughout the thickness of the tile. Although these floor tiles are considered nonfriable, the frictional forces exerted on these materials during routine floor-care maintenance operations can generate asbestos-containing particles.

The principal types of maintenance performed routinely on resilient floor tiles include spray-buffing and dry burnishing, and wet scrubbing and stripping followed by refinishing. The U.S. Environmental Protection Agency (EPA), school districts, and the Resilient Floor Covering Institute have monitored airborne asbestos levels during wet stripping of asbestos-containing floor tiles. These studies have shown elevated levels of asbestos structures in the air during the stripping operation (based on transmission electron microscopy [TEM]), but the 8-hr TWA concentrations (based on PCM) were below the OSHA permissible exposure limit and action level of 0.2 and 0.1 f/cm^3 of air, respectively. If the action level is exceeded, periodic personal air monitoring, employee training, and medical surveillance are required (29 CFR 1910.1001). The results of the two analytical techniques differ mostly because PCM does not detect the smaller fibers (<5 μm in length and <0.25 μm in width) as measured by TEM. Also, the OSHA methodology requires a length to width ratio (aspect ratio) of 3:1 or greater whereas the TEM methodology has an aspect ratio of 5:1 or greater. In response to concerns raised by school districts and building managers regarding the release of asbestos structures during stripping operations, the EPA issued interim guidance on appropriate procedures for the stripping of asbestos-containing floor coverings.

Little data are available for evaluating the extent of asbestos structures released during other floor-care maintenance procedures, such as spray-buffing. Spray-buffing is the restorative maintenance of a previously polished floor by use of a suitable floor-polishing machine immediately after the surface has been mist-sprayed with an appropriate product whereby the wet application is buffed to dryness. The levels of airborne asbestos structures released during spray-buffing could be higher than those during wet stripping, especially if the floor has been poorly maintained (i.e., minimal wax layer), is worn, or is otherwise damaged.

The Risk Reduction Engineering Laboratory (RREL) of the U.S. EPA and the Environmental Health Service (EHS) of the New Jersey Department of Health (NJDOH) conducted a study to evaluate airborne asbestos concentrations during routine spray-buffing of asbestos-containing floor tile. The primary objectives of this study were (1) to determine the airborne asbestos concentrations during routine spray-buffing of asbestos-containing resilient floor tile in a cross section of schools in northern, central, and southern New Jersey, and (2) to compare the fiber concentrations measured by PCM during routine spray-buffing of asbestos-containing floor tile with the OSHA action level of 0.1 f/cm^3 of air, 8-hr TWA (29CFR1910.1001).

Study Sites

This study was conducted at 17 schools, distributed among eight school districts, in northern, central, and southern New Jersey. Although these schools do not represent a statistical random sample, they do represent a cross section of floor conditions and floor-care maintenance operations.

Access to the schools was coordinated directly by the Environmental Health Service of the New Jersey Department of Health (EHS-NJDOH). The EHS-NJDOH collected bulk samples of all floor tiles; and documented floor-care practices, floor conditions, and characteristics of the floor-buffing equipment and materials in each school, as well as other variables that might have an effect on the release of asbestos structures.

In all of the schools, the existing custodial staff performed the floor-care maintenance operations. The floors were prepared (i.e., dry and/or wet-mopped) and spray-buffed in accordance with established practices and procedures at the respective schools.

Sampling Strategy

The first study objective was to determine whether airborne asbestos concentrations increased during the spray-buffing of floor tile. This was addressed by collecting air samples before and during floor-buffing operations. A maximum of two distinct areas were tested in each school studied. Immediately before buffing operations began, three baseline, fixed-station, area air samples were collected in each test area under normal building conditions (i.e., no intentional air disturbance beyond that attributable to normal occupancy activity in the area). Three personal breathing-zone samples were collected during buffing operations for comparison with the baseline samples. These samples also were taken under normal occupancy conditions (i.e., no air disturbance beyond that attributable to the buffing itself). These samples were collected in the breathing zone of the buffing machine operators so they would be representative of airborne asbestos levels during spray-buffing operations. The three baseline and three personal breathing zone samples were analyzed by TEM.

The second study objective was to compare total fiber concentrations during buffing operations with the OSHA action level of 0.1 f/cm^3, 8-hr TWA. This was achieved by collecting one sample in the breathing zone of the machine operator during the spray-buffing in each area. These samples were collected in accordance with OSHA sampling protocols and analyzed by PCM.

To confirm the percentage and type of asbestos in the floor tile, bulk samples of each type of floor tile present in each school were collected.

Sampling Methods

Fixed-Station Area Air Samples

The baseline, fixed-station, area air samples were collected on open-face, 25-mm-diameter, 0.45-μm-pore-size, mixed cellulose ester (MCE) filters with a 5-μm-pore-size MCE diffusing filter and a cellulose support pad contained in a three-piece cassette. The filter cassettes were positioned on tripods approximately 5 ft above the floor, with the filter face at a 45° angle toward the floor. The filter assembly was attached to an electric-powered (110 VAC) 1/6-horsepower vacuum pump operating at a flow rate of approximately 9 L/min. Air volumes ranged from 564 to 916 L. The sampling pumps were calibrated with a precision rotameter both before and after sampling.

Personal Breathing Zone Air Samples

Three personal breathing zone air samples were collected on the same filters described in the previous section and were analyzed by TEM. A fourth personal breathing zone sample was collected on a 25-mm-diameter, 0.8-μm-pore-size MCE filter, and a cellulose support pad contained in a three-piece cassette with a 50-mm conductive extension cowl. This fourth personal breathing zone sample was collected in accordance with OSHA protocols and analyzed by PCM.

The four filter cassettes were positioned in the breathing zone of the buffing machine operator. Each filter was attached to approximately 50 ft of Tygon tubing that was attached to an electric-powered (110 VAC) 1/6-horsepower vacuum pump operating at a flow rate of approximately 9 L/min. Air volumes ranged from 617 to 970 L. To achieve the target air volume of 600 L in the time required to spray-buff the test area, traditional battery-powered, personal sampling pumps could not be used because of their limited airflow rates (approximately 2 L/min with the 0.45-μm-pore-size MCE filter).

Bulk Floor Tile Samples

Bulk samples were collected of each type of floor tile present in each school. Each sample consisted of a 2-in. by 2-in. section of floor tile. A 2-in. by 2-in. template was used to delineate the area on the floor tile. A hammer and wood chisel were used to remove the tile, which was then placed in a labeled Ziploc plastic bag. The exact location of the sample was recorded on a plan drawing of the building.

Analytical Methods

Air Samples

The 0.45-μm-pore-size MCE filters were prepared and analyzed in accordance with the nonmandatory TEM method specified in the Asbestos Hazard Emergency Response Act (AHERA) Final Rule (October 30, 1987; 40 CFR Part 763). Each of the 0.8-μm-pore-size MCE membrane filters was analyzed by PCM. These 0.8 μm sample filters were prepared and analyzed according to the NIOSH 7400 protocol (Revision 3, June 5, 1989, National Institute of Occupational Safety and Health Manual of Analytical Methods).

Bulk Floor Tile Samples

The type and percentage of asbestos in the floor tile were determined by polarized light microscopy analysis in accordance with the EPA test method "Interim Method for Determination of Asbestos in Bulk Insulation Samples" (EPA 600/M4-82-020). A confirmatory analysis was performed on floor tile from 8 of the 17 schools. The samples were analyzed by TEM in accordance with Chatfield's Method (SOP-1988-02, Revision No. 1: Analysis of Resilient Floor Tile). Portions of a freshly fractured edge of the bulk samples were analyzed by scanning electron microscopy to examine the condition of the floor tile surface.

Statistical Methods

Descriptive statistics were calculated for each school and each area within a school. These descriptive statistics included the sample size; arithmetic mean, minimum, and maximum airborne asbestos concentrations; and the arithmetic standard deviation.

A two-factor analysis of variance (ANOVA) was used to compare airborne asbestos concentrations before and during floor buffing. Each school was considered separately. The experimental factors in the ANOVA analysis were the sample period (baseline, during) and area within a school (A or B). If only one area was studied at a school, the analysis was reduced to a one-factor ANOVA, which is equivalent to a Student's t-test.

Quality Assurance

Specific quality assurance procedures outlined in the AHERA rule were used to ensure the precision of the collection and analysis of air samples; these included filter lot blanks, open and closed field blanks, and repeated sample analyses (replicate and duplicate analyses).

Results and Discussion

Study-Site Characteristics

Resilient Floor Tile

The resilient flooring in the 28 study sites (representing 17 schools) included mostly 9-in. by 9-in. tiles and some 12-in. by 12-in. tiles. Although the asbestos content of the tiles ranged from 1% to 38%, the content of most of the tiles exceeded 10%. The spray-buffed areas ranged from 727 to 3386 ft^2; the average area was approximately 2150 ft^2. Any floor areas with damaged (e.g., broken) or missing tiles were isolated to prevent their contact with the buffing machine.

Floor Care Maintenance Practices

Sixteen of the 17 schools used a black pad for stripping the floors, whereas EPA's interim procedure guidelines for the stripping of resilient floor coverings recommend the use of the "least abrasive pad possible". The schools wet-stripped and refinished the floors one to three times a year (during the summer, winter, or spring breaks).

The floors were dry- and/or wet-mopped before they were spray-buffed. All of the schools dry-mopped the floors, and nine of the schools both dry and wet-mopped the floors. The floors are typically spray-buffed once a year; however, some schools spray-buffed the floors one to three times each week.

Buffing Equipment and Materials

Twelve of the schools used buffing machines operating at 1000 to 1500 rpm and five used buffing machines operating at 175 to 330 rpm. The appropriate buffing pad (i.e., a white pad with high-speed machines and a red pad with low-speed machines) was used at all of the schools except two: school No. 1 used a red pad with a high-speed machine, and school No. 13 used a green pad (designed for heavy scrubbing and light stripping applications) with a low-speed machine.

Airborne Asbestos Concentrations Before and During Spray-Buffing

Three samples were collected before and three during routine spray-buffing of asbestos-containing floor tile in each area within a school. Table 1 presents the descriptive statistics (i.e., mean, minimum, maximum, and standard deviation) separately for each school/area combination and each sampling period (i.e., baseline and during spray-buffing). Figure 1 shows the average airborne asbestos concentrations at each area before and during spray-buffing.

Increased airborne asbestos levels during spray-buffing were noted at 12 of the 17 schools. The increase was statistically significant at seven of these schools (Nos. 1, 5, 6, 7, 12, 14, and 17). When compared with baseline measurements taken before buffing, airborne asbestos concentrations were qualitatively the same or lower during buffing at the remaining five schools (Nos. 2, 4, 9, 10, and 16).

Overall, the mean relative increase in airborne asbestos concentrations during spray-buffing with the high-speed machines (1000 to 1500 rpm) was significantly higher ($p=0.0326$) than the relative increase during spray-buffing with the low-speed machines (175 to 330 rpm). On average, airborne asbestos concentrations were approximately 5 times higher during spray-buffing than before spray-buffing with the higher speed machines; whereas, spray-buffing with the lower-speed machines showed a 2-fold increase.

Airborne Asbestos Concentrations Based on Frequency of Spray-Buffing

Spray-buffing is routinely performed (one or more times weekly) at 7 schools, whereas spray-buffing is performed less frequently (once per month to once per year) at the remaining 10 schools. The mean airborne asbestos concentrations measured before buffing at the schools in which spray-buffing is routinely performed (0.035 s/cm^3) was significantly greater ($p=0.0004$) than the mean baseline concentration measured at schools in which spray-buffing is performed less frequently (0.007 s/cm^3).

Personal Breathing Zone Concentrations of Total Fibers

Table 2 presents total fiber concentrations measured in the machine operator's breathing zone during spray-buffing, as determined by PCM. The actual time spent buffing the floors ranged from 64 to 97 min.

School maintenance workers do not typically spray-buff floors for a full 8-hr work shift. According to school custodians at the five sites (Nos. 6A, 10A, 11A, 13B, and 16B) that showed measured levels above 0.1 f/cm^3, the average time spent buffing floors on a typical day ranges from 1.5 to 2.5 hr. Assuming that a maintenance worker spends no more than 2.5 hr/day buffing the floor and has no additional exposure to asbestos for the remainder of the day, the estimated 8-hr TWA concentrations for all of these sites would be less than the OSHA action level of 0.1 f/cm^3, 8-hr TWA. The maximum estimated 8-hr TWA exposure concentration (0.093 f/cm^3, 8-hr TWA) was measured at Site 11A.

Morphology and Size Distributions of Asbestos Structures

The TEM analysis of the 163 samples collected before and during spray-buffing yielded a total of 4598 asbestos structures, of which more than 99% were chrysotile and less than 1% were amphibole. The asbestos in nearly all floor tiles is chrysotile. Overall, the asbestos structures were primarily matrices (approximately 80%) and to a lesser extent, fibers, clusters, and bundles.

The structure morphology for asbestos structures observed before (i.e., baseline)

Table 1. *Summary of Airborne Asbestos Concentrations Measured By TEM Before and During Buffing of Floor Tile*

	Asbestos Concentration, s/cm³ (N=3)							
	Baseline				During Buffing			
Site	Mean	Minimum	Maximum	Standard Deviation	Mean	Minimum	Maximum	Standard Deviation
1A	0.004	0	0.009	0.005	0.014	0.010	0.019	0.005
1B	0.001	0	0.005	0.003	0.013	0.005	0.019	0.007
2A	0.006	0	0.010	0.006	0.003	0	0.005	0.003
3A	0.001	0	0.005	0.003	0.011	0	0.025	0.013
3B	0	0	0	0	0.003	0	0.009	0.005
4A*	0	0	0	0	0	0	0	0
5A	0.009	0.005	0.014	0.005	0.107	0.088	0.123	0.018
6A	0.030	0	0.076	0.040	0.163	0.065	0.302	0.123
6B	0.029	0.015	0.054	0.021	0.205	0.137	0.291	0.078
7A	0.003	0	0.010	0.006	0.145	0.097	0.179	0.043
7B	0.008	0.005	0.014	0.005	0.414	0.379	0.464	0.044
8A	0.011	0.005	0.020	0.008	0.025	0.015	0.030	0.009
8B†	0.041	0	0.103	0.055	-	-	-	-
9A	0.010	0	0.020	0.010	0.003	0	0.009	0.005
10A	0.086	0	0.254	0.145	0.067	0.033	0.094	0.031
10B	0.038	0.030	0.045	0.008	0.032	0.029	0.035	0.003
11A	0.033	0.020	0.054	0.018	0.056	0.015	0.097	0.058
11B	0.029	0.005	0.069	0.034	0.077	0.067	0.090	0.012
12A	0.012	0.009	0.014	0.003	0.067	0.043	0.113	0.039
12B	0.065	0.029	0.113	0.043	0.096	0.062	0.151	0.048
13A	0.015	0	0.040	0.022	0.082	0.015	0.206	0.040
13B	0.194	0.051	0.390	0.175	0.290	0.225	0.329	0.057
14A	0.006	0.005	0.010	0.003	0.052	0.020	0.087	0.034
15A	0.094	0.058	0.126	0.034	0.151	0.102	0.216	0.059
16A	0.001	0	0.005	0.003	0.001	0	0.004	0.002
16B	0.003	0	0.005	0.003	0	0	0	0
17A	0.001	0	0.005	0.003	0.056	0.052	0.059	0.004
17B	0.050	0.024	0.065	0.023	0.114	0.035	0.189	0.077

* *Summary statistics are based on two samples (N=2).*
† *The samples collected during spray-buffing were too heavily loaded with particulate to count.*

low-speed buffing was comparable with that observed during low-speed buffing. That is, similar percentages of fibers, bundles, clusters, and matrices were observed both before and during low-speed buffing. The structure morphologies for asbestos structures observed during high-speed buffing, however, were distinctly different; these morphologies showed that the percentage of asbestos fibers observed during high-speed buffing was approximately 2.5 times greater than the percentage of fibers observed before buffing. In contrast, the percentage of asbestos matrices were greater before high-speed buffing than during buffing. One possible explanation for a decrease in the number of asbestos matrices during buffing is that the high-speed buffing pulverizes any asbestos-containing particles lying on the surface of the floor and/or any particles contained in the wax layer on the floor tile. This could also explain the increase in the percentage of asbestos fibers during high speed buffing. Another possible explanation for the increase in the percentage of asbestos fibers during high-speed buffing could be the abrasion of surficial fibers from the floor tile.

Overall, less than 1% of the asbestos fibers measured before and during were greater than 5 µm in length. Although comparable structure size distributions were observed before and during low-speed buffing, a larger percentage of the structures observed during high-speed buffing were less than 1 µm compared to structures observed before high-speed buffing. The increased number of structures less than 1 µm in length could result from (1) the pulverization of asbestos structures on the floor surface and/or asbestos structures contained in the wax layer, and/or (2) the abrasion of surficial fibers from the floor tile.

Conclusions

Spray-buffing can cause asbestos structures to be generated from the surface of asbestos-containing resilient floor tile. Increased airborne asbestos concentrations during spray-buffing were measured at 12 of the 17 schools studied. The increase was statistically significant at seven of these schools.

Overall, the mean relative increase in airborne asbestos concentrations during spray-buffing with the high-speed machines (1000 to 1500 rpm) was significantly higher than the relative increase during spray-buffing with the low-speed machines (175 to 330 rpm). On average, airborne asbestos concentrations were approximately 5 times higher during than before spray-buffing with the high speed machines; whereas, spray-buffing with the low-speed machines showed a 2-fold increase.

Machine speed appears to have a significant effect on the structure morphology of the airborne asbestos structures generated during spray-buffing. The percentage of asbestos fibers observed during high-speed buffing was approximately 2.5 times greater than that before buffing; whereas, the percentage of asbestos fibers observed during low-speed buffing was approximately 1.3 times greater. The percentage of asbestos matrices measured during high-speed buffing were approximately 1.2 times lower than before buffing; whereas, the percent

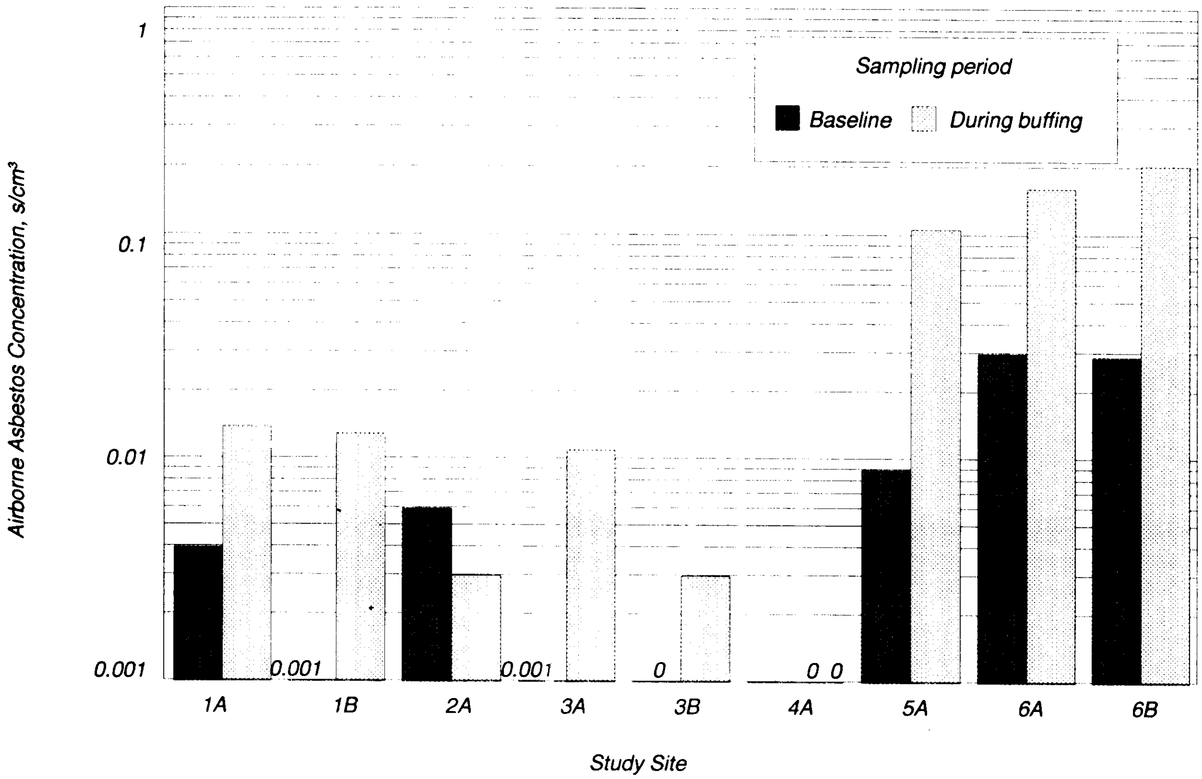

Figure 1. Average airborne asbestos concentrations (measured by TEM) before and during buffing of asbestos-containing resilient floor tile (continued).

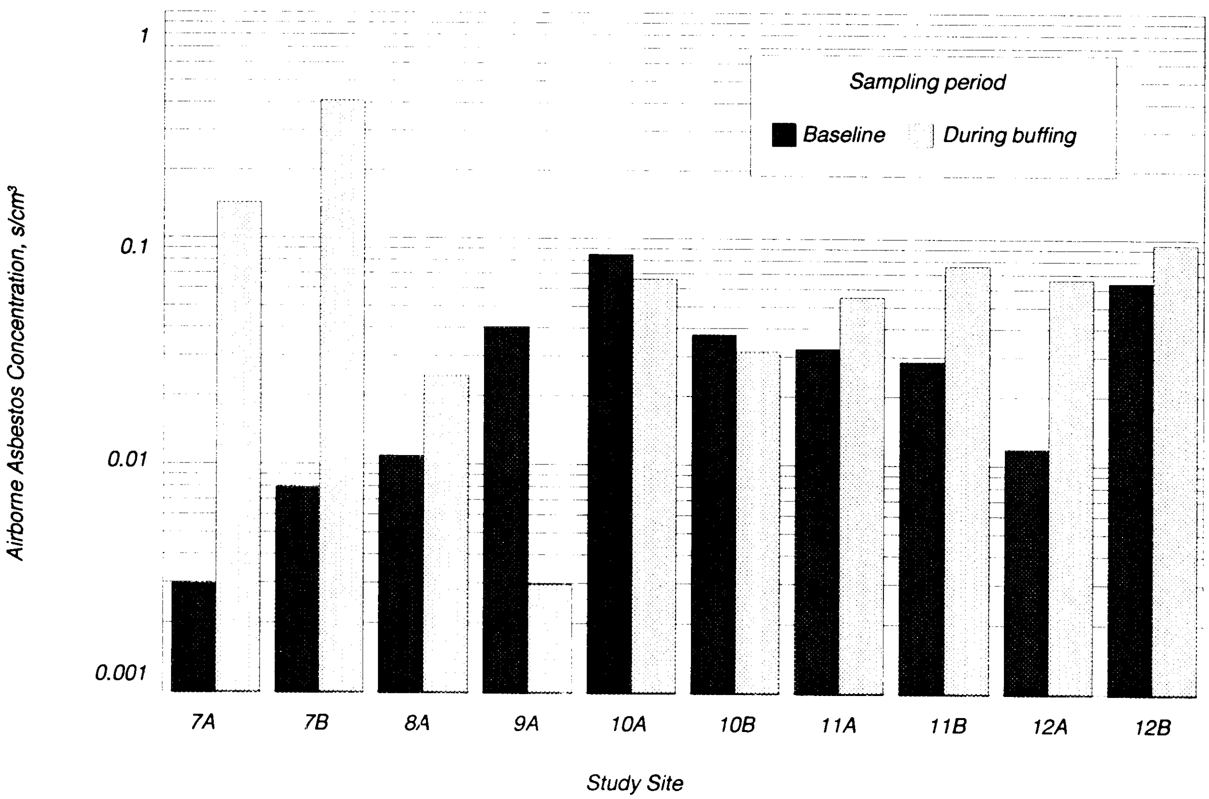

Figure 1. (continued).

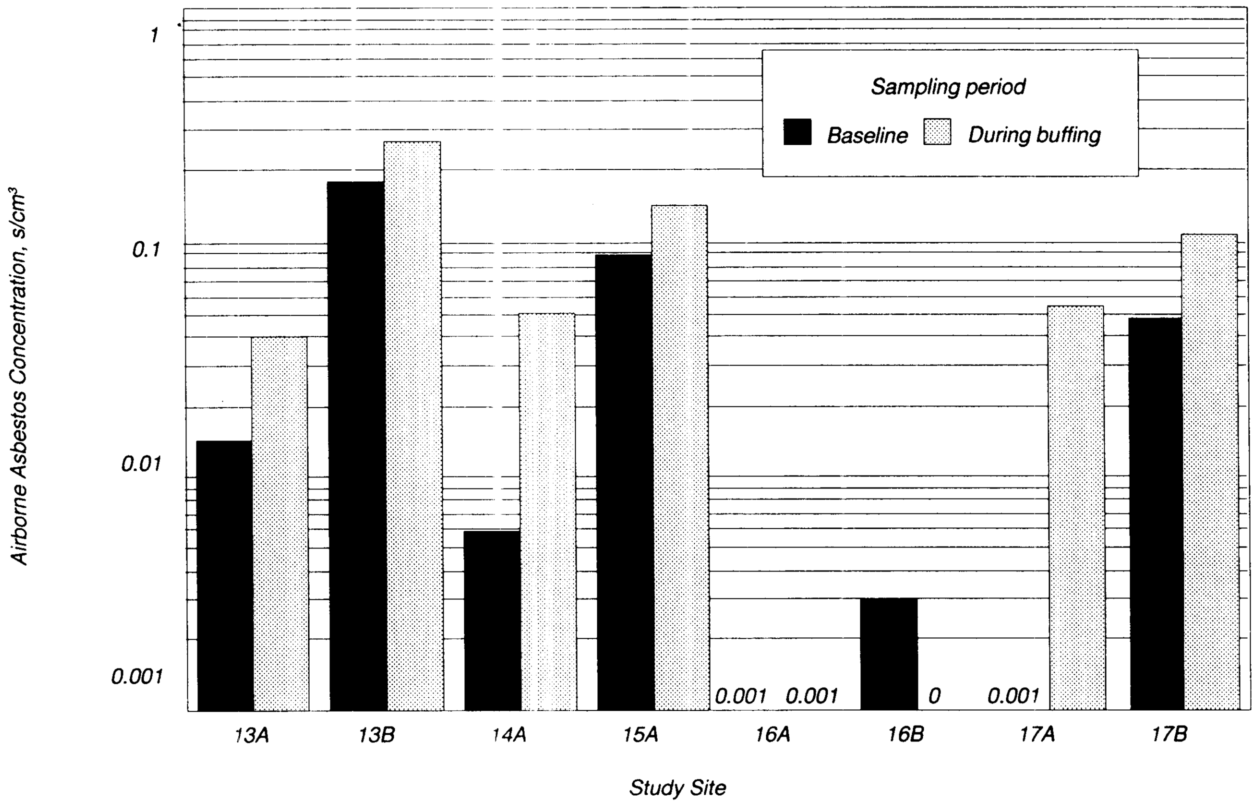

Figure 1. (concluded) .

Table 2. *Total Fiber Concentrations During Buffing of Resilient Floor Tile (As Measured by PCM)*

Site	Total Fiber Concentration, f/cm³
1A	0.033
1B	0.034
2A	0.078
3A	0.077
3B	0.076
4A	0.024
5A*	-
6A	0.130
6B*	-
7A	0.048
7B*	-
8A*	-
8B*	-
9A	0.030
10A	0.133
10B	0.061
11A	0.295
11B	0.065
12A	0.067
12B	0.070
13A	0.085
13B	0.220
14A	0.042
15A	0.076
16A	0.080
16B	0.104
17A	0.027
17B	0.055

* Samples were all too heavily loaded with particulate to count.

age of asbestos matrices measured during low-speed buffing was essentially unchanged (i.e., <0.4% lower).

The estimated 8-hr TWA of total fiber concentrations (0.093 f/cm^3 maximum) in the breathing zone of the machine operators (as determined by PCM) did not exceed the OSHA action level of 0.1 f/cm^3, 8-hr TWA.

Recommendations

Further research is recommended to study the effect of buffing methods on the release of asbestos structures from the surface of asbestos-containing resilient floor tiles. A study should be designed to evaluate the extent of asbestos release during application of the two buffing methods (low-speed spray-buffing and high-speed dry-buffing) on three levels of floor care (poor, intermediate, and good). The results of this study would define the need for and nature of guidance for the buffing of asbestos-containing resilient floor tiles.

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The complete report, entitled "Airborne Asbestos Concentrations During Buffing of Resilient Floor Tile," (Order No. PB93-227 551/AS; Cost: $27.00, subject to change) will be available only from:
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