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Evaluation of Lift and Passive Sampling Methods During Asbestos Abatement Activities

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Traditionally, asbestos-containing materials (ACM) and abatement of ACM have been evaluated through visual observations and air sampling (Environmental Protection Agency 1990). These techniques, although having many beneficial aspects, have several limitations, e.g., time period of monitoring for air samples, and have been suggested to be inappropriate under certain conditions for monitoring in-place ACM, e.g., long term qualitative analysis of ACM deterioration (EPA 1990). Lift sampling, i.e., using surface particulate adhesive samplers (SPAS), has been suggested as an applicable and feasible methodology for evaluating the deposition of asbestos and other materials (e.g., lead) on indoor and outdoor surfaces, and spread and release during an episode in a building, (Lange et al. 1992, 1993, 1994). Passive (deposition) sampling (a stationary sample plate with a SPAS) has also been reported to be useful in evaluating abatement practices and long-term monitoring of ACM (Lange et al. 1994). By combining traditional practices (e.g., visual observations) with surface (lift) and deposition sampling a more quantitative assessment of in-place ACM, abatement and episodic events may be feasible.

This investigation evaluated SPAS and deposition sampling during an asbestos abatement project in a school. Efficiency of SPAS (surface or lift samples) was determined and a relationship with stationary air samples was evaluated with deposition samplers (particulate plates). The application of these methods for the asbestos abatement industry is discussed.

MATERIALS AND METHODS

This study was conducted at an elementary school in Pennsylvania that was undergoing asbestos abatement of asbestos-containing floor tile and mastic and boiler/pipe insulation in the Fall of 1992. The asbestos in the floor tile/mastic and boiler/pipe

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insulation was primarily chrysotile, with an approximate percentage of 3 and 30, respectively. Asbestos abatement of the boiler/pipe insulation and floor tile was performed using standard removal methods (EPA 1990a), while the floor mastic was removed by a HEPA shot-blaster machine (Blastrac machine) (Wheelabrator Corporation, Newnan, GA). Areas (e.g. corners) of mastic that could not be removed with the shot-blast machine were removed by scrape-lift techniques and mastic remover.

Commercially available SPAS samplers and deposition plates were used with sampling and analysis procedures performed as previously described (Lange et al. 1993, 1994). Deposition and area air samples were obtained from the same location and were collected for the same time period. Eight match samples were collected during this project, with at least one for each time period that the shot-blaster was operated.

Surface sampling was performed by activating the adhesive film, placing the sticky surface on the "sample area", pressing firmly with fingers over the entire area of the lift sampler (area being approximately 7 X 5cm), quickly removing and placing back in the sampler container. Preparation (activation) and sampling required approximately 5 to 10 seconds to perform (Lange et al. 1994).

Initial (before abatement-day one) lift samples were obtained during setup and final samples (after abatement - day fifteen) were obtained a day after both final aggressive air sampling and completion of tear-down. Most before and after abatement lift samples were matched (in similar locations) to determine changes in surface fiber concentrations. A majority of the lift samples were obtained from surfaces in locations inside the building where abatement did not occur that were "sealed off" from the abatement (work) area by critical barriers. Critical barriers consisted of a single layer of 6 mil polyethylene that was attached by double-back tape with the edges sealed with duct tape. Doors were the only connecting openings between the abatement area and non-abatement area, which were sealed as described. The building's heating system consisted of boiler (steam heat) or individual heaters in the rooms. Sealed areas were not pre-cleaned.

Preparation and activation of deposition samplers were performed by the supplier. Deposition plates were sealed with paraffin tape, which was removed along with the lid and placed face up for dust fall collection. After collection, the lid was replaced and re-sealed with paraffin tape, which made the passive sampler air

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both SPAS samplers and deposition plates were provided by RJ Lee Group, Inc., Monroeville, Pennsylvania tight. Deposition samples were obtained during abatement, inside the work area, in the same locations where stationary air samplers were collected. The time period of air and deposition sampling were identical. Air samples were collected in an open face position with a flow rate of approximately 10 L/min using a high flow air pump as previously described (Lange et al. 1993). These air samples were analyzed by phase contrast microscopy (PCM), which counts all fibers (structures) greater than 5 um in length (Stewart 1988; EPA 1990). Final aggressive air samples were obtained using a flow rate of approximate 10 L/min for about two hours and analyzed by transmission electron microscopy (TEM) and PCM (EPA 1990). All sample results were reported as fibers (structures) per cubic centimeter (f/cc).

SPAS and deposition samplers were prepared using a direct preparation technique and analyzed by TEM, with the concentration reported in structures (fibers) per 0.2 mm^2 (s/0.2 mm^2) (Schneider 1986; Lange et al. 1993, 1994). A previously published (descriptive) qualitative indexing (Lange et al. 1993) was used for evaluating the SPAS. If fiber bundles are detected, the sample is arbitrarily defined as elevated or a concentration above background. Lift sample data are reported as uncorrected values (Lange et al. 1994). The analytical sensitivity for this indexing, in s/0.2 mm^2, is based on the observation of one structure (fiber) in 30 grid openings (0.2 mm^2). Using Poisson counting statistics, a count (structures) of four would be required at a 95% confidence level to ensure the analyst of having at least one structure in the defined area. The quantitative threshold for this method is defined as four structures in the 30 grid opening area. Index structure values are rounded up to the highest integer and zero asbestos is reported as an index value of zero (Lange et al. 1993).

Efficiency of lift samplers (percent collection efficiency) was determined by obtaining initial and repeat samples from the same surface location and during the same period of time (Lange et al. 1994). Percent collection efficiency (%CE) was calculated by the equation below, which was previously described by Guth (1989).

$$\%CE = 100 - [(\text{repeat value}/\text{initial value}) \times 100]$$

The Mann Whitney test was used in evaluating a difference between fiber concentrations in similar areas before and after abatement as determined by lift samplers (Siegel 1956; Lange et al. 1994). Descriptive statistics were used to analyze various data (Lange et al. 1993).

RESULTS and DISCUSSION

Lift sample results, before and after abatement, are shown in Table 1. All samples were obtained from horizontal (level)

Table 1. Lift sample concentration, in s/0.2 mm^2, for before and after abatement from various locations.

Location	Before <5um	Before >5um	Before Total	After <5um	After >5um	After Total
Kitchen[1]	117	5	117	94	<5	95
Kitchen[1]	5	<5	5	41	<5	41
Kitchen[1]	5	<5	5	165	<5	165
Kitchen[2]	<5	<5	<5	41	<5	41
Kitchen[2]	76	<5	<5	864	<5	864
Kitchen[3]	73	<5	73	20	<5	20
Kitchen[4]	<5	<5	<5	229	<5	229
Boiler Room[5]	68	5	73(<5)	144	5	149
Boiler Room[5]	81	<5	81(<5)	991	<5	991
Boiler Room[5]	5	<5	5(<5)	458	10	468
Gym[6]	36	<5	36(35[+])	NS	NS	NS
Gym[6]	<5	<5	<5(<5)	NS	NS	NS
Gym[6]	<5	<5	<5(<5)	NS	NS	NS
Locker[7]	10	<5	10(<5)	<5	<5	<5
Locker[7]	NS	NS	NS	<5	<5	<5
Wood Shelf[8]	NS	NS	NS	51	<5	51
Cabinet heater[9]	NS	NS	NS	763	<5	763
Cabinet heater[9]	NS	NS	NS	5	<5	5
Cabinet heater[9]	NS	NS	NS	648	<5	648
Cabinet heater[9]	NS	NS	NS	61	<5	61

() concentration of repeat sample, NS - No sample, [1] metal main serving countertop, [2] metal preparation sink area, [3] top of alarm, [4] metal table beside sterilizer, [5] top of small gas heater, [6] top of storage cabinet, [7] top of locker, [8] from an open closet, [9] top of a wall heater. [+] value had 4 structures over 5um in length. visual dust levels, as described by Lange et al. 1994, were heavy (gym and boiler room), light (locker), and all others locations were medium.

smooth painted metal surfaces, except for the locker and shelf locations. The locker surface was smooth, with a painted metal surface, but had an approximate 20^{o} angle; the shelve was level and constructed of varnished wood. Sample locations were either from sealed areas (kitchen, gym, locker cabinet heater) or were in the work area (boiler room, shelf). Abatement in the boiler room consisted of the pipe/boiler insulation, while the shelf was in the area that had the floor/tile mastic removed. Lift samples were compared using before and after concentrations in two groups, sealed and abated areas (boiler room only). A statistical difference was observed for all comparison locations ($p < 0.01$), the kitchen area only ($p=0.013$), boiler room (abated area) only ($p=0.05$) and all sealed locations combined (kitchen, boiler room and locker) ($p=0.019$). These observed statistical differences are a result of an increase in fibers that are less than 5 um in size.

Lift sample results suggest that elevated fiber levels (less than 5 um) existed before and after abatement, based on a previously described indexing method (Lange et al. 1993) which found "clean" surfaces to have less than five structures in an approximate 0.2 mm^2 area (Lange 1994). The elevated fiber levels, and statistical significance before and after abatement, suggest that the abatement cleaning methods used in this (i.e., HEPA vacuum and wet wiping) project were ineffective for minimizing residual surface fibers, especially fibers less than 5 um. Final aggressive air sample results (ten PCM-NIOSH 7400 and five TEM-AHERA analysis) were all below 0.01 f/cc. Similar disparities have been noted in other studies (Lange et. al. 1993). This suggests that final air samples may not take into account surface concentrations (Ness 1994).

In sealed areas, the elevated fiber levels after abatement support the practice of complete pre or post cleaning of the entire work location. However, since a clear definition of contamination, particularly as related to surface levels and health effects, has not been established, caution must be exercised in evaluating and interpreting these results. It is possible that the observed levels in sealed areas represent a natural background, which may not be effective to mitigate (Lange et al. 1994).

Lift sample efficiency (%CE) was shown to be variable, although could be categorized by interrelating and comparing visual dust levels, as previously described by Lange et al. (1994). Heavy and light dust samples were approximately 50 and 100% efficient, respectively. It is likely that in heavy and probably most median visual dust levels the sticky surface of the sampler becomes saturated, having a limited affinity for particles (Millette and Brown 1991). Based on this and previously reported data (Lange et al. 1994), the visual surface dust level should be reported along with SPAS sample results.

Deposition and air sample concentrations during abatement with the shotblast machine were low. Area air samples ranged from 0.001 to 0.031 f/cc during the project using PCM-NIOSH 7400 analysis. All surface samplers were below the quantitative threshold (<4 fibers per 0.2 mm^2). Although air samples were performed for the work area, and were not personal exposure samples, these data suggest that the shotblast floor tile removal method is effective and efficient in controlling emissions. The criteria for evaluating an abatement method is its work capability, minimal generation of contaminants from the process and final cleanup requirements. In general, the shotblast machine, based on the data collected during this abatement project and observations made, meet these criteria.

No correlation, using linear regression, was possible between deposition and air sample results because of the non-detection levels for deposition samplers (Hwang and Wang 1983). Previous deposition studies of particles have reported unexplained differences for observed and theoretical deposition concentrations (Nickolson 1988). Additional investigation is warranted to evaluate the use and applicability of deposition plates for monitoring abatement and its relationship with air samplers (Ness 1994).

This study suggests that lift samplers are applicable for evaluating surface contamination. SPAS sample efficiency appear to be reproducible, based on this and a previous study (Lange et al. 1994). The shotblast method appears to be effective in removal of mastic, and does not result in the generation of high airborne fiber levels. Based on this study, lift and deposition samplers are applicable for monitoring asbestos abatement. In the future, these methods may be used to determine the effectiveness of cleaning, monitoring of abatement practices, and condition of in-place ACM (Lange et al. 1994).

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