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Project Summary

Evaluation of Dust Samplers for Bare Floors and Upholstery

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The high volume small surface sampler (HVS3) has been validated for measuring lead, pesticides, PAHs, and PCBs in dust in carpets. This is described in ASTM method D5438-94. However, a reliable method is needed for measuring dust and the pollutants in dust on bare floors and upholstery to estimate exposure from such sources. The full report describes tests using the new high volume furniture sampler (HVFS) to collect dust from ten used sofas, test pillows with flat and plush covering, and bare floors. A high efficiency particle filter was used after the cyclone in three tests to determine the penetration of the cyclone by couch dust. Particles above 5 μm are captured in the cyclone. Less than 0.22% of the dust penetrated the cyclone used on the HVFS. A prototype High Volume Tripod Sampler (HVTS) was tested on bare floors and carpets, as well. The Baltimore R&M Cyclone Sampler (BRMCS) was also tested.

The HVS3, HVTS, HVFS, and BRMCS all had similar average efficiencies on bare floors or surfaces ranging from 84.2 to 86.7%. The HVFS cyclone with a flexible wand and a notched nozzle showed an average dust collection efficiency of 88.6 to 90.5% on light and heavy loading on foam cushions covered with flat and plush coverings. The HVTS had an average efficiency of 62% on plush carpet and 64.5% on level loop carpet on plush and flat upholstery. The BRMCS had a collection efficiency of 44.1% on plush and 61% on level loop carpet as well as 71.8% and 87.2% on plush and flat upholstery. Methods for sampling bare floors and upholstered furniture were developed. The HVS3 and HVFS provide a reliable method of sampling bare floors and upholstered furniture. The BRMCS is a reliable way to sample bare floors. The HVTS and BRMCS are lower in cost than the HVS3 but have limitations for sampling carpets.

The full report was submitted in fulfillment of Subcontract 46534(g217338-02)-0003EQ between Battelle Memorial Inst. and Engineering Plus, Inc. This report covers the period between January 3, 1993, and Sept. 30, 1993. Work was completed as of Sept. 30, 1993.

This Project Summary was developed by EPA's National Exposure Research Laboratory, Research Triangle Park, NC, 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 the back).

Introduction

House dust is recognized as an important source of potential exposure to allergens, lead, pesticides, and other pollutants in the home. The dust in a rug or couch and on a bare floor may also contribute to personal exposure to airborne particles, allergen, and other pollutants. The High Volume Small Surface Sampler (HVS3) is widely used to collect house dust samples for chemical analysis. Detailed tests have shown the HVS3 to be useful in sampling rugs for lead and semi-volatile organic compounds, specifically pesticides, poly-

cyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs).

Evaluation of the Need for a Filter in the Sampling Train for Upholstery Dust

The HVS3 collects its sample in a cyclone. It has been previously shown that over 99% of rug dust is collected in the cyclone. In order to determine the collection efficiency of the cyclone on couch dust, a particle filter was placed in the sampling train behind the cyclone for a series of three tests of dust collection from upholstered furniture. The average weight of the dust on the filter was less than 0.22% of the total catch on three tests. The remaining study was conducted without the filter in the system.

Validation Tests of the HVS3, HVTS, HVFS, and Baltimore R&M Cyclone Sampler for Sampling Bare Floors and Upholstery

Bare Floors

Based on previous testing, two loadings of 0.1 and 0.5 g/m^2 were selected to represent light and heavy loading conditions for application of dust to a bare floor for testing the HVS3. A combined house dust which had been collected from a number of Seattle homes, sieved through a 100 mesh screen (< 150 μm), and finally mixed, was spread on a cleaned section of an asphalt tile floor and, subsequently, a varnished wood floor. The surface was then sampled with the HVS3.

A modification of the HVS3, called the High Volume Tripod Sampler (HVTS), was designed by Cascade Stack Sampling Systems to minimize air currents next to the floor. This modification had the same nozzle and cyclone as the HVS3. This prototype of a floor sampler suspends the sampling head from a wheeled tripod and powers it with a portable vacuum cleaner that can be slung over the shoulder. A four horsepower (10.0 amp) Royal Can Vac™, Model 3004 canister vacuum cleaner was used to move air through the HVTS. The Can Vac weighs 9 pounds and the HVTS weighs 13 pounds.

The average efficiency of the HVTS for the same light and heavy dust loading was 84.2 and 85.1%, which on bare floors is nearly the same as with HVS3 (86.7 and 84.8% respectively). The HVTS was also tested on carpets, and the results averaged 62% for plush and 64.5% for level loop. The carpets were plush and level loop test carpets meeting the ASTM method F655-89 standards. The recovery rate of the HVTS is less than the 67 to 69% recovery rate of the HVS3.

Upholstery Sampling

The HVFS upholstery sampler with a notched nozzle and flexible wand was designed by CS3. The same Royal Can Vac™ used with the HVTS was used to move air. This design preserves the essential elements of the HVS3, although it was necessary to modify the nozzle to avoid sealing to the fabric being sampled.

Two popular coverings of couch cushions, a flat poly-cotton (53% cotton and 47% polyester) and a velvet (65% cotton and 35% polyester), were selected for testing. Each cushion was built around a high density polyurethane foam core. The air flow through the HVFS was adjusted to 14.4 L/S (30.5 CFM) and the pressure drop across the nozzle to 10.2 cm (4 inches) water gauge for the flat poly-cotton cushion. The air flow was set at 11.6 L/S (24.5 CFM) and the pressure drop across the nozzle at 31.8 cm (12.5 inches) water gauge for the velvet cushion. The light and heavy surface loadings of 2.5 and 5.6 g/m^2 for sampling were selected on the basis of the loadings found on ten used sofas. The dust was placed in a 45.7cm x 45.7cm (18"x18") square on the cushion and embedded with a 34 pound mallet. The dust collection efficiency of the HVFS furniture sampler is shown in Table 1. The average efficiency of dust collection varied within a range of 87 to 90% for light and heavy loadings on velvet and flat cushions.

Comparative Tests

The Baltimore R&M Cyclone Sampler (BRMCS) was developed by the Kennedy Krieger Institute as a sampler for window sills and similar hard surfaces.

The BRMCS uses the same cyclone as the HVS3 with a one-inch Tygon© tubing flexible sampling wand and nozzle. The nozzle consists of a notched end on the tube. A Royal Hand Vac™, Model No. 553 (2.0 amp), is used to move air. A paper bag was used in the Royal Hand Vac™ in the conventional way. The BRMCS was tested on a bare wood surface, upholstery, and carpets using a modified ASTM method F609-89. The protocol used for collecting dust with the BRMCS and the HVFS were developed for the University of Rochester lead dust study by the National Center for Lead Safe Housing. The BRMCS had an average collection efficiency of 84.7% on bare floors, 71.8 and 87.2% on velvet and flat upholstery, as well as 44.1% on plush and 61% on level loop carpet.

Sampling Upholstery for Dust, Lead, Organic, and Allergens

The samples collected from the ten used sofas were sieved through a 100 mesh screen and analyzed for total dust, fine dust, lead, organic, and allergens. The samples were collected with the HVFS furniture sampler followed by a Hoover Brush Vac™, Model No.S1137, with a power-driven brush in the nozzle. Each surface that was sampled was passed over eight times in two directions with each sampling nozzle. The HVFS collected 72.4 grams and the Hoover Brush Vac™ collected 80.4 grams of total dust from the sofa cushions. The HVFS and Brush Vac dust samples from each couch were combined before sieving.

The lead was analyzed using EPA method SW846 with flame atomic absorption. The couch fine dust lead concentrations ranged from 130 to 380 μg/g with an average of 229 μg/g.

Dust mite allergens in a combined sample were measured at 11.1 μg/g for D. Pteronyssinus (Der p I) and 5.2 μg/g for D. Farinae (Der f I). Above 10 μg/g is considered a high exposure for mite allergen. Cat allergen was measured at 37.2 μg/g for F. domesticus (Fel d I). Above 8 μg/g is considered a high exposure for cat allergen.

Table 1. *Efficiency of Dust Samplers*

	HVS3	*HVTS*	*HVFS*	*BRMCS*
Bare Floor	*85% —87%*	*84%—85%*	*84%*	*85%*
Rugs				
Plush	*69%*	*62%*	*NA*	*44%*
LL	*67%*	*65%*	*NA*	*61%*
Upholstery				
Velvet	*NA*	*NA*	*87%—90%*	*72%*
Flat	*NA*	*NA*	*89%—91%*	*87%*

LL=Level Loop
NA= Not Applicable

Results and Discussion

Validated methods of sampling of upholstered furniture and bare floors are necessary to estimate exposure. The three devices (HVS3, HVTS, and BRMCS) tested were equally effective (84.2 to 86.7% efficiency) in collecting dust from bare floors. The HVFS with a cyclone, wand, and notched nozzle was effective in sampling upholstery and collected 88.6% to 90.5% of the dust applied to cushions.

Using the cyclone currently used on the HVS3 on the other samplers allowed high air flows that were unaffected by the size of the sample collected. A large representative sample can usually be collected in ten minutes. The cyclone allowed less than 0.22% of the total couch dust to pass.

The prototype HVTS and the BRMCS are both lower in cost than the HVS3 but have their limitations. The HVTS can be used effectively on bare floors and hard surfaces. The HVTS efficiency on carpets was 5% below that of the HVS3. The BRMCS is lowest in cost, easier to carry, and can be used to sample bare surfaces effectively. Its efficiency on velvet and flat cotton-poly cushions was 71.8 and 87.2% respectively. Its efficiency on plush and level loop carpet was 44.1 and 61% respectively. It has no way to monitor a drop in air flow due to blinding of the bag, leaks or motor wear. It will also take longer to acquire a representative sample from a carpet.

It is easier to sample for, and may be more effective to monitor exposure to many toxic substances, by monitoring house dust rather than indoor or outdoor air. There is also a need to continuously improve the cost effectiveness of such sampling methods. The two lower cost dust sampling methods evaluated in this study (i.e., the HVTS and the BRMCS) have potential and with additional development work can contribute to effective exposure analysis on rugs and upholstery as well as bare surfaces. New procedures are provided in the full report for sampling bare floors, hard surfaces, and upholstered furniture.

Conclusions and Recommendations

This study has demonstrated that the HVS3 can obtain a reliable sample of dust from bare floors. The efficiency of all the samplers on bare floors, rugs, and upholstery are shown in Table 1. Two lower cost samplers, the prototype HVTS and BRMCS were also evaluated. The HVS3, HVTS, and BRMCS all had similar average efficiencies on bare floors or surfaces ranging from 84.2 to 86.7%. The HVFS showed an average dust collection efficiency of 88.6 to 90.5% on light and heavy loading on foam cushions covered with flat poly-cotton and velvet coverings. The HVTS had an average efficiency of 62% on plush carpet and 64.5% on level loop carpet. The BRMCS had a collection efficiency of 71.8 and 87.2% on velvet and flat upholstery as well as 44.1% on plush and 61% on level loop carpet. The efficiency of the HVTS is less than that obtained by the HVS3 but consistent across carpet types. The BRMCS is not sufficiently consistent with surfaces other than bare floors and hard surfaces. However, both the HVTS and BRMCS represent an important advance and can be expected to improve with further development. The method for sampling carpets has been revised to include bare floors. A new method for sampling furniture is also included in the appendix of the full report.

The dust loading found in ten used sofas delivered to the Seattle Salvation Army collection station ranged from 0.95 to 12.27 g/m^2 for total dust and 0.11 to 4.9 g/m^2 for fine dust (< 150 micrometers). The lead concentration in this dust averaged 229 μg/g, with a range of 130 to 380 μg/g. A combined sample of couch dust contained a high concentration of 16.3 μg/g and 37.2 μg/g of mite and cat allergen respectively.

There are several important questions that remain to be answered to assess and manage the exposure from pollutants in dust on bare floors, carpets, and upholstery. We recommend

1. Measuring the lead, pesticides, PAHs, PCBs, and allergen in upholstered furniture and on bare floors and carpets in a sufficiently large, representative sample of homes located in large cities.
2. Documenting the effect of track-in and dust control as well other cleaning techniques on exposure to the pollutants from upholstered furniture, carpets, and bare floors.
3. Doing additional development work to improve the cost-effectiveness of dust sampling devices.

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***Robert G. Lewis** is the EPA Project Officer (see below).*
The complete report, entitled "Evaluation of Dust Samplers for Bare Floors and Upholstery," (Order No. PB96-157474; Cost: $21.50, subject to change) will be available only from
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