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Project Summary

Evaluation of HVS3 Sampler for Sampling Polycyclic Aromatic Hydrocarbons and Polychlorinated Biphenyls

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A polyurethane foam (PUF) filter was positioned after the cyclone in the High Volume Small Surface Sampler (HVS3) to determine the penetration of the cyclone by polycyclic aromatic hydrocarbon (PAH) and polychlorinated biphenyl (PCB) adsorbed on house dust. Less than 3% of the PAH and less than 5% of the PCB were found on the PUF filter compared with the cyclone catch. Therefore, the HVS3 without a PUF filter can quantitatively collect PAH and PCB in house dust, and it was used to collect house dust samples from seven houses.

The collected house dust, foundation soil, and entryway soil samples were analyzed for PAH, PCB, and lead (Pb). The house dust, foundation soil, and entryway soil samples were spiked with a known amount of perdeuterated PAH, then extracted with hexane (C_6), and analyzed by gas chromatography/mass spectrometry (GC/MS) to determine PAH. Quantitative recoveries of the spiked perdeuterated PAH were obtained and ranged from 80 to 110%. A similar analytical procedure was used to determine PCB, except that 10% ether in C_6 was used as the extracting solvent and the extract was fractionated by silica gel column chromatography prior to GC/MS analysis. Quantitative recoveries of the spiked ^{13}C-labeled PCB were also obtained (73 to 100%). The dust and soil samples were analyzed for Pb by energy dispersive X-ray fluorescence (XRF).

The concentration of PAH was higher in the house dust than in the foundation soil. The PAH concentrations in the entryway soil samples were higher than that in the house dust samples in three houses, and similar or lower concentrations were observed in the remaining houses. The PAH concentrations of entryway soil were higher than that in the foundation soil samples in all houses. The sum of the concentrations of all the target PAH in the house dust ranged from 6.1 to 26 μg/g (ppm), and that in the foundation soil ranged from 1.1 to 3.7 ppm. The sum of the concentrations of PAH in the entryway soil samples varied from 2.9 to 20 ppm. The concentration of the sum of all the target PCB in the house dust and soil varied from 260 to 760 ng/g (ppb) and 58 to 240 ppb, respectively. The concentration of Pb in the house dust ranged from 250 to 2250 ppm and 200 to 4000 ppm, respectively. For all but three houses, higher concentrations of Pb were found in the foundation soil than in the house dust. By contrast, concentrations of PAH and PCB were higher in the house dust than in the soil samples.

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This Project Summary was developed by EPA's Atmospheric Research and Exposure Assessment Laboratory, Re-

search 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 back).

Introduction

House dust is becoming recognized as an increasingly important source of nonoccupational exposure to Pb and pesticides. Other data suggest that PAHs and PCBs may also be persistent in the environment and collect in soil. Menzie et al. estimate that urban soils may contain from 600 to 3000 ppb of PAH, with the higher values resulting in areas of heavy traffic or industrialization, compared to 5 to 100 ppb in background forest soils. With some of the PAH identified as potential carcinogens, the PAH content of house dust may add significantly to the health risks of very young children who typically spend a lot of time crawling on floors and carpets and may have a daily dust intake of 0.02 to 0.2 g. There is very little data currently available on PAH and PCB concentrations in house dust and its possible origins. One potential source of PAH and PCB in house dust is the foundation soil surrounding the house.

The HVS3 can collect a reproducible sample of surface dust from different surfaces, particularly carpeted surfaces, with a relatively constant removal efficiency over a wide range of dust loadings. Detailed tests have shown that the HVS3 is effective in sampling for Pb and pesticides.

The HVS3 collects a surface dust sample in a cyclone with an approximate 5-µm cut. Previous studies have shown that more than 99% of the Pb present in the dust on a rug is collected in the cyclone. These same studies showed that more than 97% of five pesticides, representing a range of vapor pressures, in rug dust were captured in the cyclone. Since the PAH and PCB of most interest are also semivolatile organic compounds that lie within the range of vapor pressures of pesticides tested, it was reasoned that the HVS3 should be a reliable instrument for collecting these compounds adsorbed on house dust.

In using the HVS3 to collect these compounds, one concern is that material may be lost by leaving the cyclone either on particles too small to be captured, on particles that are blown out of the cyclone catch cup, or by being stripped off the particles by the air stream. In any of these cases, capturing the lost material would require both a particle filter and a vapor adsorbent located behind the cyclone.

A PUF filter was used in the original High Volume Surface Sampler (HVS2) as a final gas filter. The PUF filter was preceded by a quartz-fiber filter. By contrast, a PUF filter is used alone, without a particulate matter filter, in the standard EPA TO-10 air sampling method for ambient pesticides. It is preceded by a quartz-fiber filter in both the TO-4 sampling method for PCB and the TO-13 sampling method for PAH.

Camann et al. have shown that a PUF plug without a quartz-fiber prefilter gives equivalent recovery of pesticides compared to a PUF plug with a quartz-fiber prefilter. This suggests that the PUF plug is sufficiently effective as a particle filter, that an additional filter, such as the quartz-fiber filter used with the HVS2, is not necessary. Therefore, the collection efficiency of the cyclone in the HVS3 for PAH and PCB can be demonstrated by capturing PAH and PCB with a PUF plug installed behind the cyclone.

Objectives

The objectives of this study were to 1) determine whether the HVS3 can quantitatively collect PAH and PCB adsorbed onto house dust and 2) obtain concentration profiles for PAH and PCB in house dust and foundation soil samples from nine houses in Seattle, WA, in 1993.

Procedures

The collection efficiency of the cyclone was tested in two houses. Naturally occurring PAH and PCB compounds were measured rather than compounds spiked onto house dust in known quantities. It was therefore necessary to collect all the dust and vapors that pass through the cyclone to determine the amount that is not collected by the cyclone. This was done by inserting a PUF filter in the sampling train behind the cyclone.

The added pressure drop of the PUF filter reduced the capacity of the fan installed in the HVS3. To ensure that the required volumetric flow rate would be achieved on all types of carpets, the installed fan was backed up with a blower (Cadillac Model HP33P) placed in-line behind the exhaust of the installed fan. Tests with the HVS3, the Cadillac blower, and a laminar flow element demonstrated this arrangement could provide the desired flow rates and permitted the development of new pressure drop-flow rate curves.

This modified HVS3, with the PUF filter and Cadillac blower, was used to collect dust from rugs in two houses. The tests were conducted following the American Society for Testing Materials (ASTM) method and the manufacturer's instructions at the recommended airflow rates. The location of these houses and other relevant information are provided along with information about the remaining test houses.

Foundation soil samples from these houses were collected within 2 ft of the foundation. Approximately 7 g was collected on each side from the top 2 cm of soil with a stainless steel spoon. If, for some reason, samples could not be collected from one side of the house, then extra samples were collected on the other sides of the house. About 10 g of soil from each sample was used to determine the moisture content of the sample.

A sample of entryway soil was collected from the door mat at the primary entrance of each home. The entryway soil samples No. 2 and 15 were collected under a tire-tread doormat with a brush and dust pan. Samples No. 7, 9, and 14 were collected at the side or back door. Sample No. 14 was mostly fiber from the mat. All the other samples were collected from the front door mats. These samples were obtained by fuming over the entryway mat and placing it on a clean piece of aluminum foil. The back of the mat was then beaten for several minutes before it was removed from the foil. The loose particles on the foil were poured into a clean prelabeled jar. This procedure was repeated at least three times for each entryway mat to collect as much sample as possible. After all of the entryway dirt had been collected at each home, the lid on the sample jar was sealed with Teflon tape, transported back to Battelle, and stored in a -20°C freezer prior to extraction.

Besides the two houses that were used to determine collection efficiency, the HVS3 without a PUF filter and the backup Cadillac blower (i.e., in its standard configuration) was used to collect dust from rugs in seven more houses. The HVS3 was operated according to the ASTM method and the manufacturer's instructions. The cyclone was operated at its designated air flow rate. All PAH and PCB samples were shipped to Battelle with ice by next day delivery. The Pb analyses were done by Thomas M. Spittler, Region I, EPA.

An aliquot (200 mg) of each fine portion of house dust and foundation soil samples was used for PAH analysis. Each aliquot of sample was spiked with a known amount of perdeuterated PAH and extracted by sonicating with two aliquots of 10 mL C_6 for 20 minutes. The extract was

filtered, concentrated, and analyzed by GC/MS for target PAH.

Another aliquot (500 mg) of the fine portion of house dust and foundation soil samples was used for PCB analysis. The sample was spiked with a known amount of ^{13}C-labeled PCB standards and extracted twice by sonication with 10 mL of 10% ether in C_6. The extract was filtered, concentrated, and fractionated on a silica gel column. Three eluting solvents, C_6, C_6/dichloromethane (DCM) 1:1, and methanol were applied to the silica gel column. The target (C_6/DCM) fraction was then analyzed by GC/MS for PCB.

Aliquots of the dust samples were analyzed for Pb by energy dispersive XRF. Calibration of the XRF instrument for house dust was performed by using Pb-free sand spiked with Pb. Standard soil samples prepared by the EPA's Region I Laboratory were used to calibrate the XRF instrument for soil samples.

Results

The maximum penetration of the cyclone by any of the PAH is 2.8% (phenanthrene) and 1.4% (chrysene) for any of the PAH ranked as probable human carcinogens (B-2) by EPA's Integrated Risk Information System. The maximum penetration by any of the PCB is 4.2%. Based on the low percentage losses found in this collection efficiency test, a decision was made to conduct the remaining validation study without the PUF filter in the system. In summary, the amount of PAH and PCB lost without the PUF filter was insignificant, in agreement with the results obtained earlier with the pesticides (3% loss without the PUF filter).

Among the measured target 2- to 6-ring PAR the least abundant PAH found in the house dust and the soil samples was cyclopenta(c,d)pyrene. The low concentration of cyclopenta(c,d)pyrene in house dust samples is partly due to the reactivity of this compound. We have demonstrated in a previous study that cyclopenta(c,d)pyrene can oxidize to pyrene dicarboxylic acid anhydride. The most abundant PAH found in these samples were fluoranthene, pyrene, and benzofluoranthenes. The highest PAH concentrations in house dust samples were found in the sample collected from House No. 14 (HD14). In this house dust sample, the concentration of the well known carcinogen, benzo(a)pyrene (BaP), was 1.7 ppm. The highest PAH concentrations in foundation soil and entryway soil samples were all from House No. 13. The BaP concentration in this foundation soil and entryway soil sample was 0.20 ppm and 1.3 ppm, respectively. In general, higher PAH concentrations were found in the house dust and entryway soil samples than in the foundation soil samples. The PAH concentrations in the entryway soil were higher than that in the house dust for samples collected from Houses No. 1, 2, and 13. The reverse concentration trend was observed for Houses No. 3, 7, 10, 14, and 15. Similar PAH concentrations in the entryway soil and house dust were observed in House No. 9. Note that the sum of the concentrations of the seven B-2 PAH are approximately half of the total concentrations of all 16 target PAH (3- to 6-ring) in all the house dust and foundation soil samples.

The most abundant PCB found in house dust samples was penta-PCB, and the least abundant PCB was the most volatile mono-PCB. We did not detect any nona-PCB and deca-PCB in the house dust samples. We would expect that significant portions of the more volatile mono- and di-PCB adsorbed onto house dust will evaporate into the air and result in lower concentrations in the house dust. The concentrations of total penta-PCB ranged from 85 to 620 ppb in house dust samples, which represent 22 to 81% of the total PCB concentrations. Similar PCB concentration profiles were observed in foundation soil samples collected from all but two houses. In these two houses, the highest PCB concentrations were from the total octa-PCB. The total penta-PCB concentrations ranged from 16 to 44 ppb in the foundation soil samples that represent 15 to 54% of total PCB concentrations. PCB concentrations were higher in the house dust samples than in the foundation soil samples.

The spiked PAH and PCB were quantitatively recovered from both house dust and soil samples. The average PAH recoveries in house dust and soil samples from all nine houses ranged from 93 to 99 percent and from 91 to 99%, respectively. The average recoveries for PCB were from 81 to 89% in house dust samples and from 78 to 86% in soil samples.

The dust loading in the nine houses ranged from 1.76 to 36.7 g/m^2. More than 50% of the total dust loading is in the fine dust (<150 μm) for all but one house (HD14). The fine dust loading in these houses ranged from 0.46 to 29.8 g/m^2. The house (HD7) that showed the highest loading was occupied by college students who claimed to clean the house monthly, but the house was visibly filthy. The lowest total dust loading was observed in House No. 1 (HD1) and the lowest fine dust loading was observed in HD14. The highest loadings for PAH (150 μg/m^2), PCB (17 μg/m^2), and Pb (1500 μg/m^2) were found in HD7, because of the high dust levels in this house. By the same token, the lowest loadings for PAH (3.0 μg/m^2) and for Pb (740 μg/m^2) were found in HD1 and the lowest loading for PCB (0.31 μg/m^2) was from HD14.

Conclusions and Recommendations

This study has shown that the HVS3 can be used without a PUF filter for quantitative collection of PAH and PCB adsorbed onto house dust. Less than 3% of the PAH and less than 5% of the PCB were found to penetrate the cyclone and were recovered from the PUF filter. This finding agrees with that of a previous study in which it was found that 97% of the pesticides in house dust was collected in the cyclone.

Quantitative recoveries of spiked perdeuterated PAH and ^{13}C-labeled PCB were obtained from the house dust and soil samples. The average recoveries of spiked PAH in house dust, foundation soil, and entryway soil samples from the nine houses sampled ranged from 93 (perylene-d_{12}) to 99% (pyrene-d_{10}), from 94 (chrysene-d_{12}) to 99% (fluorene-d_{10}), and from 91 (fluorene-d_{10}) to 96% (perylene-d_{12}), respectively. The average recoveries of spiked PCB ranged from 81 to 89% in house dust samples and from 78 to 87% in foundation soil samples.

The concentrations of PAH and PCB in the house dust were higher than the levels in the foundation soil. The PAH concentrations in the entryway soil samples were higher than that in the house dust samples for only three houses, and similar or lower concentrations were observed for the remaining houses. However, higher PAH concentrations were found in the entryway soil samples compared to the foundation soil samples for all nine houses. There were no known current major indoor sources of PAH, such as smokers, wood stoves, or gas cooking stoves, in any of the houses sampled. The sum of the target PAH concentrations in house dust samples ranged from 6.1 to 26 μg/g (ppm) and in the foundation soil samples ranged from 1.1 to 3.7 ppm. The sum of all target PCB concentrations in house dust samples varied between 260 and 760 ng/g (ppb) and in the foundation soil samples ranged from 58 to 240 ppb. Unlike PAH and PCB, higher Pb concentrations were found in the foundation soil samples than in the house dust samples for all but three houses. The Pb concentrations in the house dust and the soil ranged from 250 to 2250 ppm and 200 to

4000 ppm, respectively. There was no correlation among the concentrations of Pb, PAH, and PCB in the house dust samples or in the foundation soil samples. The house dust and foundation soil concentrations for PAH, PCB, and Pb also showed no significant correlation with distance from a freeway.

To assess and manage exposure from home soil and house dust, there are several important issues that remain to be addressed. In future studies, we recommend

(1) Measuring the PAH and PCB in house dust, foundation soil, walkway soil, and entryway dirt in a sufficiently large, representative sample for homes located in older, large cities in colder climates with a history of burning coal.

(2) Conducting a similar study in a city in a mountain valley with a history of wood burning.

(3) Conducting a similar study in a city with heavy traffic.

(4) Determining if pollutant magnification occurs in house dust for PAH and PCB.

(5) Documenting the effect of track-in and dust control techniques on exposure to these pollutants in house dust.

References

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The complete report, entitled "Evaluation of HVS3 Sampler for Sampling Polycyclic Aromatic Hydrocarbons and Polychlorinated Biphenyls," (Order No. PB95-123931; Cost: $19.50, subject to change) will be available only from:

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