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Project Summary

Statistical Comparison of Results of Two Indoor Air Pilot Studies

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The objective of this study was to compare results between two previous indoor air PAH monitoring studies conducted by EPA in 1984 and 1987. Both of the previous studies were pilot studies involving ambient and indoor air monitoring at a small number of residences in Columbus, Ohio. The objectives of these studies were to characterize ranges of selected PAH, nitro-PAH, and nitrogen heterocyclic compounds in the indoor air and to evaluate contributions of various indoor combustion sources to the indoor concentration levels of these compounds. The 1984 study used an EPA medium volume air sampler equipped with a quartz fiber filter and a polyurethane foam (PUF) vapor trap, while the 1987 study used a new prototype air sampler equipped with a quartz fiber filter and an XAD-4 resin vapor trap.

This current study compared the results between the 1984 and 1987 studies to determine whether the results are consistent. Where the results were found to be consistent, the data from the two studies were combined to produce more precise statistical estimates of concentration level ranges and more precise estimates of the contributions of different indoor combustion sources to indoor PAH levels.

Concentration level ranges were found to be consistent between the 1984 and 1987 studies for all compounds except quinoline and isoquinoline. For quinoline and isoquinoline, excessive breakthrough in the PUF vapor traps used in the 1984 study resulted in lower measured concentration levels than found in the 1987 study. The estimated PAH contributions of indoor combustion sources were also found to be consistent between the studies for all compounds except quinoline and isoquinoline. The data from the 1984 and 1987 study were therefore combined. Using the combined data, cigarette smoking and gas heating systems were found to be the greatest contributors to indoor PAH concentration levels. However, the data indicate that the effects of gas heating systems and gas cooking appliances are not known with as much certainty as are the effects of cigarette smoking.

Finally, data from the 1984 study were found to be consistent with models previously developed from the 1987 data for predicting levels of PAH target compounds from measured levels of potential PAH marker compounds.

This Project Summary was developed by EPA's Atmospheric Research and Exposure Assessment 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 back).

Introduction

The EPA as part of its indoor air methods development program, has

previously conducted two separate range-finding studies of indoor air levels of polynuclear aromatic hydrocarbon (PAH) compounds. The first study was conducted in 1984 and was titled "Pilot Study of Sampling and Analysis for Polynuclear Aromatic Compounds in Indoor Air." The second study was conducted in 1987 and was titled "Field Evaluation of Sampling and Analysis for Organic Pollutants in Indoor Air."Both studied involved monitoring of PAH, nitro-PAH, and nitrogen heterocyclic compounds in ambient and indoor air at a small number of homes in Columbus, Ohio. The objectives of both studies were to evaluate sampling and analysis methodology, to characterize typical concentration levels of PAH and related compounds found in the indoor air, and to investigate the individual contributions of different indoor combustion sources on PAH levels in the home.

The objective of this study was to compare the results of the 1984 and 1987 studies, and to use the data from the 1984 study to evaluate some of the key findings of the 1987 study.

Ranges of the concentration levels for the measured compounds were compared across studies. Also, the estimated pollutant contributions of various indoor combustion sources were compared. Whenever the results were consistent, the data from the two studies were pooled to produce an updated set of results based on the combined data from both studies. Key questions addressed in this study include:

1. Are the observed ranges of concentration levels of PAH, nitro-PAH, and nitrogen-heterocyclic compounds similar across studies? Are there differences in concentration levels due to differences in the degree of vapor trap breakthrough experienced between the two studies?
2. Are the estimated contributions of gas heating systems, gas cooking appliances, and cigarette smoking to the PAH concentrations in indoor air consistent between the 1984 and 1987 studies? In particular, results from the 1987 study indicated that use of electric cooking appliances contribute more to the PAH levels than do gas appliances. Do the data from the 1984 study refute or confirm this finding?
3. How well can we predict the levels of various PAH target compounds from the measured levels of potential marker compounds such as pyrene, fluoranthene, and phenanthrene? Are the prediction models developed from the 1984 study data consistent with the prediction models developed from the 1987 study data?

Procedure

In the 1984 study, a medium volume EPA sampler was used which had a quartz fiber filter to collect particulate matter and a PUF cartridge to trap vapors. The study investigated the effects of (1) gas heating systems, (2) cigarette smoking, and (3) woodburning fireplaces as possible contributors to indoor levels of PAH, nitro-PAH, and nitrogen heterocyclic compounds. Ten sample homes were selected to have different characteristics relative to the presence of gas versus electric heating systems, presence/absence of woodburning fireplaces in use, and the presence/absence of cigarette smoking in the home. At each sample home, 8-hour samples were taken at each of three indoor locations within the home: kitchen (7:00 AM to 3.00 pm), living room (3:00 PM to 11:00 PM), and bedroom (11:00 PM to 7:00 AM. A 24-hour ambient air sample was also taken outside the home to coincide with the three 8-hour indoor samples. For each home, the air exchange rate was determined by the decay rate of SF_6 injected into the house. A questionnaire was completed by the residents of each sample home to record residents' activities during the sampling periods that might have affected concentrations of indoor PAH levels.

The 1984 study found that cigarette smoking and type of heating system have the greatest effects on the indoor levels of most PAH, nitrogen heterocyclic compounds, and nitro-PAH compounds. The use of a woodburning fireplace was only weakly correlated with the levels of the target compounds. The study also found that bedroom levels were much lower than levels found in the kitchen and living room.

The 1987 study used a new prototype indoor air sampler developed by EPA's Environmental Monitoring Systems Laboratory. This new sampler allows the pumping unit to be placed inside the home with the air sampling unit. The sampler was equipped with a quartz fiber filter to collect particulate matter and XAD-4 resin to trap vapors.

The 1987 study investigated the contributions of (1) gas heating systems, (2) gas cooking appliances, and (3) cigarette smoking to the indoor concentration levels of PAH and related compounds. At each sample home, 8-hour samples were taken at each of two indoor locations within the home: kitchen (7:00 AM to 3:00 pm) and living room (3:00 PM to 11:00 PM). A 16-hour ambient air sample was also taken outside the home to coincide with the two 8-hour indoor samples. At each home, the air exchange rate was determined by the decay rate of SF_6 injected into the house. A questionnaire was completed by the residents of each sample home to record the number of cigarettes smoked and various other activities during sampling that might have affected concentrations of indoor PAH compound levels.

Results of the 1987 study found that the type of heating system and cigarette smoking had the greatest effects on the indoor levels of most PAH, nitrogen heterocyclic, and nitro-PAH compounds. And, although not statistically significant for most compounds, homes with electric cooking appliances rather than gas cooking appliances had higher estimated levels of most target compounds. This is contrary to what one would expect and is one of the key findings investigated in this comparison study.

Results

Except for quinoline and isoquinoline there was good agreement between the concentration ranges for the 1984 and 1987 studies. The discrepancies in ranges for quinoline and isoquinoline are due to breakthrough of the PUF trap used in the 1984 study. The 1987 study used XAD-4 resin vapor traps which did not experience the same level of breakthrough.

Except for the compounds quinoline and isoquinoline, there was no statistical evidence that the estimated effects of gas heating system, gas cooking appliances, cigarette smoking, and sampling location differed significantly between the two studies. However, in the 1987 study homes having electric cooking appliances were estimated to have higher levels than gas appliance homes for a number of compounds. For the 1984 study, gas appliance homes had higher average levels than electric appliance homes for most of the target compounds. Electric appliances were associated with higher levels only for the compounds phenanthrene, fluoranthene, pyrene, and coronene. However, the difference between types of cooking appliances were not statistically significant for any of the compounds except benzo(e)pyrene

Results from upcoming studies will provide additional evidence to determine the true effect, if any, of gas versus electric cooking appliances.

Because there was no statistical evidence of a difference in results between the 1984 and 1987 studies (except for quinoline and isoquinoline), the data for the two studies were combined. The combined study data provided more precise estimates of the true contributions of the various different combustion sources to indoor PAH levels. The combined data showed that gas heating systems and cigarette smoking produce the largest increases in indoor PAH concentration levels.

Results from the 1987 study showed that there are significant linear relationships between potential marker compounds and other target PAH compounds. In the 1987 study, correlation coefficients between potential marker compounds and most target compounds generally ranged from 0.30 to 0.80. Data from the 1984 study were used to assess the validity of the models developed from the 1987 data. Results from the comparison of models indicate that, except for a few compounds, there is no statistical evidence of systematic differences between the 1984 and 1987 prediction models. However, there was considerable within-study variability among the 1984 data and 1987 data. The within-study variability was sufficiently large so that the between-study variability was not considered to be statistically significant for most compounds. The data from the two studies were pooled to produce a single new prediction equation for each compound. Pyrene was found to be the best overall marker compound.

Recommendations and Conclusions

The measured concentration ranges were found to be consistent between the 1984 and 1987 studies. The quinoline and isoquinoline levels found in the 1984 study were an order of magnitude lower due to excessive breakthrough in the PUF vapor traps used in the 1984 study. From these results we conclude that PUF is not as effective as XAD-4 resin for trapping vapors of volatile compounds.

Estimates of the contributions of different indoor combustion sources to the indoor PAH concentration levels were consistent between the two studies for all compounds except quinoline and isoquinoline. From the combined data we conclude that cigarette smoking and gas heating systems produce the greatest increases in indoor PAH concentration levels. Gas cooking appliances have the least effect. However, the data show there is still considerable uncertainty in the true effects of gas heating systems and gas cooking appliances.

The 1984 and 1987 data for predicting PAH target compound levels from measured levels of potential PAH marker compounds were found to be consistent for all compounds except quinoline and isoquinoline. The combined data indicate that the levels of fluoranthene, pyrene, and phenanthrene show promise as predictors of the levels of the other PAH target compounds. Pyrene appeared to be the best marker compound for most of the target compounds investigated.

The following recommendations are based on the results of this study:

1. Winter and summer monitoring studies should be conducted to obtain a better assessment of the true effects of gas heating systems and gas cooking appliances. Cigarette smoking should be eliminated as a factor in these studies. The effects of smoking are already apparent.
2. The air samplers should be placed in only one location within the home rather than placed in different locations for each sampling period. By using only one sampling location (living room), we will be able to determine whether it is, indeed, period of the day that affects the indoor PAH concentration levels.
3. A separate statistical study should be done following the winter and summer studies to compare the data collected during the winter and summer monitoring studies and the 1984 and 1987 studies. More data are needed to further evaluate previous findings and improve prediction models.

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***Nancy K. Wilson** is the EPA Project Officer, see below.*
The complete report, entitled "Statistical Comparison of Results of Two Indoor Air Pilot Studies," (Order No. PB 89-207 021/AS; Cost: $21.95, subject to change) will be available only from:
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