

Real-Time Monitoring of Particulate-Bound Polycyclic Aromatic Hydrocarbons in Indoor and Outdoor Air

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Introduction

Public concern over the health and environmental effects of persistent organic pollutants has been increasing over the past decades. In addition to outdoor anthropogenic sources of incomplete combustion including gas flaring in the oil industry, teepee burners in the forest industry, automobile exhaust in urban centers, burning farmers fields, and forest fires, there are also many indoor sources including fireplaces, cigarette smoking, and cooking (e.g. burnt toast). Understanding of personal exposures to products of incomplete combustion is important to adequately address public health concerns associated with the emission of these pollutants. Information on the levels of personal exposure to products of incomplete combustion is needed to understand the human health implications. Additional information on the relative contribution of the various emission sources is be valuable in identifying high impact emissions and can provide support for evidence based decision making in public policies toward emissions of public health concern. This study investigated levels of exposure to products of incomplete combustion using real-time monitoring of PAHs to characterize the relationship between indoor and outdoor air concentration.

Materials and Methods

Sampling

Indoor and outdoor air at homes in three Alberta communities was monitored over a seven-day period for particulate (PM_{2.5}) bound PAHs using the PAS 2000 PAH monitor (Ecochem Analytics, West Hills, Cal.). The study involved three houses in High Level (population 5,000) and Fort McMurray (population 30,000), and one home in Edmonton (population 800,000).

Particulate bound PAHs were monitored nearly continuously in indoor and outdoor air at the residences of volunteers for the seven-day periods. The sampling method consisted of a PAS 2000 PAH monitor connected to a manifold and valve system which would alternate between drawing a sample of air from the indoors for five minutes and then from the outdoors for five minutes. A computer was used for data logging and controlling and recorded the position of the valve which determined if the sample was drawn from the indoors or outdoors. The data collected from the first and final minute of each five minute-sampling interval was discarded resulting in three acceptable one-minute average readings of both indoor and outdoor air every ten-minute cycle. The data plots developed from this data used one hour running averages to minimize the noise in the data.

PAH Monitor

The detection of PAH by the PAS 2000 monitor was based on the measurement of small electric charges induced by the photoelectric ionization of PAH adsorbed on the surface of carbon aerosols¹. The monitor has a demonstrated ability to detect PAH compounds containing 4 or more rings (i.e. Benzo(a)pyrene)². The PAS 2000 was not considered to be specific for individual PAH compounds but proved effective as a total PAH aerosol monitor for a given combustion source³. Evaluations of the performance of this monitor have recommended its use in estimating human exposure related to various activities that may generate PAH⁴. This monitor provided a good comparison of the changes in particulate bound PAH over time but caution should be used when interpreting absolute levels as they may vary depending on combustion sources. The instrument output showed a positive bias and was adjusted downwards by 1.4 ng/m³ so that the background readings would coincide with zero. While the manufacturer reports a detection limit of 3 ng/m³ for the PAS 2000 monitor, the more stable one hour running average use here had a detection limit of 0.4 ng/m³ (based on three standard deviation of background levels). There were occasions during the sampling when the monitor would give negative readings for several hours. There was no apparent explanation for the negative readings that have been shown in the data plots but they were assumed to be zero for these calculations.

Results and Discussion

Patterns of PAH levels from only four of the seven houses were provided in Figures 1a to 1d. Table 1 summarizes information taken from these figures including percent of non-detectable readings, average levels, maximum levels, and an estimate of the portion of the indoor levels due to indoor sources. Figures 1a to 1d used a dark line and a shaded line to represent the levels of PM2.5 bound PAH indoors and outdoors respectively. The PAH level indoors followed so closely to the outdoor levels in Figures 1b to 1d that the lines in the figures were difficult to distinguish from each other. This remarkable consistency between indoor and outdoor readings demonstrated that outdoor particulate-bound PAH move indoors quickly with nearly identical concentrations. While other investigators have previously reported that indoor levels of particulate-bound PAH vary in proportion to outdoor levels⁵, Figures 1b to 1d show they vary almost exactly. This close matching of indoor and outdoor PAH measures clearly identified indoor sources when indoor concentrations increased independently. These independent indoor spikes due to indoor sources have been labeled on figures and a qualitative estimate of the proportion of the total indoor PAH levels due to these sources has been calculated and is shown in Table 1. This is only a qualitative estimate because the independent indoor spike likely came from different combustion sources. The comparison of elevated indoor levels resulting from outdoor sources was a quantitative comparison because the PAH came from the same combustion source.

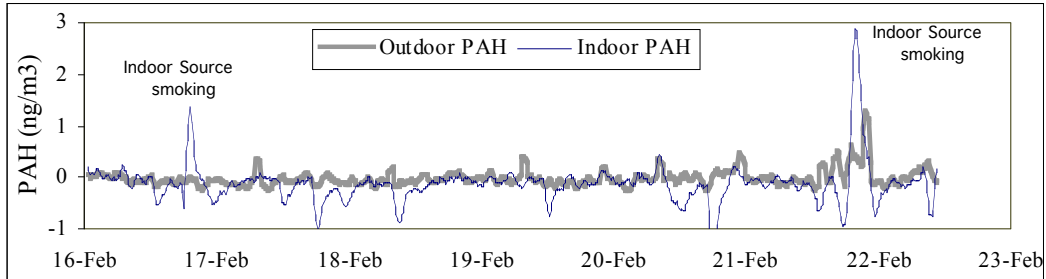


Figure 1a: Particulate-bound PAH levels indoors and outdoors at High Level House #2

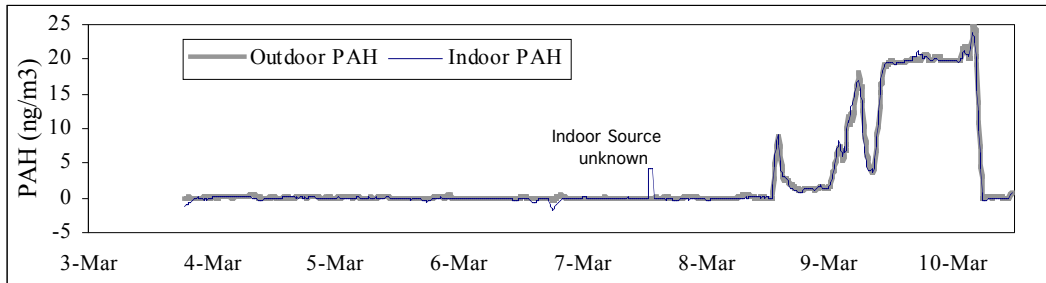


Figure 1b: Particulate-bound PAH levels indoors and outdoors at Fort McMurray House #1

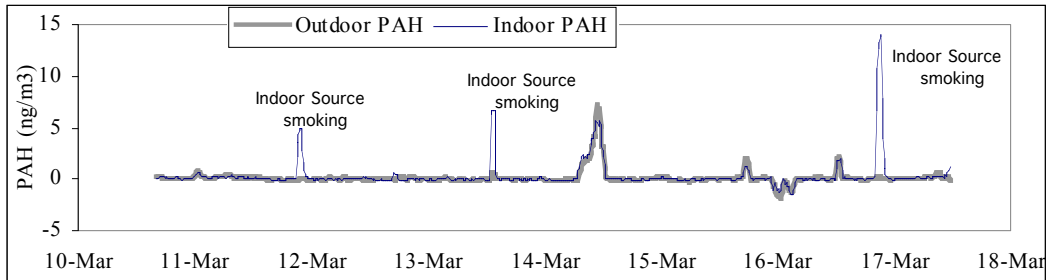


Figure 1c: Particulate-bound PAH levels indoors and outdoors at Fort McMurray House # 2

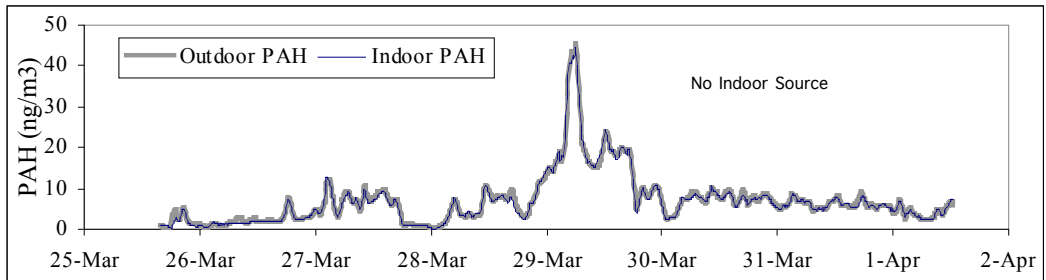


Figure 1d: Particulate-bound PAH levels indoors and outdoors at Edmonton House #1

Table 1: Summary of real-time PAH Data from houses in Study

House Sampled	Percent Non-detect		Average Level (ng/m3)*		Maximum Level (ng/m3)		Indoor Levels from indoor sources
	Indoors	Outdoors	Indoors	Outdoors	Indoors	Outdoors	
High Level #1	96%	90%	0.02	0.07	0.6	1.5	0%
High Level #2	95%	91%	0.05	0.04	2.9	1.3	93%
High Level #3	95%	90%	0.04	0.06	2.9	2.1	77%
Fort McMurray #1	73%	70%	3.12	3.13	24.0	25.1	1%
Fort McMurray #2	89%	92%	0.34	0.15	14.0	7.2	59%
Fort McMurray #3	82%	91%	0.27	0.06	11.6	1.4	88%
Edmonton #1	3%	3%	6.79	6.95	44.6	45.4	0%

* Note: Values below detection limit are taken as zero in calculation of the average

Table 1 shows the lowest readings of PM_{2.5} bound PAH were found in the smallest community (High Level) and the highest readings were found in the largest community (Edmonton). Houses #2 and #3 in High Level and houses #2 and #3 in Fort McMurray showed similar results with the low outdoor levels of particulate-bound PAH and the majority of indoor levels due to indoor sources. House #1 in High Level had no indoor sources identified. Figure 1c shows house #1 in Fort McMurray with non-detectable levels until the last two days when both indoor and outdoor readings were relatively high. The results from the house in Edmonton had detectable readings all but 3% of the time and show remarkable consistency between indoor and outdoor levels.

In summary, these data demonstrate that outdoor particulate-bound PAH move indoors very quickly with little change in concentration. In the cases of low outdoor levels of particulate bound PAH, exposures to these combustion products are driven by indoor sources. House #2 in High Level showed that two cigarettes smoked by visitors accounted for 93% of the particulate-bound PAH levels in the house during the week. In contrast, if these two cigarettes were smoked in the houses that had high outdoor levels (Edmonton #1 and Fort McMurray #1) they would have accounted for less than 5% of the PM_{2.5} bound PAH levels in the houses. This study also demonstrates the effectiveness of this sampling strategy in characterizing exposures to products of incomplete combustion and estimating the proportions from indoor and outdoor sources.

References

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