Organohalogen Compounds, Volume 61, Pages 486-489 (2003)

DIFFERENCES IN LEVELS AND PROFILES OF PCBs AND PAHs BETWEEN INDOOR AND OUTDOOR SAMPLES SIMULTANEOUSLY COLLECTED IN ROME.

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Introduction

PCBs and PAHs are air pollutants sharing a much higher density than air. Heavier PAHs are mostly associated with particulate matter[1], whilst PCBs are predominantly found in vapor phase[2]; so their presence in air should be affected by the height. As a consequence, people living or working at higher floors of buildings may be exposed to lower concentrations for the time spent there, relatively to lower floors. Moreover, for both classes of compounds, air pollution varies in opposite directions from winter to summer for different reasons: PAHs increase in winter due to favorable meteorological conditions and residential heating, whilst PCBs increase in the warmer season for their higher vapor pressure.

Indoor samplings can help in investigating the influence of indoor air pollution on the overall exposure. Indoor sources of PAHs, such as tobacco smoking or wood burning, can be easily identified and accounted for; on the contrary, possible PCB inner sources, such as paint, wood treatment, electric appliances or whatever was treated with substances containing PCBs, may be difficult to locate.

By this study, we wanted to investigate the overall exposure of the general urban population to the cited organic micropollutants, as a prosecution of a previous work in this field[3]. In particular, we investigated the differences in concentration levels indoors and outdoors, and at different floors in the same building.

Methods and Materials

During a whole year, high-volume (flow rate, 1.13 m^3/min) samples were simultaneously collected outdoors at a central site in Rome and at a background site in the Simbruini Natural Park about 50 km air distance from Rome. PCDD/Fs, PAHs and PCBs were determined. (Results at the background site and of PCDD/Fs determinations will be published elsewhere.)

In addition, simultaneous indoor and outdoor samplings were performed in four different buildings in other Rome areas. On five events, a set of five low-volume (25 L/min) samples was collected and analyzed for PAHs and PCBs. Buildings were chosen facing streets with considerable traffic. Two sampling sets were made in different seasons in the same building with the central heating system (based on a coal fired boiler) on and off, respectively. Each set of samplings included: one indoor sampling in a low-floor apartment; a repetition of the previous sampling on the next day (PAHs only); one indoor sampling in a high-floor apartment; one “out of the window” low-floor sampling, with the sampling head hanging from the building 4-5 m above the street level; one outdoor sampling on the building terrace (PAHs only). No smoker lived in or frequented the apartments in which the indoor samples were collected. Samplings were performed in the living

room and inhabitants were asked to behave regularly during sampling, especially with regards to window opening. Simultaneously with the indoor sampling, an outdoor sampling was performed by the high-volume sampler, at the above-mentioned central site.
All samples were collected during 24 h. Particle-bound PAHs were collected by quartz microfiber filters (Whatman QM-A) and PCBs by a polyurethane foam (PUF) plug. Wholly ^{13}C labeled PCB congeners were applied on the PUF plug before sampling, whilst wholly deuterated PAHs were evenly spiked on the filter before extraction .
For PCB analysis the PUF plug was extracted in an pressurized solvent system (ASE 200, DIONEX) with a 1/1 v/v *n*-hexane-acetone mixture at 100°C and 100 bar. After a first SFE clean-up, the extract was further purified on alumina before the GC-MS determination of PCB congeners.
PAHs were extracted in an ultrasonic bath by dichloromethane and purified by TLC. Determination was performed by GC-MS. The following hydrocarbons were determined: benz(a)anthracene; sum of chrysene and triphenylene; sum of benzo(b)fluoranthene, benzo(j)fluoranthene and benzo(k)fluoranthene; benzo(a)pyrene; indeno(1,2,3-cd)pyrene; dibenz(a,h)anthracene; benzo(ghi)perylene. A Thermoquest Finnigan Trace 2000 Series instrument equipped with a HT-5 column (polysiloxane-carborane, 25 mm, 0.22 mm, 0.1 µm) and a PTV splitless injector was used for both PCB and PAH analysis.

Results and Discussion

Results obtained in the indoor sampling experiments indicate that the concentration level of PCBs in indoor air is more than one order of magnitude higher than the levels measured at the outdoor site in the central area and several times higher than the outdoor values measured “out of the window” in the same building at 4-5 m above street level. The concentrations of total PCBs (the sum of 59 congeners) measured in the 10 indoor samples ranged from 6.5 to 32.8 ng/m^3 (mean value 16.0, standard deviation 8.2), whilst the concentrations measured “out of the window” ranged from 0.3 to 5.4 ng/m^3 (5 samples; mean value 2.5, st. dev. 2.3); the outdoor concentrations in the central area ranged form 0.3 to 1.2 ng/m^3 (11 samples, mean value 0.5, st. dev. 0.26).
These results clearly suggest that inner air is much more PCB polluted than outer air and that relevant sources of PCBs are found indoors. The differences found among the “out of the window” samples and the ones at the outdoor sampling site suggest that indoor air can be a contamination source for urban air: close to the buildings, PCB levels are significantly higher than at the outdoor sampling site, the latter being located at about 30 m from the closest building.
If indoor PCBs originate from in-house sources, any difference among high- and low-floor apartments should not be due to stratification caused by density (although in four out of five cases lower-floor apartments displayed higher PCB concentrations), but to the presence of PCB emitting products; these are likely to be randomly present in different houses.
The comparison of the congener profile of the indoor sample with the “out of the window” and the outdoor ones taken on the same day is shown in Figure 1; in this bar-graph not all of the 59 congeners analyzed were reported, but only those whose concentration exceeded 10% of the reference one (2,2’,5-trichlorobiphenyl, PCB 18) in at least one of the three samples. Profiles in different seasons may be somewhat different but (as shown in the graph and is generally true in most samples), the outdoor profile is richer of heavier congeners; the “out of the window” profile shows intermediate characteristics between the other two, although, in this case, it is affected by the presence of numerous congeners below the limit of determination.
As to PAHs, indoor levels of benzo(a)pyrene (BaP) ranged from 0.2 to 4.6 ng/m^3 (mean 1.4; st.dev. 1.5). The ratios of BaP indoor concentration at the high apartment to the low apartment

range from 0.4 to 1.3, whilst the ratios of the outdoor concentration at terrace (20-25 m) and street (4-5 m) levels range from 0.15 to 0.65; the other PAHs analyzed display a similar behavior. These data seem to confirm that a stratification of particle-bound PAHs occurs outdoors.

Acknowledgements
This research was jointly funded by the Italian Ministry of the Environment and the Istituto Superiore di Sanità (PR22/IS). Thanks are also due to Angelo Carere for the coordination of the whole project.

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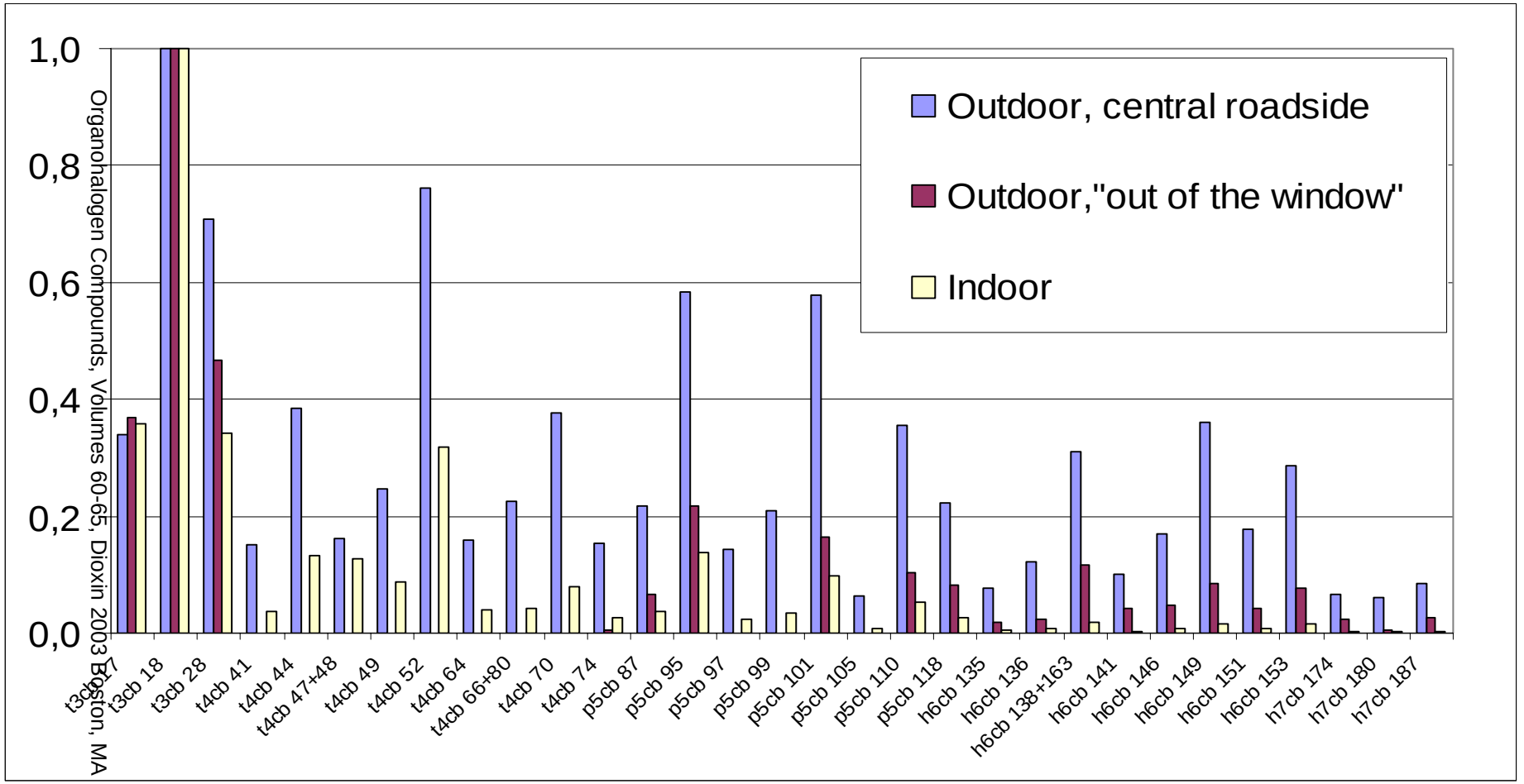

Figure 1. PCB congener profiles relative to 2,2',5-trichlorobiphenyl (18). The three samples were collected in the same day.