Polychlorinated biphenyls and flame retardants in indoor and outdoor air: evaluation of seasonal variability and relationship with house characteristics

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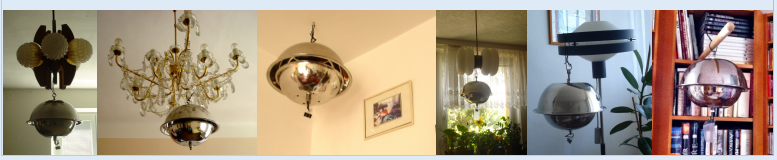
Background

- Indoor air is affected by a wide range of pollutants arising from sources both inside and outside buildings.
- Examples of indoor pollutants are semivolatile organic compounds (SVOCs).
- SVOCs, such as polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and novel flame retardants (NFRs), often have a plethora of indoor sources.
- SVOCs are prone to accumulate and persist in indoor environments, contributing to long term exposure.
- This study aims to evaluate indoor air concentrations and the ratios with outdoor concentrations of PCBs, PBDEs and NFRs across a range of residential environments with respect to house characteristics, indoor materials.



Methods

- Air samples were collected using polyurethane foam (PUF) passive air samplers (PAS) in 17 homes in residential areas of Brno, Czech Republic.
- Sampling was concurrently done in the main living area of the homes and in the adjacent garden or balcony of each home for 28 days.
- Two sampling campaigns: summer 2010 and winter 2011.
- Targeted compounds:
  - 7 PCBs, 9 PBDEs, 10 NFRs.
- General sampling rates of 1.4 and 3.5 m^3/day were used to obtain air concentrations indoors and outdoors, respectively.
- The sites were categorized based on specific characteristics such as year of construction, renovation, type of house, and house contents such as floor type, furniture, electronics, etc.
- A questionnaire was completed by each resident at the end of the sampling
- PUF disks were soxhlet extracted with dichloromethane, cleaned-up via a H_2SO_4 modified silica column, and the targeted compounds quantified using high resolution GC-MS/MS

Results

Polychlorinated biphenyls (PCBs) - Σ_7PCB

Figure 1: Concentration ranges for Σ_7PCB in summer indoors (SI), winter indoors (WI), summer outdoors (SO) and winter outdoors (WO) (left) and the indoor/outdoor ratios for Σ_7PCB (right) in summer and winter, respectively.

- The seven PCB congeners were detected in all samples.
- The PCB concentrations varied by a factor of 3-10 among the studied indoor sites.
- The indoor PCB concentrations were up to one order of magnitude lower than other indoor sites in Europe and North America while outdoor PCB concentrations were consistent with outdoor PCB concentrations in Europe and North America. [1-7]
- The PCB congener profiles were similar to those found in Delors technical mixtures, the PCB technical mixtures produced in the former Czechoslovakia. [8]
- Indoor concentrations of Σ_7PCBs were ~35% higher in homes built before the ban in Czech Republic (1984) than in those built after the ban.
- The results do not suggest clear indoor sources for PCBs in the studied region.

Polybrominated diphenyl ethers (PBDEs) – Σ_9PBDE

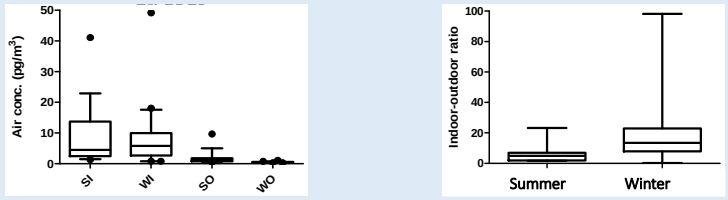


Figure 2: Concentration ranges for Σ_9PBDE in summer indoors (SI), winter indoors (WI), summer outdoors (SO) and winter outdoors (WO) (left) and the indoor/outdoor ratios for Σ_9PBDE (right) in summer and winter respectively.

- The nine PBDE congeners were detected in all samples.
- The PBDE concentrations varied by a factor of 20-100 among the studied indoor sites.
- The indoor and outdoor PBDE concentrations were similar or slightly lower than other sites in Europe and North America. [1,2,4,7,9]
- There were no correlations between PBDE levels and building parameters such as age, type, renovation status, window material, furniture, flooring, etc.
- The results suggest indoor PBDE sources and indoor environments to be a major source to outdoor environments.

Novel flame retardants (NFRs)

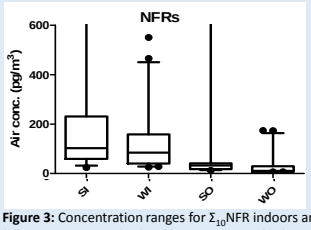


Figure 3: Concentration ranges for Σ_{10}NFR indoors and outdoors in summer indoors (SI), winter indoors (WI), summer outdoors (SO) and winter outdoors (WO).

- Of the ten targeted NFRs, six were frequently detected.
- The NFR concentrations varied by a factor of 7-150 among the studied indoor sites.
- DBE-DBCH (sum of α, β, γ, and δ isomers) and DDC-CO (sum of syn and anti isomers) were detected at the highest levels; a factor of 10-1000 higher than the other NFRs.
- The indoor NFR concentrations are comparable to indoor residential levels in Norway, with the exception of DDC-CO, which was much higher in the indoor air in Czech Republic, and TBX, which was much higher in the Norwegian indoor air. [10]
- There were no apparent correlations between NFR levels and the house parameters age, type, reconstruction status, window material, furniture, flooring, etc.

HBB | DBE-DBCH | DDC-CO

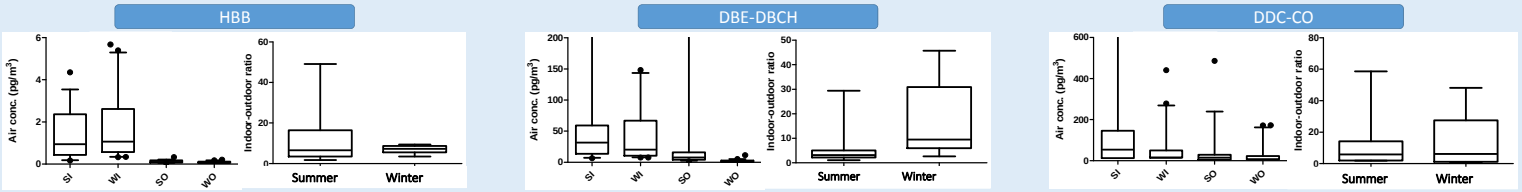


Figure 4: Concentration ranges for individual NFRs in summer indoors (SI), winter indoors (WI), summer outdoors (SO) and winter outdoors (WO) (left) and the indoor/outdoor ratios for the individual NFRs (right) in summer and winter respectively.

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