Polychlorinated biphenyls (PCBs) and Polybrominated Diphenyl Ethers (PBDEs) in Indoor Environments: Levels and Implications

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PCB and PBDE applications in indoor environments

PCB:
- Additive to concrete
- Caulking grout
- Paints
- Permanently elastic sealants
- Flame retardant coatings of acoustic ceiling tiles
- In small capacitors

PBDE:
As flame-retardant additives in different resins, polymers, and substrates used in:
- In wires, cables, textiles, polyurethane foam, carpets and upholstery used in household and business furnishings and cars
- Electronic and electrical equipment such as computers, TV sets, and household appliances
Key questions and Study aims

1. Are PCB levels declining in indoor ambient air?
2. PBDE body burden of ca 5% of Swedish individuals far exceed those of rest of population - diet does not appear to be the cause. Could these observations be related to indoor environments?
3. How important is the role of contaminated indoor air as a source of outdoor air concentrations

The study aims were:

1. To build up a data set on airborne concentrations in a wide range of indoor microenvironments
2. To investigate:
   1. Seasonal and intra-building variation in concentrations of PCBs and PBDEs
   2. Relative contribution of inhalation exposure to total human intakes
Monitoring locations

- Fully sheltered PUF disk passive samplers were used in 86 sampling locations:
  - Homes 29
  - Offices 29
  - Private cars 25
  - Public indoor microenvironments 3
- 7 sites were monitored once a month for 12 months
- Similar medium term sampling was conducted in two separate rooms within the same building for 2 homes and 1 office building
Sample preparation, analysis, and QA/QC measures

Soxhlet extraction
(HPLC grade Hexane for 8 h)

Purification
Acid wash (98% H₂SO₄), Extraction with Dimethyl Sulfoxide and back extraction in Hexane, and Florisil chromatography

Analysis
GC/MS in EI+
DB5 MS column (60 m)

Quality control measures
Recovery of sampling and internal standards reproducibility of sampling and analytical procedure
Summary of $\sum$ PCB (sum of 63 congeners) and $\sum$ PBDE (sum of 10 congeners) concentrations (ng/m$^3$) in different indoor environments

<table>
<thead>
<tr>
<th></th>
<th>PBDE (ng m$^{-3}$)</th>
<th></th>
<th>PCB (ng m$^{-3}$)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Office</td>
<td>Home</td>
<td>Public indoor</td>
<td>Car</td>
</tr>
<tr>
<td>Min</td>
<td>0.01</td>
<td>0.00</td>
<td>0.03</td>
<td>0.01</td>
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<tr>
<td>Average</td>
<td>0.17</td>
<td>0.05</td>
<td>0.11</td>
<td>0.71</td>
</tr>
<tr>
<td>Sd</td>
<td>0.28</td>
<td>0.06</td>
<td>0.07</td>
<td>1.87</td>
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<tr>
<td>GeoMean</td>
<td>0.08</td>
<td>0.03</td>
<td>0.09</td>
<td>0.08</td>
</tr>
<tr>
<td>Median</td>
<td>0.07</td>
<td>0.02</td>
<td>0.14</td>
<td>0.04</td>
</tr>
<tr>
<td>95th %ile</td>
<td>0.64</td>
<td>0.18</td>
<td>0.16</td>
<td>4.23</td>
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<tr>
<td>Max</td>
<td>1.42</td>
<td>0.25</td>
<td>0.16</td>
<td>8.18</td>
</tr>
</tbody>
</table>

Congener based passive sampling rates were used to estimate indoor air concentrations of PCBs and PBDEs.
Average $\sum$PCB and $\sum$PBDE concentrations in different indoor microenvironments.

![Graph showing PCB and PBDE concentrations in different indoor microenvironments.](image-url)
Average PCB concentrations (ng m$^{-3}$) found in this study and previous Birmingham study

- This study (excluding cars) = 11 ng m$^{-3}$
- This study (including cars) = 7.8 ng m$^{-3}$
- Currado & Harrad 1998 = 9 ng m$^{-3}$
Average PBDE concentrations (pg m\(^{-3}\)) found in this study and elsewhere

- This study (including cars): 311 pg m\(^{-3}\)
- This study (excluding cars): 106 pg m\(^{-3}\)
- Canada: 260 pg m\(^{-3}\)
- Kuwait: 15.2 pg m\(^{-3}\)
Within-building variation of $\sum$PCB concentrations in indoor microenvironments.
Within-building variation of $\sum$PBDE concentrations in indoor microenvironments

![Graph showing concentrations of PBDE in different locations.](image)

- **Office1/Livingroom**
- **Office2/Bedroom**

Concentration (pg/m$^3$)

- Home 1
- Home 2
- Office
Monthly variation in PCB concentrations in Home 1 (an example of influence of room usage pattern)
Monthly variation in PCB and PBDE concentrations (pg/m$^3$) in Office 2 (an example of influence of room content on PBDE levels)
Seasonal variation in concentrations of PCBs in indoor and outdoor air

Outdoor air data is from Mao 2000
Daily adult exposure to PCB and PBDE via Inhalation (ng person\(^{-1}\))

\[ \Sigma \text{Exposure} = [(C_H F_H) + (C_O F_O) + (C_{pF} F_{p}) + (C_{C} F_{C}) + (C_{O} A F_{OA})] \cdot R_R \]

Homes = 63.8 %
Offices = 22.3%
Public indoor environments = 5.1%
Transportations = 4.1%
Outdoor = 4.4%
\(R_R = 20 \text{ m}^3\)

<table>
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<tr>
<th></th>
<th>(\Sigma\text{PBDE})</th>
<th>(\Sigma\text{PCB})</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Lower bound</td>
<td>Upper bound</td>
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<tr>
<td>Min</td>
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<td>0.3</td>
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<td>Percentile 25</td>
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<tr>
<td>Median</td>
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<tr>
<td>GeoMean</td>
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<td>1</td>
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<tr>
<td>Average</td>
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<td>2.2</td>
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<tr>
<td>Percentile 75</td>
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<td>1.9</td>
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<tr>
<td>Percentile 90</td>
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<tr>
<td>Percentile 95</td>
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<tr>
<td>Max</td>
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<td>16.4</td>
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</table>
Relative contribution of inhalation exposure to total exposure of PCB and PBDE
Relative contribution of inhalation exposure to total exposure in 95th percentile of general population

**PCB**
- Inhalation: 63%
- Diet: 37%

**PBDE**
- Inhalation: 9%
- Diet: 91%
Conclusions

- PCB and PBDE levels in indoors are much higher than outdoor air concentrations.

- PCB and PBDE concentrations in indoor air show significant seasonality, which matches closely that of outdoor air; supporting hypothesis that indoor air is a significant source of PCBs and PBDEs to outdoor air.

- No significant decline in PCB concentrations in indoor air is evident since previous (1997) study in West Midlands.

- Indoor environments constitute an important vector of human exposure for PCBs and PBDEs in some locations for some people.
Q and A