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INDOOR CONTAMINATION WITH PERSISTENT ORGANIC POLLUTANTS - IMPLICATIONS FOR HUMAN EXPOSURE

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BACKGROUND

- Until recently, widely held that exposure to persistent organic chemicals such as dioxins, PCBs, and brominated flame retardants occurred primarily through the diet
- Does this hold where use patterns of contaminants involve extensive indoor use?
- How does indoor contamination contribute to human exposure in both a direct and indirect context?

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DIRECT EXPOSURE ARISING FROM INDOOR CONTAMINATION

- Hypothesise that emissions from use of treated goods/materials can lead to substantial contamination of indoor environments
- Significance of elevated indoor contamination compounded by high proportion of time spent indoors especially vulnerable groups

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INDIRECT EXPOSURE ARISING FROM INDOOR CONTAMINATION

- In addition to *direct* exposure, current indoor reservoir of PCBs, and BFRs like PBDEs has implications for future exposure
- This via both releases during use and disposal
- Since 1997, 500 million PCs discarded in USA alone

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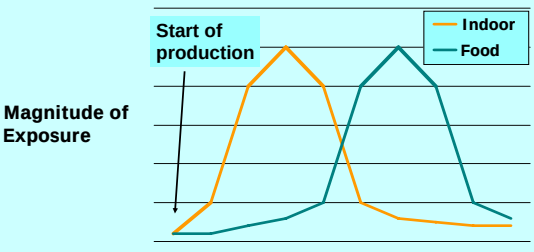
HYPOTHETICAL TIME TREND IN HUMAN EXPOSURE TO POPs



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Harrad & Diamond (2006) *Atmos Environ*, 40: 1187-1188

EVIDENCE FOR DIRECT EXPOSURE

- Surveys of contamination of indoor air
- Similar for dust

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MONITORING INDOOR AIR FOR PCBs

- Between 9/03 & 11/05 we carried out an extensive monitoring campaign to determine concentrations of PCBs in indoor air in domestic and workplace environments in the West Midlands
- Passive low volume air samplers (PUF disks) employed in 92 different microenvironments (31 homes, 33 offices, 25 cars, & 3 public environments)

Harrad et al (2006) *Environ. Sci. Technol.*, 40, 4633-4638.
Hazrati & Harrad (2006) *Environ. Sci. Technol*, 40, 7584–7589.

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PCB CONCENTRATIONS IN INDOOR AIR

- Indoor concentrations in all microenvironments combined (median = 2.53; average = 8.92 ng ΣPCB m^{-3}) exceed those detected outdoors (average = 0.25 ng ΣPCB m^{-3})
- Data are consistent with the existence of wide variation in concentrations between buildings/cars (range is 0.39 - 102 ng ΣPCB m^{-3}), and thus highly variable inhalation exposures
- Concentrations in offices are significantly higher than those in homes
- UK adult exposure via inhalation of indoor air (average = 150 ng ΣPCB/day) constitutes ~30% of sum of dietary and inhalation exposure
- No statistical evidence of a decline in ΣPCB concentrations in indoor air in the West Midlands since 1997-98[1]

[1]Currado and Harrad (1998), *Environ. Sci. Technol.*, 32, 3043-3047.

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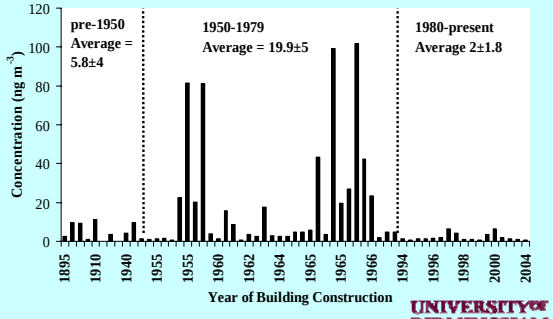
RELATIONSHIP BETWEEN ΣPCB AND BUILDING AGE



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EXPOSURE TO PBDEs VIA INGESTION OF INDOOR DUST

- While PCBs are relatively volatile meaning air inhalation will be main indoor exposure pathway, less volatile POPs like PBDEs partition preferentially to dust
- Ingestion of dust therefore needs to be assessed
- Young children particularly at risk
- Dust ingestion rates currently ***highly*** uncertain

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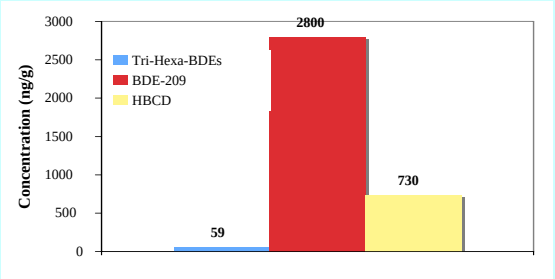
MEDIAN CONCENTRATIONS (NG/G) OF BFRs IN UK DOMESTIC DUST



S. Harrad et al, *Environ. Int.* (*in press*).
M. Abdallah, S. Harrad et al, *Environ. Sci. Technol.* (*in press*).

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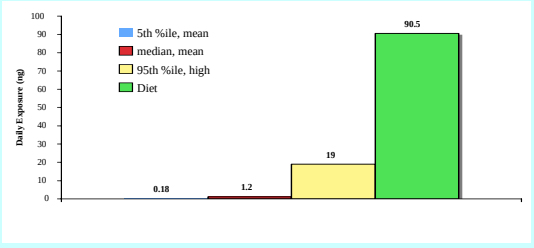
ESTIMATED UK ADULT EXPOSURE (NG/DAY)TO ΣTRI-HEXA-BDEs VIA DUST INGESTION & DIET



Mean dust ingestion 20 mg/d;
High dust ingestion 50 mg/d

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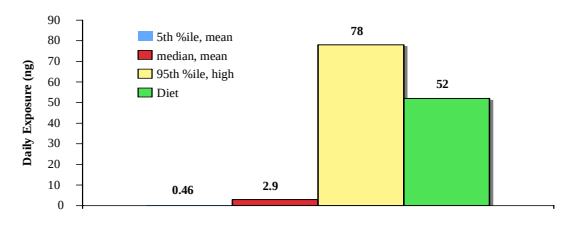
ESTIMATED UK TODDLER EXPOSURE (NG/DAY)TO ΣTRI-HEXA-BDEs VIA DUST INGESTION & DIET



Mean dust ingestion 50 mg/d;
High dust ingestion 200 mg/d

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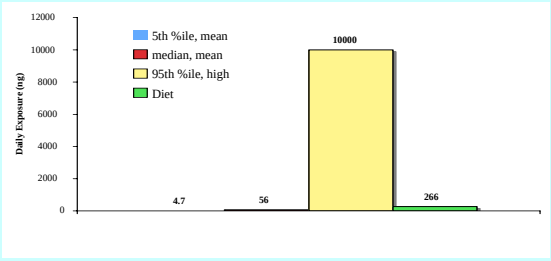
ESTIMATED UK ADULT EXPOSURE (NG/DAY)TO BDE-209 VIA DUST INGESTION & DIET



Mean dust ingestion 20 mg/d;
High dust ingestion 50 mg/d

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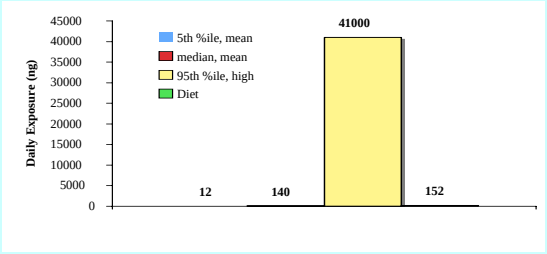
ESTIMATED UK TODDLER EXPOSURE (NG/DAY)TO BDE-209 VIA DUST INGESTION & DIET



Mean dust ingestion 50 mg/d;
High dust ingestion 200 mg/d

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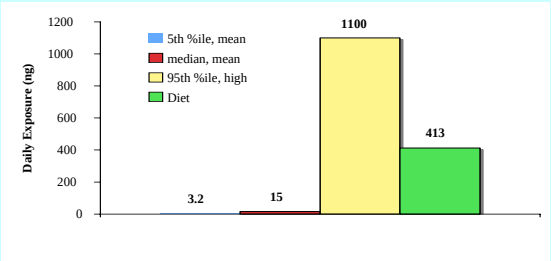
ESTIMATED UK ADULT EXPOSURE (NG/DAY)TO ΣHBCD VIA DUST INGESTION & DIET



Mean dust ingestion 20 mg/d;
High dust ingestion 50 mg/d

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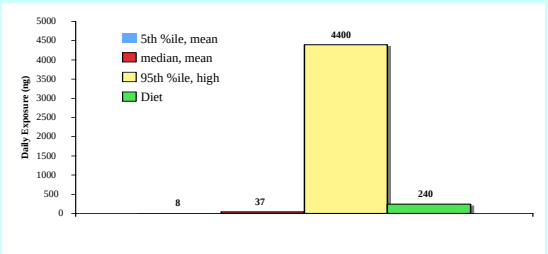
ESTIMATED UK TODDLER EXPOSURE (NG/DAY)TO ΣHBCD VIA DUST INGESTION & DIET



Mean dust ingestion 50 mg/d;
High dust ingestion 200 mg/d

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SUMMARY

- In UK, for the Deca-BDE formulation and for HBCD, it appears that for a small (but significant) proportion of the population, ingestion of household dust is the major exposure pathway
- Young children particularly exposed
- This consistent with observed human body burdens, where a small fraction of individuals are contaminated at elevated levels that do not appear to be attributable to the diet

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EVIDENCE FOR INDIRECT EXPOSURE

- Two strands:
- Higher contamination in cities
- Chiral signature work that connects indoor and outdoor contamination

Harrad & Hunter (2006) *Environ. Sci. Technol.*, 40, 4548-4553.
Jamshidi et al (2007) *Environ. Sci. Technol.*, 41, 2153-2158.

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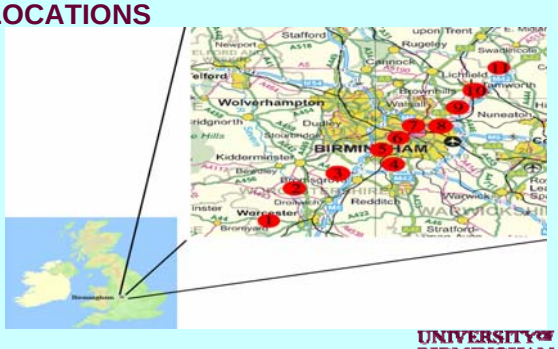
RURAL-URBAN TRANSECT SAMPLING LOCATIONS



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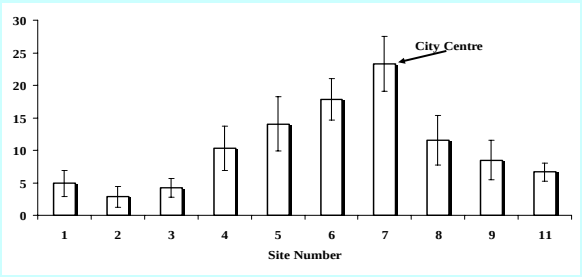
SPATIAL VARIATION IN ΣBDE CONCENTRATIONS (pg m^{-3}) IN OUTDOOR AIR ACROSS BIRMINGHAM



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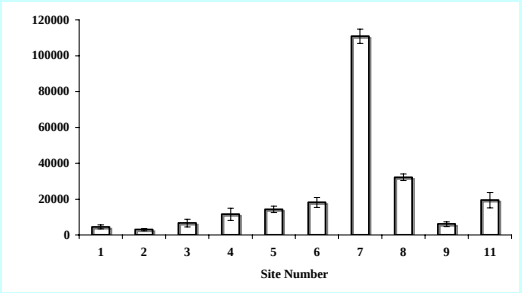
SPATIAL VARIATION IN ΣBDE CONCENTRATIONS IN SOIL (pg g OC^{-1}) ACROSS BIRMINGHAM



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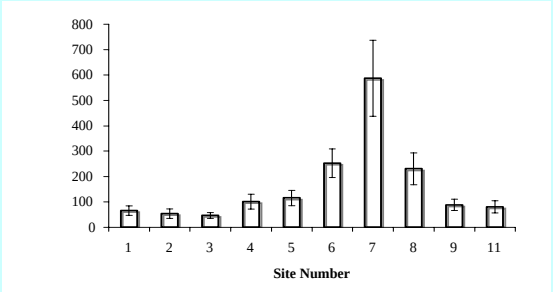
SPATIAL VARIATION IN ΣPCB CONCENTRATIONS (pg m^{-3}) IN OUTDOOR AIR ACROSS BIRMINGHAM



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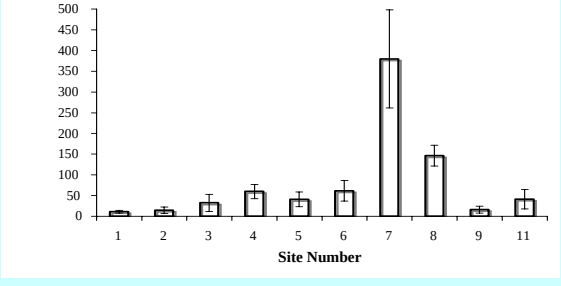
SPATIAL VARIATION IN ΣPCB CONCENTRATIONS (ng g OC^{-1}) IN SOIL ACROSS BIRMINGHAM



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WHY THE "URBAN PULSE"?

- Seems plausible that these "urban pulses" are due to emissions from contaminated indoor environments
- Supported strongly by fact that chiral signatures of PCBs in outdoor air match those in indoor air (& the commercial formulations) and NOT soil
- This indicates that emissions from built environment are driving outdoor contamination, and NOT volatilisation from soil as thought previously

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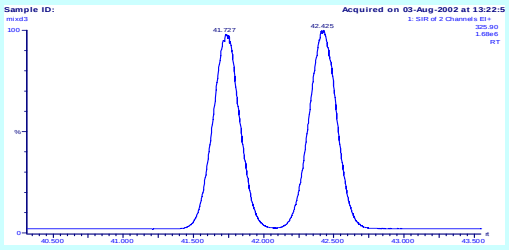
CHIRAL SIGNATURE OF PCB #95 IN INDOOR AIR



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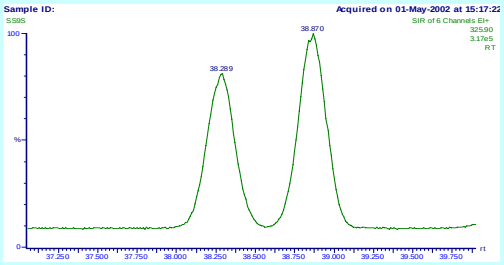
CHIRAL SIGNATURE OF PCB #95 IN SOIL



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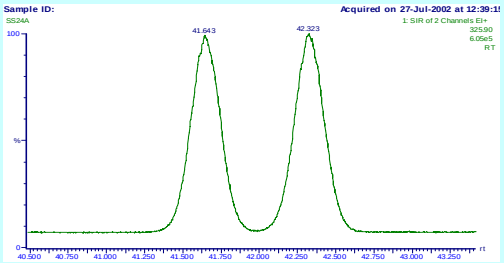
CHIRAL SIGNATURE OF PCB #95 IN OUTDOOR AIR



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IMPLICATIONS OF "URBAN PULSE"

- Consistent with hypothesis that indoor environments could provide a significant proportion of future exposure following release to outdoors, and subsequent incorporation into the food supply

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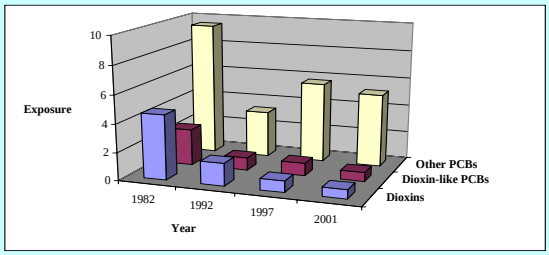
TEMPORAL TREND IN UK DIETARY EXPOSURE TO DIOXINS AND DIOXIN-LIKE PCBs (pg/kg bw/d) + NON-DIOXIN-LIKE PCBs (ng/kg bw/d)



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EXPOSURE TRENDS FOR NON-DIOXIN-LIKE PCBs

- No temporal decline in UK dietary exposure to non-dioxin-like PCBs
- Consistent with lack of downward temporal trend in UK concentrations of non-dioxin-like PCBs in indoor air over same period.
- Suggests continued emissions from PCBs remaining in use are maintaining dietary exposure
- Urgent need to manage "end-of-life" of the current vast indoor reservoir of items containing BFRs and PFSs and learn lessons of PCBs - simply banning manufacture and new use unlikely to be enough

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ACKNOWLEDGEMENTS

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