



Polybrominated dibenzofurans: potential PBDE transformation products of concern

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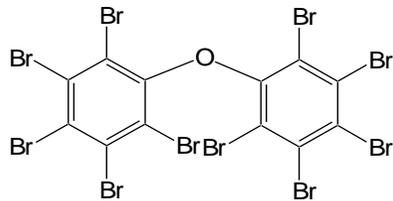
Aims

To investigate the:

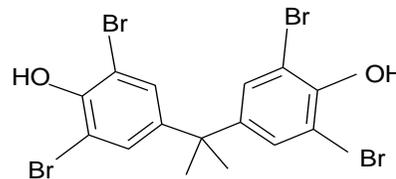
- **transformations of BFRs to PBDFs**
- **occurrence of PBDFs in flame retarded goods**
- **formation of PBDF in accidental fires**
- **levels in relevant environmental compartments**
- **human exposure**

Brominated flame retardants (BFR)

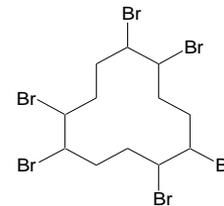
The BFRs is a diverse group:



PBDEs (BDE#209)



TBBP-A



HBCD

- **Most common in plastic, electronic equipment, cables, insulation foam, furniture upholstery**
- **200 000 tons were used around the world in the beginning of the 21st century**
- **Splitting of HBr that inhibits combustion processes**
- **But what happens with the BFRs and the bromines?**



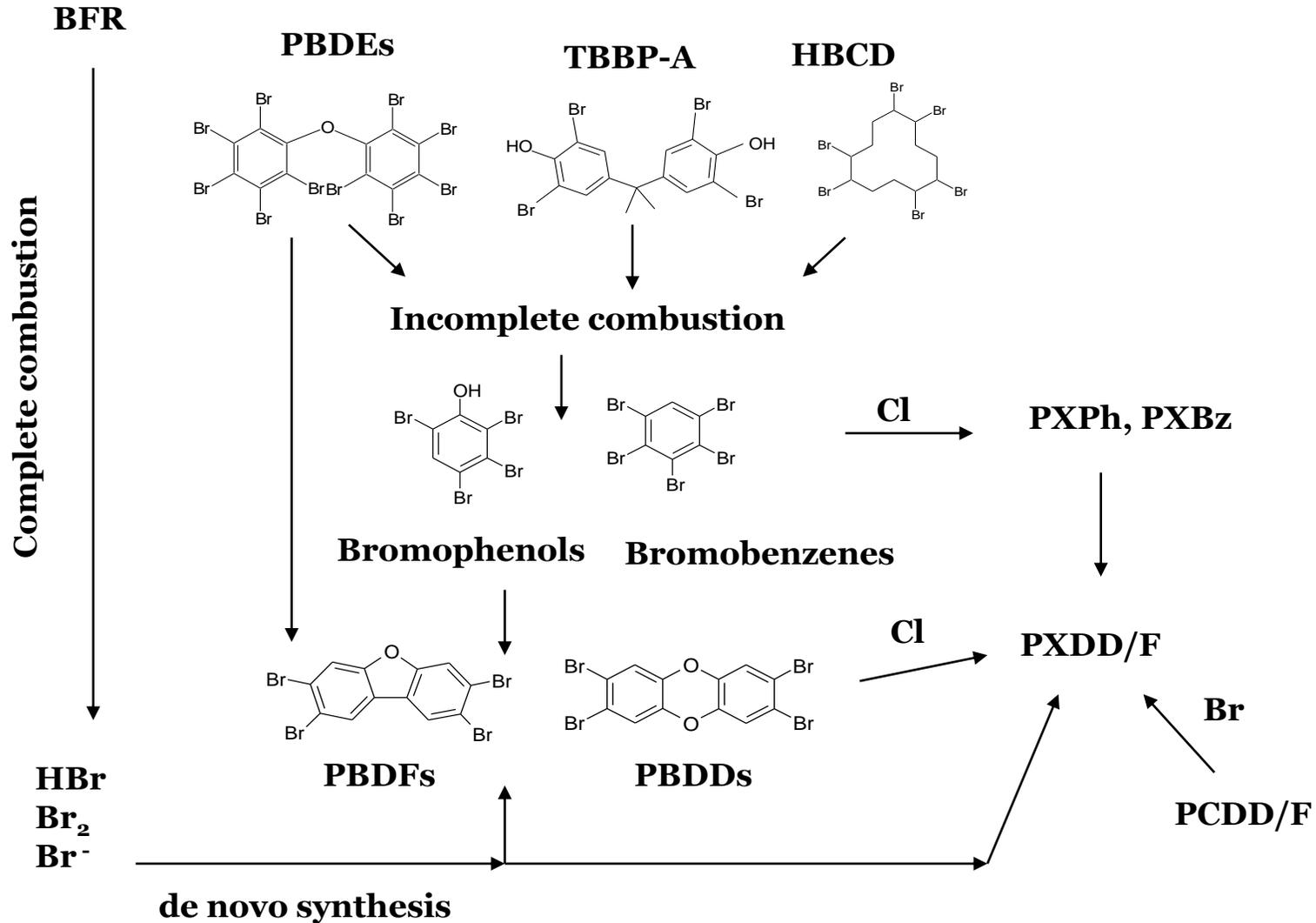
PBDD/Fs in flame retarded materials

PBDD/Fs may be present in BFR-containing materials

(Ebert & Bahadir 2003, La Guardia et al. 2006)

- **Impurity in technical BFR-mixtures**
(Hanari et al. 2006)
- **Formation of PBDD/Fs as BFR-containing materials are processed into refined products**
(Luijk et al. 1992, Weber & Kuch 2003)
- **Transformation of BFRs (e.g. PBDEs) into PBDD/Fs as the material or the product are exposed to natural sunlight**
(Kajiwara et al. 2008)

Pyrolysis and combustion of BFRs





Objective and fires studied

To investigate to what extent PBDD/Fs are emitted during real accidental fires in buildings and materials that potentially contain substantial amounts of BFRs

The fires studied:

- **Two residential houses**
 - **A shopping mall**
 - **Facility for recycling of electronic waste**
 - **A simulated TV-fire**
- **Poor and variable combustion conditions (O₂ supply, temp.)**
- **Bromine and PBDD/F-precursors highly available**



Simulated TV-fire





After the fire





Sampling





Levels of BFRs and dioxins in the TV and in the ash

- **1.8% PBDE in the TV-cabinet (3.4 kg), corresponding to 61 g pure PBDEs.**
- **0.26% TBBPA in the PC-board (230 g), corresponding to 0.61 g pure TBBPA.**
- **0.059% PBDD/F in the TV-cabinet, corresponding to 2 g pure PBDD/Fs.**





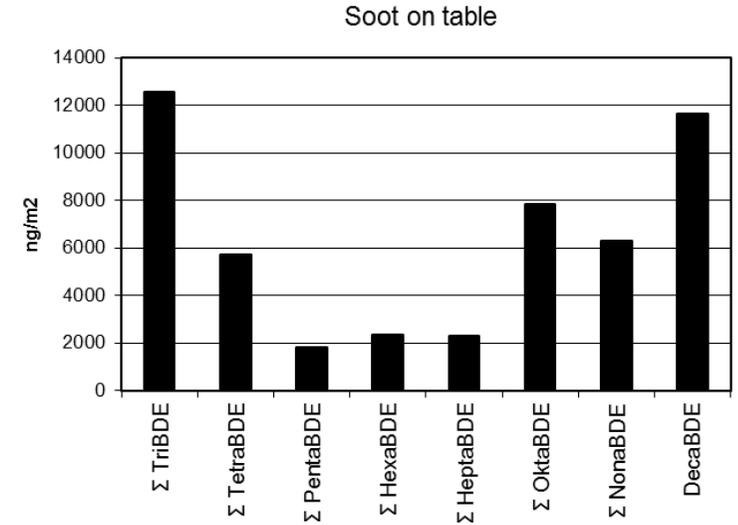
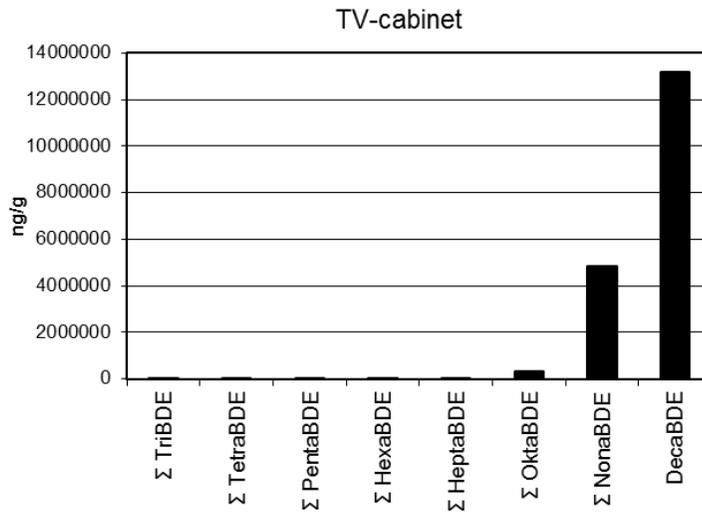
Amounts of BFRs and dioxins in the soot



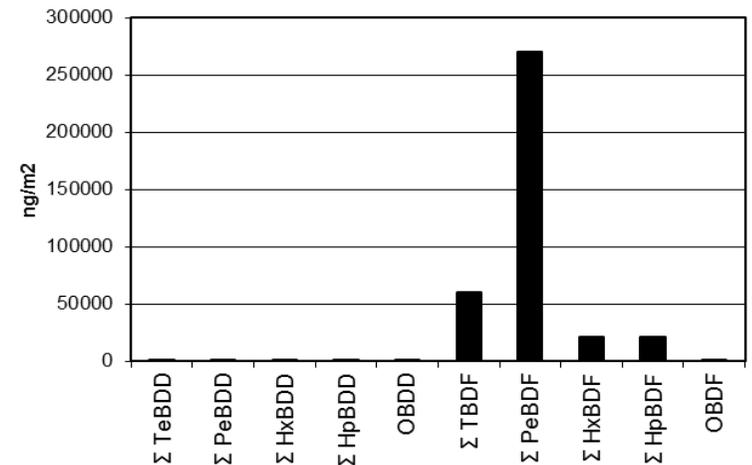
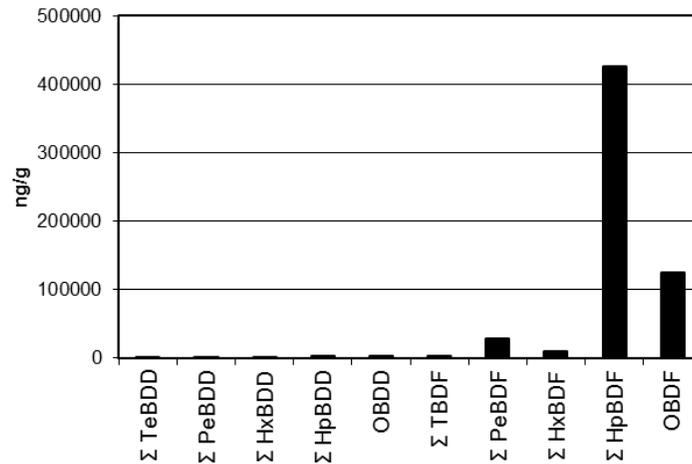


Congener profiles in TV-cabinet and soot for...

PBDEs
(ng/g)



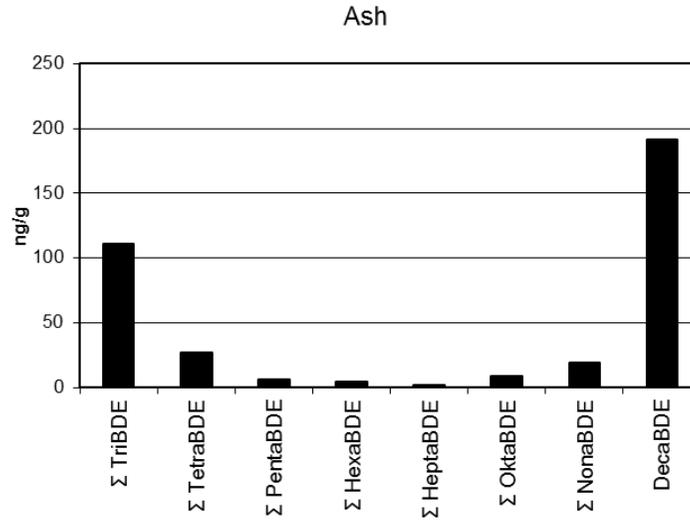
PBDD/Fs
(ng/g)



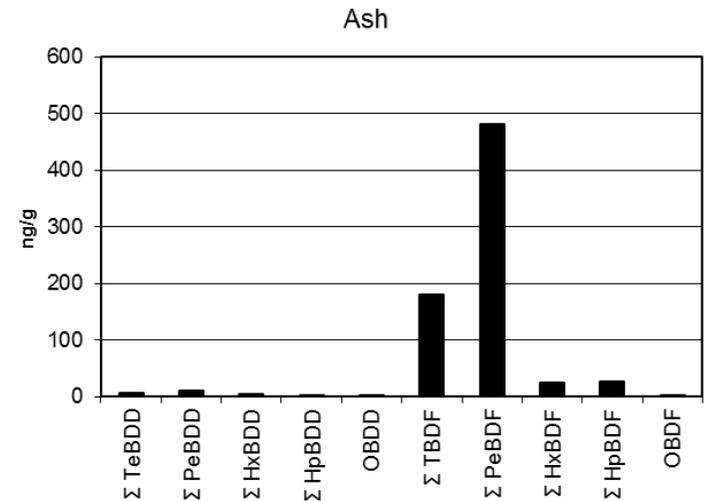


Congener profiles in the ash for...

PBDEs (ng/g)



PBDD/Fs (ng/g)





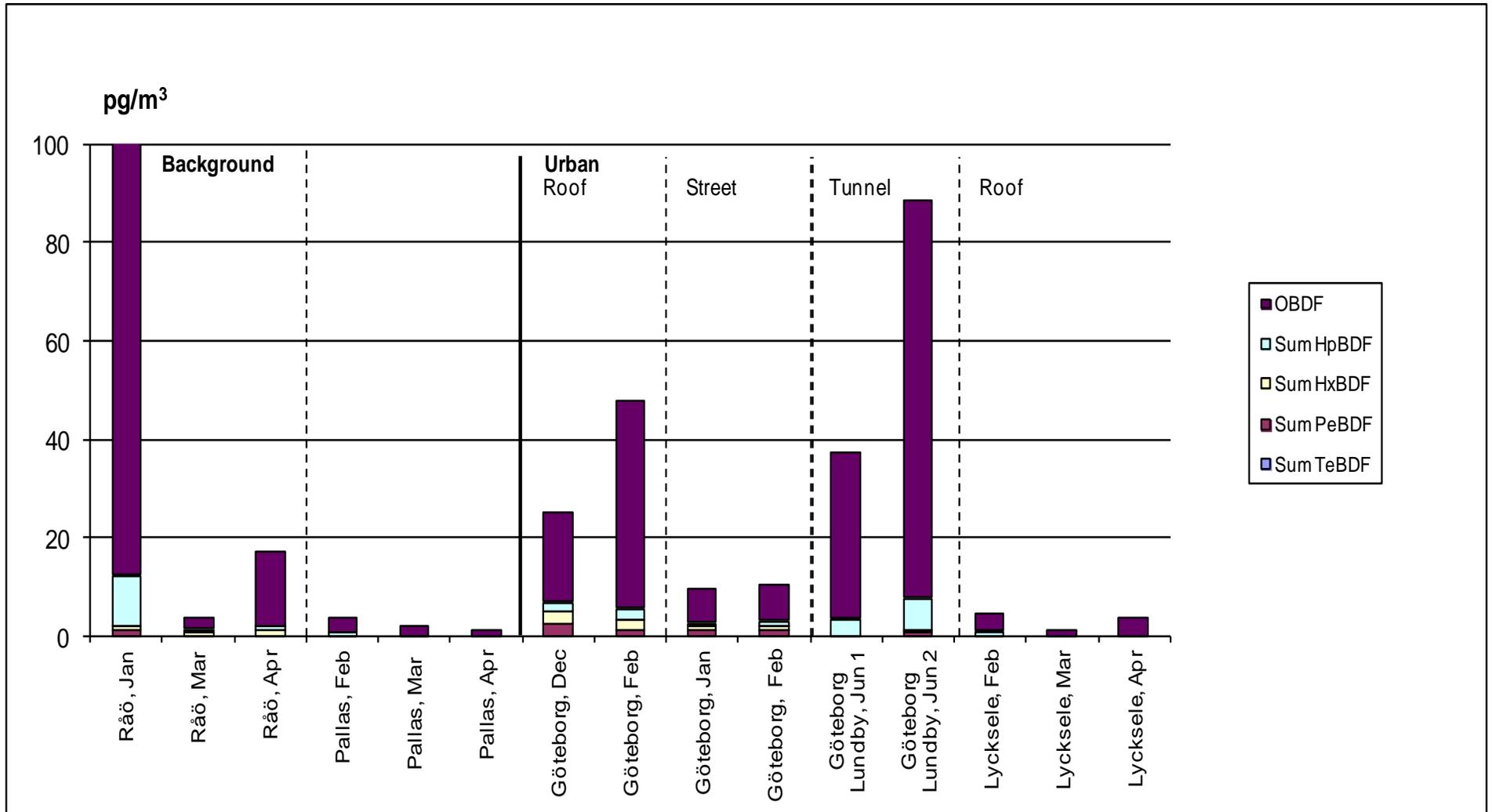
City dump in Zapallal, Peru...

...there waste, including e-waste, is combusted under more or less controlled conditions



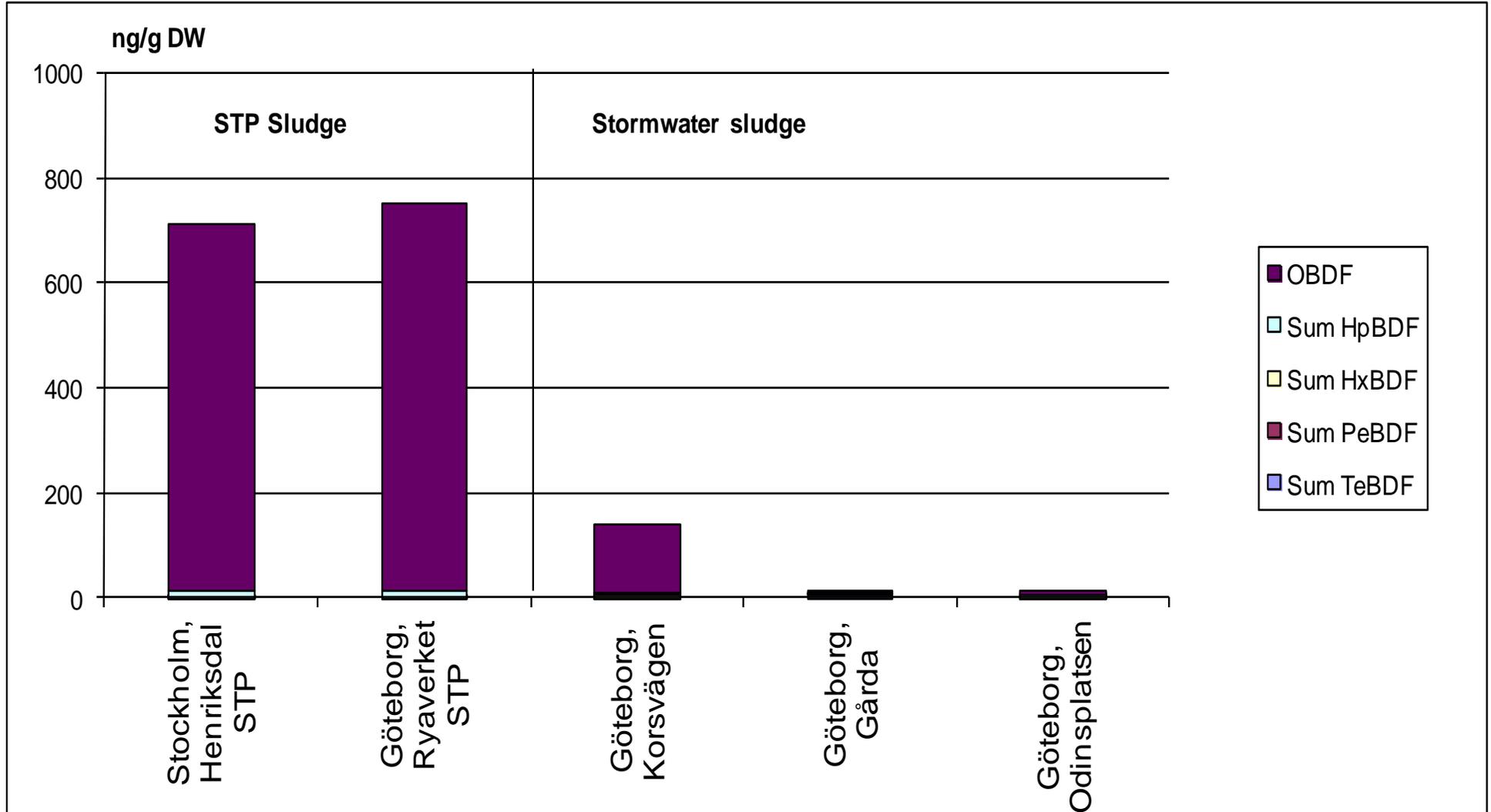


PBDFs in air



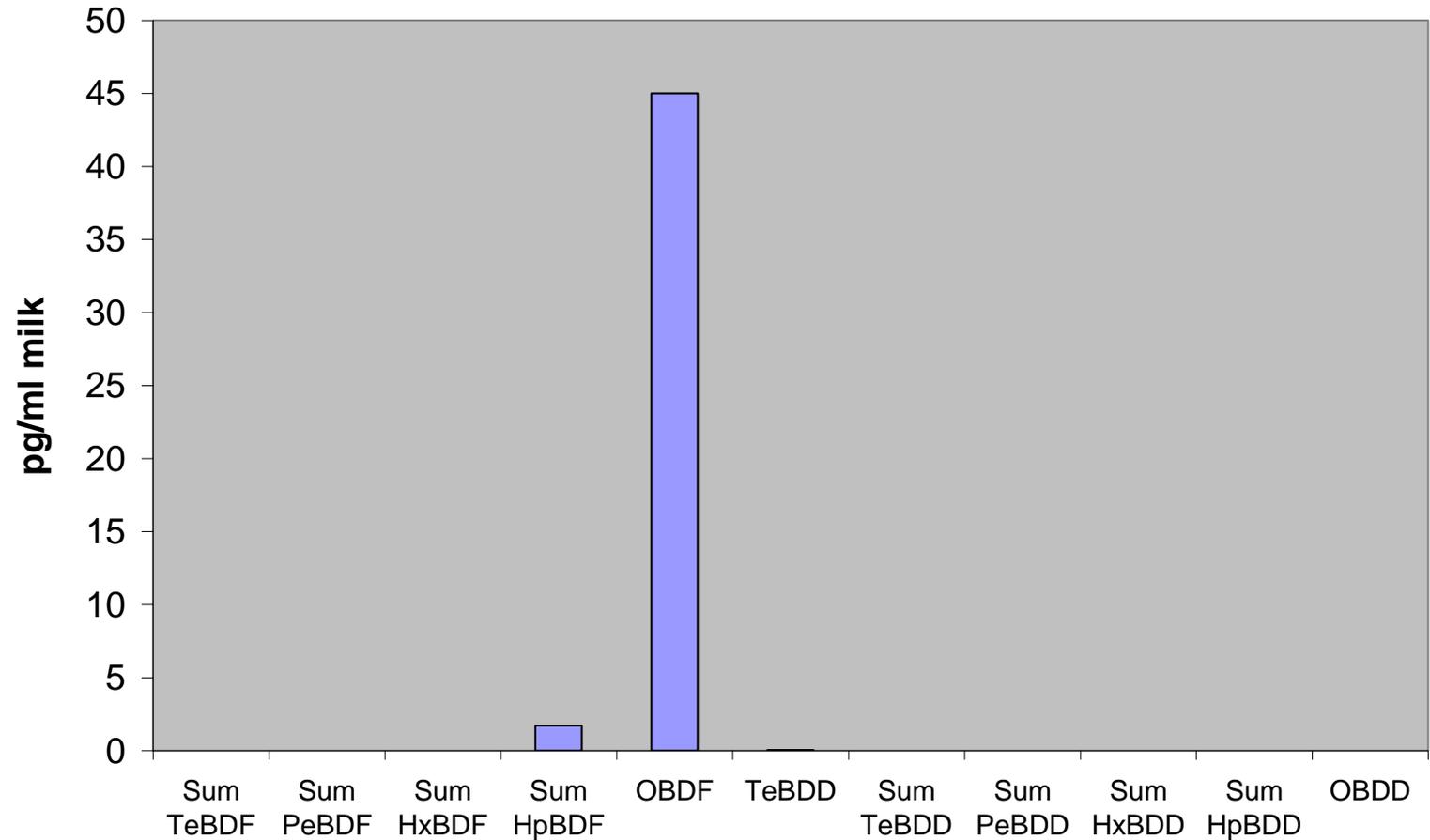


PBDFs in sludge samples





PBDF profile in human milk





Conclusions

- **PBDEs are easily transformed to PBDFs**
- **Uncontrolled fires lead to significant emissions of PBDEs and PBDFs**
- **The PBDF-emissions are often higher than the PCDD/F-emissions**
- **High temperatures/ long residence times leads to less halogenated and potentially more toxic congeners**
- **BFRs are present everywhere in society, and high levels of transformation products were detected in urban air, storm water and sludge**
- **PBDF concentrations in sewage sludge were significantly higher than the levels in storm water sludge, which indicates Technosphere sources**
- **Human milk contains high PBDF amounts; infants are significantly exposed**
- **The toxicity of the PBDFs may have to be investigated further**



Thank you!

MSB

(Swedish Civil Contingencies Agency)

Swedish EPA...

... and you for your attention!