Sakrapport till Naturvårdsverkets Miljöövervakning:

PBDE, HBCD och PCB i inomhusdamm och i bröstmjölk från förstföderskor i Uppsala 2008

Avtalsnr:	**215 0810**
Utförare:	**Livsmedelsverket**
Programområde:	**Hälsorelaterad miljöövervakning**
Delprogram:	**Biologiska mätdata – organiska ämnen**
Undersökningar/uppdrag:	**Exponering för flamskyddsmedel via andra vägar än föda**
	POPs i damm:
	1. Bromerade flamskyddsmedel - Polybromerade difenyletrar (PBDE, 16 kongener) och hexabrom-cyklododekan (HBCD)
	2. PCB (6 kongener)

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2010-04-29

Report to the Swedish Environmental Protection Agency, 2010-04-29

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PBDE, HBCD and PCB in household dust and in breast milk from primipara mothers in Uppsala 2008

Background

Persistent organic pollutants (POPs) are often connected to outdoor environments, and significant POP levels could be found in sediments and biota due to industrial or other human activities. This outdoor environmental contamination will also result in contamination of the human food chain, and the presence of measurable POP levels in many food items, of which the highest levels are generally found in fat-rich food of animal origin. As a consequence, if no occupational/industrial exposure exists, the exposure from these POPs will come mostly via the food we eat. In several studies (e.g. Liem et al., 2000) this has been shown for many of the well-known POPs, among these PCBs and dioxins, which we measure in comparably high levels in e.g. Baltic fatty fish.

However, recent research has questioned this exposure paradigm when it comes to POPs with significant indoor uses. For these compounds, extensive indoor uses will have the potential to contaminate indoor air and dust and the possible importance of this exposure route will be further stressed by the fact that a high proportion of time spent indoors; in a UK study this time was estimated to be 22 hours per day for adults (ECETOC, 2001). However, while there is still considerable uncertainty concerning human dust ingestion rates, the consensus is that they are greater for young children (US EPA, 2008).

A wide range of POPs is present in indoor environments (Rudel and Perovich, 2009). In this report, we will focus on the BFRs polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecanes (HBCDs), compounds that are found in human tissues and are known to have adverse effects in animals and, potentially, in man (de Wit, 2002; Darnerud, 2003; Covaci et al., 2006). In addition we have also included PCBs, as reference compounds, but also due to the fact that low-chlorinated PCBs are found in certain building materials, with the potential for human exposure by this route (Seldén et al., 2008).

PBDEs are used in areas where hindrance or retardation of fire is highly prioritised. Thus, in high impact polystyrene (HIPS) electronic housings, furniture foams and fabrics the PBDEs may be found at up to per cent levels. The most recent figures for the three commercial formulations (Penta-BDE, Octa-BDE, and Deca-BDE) give global production volumes in 2001 of 7,500, 3,790, and 56,100 tons, respectively (BSEF, 2004). Comparably high levels of PBDEs have been found in human samples especially from certain countries (USA and Canada) (Hites, 2004; Roosens et al., 2009) and these findings are of course of concern owing to their potential health risks (Akutsu et al., 2008; Birnbaum and Staskal, 2004; Darnerud, 2008; Main et al., 2007; Tyruk et al., 2008). The usage of several PBDE formulations has now been legally restricted, both in EU and in USA. Penta-BDE and Octa-BDE were recently

listed under the Stockholm Convention on POPs (Stockholm Convention, 2009).

Global production of HBCD in 2001 was 16,700 tons (BSEF, 2004). HBCD has found use as a flame retardant additive to expanded and extruded polystyrene foams for thermal insulation of buildings, back-coating of fabrics for furniture and (to a lesser extent) in HIPS for electronic equipment like TVs (Covaci et al., 2006). Like PBDEs, HBCD is not bound to polymeric products and is persistent and similarly ubiquitous in the environment and humans (Eljarrat et al., 2009; Roosens et al., 2009). Adverse health impacts of HBCD in laboratory animals have been observed and raised concerns (Canton et al., 2008; Ema et al., 2008; Lilienthal et al., 2009; van der Ven et al., 2009), but today no recognised health-based standard exists. HBCD is under active consideration for listing under the Stockholm Convention, and the European Chemicals Agency has declared it a priority substance under EU regulation (ECHA, 2009).

Both PBDEs and HBCD have been found in breast milk from Swedish primipara women from Uppsala county and the temporal trend for the PBDE group during the years 1996-2006 did not follow any consistent pattern, in contrast to the clear decrease for most other POPs that were simultaneously studied (Lignell et al., 2009a). However, among the PBDE congeners BDE-47 and BDE-99 show significant decreases during this time period, whereas BDE-153 levels significantly increases in breast milk. In order to better understand the possible sources behind these measured body burdens, we have monitored dust sampled in the homes of these primipara women for selected POPs. The aim of the report is to evaluate methods for sampling and POP analyses of household dust, to specifically compare two previously used sampling methods, to confirm whether the actual POPs could be found and in what concentrations, and to investigate possible correlation in levels between dust data and earlier obtained breast milk data. This report should be taken as a first presentation of a data set that will be further expanded and examined more in depth.

Material and methods

Recruitment, human sampling and questionnaire

Thirty primipara women were randomly recruited from the birth register held at Akademiska hospital, Uppsala, during January to December 2008, of which 18 participated in a dust sampling study in their homes. A contracted midwife contacted the mothers by telephone and informed them about the actual study. The mothers that were willing to participate in the study received a home visit, whereby the midwife gave additional information and material for milk sampling etc. Breast milk (up to 500 ml) was collected by the mother at home during the third week after delivery and is kept in the freezer. A second visit by the midwife was made at the end of the week of milk sampling. At this time, the midwife collected the breast milk, and also venous blood, urine and hair samples from the mother. In addition, the mother answered a questionnaire on basal data, diet and life style factors, and dust sampling was performed.

Dust sampling

The mothers (N=18) were instructed to collect dust from certain rooms (living-room first priority) in between the two visits by the midwife, by use of the family's ordinary vacuum cleaner and with a new bag inserted (about 1 g dust needed). If this was not done, the existing vacuum cleaner bag was taken for analysis. In trying to standardize dust sampling, dust was also sampled by an accompanying person from NFA by use of a specific dust sample device. A filter, used in forensic investigations, was adapted to a filter holder and mounted on the in-

air tube of a compact vacuum cleaner. This dust sampling took place above floor levels, and dust was sampled from e.g. door frames, bookshelves and on other furniture (0.01-0.1 g necessary according to instruction). The dust was sampled in the living room, but if the dust volume was estimated unsufficient the hall, sleeping room and kitchen were sometimes sampled. A specific dust questionnaire was also filled in during this visit.

Analyses

Breast milk

The compounds (congeners/metabolites) that were analysed in the mother's milk samples were 13 mono- and di-*orto* PCBs (PCB 28, PCB 52, PCB 101, PCB 118, PCB 114, PCB 153, PCB 105, PCB 138, PCB 167, PCB 156, PCB 157, PCB 180, PCB 170), polybrominated diphenylethers (BDE-28, BDE-47, BDE-66, BDE-100, BDE-99, BDE-154, BDE-153, BDE-138, BDE-183) and hexa-bromocyclododecane (HBCD). All analyses were performed at the NFA using previously described methods (Atuma et al. 2000; Atuma and Aune 1999; Aune et al. 1999; Lind et al. 2003). All samples were fortified with internal standards (PCB 189, BDE-85) prior to extraction to correct for analytical losses and to ensure quality control. A number of control samples were analysed together with the samples to verify the accuracy and precision of the measurements. The laboratory is accredited for analysis of PCBs, chlorinated pesticides and brominated flame retardants in human milk.

Dust

Extraction and clean-up Vaccum cleaner dust was first sieved, to eliminate gravel, sand and other larger particles that would give a non-proportionally large input to the weight of the dust samples. Thereafter, dust samples were prepared and analyzed in sets of 30, including three solvent blank samples, three QC-samples (SRM 2585 NIST house dust) and three surrogate reference samples resulting in 21 actual samples per series. Surrogate standards (50 µl of each) of Dechlorane (266 ng/ml) and ^{13}C-BDE209 (25 ng/ml) were added to samples. The samples were then extracted with 18 ml DCM for 30 minutes in an ultrasound bath. Each extract was collected and the extraction procedure was repeated once. The extract's solvent was reduced and changed by gently heating and evaporating the solvent with a gentle stream of nitrogen, to a final volume of approximately 100 ul. Then 5 ml of hexane was added and the sample volume again reduced to 2 ml. For clean-up of samples acid/silica-cartridges were prepared. Cartridges were plugged with a frit at the bottom, and packed with 0.5 g H_2SO_4/SiO_2-gel (1:2, w/w), and closed with a frit on top. The silica was heated overnight at 350 °C prior to mixing with sulfuric acid, and all frits used were cleaned with methanol using soxhlet extraction overnight. The acid/silica-cartridges were pre-washed twice with 6 ml n-hexane prior to use. After solvent exchange and solvent reduction, the samples were transferred to the acid/silica-cartridges. Samples were then eluted with 6 ml n-hexane, using a VacMaster to create vacuum suction, and the collected extract was then reduced to 700 µl. Concentrated samples were transferred to a GC/MS-vial and pre-spiked with 50 µl injection standard of BDE-77 (2 ng/ml). The sample volume was then reduced to 50 µl before analysis on GC/MS.

Instrumental analysis

Samples were analyzed for tri-decaBDEs (BDE-28, 47, 49, 66, 85,99, 100, 153, 154, 183, 197, 203, 206, 207, 208, 209) and total HBCD using a GC-MS with electron capture negative ionization, (GC-ECNI-MS)) with ammonia as buffering or moderating gas. The system used was a Finnigan MAT SSQ 7000 MS instrument coupled to a Hewlett-Packard 5890 II GC. The GC column used was a 15 m DB-5MS fused silica column (J&W Scientific, 0.25 mm i.d., film thickness 0.25 µm). The injections were made in split-split less mode, with the

injector at 270 °C. The oven was programmed as follows: Start at 80 °C and held for 2 min with split valve closed for 1.5 min, increase by 20 °C7min to 200 °C followed by 6 °C/min to 315 °C, and held for 5 min. MS conditions were: electron energy 70 eV, ion source temperature 180 °C, reagent gas pressure 7000-8000 mTorr. Analyses were performed by monitoring m/z 237 and 239 for the surrogate standard of Dechlorane and 494.3 and 496.3 for ^{13}C-BDE209. The analysis of nonaBDE and BDE-209 was done by monitoring m/z 484.2 and 486.2. The injection standard of BDE-77 and the rest of the brominated analytes (PBDEs and HBCD) were analyzed by monitoring m/z 79 and 81. Since there was no available authentic reference standard for BDE-208, the response factor for BDE-207 was applied with the assumption that the difference in responses was minimal.

Calculations and statistics

Mother's milk concentrations of POPs were lipid-adjusted since lipid-adjusted concentrations give a better estimate of the body burden than non-adjusted concentrations. When the POP concentrations in milk and dust were below the limit of quantification (LOQ), half of LOQ was taken as an estimated value in the calculations.

Statistical analyses of temporal trends were performed both on original data and after ranking of data, the latter procedure performed since the distribution of data did not follow a normal distribution. Correlation analyses on filter - dust bag data and on dust (filter/dust bag) – breast milk data were performed according to Pearson and to Sperman after ranking, using MINITAB 15® Statistical Software for Windows. Statistical analyses were performed only on data sets for which most analyses were above LOQ.

Results and Discussion

POP levels in dust

The result clearly showed that the collected dust, irrespective of whether it was sampled from the vacuum cleaner bag or on the filter, contained appreciable amounts of a number of POPs. In Table 1, levels of PBDE congeners and of HBCD are shown both in the vacuum cleaner bags and in the filter samples in ng/g dry wt. It could be noted that the levels in almost every case were higher on the filter samples than in the dust bag, a possible consequence of the more uniform, "cleaner" dust in the filter compared to that from the vacuum cleaner. However, in case of HBCD, the reverse was shown and higher levels were measured in vacuum cleaner dust samples. The cause behind this phenomenon is not known, but may be connected to the presence of BFR in materials in the vacuum cleaner bag or the vacuum cleaner itself. The filter sampling holder has previously been tested and should not contain any BFRs.The levels of the separate PBDE and HBCD congeners show a broad and skewed distribution, with a few samples with levels much higher than the rest. This result may not be surprising, as dust is considered to constitute a quite non-homogenous type of sample and large distribution ranges have earlier been registered (Harrad et al., 2010). Notably, earlier studies of PBDE in human samples (blood, breast milk) have shown broad distributions with a small fraction of the samples having much higher levels than the average (e.g. Johnson-Restropo et al., 2005.).

There are a number of PBDE congeners with levels above LOQ, and the absolute levels between the congeners vary a great deal. In Figure 1 is shown the relative contribution of the separate congeners (with levels above LOQ) to the total PBDE level. Above all, the dominating role of the higher brominated BDE congeners, especially the fully brominated BDE-209, is shown. Of the total PBDE congeners analysed, the nona and deca congeners constitute 92 % of total. This congener distribution is very different from that observed in biological samples, e.g. breast milk (see below).

The levels of PCBs in dust are given in Table 2. Due to analytical problems, analyses have up to now only been made on filter samples, and data from the vacuum cleaner samples will come later. For each PCB congener studied the range of levels between samples was broad, and one specific dust sample contained about 50 times the median levels of several congeners. At the same time, the median levels of the different congeners were about the same, roughly 5-15 ng/g dry wt.

POP levels in milk

Analyses of POPs in breast milk obtained 2008 from primipara women in Uppsala region has earlier been described (Lignell et al., 2009b). In that study breast milk samples from 31 women were included. From 18 of these women, residence dust samples were also obtained by the two different methods as described above. Thus, results from these 18 milk samples are shown in Table 3. As expected, the table shows similar levels of PCB and PBDE as previously reported. In many samples the PBDE levels were below LOQ, and quantifiable levels (in percentage of total no. of samples) in the case of BDE-28, -47, -99, -100, and -153 were 11, 72, 17, 38 and 100%, respectively (results for other BDE congeners were consistently below the LOQ). In the case of HBCD, data are not presented because of low levels; only three samples had levels that were above the LOQ (LOQ about 0.4 ng/g fat) and of these the highest level was 1.51 ng/g fat.

When comparing the predominant BFR congeners in breast milk with those in household dust, the lower brominated BDE congeners (tetra- to hexa congeners) are the major congeners in breast milk samples, in contrast to the results in dust. However, it should be noted that the higher brominated BDEs have not often been analysed in biological samples, partly due to analytical difficulties. When such an analysis has been done, BDE-209 indeed shows measurable levels in breast milk samples also from Nordic countries (Fängström et al., 2008, Thomsen et al., 2010). In some populations, the BDE-209 levels in breast milk could be high and dominating, probably due to occupational exposure or vicinity to production sites (e.g. Jin et al., 2009 – data from China). It should however be noted that Fängström and co-workers do not consider BDE-209 to be a suitable biomarker for at least trend studies in humans, because of the short apparent half-life and the poor transfer from blood to milk.

The PCB levels in breast milk were in most cases quantifiable (cf. Table 3); only for three of the analysed congeners were the levels below the LOQ (CB-52, -101, and -114). For PCBs in breast milk, the congeners with the largest contribution to the sumPCB were PCB-153, -138 and -180, with mean values of ca 15-30 ng/g fat, whereas other congeners had much lower values (<1 ng/g fat). In dust however, the analysed PCB congeners all had similar median values (ca 5-15 ng/g dry wt.), in spite of broad spans in levels and large standard deviations. Thus, there is no clear similarity in congener pattern between PCB in indoor dust (filter) and in breast milk obtained from the mothers living in the studied homes.

Comparison of levels between dust sampling methods

As described in Materials and Methods, the dust samples were obtained by two different methods. The two methods may result in somewhat different types of dust collected, and it is of interest to compare these methods as regards levels of PBDEs, HBCD and PCBs. The statistical correlations between the levels of each analyte in dust sampled from the ordinary vacuum cleaner bag and from the specific filter device for all residences are shown in Table 4. In this table, a highly significant correlation was in several cases observed for the raw data using parametric methods (Pearson's correlation). However, the data were not normally distributed, but instead highly skewed, suggesting that a few high-level data points may play a major role for the correlation. Thus, the data were adjusted for this by transformation using

the natural logarithm (not shown), followed by correlation calculations according to Pearson. This option showed correlation in some cases, with p values suggesting moderate significance. Even with transformation, some of the BDE congeners and HBCD were still moderately skewed, and non-parametric methods may be more appropriate. Using non-parametric correlation methods (Spearman's rank correlation) resulted in the earlier correlation between vacuum bag and filter almost totally disappearing (correlation found only for PBDE-183, p=0.048). Thus, the choice of statistical method has a profound influence on the significance of this potential correlation. The three statistical options can be visualised by expressing the correlation between the levels of BDE-209 in dust from vacuum cleaner bag and from filter as raw data, after ranking, and after n-logarithmic transformation (Figure 2 a-c). To conclude, from the statistical viewpoint most suitable option (non-parametric ranking of skewed data sets) no correlation could be observed between PBDE, HBCD and PCB as regards levels in vacuum cleaner bag and filter. However, the few high-level data points may have relevance and suggest that for highly contaminated dust samples, a correlation may exist between the two dust sampling methods. The present data set contains samples from only 18 individuals, and possible correlations may be more obvious when further samples are being analysed.

Correlation between POP levels in dust and breast milk

One interesting question to elucidate is the possible correlation between the levels of POPs in household dust and in breast milk from women living in the actual apartment/house. The correlations calculated between the BFR and PCB in dust and in breast milk using the raw data are given in Table 5. A few correlations are seen after correlation calculations according to Pearson (BDE-47 dust bag vs. milk; PCB-28 filter vs. milk, Fig. 3), but these disappeared after non-parametrical adjustment (Spearman's rank correlation). However, in one case (BDE-47 vacuum cleaner bag dust vs. breast milk) the p value after ranking was still near significance (p=0.058). Also in these correlations, the calculations are hampered by the facts already given above, i.e. the number of individuals is small, and the management of a few high-level samples is complicated. Moreover, the higher brominated BDE congeners that give the major contribution to the total PBDE in dust (nona- and deca BDE congeners) have not yet been analysed in breast milk. As already discussed above, these higher brominated congeners should be found in measurable levels also in Swedish breast milk (Fängström et al, 2008; Thomsen et al., 2010) even if the levels in blood may be higher and therefore easier to measure in that matrix. Therefore, the inclusion of more individuals and of data on higher brominated PBDE in breast milk (which both are planned) will probably improve the possibility to find these correlations and possibly lead to future interesting discussions on the role of household dust in Swedish apartments and houses in the POP exposure in adults and in children.

There are other possible correlations that could be investigated, e.g. that between BFR levels in dust (and possibly breast milk) and the presence and number of of electronic equipment, furniture with upholstery and wall-to-wall carpets, according to answers in questionnaires used in this study. However, these questions have to wait for future more detailed investigations.

Conclusions

- Quantifiable levels of HBCD and a number of PBDE congeners, and also PCBs, were present in household dust obtained during 2008 from homes of families with new-born children, in the Uppsala region.
- High-brominated PBDE congeners were totally dominating in our dust samples, and nona- and decaBDEs constituted 92% of total PBDE levels. This congener distribution is very different from what is observed in biotic samples, e.g. in breast milk (tetra- to hexa-BDEs the main congeners).
- Correlations between levels in filters and dust bags were observed regarding nona- and decaBDEs and HBCD (Pearson corr.). These significant correlations did however mostly disappear after adjustment for non-normal distribution (Spearman rank corr.).
- BFR levels in breast milk were in many cases below LOQ, and only BDE-47 and -154 showed levels generally above LOQ. Moreover, correlations between BFR levels in dust and in breast milk were rarely found after adjustment using non-parametrical methods. This, and the fact that high-brominated BDE congeners are not analysed for in breast milk, limit the possibility investigate for possible correlations BFR correlations between dust and milk.
- The present report is a first attempt to describe the findings as regards dust occurrence and potential exposure in homes in the Uppsala region. Additional studies will be performed later and the data will be subjected to further in-depth studies in order to investigate the POP exposure potential from dust, with focus on children.

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Table 1. Levels of PBDE and HBCD in indoor dust sampled from vacuum cleaner bags (B) or from dust filter (F) device (in ng/g dry wt.)

	BDE-28	BDE-47	BDE49	BDE 66	BDE 85	BDE-99	BDE100	BDE-153	BDE 154	BDE-183	BDE-197	BDE203	BDE-208	BDE-207	BDE-206	BDE-209	HBCD
Median B	0,2	15,0	1,4	0,6	0,6	12,6	2,7	2,2	1,5	1,5	0,7	0,5	89,4	4,8	7,7	277,4	86,2
Median F	0,7	42,3	2,8	1,8	0,8	26,7	6,4	6,3	2,9	5,7	2,2	1,6	362,2	16,4	23,0	522,6	9,2
Min B	0,1	1,5	0,5	0,1	0,2	0,1	0,8	0,1	0,5	0,4	0,2	0,1	26,4	1,2	2,6	104,6	9,0
Min F	0,2	8,5	0,6	0,2	0,4	3,3	0,8	1,0	0,6	1,1	0,6	0,6	179,0	6,6	7,9	191,8	5,9
Max B	2,2	47,5	18,9	18,9	2,5	67,7	13,2	11,6	9,6	8,8	4,1	5,1	1042,0	73,6	284,2	6617,2	95012,2
Max F	12,0	1529,1	50,0	28,4	20,8	779,1	137,7	62,0	44,3	69,2	14,7	10,1	5081,7	213,9	217,8	9269,3	88,6
# B	19,0	19,0	19,0	19,0	19,0	19,0	19,0	19,0	19,0	19,0	19,0	19,0	19,0	19,0	19,0	19,0	19,0
# F	18,0	18,0	18,0	18,0	18,0	18,0	18,0	18,0	18,0	18,0	18,0	18,0	18,0	18,0	18,0	18,0	18,0
Det. freq. B	0,8	1,0	1,0	1,0	0,9	1,0	1,0	0,9	1,0	0,8	0,9	1,0	1,0	1,0	1,0	1,0	0,9
Det. Freq. F	0,7	1,0	1,0	1,0	0,9	0,9	1,0	1,0	1,0	1,0	0,9	0,9	1,0	1,0	1,0	1,0	0,8

Table 2. Levels of PCB in indoor dust sampled from dust filter device (in ng/g dry wt.) (N=19; levels in all cases above LOQ)

	CB-28	CB-52	CB-101	CB-153	CB-138	CB-180
Median	5,4	4,3	9,2	13	12	9,0
StDev	12	8,2	45	117	91	110
Min	1,9	1,8	3,1	5,6	3,1	2,7
Max	56	29	209	549	427	514

Table 3. Levels of PBDE and PCB in breast milk from primipara women, Uppsala county (in ng/g fat; N=18). HBCD levels not shown due to low levels (15 of 18 sample analyses below the LOQ)

	median	min	max	det. freq.
PCB-28	0,9755	0,584	5,73	1
PCB-105	0,718	0,24	1,84	0,94
PCB-118	5,33	1,97	11,2	1
PCB-138	14	8,05	25,5	1
PCB-153	30	13,3	68,5	1
PCB-156	2,725	1,41	7,36	1
PCB-170	6,86	2,65	20,1	1
PCB-180	13,75	5,62	44,2	1
sumPCB*	77,472	34,213	182,27	
BDE-47	0,846	0,21	11,9	0,72
BDE-100	0,1675	0,105	2,76	0,39
BDE-153	0,575	0,259	1,63	1
sumBDE**	1,8785	0,788	18,163	

*sum of PCB 28, 105, 118, 138, 153, 156, 157, 167, 170, 180

**sum of BDE 28, 47, 99, 100, 153

Table 4. Statistical evaluation by two different models presenting p values and correlations coefficients (in brackets), of possible correlations between levels of PBDE congeners and HBCD in dust from vacuum cleaner bag contents vs. from filters from 18 homes. Statistical significance (bold values) at $p<0.05$.

Compound	Pearson corr.	Spearman rank corr.
BDE-47	0,331 (-0,253)	0,424 (0,201)
BDE-99	0,614 (-0,128)	**0,038** (0,492)
BDE-153	0,903 (0,031)	0,106 (0,393)
BDE-183	0,156 (0,349)	**0,048** (0,473)
BDE-206	**0,011** (0,582)	0,178 (0,332)
BDE-207	**0,004** (0,640)	0,222 (0,303)
BDE-208	**0,003** (0,663)	0,325 (0,246)
BDE-209	**0,000** (0,926)	0,635 (0,120)
HBCD	**0,037** (0,496)	0,081 (0,442)

Table 5. Statistical evaluation presenting p values and correlations coefficients (in brackets) of possible correlations between levels of selected PBDE and PCB congeners in dust from filter or vacuum cleaner bag, vs. levels in breast milk. Statistical significance (bold values) at $p<0.05$

Compound	Pearson correlation	Spearman rank correlation
BDE-47 B	**0,039** (0,490)	**0,058** (0,454)
BDE-47 F	0,605 (-0,135)	0,413 (-0,212)
BDE-153 B	0,962 (0,012)	0,875 (0,040)
BDE-153 F	0,513 (-0,170)	0,688 (0,105)
PCB-28 F	**0,000** (0,817)	0,741 (0,087)
PCB-138 F	0,785 (-0,072)	0,840 (0,053)
PCB-153 F	0,982 (0,006)	0,688 (0,103)
PCB-180 F	0,930 (0,023)	0,856 (0,047)

Figure 1. Relative contribution of PBDE congener groups to the total PBDE level in indoor dust sampled from filters (in % of total)

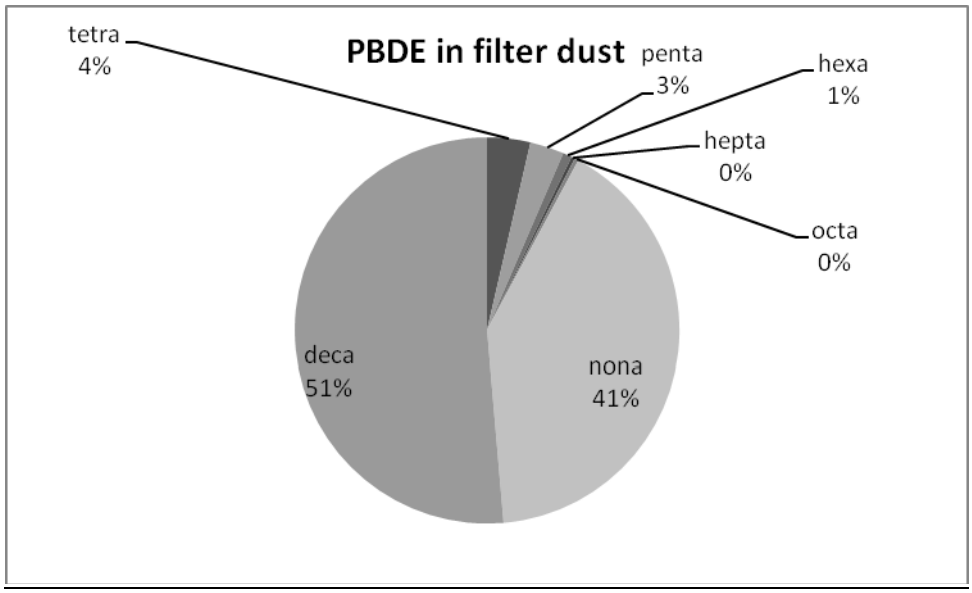
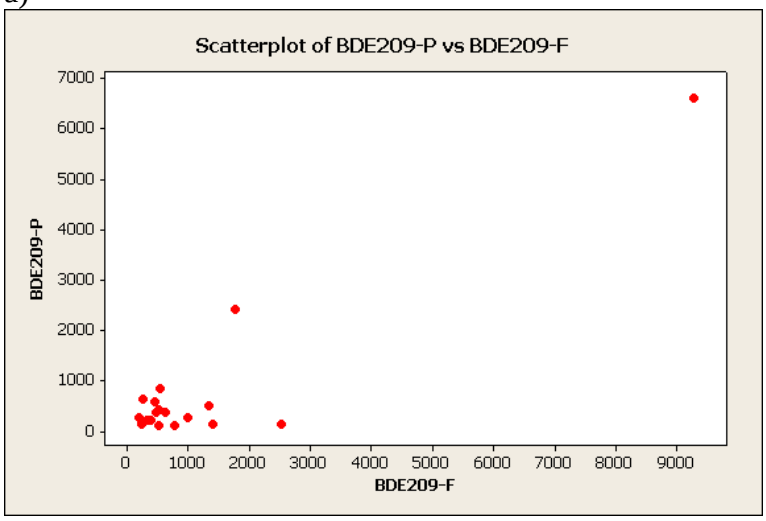
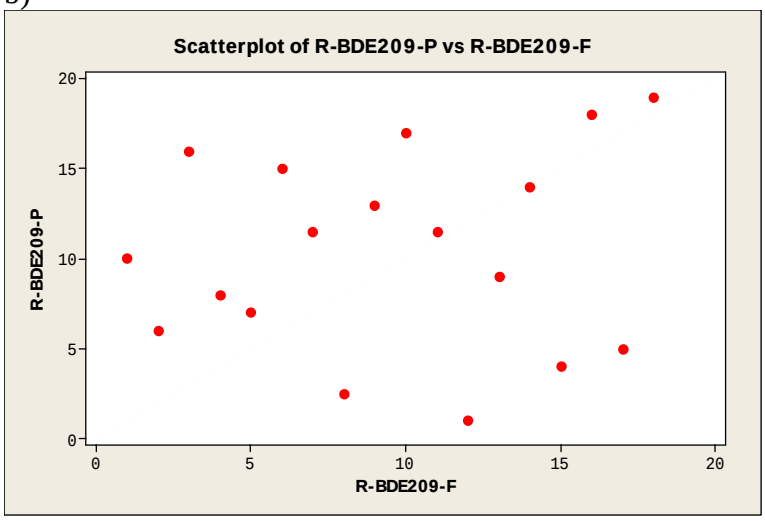


Figure 2. Scatterplots of levels of BDE-209 vacuum cleaner bag (P) versus BDE-209 filter (F), showing original data (a), after ranking of levels (b), and (c) after n-logarithmic conversion of original data ((a) in ng/g dry wt.)

a)



b)



c)

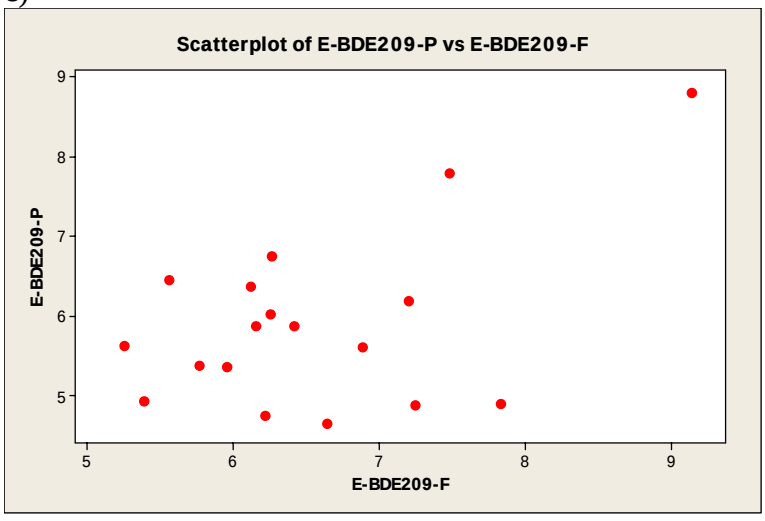


Figure 3. Scatterplot of levels of PCB-28 in filter (F) versus breast milk (B) (in ng/g dry wt., and ng/g fat, respectively)