SWEDISH RESEARCHERS HAD INCREASED PBDE-LEVELS IN SERUM AFTER INTERCONTINENTAL FLIGHTS– AN EXPLORATORY STUDY

Christiansson Anna[1], Hovander Lotta[1], Athanassiadis Ioannis[1], Rignell-Hydbom Anna[2], Jakobsson Kristina[2] and Bergman Åke[1]

[1] Department of Environmental Chemistry, Stockholm University, SE-106 91 Stockholm, Sweden
[2] Department of Occupational and Environmental Medicine, Lund University. University Hospital, SE-221 85 Lund, Sweden

Introduction

In contrast to the classical persistent organic pollutants (POPs), dust has been identified as a potential source of human exposure to brominated flame retardants (BFRs) as first shown in occupational settings, later on also in the general indoor environment. A summary of the evidence was recently published, focusing on polybrominated diphenyl ethers (PBDEs) (1). The marked variability in PBDE levels in the general population, far higher than the variability for most traditional POPs of mainly dietary origin, indicate that there are specific sources of exposure in the general indoor environment. One such source of exposure might be specific indoor environments requiring high degree of fire protection, i.e. aircrafts, in which BFRs are applied, potentially including PBDEs. Thus, as a consequence of the adsorptivity of the PBDEs to particles (2,3), there is a potential for PBDE exposure for crew and passengers via inhalation.

The first aim of this exploratory study was to assess whether PBDEs could be found in aircraft cabin dust. The second aim was to investigate if significant changes in PBDE serum concentrations could be demonstrated in air passengers after long-distance flights.

Material and methods

Nine adults (A-I), travelling on intercontinental flights from Sweden to Japan, Bangladesh, Canada and the USA and back home during September and October 2007, participated in the investigation. They all participated in international conferences, or other scientific meetings. Some of the subjects also spent some days on vacation abroad (Table 1).

Cabin dust was collected by the subjects during the flights, transferred to clean glass jars or plastic tubes, and stored in the dark immediately after sampling. There was little visible dust onboard; however, fine dust was generally to be found in the suction ventilation outlets in the air craft toilets. Blood (8ml) was drawn from the cubital vein into evacuated plain tubes prior to the departure, and after the return home. The blood was centrifuged, the serum was transferred to dark coloured acetone-washed glass bottles, frozen and kept at -20°C until chemical analysis. None of the subjects had been travelling by air during at least two months prior to the study period.

Also, another two subjects (J, K) who were domestic frequent flyers only, with one or two weekly one-hour flights during the preceding year, were enrolled in the study, and were sampled once. Dust samples were not taken during domestic flights.

Table 1. Serum sampling information and travelling data.

Sample / Person	Destination / Duration	Total flight hours
A	5 days Dioxin 2007 Japan, 5 days in China	18
B	10 days Dioxin 2007 Japan	26
C	5 days in Dioxin 2007 Japan, 6 days in Poland	28
D	10 days Dioxin 2007 Japan	26
E	12 days Dioxin 2007 Japan	26
F	7 days EPICOH 2007 Canada, 6 days in USA	28
G	6 days EPICOH 2007 Canada	19
H	11 days in Bangladesh, 4 days in Crete	36
I	2 days in UK, 11 days in Bangladesh	23
J	weekly travels within Sweden	-
K	weekly travels within Sweden	-

Extraction, lipid removal and clean up of the serum samples were performed as described by Hovander and coworkers (4). The dust samples were analyzed by gas chromatography/mass spectrometry with an ion trap GCQ Finnigan Mat instrument and the serum samples were analyzed on by GC/MS on a SSQ 710 Finnigan Mat instrument, with selected ion monitoring by scanning for the negative bromide ion (isotopes *m / z 79* and *81*) formed by electron capture negative ionization. BDE-209 was analyzed for the negative ions *m/z*: 484.6 and 486.6. Quantifications were done using authentic standards as reference compounds. The standards were all synthesized in house (5-7) except for BDE-209 which was purchased (Fluka Chemie AG, Buchs, Switzerland). PBDE concentrations are reported on wet weight basis, and also adjusted to lipid weight, as obtained by gravimetric determination. Limit of quantification (LOQ) was set at either three times the limit of detection (LOD = 3 x S/N) or three times the value in the blank sample.
For comparison of serum levels prior to, and after the intercontinental travels, we used wet weight results, in order not to introduce an unnecessary error from the gravimetric lipid weight determinations. Serum levels below the LOQ were substituted by LOQ/2. However, if both pre- and post travel PBDE levels were below LOQ, the subject was excluded from the analysis. Wilcoxon´s matched pairs signed rank test was used. A p-level <0.05 denotes a statistically significant difference.

Results
Aircraft dust: The concentrations of PBDE congeners determined in the dust samples are reported in Table 2. The following PBDE congeners were all indicated in the dust from the aircrafts: BDE-17,-28, -47, -66, -85, -99, -100, -128, -138, -153, -154,-183, -203, and BDE-209. The presence of 1,2-Bis(2,4,6-tribromophenoxy)ethane (BTBPE) was also indicated.

Table 2. Concentrations of PBDEs in 19 dust samples from aircraft cabins.

	BDE-28 pmol/g	BDE-47 pmol/g	BDE-99 pmol/g	BDE-100 pmol/g	BDE-153 pmol/g	BDE-154 pmol/g	BDE-183 pmol/g	BDE-203 pmol/g	BDE-209 pmol/g
	MW 407	MW 486	MW 565	MW 565	MW 644	MW 644	MW 722	MW 801	MW 959
median	480	6700	5200	1300	590	230	450	nd	14000
min	nd	85	25	nd	nd	nd	nd	nd	nd
max	6800	470000	510000	320000	36000	95000	270000	39000	203000

Serum: Thirteen PBDE congeners were detected (with number of samples in which the congener was detected, if not present in all samples, in parenthesis): BDE-17(2), -28, -47, -66(9), -71(4), -85(2), -99, -100, -138(18), -153, -154, -183 and BDE-209. The serum levels observed in the present study (subject A-I: pre- and post trip samples, subject J,K: one sample) are given in Table 3. All results are presented as lipid weight adjusted, to allow for comparison with levels observed in previous studies of non-occupationally PBDE-exposed groups in Sweden from our laboratory.

Table 3. PBDE concentrations in serum (pmol/g lipid) in the present, and other recent Swedish studies.

Year	Subjects	BDE-47[a]	BDE-100[a]	BDE-153[a]	BDE-183[a]	BDE-209[a]	Ref.
2007	Adult men and women	2,5 (0,99-16)	0,70 (0,27-4,1)	2,8 (1,1-7,3)	0,71 (0,21-2,8)	2,7 (1,2-10)	This study
2006	Young men, N=50	2,7 (<LOQ-32)	0,49 (<LOQ-3,4)	3,8 (1,3-18)		<LOQ (<LOQ-4,0)	10
2000	Adult men, N=17	2,5 (<1-13)	1,0 (0,44-2,8)	2,9 (1,7-5,7)	all <0,1	2,5 (0,92-9,7)	8
2000	Elderly women, N=58	1,9 (0,55-17)	0,51 (0,14-4,7)	1,7 (0,44-7,2)		0,48 (<0,18-3,5)	9

[a] Median and range is given.

The eight most abundant PBDE congeners were quantitated in samples prior to and after the trips (Table 4). For BDE-28, BDE-99, BDE-100, BDE-153, and BDE-154, the post-travel serum levels were significantly higher than the pre-travel levels. Five out of seven subjects had higher post-travel BDE-47 serum levels, and six out of eight subjects had higher post-travel BDE-183 serum levels, but the differences compared to pre-travel levels were not statistically significant. For BDE-209, only four out of seven subjects had higher post-travel serum

levels. The results are presented on wet weight bases, as to avoid the introduction of unnecessary variation from lipid weight determinations.

Table 4. PBDE concentrations (fmol/g serum) from nine subjects, A-I) sampled prior to and after inter-continental travels, and in two subjects (J-K) with frequent domestic flights. LOQ levels are given within brackets.

Sample	BDE-28 (fmol/g)	BDE-47 (fmol/g)	BDE-99 (fmol/g)	BDE-100 (fmol/g)	BDE-153 (fmol/g)	BDE-154 (fmol/g)	BDE-183 (fmol/g)	BDE-209 (fmol/g)
	MW 407	MW 486	MW 565	MW 565	MW 644	MW 644	MW 722	MW 959
A pre	1.2	[<19]	3.3	2.6	6.5	2.6	[<2.7]	35
A post	2.8	[<22]	24	7.2	10	4.2	3.9	[<30]
B pre	1.2	[<18]	1.8	[<1.8]	7.0	[<2.8]	[<2.6]	[<25]
B post	3.0	[<23]	[<3.3]	[<2.3]	6.9	[<3.6]	[<3.3]	[<32]
C pre	3.6	29	7.7	8.6	57	12	4.3	28
C post	8.2	50	12	13	71	16	8.2	40
D pre	3.4	27	7.0	7.9	9.2	[<3.7]	[<3.4]	[<33]
D post	4.1	28	7.7	7.9	10	3.9	4.0	[<36]
E pre	3.6	87	31	23	23	6.5	12	36
E post	7.0	170	70	44	47	13	27	39
F pre	[<1.2]	9.2	3.9	2.0	25	10	20	79
F post	0.99	10	4.2	2.0	26	9.7	7.4	20
G pre	0.85	16	3.6	4.9	20	8.5	3.2	[<19]
G post	1.6	20	4.3	5.9	27	12	9.4	24
H pre	1.8	24	3.8	5.4	10	3.6	3.2	[<19]
H post	2.8	22	9.1	6.3	18	6.4	7.0	23
I pre	[<1.2]	[<14]	2.1	1.8	20	3.4	12	31
I post	0.88	9.0	3.2	2.1	17	2.6	5.6	[<20]
J	1.0	15	5.2	3.6	14	5.7	2.0	[<19]
K	1.2	11	4.5	2.7	16	5.3	8.8	[<19]
p-value[a] *(pre-post travel comparison, A-I)*	*0.008*	*>0.3*	*0.015*	*0.028*	*0.038*	*0.036*	*>0.3*	*>0.3*

[a] Wilcoxon´s matched pairs signed rank test

Discussion

It is notable that all commercial PBDE products seem to have been used as flame retardants in the aircrafts; i.e. PentaBDE, OctaBDE and DecaBDE. The concentrations observed in the samples taken are intriguingly high, overall an order of magnitude higher than in most other studies on indoor dust (11,12). However, it has to be remembered that the sampling procedure was not standardized, and the number of samples was small.

Clearly, the serum PBDE congener concentrations were overall in the range expected among Swedes, i.e. low pmol/g fat concentrations. However, the post-travel concentrations were higher than the pre-travel levels for most of the PBDE congeners analyzed. It is important to remember that the observation period includes not only two intercontinental flights, but also time spent at airports, and hotels abroad. However, it should be noted that seven of the nine travelers went to the far East, and visited countries where the exposure situation is rather similar to the Swedish PBDE exposure situation (13). Only two travelers visited North America, where indoor exposure to PBDEs might be higher than in Sweden.

This is a small exploratory study with methodological flaws in sampling strategies. Still, the results are interesting. Even though it is not possible to identify the source of exposure for the travellers, it is obvious that they returned home with higher PBDE concentrations compared to the levels determined prior to the flights. Clearly, PBDEs were present in cabin dust. Thus, the present results call for an extended study, with a primary focus on aircraft cabin crew and pilots. Structured air sampling in the aircraft cabins is also suggested for exposure monitoring.

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