Polybrominated Diphenyl Ethers (PBDEs) in Breast Milk from Primiparous Women in Uppsala county, Sweden

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Introduction

Due to the large and long use of polybrominated diphenyl ethers (PBDEs) as flame retardants in materials and the leaching of these compounds into the environment, PBDEs are present in environmental samples. The highest PBDE levels are found in top predators of aquatic ecosystems, similarly to what has earlier been observed for other persistent halogenated compounds, e.g. PCBs. The PBDE levels have been increasing in several matrices for a number of years in Sweden, but the present trend is somewhat difficult to interpret (for reviews see 1-4).

The intake of PBDEs via the food is at present difficult to calculate due to the shortage of food analysis data, but may be in the range of 0.2-0.7 microgram per day (4); other human sources of exposure could not be excluded. Consequently, PBDEs are also expected to be found in human breast milk, in correspondence with other environmental chemicals such as polychlorinated biphenyls (PCBs) and DDT. Apart from a recent personal communication on PBDE in Swedish breast milk (Koidu Norén), the only published study regarding PBDEs in human breast milk reports data from a Germany survey (5). Here we report PBDE levels in breast milk from 39 primiparous mothers from Uppsala county, Sweden, and present some correlations between these levels and questionaire answers on potential factors influencing PBDE levels in breast milk.

Materials and Methods

The breast milk was obtained from primiparous mothers recruited in an ongoing study on persistent organic pollutants in blood and breast milk from mothers in the Uppsala county, planning to include ca 250 mothers. The study is coordinated by the National Food Administration and Dept. of Medical Epidemiology, Karolinska Institute. Breast milk samples (n=39) from this main study were randomly taken out for PBDE analysis. The participating mothers in this substudy were from 22 to 36 years old. The women had to answer a questionaire focusing on the present pregnancy, including symptoms, dietary and other habits (including smoking and alcohol consumption). The answer to some of these questions were used in correlation calculations in the present study.

The milk samples (35 g) were extracted twice with a n-hexane/acetone mixture (1:1). After sulphuric acid treatment, the PBDEs were separated from the dominating PCB congeners over a silica column. The analysis was performed on a Hewlett-Packard model 5890 GC equipped with dual capillary columns (Ultra-2 and DB-17) and dual electron-capture detectors. PBDE-85 (2,2',3,4,4'-pentaBDE) was used as an internal standard. The individual PBDE levels found in the breast milk were sums (sPBDE) from the five most frequently found PBDE congeners (PBDE-47, -99, -100, -153, and -154; IUPAC nomenclature). In case of levels below the detection limit, half of the detection limit was taken as an estimated value. The fat content of the milk was gravimetrically assayed, and the PBDE levels were given both on fresh and fat weight basis.

Regression analysis was used to describe a possible relationship between PBDE levels in milk and some selected parameters from the questionaire answers. Similarly, the correlation between the fat weight sPBDE and PBDE-47 levels, as well as the correlation between the fat and fresh weight sPBDE levels, was tested.

Results and Discussion

Data on fat and fresh weight based PBDE levels in breast milk samples are given in Table 1. The observed mean value of sPBDE was 4.4 ng/g fat whereas the median was 3.4 ng/g fat, which in part could be a consequence of a single, high peak value (Fig. 1). Indeed, the peak value of 28.2 ng/g was three times higher than the second highest value, 9.4 ng/g, which resulted in a wide range in PBDE levels (lowest value 1.1 ng/g fat). PBDE-47 was the major congener in the breast milk, comprising ca 55% of sPBDE. The mean fat content in milk was 3.2 %.

Table 1. *PBDE levels in breast milk from primiparous women in the Uppsala county, Sweden (n=39)*

	PBDE-47	PBDE-99	PBDE-100	PBDE-153	PBDE-154	sumPBDE
pg PBDE/g fat weight						
mean	2516	717	475	648	70	4452
median	1830	442	340	478	60	3373
min	331	181	60	255	30	1139
max	16100	4470	5140	4320	270	28170
pg PBDE/g fresh weight						
mean	77	24	14	19	2,1	137
median	58	16	10	14	1,5	102
min	8	4	1,5	8	1,5	28
max	358	222	114	96	6	626

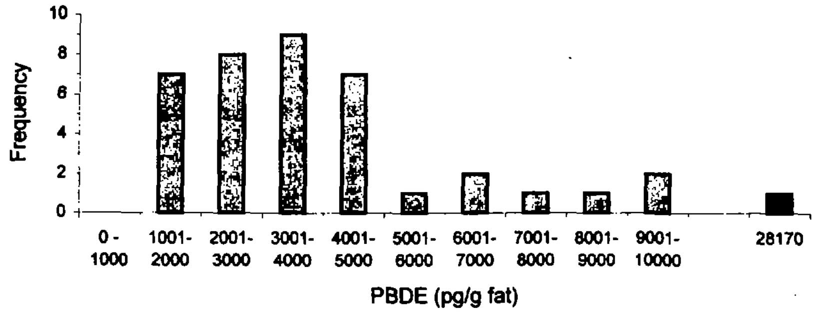

Figure 1. *Frequency diagram showing the distribution in sPBDE (fat wt.) values in breast milk from the studied mothers (n=39), each bar covering a 1 000 pg/g fat range. Note the single, very high peak value*

The median sPBDE value in breast milk in the present study, 3.4 ng/g fat, is more or less a hundred times smaller than that found for PCBs (cf. 6), a well-known and ubiquitous environmental hazard. However, the high peak sPBDE value is similar to the levels of many of the commonly found PCB congeners (e.g. 7).

The correlation between the fat weight sPBDE and PBDE-47 levels was strong ($r=0.937$, $p<0.001$) which could be expected as BDE-47 comprises such a large part of the sPBDE. An expected distinct correlation was also observed between fat and fresh weight sPBDE levels ($r=0.853$, $p<0.001$). The sPBDE peak value observation (28.2 ng/g fat) would exert an unreasonable strong influence on the estimation of the model parameters and was therefore excluded from the regression analysis.

Significant relationships were found (when regression models with only one independent variable were analysed) between fat weight sPBDE and smoking ($p=0.001$), and between fat weight sPBDE and BMI ($p=0.014$). Therefore, a stepwise regression procedure was used and the result was a model containing both BMI and smoking habit as independent variables (Table 2). The regression model showed that smoking increased the value of sPBDE significantly, when differences in sPBDE due to BMI had been accounted for. From the

Table 2. *Effects of BMI and smoking habit on sPBDE levels in breast milk studied by multiple regression*

	Regression Coefficient	Standard error	P-value
Constant	-1359.00	1814.00	0.446
BMI	192.35	79.77	0.022
Former smoker	1973.00	870.60	0.030
Present smoker	2743.70	666.9	0.000

For the entire model; $R^2 = 47.9\%$ and p-value<0.001, n=34 model it could be estimated that, on the average, sPBDE increases by 192 pg/g fat with each unit increase in BMI, assuming no change in smoking habits.

Apart from the significant relationships between sPBDE, and BMI and smoking habits, there were no other significant relationships found ($p>0.14$). Thus, the present study could not find any correlation between on one hand PBDE levels and on the other hand the mothers age, computer usage frequency, consumption of fish (total or specifically fatty Baltic), consumption of alcohol, place of residence during the mothers own childhood and adolescence (in fishing village or not), or the birth weight of the child. However, the number of observations in the present study may be too small to reveal significant changes regarding these correlations.

It is at present not known if the PBDE levels in breast milk is correlated to levels of other organohalogenated compounds, e.g. PCBs, and this will be looked upon in future studies. The knowledge on sources of human exposure is very limited; few data are available on dietary levels (4), and almost nothing is known about other types of exposure (the present study could not find any influence on PBDE levels of computer usage or fish consumption). The possible association between PBDE levels and smoking is notable; however, it is possible that this association is due to a third factor, not examined in this study, which influences both the PBDE levels and smoking habits. Hence, smoking habits do not necessarily causally affect the level of sPBDE.

Finally, the shortage of data both on dietary and other exposure levels, and on harmful effects, stresses the importance of improving the basis for risk assessment within the brominated flame retardant area.

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