Sakrapport till Naturvårdsverkets hälsorelaterade miljöövervakning (HÄMI):

Persistenta halogenerade organiska miljöföroreningar i modersmjölk från förstföderskor i Uppsala 2008.

Avtalsnummer:	**215 0615**
Utförare:	**Livsmedelsverket**
Programområde:	**Hälsorelaterad miljöövervakning**
Delprogram:	**Exponering via livsmedel**
Undersökningar/uppdrag:	**Undersökningar av organiska ämnen i bröstmjölk:**
	1. Mono- och di-*orto* PCBer
	2. Klorerade pesticider
	3. Bromerade flamskyddsmedel

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SAMMANFATTNING

Sedan 1996 har Livsmedelsverket regelbundet samlat in modersmjölk från förstföderskor i Uppsala för analys av persistenta, halogenerade organiska miljöföroreningar (POP, persistent organic pollutants). Tidstrender för POP i modersmjölk mellan 1996 och 2006 har rapporterats tidigare (Glynn et al. 2007a, Lignell et al. 2008). I följande rapport redovisas halterna av mono- och di-*orto* PCBer, klorerade pesticider och bromerade flamskyddsmedel i modersmjölk från den senaste insamlingen som genomfördes 2008 (N=31). För några av substanserna uppdateras även de tidstrender som redovisats tidigare med nya data från 2008. Under 2009 och 2010 tas en metod för analys av dioxiner (PCDD/F) och non-*orto* PCB fram vid Livsmedelsverket. Dessa substanser kommer också att analyseras i proverna från 2008 och redovisas 2011.

Medianåldern hos de kvinnor som deltog i insamlingen 2008 var 29,3 år. Bland PCBerna var mediankoncentrationen i modersmjölk högst för PCB 153 (28 ng/g fett), följt av PCB 180 (14 ng/g fett) och PCB 138 (13 ng/g fett). *p,p´*-DDE hade högst mediankoncentration (39 ng/g fett) av samtliga analyserade substanser. Medianhalten hos övriga klorerade pesticider var ≥5 gånger lägre. Bland de polybromerade difenyletrarna (PBDE) uppvisade BDE-47 den högsta mediankoncentrationen (0,76 ng/g fett) följt av BDE-153 (0,57 ng/g fett).

Utvärdering av tidstrender för perioden 1996-2008 (multipel linjär regression) visade att halterna av PCB 28, PCB 138, PCB 153, PCB 180, HCB och *p,p´*-DDE har minskat med i medeltal 4,6-8,7% per år. Halterna minskade snabbast för *p,p´*-DDE och långsammast för PCB 28. Minskningshastigheterna för PCBer, HCB och *p,p´*-DDE stämmer överens med de trender som observerades för perioden 1996-2006 (Glynn et al. 2007a). Resultaten för PBDEer stämmer också överens med det som rapporterats tidigare för perioden 1996-2006 (Lignell et al. 2008), dvs. halterna av BDE-47 och BDE-100 har minskat, medan nivåerna av BDE-153 har ökat. Tidigare var dock inte trenden för BDE-100 signifikant. Osäkerheten i resultaten för BDE-100 och BDE-153 är dock stor eftersom den tid det beräknas ta för halterna att halveras/dubbleras är mycket längre än studieperioden.

Report to the Swedish Environmental Protection Agency, 2009-04-01

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Levels of persistent halogenated organic pollutants (POP) in mother's milk from primiparae women in Uppsala, Sweden 2008

INTRODUCTION

Among the Swedish human population, food is the major source of exposure to persistent halogenated organic pollutants (POP), such as polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), polychlorinated biphenyls (PCBs), DDT-compounds and polybrominated diphenylethers (PBDEs). These compounds are lipophilic and accumulate in the lipid compartment of the human body. The POP levels in body lipids therefore reflect the long-term exposure of the individual. Exposure estimation is an important part of risk assessment of POP in food. Due to the relatively high lipid content, mother's milk is a good human matrix for analysis of POP body burdens at the time of pregnancy and nursing.

In order to estimate the body burdens of POP among pregnant and nursing women, and to estimate the intake of the compounds by breast-feeding infants, the Swedish National Food Administration (NFA) has made recurrent measurements of concentrations of POP in mother's milk from primipare women in Uppsala since 1996. Temporal trends of POP between 1996 and 2006 have been reported earlier (Glynn et al. 2007a, Lignell et al. 2008). The following report shows the results of analysis of POP (mono- and di-*ortho* PCBs, chlorinated pesticides and brominated flame retardants) in mother's milk sampled in 2008. For some of the compounds, the temporal trends that were established earlier (1996-2006) are revised with the new data from 2008. During 2009 and 2010, a method for analysis of PCDD/Fs and non-*orto* PCBs will be established at the NFA. These substances will be analysed in milk samples from 2008 and reported in 2011.

MATERIALS AND METHODS

Recruitment and sampling

Mothers (N=31) were randomly recruited among primiparas who were Swedish by birth and delivered at Uppsala University Hospital from January to December 2008. A total of 54 women were asked to participate in the study, and 31 (57%) agreed to donate mother's milk.

The mothers sampled milk at home during the third week after delivery (day 14-21 post partum). Milk was sampled during nursing using a manual mother's milk pump and/or a passive mother's milk sampler. The women were instructed to sample milk both at the beginning and at the end of the breast-feeding sessions. The goal was to sample 500 mL from each mother during 7 days of sampling. During the sampling week, the milk was stored in the home freezer in acetone-washed bottles. Newly sampled milk was poured on top of the frozen milk. At the end of the sampling week, a nurse visited the mother to collect the bottles. Data on age, weight, lifestyle, medical history etc. of the mothers were obtained from questionnaires (Table 1).

Table 1. Characteristics of the mothers donating mother's milk in 2008.

Variable		**N**	**Mean**	**Median**	**Min**	**Max**
Age of the mothers (yr)		31	28.6	29.3	17.4	35.8
Pre-pregnancy body mass index (BMI, kg/m^2)		31	23.3	22.4	17.8	33.9
Weight gain during pregnancy (% of initial wt/week)		31	0.61	0.57	0.31	1.12
Weight reduction from delivery to sampling (%)[a]		31	9.3	9.4	2.2	14.6
		N	**%**			
Education	max 3-4 yr high school	10	32			
	1-3 yr higher education	3	10			
	>3 yr higher education	18	58			
Smoking during pregnancy[b]	Non-smoker	20	65			
	Former smoker	3	9.7			
	Smoker	8	26			

[a]Weight reduction minus birth weight of the child in % of weight just before delivery.
[b]Women who stopped smoking before pregnancy are considered to be former smokers, and women who stopped smoking during the first or second month of pregnancy are considered to be smokers.

The recruitment during the period 1996-2006 (N=335) is described in Glynn et al. (2007a). A total of 366 women were recruited from 1996 to 2008. Mothers who were born in non-Nordic countries (N=10) were excluded before the statistical analysis of temporal trends. After this exclusion, a total of 356 women were included in the data set.

Analysis

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), hexachlorobenzene (HCB), hexachlorocyclohexane (β-HCH), chlordane (oxychlordane and *trans*-nonachlor), DDT (*p,p´*-DDE, *p,p´*-DDD, *p,p´*-DDT, *o,p´*-DDT), polybrominated diphenylethers (BDE-28, BDE-47, BDE-66, BDE-100, BDE-99, BDE-154, BDE-153, BDE-138, BDE-183) and hexabromocyclododecane (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, *o,p´*-DDD, 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.

Calculations and statistics

Mother's milk concentrations of POP were lipid-adjusted since lipid-adjusted concentrations give a better estimate of the body burden than non-adjusted concentrations (Lignell et al. 2004). When the concentrations 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 on logarithmically transformed data, since the distribution of data closely followed a log-normal distribution.

Multiple linear regressions (MINITAB 15® Statistical Software for Windows) were used to analyse associations between concentrations of POP (PCB 28, PCB 138, PCB 153, PCB 180, HCB, *p,p´*-DDE, BDE-47, BDE-100, BDE-153 and sumPBDE) in mother's milk and sampling year. Independent variables (life-style factors) that have been shown to influence POP levels in serum and mother's milk (Glynn et al. 2007b, Lignell et al. 2006) were included as explanatory variables in the model. The variables considered were age of the mother (years), pre-pregnancy body mass index (BMI) (kg/m^2), body weight change during pregnancy (% per week), and body weight change during the period from delivery to sampling (%) (Table 1). In the regression analyses, observations with standardized residuals ≥3 were excluded due to their large influence on the results. As a consequence of the logaritmic transformation, the associations between sampling year and POP concentrations are presented as percent change of concentrations per year, and not as change in absolute levels.

RESULTS AND DISCUSSION

POP concentrations in mother's milk

Levels of PCBs, chlorinated pesticides and brominated flame retardants in the milk samples collected in 2008 are shown in table 2. Among the PCBs, the di-*ortho* congener PCB 153 showed the highest mean and median concentration followed by the di-*ortho* congeners PCB 138 and PCB 180. The levels of PCB 52, PCB 101 and PCB 114 were below LOQ in more than 80% of the samples (results not shown). LOQ for the PCBs was 0.23-0.61 ng/g milk fat. The mono-*ortho* TEQ concentrations were calculated using both 1998 and 2005 TEFs (Van den Berg et al. 1998 and 2006). The median mono-*ortho* TEQ concentration using the 2005 TEFs was 8.5 times lower than the median mono-*ortho* TEQ concentration obtained using the 1998 TEFs.

p,p´-DDE was the compound with the overall highest median concentration. Median concentrations of the other chlorinated pesticides were ≥5 times lower. The levels of *p,p´*-DDD and *o,p´*-DDT were below LOQ in all samples (results not shown). LOQ for the DDT-compounds was 0.45-1.2 ng/g milk fat.

Among the PBDEs, BDE-47 showed the highest median concentration followed by BDE-153. The levels of BDE-28, BDE-66, BDE-99, BDE-154, BDE-138, BDE-183 and HBCD were below LOQ in 87-100% of the samples (results not shown). LOQ for PBDEs and HBCD was 0.14-1.2 ng/g milk fat.

Table 2. Concentrations (ng/g lipid) of persistent halogenated organic pollutants in mother's milk sampled from primipara women in Uppsala during 2008 (N=31). Values below the LOQ were set to ½ LOQ in the calculations of means, medians, mono-*ortho* TEQ, sumDDT and sum PBDE.

Compound	Mean	Median	Min[a]	Max	N<LOQ
PCBs					
PCB 28	1.3	1.0	0.58	5.7	1
PCB 105	0.87	0.69	0.34	3.0	5
PCB 118	5.7	5.1	1.3	17	0
PCB 138	16	13	4.2	65	0
PCB 153	31	28	7.3	119	0
PCB 156	3.1	2.7	0.70	12	0
PCB 167	0.61	0.58	0.31	2.2	9
PCB 180	15	14	2.7	60	0
PCB 157	0.51	0.38	0.31	2.5	12
PCB 170	7.2	6.4	1.5	25	0
mono-*ortho* TEQ 98 (pg/g lipid)[b]	2.6	2.3	0.65	9.5	-
mono-*ortho* TEQ 05 (pg/g lipid)[c]	0.33	0.27	0.08	1.1	-
Chlorinated pesticides					
HCB	8.4	7.9	4.8	15	0
β-HCH	4.5	3.9	2.1	11	0
oxychlordane	2.3	2.1	0.56	6.5	0
trans-nonachlor	4.4	3.7	0.78	18	0
p,p'-DDE	51	39	12	196	0
p,p'-DDT	2.3	2.0	0.80	10	1
sumDDT[d]	54	43	13	203	-
Brominated flame retardants					
BDE-47	1.2	0.76	0.41	12	13
BDE-100	0.31	0.14	0.17	2.8	22
BDE-153	0.80	0.57	0.26	4.7	1
sumPBDE[e]	2.7	1.8	0.68	17	-

[a]Lowest value >LOQ.
[b]Including PCB 105, 118, 156, 167, 114 and 157 TEQs based on 1998 WHO TEFs (Van den Berg et al. 1998).
[c]Including PCB 105, 118, 156, 167, 114 and 157 TEQs based on 2005 WHO TEFs (Van den Berg et al. 2006).
[d]Sum of *p,p'*-DDE, *p,p'*-DDD, *p,p'*-DDT and *o,p'*-DDT.
[e]Including BDE-47, -100, -99 -154, and -153.

Temporal trends

Multiple linear regressions showed that the adjusted mean decrease in concentrations of PCB 28, PCB 138, PCB 153 and PCB 180 varied between 4.6 and 8.1 % per year (Table 3, Figure 1). The regression model explained 9.8-80 % of the variation in PCB-levels, with the lowest degree of explanation for PCB 28 and the highest for PCB 180. The adjusted mean decrease in levels of HCB and *p,p´*-DDE was 7.0 and 8.7 % per year respectively (Table 3, Figure 1). The rates of decline for PCBs, *p,p´*-DDE and HCB are similar to those observed for the period 1996-2006 (Glynn et al. 2007a). The results for PBDEs are also in agreement with those reported earlier (Lignell et al. 2008), i.e. the levels of BDE-47 and BDE-100 have decreased, while the levels of BDE-153 have increased (Table 3, Figure 1). However, the trend for BDE-

100 was not significant during 1996-2006. The uncertainty of the results for BDE-100, BDE-153 and sumPBDE is large since the estimated time needed for the adjusted mean concentration to be halved/doubled in the population ("half-time") was much longer than the duration of the study period.

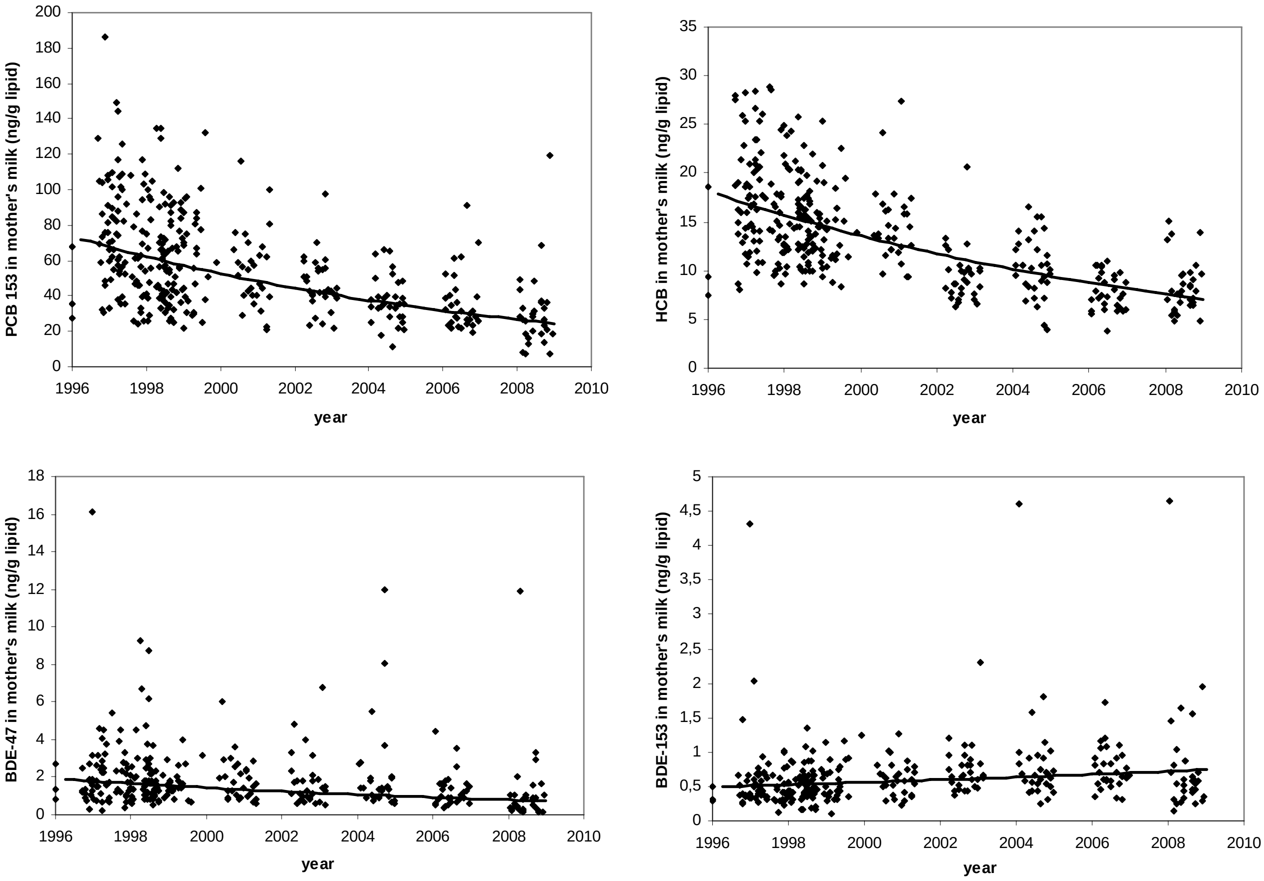

Figure 1. Temporal trends (1996-2008) of PCB 153 (N=356), HCB (N=356), BDE-47 (N=307) and BDE-153 (N=307) in mother's milk from primiparas in Uppsala, Sweden. Each point corresponds to the contaminant concentration in a milk sample from an individual woman. The lines represent regression lines obtained from multiple regression analysis including important life-style factors in the model.

Table 3. Percent change in concentrations of POP per year in mother's milk from primiparous women in Uppsala 1996-2008. Adjusted for age, pre-pregnancy BMI, weight gain during pregnancy and weight loss after delivery.

Compound	**Change/year (%)**[a]		**R^2**[b]	**"half-time"**[c]	**P**
	Mean	**SE**	**(%)**	**(years)**	
PCB 28	-4.6	1.0	9.8	15	<0.0005
PCB 138	-7.3	0.4	63	9	<0.0005
PCB 153	-8.1	0.4	73	8	<0.0005
PCB 180	-7.7	0.3	80	9	<0.0005
HCB	-7.0	0.3	65	10	<0.0005
p,p'-DDE	-8.7	0.6	46	8	<0.0005
BDE-47	-7.1	0.9	18	9	<0.0005
BDE-100	-2.9	1.0	5.5	24	0.003
BDE-153	+3.2	0.6	28	-22[d]	<0.0005
sumPBDE[e]	-3.5	0.7	9.4	20	<0.0005

[a]Percent change (decrease (-) or increase (+)) of the concentrations per year during 1996 to 2008.
[b]Coefficient of determination for the regression model
[c]The estimated time it takes for the concentrations to be halved in the population.
[d]Estimated time for the concentrations to be *doubled* in the population.
[e]Including BDE-47, -99, -100, -153 and 154.

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