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TNO-report

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Man-Made Chemicals in Maternal and Cord Blood

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Summary

In a recent Greenpeace study, conducted by the Academic Hospital Groningen in cooperation with TNO, the presence of a number of well known man-made chemicals in human blood from volunteers in The Netherlands was determined. The results clearly showed the presence of such compounds in human blood, probably resulting from day-to-day exposure to these chemicals from their presence in the diet and the environment. This second study focuses on the presence of similar compounds in blood serum samples from mother and child, e.g. maternal and umbilical cord blood.

The compounds considered in this study were tetrabromobisphenol-A, several phthalates and artificial musks, bisphenol-A and alkylphenols, certain organochlorine pesticides, triclosan and two perfluorinated compounds. The results showed that tetrabromobisphenol A, several phthalates, bisphenol-A, the organochlorine pesticides DDT, DDE and HCB, several artificial musks, triclosan and two perfluorinated compounds could be detected in maternal blood samples. The concentration of these compounds was generally within the range of concentrations determined by previous studies. These chemicals could also be detected in cord blood, although tetrabromobisphenol-A and bisphenol-A were only detected in a limited number of cord blood samples. With the exceptions of the phthalates and triclosan, the concentrations in cord blood serum were somewhat lower than in maternal blood serum. For phthalates they are more or less equal while triclosan concentrations were higher in cord blood samples than in maternal blood samples.

A search of the scientific literature revealed that this study was the first to quantify triclosan in human blood. Furthermore, it appeared that it was the first time that nonylphenol and tetrabromobisphenol-A have been detected in cord blood serum. Tetrabromobisphenol-A, a brominated flame retardant, was found in about 20% of the samples in concentrations ranging from 0.05 to 0.19 ng/g serum. The main phthalates found were di-ethyl-, di-isobutyl-, butyl-, butylbenzyl- and especially di-(2-ethylhexyl) phthalate. The median concentration of the latter was about 250 ng/g serum for both the maternal and cord blood serum samples. The maximum di-(2-ethylhexyl) phthalate concentrations were 5559 ng/g serum for maternal blood and 4004 ng/g serum for cord blood. A weak correlation was found between the DEHP levels in maternal and the corresponding cord blood serum. Di-isononyl phthalate was found in a limited number of samples while di-isodecyl phthalate was not found at all. Eight of the ten artificial musk compounds were found with galaxolide and tonalide being the dominant musks. Galaxolide was found in concentrations ranging from 0.11 to 3.2 ng/g serum. A good correlation was found between the galaxolide levels in maternal and the corresponding cord blood serum. Bisphenol-A was found in a limited number of samples at concentrations of 0.5 to 1.7 ng/g serum, while nonylphenol was found in 12 of the 17 cord blood serum samples in concentrations ranging from 0.5 to 7.5 ng/g serum. Hexachlorobenzene,

p,p'-DDE and p,p'-DDT were found in almost all samples, maternal as well as cord blood. The DDD isomers were also found, predominantly in maternal blood, probably because the levels in cord blood were close to, or below the detection limit of the method. Triclosan, was found in about 50% of the samples at concentrations of 0.1 to 1.3 ng/g serum. The perfluorinated compounds perfluoro-octane sulfonate and perfluoro-octanoic acid were found in almost all samples in concentrations ranging from 0.1 to 1.3 ng/g serum for perfluoro-octane sulfonate and 0.2 to 4.2 ng/g for perfluoro-octanoic acid. Correlations between maternal and the corresponding cord blood serum were observed for HHCB and to a lesser extent for DEHP. For p,p'-DDE the span of concentrations was to small to identify a correlation

In general, the results clearly indicate the presence of this broad suite of man-made chemicals in human blood. Although the concentrations in cord blood appear to be somewhat lower for a number of compounds (partly biased by detection limits), the results show that exposure of the mother inevitable leads to exposure of the unborn child.

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1. Introduction

Nowadays a large number of man-made chemicals are being used. As a consequence their widespread presence in the environment is becoming increasingly well documented[1,2]. Since many of these chemicals are used as additives in consumer products such as carpets, curtains, toys and electronic equipment, their presence in house dust may be expected [3,4,5]. This implies that there is a potential for human exposure, and since many of these compounds have a lipophilic nature they may be bio-accumulated, resulting in prolonged residence time in the human body. That such compounds are indeed present in the human body has been shown by many studies.

In the US, the 2001 National Report on Human Exposure to Environmental Chemicals provides information about levels of 27 environmental chemicals measured in the US population. Chemicals included are metals, organophosphate pesticide metabolites, phthalate metabolites and cotinine, a marker of exposure to tobacco smoke[6]. In the second National Report on human Exposure to Environmental Chemicals the study was extended with polycyclic aromatic hydrocarbons, polychlorinated dibenzo-p-dioxins and -furans, polychlorinated biphenyls, phytoestrogens and other groups of pesticides to a total of 116 chemicals[7]. Chemicals and their metabolites were measured in blood and urine samples from selected participants.

The WWF-UK National Biomonitoring Survey presented results of blood sample analyses of 155 volunteers for 78 chemicals including organochlorine pesticides, polychlorinated biphenyls and polybrominated diphenyl ethers[8]. In a second WWF campaign, blood samples from 47 volunteers from 17 European countries were analysed for 101 chemicals, predominantly persistent, bio-accumulative man-made chemicals including including organochlorine pesticides, polychlorinated

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1 Peters RJB. *Hazardous Chemicals in Precipitation.* TNO report R2003/198, May **2003**.

2 Vethaak AD, Rijs GBJ, Schrap SM, Ruiter H, Gerritsen A, Lahr J. *Estrogens and xeno-estrogens in the aquatic environment of the Netherlands.* RIZA/RIKZ-report 2002.001, February **2002**.

3 Santillo D, Labunska I, Davidson H, Johnston P, Strutt M, Knowles O. *Consuming Chemicals.* Greenpeace Research laboratories Technical Note 01/2003 (GRL-TN-01-2003) **2003**.

4 Peters RJB, *The Determination of Hazardous Chemicals in House Dust from Belgium homes and offices*. TNO report R2004/087, April **2004**.

5 Peters RJB, *The Determination of Hazardous Chemicals in House Dust from Brazilian homes*. TNO report R2004/159, April **2004**.

6 CDC report: *National Report on Human Exposure to Environmental Chemicals*. CDC, Atlanta, Georgia, March **2001**.

7 CDC report: *National Report on Human Exposure to Environmental Chemicals*. CDC, Atlanta, Georgia, January **2003**.

8 WWF-UK *National Biomonitoring Survey*, November **2003**.

biphenyls, brominated flame retardants, phthalates and perfluorinated chemicals[9]. The latter are chemicals used for their non-sticking properties in various applications.

In a recent Greenpeace study, conducted by the Academic Hospital Groningen in cooperation with TNO, the presence of a number of typical man-made chemicals in blood samples from volunteers in The Netherlands was determined. The chemicals considered in that study were brominated flame retardants (polybrominated diphenyl ethers as well as hexabromocyclododecane and tetrabromobisphenol-A), phthalates, artificial musks (nitro musks as well as polycyclic musks), organotin compounds, alkylphenols and alkylphenol ethoxylates and bisphenol-A. The results showed that many of these compounds are present in human blood, and sometimes in relatively high concentrations. Di-(2-ethylhexyl) phthalate, the brominated flame retardant BDE-153 and the artificial musks galaxolide and tonalide were found in almost all samples[10].

The objective of this study was to determine the concentration of a number of chemicals in maternal and cord blood serum samples. The chemicals considered in this study were; phthalates, artificial musks, bisphenol-A, tetrabromobisphenol-A, alkylphenols, triclosan, organochlorine pesticides, and perfluorinated compounds.

[9] WWF Detox campaign: *Chemical Check Up: An analysis of chemicals in the blood of Members of the European Parliament*. April **2004**.

[10] Peters RJB. *Man-made chemicals in Human Blood*, TNO report R 2004/493, November **2004**.

2. Samples and Chemical Parameters

2.1 Samples

The samples, 42 maternal blood serum and 27 cord blood serum samples, were received from the Academic Hospital of Groningen in glass tubes, closed with screw caps. The samples were received frozen and stored at -18°C until analysis.

2.2 Chemical parameters

The chemical parameters determined in this examination in human blood are listed below, including the abbreviations that are used throughout the text and in the result tables in the text and appendix.

Table 1 Lists of all individual parameters determined in the samples and their abbreviations used in the text and tables.

Brominated flame retardants:	
tetrabromobisphenol-A	TBBPA
Phthalates:	
dimethyl phthalate	DMP
diethyl phthalate	DEP
di-iso-butyl phthalate	DIBP
di-n-butyl phthalate	DBP
butylbenzyl phthalate	BBP
dicyclohexyl phthalate	DCHP
di-(2-ethylhexyl) phthalate	DEHP
di-n-octyl phthalate	DOP
di-iso-nonyl phthalate	DINP
di-iso-decyl phthalate	DIDP
Musk compounds:	
celestolide	ADBI
tonalide	AHTN
traseolide	ATTI
cashmeron	DPMI
galaxolide	HHCB
musk ambrette	MA
musk ketone	MK
musk moskene	MM
musk tibetene	MT
musk xylene	MX

Alkylphenols:	
bisphenol-A	BPA
nonylphenol	NP
octylphenol	OP
Antibacterial agents:	
triclosan	TCS
Organochlorine pesticide:	
pentachlorobenzene	PCB
hexachlorobenzene	HCB
o,p'-DDD	opDDD
p,p'-DDD	ppDDD
o,p'-DDE	opDDE
p,p'-DDE	ppDDE
o,p'-DDT	opDDT
p,p'-DDT	ppDDT
Perfluorinated compounds:	
perfluoro-octane sulfonate	PFOS
perfluoro-octanoic acid	PFOA

3. Materials and methods

With the exception of PFOS, PFOA and triclosan all methods used in this study were validated in previous studies. The validation experiments were carried out using fresh calf's blood as such and spiked with the analytes of interest. The validation study resulted in standard operation procedures that were tested on a limited number of human blood samples. The methods for PFOS, PFOA and triclosan are validated for environmental matrices and materials (triclosan only) but not specifically for the matrix human blood. The determination of PFOS and PFOA in this study was considered to be a an estimation quantitatively because only serum samples were available while whole blood samples are considered to be more representative for these compounds.

3.1 Sample analysis

3.1.1 Extraction of serum samples

All glassware used in the analyses was cleaned, rinsed with demi-water and baked in oven for 16 hours at 280°C prior to use. All solvents were distilled prior to use to achieve low blank results. The latter is especially important for the determination of the phthalates.

The serum sample was put into a clean glass 60 ml vial. Methanol, 0.1 M HCl and a set of internal standards (one or more for each group of chemicals) were added to the sample. The sample was extracted twice with a hexane-diethyl ether mixture and centrifuged after each extraction to separate the organic phase. The combined extracts were washed with a 1% KCl-solution and dried with anhydrous sodium sulphate. The extract was split into two equal parts, A and B. Part A was used for the analysis of bisphenol-A, alkylphenols, triclosan, PFOS and PFOA and part B was used for the analysis of tetrabromobisphenol-A, phthalates, artificial musks and organochlorine pesticides.

3.1.2 Bisphenol-A, alkylphenols, triclosan, PFOS and PFOA

Part A of the extract was concentrated to a small volume without further purification. Methanol was added to the extract and the extract was concentrated further to remove all hexane-diethyl ether residues. The methanol extract was processed further for the determination of BPA, NP, OP, TCS, PFOS and PFOA. The final extracts were analysed with liquid chromatography coupled with mass spectrometry (LC/MS) in the selected ion monitoring mode (SIM). Note that while the instru-

mental analysis of PFOS and PFOA is validated, the method was not optimized for this matrix.

3.1.3 Tetrabromobisphenol-A, phthalates, artificial musks and organochlorine pesticides

Part B of the extract was concentrated to a small volume and a diazomethane solution was added for the derivatization of TBBPA. The extract was concentrated again and purified using a florisil clean-up procedure in which separate fractions were collected containing one or more of the compound groups. The purified extracts were concentrated to a small volume and an injection standard was added. The final extracts were analysed with gas chromatography coupled with mass spectrometry (GC/MS) in the selected ion monitoring mode (SIM).

3.2 Identification, quantification and expression of results

The identification of analytes was based on correct retention times and qualifier ion ratios, compared to an external standard. The quantification was based on an external standard analysed together with the samples. The recovery of the added internal standards was used to determine the performance of the analysis, but not to correct the results of the target compounds.

Some chemicals which are contaminants in the environment are soluble in fats, that is, they are lipophilic. The quantification of such compounds in blood can be expressed as the concentration of the compound per gram of blood fat, for example in ng/g lipid. In this way the concentration in blood can be compared to the concentration in adipose (fat) tissue which is measured in some studies. In the present study, the amount of sample was not sufficient for the determination of the lipid content of the serum, the results in this report are expressed in ng/g serum. Since the lipid content in blood serum generally is about 0.65%, results in ng/g serum may be converted into ng/g lipid by multiplying with a factor 153. This, however, is of course only valid for lipophilic compounds.

When reading the tables in section 4 and the appendix of this report please note that while results are rounded to the correct decimal number, they are not always rounded to the correct number of significant units. In general no more than two significant numbers apply. Non-rounded numbers are used throughout the report because of the traceability of the numbers in the different tables and the text.

In the summary tables in section 4, percentiles (10^{th}, 25^{th}, 50^{th}, 75^{th} and 90^{th}) are given to provide additional information about the shape of the distribution. The 50^{th} percentile is the median concentration. The percentiles are calculated on the results

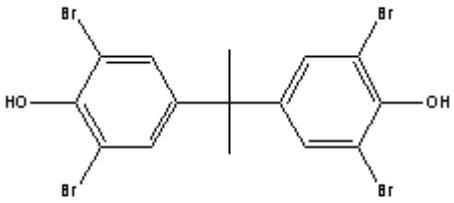
of all samples. If the calculated percentile is smaller than the method detection limit, it is replaced by the method detection limit.

4. Results

4.1 Tetrabromobisphenol-A

4.1.1 General information

In this study the determination of brominated flame retardants was restricted to TBBPA because other brominated flame retardants were already determined by a previous Greenpeace study performed at the Academic Hospital in Groningen. TBBPA is mainly used as a flame retardant in epoxy polymers such as printed circuit boards in electronic equipment like computers and television sets. TBBPA is a reactive flame retardant, e.g. it is added as a copolymer which means that it is chemically bound to the polymer material. Nevertheless, small amounts of the TBBPA monomer will not be polymerized and can "leak" into the environment. The structure of TBBPA is shown below.



tetrabromo bisphenol-A (TBBA)

There are several studies dealing with the presence of brominated flame retardants in human blood[11,12,13], but only a limited number include TBBPA. For example, Thompsen et al (2002) reported TBBPA in samples of human serum in the range of 0.34 to 0.71 ng/g lipid[14]. If converted to ng/g serum for comparison purposes, the concentrations would be 0.002 to 0.005 ng/g serum. The more recent WWF study did include TBBPA and showed that this was found in about half of the 47 samples in concentrations ranging from 0.002 to 0.333 ng/g blood[9]. In a recent Greenpeace

[11] Sjödin A, Hagmar L, Klasson-Wehler E, Kronholm-Diab K, Jakobsson E, Bergman A. Environ. Health Perspec. 643-648, *107*, **1999**.

[12] Mazdai A, Dodder NG, Abernathy MP, Hites RA, Bigsby RM. Environ. Health Perspec. 1249-1252, *111*, **2003**.

[13] Thomas GO, Hodson S, Jones KC. WWF-UK National Biomonitoring Survey 2003, Appendix 3: Lancaster University Analytical report, November **2003**.

[14] Thomsen C, Lundanes E, Becher G. *Brominated flame retardants in archived serum samples from Norway: A study on temporal trends and the role of age*. Environmental Science and Technology 1414-1418, *36*, **2002**.

study TBBPA was found in about one third of the 91 samples in concentrations ranging from 0.056 to 0.787 ng/g serum[10].

4.1.2 Results for tetrabromobisphenol-A in this study

A summary of the results for TBBPA is given in table 2 and detailed results are given in the appendix. TBBPA was found in 9 of the 42 maternal blood samples in concentrations that varied from 0.06 to 0.19 ng/g serum. Compared to other studies TBBPA was quantified slightly less frequently but concentrations were within the same range as previous studies. TBBPA was found in one cord blood sample at a concentration of 0.05 ng/g. TBBPA does not appear to have been reported in cord blood in previous studies.

Table 2 Summary of tetrabromobisphenol-A in ng/g in maternal and cord blood serum.

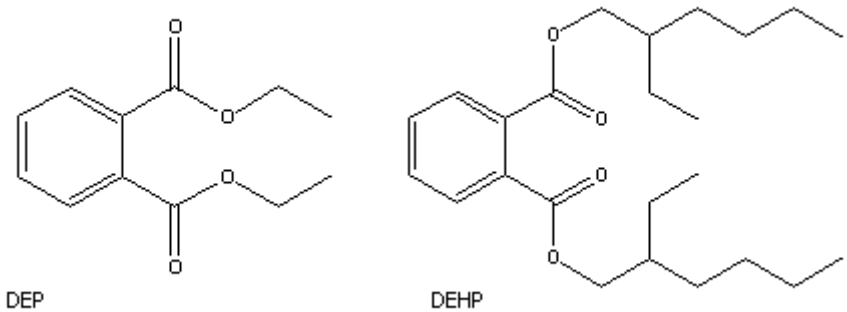
Compound	TBBPA
Maternal blood (42 samples):	
number of samples above MDL	9
minimum measured value	0.06
maximum measured value	0.19
10th percentile	<
25th percentile	<
50th percentile (median)	<
75th percentile	<
90th percentile	0.08
Cord blood (27 samples):	
number of samples above MDL	1
minimum measured value	0.05
maximum measured value	0.05
10th percentile	<
25th percentile	<
50th percentile (median)	<
75th percentile	<
90th percentile	<
method detection limit (MDL)	< 0.05

4.2 Phthalates

4.2.1 General information

Phthalates are one of the most ubiquitous classes of chemical contaminants in our everyday environment as a consequence of their high volume uses in open applications. They are used as plasticizers to increase the flexibility of high molecular weight polymers (mainly in PVC), as heat-transfer fluids and as carriers, and can

be found in ink, paint, adhesives, pesticides, vinyl flooring[2], but also in cosmetics and personal care products. Consequently, the potential for human exposure is very high. DEHP is the most commonly used plasticizers but nowadays is gradually being replaced by iso-alkyl phthalate mixtures like DINP. The chemical structure of DEP and DEHP is shown below.



DEP DEHP

Phthalates have been measured in blood, but more frequently as their metabolites in urine[6,7]. In a study of DEHP levels in blood samples from girls younger than eight years old who had premature breast development, a condition known as thelarche, the average concentrations between control subjects and those with thelarche ranged from 70 to 450 ng/g serum respectively[15]. In another study, cord blood samples were analysed for DEHP and/or MEHP (the metabolite of DEHP). These compounds were found in 88% of the samples, with average concentrations of 1190 ng/g serum for DEHP and 520 ng/g serum for MEHP[16]. In the recent WWF-UK study, phthalates were determined in the human blood of 47 volunteers[9]. DEHP was found in most samples with a median concentration of 160 ng/g blood. DIBP and DINP were found in about half of the samples with median concentrations of 7 and 31 ng/g blood. In the recent Greenpeace study DEHP was the major phthalate found in 84 of the 91 samples in concentrations ranging from 28 to 5863 ng/g serum[10].

4.2.2 Results for phthalates in this study

The results for the phthalates are summarized in table 3. The results are comparable with those of the earlier study conducted by TNO for Greenpeace[10]. In addition, the results between the maternal and cord blood samples are also comparable, possibly with an exception for DIBP which seems more pronounced in the maternal blood serum samples. As in earlier studies[10,16], DEHP seems to be the most common phthalate found in blood serum samples with a median concentration of 263 ng/g

[15] Colon I. Environ. Health Perspec. 895-900, *108*, **2000**.

[16] Latini G, de Felice C, Presta G, del Vecchio A, Paris I, Ruggieri F, Mazzeo P. Environ. Health Perspec. On line 19 August **2003**.

serum and a maximum concentration of 5559 ng/g serum in maternal blood. In cord blood the median DEHP concentration was 256 ng/g serum with a maximum concentration of 4004 ng/g serum. DINP and DIDP were found only in a very limited number of samples.

Table 3 Summary of phthalates in ng/g in maternal and cord blood serum.

Compound	DMP	DEP	DIBP	DBP	BBP
Maternal blood (42 samples):					
number of samples above MDL	2	15	18	18	16
minimum measured value	1.5	2.5	8.3	3.9	2.3
maximum measured value	2.0	19	541	257	11
10th percentile	<	<	<	<	<
25th percentile	<	<	<	<	<
50th percentile (median)	<	<	<	<	<
75th percentile	<	3.0	83	43	3.1
90th percentile	<	5.9	151	97	5.2
Cord blood (27 samples):					
number of samples above MDL	0	12	5	11	11
minimum measured value		2.4	7.3	2.1	2.0
maximum measured value		22	47	489	1321
10th percentile	<	<	<	<	<
25th percentile	<	<	<	<	<
50th percentile (median)	<	<	<	<	<
75th percentile	<	6.7	<	26	3.2
90th percentile	<	15	11	83	3.9
method detection limit (MDL)	< 1	< 2	< 5	< 2	< 2

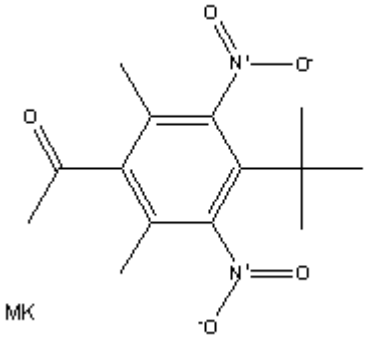
Table 3 (continued). Summary of phthalates in ng/g in maternal and cord blood serum.

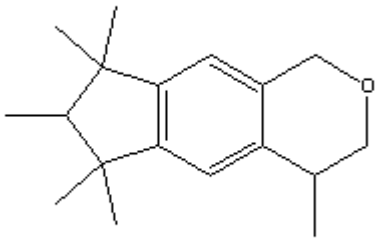
Compound	DCHP	DEHP	DOP	DINP	DIDP
Maternal blood (42 samples):					
number of samples above MDL	0	29	9	1	0
minimum measured value		30	1.1	758	
maximum measured value		5559	3.5	758	
10th percentile	<	<	<	<	<
25th percentile	<	<	<	<	<
50th percentile (median)	<	263	<	<	<
75th percentile	<	1162	<	<	<
90th percentile	<	2591	1.5	<	<
Cord blood (27 samples):					
number of samples above MDL	0	24	5	2	0
minimum measured value		27	1.2	48	
maximum measured value		4004	1.6	199	
10th percentile	<	<	<	<	<
25th percentile	<	59	<	<	<
50th percentile (median)	<	256	<	<	<
75th percentile	<	1059	<	<	<
90th percentile	<	2547	1.2	<	<
method detection limit (MDL)	< 1	< 25	< 1	< 10	< 10

4.3 Musk compounds

4.3.1 General information

In nature, musk is a compound produced by a gland in male deer which has been used in perfumes, but the increasing demand resulted in the production of artificial musk compounds. The most well known are nitro musks like MX and MK that are nowadays replaced by polycyclic musks like AHTN and HHCB. Musks are used as additives for perfumes, in detergents and soaps, in body lotions and deodorizers. The structure of MK and HHCB is presented below.





The first studies of artificial musks in human blood were concerned with MK and MX. In a study in1993, MX was found in 92% of the serum samples with a median concentration of 24 ng/g lipid[17]. When this study was repeated in 1998, MX was found in only 12% of the samples with a median concentration <10 ng/g lipid, suggesting a lower exposure to MX[18]. Another study reported median values of 6.5 ng/g lipid for MX and 5.5 ng/g lipid for MK[19]. For human adipose tissue samples, maximum concentrations found for MX and HHCB were 288 ng/g lipid and 171 ng/g lipid, respectively[20]. In the Greenpeace study in 2004, MK and MX were found in respectively 9 and 6 of the 91 samples[10]. Other nitro-musks found in that study were MA, MM and MT. The major artificial musks however were the polycyclic musks HHCB, found in all samples in concentrations ranging from 0.2 to 9.2 ng/g serum, and AHTN, found in 88 of the 91 samples in concentrations ranging from 0.1 to 11 ng/g serum. There appears to be no other published literature on the quantification of AHTN and HHCB in human blood. However, in a study on 53 human milk samples, AHTN and HHCB were detected in a high proportion of

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17 Angere J, Kafferlein HU. J. Chromatogr. B Biomed. Sci. Appl. 71-78, *693*, **1997**.

18 Kafferlein HU, Angerer J. Int. Arch. Occup. Environ. Health. 470-476, *74*, **2001**.

19 Eisenhardt S, Runnebaum B, Bauer K, Gerhard I. Environ. Res. 123-130, *87*, **2001**.

20 Muller S, Schmid P, Schlatter C. Chemosphere. 17-28, *33*, **1996**.

samples at mean concentrations of 44 and 73 μg/kg fat respectively[21]. In another study, these chemicals were detected in all 5 samples of human milk and in all 14 samples of adipose tissue that were analysed at concentrations of 8 to 58 μg/kg fat for AHTN and 16 to 189 μg/kg fat for HHCB[22].

4.3.2 Results for musks in this study

The results for the artificial musks are summarized in table 4 while the full results are given in the tables in the appendix. As in the previous Greenpeace study, in the present study HHCB was found to be the major artificial musk compound in human blood, and was present in 38 of the 42 maternal blood samples and in 26 of the 27 cord blood samples. The concentrations found in this study are about half of those found in the earlier Greenpeace study of the general population[10]. The other frequently used polycyclic musk, AHTN, was also found less frequently and in lower concentrations than in the previous study. The concentrations of HHCB and AHTN found in maternal and cord blood samples were more or less comparable. When the concentrations of AHTN and HHCB in maternal blood were converted to ng/g lipid by multiplication by 153, (AHTN 9.2 to 75 ng/g lipid, HHCB 23 to 490 ng/g lipid or μg/kg lipid), the concentrations were similar to concentrations reported previously for human milk and adipose tissue by Zehringer and Herrmann[21] and Rimkus and Wolf[22].

The nitromusks MK and MX were found in 21% and 9% respectively of maternal blood samples and less frequently in cord blood samples (7% and 0%). As in the previous studies, MA was found in a relatively high number of samples of maternal blood (35%) and cord blood (44%) samples, although in lower concentrations than in the previous study.

[21] Zehringer M, Herrmann A. *Analysis of polychlorinated biphenyls, pyrethroid insecticides and fragrances in human milk using a laminar cup liner in the GC injector*. European Food Research and Technology 247-251, *212*, **2001**.

[22] Rimkus G.G. and Wolf M. *Polycyclic musk fragrances in human adipose tissue and human milk*. Chemosphere 2033-2043, *33*, **1996**.

Table 4 Summary of artificial musks in ng/g in maternal and cord blood serum.

Compound	ADBI	AHTN	ATTI	DPMI	HHCB
Maternal blood (42 samples):					
number of samples above MDL	4	18	0	0	38
minimum measured value	0.09	0.06			0.15
maximum measured value	0.34	0.49			3.2
10th percentile	<	<	<	<	0.15
25th percentile	<	<	<	<	0.33
50th percentile (median)	<	<	<	<	0.67
75th percentile	<	0.17	<	<	0.99
90th percentile	<	0.29	<	<	1.9
Cord blood (27 samples):					
number of samples above MDL	6	16	0	0	26
minimum measured value	0.07	0.10			0.11
maximum measured value	0.26	1.5			1.6
10th percentile	<	<	<	<	0.14
25th percentile	<	<	<	<	0.29
50th percentile (median)	<	0.11	<	<	0.56
75th percentile	<	0.24	<	<	0.86
90th percentile	0.14	0.72	<	<	1.3
method detection limit (MDL)	< 0.05	< 0.1	< 0.05	< 0.05	< 0.1

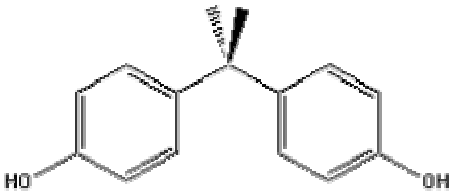
Table 4 (continued). Summary of artificial musks in ng/g in maternal and cord blood serum.

Compound	MA	MK	MM	MT	MX
Maternal blood (42 samples):					
number of samples above MDL	15	9	0	1	4
minimum measured value	0.13	0.06		0.23	0.06
maximum measured value	0.72	0.81		0.23	0.09
10th percentile	<	<	<	<	<
25th percentile	<	<	<	<	<
50th percentile (median)	<	<	<	<	<
75th percentile	0.26	<	<	<	<
90th percentile	0.36	0.22	<	<	<
Cord blood (27 samples):					
number of samples above MDL	12	2	0	2	0
minimum measured value	0.06	0.09		0.17	
maximum measured value	0.25	0.10		0.75	
10th percentile	<	<	<	<	<
25th percentile	<	<	<	<	<
50th percentile (median)	<	<	<	<	<
75th percentile	0.10	<	<	<	<
90th percentile	0.14	<	<	<	<
method detection limit (MDL)	< 0.1	< 0.05	< 0.05	< 0.05	< 0.05

4.4 Bisphenol-A and alkylphenols

4.4.1 General information

BPA is a widely used intermediate in the production of epoxy resins, polycarbonate plastics and flame retardants, and as a consequence it is a substance used in an extensive range of products. The most common monomer for polycarbonates intended for food contact is BPA[23]. Not polymerised BPA may be released from the polycarbonate and BPA was found in canned food in concentrations up to 7 µg/kg[24], probably due to migration of polymer material on the inside of the can to the food. The chemical structure of BPA is given in the figure below.



Alkylphenols and primarily alkylphenol ethoxylates are used as additives in plastics and as surface-active ingredients in industrial detergents and emulsifiers. The ethoxylates are produced by a condensation reaction of alkylphenols with ethylene oxide. While the lower condensates (number of ethoxylate units about 4) are used as emulsifiers, the higher ethoxylates are used in textile and carpet cleaning, and as emulsifiers in solvents and agricultural pesticides[25]. Alkylphenols commonly used are NP and to a lesser extent OP, in both cases pre-dominantly the para-substituted isomers (>90%). Alkylphenols may be produced as a consequence of chemical degradation of the ethoxylates. The chemical structure of n-NP is shown below.

23 Mountfort KA, Kelly J, Jickels SM, Castle L. Food Additives and Contaminations, 56-63, *14*, **1997**.

24 Goodson A, Summerfield W, Cooper I. Food Additives and Contaminants. 1-12, *19*, **2002**.

25 Maguire R.J. Water Qual. Res. J. Canada 34, 37-78, **1999**.

BPA has been found in human blood serum at concentrations of 1-2 ng/g serum[26]. In another study, BPA was reported in maternal serum at concentrations of 0.21 to 0.79 ng/g and in cord blood serum at 0.45 to 0.76 ng/g[27]. In the previous Greenpeace study BPA was found in about one third of the whole blood samples in concentrations ranging from 0.57 to 16 ng/g blood.

NP has been detected in serum at concentrations ranging from 14 to 222 ng/g serum while octylphenol OP was found in only one sample out of five samples at a concentration of 0.5 ng/g serum[28]. In the previous Greenpeace study, NP was found in 16 of the 91 samples and OP was found in only two samples. The concentrations of NP and OP ranged from 0.58 to 16 ng/g blood[10]. Evidence for the presence of NP (and BPA) in umbilical cords were found by Takada et al who analysed human umbilical cord tissue and identified BPA and NP in concentrations in the ng/g wet tissue range[29].

4.4.2 Results for bisphenol-A and alkylphenols in this study

The results for BPA and the alkylphenols are summarized in table 5 while the full results are in the tables in the appendix. While BPA was found in about 40% of the samples in the previous study, it was found in about 15% of the maternal blood samples in this study. The concentrations in maternal blood ranged from 0.5 to 1.7 ng/g serum which is similar to concentrations reported in previous studies[23,27]. In cord blood, BPA was found in only one sample at a concentration of 1.3 ng/g serum. This is different to the previous study by Kuroda *et al.* which detected BPA in all 9 samples of cord blood that were analysed[27].

OP was not detected in any blood samples. This was not surprisingly since OP is rarely found in biological or environmental samples. There were some analytical problems with the determination of NP in maternal blood samples. Unknown interferences in the chromatograms didn't allow a correct identification and quantification of NP. Although attempts were made, no satisfactory solution was found to overcome these problems. Therefore, the two maternal blood samples in which NP could be identified may be an underestimation of the real number of samples that

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26 Ikezuki Y, Tsutsumi O, Kamei Y, Taketani Y. Hum. Reprod. 2839-2841, *11*, **2002**.

27 Kuroda N, Kinoshita Y, Sun Y, Wada M, Kishikawa N, Nakashima K, Makino T, Nakazawa H. *Measurement of bisphenol A levels in human blood serum and ascitic fluid by HPLC using a fluorescent labelling reagent*. Journal of Pharmaceutical and Biomedical Ananlysis 1743-1749, *30*, **2003**.

28 Inoue K, Yoshimura Y, Makino T, Nakazawa H. Analyst. 1959-1961, *125*, **2000**.

29 Takada H, Isobe T, Nakada N, Nishiyama H, Iguchi T, Irie H, Mori C. *Bisphenol-A and nonylphenols in human umbilical cords.* Proceedings of the International Scientific Conference on Environmental Endocrine Disrupting Chemicals,Monte Verita ,Ascona, Switzerland, March, **1999** (also http://www.eawag.ch/courses/eedc/abstracts.html).

contained this compound. However, similar problems were not encountered in the analysis of the cord blood samples. NP was detected in 12 of the 17 samples in concentrations ranging from 0.5 to 7.5 ng/g serum which is lower than those detected in human blood a previous study[24] and within the range of concentrations reported in the previous Greenpeace study. A search of the scientific literature suggested that this is the first time NP concentrations in cord blood are reported.

Table 5 Summary of bisphenol-A and alkylphenols in ng/g in maternal and cord blood serum.

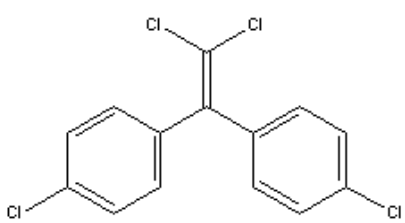
Compound	BPA	OP	NP[A]
Maternal blood (39 samples):			
number of samples above MDL	6	0	*2*
Minimum measured value	0.5		*0.8*
maximum measured value	1.7		*1.0*
10th percentile	<	<	
25th percentile	<	<	
50th percentile (median)	<	<	
75th percentile	<	<	
90th percentile	0.6	<	
Cord blood (17 samples):			
number of samples above MDL	1	0	12
minimum measured value	1.3		0.5
maximum measured value	1.3		7.5
10th percentile	<	<	<
25th percentile	<	<	<
50th percentile (median)	<	<	1.0
75th percentile	<	<	1.5
90th percentile	<	<	2.8
method detection limit (MDL)	< 0.5	< 0.5	< 0.5

A: Due to an as yet unknown interference NP could not be determined in 35 of the 39 maternal blood samples

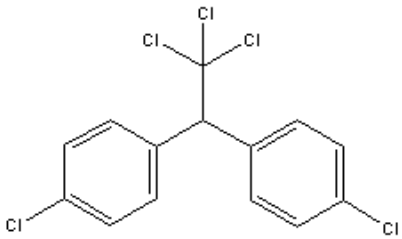
4.5 Organochlorine pesticides

4.5.1 General information

In the past, organochlorine pesticides such as DDT were widely used on a global basis. Although their manufacture and application are now largely prohibited or restricted in industrialized western countries, they can still be found in environmental and biological matrices due to their persistence. The structures of ppDDT and the breakdown product of DDT, ppDDE, are given below.



p,p'-DDE



p,p'-DDT

In previous studies on human blood, ppDDE and ppDDT were found in most samples while opDDD, opDDE, opDDT and ppDDD were found in only a few samples[6,7,8,30,31]. A study in Belgium reported concentrations of 0.565 to 20.7 ng/g for ppDDE in maternal serum[30], whilst a study in Portugal reported concentrations of undetectable to 390.5 ng/g serum for the general population[32]. In the most recent WWF study, the ppDDT concentrations varied from 0.007 to 0.65 ng/g serum while those of ppDDE ranged from 0.25 to 8 ng/g serum[9]. The fact that ppDDE concentrations are about one factor higher than those of ppDDT is a common feature in most studies and most probably indicates that exposure to the DDT pesticide was either through indirect routes (e.g. through the diet) or some time in the past[8]. For cord blood, concentrations of 0.12 to 2.91 ng/g serum were reported in all samples tested for ppDDE in the Belgian study[30].

The Belgian study reported HCB levels in maternal serum in the range of 0.06 to 0.515 ng/g serum[30]. The study also reported that HCB was present in all samples of cord blood tested at concentrations of 0.025 to 0.24 ng/g serum.

4.5.2 Results for organochlorine pesticides in this study

The results for a number of organochlorine pesticides are summarized in table 6 and are presented in full in the appendix. As in other studies, HCB, ppDDE and ppDDT were found in the majority of samples (three quarters or more), in maternal as well as cord blood. Although the frequency is comparable to other studies, the concentrations of ppDDE (0.33 to 1.9 ng/g serum with a median value of 0.75 ng/g

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[30] Covaci A, Jorens P, Jacquemyn Y, Schepens R. Distribution of PCBs and organochlorine pesticides in umbilical cord and maternal serum. Sci. Total Environ. 45-53, 298, **2002**.

[31] Koppen G, Covaci A, Van Cleuvenbergen R, Schepens R, Winneke G, Nelen V, Van Larebeke N, Vlietink R, Schoeters G. Persistemt organochlorine pollutants in human serum of 50-65 years old woman in the Flanders Environmental Health Study (FLEHS). Part 1: Concentrations and regional differences. Chemosphere 811-825, 48, **2002**.

[32] Cruz S, Lino C, Silveira MI . *Evaluation of organochlorine pesticide residues in human serum from an urban and two rural populations in Portugal*. The Science of the Total Environment 23-25, *317*, **2003**.

serum) were at the lower end of the range of those detected in a Belgian study[30] and the WWF study. Concentrations of ppDDT (0.09 to 1.5 ng/g with a median value of 0.27 ng/g) were similar to or slightly higher than those in the WWF study. In cord blood, concentrations of ppDDE (0.15 to 0.83 ng/g serum with a median value of 0.29 ng/g serum) were within the range of those detected in the study in Belgium[30].

Unlike previous studies, there were a high number of samples that contained opDDD and ppDDD. In the present study, most of the maternal blood samples did contain these metabolites while they were only present in a few cord blood samples. However, considering the fact that the HCB, ppDDE and ppDDT concentrations in cord blood were about half of those in the maternal blood, the absence of the DDDs in cord blood may be a detection limit problem.

Concentrations of HCB in maternal serum (0.06 to 0.68 ng/g with a median value of 0.15 ng/g serum) and cord blood (0.05 to 0.13 ng/g with a median value of 0.07 ng/g serum) were within the range of concentrations reported in a previous study conducted in Belgium[31].

Table 6 Summary of organochlorine pesticides and metabolites in ng/g in maternal and cord blood serum.

Compound	PCB	HCB	opDDD	ppDDD	opDDE
Maternal blood (42 samples):					
number of samples above MDL	2	42	41	35	0
minimum measured value	0.06	0.06	0.07	0.07	
maximum measured value	0.09	0.68	0.51	0.74	
10th percentile	<	0.09	0.10	<	<
25th percentile	<	0.11	0.15	0.12	<
50th percentile (median)	<	0.15	0.23	0.18	<
75th percentile	<	0.18	0.31	0.25	<
90th percentile	<	0.23	0.37	0.32	<
Cord blood (27 samples):					
number of samples above MDL	1	23	1	3	0
minimum measured value	0.06	0.05	0.10	0.20	
maximum measured value	0.06	0.13	0.10	0.28	
10th percentile	<	<	<	<	<
25th percentile	<	0.06	<	<	<
50th percentile (median)	<	0.07	<	<	<
75th percentile	<	0.08	<	<	<
90th percentile	<	0.1	<	<	<
method detection limit (MDL)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Table (continued). Summary of organochlorine pesticides and metabolites in ng/g in maternal and cord blood serum.

Compound	ppDDE	opDDT	ppDDT
Maternal blood (42 samples):			
number of samples above MDL	42	0	39
minimum measured value	0.33		0.09
maximum measured value	1.9		1.5
10th percentile	0.50	<	0.13
25th percentile	0.64	<	0.19
50th percentile (median)	0.75	<	0.27
75th percentile	1.1	<	0.38
90th percentile	1.2	<	0.57
Cord blood (27 samples):			
number of samples above MDL	27	0	20
minimum measured value	0.15		0.09
maximum measured value	0.83		0.51
10th percentile	0.19	<	<
25th percentile	0.23	<	<
50th percentile (median)	0.29	<	0.14
75th percentile	0.39	<	0.27
90th percentile	0.54	<	0.33
method detection limit (MDL)	< 0.05	< 0.05	< 0.05

4.6 Triclosan

4.6.1 General information

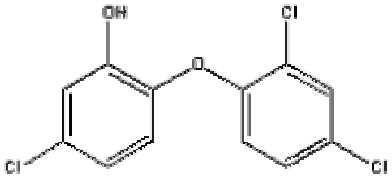
TCS, also known as 5-chloro-2-(2,4-dichlorophenoxy)phenol, is a well known, and widely used, antibacterial and antimicrobial agent[33]. Due to its effectiveness against bacteria that cause spoilage, odour and infection, TCS has been incorporated into many common consumer products including toothpaste, deodorants, cosmetics, textiles, toys and antibacterial soaps and detergents. The increasing use of these products over the last 30 years has invariably led to TCS, and its breakdown product methyl-triclosan, being found in the environment. Okumura and Nishikawa found traces of TCS in water, sediment and fish[34]. It was also found in the bile of fish exposed to municipal wastewater and in wild living fish from the receiving waters of wastewater treatment plants[35]. Studies have indicated that TCS is

[33] Glaser A. The Ubiquitous Triclosan. A common antibacterial agent exposed. Pesticides and You, 12-17, 24, **2004**.

[34] Okumura T, Nishikawa Y. *Gas chromatography – mass spectrometry determination of triclosans in water, sediment and fish samples via methylation with diazomethane*. Analytica Chimica Acta, 175-184, 325, **1996**.

[35] Lindstrom A, Buerge IJ, Poiger T, Berqvist P. *Occurrence and environmental behaviour of the bactericide triclosan and its methyl derivate in surface waters and in wastewater*. Env. Sci. Technol. 2322-2329, 36, **2002**.

environmentally persistent and acutely toxic to biota, with methyl-triclosan being more persistent and exhibiting a potential for bioconcentration[36,37]. The structure of TCS is shown below.



Because of the use of TCS in personal care products and its potential for bioconcentration its presence in human blood should be no surprise. A study in Sweden detected triclosan in human blood plasma but did not quantify the concentration[38]. Triclosan was also detected in 3 out of 5 human breast milk samples in another Swedish study at concentrations of 60, 130 and 300 ng/g lipid[39].

4.6.2 Results for triclosan in this study

Table 7 shows a summary of results for triclosan and the full results are presented in the appendix. TCS was found in approximately half of the samples. For maternal blood the concentrations ranged from 0.1 to 1.3 ng/g serum while those for cord blood ranged from 0.5 to 5.0 ng/g serum. Although the frequency of occurrence in maternal and cord blood is comparable, the levels in cord blood were higher than in maternal blood. As far as we know these results are the first to quantify TCS in human blood samples. If the TCS concentrations in maternal blood are based on lipid content (15 to 199 ng/g lipid), the concentrations found are comparable with those found in human breast milk samples by Adolfsson-Erici[39]. It should be mentioned that in this study only TCS and not the metabolite methyl-triclosan was determined. From environmental studies it is known that the methyl-triclosan concentrations are generally higher than those of TCS itself[36].

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[36] Böhmer W, Rüdel H, Wenzel A. Fraunhofer IME Presentation "Retrospective Monitoring of Triclosan and Methyl-triclosan in Fish, www.ime.**fraunhofer**.de/presentations/ methyl**triclosan**_esb.pdf, Bordeaux 2004.

[37] Balmer ME, Poiger T, Droz C, Romanin K. Occurrence of methyl triclosan, a transformation product of the bactericide troclosan in fish from various lakes in Switzerland. Env. Sci. Technol. 390-395, 38, **2004**.

[38] Hovander L, Malmberg T, Athanasiadou M, Athanassiadis I, Rahm S, Bergman A, Klasson Wehler E. *Identification of hydroxylated PCB metabolites and other phenolic halogenated pollutants in human blood plasma*. Archives of Environmental Contamination and Toxicology, 105-117, **42**, 2002.

[39] Adofsson-Erici M, Pettersson M, Pakkonen J, Sturve J. *Triclosan, a commonly used bactericide found in human milk and in the aquatic environment in Sweden*. Chemosphere, 1485-1489, 46, **2002**.

Table 7 Summary of triclosan in ng/g in maternal and cord blood serum.

Compound	TCS
Maternal blood (39 samples):	
number of samples above MDL	16
minimum measured value	0.1
maximum measured value	1.3
10th percentile	<
25th percentile	<
50th percentile (median)	<
75th percentile	0.2
90th percentile	0.6
Cord blood (17 samples):	
number of samples above MDL	8
minimum measured value	0.5
maximum measured value	5.0
10th percentile	<
25th percentile	<
50th percentile (median)	<
75th percentile	1.1
90th percentile	1.7
method detection limit (MDL)	< 0.1

4.7 Perfluorinated compounds

4.7.1 General information

Perfluorinated compounds (PFCs) are synthetic compounds characterised by an alkyl chain in which the hydrogen atoms are completely replaced by fluorine atoms. PFCs are heat stable, very resistant to degradation and environmental breakdown and have an amphiphilic nature (they repel water as well as oil). Because of these properties PFCs are used a myriad of applications, such as non-stick pans and stain/water repelling coatings for clothing, furniture and paper. Typical brand names are Teflon, Gortex, Stainmaster and Scotchguard[40]. However, it has been known for many years that PFCs accumulate in the environment and they have been detected far from manufacturing plants in birds, marine plants and mammals from the Arctic to the Pacific and Indian Oceans and in land creatures in Europe and the USA. The PFCs detected in such environmental samples include PFOS and PFOA. In response to the widespread distribution of PFOS, the major manufacturer (3M company) ceased the production of PFOS in 2001[40].

[40] 3M. *Fluorochemical Use, Distribution and Release Overview*. EPA docket AR226-0550, **1999**.

Although recently a number of other, potentially bioaccumulating, perfluorinated acids were reported in wildlife and in human blood[9,41,42,43], PFOS is the PFC compound that has been reported most frequently. Levels found in human serum from the general population vary between different countries but generally fall within the range of <1 to 200 ng/g serum[44]. For PFOA, a study on human blood samples from several countries determined that PFOA was generally found at concentrations 2 to 7 fold lower than PFOS[44]. In blood, PFOS and PFOA are assumed to bind to plasma proteins, and thus analysis of whole blood samples is most considered most representative[45,46]. In addition to PFOS and PFOA other PFCs such as perfluorohexane sulfonate (PFHxS), perfluorononanoic acid (PFNA) and perfluorooctane sulphonamide (PFOSA) have been found in human blood at concentrations that are generally lower than PFOS[43,44].

PFOS and PFOA have also been detected in cord blood. In a study of PFCs in human blood samples from northern Canadian populations, Tittlemier *et al* detected PFOS (mean concentration 16.7ng/ml) and PFOA (mean concentration 3.4 ng/ml) in samples of umbilical cord blood plasma[47]. Another study in Japan reported the presence of PFOS in cord blood serum at concentrations of 1.6 to 5.3 ng/ml[48]. The study detected PFOA a small number of serum samples from the mothers but not in cord blood serum.

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[41] Calafat AM, Kuklenyik Z, Reich JA, Butenhoff JL, Needham LL. Organohalogen compounds, 319-322, 62, **2003**.

[42] Moody CA, Martin JW, Kwan WC, Muir DC, Malbury SA. Env. Sci. Technol. 545-551, 36, **2002**.

[43] Karrman A, Van Bavel B, Jarnberg U, Hardell L, Lindstrom G. *Levels of perfluoroalkylated compounds in whole blood from Sweden.* Organohalogen compounds, 4058-4062, 66, **2004**.

[44] Kannan K, Corsolini S, Falandysz J, Fillman G, Kumar KS, Loganathan BG, Mohd MA, Olivero J, Van Wouwe N, Yang JH, Aldous KM. (2004). *Perfluorooctanesulfonate and related fluorochemicals in human blood from several countries.* Environmental Science and Technology, 4489-4495, *38*, **2004**.

[45] Jones PD, Hu W, de Coen W, Newsted JL, Giesy JP. Env. Toxicol. Chem. 2639-2649, 22, **2003**.

[46] Han X, Snow TA, Kemper RA, Jepson GW. Chem. Res. Toxicol. 775-781, 16, **2003**.

[47] Tittlemier S, Ryan JJ, Van Oostdam J. (2004). Presence of anionic perfluorinated organic compounds in serum collected from northern Canadian populations. Organohalogen Compounds,4009-4014, 66, **2004**.

[48] Inoue K, Okada F, Ito R, Kato S, Sasaki S, Nakajima S, Uno A, Saijo Y, Sata F, Yoshimura Y, Kishi R, Nakazawa H. (2004). Perfluorooctane sulphonate (PFOS) and related perfluorinated compounds in human maternal and cord blood samples: assessment of PFOS exposure in a susceptible population during pregnanacy. Environmental Health Perspectives, 1204-1207, *112*, **2004**.

4.7.2 Results for perfluorinated compounds in this study

In this study PFOS and PFOA were determined in serum samples. Since this may not be a representative matrix for these compounds in human blood and the determination of these compounds was not yet validated for human blood, the results should only be interpreted as an indication of the concentration of these compounds in the serum samples. The results are summarized in table 8 and given in full in the appendix. The results indicate that PFOS and PFOA are both found in virtually every maternal blood serum sample. In maternal blood the concentrations ranged from 0.2 to 4.2 ng/g serum for PFOA and from 0.1 to 1.3 ng/g serum for PFOS. This is at the lower end of the range of concentrations found in previous studies.

The PFOA results for cord blood serum were comparable with those for maternal blood. For PFOS, the concentration in cord blood was lower than concentrations reported in previous studies. The frequency of detection and the concentrations of PFOS were also lower than results for maternal blood in the present study. In addition, the results for cord blood are different from other studies in that PFOA was found in higher concentrations then PFOS

Table 8 Summary of perfluoro-alkylated compounds in ng/g in maternal and cord blood serum.

Compound	PFOA	PFOS
Maternal blood (39 samples):		
number of samples above MDL	39	38
minimum measured value	0.2	0.1
maximum measured value	4.2	1.3
10^{th} percentile	0.4	0.1
25^{th} percentile	0.6	0.2
50^{th} percentile (median)	0.9	0.4
75^{th} percentile	1.3	0.5
90^{th} percentile	2.2	0.8
Cord blood (17 samples):		
number of samples above MDL	16	7
minimum measured value	0.6	0.1
maximum measured value	2.3	0.2
10^{th} percentile	0.6	<
25^{th} percentile	0.9	<
50^{th} percentile (median)	1.1	<
75^{th} percentile	2.0	0.1
90^{th} percentile	2.2	0.1
method detection limit (MDL)	< 0.1	< 0.1

4.8 Relation between maternal and cord blood

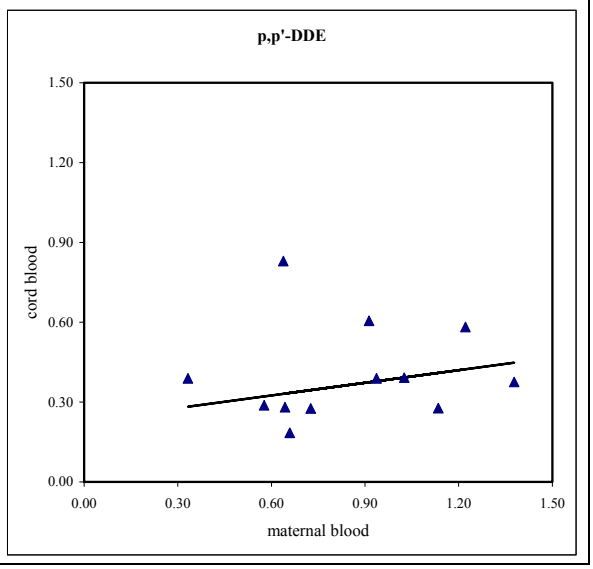
It is interesting to see whether relations exist between maternal blood and the cord blood. However, there are only a limited number of samples of maternal blood se-

rum samples with corresponding cord blood serum samples available. These are the samples with M- and K- numbers 6, 16, 17, 20, 28, 32, 45, 47, 52, 54, 63 and 84. In stead of applying an extensive statistical analysis, only a simple correlation between the results has been determined. This determination has only been made for three compounds that were quantified in the majority samples, the pesticide p,p'-DDE, the phthalate DEHP and the artificial musk HHCB. The few detection limits in these data sets were replaced by half the detection limit value since the actual concentration may be any value between zero and the detection limit. One of the samples, M16/K16, was excluded from the statistics since it was considered to be an outlier.

The results for p,p'-DDE are presented in the figure below. There seems to be no clear correlation between the concentrations found in maternal and cord blood serum as indicated by r^2=0.15. The range of the p,p'-DDE concentrations in the maternal and cord blood serum samples is relatively small as indicated by the standard deviation (a rel sd of 0.35 for both). The low r^2 may partly be the results of the small scatter in the data.

Compound:		**p,p'-DDE**	
Mx:		**maternal blood**	
Kx:		**cord blood**	
Units:		**ng/g serum**	
Data:			
M6	0.91	K6	0.61
M16	0.64[A]	K16	0.83[A]
M17	1.22	K17	0.58
M20	0.33	K20	0.39
M28	0.58	K28	0.29
M32	1.13	K32	0.28
M45	0.66	K45	0.19
M47	1.03	K47	0.39
M52	1.38	K52	0.38
M54	0.73	K54	0.28
M63	0.64	K63	0.28
M84	0.94	K84	0.39
aver.	0.87	aver.	0.37
stdev.	0.31	stdev.	0.13
r^2	0.15		

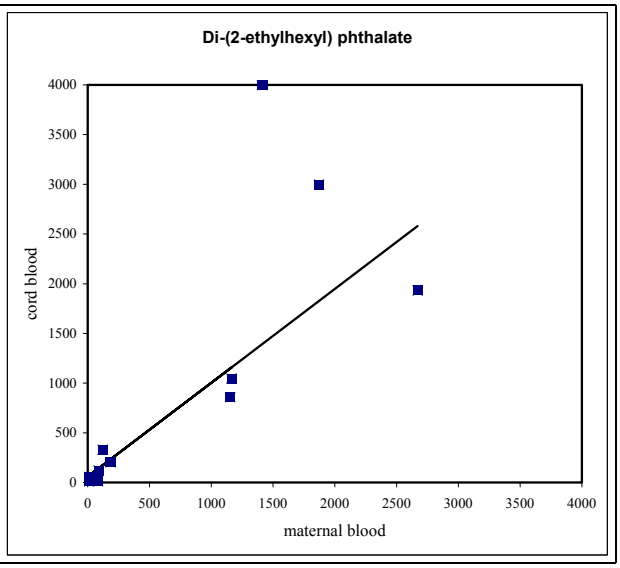
Remarks: [A]: M16/K16 excluded from statistics



The concentrations of the phthalate DEHP show a much larger span which makes it easier to determine any relation. The results of the simple correlation shown below indicate a weak correlation between the DEHP levels in maternal and cord blood serum with r^2=0.80. This relative high correlation may be strongly influenced by the small number of higher concentrations, although the latter give a wide scatter.

Compound:	**Di-(2-ethylhexyl) phthalate**		
Mx:	**maternal blood**		
Kx:	**cord blood**		
Units:	**ng/g serum**		
Data:			
M6	2670	K6	1933
M16	1411[A]	K16	4004[A]
M17	1873	K17	2997
M20	1153	K20	859
M28	185	K28	205
M32	90	K32	120
M45	84	K45	12.5[B]
M47	12.5[B]	K47	12.5[B]
M52	1165	K52	1045
M54	12.5[B]	K54	49
M63	122	K63	330
M84	12.5[B]	K84	57
aver.	918	aver.	844
stdev.	975	stdev.	1019
r^2	0.80		

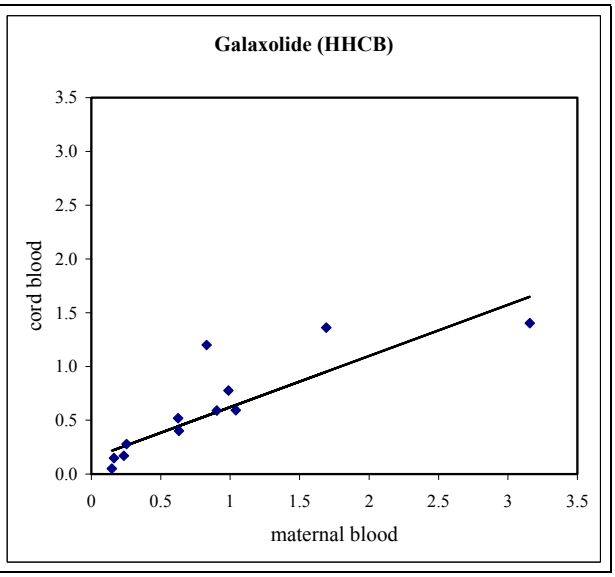
Remarks: [A]: M16/K16 excluded from statistics
[B]: detection limits replaced by 50% of the detection limit value



The results for HHCB show a more evenly distribution over the concentration range with a reasonable span. The results in the figure below indicate a correlation between HHCB in maternal blood serum and in the corresponding cord blood serum with an r^2=0.85. Comparable with p,p'-DDE the average HHCB concentrations in cord blood serum seem to be about 50% of those in maternal blood serum.

Compound:	**Galaxolide (HHCB)**		
Mx:	**maternal blood**		
Kx:	**cord blood**		
Units:	**ng/g serum**		
Data:			
M6	1.7	K6	1.4
M16	0.83[A]	K16	1.2[A]
M17	0.16	K17	0.15
M20	0.25	K20	0.28
M28	3.2	K28	1.4
M32	0.23	K32	0.17
M45	0.15	K45	0.05[B]
M47	0.63	K47	0.40
M52	0.99	K52	0.78
M54	1.0	K54	0.59
M63	0.62	K63	0.52
M84	0.90	K84	0.59
aver.	0.89	aver.	0.62
stdev.	0.89	stdev.	0.45
r^2	0.85		

Remarks: [A]: M16/K16 excluded from statistics
[B]: detection limits replaced by 50% of the detection limit value



4.9 Quality control measurements

4.9.1 Method validation parameters

All methods used in this study were validated for the analytes listed in chapter 2 with the exception of TCS, PFOA and PFOS. The latter compounds are validated in environmental matrices but not for the matrix blood serum. All prior validation experiments were carried out using fresh calf's blood as such and spiked with the analytes of interest. The parameters determined were the repeatability, recovery and the method detection limit (MDL). The validation study resulted in standard operation procedures that were tested on a limited number of human blood samples and that are now routinely used in the analyses of blood samples.

Table 9 Summary of method validation parameters and actual recoveries of added internal standards.

Compound or group	Average recovery (n=6) %	Average repeatability (n=6) %	Method detection limit ng/g serum	Actual recovery added internal standards %
brominated flame retardants	86	12	0.001 – 0.15	
phthalates	90	13	1 – 25	82 ± 22
artificial musks	97	9	0.05 – 0.1	78 ± 12
bisphenol-A, alkylphenols	82	10	0.5 – 2.5	74 ± 19
organochlorine pesticides	89	10	0.01 – 0.1	

4.9.2 Recovery of internal standards

For the determination of phthalates, artificial musks and bisphenol-A internal standards were added before the analysis of the samples. The actual recovery of these internal standards is given in table 9. As pointed out earlier the results are not corrected for the recovery of the internal standards.

4.9.3 Blank samples

With each series of samples a blank sample was included. For the blank analysis the complete analytical procedure was followed, including all chemicals and solvents, but no sample was added. Blank results were found for HHCB and AHTN (both 0.1 ng/g serum) and for DIBP (3 ng/g serum), DBP (2 ng/g serum) and DEHP (20 ng/g serum). Only for the phthalates a correction of the results for the blank value was applied, and the detection limit was raised to 5 ng/g serum (DIBP), 2 ng/g (DBP) and 25 ng/g serum (DEHP).

5. Conclusions

In this study the concentrations of a number of man-made chemicals in maternal and cord blood serum were determined. The compound groups of interest were tetrabromobisphenol-A, phthalates, artificial musks, bisphenol-A and alkylphenols, organochlorine pesticides, triclosan and perfluorinated compounds. The results show that:

- Many of these compounds are present in maternal as well as cord blood. This is especially true for compounds as phthalates, artificial musks, triclosan, the organochlorine pesticides and perfluorinated compounds.
- With the exception of the phthalates and triclosan, the concentrations in cord blood appear to be somewhat lower than in maternal blood. In part this image may be biased by the detection limit.
- Tetrabromobisphenol-A was found in about 20% of the samples in concentrations ranging from 0.06 to 0.19 ng/g serum in maternal blood. This was within the range of previous studies on TBBPA. It was detected in just 1 out of 27 samples of cord blood.
- For the phthalates the results for maternal and cord blood are comparable to each other and to results found for the general population. In both cases di-(2-ethylhexyl) phthalate is the prominent phthalate with maximum concentrations up to 5559 ng/g in maternal blood serum and 4004 ng/g in cord blood serum. Median di-(2-ethylhexyl) phthalate concentrations are for both around 250 ng/g serum. Other phthalates that were frequently found are di-ethyl-, di-isobutyl, dibutyl- and benzylbutyl phthalate.
- As in the earlier study, HHCB was the major artificial musk found in almost all samples. The artificial musk concentrations in maternal and cord blood were more or less comparable, but were at the lower end of the range of concentrations found for the general population in a previous Greenpeace study. Other artificial musks that were found were the polycyclic musks AHTN, ADBI and the nitromusks MA, MK, MT and MX.
- Bisphenol-A was detected in 15% of maternal samples in concentrations similar to those reported in previous studies. Nonylphenol was found in about 70% of the cord blood samples in concentrations ranging from 0.5 to 7.5 ng/g serum. Results for nonylphenol in maternal blood are not available due to unknown interferences in the chromatograms of those samples.
- The p,p'-isomers of DDE and DDT, and hexachlorobenzene were found in most maternal and cord blood samples. Median concentrations in maternal blood were 0.75 ng/g serum for p,p'-DDE, 0.27 ng/g serum for p,p'-DDT and 0.15 ng/g serum for HCB. In cord blood serum, the concentrations of ppDDT, ppDDE and HCB were somewhat lower than those in maternal blood serum. In addition to these, both DDD-isomers were found in most maternal blood samples but only in a limited number of cord blood samples, possibly due to the detection limit of the method.

- Triclosan, the well known antibacterial agent, was found in about 50% of all samples, maternal as well as cord blood serum. The concentrations ranged from 0.1 to 1.3 ng/g for maternal blood serum and from 0.5 to 5.0 for cord blood serum. Concentrations in cord blood were therefore higher than in maternal blood serum.
- Of the perfluorinated compounds PFOA was found in almost all samples in concentrations ranging from 0.2 to 4.2 ng/g serum. PFOS was found in almost all maternal blood serum samples in concentrations from 0.1 to 1.3 ng/g, but in a limited number of cord blood samples, possibly because of the detection limit for these compounds.
- Correlations between maternal and the corresponding cord blood serum were observed for HHCB and to a lesser extent for DEHP. For p,p'-DDE the span of concentrations was to small to identify a correlation

In general, the results clearly indicate the presence of this broad suite of man-made chemicals in human blood. Although the concentrations in cord blood seem to be somewhat lower for a number of compounds (if not biased by the detection limit), the results show that exposure of the mother inevitable leads to exposure of the unborn child.

6. QA/QC Statement

The analytical determinations in this study are performed in compliance with NEN-EN-ISO/IEC 17025 and RvA accreditation no. 54, “The development and application of methods for the determination of organic contaminants in environmental matrices, wastes and materials”, with the exception of the determination of triclosan and the perfluorinated compounds. TNO Environment and Geosciences is listed in the RvA register under no. L 026.
RvA is the Dutch Council for Accreditation and is a member of the European co-operation for Accreditation (EA) and the International Laboratory Accreditation Co-operation (ILAC). In addition TNO Environment and Geosciences operates in compliance with the Quality System standard ISO 9001 (certificate no. 07246-2003-AQ-ROT-RvA).

7. Authentication

Name and address of the principal:

Greenpeace Nederland
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Name and functions of the cooperators:

Dr. R.J.B. Peters	Project Leader
Drs. R.J. van Delft	Technician
Ing. H. Beeltje	Technician
Ing. S. Walraven	Technician

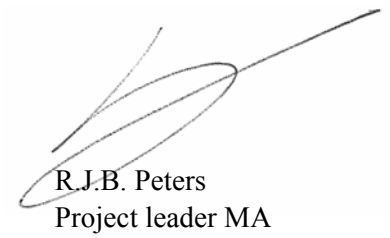
Names and establishments to which part of the research was put out to contract:

-

Date upon which, or period in which, the research took place:

March 2005 – April 2005

Signature:



R.J.B. Peters
Project leader MA

Approved by:

Dr. M.P. Keuken
Coordinator MA

Appendix 1 Full results of all samples

In the result tables in this appendix the abbreviations of table 1 are used. Results below the detection limit are indicated with a < sign. The method detection limits are given at the end of each table.
Note that results for all compounds are expressed in ng/g serum. When reading the tables in this appendix please note that while results are always rounded to the correct decimal number, they are not always rounded to the correct number of significant units. Due to the analytical uncertainty in the results the number of significant units is limited. This especially true when concentrations of several hundreds, or thousands of ng/g are reported. In general no more than two significant numbers apply.
For example, the DEHP concentration in sample 5039-10 is listed as 1873 ng/g serum but should be interpreted as 1900 ng/g serum.

During the analysis the extracts of two samples, sample 5039-35 (M77) and 5039-36 (M80) were accidentally mixed. In the tables this “new” sample is indicated as 5039-35/36 (M77/80). As a consequence the results represent the average of these two samples

Table 1a Tetrabromobisphenol-A in maternal blood serum.

sample code TNO	sample code Greenpeace	TBBPA ng/g serum
5039-01	M1	0.11
5039-02	M2	<
5039-03	M5	<
5039-04	M6	0.19
5039-05	M7	0.06
5039-06	M9	0.07
5039-07	M13	0.08
5039-08	M15	0.06
5039-09	M16	<
5039-10	M17	<
5039-11	M20	<
5039-12	M22	<
5039-13	M23	<
5039-14	M27	<
5039-15	M28	<
5039-16	M32	0.06
5039-17	M34	<
5039-18	M37	0.09
5039-19	M40	<
5039-20	M43	<
5039-21	M45	<
5039-22	M47	<
5039-23	M49	<
5039-24	M52	<
5039-25	M53	<
5039-26	M54	<
5039-27	M59	<
5039-28	M61	<
5039-29	M62	<
5039-30	M63	<
5039-31	M65	<
5039-32	M69	<
5039-33	M75	<
5039-34	M76	<
5039-35/36	M77/80	<
5039-37	M83	<
5039-38	M84	<
5039-39	M85	<
5039-40	M91	<
5039-41	M92	<
5039-42	M94	<
5039-43	M101	0.12
MDL		< 0.05

Table 1b Tetrabromobisphenol-A in cord blood serum.

sample code TNO	sample code Greenpeace	TBBPA ng/g serum
5039-44	K6	<
5039-45	K11	<
5039-46	K12	<
5039-47	K16	<
5039-48	K17	<
5039-49	K20	<
5039-50	K26	<
5039-51	K28	<
5039-52	K32	0.05
5039-53	K45	<
5039-54	K47	<
5039-55	K48	<
5039-56	K52	<
5039-57	K54	<
5039-58	K63	<
5039-59	K77	<
5039-60	K78	<
5039-61	K84	<
5039-62	K87	<
5039-63	K88	<
5039-64	K90	<
5039-65	K93	<
5039-66	K103	<
5039-67	K109	<
5039-68	K113	<
5039-69	K114	<
5039-70	K96	<
MDL		< 0.05

Table 2a Phthalates in maternal blood serum.

sample code TNO	sample code Greenpeace	DMP ng/g serum	DEP ng/g serum	DIBP ng/g serum	DBP ng/g serum	BBP ng/g serum
5039-01	M1	<	2.8	141	99	<
5039-02	M2	<	<	147	138	<
5039-03	M5	<	<	<	<	<
5039-04	M6	<	5.3	<	49	<
5039-05	M7	<	<	170	73	<
5039-06	M9	<	<	85	80	<
5039-07	M13	<	<	<	44	5.2
5039-08	M15	<	6.9	<	<	2.7
5039-09	M16	<	6.0	<	<	<
5039-10	M17	<	11	541	257	11
5039-11	M20	<	19	<	<	5.9
5039-12	M22	<	2.5	18	<	3.7
5039-13	M23	<	2.8	<	229	<
5039-14	M27	<	<	76	22	2.8
5039-15	M28	<	<	<	<	<
5039-16	M32	<	<	<	<	3.8
5039-17	M34	<	<	<	<	<
5039-18	M37	<	<	<	<	<
5039-19	M40	<	<	<	38	7.2
5039-20	M43	<	<	<	<	3.5
5039-21	M45	<	<	<	<	4.0
5039-22	M47	<	<	158	38	<
5039-23	M49	<	<	17	<	4.7
5039-24	M52	<	<	134	14	<
5039-25	M53	<	<	76	18	<
5039-26	M54	<	<	22	<	3.3
5039-27	M59	<	6.4	<	<	<
5039-28	M61	<	3.1	111	18	<
5039-29	M62	<	<	91	<	2.4
5039-30	M63	<	<	<	<	<
5039-31	M65	<	<	<	<	<
5039-32	M69	<	<	151	47	<
5039-33	M75	2.0	5.4	407	76	<
5039-34	M76	<	<	<	<	<
5039-35/36	M77/80	<	<	60	111	<
5039-37	M83	<	2.8	<	<	<
5039-38	M84	<	<	8.3	<	<
5039-39	M85	<	3.3	<	3.9	<
5039-40	M91	<	<	<	<	<
5039-41	M92	1.5	3.7	<	<	6.6
5039-42	M94	<	<	<	<	2.3
5039-43	M101	<	5.7	<	<	2.3
MDL		< 1	< 2	< 5	< 2	< 2

Table 2a (continued). Phthalates in maternal blood serum.

sample code TNO	sample code Greenpeace	DCHP ng/g serum	DEHP ng/g serum	DOP ng/g serum	DINP ng/g serum	DIDP ng/g serum
5039-01	M1	<	<	<	<	<
5039-02	M2	<	211	1.9	<	<
5039-03	M5	<	<	<	<	<
5039-04	M6	<	2670	1.1	<	<
5039-05	M7	<	<	<	<	<
5039-06	M9	<	<	<	<	<
5039-07	M13	<	<	<	<	<
5039-08	M15	<	<	<	<	<
5039-09	M16	<	1411	<	<	<
5039-10	M17	<	1873	3.5	<	<
5039-11	M20	<	1153	<	<	<
5039-12	M22	<	30	<	<	<
5039-13	M23	<	<	<	<	<
5039-14	M27	<	395	1.1	<	<
5039-15	M28	<	185	<	<	<
5039-16	M32	<	90	<	<	<
5039-17	M34	<	<	<	<	<
5039-18	M37	<	376	1.9	<	<
5039-19	M40	<	5559	2.9	<	<
5039-20	M43	<	91	<	<	<
5039-21	M45	<	84	<	<	<
5039-22	M47	<	<	<	<	<
5039-23	M49	<	204	<	758	<
5039-24	M52	<	1165	<	<	<
5039-25	M53	<	747	<	<	<
5039-26	M54	<	<	<	<	<
5039-27	M59	<	1213	1.4	<	<
5039-28	M61	<	702	<	<	<
5039-29	M62	<	314	<	<	<
5039-30	M63	<	122	<	<	<
5039-31	M65	<	946	<	<	<
5039-32	M69	<	<	<	<	<
5039-33	M75	<	3082	<	<	<
5039-34	M76	<	2708	<	<	<
5039-35/36	M77/80	<	<	1.3	<	<
5039-37	M83	<	1669	1.5	<	<
5039-38	M84	<	<	<	<	<
5039-39	M85	<	1582	<	<	<
5039-40	M91	<	534	<	<	<
5039-41	M92	<	3238	<	<	<
5039-42	M94	<	429	<	<	<
5039-43	M101	<	1009	<	<	<
MDL		< 1	< 25	< 1	< 10	< 10

Table 2b Phthalates in cord blood serum.

sample code TNO	sample code Greenpeace	DMP ng/g serum	DEP ng/g serum	DIBP ng/g serum	DBP ng/g serum	BBP ng/g serum
5039-44	K6	<	17	<	40	<
5039-45	K11	<	<	7.3	2.1	<
5039-46	K12	<	<	<	2.3	<
5039-47	K16	<	11	<	<	<
5039-48	K17	<	<	<	<	<
5039-49	K20	<	7.1	<	<	<
5039-50	K26	<	11	<	112	1321
5039-51	K28	<	6.4	<	41	<
5039-52	K32	<	<	<	<	<
5039-53	K45	<	<	8.5	<	4.6
5039-54	K47	<	<	<	7.8	2.0
5039-55	K48	<	<	15	<	<
5039-56	K52	<	2.4	47	63	<
5039-57	K54	<	<	<	<	3.4
5039-58	K63	<	5.8	<	26	2.9
5039-59	K77	<	<	<	<	3.5
5039-60	K78	<	22	31	489	<
5039-61	K84	<	2.6	<	<	3.0
5039-62	K87	<	<	<	<	<
5039-63	K88	<	<	<	<	<
5039-64	K90	<	18	<	245	3.5
5039-65	K93	<	<	<	<	5.6
5039-66	K103	<	<	<	26	<
5039-67	K109	<	<	<	<	<
5039-68	K113	<	<	<	<	<
5039-69	K114	<	14	<	<	3.4
5039-70	K96	<	2.5	<	<	2.4
MDL		< 1	< 2	< 5	< 2	< 2

Table 2b (continued). Phthalates in cord blood serum.

sample code TNO	sample code Greenpeace	DCHP ng/g serum	DEHP ng/g serum	DOP ng/g serum	DINP ng/g serum	DIDP ng/g serum
5039-44	K6	<	1933	<	<	<
5039-45	K11	<	256	<	<	<
5039-46	K12	<	3046	1.4	<	<
5039-47	K16	<	4004	<	<	<
5039-48	K17	<	2997	<	<	<
5039-49	K20	<	859	<	<	<
5039-50	K26	<	343	1.6	<	<
5039-51	K28	<	205	1.6	199	<
5039-52	K32	<	120	1.2	<	<
5039-53	K45	<	<	<	<	<
5039-54	K47	<	<	<	<	<
5039-55	K48	<	1222	<	<	<
5039-56	K52	<	1045	<	<	<
5039-57	K54	<	49	<	<	<
5039-58	K63	<	330	1.2	<	<
5039-59	K77	<	44	<	<	<
5039-60	K78	<	662	<	<	<
5039-61	K84	<	57	<	<	<
5039-62	K87	<	27	<	<	<
5039-63	K88	<	62	<	48	<
5039-64	K90	<	326	<	<	<
5039-65	K93	<	130	<	<	<
5039-66	K103	<	67	<	<	<
5039-67	K109	<	2248	<	<	<
5039-68	K113	<	180	<	<	<
5039-69	K114	<	1073	<	<	<
5039-70	K96	<	<	<	<	<
MDL		< 1	< 25	< 1	< 10	< 10

Table 3a Artificial (polycyclic) musks in maternal blood serum.

sample code TNO	sample code Greenpeace	ADBI ng/g serum	AHTN ng/g serum	ATTI ng/g serum	DPMI ng/g serum	HHCB ng/g serum
5039-01	M1	<	0.27	<	<	1.2
5039-02	M2	<	0.34	<	<	2.8
5039-03	M5	<	<	<	<	0.37
5039-04	M6	<	0.15	<	<	1.7
5039-05	M7	<	<	<	<	<
5039-06	M9	<	0.09	<	<	0.86
5039-07	M13	<	<	<	<	2.0
5039-08	M15	<	<	<	<	<
5039-09	M16	<	0.06	<	<	0.83
5039-10	M17	<	<	<	<	0.16
5039-11	M20	<	0.11	<	<	0.25
5039-12	M22	<	0.33	<	<	2.1
5039-13	M23	<	0.20	<	<	0.56
5039-14	M27	<	0.25	<	<	0.85
5039-15	M28	<	0.27	<	<	3.2
5039-16	M32	<	<	<	<	0.23
5039-17	M34	<	<	<	<	0.93
5039-18	M37	<	<	<	<	<
5039-19	M40	<	<	<	<	1.0
5039-20	M43	<	<	<	<	0.37
5039-21	M45	<	<	<	<	0.15
5039-22	M47	<	0.18	<	<	0.63
5039-23	M49	<	0.20	<	<	1.0
5039-24	M52	<	0.11	<	<	0.99
5039-25	M53	<	0.49	<	<	3.2
5039-26	M54	0.15	<	<	<	1.0
5039-27	M59	<	<	<	<	0.60
5039-28	M61	<	0.29	<	<	1.3
5039-29	M62	<	<	<	<	0.77
5039-30	M63	<	<	<	<	0.62
5039-31	M65	<	0.49	<	<	0.66
5039-32	M69	<	<	<	<	0.70
5039-33	M75	0.09	0.11	<	<	0.68
5039-34	M76	0.14	<	<	<	0.51
5039-35/36	M77/80	<	<	<	<	0.44
5039-37	M83	<	<	<	<	0.33
5039-38	M84	<	0.15	<	<	0.90
5039-39	M85	<	<	<	<	<
5039-40	M91	<	<	<	<	0.29
5039-41	M92	0.34	<	<	<	0.69
5039-42	M94	<	<	<	<	0.35
5039-43	M101	<	<	<	<	0.15
MDL		< 0.05	< 0.1	< 0.05	< 0.05	< 0.1

Table 3a (continued). Artificial (nitro) musks in maternal blood serum.

sample code TNO	sample code Greenpeace	MA ng/g serum	MK ng/g serum	MM ng/g serum	MT ng/g serum	MX ng/g serum
5039-01	M1	<	<	<	<	<
5039-02	M2	<	<	<	<	0.09
5039-03	M5	<	<	<	<	<
5039-04	M6	<	<	<	<	<
5039-05	M7	<	<	<	<	<
5039-06	M9	<	<	<	<	<
5039-07	M13	<	<	<	<	0.06
5039-08	M15	<	<	<	<	<
5039-09	M16	<	0.06	<	<	<
5039-10	M17	0.57	<	<	0.23	<
5039-11	M20	<	<	<	<	<
5039-12	M22	<	<	<	<	0.07
5039-13	M23	<	<	<	<	<
5039-14	M27	<	<	<	<	<
5039-15	M28	<	<	<	<	0.08
5039-16	M32	<	0.23	<	<	<
5039-17	M34	0.14	0.22	<	<	<
5039-18	M37	<	<	<	<	<
5039-19	M40	0.34	<	<	<	<
5039-20	M43	0.19	<	<	<	<
5039-21	M45	0.15	0.06	<	<	<
5039-22	M47	<	<	<	<	<
5039-23	M49	<	<	<	<	<
5039-24	M52	0.43	0.16	<	<	<
5039-25	M53	<	<	<	<	<
5039-26	M54	0.42	<	<	<	<
5039-27	M59	<	<	<	<	<
5039-28	M61	<	<	<	<	<
5039-29	M62	0.67	<	<	<	<
5039-30	M63	0.33	<	<	<	<
5039-31	M65	<	<	<	<	<
5039-32	M69	0.65	<	<	<	<
5039-33	M75	0.71	<	<	<	<
5039-34	M76	0.28	<	<	<	<
5039-35/36	M77/80	<	<	<	<	<
5039-37	M83	<	0.13	<	<	<
5039-38	M84	<	<	<	<	<
5039-39	M85	<	0.34	<	<	<
5039-40	M91	<	0.23	<	<	<
5039-41	M92	0.72	<	<	<	<
5039-42	M94	0.33	<	<	<	<
5039-43	M101	0.13	0.81	<	<	<
MDL		< 0.1	< 0.05	< 0.05	< 0.05	< 0.05

Table 3b Artificial (polycyclic) musks in cord blood serum.

sample code TNO	sample code Greenpeace	ADBI ng/g serum	AHTN ng/g serum	ATTI ng/g serum	DPMI ng/g serum	HHCB ng/g serum
5039-44	K6	<	1.1	<	<	1.4
5039-45	K11	<	0.11	<	<	0.29
5039-46	K12	<	1.5	<	<	1.6
5039-47	K16	0.26	0.50	<	<	1.2
5039-48	K17	<	<	<	<	0.15
5039-49	K20	0.14	0.22	<	<	0.28
5039-50	K26	<	0.35	<	<	1.3
5039-51	K28	<	1.1	<	<	1.4
5039-52	K32	<	<	<	<	0.17
5039-53	K45	<	<	<	<	<
5039-54	K47	0.13	0.12	<	<	0.40
5039-55	K48	<	0.10	<	<	0.11
5039-56	K52	<	0.25	<	<	0.78
5039-57	K54	<	0.19	<	<	0.59
5039-58	K63	<	<	<	<	0.52
5039-59	K77	0.07	<	<	<	0.33
5039-60	K78	<	0.26	<	<	1.1
5039-61	K84	<	<	<	<	0.59
5039-62	K87	<	<	<	<	0.40
5039-63	K88	<	<	<	<	0.12
5039-64	K90	0.13	0.11	<	<	0.71
5039-65	K93	<	<	<	<	0.87
5039-66	K103	0.16	<	<	<	0.36
5039-67	K109	<	0.10	<	<	0.31
5039-68	K113	<	<	<	<	0.20
5039-69	K114	<	0.23	<	<	0.84
5039-70	K96	<	0.21	<	<	0.71
MDL		< 0.05	< 0.1	< 0.05	< 0.05	< 0.1

Table 3b (continued). Artificial (nitro) musks in cord blood serum.

sample code TNO	sample code Greenpeace	MA ng/g serum	MK ng/g serum	MM ng/g serum	MT ng/g serum	MX ng/g serum
5039-44	K6	<	<	<	<	<
5039-45	K11	<	<	<	<	<
5039-46	K12	0.10	<	<	<	<
5039-47	K16	0.08	<	<	<	<
5039-48	K17	<	<	<	0.75	<
5039-49	K20	0.06	<	<	<	<
5039-50	K26	0.21	<	<	0.17	<
5039-51	K28	0.15	<	<	<	<
5039-52	K32	<	0.09	<	<	<
5039-53	K45	<	<	<	<	<
5039-54	K47	0.1	<	<	<	<
5039-55	K48	<	<	<	<	<
5039-56	K52	<	0.10	<	<	<
5039-57	K54	<	<	<	<	<
5039-58	K63	<	<	<	<	<
5039-59	K77	0.07	<	<	<	<
5039-60	K78	<	<	<	<	<
5039-61	K84	0.25	<	<	<	<
5039-62	K87	<	<	<	<	<
5039-63	K88	0.11	<	<	<	<
5039-64	K90	0.14	<	<	<	<
5039-65	K93	0.09	<	<	<	<
5039-66	K103	0.11	<	<	<	<
5039-67	K109	<	<	<	<	<
5039-68	K113	<	<	<	<	<
5039-69	K114	<	<	<	<	<
5039-70	K96	<	<	<	<	<
MDL		< 0.1	< 0.05	< 0.05	< 0.05	< 0.05

Table 4a. Bisphenol-A and alkylphenols in maternal blood serum.

sample code TNO	sample code Greenpeace		BPA ng/g serum	OP ng/g serum	NP ng/g serum
5039-01	M1		1.7	<	<
5039-02	M2		0.7	<	1.0
5039-03	M5		0.7	<	int.
5039-04	M6		<	<	int.
5039-05	M7		<	<	int.
5039-06	M9		<	<	int.
5039-07	M13		<	<	int.
5039-08	M15		<	<	int.
5039-09	M16		<	<	int.
5039-10	M17		<	<	int.
5039-11	M20		<	<	int.
5039-12	M22	not determined			
5039-13	M23		<	<	int.
5039-14	M27		<	<	int.
5039-15	M28	not determined			
5039-16	M32		<	<	int.
5039-17	M34		<	<	int.
5039-18	M37		<	<	int.
5039-19	M40		<	<	<
5039-20	M43		<	<	int.
5039-21	M45		0.7	<	int.
5039-22	M47		<	<	int.
5039-23	M49	not determined			
5039-24	M52		0.5	<	int.
5039-25	M53		0.5	<	int.
5039-26	M54		<	<	int.
5039-27	M59		<	<	int.
5039-28	M61		<	<	int.
5039-29	M62		<	<	int.
5039-30	M63		<	<	int.
5039-31	M65		<	<	int.
5039-32	M69		<	<	int.
5039-33	M75		<	<	int.
5039-34	M76		<	<	0.8
5039-35	M77		<	<	int.
5039-36	M80		<	<	int.
5039-37	M83		<	<	int.
5039-38	M84	not determined			
5039-39	M85		<	<	int.
5039-40	M91		<	<	int.
5039-41	M92		<	<	int.
5039-42	M94		<	<	int.
5039-43	M101		<	<	int.
MDL			< 0.5	< 0.5	< 0.5

int. = interference, see text

Table 4b Bisphenol-A and alkylphenols in cord blood serum.

sample code TNO	sample code Greenpeace		BPA ng/g serum	OP ng/g serum	NP ng/g serum
5039-44	K6		<	<	<
5039-45	K11	not determined			
5039-46	K12		<	<	<
5039-47	K16		<	<	0.6
5039-48	K17		<	<	1.2
5039-49	K20		<	<	<
5039-50	K26		<	<	<
5039-51	K28		<	<	1.5
5039-52	K32		<	<	1.5
5039-53	K45	not determined			
5039-54	K47		<	<	0.8
5039-55	K48	not determined			
5039-56	K52	not determined			
5039-57	K54		<	<	1.0
5039-58	K63		<	<	0.5
5039-59	K77	not determined			
5039-60	K78	not determined			
5039-61	K84		1.3	<	2.3
5039-62	K87	not determined			
5039-63	K88	not determined			
5039-64	K90		<	<	1.1
5039-65	K93		<	<	<
5039-66	K103		<	<	7.5
5039-67	K109	not determined			
5039-68	K113	not determined			
5039-69	K114		<	<	3.5
5039-70	K96		<	<	2.2
MDL			< 0.5	< 0.5	< 0.5

Table 5a. Organochlorine pesticides and metabolites in maternal blood serum.

sample code TNO	sample code Greenpeace	PCB ng/g serum	HCB ng/g serum	o,p'-DDD ng/g serum	p,p'-DDD ng/g serum	o,p'-DDE ng/g serum
5039-01	M1	<	0.13	0.10	<	<
5039-02	M2	<	0.14	0.07	0.13	<
5039-03	M5	<	0.08	0.16	0.28	<
5039-04	M6	<	0.17	0.24	0.18	<
5039-05	M7	<	0.19	0.47	0.23	<
5039-06	M9	<	0.12	0.23	0.51	<
5039-07	M13	<	0.10	0.10	<	<
5039-08	M15	<	0.09	0.21	0.14	<
5039-09	M16	<	0.11	0.27	0.25	<
5039-10	M17	<	0.15	0.37	0.22	<
5039-11	M20	<	0.06	0.20	0.16	<
5039-12	M22	<	0.14	0.14	<	<
5039-13	M23	<	0.08	0.24	0.15	<
5039-14	M27	<	0.13	0.34	0.23	<
5039-15	M28	<	0.09	0.23	0.31	<
5039-16	M32	<	0.10	0.48	0.20	<
5039-17	M34	<	0.14	0.29	0.74	<
5039-18	M37	<	0.11	0.13	0.21	<
5039-19	M40	<	0.23	0.21	0.21	<
5039-20	M43	<	0.11	0.15	0.16	<
5039-21	M45	<	0.15	0.31	0.15	<
5039-22	M47	<	0.15	0.33	0.14	<
5039-23	M49	<	0.29	0.11	<	<
5039-24	M52	<	0.20	0.20	0.11	<
5039-25	M53	<	0.12	0.16	0.37	<
5039-26	M54	<	0.18	0.31	0.07	<
5039-27	M59	<	0.14	0.23	0.17	<
5039-28	M61	<	0.18	0.36	0.23	<
5039-29	M62	<	0.21	0.29	0.10	<
5039-30	M63	<	0.10	0.22	0.25	<
5039-31	M65	<	0.68	0.20	0.12	<
5039-32	M69	<	0.17	0.25	0.25	<
5039-33	M75	0.09	0.24	0.36	0.19	<
5039-34	M76	<	0.15	<	<	<
5039-35/36	M77/80	<	0.24	0.51	0.37	<
5039-37	M83	<	0.18	0.24	0.15	<
5039-38	M84	<	0.07	0.09	<	<
5039-39	M85	<	0.18	0.38	0.32	<
5039-40	M91	<	0.15	0.12	0.17	<
5039-41	M92	0.06	0.23	0.14	<	<
5039-42	M94	<	0.35	0.21	0.31	<
5039-43	M101	<	0.17	0.35	0.23	<
MDL		< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Table 5a (continued). Organochlorine pesticides and metabolites in maternal and cord blood serum.

sample code TNO	sample code Greenpeace	p,p'-DDE ng/g serum	o,p'-DDT ng/g serum	p,p'-DDT ng/g serum
5039-01	M1	0.65	<	0.38
5039-02	M2	0.77	<	0.38
5039-03	M5	0.61	<	0.18
5039-04	M6	0.91	<	0.24
5039-05	M7	1.06	<	0.69
5039-06	M9	0.42	<	0.17
5039-07	M13	0.61	<	0.34
5039-08	M15	0.37	<	0.26
5039-09	M16	0.64	<	0.25
5039-10	M17	1.22	<	< 0,05
5039-11	M20	0.33	<	0.19
5039-12	M22	0.92	<	0.44
5039-13	M23	0.66	<	0.19
5039-14	M27	0.47	<	0.16
5039-15	M28	0.58	<	0.63
5039-16	M32	1.13	<	0.27
5039-17	M34	0.67	<	0.27
5039-18	M37	0.67	<	0.21
5039-19	M40	0.65	<	0.57
5039-20	M43	0.59	<	0.20
5039-21	M45	0.66	<	0.09
5039-22	M47	1.03	<	0.48
5039-23	M49	0.69	<	0.13
5039-24	M52	1.38	<	0.26
5039-25	M53	0.69	<	0.14
5039-26	M54	0.73	<	0.37
5039-27	M59	1.20	<	0.33
5039-28	M61	1.12	<	0.28
5039-29	M62	1.90	<	0.11
5039-30	M63	0.64	<	0.31
5039-31	M65	1.71	<	0.32
5039-32	M69	1.03	<	0.27
5039-33	M75	1.03	<	0.43
5039-34	M76	0.74	<	<
5039-35/36	M77/80	1.04	<	0.33
5039-37	M83	1.63	<	0.67
5039-38	M84	0.94	<	0.27
5039-39	M85	0.89	<	0.55
5039-40	M91	0.99	<	0.35
5039-41	M92	1.10	<	1.53
5039-42	M94	1.25	<	0.55
5039-43	M101	0.49	<	<
MDL		< 0.05	< 0.05	< 0.05

Table 5b. Organochlorine pesticides and metabolites in cord blood serum.

sample code TNO	sample code Greenpeace	PCB ng/g serum	HCB ng/g serum	o,p'-DDD ng/g serum	p,p'-DDD ng/g serum	o,p'-DDE ng/g serum
5039-44	K6	<	0.10	<	0.20	<
5039-45	K11	<	0.08	<	<	<
5039-46	K12	<	0.07	<	<	<
5039-47	K16	<	0.10	<	<	<
5039-48	K17	<	0.10	<	<	<
5039-49	K20	<	0.08	<	0.27	<
5039-50	K26	<	0.08	<	<	<
5039-51	K28	<	0.13	<	0.28	<
5039-52	K32	<	<	<	<	<
5039-53	K45	<	0.07	<	<	<
5039-54	K47	<	0.07	<	<	<
5039-55	K48	<	0.09	<	<	<
5039-56	K52	<	0.09	<	<	<
5039-57	K54	<	0.07	<	<	<
5039-58	K63	<	<	<	<	<
5039-59	K77	<	0.08	<	<	<
5039-60	K78	<	0.07	0.10	<	<
5039-61	K84	0.06	<	<	<	<
5039-62	K87	<	0.05	<	<	<
5039-63	K88	<	<	<	<	<
5039-64	K90	<	0.08	<	<	<
5039-65	K93	<	0.06	<	<	<
5039-66	K103	<	0.07	<	<	<
5039-67	K109	<	0.05	<	<	<
5039-68	K113	<	0.06	<	<	<
5039-69	K114	<	0.09	<	<	<
5039-70	K96	<	0.07	<	<	<
MDL		< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Table 5b (continued). Organochlorine pesticides and metabolites in cord blood serum.

sample code TNO	sample code Greenpeace	p,p'-DDE ng/g serum	o,p'-DDT ng/g serum	p,p'-DDT ng/g serum
5039-44	K6	0.61	<	<
5039-45	K11	0.35	<	0.12
5039-46	K12	0.30	<	<
5039-47	K16	0.83	<	<
5039-48	K17	0.58	<	<
5039-49	K20	0.39	<	<
5039-50	K26	0.19	<	<
5039-51	K28	0.29	<	0.48
5039-52	K32	0.28	<	0.26
5039-53	K45	0.19	<	0.17
5039-54	K47	0.39	<	0.32
5039-55	K48	0.36	<	0.09
5039-56	K52	0.38	<	<
5039-57	K54	0.28	<	0.18
5039-58	K63	0.28	<	0.25
5039-59	K77	0.28	<	0.14
5039-60	K78	0.36	<	0.15
5039-61	K84	0.39	<	0.28
5039-62	K87	0.15	<	0.11
5039-63	K88	0.19	<	0.09
5039-64	K90	0.51	<	0.29
5039-65	K93	0.28	<	0.28
5039-66	K103	0.25	<	0.34
5039-67	K109	0.20	<	0.10
5039-68	K113	0.50	<	0.09
5039-69	K114	0.22	<	0.51
5039-70	K96	0.20	<	0.18
MDL		< 0.05	< 0.05	< 0.05

Table 6a. Triclosan in maternal blood serum.

sample code TNO	sample code Greenpeace	TCS ng/g serum
5039-01	M1	0.3
5039-02	M2	1.0
5039-03	M5	0.1
5039-04	M6	<
5039-05	M7	<
5039-06	M9	<
5039-07	M13	0.5
5039-08	M15	<
5039-09	M16	0.1
5039-10	M17	<
5039-11	M20	<
5039-12	M22	not determined
5039-13	M23	0.3
5039-14	M27	<
5039-15	M28	not determined
5039-16	M32	<
5039-17	M34	0.8
5039-18	M37	<
5039-19	M40	0.2
5039-20	M43	<
5039-21	M45	<
5039-22	M47	1.3
5039-23	M49	not determined
5039-24	M52	0.1
5039-25	M53	<
5039-26	M54	1.0
5039-27	M59	<
5039-28	M61	0.1
5039-29	M62	<
5039-30	M63	<
5039-31	M65	0.2
5039-32	M69	<
5039-33	M75	<
5039-34	M76	0.2
5039-35	M77	<
5039-36	M80	<
5039-37	M83	<
5039-38	M84	not determined
5039-39	M85	<
5039-40	M91	0.1
5039-41	M92	0.1
5039-42	M94	<
5039-43	M101	<
MDL		< 0.1

Table 6b. Triclosan in cord blood serum.

sample code TNO	**sample code Greenpeace**		**TCS ng/g serum**
5039-44	K6		<
5039-45	K11	not determined	
5039-46	K12		<
5039-47	K16		0.5
5039-48	K17		<
5039-49	K20		<
5039-50	K26		1.6
5039-51	K28		<
5039-52	K32		<
5039-53	K45	not determined	
5039-54	K47		1.8
5039-55	K48	not determined	
5039-56	K52	not determined	
5039-57	K54		1.1
5039-58	K63		<
5039-59	K77	not determined	
5039-60	K78	not determined	
5039-61	K84		<
5039-62	K87	not determined	
5039-63	K88	not determined	
5039-64	K90		0.5
5039-65	K93		<
5039-66	K103		0.6
5039-67	K109	not determined	
5039-68	K113	not determined	
5039-69	K114		1.2
5039-70	K96		5.0
MDL			< 0.1

Table 7a. Perfluorinated compounds in maternal blood serum.

sample code TNO	sample code Greenpeace		PFOA ng/g serum	PFOS ng/g serum
5039-01	M1		1.1	0.2
5039-02	M2		4.2	0.4
5039-03	M5		0.9	0.5
5039-04	M6		1.7	0.8
5039-05	M7		0.9	0.2
5039-06	M9		0.6	0.5
5039-07	M13		1.5	0.4
5039-08	M15		0.8	0.4
5039-09	M16		0.9	0.5
5039-10	M17		0.4	1.0
5039-11	M20		0.6	0.6
5039-12	M22	not determined		
5039-13	M23		0.6	0.7
5039-14	M27		1.0	0.6
5039-15	M28	not determined		
5039-16	M32		1.6	0.3
5039-17	M34		1.0	0.3
5039-18	M37		0.7	0.9
5039-19	M40		2.4	0.1
5039-20	M43		1.0	0.2
5039-21	M45		1.0	0.5
5039-22	M47		0.9	0.2
5039-23	M49	not determined		
5039-24	M52		0.8	0.4
5039-25	M53		0.4	0.8
5039-26	M54		0.4	<
5039-27	M59		0.2	0.8
5039-28	M61		2.1	0.1
5039-29	M62		1.5	0.4
5039-30	M63		0.4	0.3
5039-31	M65		0.5	0.2
5039-32	M69		1.1	0.3
5039-33	M75		2.4	0.3
5039-34	M76		2.6	0.2
5039-35	M77		0.9	1.3
5039-36	M80		1.1	0.5
5039-37	M83		1.1	0.2
5039-38	M84	not determined		
5039-39	M85		0.3	0.2
5039-40	M91		0.3	0.4
5039-41	M92		1.4	0.1
5039-42	M94		0.6	0.7
5039-43	M101		0.2	0.2
MDL			< 0.1	< 0.1

Table 7b. Perfluorinated compounds in cord blood serum.

sample code TNO	sample code Greenpeace		PFOA ng/g serum	PFOS ng/g serum
5039-44	K6		1.0	0.1
5039-45	K11	not determined		
5039-46	K12		1.3	0.1
5039-47	K16		1.3	0.1
5039-48	K17		1.1	0.2
5039-49	K20		2.0	0.1
5039-50	K26		0.9	0.1
5039-51	K28		2.2	<
5039-52	K32		2.2	<
5039-53	K45	not determined		
5039-54	K47		0.9	<
5039-55	K48	not determined		
5039-56	K52	not determined		
5039-57	K54		0.6	<
5039-58	K63		0.7	<
5039-59	K77	not determined		
5039-60	K78	not determined		
5039-61	K84		1.1	<
5039-62	K87	not determined		
5039-63	K88	not determined		
5039-64	K90		2.0	<
5039-65	K93		<	<
5039-66	K103		0.7	<
5039-67	K109	not determined		
5039-68	K113	not determined		
5039-69	K114		2.3	<
5039-70	K96		1.1	0.1
MDL			< 0.1	< 0.1