Environmental pollutants in blood from Margot Wallström and Jytte Guteland

SUMMARY OF ANALYSIS RESULTS

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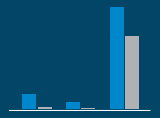

Results in brief

While it is relatively straightforward to analyse some persistent organic pollutants (POPs) such as PCB and DDE in human blood, many other POPs present a greater challenge. This particularly applies to chlorinated paraffins (CPs).

We can observe that there is no continual monitoring of POPs in blood in Swedish or any other EU citizens. However, Sweden has the longest temporal trend analysis of POPs in mothers' milk in the world, through programmes that started in the late 1960s. The environmental pollutants monitored in the mothers' milk programmes include a number of chlorinated and brominated chemicals. The programmes have indicated downward trends in levels of POPs that have been banned or strongly regulated in Sweden, such as PCB, DDT, PBDEs and dioxins. Banning chemicals does make a difference.

Half a century after DDT and PCB were posing a threat to people's health and the welfare of animals, other environmental pollutants are now occurring at levels that remind us of those we saw 50 years ago for DDT and PCB. This particularly applies to the PFAS groups (per- and polyfluoroalkyl substances) and chlorinated paraffins. Such concentrations were found in the analyses we performed on blood from Margot Wallström and Jytte Guteland.

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Background

Margot Wallström

Jytte Guteland

Margot Wallström, then Minister of Foreign Affairs and previously EU Commissioner for the Environment (1999-2004), and Jytte Guteland, member of the EU Parliament for the Social Democratic Party, contacted Professor Åke Bergman to investigate whether it was possible to have their blood analysed for POPs.

At a press event in May 2019, Margot, Jytte and Åke spoke generally about the problems associated with environmental pollutants, and Margot and Jytte gave samples of their blood for analysis. The discussion was broadcast online, and can be seen in full here. A shorter version, with English subtitles, is also available here.

Procedure and scope

The chemical analyses involved 29 fluorinated environmental pollutants (PFAS) and the, from the historical perspective, important substances DDE (main transformation product of DDT), 14 PCBs, BDE-47 (an individual substance in the polybrominated diphenyl ethers group among brominated flame retardants), trans-nonachlor, trans-chlordane, hexachlorobenzene and octachlorodibenzo-p-dioxin (OCDD). The analyses also included chlorinated paraffins (CP), which have never previously been analysed in human blood in Sweden but have previously been analysed in Swedish mothers' milk. We were unable to find any published data on CPs in blood from any other EU country.

The data on levels was compiled and presented by Åke Bergman, who was also responsible for the first part of the sample processing. Anna Kärrman and colleagues carried out all analyses apart from those concerning CP, which were performed by Dr. Bo Yuan of Stockholm University.

MARGOT WALLSTRÖM A COMPARISON BETWEEN 2003 AND 2019

The results of the chemical analyses of several PCBs, DDE and trans-nonachlor are shown in Figure 1. The concentrations are compared with those reported in Margot Wallström's blood in 2003, when her blood was sampled and analysed for the first time. Unfortunately, the analysis of hexachlorobenzene (HCB) in 2019 was not successful due to background problems, but the level of trans-nonachlor is shown, which was not analysed in 2003.

Levels of the traditional environmental pollutants in Margot Wallström's blood were almost identical in 2003 and 2019. Margot Wallström demonstrates a typical pattern for her generation in terms of levels of commonly found POPs, and the analyses show that these xenobiotic substances are very stable (persistent).

Levels of regulated POPs decrease over time

The diagram below shows trends in concentrations of a PCB (CB-153) and of DDE in breast milk from mothers in Stockholm. The diagrams were produced by Professor Emeritus Anders Bignert. See Nyberg et al. (2017) for more information.

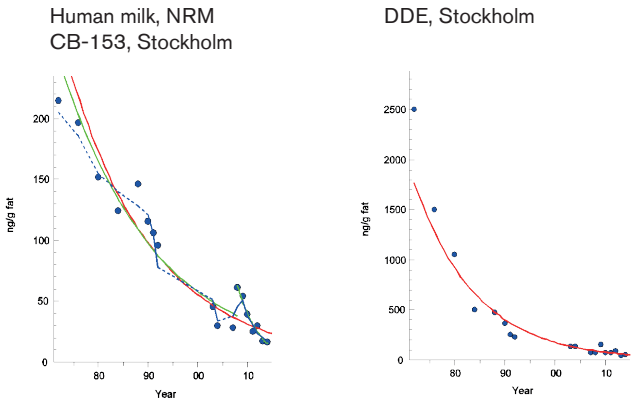


FIGURE 1

Concentrations of persistent organic environmental pollutants in Margot Wallström's blood, 2003 and 2019.

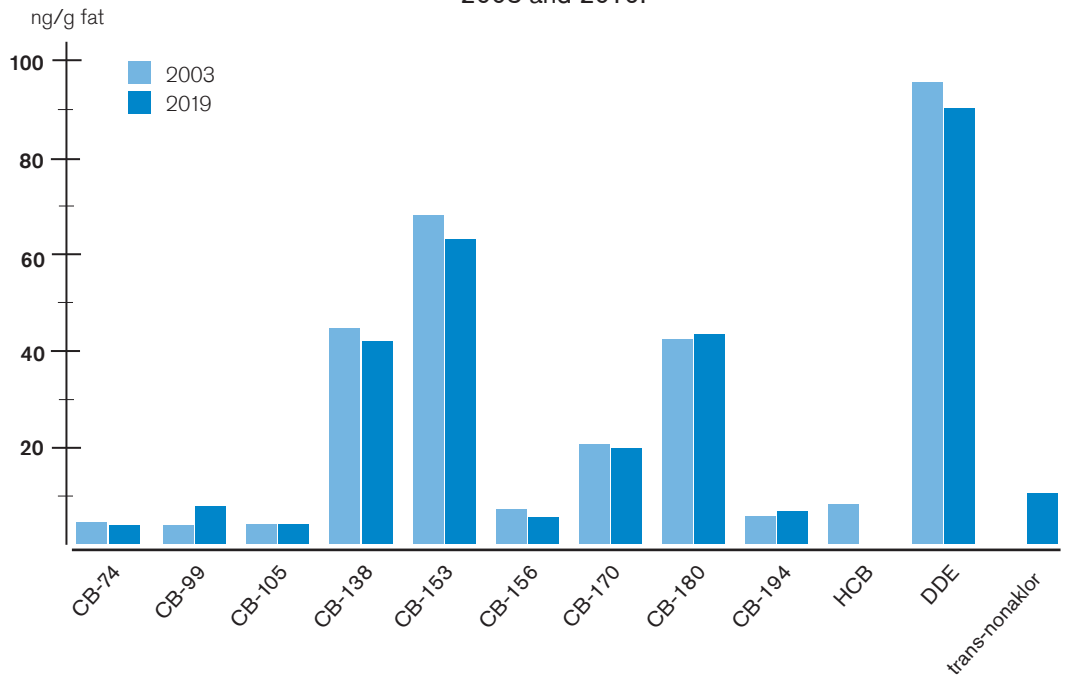


Figure 1. Concentrations (ng/g fat in plasma) of polychlorinated biphenyls (PCB), two chlorinated pesticides, the most stable DDT-related substance, DDE, (transformation product of DDT) and trans-nonachlor. All the substances are POPs according to the Stockholm Convention (see more information here).

Reference: Nyberg et al. 2017. Monitoring of POPs in human milk from Stockholm and Gothenburg, 1972-2015. Report 9:2017. Swedish Museum of Natural History.


MARGOT WALLSTRÖM AND JYTTE GUTELAND 2019

PCB AND DDE

The concentrations of the individual PCBs and 'total PCB' shown in Jytte Guteland's blood are approximately 20% of the concentrations found in Margot Wallström's blood. The results are shown in Figure 2. For DDE, the difference is somewhat greater – Margot's blood contained 86 ng/g fat in plasma while Jytte's contained 14 ng/g fat.

Concentrations in Jytte's blood are slightly lower than levels shown in pregnant women in the SELMA cohort in Värmland. Her concentrations also correspond well with those found in Swedish mothers' milk (see the trends shown on page 2).

The SELMA cohort

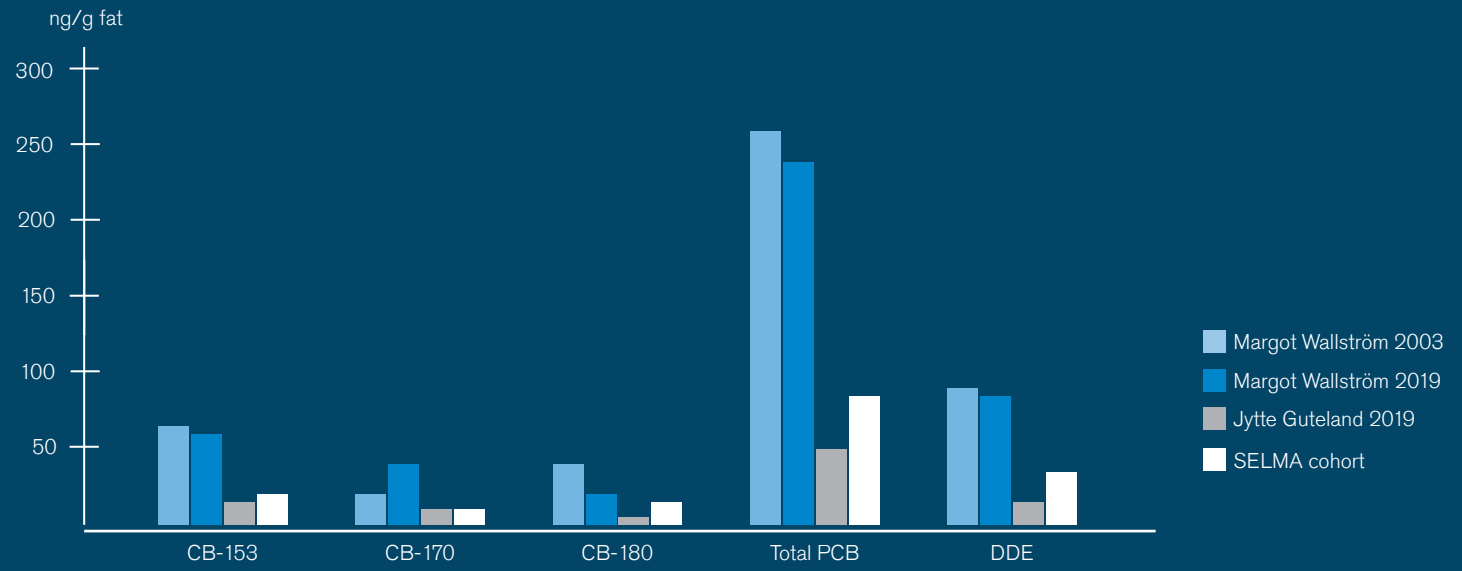
In the Swedish county of Värmland, pregnant women were recruited in 2007-2009 to participate in a study on women's exposure to chemicals that could be transferred to their children. Over 2300 pregnant women were recruited. Their blood and urine were sampled during pregnancy, and these were analysed to detect the presence of a number of environmental pollutants. The pollutants have been monitored in their children since birth, and this monitoring continues.

Here, analysis data from the women in the SELMA project is compared with the levels found in blood from Margot Wallström and Jytte Guteland. More information about the cohort and the project can be found at the website, selmastudien.se.

Figure 2. Concentrations (ng/g fat in plasma) of some individual PCBs, total PCB and DDE detected in the blood from Margot Wallström and Jytte Guteland. The concentrations are compared with those found in the pregnant women in the SELMA cohort approximately ten years ago.

FIGURE 2

Concentrations of PCB and DDE detected in the blood of Margot Wallström and Jytte Guteland, 2019.



Margot Wallström

Jytte Guteland

Chlorinated paraffins (CPs)

Today, CPs are analysed and reported in three groups (SCCP, MCCP and LCCP, see page 6) and as an aggregated total, 'total CP'.

Figure 3 shows that concentrations of 'total CP' are 1400 ng/g fat in plasma for Margot Wallström and 1000 for Jytte Guteland, calculated on a fat weight basis. These concentrations correspond to 1.4 and 1.0 ppm respectively.

Chlorinated paraffins were analysed according to the established division into SCCP, MCCP and LCCP (short, medium and long carbon chains), and results are shown in Figure 4 for Margot Wallström and Figure 5 for Jytte Guteland. SCCP dominate in both cases, followed by MCCP, and LCCP comprise only a small proportion of total CP. We also found a group of CPs with very short carbon chain lengths (vSCCP).

The differences between the two women can perhaps be interpreted as an effect of the ban on SCCP, where SCCP have been replaced with products that contain more MCCP than previously.

Concentrations of environmental pollutants at ppm level are remarkably high, at the same level as PCB and DDE measured 50 years ago. However, the concentrations are lower than those reported in blood from people in China (e.g. Li et al. 2017).

Figure 3. Concentrations (ng/g fat) of chlorinated paraffins in the blood of Margot Wallström and Jytte Guteland. The concentrations are compared with total PCB and DDE measured in the blood of both women.

Figures 4 and 5. Proportions of the different groups of chlorinated paraffins in the blood of Margot Wallström and Jytte Guteland. The circle diagram shows the relative proportions of SCCP, MCCP, LCCP and vSCCP.

Reference: Li m.fl. 2017, Environmental Science and Technology, 51, 3346–3354.

FIGURE 3

Concentrations of chlorinated paraffins compared with PCB and DDE.

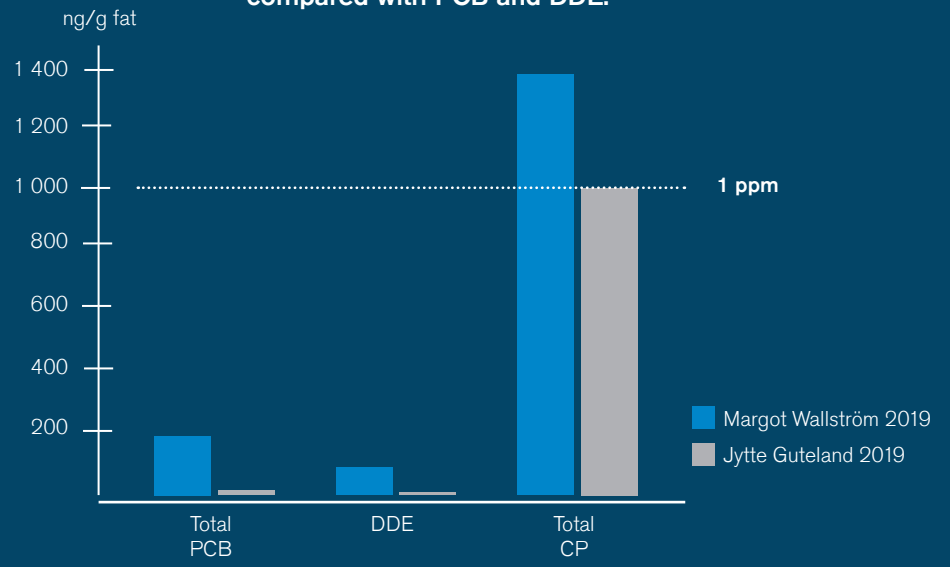
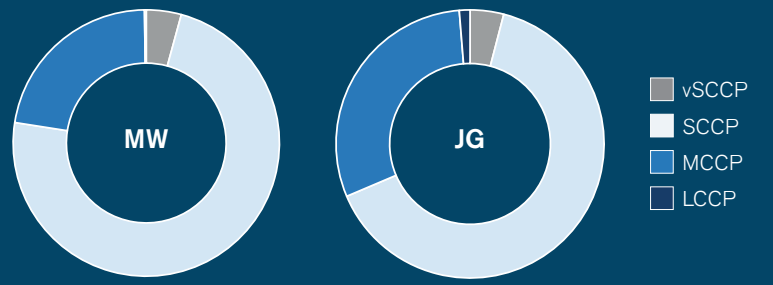


FIGURE 4 AND 5

Proportions of chlorinated paraffins in the blood of Margot Wallström (MW) and Jytte Guteland (JG).



Margot Wallström

Jytte Guteland

Per- and polyfluoroalkyl substances (PFAS)

Concentrations of PFAS are shown in Figure 6. Substances that end in 'S' are sulfonic acids, and those that end in 'A' are carboxylic acids. PFAS are not a traditional POP with high solubility in fat, so here the concentrations are reported in the unit ng/ml plasma. 'Tot PFOS' is the aggregated levels of five types (isomers) of PFOS. The next highest concentrations of PFAS derive from the PFOA substance, followed by PFNA and PFHxS. Several of the analysed PFAS were below the detection limits for each substance, while others were only detected at very low levels.

Margot Wallström consistently showed the highest concentrations of PFAS, with 'Tot-PFOS' approximately 14 ng/ml, five times higher than that of Jytte Guteland. PFOA accounted for the biggest difference in concentrations of PFAS, and levels were nearly ten times greater in the blood of Margot Wallström than in Jytte Guteland's. However, the concentrations of various PFAS vary between the two women, generally 2-5 times higher for Margot Wallström compared with Jytte Guteland.

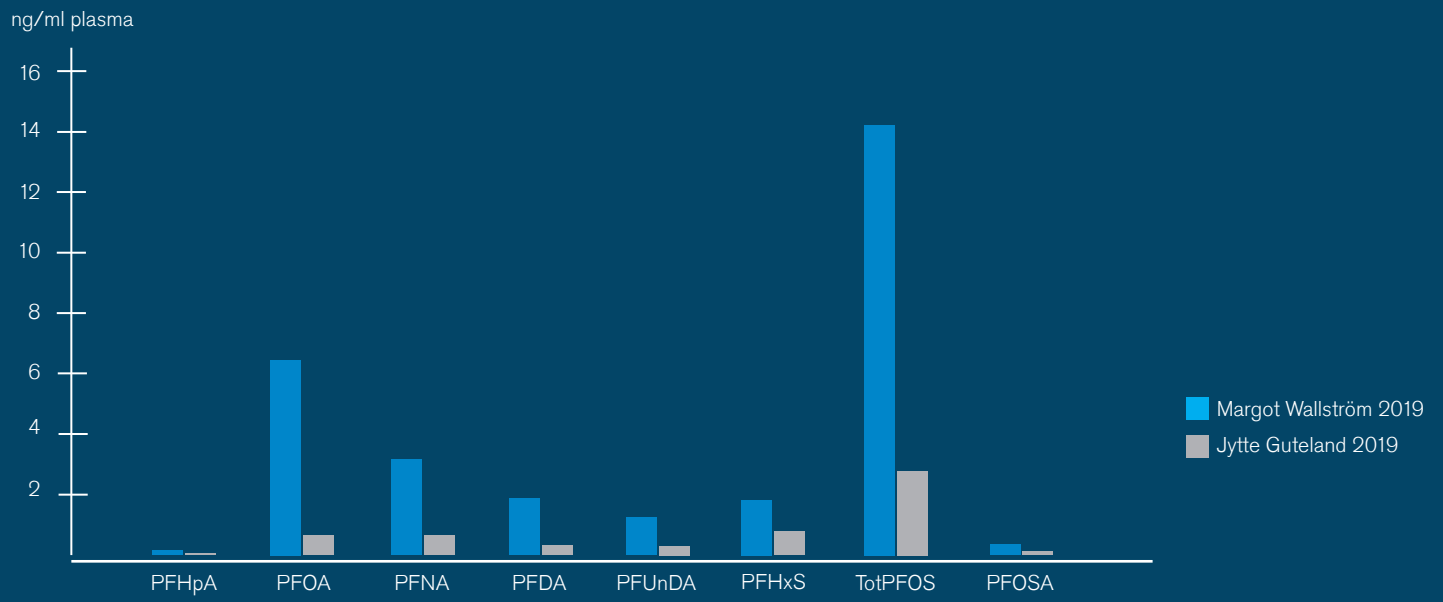
The results for PFAS in the blood from the two women follow the familiar pattern, even if the actual concentrations differ.

Exposure can be different for different individuals. Food is the basic source of PFAS, but drinking water and the indoor environment can sometimes be significant exposure routes, so it is difficult to speculate on the difference between two individuals. A declining trend is generally seen for PFOS and PFOA as a result of regulation and the chemicals being phased out. Consequently, exposure has declined, but the substances are persistent, and the response (decreasing internal exposure) can be seen more clearly in younger individuals.

Figure 6. Concentrations of PFAS for which the substances could be quantified. An exception is 'tot PFOS', which is the aggregate level of five types of PFOS. The concentrations are shown in ng/ml plasma.

FIGURE 6

Concentrations of PFAS in the blood of Margot Wallström and Jytte Guteland, 2019.



ENVIRONMENTAL POLLUTANTS

	PCB & DDE	CHLORINATED PARAFFINS (CPs)	PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)
USE	DDE is a breakdown product of DDT, an insecticide tused on a large scale between the 1940s and 1970s. It is still used today in certain countries to combat malaria. PCB are industrial chemicals with many areas of application, such as in capacitors, transformers, sealants, paints, and pulp.	CPs comprise short, medium and long alkanes, with carbon chains that are chlorinated to varying degrees. The groups are based on different carbon chain lengths: short (SCCP), medium (MCCP) and long (LCCP). Approximately 2 million tonnes of CPs are manufactured annually, with China as the biggest producer, but India is also a big producer. In theory, approximately a billion different CP structures can be formed when paraffins are chlorinated, with 10-30 carbon atoms in the chains, assuming that not more than one chlorine atom is permitted per carbon atom. The corresponding figure for PCB is 209. Chlorinated paraffins have very broad areas of application, including flame retardants and softeners in polymers, and they are also found in cutting fluids for metals, PVC, sealants, textiles and leather products.	Per- and polyfluoroalkyl substances (PFAS) comprise nearly 5000 different chemical substances. The substances have been/are used in fire extinguishing foams, textile and leather impregnation, food packaging, pesticides, cosmetics, etc.
PROPERTIES	DDT is transformed relatively quickly to DDE. The transformation product DDE, like PCB, is a stable and fat-soluble compound that is very difficult to metabolise further. It persists in the environment and in the body for a long time, despite its use being restricted since the 1970s. The substances are concentrated in the food chain, with the highest levels found in aqueous predators. DDE disrupts reproduction in birds, and can also lead to premature birth and low birth weight in mammals. PCB is associated with reduced reproductive capacity in seals and minks. In humans, birth defects and neurological damage have been linked to high levels of exposure to PCB. Both DDE and PCB are documented endocrine disrupting chemicals (UNEP/WHO 2013).	CPs are very lipophilic (fat soluble) and have high chemical stability. CPs are bioaccumulative and undergo long-distance transports in the environment. SCCP is the CP that has been most studied, but more data is now being produced for MCCP and LCCP. CPs are toxic for aqueous organisms, and are classified as 'possibly carcinogenic' for humans, with the thyroid, liver and kidneys identified as target organs. MCCP seem to display higher toxicity than SCCP. *Read more about CPs and their toxicity in the environment and for humans in, for example, El-Sayed Ali, Y.; Legler, J., Overview of the Mammalian and Environmental Toxicity of Chlorinated Paraffins. In Handb Environ Chem, Boer, J., Ed. Springer-Verlag Berlin Heidelberg: 2010; Vol. 10, pp 135-154.*	PFAS are extremely stable, and completely fluorinated substances (perfluorinated) are, in principle, never broken down under natural conditions. The PFAS group contains both strongly bioconcentrated substances that are found in high concentrations near the top of the food chain, and very water-soluble substances that are mobile in the environment and contaminate groundwater. Most PFAS are stored in the body and are eliminated very slowly. Studies show that they can affect fatty acid metabolism and the liver, reduce birth weight, and reduce the immune response after vaccination. In addition, PFOA is suspected to be carcinogenic. PFAS can also be transferred to the foetus and infants via the placenta and the mothers' milk. Both PFOS and PFOA are endocrine disrupting chemicals (UNEP/WHO 2013).
LEGISALTION	DDT is banned worldwide, and is included in the Stockholm Convention list, but some exceptions are granted for areas with severe malaria outbreaks. PCB was banned in Sweden in 1972 with certain exceptions, but has been completely banned since 1995. PCB is also included in the Stockholm Convention list. Today, dietary recommendations from the Swedish Food Agency state that children, young people and women of child-bearing age should not eat certain types of fish more often than 2-3 times a year, partly because of high concentrations of PCB, but also because of excessive POP levels generally.	SCCP is listed as a POP in the Stockholm Convention, where the intention is to prevent SCCP from contaminating the environment, but the regulation contains a number of exceptions. SCCP is regulated in the EU (Commission Regulation (EU) 2015/2030), which concerns new production, trade involving SCCP, and compounds that contain >1% SCCP and articles that contain >0.15% SCCP. Neither MCCP nor LCCP are regulated according to the Stockholm Convention or the REACH Regulation in the EU.	The most studied PFAS are PFOS and PFOA. PFOS have been banned in the EU since 2008, with certain exceptions, and PFOS are also included in the UN list of POPs (Stockholm Convention). PFOA will be banned in the EU from 1 July 2020. For other PFAS, there are currently no restrictions, but a growing number of studies indicate that further restrictions are to be expected. Applying the precautionary principle, the Swedish Food Agency has included 11 PFAS in the guidelines for drinking water, despite the effects of most of the substances being largely unknown.

Reference: UNEP/WHO (2013), State of the Science of Endocrine Disrupting Chemicals – 2012, www.who.int/phe/en/.

Analysed substances

The following substances were analysed in plasma from Margot Wallström och Jytte Guteland. Substances not detected over the quantification limits are not mentioned in the results.

Organochlorine pesticides (OCPs)

1,1-dichlorodiphenyldichloroethylene (p,p´-DDE, referred to here as DDE); hexachlorobensene (HCB); cis-chlordane, trans-chlordane, trans-nonachlor.

Brominated flame retardants

One polybrominated diphenyl ether; 2,2´,4,4´-tetrabromodiphenyl ether (BDE-47)

Dioxins

Octachlorodibenzo-p-dioxin

Polychlorinated biphenyls (PCBs)

Listed here are the abbreviations used instead of the full names; CB-74, CB-99, CB-118, CB-105, CB-153, CB-138, CB-156, CB-157, CB-180, CB-170, CB-189, CB-194, CB-206, and CB-209. The abbreviations are presented in https://en.wikipedia.org/wiki/PCB_congener_list

Chlorinated paraffins (CPs)

CP are not analysed by individual substances but as the following groups; very short-chain CP with chain lengths C6 to C9 (vSCCP); short-chain CPs (SCCP) (C10 to C13), medium-chain CPs (MCCP)(C14-C17); and long-chain CP (LCCP) (C>17)

Per- and polyfluoroalkyl substances (PFAS)

Perfluoroalkyl sufonic acids: Perfluorobutane sulfonic acid (PFBS); Perfluoropentane sulfonic acid (PFPeS); Perflurohexane sulfonic acid (PFHxS); Perfluoroheptane sulfonic acid (PFHpS); Perfluorooctane sulfonic acid (PFOS); Perfluorononane sulfonic acid (PFNS); Perfluorodecane sulfonic acid (PFDS); Perfluorododecane sulfonic acid (PFDoS). Total PFOS (TotPFOS) is the aggregated sum of five groups; L-PFOS, dimethyl-PFOS, 3/4/5-PFOS, 6/2-PFOS, and 1-PFOS

Perfluoroalkyl carboxylic acids: Perfluorobutanoic acid (PFBA); Perfluoropentanoic acid (PFPeA); Perfluorohexanoic acid (PFHxA); Perfluoroheptanoic acid (PFHpA); Perfluorooctanoic acid (PFOA); Perfluorononanoic acid (PFNA); Perfluorodecanoic acid (PFDA); Perfluoroundecanoic acid (PFUnDA); Perfluorododecanoic acid (PFDoDA); Perfluorotridecanoic acid (PFTrDA); Perfluorotetradecanoic acid (PFTDA); Perfluorooctadecanoic acid (PFOcDA).

Fluorotelomersulfonic acids: 6:2 Fluorotelomer sulfonic acid (6:2 FTSA); 6:2 Fluorotelomer sulfonic acid (4:2 FTSA); 8:2 Fluorotelomer sulfonic acid (8:2 FTSA). One additional substance was analysed, Perfluorooctanesulfonamide (PFOSA).

Analysis methods

Organic chlorinated pesticides and PCB, OCDD and BDE-47 were analysed according to the method described by Stubleski et al. (2018). The analysis instrument used was an APGC-MS/MS (APGC-TQ-S, Waters Corporation).

Chlorinated paraffins, divided into vSCCP, SCCP, MCCP and LCCP, were analysed according to the methods described for the different analytical stages, as described by Fängström et al. (2002), Hovander et al. (2002). and by Du et al. (2018). The analysis instrument used was an APCI-Orbitrap-MS or an APCI-HRMS (Q Exactive, Thermo Fisher Scientific, San Jose, USA). Quantification was carried out in the way described in Bogdal et al. (2015).

The PFAS analyses were performed according to Salihovic et al. (2013), using a UP-LC-MS/MS (UPLC-TQ-S, Waters Corporation).

References to the methods used in the chemical analyses

Bogdal, C., Alsberg, T., Diefenbacher, P. S., MacLeod, M. and Berger, U., (2015), Fast quantification of chlorinated paraffins in environmental samples by direct injection high-resolution mass spectrometry with pattern deconvolution, *Analytical chemistry*, **87**, (5), 2852-60.

Du, X., Yuan, B., Zhou, Y., Benskin, J. P., Qiu, Y., Yin, G. and Zhao, J., (2018), Short-, Medium-, and Long-Chain Chlorinated Paraffins in Wildlife from Paddy Fields in the Yangtze River Delta, *Environmental Science & Technology,* **52**, (3), 1072-1080.

Fängström, B., Strid, A., Grandjean, P., Weihe, P. and Bergman, Å., (2002), Hydroxylated PCB metabolites and PCBs in serum from pregnant Faroese women, *Environ. Health Perspect.* **110**, 895-899.

Hovander, L., Malmberg, T., Athanasiadou, M., Athanassiadis, I., Rahm, S., Bergman, Å., and Klasson Wehler, E., (2002), Identification of hydroxylated PCB metabolites and other phenolic halogenated pollutants in human blood plasma, *Arch. Environ. Contam. Toxicol.*, **42**, 105-117.

Salihovic, S., Kärrman, A., Lindström, G., Lind, PM., Lind, L. and van Bavel, B., (2013), A rapid method for analysis of PFAS including structural PFOS isomers in human serum using 96-well plate column-switching UPLC-MS/MS, *Journal of Chromatography A,* **1305**, 164-170.

Stubleski, J., Kukucka, P., Salihovic, S., Lind, PM., Lind, L. and Kärrman, A., (2018), A method for analysis of marker persistent organic pollutants in low-volume plasma and serum samples using 96-well plate solid phase extraction, *Journal of Chromatography A,* **1546**, 18-27.