LEVELS OF POPs IN HUMAN BREAST MILK SAMPLES FROM NORTHERN PROVINCE, SOUTH AFRICA; COMPARISON TO SWEDISH LEVELS

Darnerud PO[1], Aune M[2], Larsson L[2], Lignell S[1], Mutshatshi N[3], Agyei, N[4], Botha B[3], Okonkwo J[3]

[1]Toxicology Division, National Food Administration, P.O. Box 622, SE-751 26 Uppsala
[2]Chemistry Division 2, National Food Administration, P.O. Box 622, SE-751 26 Uppsala
[3]Faculty of Nat. Sci., Tshwane Univ. of Technology, Pretoria, South Africa
[4]Dept. of Chemistry, Limpopo Univ., Medunsa, South Africa

Introduction

Breast milk surveys of persistent organic pollutants (POPs) in breast milk are recognised as a relevant, simple and non-invasive method to assess the body burden of these potentially harmful chemicals in nursing mothers and their intake in breast-feeding babies. The World Health Organisation (WHO) has performed three international surveys on POP levels in breast milk, and in the latest, third "round" analytical results from many countries all over the world were presented. In the WHO presentation differences in POP levels between countries were observed, which in several cases may result from the degree of industrialisation and/or the degree and intensity of agriculture in specific countries.

The levels of POPs in the population of southern Africa has been the subject of very few studies. Earlier surveys of POPs in breast milk was performed in Kwa-Zulu Natal[1] and in Swaziland[2]. In these studies, the levels of DDTs in the milk was of primary interest because of recent or ongoing spraying activities to fight malaria mosquitos, the principal vector of this serious disease. Each year, between one and over two million people are estimated to die from malaria and of these deaths, 90% occur in sub-Saharan Africa, mainly in children under five years of age. In the 1998/99 spraying season some 24 tons of DDT were sprayed in the Northern Region, Northern Province, South Africa (data from Dr. Okonkwo).

In the present study, breast milk samples were collected from mothers living in the Northern Region, an agricultural area with few industries. For comparative reasons, the POP levels in the South African milk were compared to those in Swedish breast milk (Uppsala County) representing a more industrialised region.

Materials and Method

Mothers (n=30; mixed parity) were recruited from the Thohoyandou area, Northern Region, Northern Province, South Africa (S.A.) in April to November 2004. The mothers from several villages in this area were asked for the possibility to donate breast milk at local clinics. The amount of milk (ca. 5-25 ml/donor) represents the volume expressed at one sampling occasion, and the milk was sampled 2-16 weeks after delivery. At the time of sampling, the sampling coordinator and the mother together filled in a simple questionnaire on basic personal measures (age, weight, length), occupation, diet and certain life style factors, and birth data.

The samples were shipped in frozen condition (dry ice) from S.A. to Sweden. Analyses of the milk were subsequently performed at the Swedish National Food Administration (NFA), using previously described methods[3,4]. In brief, 1 g of homogenized milk was extracted with a mixture of n-hexane/acetone. The extracted lipid content was determined gravimetrically after evaporation of the solvents and the samples were then treated with sulphuric acid. The PCBs were separated from most of chlorinated pesticides on a silica gel column. Finally, the samples were quantified on a GC equipped with dual capillary columns and dual electron-capture detectors (ECD). The compounds analysed were hexachlorobenzene (HCB), hexachlorocyclohexane (alfa-, beta- and gamma-HCH), DDTs (o,p'-DDT, p,p'-DDT, p,p'-DDD and p,p'-DDE) and the PCB congeners 28, 52, 101, 105, 114, 118, 138, 153, 156, 157, 167, 170 and 180. All samples were fortified with internal standards prior to extraction to correct for analytical losses and to ensure quality control. A number of control samples were analysed together with the samples to verify the accuracy and precision of the measurements. The laboratory is accredited for analysis of PCBs and chlorinated pesticides in human milk.

Because of a broken sample vial, this sample was not used and 29 samples were analysed. In case of the PCB analyses, the results from one additional sample was omitted because of interfering peaks on the chromatogram, and thus 28 samples were analysed for PCBs.

Results and Discussion

Age, weight and additional data on the S.A. mothers/babies are given in Table 1. The mothers' mean age was 26 years, and the mean birth weight of the children was 3.0 kg. The children's mean age at sampling was 6 weeks. The parity of the mothers was unfortunately not evident from the questionnaires. More than 80% of the mothers reported a rural area of residence within the last five years.

The levels of PCBs, HCB and HCHs are given in Table 2. In this table, the mean, median, min and max levels are calculated from the 28-29 samples. In one sample, unusually high levels of the PCB congeners PCB-170 and PCB-180 were noted, which resulted in the highest sumPCB level measured (42 ng/g fat). In one sample, a very high beta-HCH level was noted (112 ng/g fat).

In Table 3, the DDT levels are presented. The p,p'-DDE and sumDDT levels are presented, together with the p,p'-DDE/p,p'-DDT ratio. This ratio may give an indication on if the DDT exposure has occurred recently or long time ago.

For comparative reasons, the POP levels in the South African milk were compared to those of breast milk from Swedish women (Table 4). Milk samples from primiparae women from Uppsala County, Sweden, were obtained during 2004 and analysed at NFA[5]. The women (n=32) were in all cases born in Sweden, and the mean age of the Swedish women was 29 years.

Table 1. *Personal data on women from Northern Province, South Africa*

	Mean	**Median**	**Min**	**Max**
Age (years)	26	26	14	41
Hight (cm)	147	147	131	157
Weight before pregnancy (kg)	57	52	40	103
BMI[1] before pregnancy (kg/m^2)	26	26	19	43
Birth weight of the child (g)	3004	3000	2210	4110
Childs age at sampling (weeks)	6	6	2	16

[1]Body mass index

Table 2. *Levels of PCBs (PCB-153, sumPCB), HCB and HCHs (alfa, beta and gamma isomers) in breast milk from Northern Province, South Africa (n=28-29), in ng/g fat wt.*

	PCB-153	**sumPCB (13)**	**HCB**	**sumHCH (3)**
mean	2.51	10.1	1.91	11.3
median	1.96	8.40	1.74	4.24
min	0.61	3.11	0.74	1.53
max	9.65	42.0	4.31	113

Table 3. *Levels of DDTs (p,p-DDE, sumDDT)) in breast milk from Northern Province, South Africa (n=29), in ng/g fat wt., and the ratio p,p'-DDE/p,p'-DDT*

	p,p'-DDE	sumDDT	p,p'-DDE/p,p'-DDT
mean	4 490	6 200	3.53
median	3 330	4 640	2.43
min	97.9	162	0.53
max	13 600	20 200	11.7

Table 4. *Comparison between South African (Northern Province; n=28-29, mixed parity) and Swedish (Uppsala County; n=32, primipara) median levels of POPs in breast milk (in ng/g fat), sampled in 2004*

	SumPCB (13)	HCB	HCH	p,p'-DDE	sumDDT
South Africa	8.40	1.74	4.24 (sumHCH)	3 330	4 640
Sweden	96.2	10.4	7.80 (β-HCH)	61.9	71.4
Ratio SA/Swe	0.09	0.17	(0.54)	54	65

The high levels seen in occasional samples may reflect a specific exposure route for these mothers. Some of the Swedish samples showed comparatively high concentrations of low-chlorinated PCB congeners, which may come from other routes than the food, e.g. PCB-containing materials present in houses, cars etc. In the S.A. samples we occasionally found the high-chlorinated PCB congeners, i.e. PCB-170 and -180, in high levels. Some local pollution source may be responsible for the comparably high PCB levels, and the same could be assumed for the single high beta-HCH level.

The very high DDT levels and the low PCB levels in the breast milk from the Northern Province, S.A. (in comparison to Swedish levels) probably reflect the rural, non-industrial character of this region, and not least the fact that DDT spraying is still ongoing. The lower levels of HCB and HCHs in S.A. compared to Swedish samples could however not be explained by rural - urban/industrial differences, as HCB and HCHs are, or have been, used as pesticides. On the other hand, the Swedish HCB exposure comes primarily from incineration of chlorine-containing material and not from pesticide usage. The comparably low S.A. breast milk levels of HCB and HCH may result from a small use of these chemicals in S.A., a faster elimination of these chemicals in the S.A. environment, or a selective accumulation of these compounds in the Swedish environment.

The high breast milk levels of DDTs in the S.A. samples are results of an ongoing DDT spraying operation in this area. The large span and clear difference in DDT levels between different individuals will also point towards an exposure that is very local and specific, which would not be the case if basal food supply was contaminated. In milk from six of the 29 women, sumDDT levels of less than 1 000 ng/g fat were reported, whereas the median and maximum sumDDT levels for the S.A. samples were about 4 600 and over 20 000 ng/g fat, respectively. Also the p,p'-DDE/p,p'-DDT ratio among the S.A. samples (median 2.4) suggests recent exposure to DDT preparations, as otherwise this ratio would have been higher (in the Swedish milk samples from 2004 this median ratio was 17.3).

The comparison between S.A. and Swedish samples is relevant from the point of view that the median age of the mothers did not differ that much (26 and 29 years, respectively), and neither did the post partum sampling time (6 (median) and 3 weeks after partus, respectively). However, whereas the Swedish women were all primiparae, corresponding data from the S.A women were missing, and they were therefore considered to be of mixed parity. The parity has shown to be of importance for POP levels in breast milk, as each breast-feeding period will result in lower body burden for the mother. In any case, the clear difference between the S.A. and Swedish breast milk POP levels would not be drastically altered if the parity for the S.A. women had been known and corrected for.

The high DDT levels in the breast milk will result in a considerable intake of DDT for the little baby. If we consider a 5 kg baby feeding entirely on breast milk (0.7 L/day) with a fat content of 4%, the baby will consume 28 g milk fat per day, or 5.6 g fat/kg bw/day. If we calculate the sumDDT-intake from min-max levels in the milk (162-20 200 ng/g fat), the resulting intake will be 0.9-113 µg/kg bw/day. The agreed PTDI for sumDDT is 10 µg/kg[6], which means that the children with the highest intakes will exceed the PTDI with a factor of about 10. The situation with neonatal intakes well above the TDI has also been observed for other POPs, such as the dioxins. The health consequences from a high neonatal, but transient, DDT intake is not known, but it should be noted that the TDI concept is based on a life-long exposure of the compound. In recent reviews on health effects of DDT the carcinogenic and endocrine-disrupting potentials are discussed, but inconclusive results makes it, still, difficult to judge on the role of DDTs in disease development[7,8].

The potential risk with DDT exposure should be weighed against the benefit with a decrease in numbers of persons falling ill in malaria. If just a part of the potentially infected individuals could escape the illness, many lives are saved. On the other side of the balance the much more diffuse symptoms from DDTs have to be considered. In this situation, the controlled use of DDT may be acceptable as long as other treatments for eradication of malaria mosquitoes are less effective. However, all efforts must be taken to exchange DDT for other effective anti-malaria compounds, or techniques, with less harmful effects on health and environment.

Acknowledgements
Economic support has been given from Sida, in the form of a travel grant.

References

1. Bouwman H, Coopan RM, Reineck AJ, Becker PJ. *WHO Bulletin OMS*, 1990, vol. 28.
2. Okonkwo JO, Kampira L, Chingkule DDK. *Bull. Environ. Contam. Toxicol.* 1999;2:243.
3. Atuma SS, Aune M. *Bull Environ Contam Toxicol* 1999;62:8.
4. Aune M, Atuma S, Darnerud PO, Wicklund-Glynn A, Cnattingius S. *Organohalogen Compds*. 1999;44:93.
5. Lignell S, Aune M, Darnerud PO, Glynn A. Report to the Swedish EPA (2005-10-04)
6. FAO: Pesticide residues in food – 2000. FAO Plant Production and Protection Paper, 163, 2001.
7. Turusov V, Rakitsky V, Tomatis L. *Environ Health Perspect.* 2002;110:125.
8. Beard J. *Sci. Total Environ.* 2006;355:78.