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Occurrence and levels of organochlorine compounds in human breast milk in Bangladesh

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ABSTRACT

In low-income countries, the use of some organochlorine pesticides is still common in order to increase food production. Monitoring the chemical exposure is an important step in risk-reducing strategies. This is the first study to report concentrations of organochlorines in breast milk of women from Bangladesh where farming is the main income source.

Organochlorines such as *p,p′*-DDT, *o,p′*-DDT, *p,p′*-DDE, *p,p′*-DDD (i.e., ∑DDT), HCB, α-, β- and γ-HCH, *trans*-chlordane, *cis*-chlordane, *oxy*-chlordane, *trans*-nonachlor, *cis*-nonachlor, mirex and polychlorinated biphenyls (CB 28, 52, 99, 101, 105, 114, 118, 123, 128, 138, 141, 149, 153, 156, 157, 163, 167, 170, 180, 183, 187, 189, 194) were analyzed in breast milk collected in 2002 from 72 first-time mothers (median age 20 years) living in the rural area Matlab, Bangladesh.

While the concentrations of PCBs and many of the pesticides were low, the concentrations of *p,p′*-DDT and its metabolite *p,p′*-DDE were high (median 349 and 1645 ng g^{-1} lipid, respectively) in comparison to other countries. The median value of ∑DDT was 2123 ng g^{-1} lipid. The estimated daily exposure to *p,p′*-DDT, *p,p′*-DDE and ∑DDTs was 10, 30 and 42 μg kg^{-1} body weight, respectively, in 3 months old infants. The *p,p′*-DDE/*p,p′*-DDT ratio ranged from 1 to 23, where 58% of the mothers had a ratio below 5 indicating recent or ongoing DDT exposure.

This study reports infant exposure and maternal body burden of organochlorines through breast milk. Although the findings give no reason to limit breast-feeding, it is essential to identify the main exposure sources and find means to decrease the exposure.

1. Introduction

Many organochlorine compounds, including pesticides, e.g., DDT, HCB and HCH and industrial chemicals, e.g., polychlorinated biphenyls; PCBs (used mainly for electric equipment) belong to the group of persistent organic pollutants (POPs). These pollutants can persist in the environment for long periods of time due to their resistance to bio-degradation and travel long distances to remote areas such as the Arctic (Oehme, 1991). Due to the lipophilic properties of POPs, they have the ability to bio-accumulate and biomagnify up the food chain, thereby posing toxic threats to humans and animals (UNEP, 2002). For this reason, many of the POPs were banned worldwide in the 1970–1980s. In 2001, a global action (the Stockholm Convention Treaty initiated by the United Nations Environmental Programme) was taken to eliminate or restrict the production and use of POPs (UNEP, 2002). Bangladesh ratified the Stockholm Convention Treaty in 2007.

Worldwide, emphasis has been given to increase the food production by intensifying the use of some organochlorine pesticides. Pesticides like DDT have not only been used for agricultural purposes, they have also been and are still being used in the health sector in an attempt to control mosquito vectors of diseases like malaria and Dengue (ESDO, 2005a; van den Berg, 2009; WHO, 2011). High exposure to organochlorines have been observed among people from developing countries and tropical areas where pesticide exposure may take place via ingestion of contaminated foods as well as inhalation during agricultural work and sprayed home environments (van den Berg, 2009).

In Bangladesh, where agriculture provides income to more than two-thirds of the rural population, the use of some pesticides was encouraged through price reduction until the 1980s. Consequently,

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the import of pesticides increased from 2 metric tons in 1956 to about 8000 metric tons in 1993 (Rahman and Alam, 1997). The use of DDT was banned in the early 1980s in Bangladesh, although the DDT plant situated in Chittagong, southeast of Bangladesh, was officially producing DDT mainly for malaria control until 1991 (ESDO, 2005a). Chlordane, dieldrin and heptachlor were not banned until 1997 (ESDO, 2005a). Still, the percentage of farmers using DDT and the consumption of insecticides, fungicides and herbicides has increased since the year 2000 (ESDO, 2005a). As recently as 2005, a global NGO project (International POPs Elimination Project; the Environment and Social Development Organization, ESDO) reported that PCBs are still being used in the electric energy sector in Bangladesh under different trade names, even though PCBs are also prohibited in the country (ESDO, 2005a).

The most vulnerable time of exposure to organochlorines appears to be during the embryonic and fetal period (Weisglas-Kuperus et al., 2000; Siddiqui et al., 2003; Damgaard et al., 2006; Ribas-Fito et al., 2006, 2007; Maervoet et al., 2007; Torres-Sanchez et al., 2007; Pan et al., 2009; Toft et al., 2010; Wojtyniak et al., 2010). High correlations of organochlorines exist between maternal adipose tissue, plasma, cord blood and breast milk, demonstrating both placental and lactational transfer (Eik Anda et al., 2007; Bergonzi et al., 2009). A greater elimination of organochlorine compounds occurs from the maternal body during breastfeeding (Uemura et al., 2008). For this reason, women who have breastfed one or more children will have a lower body burden of these compounds compared to women who have not breastfed. Breast milk is a sensitive matrix for monitoring maternal body burden of pesticides (Bergonzi et al., 2009) and the sampling of milk is non-invasive and, therefore, generally accepted by the mothers (Esteban and Castano, 2009).

Although high concentrations of pesticides in breast milk have been reported in women working in agricultural fields (Kumar et al., 2006) and living in malaria affected areas (Bouwman et al., 2006), there is no information on the presence of pesticides in human milk from Bangladesh. Hence, the aim of the study was to monitor the concentrations of organochlorine pesticides and PCBs in breast milk of women living in a rural area of Bangladesh, where small-scale farming is the main income source.

2. Materials and methods

2.1. Study area

The present study is part of our ongoing research concerning health effects of early-life exposure to toxic agents in food and drinking water in rural Bangladesh (Vahter et al., 2006; Bergkvist et al., 2010a). This research is nested into a population-based randomized food and micronutrient supplementation trial called Maternal and Infant Nutrition Interventions in Matlab, MINIMat (Tofail et al., 2008). Matlab is a poor rural sub-district located 53 km southeast of Dhaka (Fig. 1), the capital city of Bangladesh, and situated in a low-lying area that is intersected by the tidal river Gumoti and its numerous canals (Razzaque et al., 2007). The prevalence of malaria in this area is very low (Haque et al., 2010). Small-scale farming is the main income source, with some fishing and trading. Sharecropping and working on other people's land on a daily wage basis are the main sources of income for the many landless people. Some men from the village are also involved in subsistence farming in other districts. Women spend on average 3 h per day on agricultural work and even more during high seasons (Zaman, 1995). The rate of illiteracy is high, especially among older people. In about half of the area of Matlab, ICDDR,B (International Centre for Diarrhoeal Disease Research, Bangladesh) provides community based reproductive and child health services to about 110 000 inhabitants and supports clinical and public health research via a central hospital and four sub-centers (Block A, B, C and D). A Health and Demographic Surveillance System (HDSS) that is run by ICDDR,B is updated regularly with information on all vital events, e.g., marriages, births, deaths, and in- and out-migration. A wealth index based on information on household assets (collected in the MINIMat trial or excerpted from the HDSS database), structure of walls of the house and land ownership was used as a measure of socioeconomic status (SES) (Saha et al., 2008).

2.2. Study population and sample collection

Of a total of 2119 non-smoking women, who were asked after a positive pregnancy test to participate in the MINIMat project in 2002 (January–December), 1000 women were randomly selected and followed from pregnancy to 6 months postpartum (response rate 75%). Of the randomly selected women, 251 women donated breast milk at two months postpartum. A subsample of 72 first-time mothers whose breast milk samples have previously been measured for metals (Bergkvist et al., 2010a) was selected for exploratory organochlorine analysis in the present study. We chose first-time mothers to avoid a decrease in levels of pesticides due to pregnancy and breastfeeding. The mean age of the mothers was 21 years and ranged from 14 to 30 years (Table 1). Their mean body mass index (BMI) at gestational week 8 was 20 kg m^{-2} ranging from 16 to 25 kg m^{-2}.

Before collection, the breast was cleansed with water. Milk was collected from one breast while the other was given to the baby. If sufficient milk was not expressed from one breast, the mother tried with the other breast. Spot breast milk (10 mL) was gently expressed by hand into 24 mL plastic vials (Zinsser Analytic GMBH, Frankfurt, Germany). The samples were transported in cooling box to Matlab hospital laboratory where they were divided into 2 mL aliquots (cryo vials, SARSTEDT) and deep-frozen at −70 °C. Frozen samples were transported by air to Sweden where they were kept in −20 °C freezers at Karolinska Institutet until analysis. The study was approved by the ethical committees at ICDDR,B in Bangladesh and Karolinska Institutet in Sweden. Written informed consent was obtained from all participants.

2.3. Chemical analysis

A pilot study was first conducted on 5 out of 72 breast milk samples and analyzed at the Norwegian Institute for Air Research (NILU) for the following organochlorines: 1,1,1-trichloro-2,2-bis(*p*-chloro phenyl)ethane (*p*,*p*′-DDT) and 1,1,1-trichloro-2-(*o*-chlorophenyl)-2-(*p*-chlorophenyl)ethane (*o*,*p*′-DDT) and their metabolites 1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene (*p*,*p*′-DDE), 1,1-dichloro-2(*o*-chlorophenyl)-2-(*p*-chlorophenyl)ethylene (*o*,*p*′-DDE), 1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethane (*p*,*p*′-DDD), 1,1-dichloro-2-(*o*-chlorophenyl)2-(*p*-chlorophenyl)ethane (*o*,*p*′-DDD), hexachlorobenzene (HCB), alfa-, beta- and gamma-hexachlorocyclohexane (α-, β- and γ-HCH), *trans*-chlordane, *cis*-chlordane, oxychlordane, *trans*-nonachlor, *cis*-nonachlor, mirex and PCBs (CB 28, 52, 99, 101, 105, 114, 118, 123, 128, 138, 141, 149, 153, 156, 157, 163, 167, 170, 180, 183, 187, 189, 194). The chemical analysis has previously been described (Eik Anda et al., 2007). Briefly, to the breast milk samples (approx. 1 g), ^{13}C labeled internal standards were added together with sodium oxalate and methanol, mixed thoroughly, and extracted three times with methyl tert-buthyl ether and hexane (50/50). Lipid content was determined gravimetrically after gentle evaporation of the solvent. The extract was further cleaned up on an acidic silica column before analysis. The PCBs and pesticides were separated and quantified on a HP-5 column (30 m × 0.25 mm, df = 0.25 μm) installed in a 7890A gas

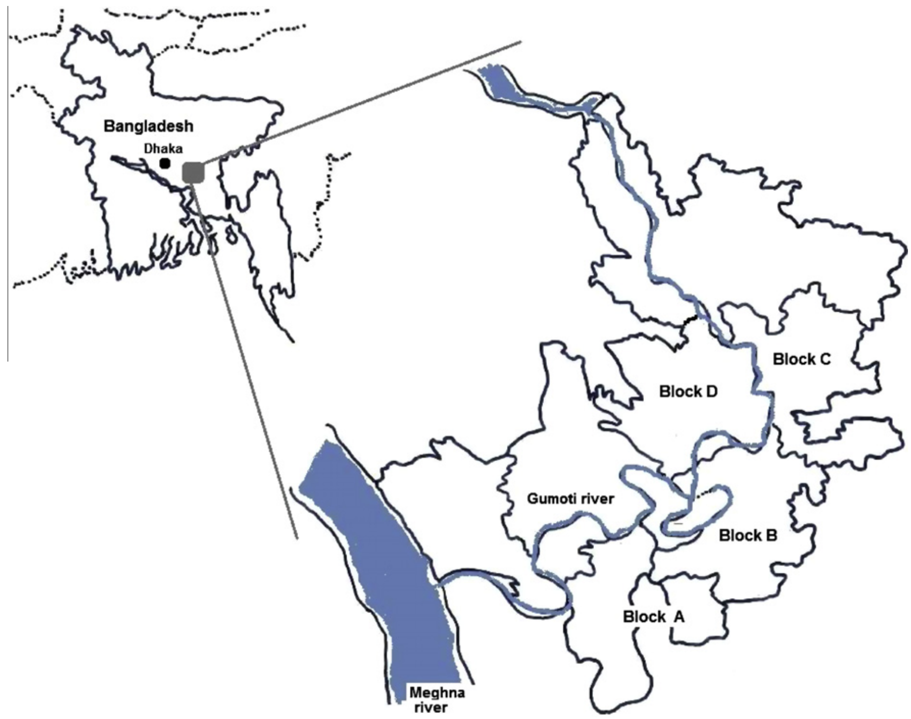

Fig. 1. Map of the study area in Matlab, Bangladesh, defined as Block A, B, C and D.

Table 1
Characteristics of 72 first-time mothers from Matlab, Bangladesh.

	Mean (± SD)	Median	Range (min–max)
Characteristics			
Age (years)	21 ± 3.2	20	14–30
Weight (kg)	44 ± 5.2	44	33–57
Height (m)	1.5 ± 0.1	1.5	1.4–1.6
BMI (kg m^{-2})[a]	20 ± 2.1	20	16–25
Breast milk fat (%)	4.3 ± 1.8	4.1	0.9–8.2

[a] BMI = body mass index at gestational week 8.

chromatograph (Agilent) equipped with a 5975C MSD (Agilent), operated in single ion monitoring mode (SIM). The limit of quantification (LOQ) was set to six times the average noise for each compound. None of the compounds were detected in blanks. The LOQ for the pesticides ranged from 10 to 300 pg g^{-1} wet weight, whereas the LOQ for the PCBs ranged from 3.2 to 92 pg g^{-1} wet weight. Concentrations of *o,p*′-DDE, *o,p*′-DDD, α- and γ-HCH, *trans*-chlordane, *cis*-chlordane, *cis*-nonachlor, mirex and many of the PCB congeners were all below or close to the LOQ and therefore not considered for further chemical analysis of the remaining samples. The laboratory participates in annual proficiency testing (Rudge et al., 2012).

The remaining 67 breast milk samples were analyzed for *p,p*′-DDT, *o,p*′-DDT, *p,p*′-DDE, *p,p*′-DDD, HCB, β-HCH, oxychlordane, *trans*-nonachlor and PCBs (CB 28, 52, 101, 105, 114, 118, 138, 153, 156, 157, 167, 170, 180) at the Swedish National Food Agency (NFA) according to previously described methods (Atuma and Aune, 1999; Aune et al., 1999) with some minor modifications. In brief, thawed and homogenized breast milk samples (0.5 g) were extracted twice with a mixture of acetone and *n*-hexane (50/50) and the lipid content was determined gravimetrically after evaporation of the solvent. The fat was re-dissolved in *n*-hexane and treated with sulfuric acid. PCBs were separated from the rest of the chlorinated pesticides, except *p,p*′-DDE and HCB, on a silica gel column. The residue concentrations were quantified with an Agilent Technologies model 6890 N gas chromatograph with dual capillary columns of different polarity and dual electron-capture detectors. All samples were fortified with the internal standards *o,p*′-DDD and CB 189 prior to extraction to correct for analytical losses and to ensure quality control. A number of blank and control samples were analyzed together with the samples to verify the accuracy and precision of the measurements. The coefficient of variation (CV) for the analyzed compounds was less than 10%. The recoveries of the compounds have earlier been determined by the fortification of cow's milk and the recoveries ranged from 87% to 118% for the PCB congeners and from 79% to 106% for the chlorinated pesticides. The LOQ was determined by the lowest calibration level. The LOQ ranged from 200 to 420 pg g^{-1} wet weight for the analyzed pesticide compounds whereas the LOQ for PCBs was 200 pg g^{-1} wet weight. The number of values below LOQ is presented for each pesticide in Table 2. The laboratory has successfully participated in several international proficiency tests and is accredited for analysis of organochlorine compounds in human milk.

2.4. Statistical analysis

The statistical and descriptive analyses were carried out on 72 breast milk samples, where values below the LOQ were treated as ½ of this limit. Spearman's correlations test (r_s) was used for examining correlations between continuous variables that were log-normally distributed. The statistical analyses were performed in STATA (Intercooled STATA software version 11; StataCorp, LP). Reported *p* values were from two-sided statistical tests where a *p* value of <0.05 was considered statistically significant.

3. Results

The concentrations of organochlorine compounds in breast milk samples, expressed as ng g^{-1} wet weight and ng g^{-1} lipid

Table 2
Concentrations of organochlorine compounds in breast milk sampled at 2 months postpartum from first-time mothers from Matlab, Bangladesh during 2002. Values below the LOQ were substituted with half of this limit.

Organochlorines	Mean (±SD)	Median	Range (min–max)	<LOQ[a]
Wet weight (ng g^{-1}; 67 samples)				
p,p′-DDT	31	13	2.5–647	0
p,p′-DDE	89	56	7.8–734	0
p,p′-DDD	0.5	0.2	0.2–7.3	41
o,p′-DDT	2.9	1.8	0.2–42	6
∑DDT[b]	124	70	12–1430	41
p,p′-DDE/*p,p′*-DDT	4.4	3.9	1.1–14	0
HCB	0.1	0.1 (<LOQ)	0.1–0.3	66
β-HCH	3.2	2.5	0.2–21	1
Oxychlordane	0.3	0.1 (<LOQ)	0.1–2.1	38
Trans-nonachlor	0.1	0.1 (<LOQ)	0.1–0.6	61
Lipid weight (ng g^{-1}; 67 samples)				
p,p′-DDT	707	337	86–10,400	0
p,p′-DDE	2123	1520	326–11,800	0
p,p′-DDD	12	7.5	2.5–117	41
o,p′-DDT	65	39	5.0–672	6
∑DDT	2907	2033	557–22,989	41
p,p′-DDE/*p,p′*-DDT	4.4	3.9	1.1–14	0
HCB	3.0	2.5	1.3–11	66
β-HCH	76	58	11–389	1
Oxychlordane	6.0	3.9	1.6–36	38
Trans-nonachlor	3.5	2.7	1.3–14	61
Pilot study (ng g^{-1} lipid; 5 samples)				
p,p′-DDT	350	361	50–660	0
p,p′-DDE	4729	3591	1148–8831	0
p,p′-DDD	43	34	8.6–109	0
o,p′-DDT	35	46	9.3–55	0
o,p′-DDE	4.1	2.6	1.2–8.6	2
o,p′-DDD	3.5	3.6	1.1–6.4	2
∑DDT	5158	4017	1316–9593	0
p,p′-DDE/*p,p′*-DDT	15	13	9.9–23	0
HCB	4.2	2.2	1.8–12	0
β-HCH	99	86	66–138	0
Oxychlordane	6.6	5.8	1.0–17	1
Trans-nonachlor	2.1	1.6	0.3–4.4	1

[a] Number of samples below the limit of quantification (LOQ).
[b] ∑DDT = *p,p′*-DDT, *p,p′*-DDE, *p,p′*-DDD and *o,p′*-DDT.

are presented in Table 2. When combining the concentration data from the pilot study with the concentration data of the remaining samples, we observed that *p,p′*-DDE had the highest concentrations in breast milk (median 1645 ng g^{-1} lipid) compared to the other organochlorine compounds, followed by *p,p′*-DDT (median 349 ng g^{-1} lipid), β-HCH (median 64 ng g^{-1} lipid) and *o,p′*-DDT (median 39 ng g^{-1} lipid). The *p,p′*-DDE/*p,p′*-DDT ratio ranged from 1 to 23 of which 58% of the samples had a ratio below 5. For *p,p′*-DDD, HCB, oxychlordane and trans-nonachlor, most of the values were below the LOQ (Table 2). There was no statistically significant correlation between any of the pesticide measurements and maternal age, height, weight, BMI or SES.

Of the PCB congeners analyzed, only a few concentrations were above the LOQ in the 72 breast milk samples. Those were CB28 (0.42 and 0.49 ng g^{-1} lipid), CB101 (0.56 and 3.4 ng g^{-1} lipid), CB118 (1.1, 1.8, 1.8, 3.6, 4.1 and 4.6 ng g^{-1} lipid), CB138 (2.5, 3.2, 3.9, 6.0, 8.6, 14 and 25 ng g^{-1} lipid), CB153 (2.0, 2.2, 3.3, 3.6, 4.2, 5.8, 12, 18 and 35 ng g^{-1} lipid), CB170 (7.4 ng g^{-1} lipid) and CB180 (5, 11 and 18 ng g^{-1} lipid).

Table 3 shows the correlations between the organochlorine pesticides. *p,p′*-DDT was significantly associated with its metabolites as well as with ∑DDT but also with oxychlordane, whereas none of the pesticides were correlated with β-HCH.

4. Discussion

We found on average high concentrations with wide variations of the compounds *p,p′*-DDT and *p,p′*-DDE in breast milk of women living in a rural area in central Bangladesh where the prevalence of malaria is low. The concentrations of *p,p′*-DDT and *p,p′*-DDE are on average over 100 times higher than those in Europe (Polder et al., 2009). Almost two third of the women had a *p,p′*-DDE/*p,p′*-DDT ratio below 5, indicating ongoing or recent exposure.

Table 3
Spearman correlations between concentrations of organochlorine compounds in 72 breast milk samples of first-time mothers from Matlab, Bangladesh.

	p,p′-DDT	*p,p′*-DDE	*p,p′*-DDD	*o,p′*-DDT	∑DDT	β-HCH
p,p′-DDE	0.714*					
p,p′-DDD	0.511*	0.485*				
o,p′-DDT	0.832*	0.568*	0.400*			
∑DDT	0.809*	0.986*	0.527*	0.655*		
β-HCH	0.089	0.183	0.142	−0.020	0.178	
Oxychlordane	0.236*	0.302*	0.184	0.029	0.296*	0.159

* p value <0.05.

Based on the average breast milk concentration of *p,p′*-DDT, *p,p′*-DDE and ∑DDTs (30, 93 and 126 μg kg^{-1} wet weight, respectively) and a mean milk consumption of about 900 mL d^{-1} in 3 months old infants (Moore et al., 2007), the estimated daily exposure would be 27, 84 and 113 μg, respectively, corresponding to an estimated exposure of 10, 30 and 42 μg kg^{-1} body weight, respectively. The lack of guideline values for exposure to organochlorines in breastfeeding infants makes any interpretation of the estimated exposure difficult with regard to potential adverse health outcomes.

As far as we know, only three previous articles have reported concentrations of organochlorines in inhabitants from Bangladesh (Mamun et al., 2007; Zamir et al., 2009; Linderholm et al., 2011), but those studies used plasma as their biomarker matrix and their study subjects were children, teenagers and adults living in the urban area surrounding the capital city Dhaka. Even though the sources of exposure may differ, the reported plasma concentrations of organochlorines showed similar exposure patterns as those in the present study, i.e., high plasma concentrations of *p,p′*-DDT (median 370–670 ng g^{-1} lipid) and *p,p′*-DDE (median 2900–3900 ng g^{-1} lipid) and low concentrations of PCBs and HCB (Mamun et al., 2007). Highest concentrations of *p,p′*-DDT were found in fishermen and fishermen's wives living in Dhaka (median 1100 and 1340 ng g^{-1} lipid, respectively) (Zamir et al., 2009).

This may be due to the common practice of treating fresh water fish that is left to sun dry with DDT and heptachlor insecticides to protect the fish from infestation and remain fresh on the market (Bhuiyan et al., 2009; Chowdhury et al., 2010). In general, there is a lack of information regarding possible sources of exposure as well as levels of pesticides in the environment, including food, in Bangladesh. Some of the countries surrounding Bangladesh have shown to have, on average, 10 times higher emission levels of DDT over the past years as a consequence of the production and use of organochlorines as compared to other parts of the world including Europe, Africa and North America (AMAP, 2002).

The median breast milk concentrations of *p,p′*-DDT and *p,p′*-DDE from the present study (349 and 1645 ng g^{-1} lipid, respectively) are high compared to concentrations of the same compounds in breast milk from countries such as US – North Carolina (median 5 and 121 ng g^{-1} lipid, respectively), Norway (median 3 and 41 ng g^{-1} lipid, respectively), Croatia (median 13 and 104 ng g^{-1} lipid, respectively), Russia (median 74 and 959 ng g^{-1} lipid, respectively) and the Philippines (median 24 and 585 ng g^{-1} lipid, respectively) (Polder et al., 2008, 2009; Krauthacker et al., 2009; Pan et al., 2009; Satyan et al., 2009). Countries that have recently used or are still using organochlorines show comparable results to those in the present study for *p,p′*-DDT and *p,p′*-DDE; China – Dalian (mean 130 and 2000 ng g^{-1} lipid, respectively) and Hong Kong (mean 99 and 1380 ng g^{-1} lipid, respectively) (Kunisue et al., 2004; Hui et al., 2008). The decreasing trend of organochlorines in many countries is due to restrictions in use and production of these compounds (Smith, 1999), whereas a dilemma exists for many developing countries between phasing out organochlorines and taking actions against vector borne diseases such as malaria (WHO, 2011). Higher concentrations of *p,p′*-DDT and *p,p′*-DDE, compared to the present study, have been found in human breast milk from regions in South Africa where they actively use indoor residual spraying against malaria (median 4500 and 4600 ng g^{-1} lipid, respectively). This has resulted in markedly elevated DDT exposure and low *p,p′*-DDE/*p,p′*-DDT ratios compared to populations without ongoing exposure (Sereda et al., 2009).

In the body, DDT is metabolized to DDE, which will persist for longer periods in the body's adipose tissue than DDT (Kirman et al., 2011). Because of this, a low DDE/DDT ratio, as found in the present study, is the result of ongoing exposure to DDT in relation to the levels of DDE in the body. High DDE/DDT ratio implies that DDT is no longer emitted to the environment and that the exposure is food chain related (Jaga and Dharmani, 2003). The ongoing DDT exposure in Bangladesh may mainly be the result of current use of pesticides for agricultural purposes or against vector borne diseases (ESDO, 2005a), besides the consumption of treated fish, as mentioned above. Matlab belongs to the region where farmers are heavy users of pesticides. Still, only a few percent of the farmers are formally trained in pesticide handling and most of them use little or no protective measures when handling the chemicals (Rahman, 2003; Matthews, 2008). Under present weak control systems, pesticides enter the country illegally under different trade names and labels, resulting in localized elevated residues (Matin et al., 1998; ESDO, 2005a).

Concentrations of *p,p′*-DDT in breast milk were significantly correlated with its metabolites and $\sum$DDT as well as with oxychlordane but not with β-HCH, which is produced as part of technical HCH used as an insecticide. The correlation may be attributed to the co-exposure of these pesticides in the environment and the on-going use of these pesticides.

In comparison to data from industrialized countries (Bergkvist et al., 2010b), the present study showed very low concentrations of PCBs in breast milk and where many of the values were below the LOQ. The most abundant PCB congener was 153 followed by 138 and 118. Low concentrations of PCB 138 and 153 were also found in plasma of children and adults from Dhaka (median 12–14 ng g^{-1} and 11–15 ng g^{-1} lipid, respectively) (Mamun et al., 2007; Zamir et al., 2009). PCBs are still in use in Bangladesh but usually in power and industrial sectors (ESDO, 2005b). In 1999, PCB residues in water samples collected from five major rivers in Bangladesh contained 1–3 mg L^{-1}, however, the highest amounts were detected in rivers flowing through industrial or densely populated areas (ESDO, 2005a).

Epidemiological studies have reported inconsistent results of health effects in infants exposed to organochlorine pesticides during pregnancy and breastfeeding (Jurewicz et al., 2006; Eskenazi et al., 2008). Nonetheless, there is a concern regarding infant exposure to organochlorine pesticides, as they have potential endocrine disrupting properties. High concentrations of *p,p′*-DDE in breast milk, serum of pregnant women and cord blood have been associated with lower birth weight, shortening of gestational age, increased risk of fetal loss, reduced thyroid hormones, intra-uterine growth retardation, cryptorchidism, neurodevelopmental and behavioral effects (Siddiqui et al., 2003; Damgaard et al., 2006; Ribas-Fito et al., 2006; Maervoet et al., 2007; Torres-Sanchez et al., 2007; Pan et al., 2009; Toft et al., 2010; Wojtyniak et al., 2010). Concentrations of HCB in cord blood have been associated with reduced thyroid hormones, neurodevelopmental and behavioral effects (Maervoet et al., 2007; Ribas-Fito et al., 2007).

Breast milk is an important source of balanced nutrition and passive immunization for the infant. Since long, many programs and projects have been promoting breastfeeding in Bangladesh (Arifeen et al., 2009; Haider et al., 2010). The findings of elevated pesticide concentrations in the present study are not associated with sufficient evidence of harmful effects to suggest modifications of the present recommendations of breast feeding, i.e., exclusively for 6 months (Lonnerdal, 2000; WHO, 2001). Also, breast-feeding seem to protect against exposure to other toxicants such as arsenic (Fangstrom et al., 2008), which is frequently occurring in drinking water in Bangladesh.

In our study, breast milk samples were analyzed for organochlorines at two different laboratories, the NILU and the Swedish NFA. The concentrations obtained from the pilot study at the NILU (five samples) were within the same range as those analyzed in the remaining breast milk samples at the Swedish NFA. Therefore, we conclude that any differences between the two laboratories would have little impact on the results. Further, *o,p′*-DDD was used as an internal standard in the analysis of organochlorines at the Swedish NFA. Since the concentrations of this metabolite were very low (many below or close to the LOQ in the pilot study) and also low in relation to the internal standard, the amount of *o,p′*-DDD were neither determined in the remaining 67 breast milk samples nor considered to have an impact on the analysis of the other organochlorines. This discrepancy is regarded as being covered by the measurement uncertainty for the method.

5. Conclusion

This study shows moderate to high exposure concentrations of organochlorine pesticides like DDT and DDE in women from a rural area of Bangladesh, where crop production is the main occupation and the prevalence of malaria is low. There is a general lack of information regarding organochlorine pesticides in food and in the environment as well as the use of these chemicals in homes and in occupational settings in different parts of Bangladesh. For this reason, further studies should focus on investigating major sources of exposure for specific areas of Bangladesh and the possibilities of decreasing the exposure. Also, potential adverse health effects in children and adults from Matlab should be assessed in relation to the exposure of organochlorines.

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