Inuit Exposure to Organochlorines through the Aquatic Food Chain in Arctic Québec

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Inuit people (Eskimos) are likely exposed to persistent organochlorine compounds because their traditional diet includes fatty tissues of the arctic marine biota. Here we present the results of organochlorine compound analysis in milk fat samples from arctic Québec Inuit women and in fat tissues from various animal species inhabiting that region. The total concentration of polychlorinated biphenyl congeners in Inuit milk fat was similar to that of the beluga, while the profile of the 10 congeners resembled that of the polar bear. Mean concentrations of various organochlorines in milk-fat samples from Inuit women were between 2 and 10 times greater than those found in samples previously collected from southern Québec women. The Inuit mothers exhibit the greatest body burden known to occur from exposure to organochlorine residues present in the environment by virtue of their location at the highest trophic level of the arctic food web. *Key words:* Arctic, breast milk; food chain contamination; Inuit; organochlorine compounds; polychlorinated biphenyls. *Environ Health Perspect* 101:618–620(1993)

The contamination of the arctic aquatic food chain by organochlorine compounds has been brought to light through the last decade (*1–4*). These contaminants are anthropogenic organic compounds which include pesticides (e.g., lindane, chlordane, endrin, dieldrin, toxaphene, DDT), industrial compounds, and byproducts of various industrial processes [e.g., hexachlorobenzene (HCB), polychlorinated biphenyls (PCBs), polychlorodibenzo-*p*-dioxins (PCDDs), and polychlorodibenzofurans (PCDFs)]. Despite regulatory actions adopted since the late 1970s in North America and Western Europe to limit their release into the environment, these compounds are still being emitted because of improper storage and disposal and on-going use in other parts of the world.

Once released into the environment at middle and lower latitudes, organochlorines reach the Arctic via long-range atmospheric transport, waterways, and ocean currents (*1*). High lipophilicity and resistance to biodegradation allow their bioconcentration in fatty tissues of organisms. Through the arctic aquatic food chain, biomagnification takes place, resulting in relatively high levels of contaminants in predator species located at the top of the food chain (polar bear, beluga) (*2,3*). Concentrations of DDT, PCBs, toxaphene, and chlordane in sea mammal blubber from the Canadian Arctic are generally between 1 and 5 µg/g (lipid basis) (*4*). In polar bear fat, PCB concentrations ranging from 3 to 8 µg/g (lipid basis) have been reported (*5*).

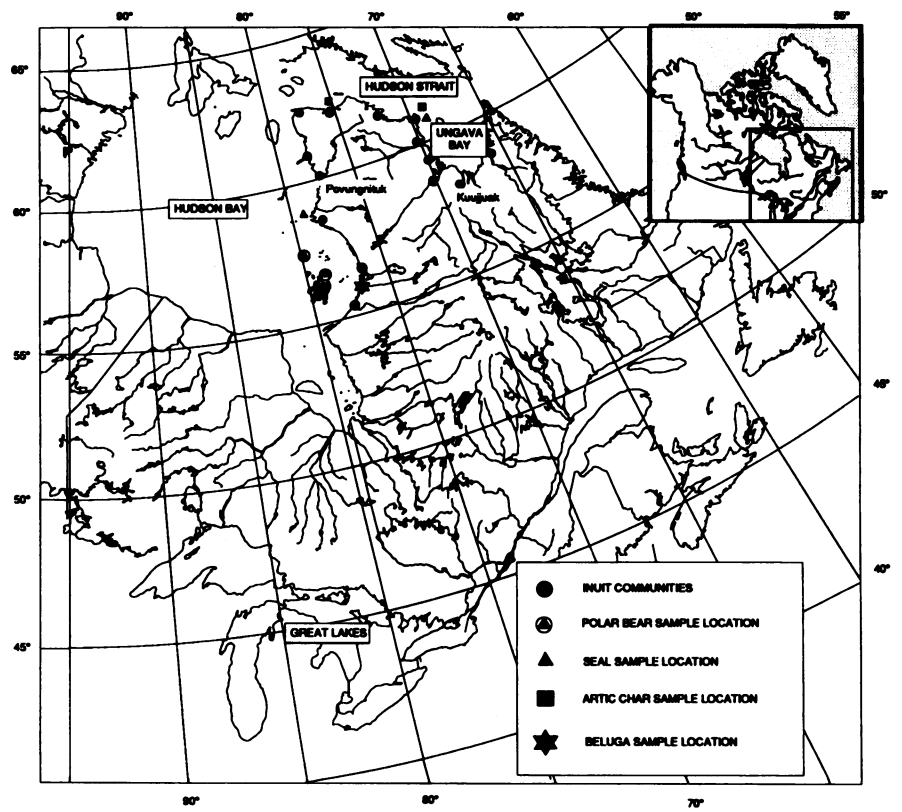

Fig. 1. Map of arctic Québec showing sampling locations. Arctic Québec is situated between 55° and 63° north. Approximately 6500 Inuit inhabit 14 settlements scattered along a 2000-km shore line. The regional hospitals are located in Povungnituk and Kuujjuaq. Polar bear and beluga were sampled in Hudson Bay, arctic char in Hudson Strait, and ringed seal in Hudson Bay, Hudson Strait, and Ungava Bay (map source: Energy, Mines and Resources Canada).

For cultural and economic reasons, the Inuit from arctic Québec (Fig. 1) rely heavily on country foods for their subsistence. Based on data pertaining to harvested marine species collected in 1982 and 1988 (*6*), their daily consumption of ringed seal, bearded seal, ***muktuk*** (beluga skin), and walrus amounts to approximately 300 g per day. Knowing the contamination levels reported in the edible tissues of sea mammals and their estimated daily consumptions, one would anticipate a relatively high body burden of organochlorine contaminants for native people living in arctic Québec. Indeed, we reported in 1989 preliminary data which showed that the breast milk of Inuit women from the

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Table 1. PCB congener concentration (ng/g, lipid basis) in milk from Inuit women and in fatty tissues of species from the arctic Québec aquatic food web

Species and tissues	N	PCB congeners (no. IUPAC) 28	52	101	118	138	153	170	180	183	187	∑ PCB[a]
Polar bear fat	35	<1	<1	<1	52 ± 6[b]	882 ± 55	3767 ± 652	720 ± 146	1656 ± 333	88 ± 18	43 ± 9	7002 ± 1276
Human milk (Arctic)	107	<1	7 ± 1	7 ± 1	59 ± 20[c]	233 ± 37	400 ± 67	46 ± 12[c]	194 ± 38	19 ± 3	55 ± 13[c]	1052 ± 148
Beluga blubber	16	26 ± 10	115 ± 58	139 ± 71	98 ± 48	184 ± 92	226 ± 113	27 ± 12	70 ± 31	41 ± 18	78 ± 34	1002 ± 469
Seal blubber	16	8 ± 4	34 ± 36	71 ± 83	43 ± 39	104 ± 148	156 ± 225	112 ± 19	39 ± 60	22 ± 35	38 ± 53	527 ± 692
Arctic char muscle	9	10 ± 5	19 ± 6	30 ± 7	24 ± 6	20 ± 6	26 ± 8	1 ± 0.3	6 ± 2	5 ± 1	11 ± 3	152 ± 42
Human milk (south)	16[d]	13 ± 2	<6.8	<2.6	17 ± 4	39 ± 10	37 ± 12	10 ± 2	20 ± 5	3 ± 1	7 ± 2	157 ± 37

[a]Sum of the ten PCB congeners.
[b]Arithmetic mean and 95% confidence interval; when more than one sample contained a nondetectable concentration, the arithmetic mean and the confidence interval were computed by log-probit regression (*18*).
[c]Only 35 milk samples analyzed.
[d]Sixteen pools of milk, 6 samples each; these results from Dewailly et al. (*8*) are provided for comparative purposes.

east coast of Hudson Bay contained an average PCB (Aroclor 1260) concentration of 3.6 µg/g (fat), an unusually high concentration compared to the average value of 0.77 µg/g for a control group of Caucasian women living in southern Québec (*7*).

To expand our database on the organochlorine body burden of natives from arctic Québec and to investigate its relationship with their dietary habits, we initiated in 1989 a 1-year survey in the regions of Ungava and eastern Hudson Bay (Fig. 1). Between mid-July 1989 and mid-July 1990, 224 births occurred in Kuujjuaq and Povungnituk hospitals; among the 125 breast-feeding mothers, 107 provided a 60-ml breast-milk sample within 3 days of delivery. These early milk samples were sent frozen to the laboratory for organochlorine analysis. Informed consent was obtained from all women entering the study. Results were forwarded to the regional hospitals, and nurses provided individual counseling to the mothers, taking into account the potential risk associated with the contaminants and the known benefits of breast-feeding.

Ten PCB congeners (IUPAC nos. 28, 52, 101, 118, 138, 153, 170, 180, 183, 187) and seven chlorinated pesticides (DDE, mirex, HCB, dieldrin, heptachlor epoxide, trans-chlordane, endrin) were measured in milk fat extracts by high-resolution gas chromatography using an electron capture detector, as described in Dewailly et al. (*8*). To effect comparisons, we randomly selected 50 milk samples (50 ml) for organochlorine pesticide analyses from 550 milk samples collected during a survey in southern Québec conducted in 1988–1989. The coefficients of variation ranged from 9% to 17% for the various organochlorines. For PCB congeners, we used as comparative data the concentrations measured in 16 pools made of 6 40-ml milk samples collected during the provincial survey (*8*).

A bilingual (English-Inuktitut), pretested dietary questionnaire was administered by trained Inuit interviewers to determine by a semiquantitative method the yearly consumption frequency of different species from the arctic marine biota. A precise quantitative dietary survey was not applicable in this culturally different population.

Table 2. Organochlorine concentrations in human milk from Inuit and Caucasian women (ng/g, lipid basis)

Organochloride compounds	Inuit women (N = 107) n[a]	Mean[b] ± CI	Caucasian women (N = 50) n	Mean ± CI
DDE	107	1212 ± 170	50	336 ± 18
Hexachlorobenzene	107	136 ± 19	48	28 ± 3
Dieldrin	102	37 ± 5	46	11 ± 1
Mirex	90	16 ± 4	3	1.6 ± 0.3
Heptachlor epoxide	45	13 ± 2	29	8 ± 1
Trans-chlordane	18	3.7 ± 0.4	0	<6
Endrin	1	<8	0	<6

[a]*n* = number of milk samples with concentration above the detection limit.
[b]Arithmetic mean and 95% confidence interval; when more than one sample contained a nondetectable concentration, the arithmetic mean and the confidence interval were computed by log-probit regression (*18*).

Tissue samples from polar bear (*Ursus maritimus*), ringed seal (*Phoca hispida*), beluga (*Delphinapterus leucas*), and arctic char (*Salvelinus alpinus*) were collected during the same period in Hudson Bay or Hudson Strait (Fig. 1). Blubber (marine mammals), fat (polar bear), or muscle (arctic char) samples were analyzed for the same 10 PCB congeners as described previously (*5,9*).

Total PCB concentration in the milk fat of Inuit women was similar to that found in beluga blubber (Table 1). Both were seven times greater than that found in the arctic char. In the adipose tissue of the polar bear, a predator located on top of the arctic food chain, total PCB concentration was seven times greater than that measured in Inuit milk fat.

The persistent PCB congeners 138, 153, and 180 (*10–12*) showed biomagnification throughout this food web. The apparent biomagnification factors (BMF) from arctic char to polar bear were 44, 145, and 276, respectively. From arctic char to Inuit, BMF for the same congeners were 12, 15, and 32, respectively. In contrast, for PCB congeners 28, 52, and 101, which display shorter half-lives in various mammalian species (*10–12*), biomagnification was only observed at the lower trophic levels, up to the beluga. A bioelimination process was observed at the highest trophic levels, as suggested by the BMF from arctic char to polar bear, which were < 0.1, < 0.05, and < 0.03, respectively. From arctic char to Inuit, BMF for the same congeners were < 0.1, 0.4, and 0.2, respectively. Globally, the profile of the 10 PCB congeners observed in Inuit women is similar to that found in the polar bear, a highly ranked predator of this food web.

Total PCB concentration in the milk fat of Inuit women was seven times greater than that measured in milk-fat samples from southern Québec women (Table 1). Differences between the two groups were even greater for the most persistent PCB congeners, reaching a concentration ratio of 10:1 for the congener 153. In contrast, PCB congener 28 was detected in only two Inuit milk samples but in 100% of Caucasian milk samples; the mean concentration for the latter group was at least 13 times greater than that of the Inuit group.

DDE, HCB, and dieldrin were detected in almost all milk samples (Table 2). Their mean concentration in milk samples from Inuit women were on average four times greater than those from Caucasian women. Mirex, an organochlorine totally refractory to mammalian metabolism, was detected in 95% of Inuit milk samples but in only 6% of southern Québec samples, with mean levels in Inuit milk-fat samples being 10 times greater than those of southern Québec milk samples. Trans-chlordane

and endrin were rarely detected (22% and 1%, respectively) in Inuit samples and never detected in Caucasian breast milk.

The dietary questionnaire revealed that 20%, 14%, 23%, and 17% of mothers consume ringed seal blubber, beluga blubber, *muktuk* (beluga skin) and *misirak* (fermented seal or beluga blubber) at least once a week, respectively. These are fatty food items containing elevated concentrations of organochlorine compounds. Results do not allow for a quantitative analysis of the relationship between the consumption of traditional food and the concentration of organochlorine compounds in breast milk. To indirectly address this question, we compared the average concentration of various organochlorine compounds found in the milk fat of 27 mothers from the remote Hudson Strait region, where the most traditional Inuit settlements are located, to that of 23 less traditional lactating mothers from Ungava Bay. The Inuit from the Hudson Strait settlements consume more fat tissues of sea mammals than the Inuit from the less traditional regions. The consumption of *misirak* is probably a good indicator of the traditional diet. In the Hudson Strait region, 89% of the women declared consuming *misirak* once a year or more, whereas only 28% of the women from the Ungava region reported this dietary habit. Accordingly, DDE and HCB concentrations for the Hudson Strait group (1566 and 188 ng/g, respectively) were on average 1.7 times greater ($p < 0.05$) than those of the Ungava Bay group (849 and 115 ng/g, respectively).

Similar differences were observed for PCBs and the other organochlorines (data not shown). This cannot be explained by a difference in the age of the mothers (Hudson Strait: mean = 25.6 years; Ungava: mean = 23.2 years) or a difference in the total time spent breast-feeding children during their lifetime. In fact, Hudson Strait women breast fed on average for a total of 37.6 months, whereas Ungava mothers with a lower organochlorine body burden breast fed on average for 14.6 months. Moreover, mean concentration of total PCBs in ringed seals from Hudson Strait and Ungava Bay were not significantly different. The mean total PCB concentration measured in fat samples from the eight ringed seals from Hudson Strait was 640 ng/kg lipids (SD: 440), compared to 400 ng/kg (SD: 225) for the samples from the five ringed seals from Ungava Bay. Hence, although exposure to organochlorine compounds can occur by other pathways, the high body burden observed in Inuit women is, for the most part, likely the result of their traditional dietary habits, as for the other highly ranked predator species in the arctic aquatic food chain. Due to their high lipid solubilities and low vapor pressures (*1*), the inhalation from ambient air and the consumption of drinking water are probably negligible contributors to organochlorine compound exposure in the Arctic.

The mean PCB concentration in the milk fat of Inuit women is greater than that recently reported for the general female populations of various countries (*13*). This surprisingly high organochlorine body burden in Inuit women may bear public health consequences. Because of the ability of these compounds to cross the placental barrier and to bioconcentrate in milk fat, fetuses and breast-fed babies constitute the most heavily exposed group, as well as the most susceptible. In the United States, a study conducted in the Great Lakes basin (*14*) investigated children whose mothers were exposed to relatively low doses of PCBs. This study reported adverse neurodevelopmental effects in exposed children, which correlated with the estimated maternal exposure and presumably with *in utero* exposure. In laboratory animals, PCBs can interfere with reproduction and possess carcinogenic, teratogenic, and immunotoxic properties (*15*). This last effect may be relevant in explaining the high incidence of infectious diseases noted in Inuit infants from arctic Québec (*16,17*). Epidemiologic studies are underway to examine the putative effects of this exposure on the development and the immune status of Inuit newborns in arctic Québec.

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