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Indications of decreasing human PTS concentrations in North West Russia

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Background: The Russian Arctic covers an enormous landmass with diverse environments. It inhabits more than 20 different ethnic groups, all of them with various living conditions and food traditions. Indigenous populations with a traditional way of living are exposed to a large number of anthropogenic pollutants, such as persistent organic pollutants (POPs) and toxic metals, mainly through the diet. Human monitoring of persistent organic pollutants (POPs) and heavy metals in the Russian Arctic has only been performed on irregular intervals over the past 15 years, thus, there is still a lack of baseline data from many ethnic groups and geographical regions. The aim of the current study was to investigate concentrations of POPs and toxic metals in three groups of indigenous people from the Russian Arctic. Plasma concentrations of POPs were measured in one of the locations (Nelmin-Nos) in 2001–2003 which gave the unique opportunity to compare concentrations over time in a small Russian arctic community.

Methods: During 2009 and early 2010, 209 blood samples were collected from three different study sites in North West Russia; Nelmin-Nos, Izhma and Usinsk. The three study sites are geographically separated and the inhabitants are expected to have different dietary habits and living conditions. All blood samples were analyzed for POPs and toxic metals.

Results: PCB 153 was present in highest concentrations of the 18 PCBs analyzed. *p*, *p*′-DDE and HCB were the two most dominating OC pesticides. Males had higher concentrations of PCB 138, 153 and 180 than women and age was a significant predictor of PCB 153, 180, HCB and *p*, *p*′-DDD. Males from Izhma had significantly higher concentrations of HCB than males from the other study sites and women from Usinsk had higher concentrations of *p*, *p*′-DDE. Parity was a significant predictor of *p*, *p*′-DDE. Hg and Pb concentrations increased with increasing age and males had significantly higher concentrations of Pb than women. The study group from Izhma had significantly higher concentrations of Cd when controlling for age and gender and the study group from Usinsk had higher concentrations of Se than the others. Compared to the results from Nelmin-Nos in 2001–2003, a clear decrease in *p*, *p*′-DDE concentrations for both women and men was observed.

Conclusions: The current study indicates a significant reduction of several PTSs in human blood samples from North West Russia over the past 10 years.

Keywords: *PTS*; *human blood*; *decreasing levels*; *North West Russia*

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The Russian Arctic covers an enormous landmass with diverse environments. It is inhabited by more than 20 different ethnic groups, all of them with various living conditions and food traditions (1). It is described that indigenous people with a traditional way of living are exposed to a large number of anthropogenic pollutants, such as persistent organic pollutants (POPs) and toxic metals, mainly through the diet (2–4).

Persistent organic pollutants refer to a large group of organic compounds that are highly lipophilic and persistent to degradation (2–4). Many of these compounds have been used in industrial applications (e.g. polychlorinated

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biphenyls (PCBs)) or as pesticides (e.g. dichlorodiphenyltrichloroethane (DDT) and hexachlorobenzene (HCB)). Due to their chemical properties, many POPs biomagnify in the food chain and high concentrations are therefore found in species at the top of the food web. Toxic metals, such as Lead (Pb) and Mercury (Hg), are naturally occurring substances. Through human activities, for example mining and the use of leaded gasoline, large amounts of these metals have been released into the environment where they bioaccumulate in organisms and biomagnify in food webs. As many indigenous people in the Russian Arctic live from subsistence hunting and fishing and sometime close to point sources, they are likely to be exposed to elevated concentrations of POPs and toxic metals. High concentrations of *p,p′*-DDE (metabolite of DDT; dichlorodiphenyldichloroethylene) has, for example, been monitored in blood from people residing in Chukotka in eastern Russia and high levels of toxic metals, e.g. Pb, have been reported among several ethnic groups in Russia (1–4).

There are many potential effects of human exposure to persistent toxic substances (PTSs) e.g. endocrine disrupting effects, neurodevelopmental, and immunological effects (5–7). However, the evidence base is sometimes weak (8, 9). Recently, POP exposure was linked to the increasing incidence of cancer and diabetes (7–9). Accidental release of Hg, has shown that exposure to this metal has deleterious effects on human health (9). The effects of environmental pollutants on human health are, often subtle, long term, sometimes transgenerational, and difficult to measure even in long-term epidemiological studies in large populations. There is therefore a need for comprehensive research that monitors the concentration and distribution of toxic substances in different geographical regions in humans over time (4).

Human monitoring of POPs and heavy metals in the Russian Arctic has only been performed on irregular intervals over the past 15 years; thus, there is still a lack of baseline data from many ethnic groups and geographical regions (1–4). To be able to properly evaluate the health-related effects of contaminants, high-quality baseline data is crucial.

The aim of the current study was to investigate concentrations of POPs and toxic metals in three groups of indigenous people from the Russian Arctic. Plasma concentrations of POPs were measured in one of the locations (Nelmin-Nos) in 2001–2003 that gave the unique opportunity to compare concentrations over time in a small Russian arctic community (10, 11).

Materials and methods

Study participants and blood collection

During 2009 and early 2010, 209 blood samples were collected from three different study sites in North West Russia; Nelmin-Nos, Izhma, and Usinsk (Table 1). Nelmin-Nos is a community of about 800 inhabitants located in the Pechora River Basin in the Nenets Autonomous Okrug. The inhabitants of this area are Nenets, except 14 adult participants who are of Russian ethnicity. Izhma is a rural inland district in the Komi Republic. All of the participants from Izhma reported that they were Komi of ethnicity. People in this area are mainly reindeer herders. Fifty blood samples were also collected in the city of Usinsk (44,000 inhabitants) in the Komi Republic. Usinsk is the center for oil and gas production in the Komi Republic. Eighty eight percent of the study participants from Usinsk reported that they were Komi of ethnicity.

The blood samples were collected from the participants at the same time as they took part in a general health examination. The study participants were invited to the health survey through advertisement in various public areas (medical center, shops, school, school canteen, day care center,museum, and public wash place). An informed consent was signed before inclusion, and the study was accepted by the ethical committees of the different regions.

Chemical analysis

Persistent organic pollutants

The blood samples were analyzed for POPs in the scientific production facility ‘Typhoon’ at the Center for Environmental Chemistry in Obninsk in Russia. The methods used were described in detail by Konoplev (11). In brief, all samples were spiked with mass-labeled internal standards (six PCBs and six pesticides) before extraction. One to four milliliters of serum was extracted using liquid–liquid extraction with 20–35 ml (depending on sample volume) of methyl tertiary butyl ether as solvent. The extraction procedure was repeated twice. The extracts were dried on anhydrous sodium sulphate and up-concentrated to 10 ml on a rotary evaporator. Lipids were removed using gel permeation chromatography with Bio Bead SX-3 as sorbent and a 1:1 mixture of hexane and dichloromethane (DCM) as solvent. After further volume reduction to 0.5 ml, the extracts were cleaned up on prepacked deactivated silica (3%) columns using hexane and DCM/hexane (1:1) as solvent.

Metals

The analyses of metals in full blood were also performed in the scientific production facility ‘Typhoon’ at the Center for Environmental Chemistry in Obninsk in Russia. Only samples from the Komi Republic were analyzed for metals due to limited sample volumes from Nelmin-Nos. The methods used have been described elsewhere (11). In brief, samples for Pb and cadmium (Cd) analysis were prepared using 0.1% triton X-100 and 2N nitric acid. The samples were analyzed with atomic

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Table 1. Study group characteristics

	Nelmin-Nos, $n=109$	Izhma, $n=50$	Usinsk, $n=50$
% Males/Females	20/80	50/50	50/50
Age, mean (min–max)	41 (6–77)	31 (15–55)	40 (19–62)
Parity, mean (min–max)	2.8 (0–9)	2.3 (1–3)	2.1 (1–4)
Ethnicity	Nenets–except 14 Russian	Komi	88% Komi, 10% Russian, 2% others

absorption spectrometry. In advance of the Hg analysis, full blood samples were prepared using 5% potassium permanganate and concentrated nitric and sulfuric acid (1:3). The mixture was heated at 60°C for 4 hours and analyzed with the 'cold vapor' technique on a spectrophotometer. Full blood samples for selenium analysis were prepared by adding ascorbic acid, 5% sodium molybdate (aq.), and a mixture of concentrated nitric acid and sulfuric acid (3:4). The solution was heated in 15 min at 120°C and afterwards to 160°C to complete decomposition. After cooling and filtration, 1% of 1,2 diamino-4 nitrobenzene was added. One hour later, 5-nitro-2, 1, 3-benzoselendiazol was extracted using chloroform. Selenium concentration was later analyzed by electrothermal atomic-absorption spectrometry.

Determination of lipids

The content of cholesterol, triglycerides, and phospholipids were determined enzymatically and total lipids were calculated according to the formula:

$$TL = 1.677(TC - FC) + FC + TG + PL$$

TL, total lipids, TC, total cholesterol, FC, free cholesterol, TG, triglycerides, and PL, phospholipids, after Akins et al. (12).

Quality control of chemical analysis

The recovery of each analyte was calculated in spiked serum samples and varied between 65 and 110% for both the PCBs and the pesticides. Blank samples containing matrix and reference samples were analyzed for each batch of samples with successful results. The current laboratory also participates in the AMAP interlaboratory comparison program for POPs organized by Institut National de Santé Publique du Québec, Canada thrice each year. Results from the interlaboratory comparisons indicate that the uncertainties of the analysis are well within ±20% of the assigned values. The analytical QA/QC for the two time periods of analyses was identical, and both time windows performed very good in the AMAP QA/QC Ring Test (2, 4).

There were some analytical challenges linked to the analyses of POPs in the dataset. The samples from the Komi Republic were prepared using 3–5 ml of serum, whereas only 1 ml was used from the samples from Nelmin-Nos, due to limited serum volumes. Larger sample volumes result in lower limit of detections (LOD). To avoid systematic errors, the LODs for the smaller sample volumes from Nelmin-Nos were also applied to the data from the Komi Republic.

Statistical analysis

Statistical analysis was performed using the freely available software R, version 2.12.1 (http://cran.r-project.org), and the NADA package for R. Kaplan-Meier methods and ROS were used for finding central tendency for analytes with more than 10% non-detects (Table 2). All contaminant data were right skewed and log transformed by the natural logarithm before analyses in order to achieve normality. Significant predictors were evaluated by linear models controlling for potential confounding factors. Diagnostic plots of the residuals were evaluated to ensure that model assumptions were met. In order to avoid misclassification, statistical analyses were only performed on analytes with more than 60% detected (PCB 138, PCB 153, PCB 180, *p,p′*-DDE, and HCB).

Results

The detection frequencies and the method LOD in the dataset are reported in Table S1 in the supporting information. Blood concentrations of POPs and metals among the study participants are provided in Tables 2–4.

Of the 18 PCBs analyzed, PCB 153 was present in highest concentrations in samples from all three study sites, whereas *p,p′*-DDE and HCB were the two most dominating OC pesticides. The PCB pattern among men at all three study sites was as follows: PCB1 53 > PCB 180 > PCB 138 > PCB 118. For women, the PCB pattern varied between study site; Nelmin-Nos: PCB 153 > PCB 180 > PCB 118 > PCB 138, Izhma, and Usinsk; PCB 153 > PCB 118 > PCB 138 > PCB 180.

Males had significantly higher concentrations of PCB 138, 153, and 180 than women ($p = <0.05$). Older people had also higher concentrations of PCB 153, 180, HCB and *p, p′*-DDE ($p = <0.001$). When adjusting for age and gender, there was no difference in PCB 138, PCB 153, and PCB 180 concentrations between the three study locations; however, males from Izhma had significantly higher concentrations of HCB than the others ($p = 0.003$). Among women, the participants from Usinsk had higher concentrations of *p,p′*-DDE when adjusting

Table 2. Concentrations of OCs (ng/g) lipid weight in women

Concentration (ng/g) l.w		Nelmin-Nos ($n=87$)	Izhma ($n=25$)	Usinsk ($n=25$)
PCB 28/31	AM(min–max)	38 (<LOD-396)	N/A	18 (<LOD-45)
	Median	16	N/A	12
PCB 52	AM(min–max)	38 (<LOD-277)	14 (<LOD-31)	25 (<LOD-35)
	Median	22	11	15
PCB 99	AM(min–max)	31 (<LOD-304)	16 (<LOD-56)	25 (<LOD-35)
	Median	20	9.4	25
PCB 101	AM(min–max)	35 (<LOD-294)	22 (<LOD-77)	29 (<LOD-43)
	Median	12	13	25
PCB 105	AM(min-max)	28 (<LOD-99)	18 (<LOD-38)	18 (<LOD-41)
	Median	17	14	14
PCB 110	AM(min–max)	34 (<LOD-152)	26 (<LOD-49)	27 (<LOD-50)
	Median	19	19	24
PCB 118	AM(min–max)	48 (<LOD-268)	41 (<LOD-66)	44 (<LOD-106)
	Median	30	35	40
PCB 128	AM/median	N/A	N/A	N/A
PCB 138	AM(min–max)	46 (<LOD-169)	32 (<LOD-61)	40 (<LOD-66)
	Median	35	31	37
PCB 153	AM(min–max)	98 (<LOD-534)	65 (<LOD-156)	72 (<LOD-137)
	Median	78	59	67
PCB 156	AM(min–max)	N/A	N/A	N/A
PCB 170	AM(min–max)	21 (<LOD-288)	N/A	N/A
	Median	9	N/A	N/A
PCB 180	AM(min–max)	57 (<LOD-286)	23 (<LOD-108)	30 (<LOD-113)
	Median	47	8.5	25
PCB 183	AM/median	N/A	N/A	N/A
PCB 187	AM(min–max)	16 (<LOD-243)	N/A	N/A
	Median	6	N/A	N/A
HCB	AM(min–max)	135 (<LOD-373)	122 (32–297)	117 (35–320)
	Median	110	102	103
a-HCH	AM/median	N/A	N/A	N/A
b-HCH	AM/median	N/A	N/A	N/A
g-HCH	AM/median	N/A	N/A	N/A
Heptachlor	AM/median	N/A	N/A	N/A
Oxychlordane	AM/median	N/A	N/A	N/A
trans-Chlordane	AM/median	N/A	N/A	N/A
cis-Chlordane	AM/median	N/A	N/A	N/A
trans-Nonachlor	AM(min–max)	N/A	N/A	3.6 (<LOD-21)
	Median	N/A	N/A	1.3
cis-Nonachlor	AM/median	N/A	N/A	N/A
Dieldrin	AM/median	N/A	N/A	N/A
o,p′-DDE	AM/median	N/A	N/A	N/A
p,p′-DDE	AM(min–max)	246 (<LOD-1342)	127 (41–517)	234 (91–600)
	Median	163	107	203
o,p′-DDD	AM/median	N/A	N/A	N/A
p,p′-DDD	AM/median	N/A	N/A	N/A
o,p′-DDT	AM/median	N/A	N/A	N/A
p,p′-DDT	AM/median	N/A	N/A	N/A
Mirex	AM/median	N/A	N/A	N/A

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Table 3. Plasma concentrations (ng/g) lipid weight of organochlorines among men

Concentration (ng/g) l.w		Nelmin-Nos ($n=22$)	Izhma ($n=25$)	Usinsk ($n=25$)
PCB 28/31	AM(min–max)	50 (<LOD-218)	9.7 (<LOD-96)	19 (<LOD-72)
	Median	18	3.2	7.5
PCB 52	AM(min–max)	56 (<LOD-203)	13 (<LOD-120)	23 (<LOD-62)
	Median	28	3.3	17
PCB 99	AM(min–max)	36 (<LOD-136)	29 (<LOD-175)	33 (<LOD-70)
	Median	26	22	31
PCB 101	AM(min–max)	73 (<LOD-266)	32 (<LOD-285)	34 (<LOD-79)
	Median	45	11	28
PCB 105	AM(min–max)	42 (<LOD-385)	24 (<LOD-268)	20 (<LOD-59)
	Median	14	10	11
PCB 110	AM(min–max)	45 (<LOD-308)	26 (<LOD-370)	37 (<LOD-82)
	Median	21	3.6	29
PCB 118	AM(min–max)	57 (<LOD-532)	43 (<LOD-478)	39 (<LOD-106)
	Median	26	15	28
PCB 128	AM/median	N/A	N/A	N/A
PCB 138	AM(min–max)	58 (<LOD-291)	54 (<LOD-270)	53 (<LOD-104)
	Median	36	36	55
PCB 153	AM(min–max)	104 (<LOD-222)	123 (<LOD-297)	110 (36–236)
	Median	92	106	97
PCB 156	AM(min–max)	23 (<LOD-164)	N/A	N/A
	Median	6	N/A	N/A
PCB 170	AM(min–max)	24 (<LOD-89)	33 (<LOD-85)	19 (<LOD-67)
	Median	10	28	10
PCB 180	AM(min–max)	64 (<LOD-152)	79 (<LOD-170)	63 (<LOD-158)
	Median	57	73	59
PCB 183	AM/median	N/A	N/A	N/A
PCB 187	AM(min–max)	12 (<LOD-43)	13 (<LOD-45)	11 (<LOD-66)
	Median	7	3.7	4.4
HCB	AM(min–max)	98 (<LOD-203)	183 (46–361)	122 (53–427)
	Median	86	160	107
a-HCH	AM/median	N/A	N/A	N/A
b-HCH	AM/median	N/A	N/A	N/A
g-HCH	AM/median	N/A	N/A	N/A
Heptachlor	AM/median	N/A	N/A	N/A
Oxychlordane	AM/median	N/A	N/A	N/A
trans-Chlordane	AM/median	N/A	N/A	N/A
cis-Chlordane	AM/median	N/A	N/A	N/A
trans-Nonachlor	AM(min–max)	N/A	N/A	8.9 (3.1–26)
	Median	N/A	N/A	4.6
cis-Nonachlor	AM/median	N/A	N/A	N/A
Dieldrin	AM/median	N/A	N/A	N/A
o, p′-DDE	AM/median	N/A	N/A	N/A
p,p′-DDE	AM(min–max)	245 (51–732)	168 (20–428)	228 (53–782)
	Median	176	138	190
o, p′-DDD	AM/median	N/A	N/A	N/A
p,p′-DDD	AM/median	N/A	N/A	N/A
o, p′-DDT	AM/median	N/A	N/A	N/A
p,p′-DDT	AM/median	N/A	N/A	N/A
Mirex	AM/median	N/A	N/A	N/A

Table 4. Full blood concentrations of metals (μg/L) in study participants from the Komi Republic

		Men		Women	
Concentration μg/L		Izhma ($n=25$)	Usinsk ($n=25$)	Izhma ($n=25$)	Usinsk ($n=25$)
Hg	AM (min–max)	2.7 (1–8.1)	2.7 (1–10)	2.8 (1–10)	2.6 (1–6.4)
	GM	2.3	2.2	2.3	2.3
Pb	AM (min–max)	37 (14–88)	38 (11–63)	30 (11–57)	25 (11–63)
	GM	33	32	27	23
Cd	AM (min–max)	0.54 (0.1–1.4)	0.37 (0.1–1.0)	0.51 (0.1–1.5)	0.32 (0.1–1.3)
	GM	0.43	0.28	0.40	0.23
Se	AM (min–max)	90 (61–130)	100 (61–134)	89 (57–119)	102 (63–139)
	GM	88	99	87	100

for parity ($p=0.0473$). Parity was only a significant predictor of *p,p′*-DDE ($p=0.0368$).

Mercury, Pb, Cd, and Selenium (Se) were detected in more than 85% of all samples. Hg and Pb concentrations increased with increasing age ($p=<0.05$) and males had significantly higher concentrations of Pb ($p=0.014$) than women. Parity did not affect metal concentration. When adjusting for age and gender, there was no difference in Hg and Pb concentration between Usinsk and Izhma. The study group from Izhma had significantly higher concentrations of Cd ($p=0.00019$) when controlling for age and gender and the study group from Usinsk had higher concentrations of Se ($p=0.018$).

Discussion

This unique study contributes with new and valuable data on blood concentrations of PTSs among indigenous people from North West Russia. In total, 209 samples from three different study sites were analyzed for 18 PCBs, 18 OCs, and 4 metals. Only five POPs were detected in more than 60% of all samples, indicating low levels or analytical challenges. *p,p′*-DDE was the most dominating compound at all three study sites, followed by HCB, and PCB 153. The concentrations found were definitely higher than in samples from Northern Norway (*p,p′*-DDE: 67 ng/g in women) and Sweden (*p,p′*-DDE: 34 ng/g in women) and in the same range as in samples from Inuit women in Nunavik, Canada (*p,p′*-DDE: 158 ng/g) and in Inuit women from Disko Bay, Greenland (*p,p′*-DDE: 178 ng/g) (2–4).

There was no difference in PCB, Hg, and Pb concentration between study sites, even though the study areas were geographically separated and the study participants were expected to have different ways of living and different dietary habits. These findings suggest therefore that the global distribution of these contaminants is more important than local sources and that different dietary habits have little impact on the concentrations of PCBs, Hg, and Pb in this study group.

HCB and Cd concentrations were significantly higher in the rural reindeer district Izhma, whereas Se and *p,p′*-DDE (women only) concentrations were significantly higher in the urban area Usinsk, where most people make their living as oil and gas workers. Differences could possibly be a result of different dietary habits (most likely a higher intake of reindeer liver in Izhma) or an historical point source being present in the local environment (paint, alloys, batteries, plastics, impregnated wood, etc). It is evident that humans are exposed to PTSs mainly from their diet and that indigenous people with a traditional way of living often are exposed to high concentrations of POPs and some heavy metals, especially if they feed from the marine food web. The village Nelmin-Nos is located at the outlet of the river Pechora and people in that area are expected to have a high intake of fish and seafood. Despite of that, their concentrations of PTSs were not higher than the other study groups from the inland Komi republic, indicating either similar diets in all three locations or other, more important exposure routes than the diet. It must be emphasized that marine mammals are not an important part of the diet in Nelmin-Nos. The usual mixture of imported food, local sea food, and reindeer meat will not contribute with contaminant levels comparable to a diet based on marine mammals.

During the years of 2001–2003, blood samples were collected from 31 women (mean age: 37) and 13 men (mean age: 25) from Nelmin-Nos as part of the PTS project in the Russian North (1). The samples were analyzed for POPs and heavy metals and the results were published in the AMAP Assessment 2009: Human health in the Arctic (4) and by Sandanger et al. 2009 (10). By comparing the results from the current study with the study in Nelmin-Nos in 2001–2003, a unique opportunity to investigate differences in POP concentration over time within a Russian indigenous population is allowed. Results from the two studies are summarized in Fig. 1.

A clear decrease in *p,p′*-DDE concentrations since 2001–2003 for both women and men was observed. In

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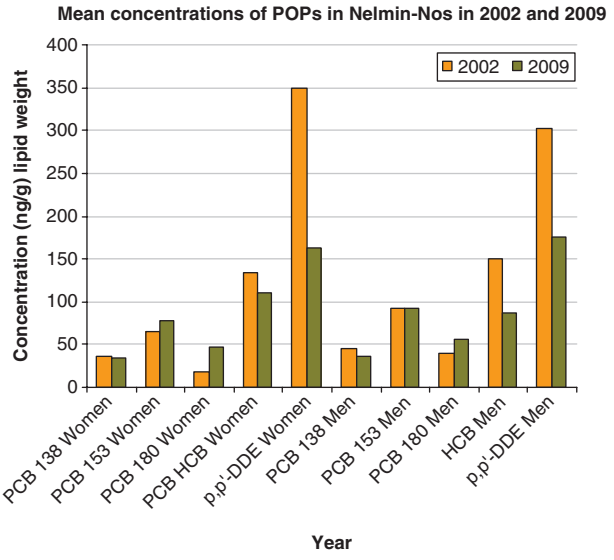

Fig. 1. Differences in blood concentrations of POPs in Nelmin-Nos from 2001–2003 to 2009.

addition, only 2% of all samples from 2010 contained detectable concentrations of *p,p′*-DDT. The low *p,p′*-DDT levels in 2010 can partly, but not fully, be explained by low sample volumes perhaps insufficient for such sensitivity of the analytical instrument. In 1996, high concentrations of *p,p′*-DDE and *p,p′*-DDT were reported in breast milk from Arkhangelsk (1,687 ng/g lipid weight of *p,p′*-DDE and 344 ng/g l.w. of *p,p′*-DDT) (2). The DDE/DDT ratio was 4.9 in the breast milk samples from 1996; thus, they indicated a recent source of DDT. In the samples from 2001—2003, the DDE/DDT ratio varied between 12.6 and 17.9 (different laboratories) indicating a reduction of DDT sources from 1996 (1). In the current study, it was not possible to calculate the DDE/DDT ratio due to the majority of samples having concentrations of *p,p′*-DDT below the LOD. Taken together, the current results combined with old data indicate a reduction of DDT compounds in the environment in some areas of the Russian Arctic and thus, confirm national and international restrictions on chemicals and metals.

Fig. 1 also indicates decreased HCB concentrations in Nelmin-Nos over the past 7–9 years. This is especially pronounced among men. PCB 138 and 153 show no distinct difference over time; however, a small increase in PCB 180 concentration for both gender, but especially for women, was observed when comparing the two datasets. It has to be emphasized that the datasets have not been adjusted for possible confounders. However, the participating women in 2010 were older than the women participating in 2001–2003 (46 years vs. 25 years). For men, the participants in 2001–2003 were slightly older (37 years vs. 32 years in 2010) (1). The decreasing concentrations of POPs over time could therefore not be confounded by age. Similar reductions in POP levels have also been reported in other parts of the Arctic (4).

In 2001–2003, heavy metals were measured in whole blood from indigenous men and women from the Kola Peninsula (Sami, Komi, and Nenets in Lowosero and Krasnoschelye) (1). Fig. 2 compares the concentrations of Hg from that study with the concentrations among Komi people from 2010. There has been observed large variations in Hg concentrations within the Russian Arctic (1, 3, 4), which is also reflected in the results from 2001–2003 (Fig. 2). The 2010 results from the Komi Republic are comparable between genders and regions. Together, the two datasets from 2001–2003 and 2010 indicate a decrease, rather than an increase in Hg concentrations over the past 7–9 years. However, the results should be interpreted carefully because samples sites are geographically separated. In the Canadian Arctic, levels of Hg have declined up to 50% in human populations over the last 8–15 years and are likely a further indication of broadly applied domestic and international controls on chemicals and metals. Despite that, there are still large geographical differences within the Canadian Arctic with some areas having very high concentrations of Hg.

Lead and Cd were also analyzed in that same study in 2001–2003 (1). There are indications that the Pb concentrations were higher in 2001–2003; (women = 31–38 µg/L in 2001–2003 vs. 23–27 µg/L in 2010 and men = 58–72 µg/L in 2001–2003 vs. 32–33 µg/L in 2010). The same trend was observed for Cd (women = 0.49–1.0 µg/L in

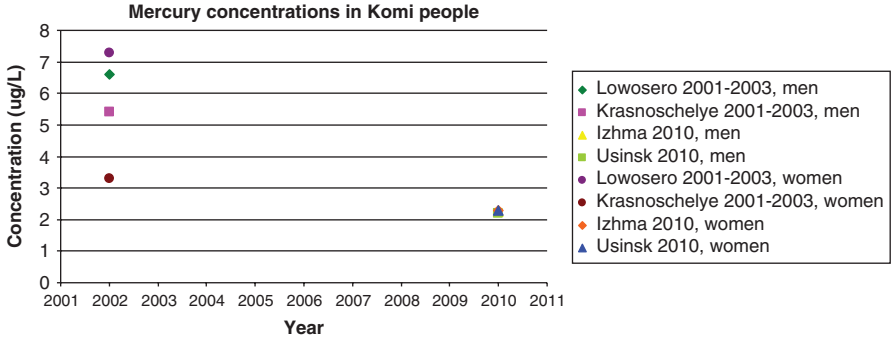

Fig. 2. Differences in blood concentrations of Mercury in North West Russia from 2001–2003 and 2010.

2001–2003 vs. 0.23–0.40 μg/L in 2010 and men = 0.60–0.89 μg/L in 2001–2003 and 0.28–0.43 μg/L in 2010). However, it is evident that the 2001–2003 data contain samples from several different ethnic groups and from a geographically closely related area to the Komi Republic. In addition, the numbers are not corrected for potential confounders, e.g. age and smoking. The participating women in 2010 were of the same age as the female participants in 2001–2003 (46 years vs. 42–44 years), and it is therefore not likely that the higher concentrations in 2001–2003 are explained by age. For men, the participants in 2001–2003 were older (mean age 40–55 years vs. 32 years in 2010) which could be one reason for the higher concentrations in 2001–2003. These limitations need to be kept in mind when evaluating the data.

There are a few limitations in the current study. Because of low sample volumes, many samples had analyte concentrations below the method LOD, indicating low concentrations of these analytes in the samples or insufficient sensitivity of the analytical instruments. Only 2% of all samples had *p,p′*-DDT concentrations above LOD; however, this could not fully be explained by the instrument performance as previous studies from the same areas have reported considerably higher concentrations of *p,p′*-DDT than the LOD in the current study. It is therefore likely that the low concentrations of *p,p′*-DDT are a result of reduced environmental pollution.

The reasons for the results presented in this follow-up study might be complex. There has been increasing focus on international agreements and collaboration to reduce the global exposure to contaminants (4). There has been a very good feedback to the local communities through the Russian colleagues, with systematic information and dietary advice through information campaigns and public meetings, especially in cooperation with the Russian Association of Indigenous Peoples of the North (1). A complicating, emerging issue will be the upcoming climate change, making people more vulnerable to dietary changes and also changing release and exposure to contaminants through the environment and the food chain (4). There is a need for regular and systematic follow-up studies of human exposure in the Russian Arctic. A time span of 5–10 years is needed to observe changes, due to the long half-life of the most persistent POPs (4).

Conclusions

The current study indicates a reduction of several PTSs in human blood samples from North West Russia over the past 10 years. The results point out the importance of systematic follow-up studies to observe trends in human exposure to protect the health of the people of the Russian Arctic.

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References

1. AMAP (2004). Persistent toxic substances, food security and indigenous peoples of the Russian North. Final Report, No.2. Oslo: Arctic Monitoring and Assessment Programme; p. 192.
2. AMAP. AMAP Assessment 2002. In: Hansen JC, Gilman A, Klopov V, Odland JO, eds., Human health in the Arctic. Oslo, Norway: Arctic Monitoring and Assessment Programme; 2003, pp. xiv+137.
3. AMAP. Assessment report: arctic pollution issues. In: Hansen JC, Gilman A, Klopov V, Odland JO, eds., Oslo: AMAP Secretariate; 1998, 775–844.
4. AMAP. Human health in the Arctic. Oslo, Norway: Arctic Monitoring and Assessment Programme; 2009, pp. Xiv+254.
5. Tan SW, Meiller JC, Mahaffey KR. The endocrine effects of mercury in humans and wildlife. Critic Rev Toxicol 2009; 39: 228–69.
6. Dallaire R, Dewailly E, Pereg D, Dery S, Ayotte P. Thyroid function and plasma concentrations of polyhalogenated compounds in Inuit Adults. Environ Health Perspec 2009; 117: 1380–6.
7. Grandjean P, Henriksen JE, Choi AL, Petersen MS, Dalgård C, Nielsen F, et al. Marine food pollutants as a risk factor for hypoinsulinemia and type 2 diabetes. Epidemiol 2011; 22: 410–7.
8. Ruder AM, Yiin JH. Mortality of US pentachlorophenol production workers through 2005. Chemos 2011; 83: 851–61.
9. Eto K, Marumoto M, Takeya M. The pathology of methylmercury poisoning (Minamata disease). Neuropathol 2010; 30: 471–9.
10. Sandanger TM, Anda EE, Dudarev AA, Nieboer E, Konoplev AV, Vlasov SV, et al. Combining data sets of organochlorines (Ocs) in human plasma for the Russian Arctic. Sci Total Environ 2009; 407: 5216–22.
11. Konoplev A. Final report on the sub-project 'Analytical determination of PTS levels in blood samples'. AMAP project: persistent toxic substances, food security and indigenous people of the Russian north. Activity 6 'Monitoring of PTS levels in humans'. AMAP, ed., 2003: Oslo, Norway.
12. Akins JR, Waldrep K, Bernert JT. The estimation of total serum lipids by a completely enzymatic 'summation' method. Clinica Chimica Acta 1989; 184: 219–26.

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