

Blood concentrations of persistent toxic substances in the indigenous communities of the Russian Arctic

Dudarev AA ¹, Konoplev AV ², Sandanger TM ³, Vlasov SV ⁴, Miretsky GI ⁵, Samsonov DP ², Chernik GV ², Morshina TN ², Pasyukova EM ², Pervunina RI ², Dorofeev VM ¹, Chaschin MV ¹, Sedenkov DA ¹, Zibarev EV ¹, Kuzmin AV ¹, Abryutina LI ⁶, Kimstach VA ⁷, Chaschin VP ¹

¹ North-West Public Health Research Center, St. Petersburg, Russia

² Center for Environmental Chemistry SPA "Typhoon", Obninsk, Russia

³ Institute for Air Research, The Polar Environmental Center, Tromsø, Norway

⁴ Regional Center "Monitoring of the Arctic", St-Petersburg, Russia

⁵ Kola Research Laboratory for Occupational Health, Kirovsk, Russia († deceased)

⁶ RAIPON, Moscow, Russia

⁷ AMAP Secretariat, Oslo, Norway

ABSTRACT

Objectives. Investigation was carried out within the framework of the large-scale international project "Persistent Toxic Substances (PTS), Food Security and Indigenous People of the Russian North" under RAIPON/AMAP/GEF aegis. Objectives of the project are to obtain comprehensive information on exposure of indigenous populations to contaminants through food chains (and other sources), and to investigate the possible health effects connected to this exposure. Four regions of Russia are involved in the project: Kola Peninsula (Murmansk oblast), Nenetskiy okrug (Pechora river basin), Taymyr Peninsula, Chukotka Peninsula. **Methods.** Questionnaire and paired sampling of maternal/cord blood among indigenous women at childbirth (more than 250 persons) as well as among general indigenous population (more than 1,400 persons), additionally breast milk sampling of lactating women (more than 50 persons) in Chukotka was conducted. About 700 blood samples have been analyzed at the Center for Environmental Chemistry, SPA "Typhoon" (Obninsk, Russia), the Regional Center "Monitoring of the Arctic", RCMA (St. Petersburg, Russia), the Norwegian Institute for Air Research, NILU (Tromsø, Norway) and at INSPQ (Sainte-Foy, Quebec, Canada). **Results and conclusions.** On the whole, PTS in human blood of the Russian Arctic natives are similar to those in the coastal areas of Greenland and Canada, and for some POPs such as toxaphenes and mirex, these levels are lower.

Key words: DDTs, PCBs, metals, indigenous, maternal, cord.

INTRODUCTION

The large-scale international scientific project "Persistent Toxic Substances (PTS), Food Security and Indigenous People of the Russian North" under RAIPON/AMAP/GEF aegis, started in 2001.

Due to their environmental persistence, global contaminants, such as heavy metals and persistent organic pollutants (POPs), are subject to long-range transport via atmosphere, marine and riverine pathways. In addition to their environmental persistence, many of these contaminants are toxic to living organism and/or have the tendency to

bioaccumulate and biomagnify in food chains (particularly marine food chains) with the result that organisms, including humans, that feed at the top of these food chains may be highly exposed. Potential health effects of PTS include those on neurological development and behavior, reproduction and the immune system; some of these substances are carcinogens. Due to their ability to pass the placenta barrier and to be transferred from mother to newborn with breast milk, possible effects during critical stages of fetal development in the first years of life are of greatest significance.

Assessment of the pollution situation in the northern regions carried out by the Arctic Monitoring and Assessment Program (AMAP), an international program based on coordinated national activities of the 8 Arctic countries, has shown that PTS have a tendency to be transported to, and accumulate in, the Arctic region. At the same time, Arctic ecosystems are particularly vulnerable to exposure to PTS, and certain Arctic indigenous communities have some of the highest exposures to PTS of any populations on Earth. This is the result of a number of factors, which include the cold climate, lipid-rich food chains, and the lifestyle of the indigenous peoples concerned, in particular their reliance on traditional (country) foods.

Objectives of the project are to obtain comprehensive information on exposure of indigenous populations to contaminants through food chains (and other sources), to investigate the possible health effects connected to this exposure, and to bring information to the attention of states negotiating the global PTS treaty.

Persistent Toxic Substances under the scope of the project:

- PCBs (15 congeners of PCB 28/31; 52; 99; 101; 105; 118; 128; 138; 153; 156; 170; 180; 183 and 187);
- Hexachlorocyclohexanes (α , β , γ - HCH);
- Oxichlordane; trans-chlordane; cis-chlordane;
- DDTs (2,4 DDE; 4,4 DDE; 2,4 DDD; 4,4 DDD; 2,4 DDT; 4,4 DDT)
- Hexachlorobenzene
- Heptachlor
- Dieldrin
- Mirex
- Trans-nonachlor; cis-nonachlor
- Toxaphenes (Par 26; Par 50; Par 62)
- PBDEs (7 congeners of PBDE 28; 47; 100; 99; 153; 154; 183)
- PAHs (Naphthalene; 2-Methylnaphthalene; Acenaphthene; Acenaphthylene; Fluorene; Phenanthrene; Anthracene; Fluoranthene; Pyrene; Benzo(a)anthracene; Chrysene; Benzo(k)fluoranthene; Benzo(e)pyrene; Benzo(a)pyrene; Indeno(1,2,3cd)pyrene;

Dibenz(a,h)anthracene; Benzo(g,h,i)perylene)

- Metals (Cd, Pb, Hg) in blood
- Se and Fe in serum
- Lipids

STUDY DESIGN

The project has been designed:

- to ascertain the PTS levels in the environmental substrates as a result of global (long-range transport) and local emissions of PTS.
- to evaluate different ways of PTS migration to humans, particularly via local food products consumed by indigenous populations of the Russian north.
- to define PTS content in the blood of aborigines.
- to qualify (via questionnaires) dietary habits, life style and health status of northern populations.

Geographical scope

Four regions of the Russian Federation have been involved in the project: Kola Peninsula, Pechora basin (Nenetsk okrug), Taimyr and Chukotka. The particular significance of the Chukotka region within the framework of the project is defined by the possibility of investigation of the exclusive population of Russia, which feed upon marine mammals (whale, walrus, seal), in comparison with other northern natives consuming mainly reindeer meat and fish. Due to a high-fat diet Eskimo and inshore Chukchy may be seriously affected because of chronic exposure to organochlorines and other persistent organic pollutants (POPs).

Two separate investigations were carried out in all selected regions:

1. Questionnaire and paired sampling of maternal and cord blood among indigenous women at childbirth at delivery departments of the hospitals for further analyses of POPs, heavy metals and essential elements. Additionally, breast milk sampling of lactating women was conducted in Chukotka.

2. Blood sampling and questionnaire among general indigenous population.

Questionnaires for pregnant women and the general population were different. The first one was mainly aimed at revealing peculiarities of reproductive anamneses of "risk group" for PTS (mother-child). The second one was elaborated specifically for use in a compact ethnic group having unique features of lifestyle and nutrition, aiming at defining pathways of contaminants' migration.

More than 1,400 northern aborigines were examined by means of questionnaire and blood sampling during expeditions to selected regions.

MATERIALS AND METHODS

Blood was collected from mothers' vena ulnaris and from fetus' umbilical cord step by step, one after another. Blood sampling was performed using vacutainers, i.e. plungerless vacuum fiberglass test-tubes with a needle screwed onto a holder for dosed intravenous blood sampling. For further blood treatment, special pipettes and vials tested for absence of pollutants capable of confusing blood analysis findings are required. A 3000 rpm centrifuge was used for sampled blood processing. Blood samples were kept in a freezing chamber at -20°C . Frozen blood samples were transported in special thermo containers.

Blood collection from mother's vein was carried out on the 1st – 3rd day after delivery. Cord blood collection was done immediately after umbilical cord ligation and cutting off. Blood sampling and treatment technique from mother's vein is identical to that of umbilical cord. Mothers were interviewed on the 3rd – 5th day after delivery.

About 700 blood samples have been analyzed at the Center for Environmental Chemistry, SPA "Typhoon" (Obninsk, Russia), the Regional Center "Monitoring of the Arctic", RCMA (St. Petersburg, Russia), the Norwegian Institute for Air research, NILU (Tromsø, Norway) and at INSPQ (Sainte-Foy, Quebec, Canada).

Analytical methods

The analysis conducted in CEC of SPA "Typhoon" is based on GC/MS method. As part of QA/QC program the samples were analyzed in series. Each series included no more than 12 samples, a proce-

dural blank and a control sample, containing known amounts of analytes. The validity and accuracy of measurements was ensured by using isotope-labeled surrogate standards: analogues of analytes introduced to the samples prior to extraction.

Analysis conducted by the RCMA laboratory was based on chromatographic separation of analytes and their identification by retention time using electron capture detector. Quantitative calculations were done based on external calibration using standard solutions of analytes.

RESULTS AND CONCLUSIONS

Since the occurrence of PTS in human blood in the Russian North is explained by intake of contaminated fish (marine and freshwater), marine mammals, sea birds and reindeer meat, the PTS concentrations in blood of women giving birth and their children are also associated with the traditional diet of indigenous people. The highest concentrations of PTS (Figures 1-5) in maternal and umbilical cord blood were detected in the Chukotsky District of Chukotka, and the cause of these high levels of PTS in blood in this particular district is envisaged to be determined by high consumption of traditional food based on higher trophic levels of long marine food chains.

Concentrations of organochlorine pesticides in cord blood of newborns are normally lower than in maternal blood, which leads to the conclusion that there is a placenta barrier to transfer of toxic substances from mother to fetus, even though it is not always very effective.

Among compounds of the DDT group the prevailing one is DDE, and the ratio of DDE/DDT concentrations is 3-8.

The comparison with results presented in the AMAP-2002 Report shows that on the whole, the OCP levels in human blood from the Russian Arctic are similar to those in the coastal areas of Greenland and Canada, and for some POP such as toxaphenes and mirex, these levels are much lower.

Concentrations of dioxins (geometric means) in blood samples from adults of both sexes for all regions are within the range 0.3-9.4 pg/g TEQ of

Table I. Blood concentration in plasma of PCB compounds ($\mu\text{g/l}$) in native population of Russian arctic, geometric means.

Population	Kola Peninsula	Pechora basin	Taimyr	Chukotka Coast	Inland
Pregnants	1.14	1.59	1.64	1.86	
Newborns	0.44	0.72	0.54	0.69	
Females	2.25	1.78	1.37	4.56	0.87
Males	2.69	1.80	2.08	10.47	1.44

Table II. Blood concentration in plasma of HCH compounds ($\mu\text{g/l}$) in native population of Russian arctic, geometric means.

Population	Kola Peninsula	Pechora basin	Taimyr	Chukotka Coast	Inland
Pregnants	0.57	0.53	0.74	1.13	
Newborns	0.25	0.20	0.23	0.40	
Females	1.30	0.63	1.14	1.74	0.61
Males	0.72	0.54	1.13	2.67	0.76

Table III. Blood concentration in plasma of DDT compounds ($\mu\text{g/l}$) in native population of Russian arctic, geometric means.

Population	Kola Peninsula	Pechora basin	Taimyr	Chukotka Coast	Inland
Pregnants	2.37	1.91	1.76	2.03	
Newborns	1.14	0.72	0.52	0.71	
Females	5.30	2.81	1.55	2.31	1.31
Males	2.90	2.24	2.20	3.74	1.93

Table IV. Blood concentration in whole blood of Pb compounds ($\mu\text{g/l}$) in native population of Russian arctic, geometric means.

Population	Kola Peninsula	Pechora basin	Taimyr	Chukotka Coast	Inland
Pregnants	28.15	31.14	48.88	39.97	
Newborns	21.06	25.78	36.83	38.23	
Females	30.11	45.27	34.71	84.55	46.46
Males	60.48	53.00	80.19	129.46	96.72

Table V. Blood concentration in whole blood of Hg compounds ($\mu\text{g/l}$) in native population of Russian arctic, geometric means.

Population	Kola Peninsula	Pechora basin	Taimyr	Chukotka Coast	Inland
Pregnants	0.89	0.85	1.86	1.50	
Newborns	0.85	0.87	1.54	1.27	
Females	4.58	1.67	2.24	7.66	5.74
Males	6.57	2.38	2.93	10.33	6.54

lipids. The highest concentrations in separate samples are 18.7-18.1 pg/g TEQ of lipids (Chukchi and Taimyr AOs, respectively). The highest concentrations of PCDD/PCDF in human blood from the northern areas of Russia (18.7 pg/g TEQ of lipid) are close to minimal concentrations in residents of industrial regions.

With respect to levels of such compounds as PCBs, oxychlordane, DDT and DDE, trans-nonachlor, the Chukotsky District is similar to Nunavik in Canada.

Since maximum contamination of human blood samples of adult population with all determined PTS, including PCDD/F and PBDE, was detected in the Chukotsky District situated in the coastal area of the Chukchi peninsula, the cause of it should be found in dietary habits of the native population of the district.

From the comparison of concentrations PBDE and PCDD/F in blood samples of adult population it was shown that there is a vital difference in spreading of this PTS in the Russian North. It is especially important for Taimyr AO, Nenets AO (Nelmin Nos) and Kola Peninsula (Krasnoshcheliye). There are not enough data to find out the reason for the difference in spreading of dioxin and PBDE, but it is obvious that nowadays sources of pollution and pathways of each of these toxicants differ from each other.

Maximum PBDE concentrations in blood samples of population from the Russian Arctic regions were determined in the Kola peninsula (Krasnoshcheliye) (934 pg/g of lipids).

REFERENCE

AMAP (2002c). Human Health in Arctic. Arctic Monitoring and Assessment Programme (AMAP). Oslo, 2003, 137 p.

Dudarev AA
North-West Public Health Research Center
193036 St-Petersburg
Russia
4, 2-Sovetskaya st.

Email: dudarev@sp.ru