Chapter 10

Discussion on human health effects

10.1. Main findings of health importance

The representative survey groups from indigenous populations in each of the study areas, including 255 mother-child pairs and 1576 adults, have provided comprehensive data on gender, age, place of residence, the nature of traditional activities undertaken, diet, life-style details, self-evaluated health status and family health history. In addition, this database is supported by reliable medical information, obtained from personal medical records held by local hospitals and measurements of blood levels of all major PTSs. All of which information, helps to suggest that the study populations used in this report adequately reflect the general conditions characteristic of the indigenous population of the Russia Arctic as a whole.

Blood PTS concentrations show that all indigenous communities residing in the areas of the Russian Arctic studied, have suffered moderate exposure to the major groups of global environmental pollutants known to be transmitted through food chains, such as PCBs, DDT, HCH, HCB, lead and mercury. Only lead concentrations in blood, however, were found to exceed the threshold level currently recommended by WHO (100 µg/L) and then only in some cases. The main sources of lead exposure in the arctic are assumed to be the contamination of local food through both long-range transport of lead and the uncontrolled use of materials containing lead, such as paints and homemade ammunition (from pellet and bullet casting).

Actual serum concentrations of total PCBs (Arochlor 1260) were frequently found at levels of 5-8 µg/L. Regardless of the fact that national guideline levels for these toxic substances in blood have not been established, this may still be considered as a matter of concern for human health. Recent evidence suggests that PCBs may cause adverse reproductive, developmental, and endocrine effects (ATSDR, 2003, June Update). Despite the manufacture of PCBs being banned in most Arctic countries since 1977 (since the early 1990s in Russia), a number of current exposure sources do remain. It is well documented that the greatest human exposure to PCBs occurs through the consumption of contaminated fish. It is likely that PCB congeners are capable of being released into the general environment and thus, are able to contaminate local food by means of poorly maintained toxic waste sites, contaminated dwellings and through the unacceptably poor sanitation systems found in most native communities in the Russian Arctic.

As seen from concentrations of contaminants measured in maternal blood serum, indigenous pregnant women living in coastal areas of the Russian Arctic, show levels of exposure to a group of 'long-banned' pollutants, and in particular to HCB, DDT and PCBs, that are among the highest currently reported for all Arctic indigenous peoples (AMAP, 1997 and 2002).

It is likely that DDT and HCH blood contamination largely originate from common exposure sources which are not closely associated with the contamination of natural areas or wildlife. Based on the results of the targeted survey, extensive uncontrolled household use of materials which contain lead, and also use of insecticides and pesticides for rodent control, may significantly contribute to human PTS loads, through the secondary contamination of food which is stored and processed at home.

From the survey, it was found that in randomly selected wash-outs and wall scrapes taken from 28 houses occupied by indigenous families in the Nenets, Taymir and Chukchi Autonomous Okrugs, all major POPs were detected in 100% of cases. Levels were highest in Chukchi samples, where HCH was over 4 µg/m² and DDT was up to 4500 µg/m². Taymir wash-outs contained up to 38 µg/m² of total PCBs. DDE and DDD metabolites in the wash-outs and scrapes constituted 27% of total DDTs on average, (within a range of 10-70%), which suggests significant recent indoor contamination by chemicals containing DDT.

Between 65 % and 100% of home-made local foods, including both food which is prepared for cooking in the kitchen (i.e. trimmed and sliced) and ready-to-eat foodstuffs (salted, boiled or fermented) were contaminated by PCBs and DDT. Furthermore, 12 out of 13 domestic food samples from the Nenets AO communities, were contaminated by DDT at levels exceeding national food safety limits, while reindeer meat and fish samples taken from the natural environment at these locations were not found to be excessively contaminated by POPs. Data obtained during targeted surveys indicate that levels of indoor PCB contamination (of walls, kitchen facilities and appliances) correlate well to PCB levels measured in the blood of indigenous people living in houses surveyed. It is believed that intake of these substances by family members from the indoor environment takes place through the secondary contamination of food.

Based on concentrations measured in maternal blood serum, exposure of Russian Arctic indigenous peoples to PTS, and specifically to HCHs, HCB, DDT and PCBs, is one of the highest reported for all Arctic regions. The discovery of up to a 25-fold increase in *p,p'*-DDT serum concentrations in women from all of the study areas, may indicate a fresh source of exposure, bearing in mind that DDE concentrations of the women are at level comparable to other arctic populations (Hansen *et al.*, 2000; J. Oostdam *et al*, 1999).

The POP exposure intensity (body burden) of arctic indigenous women as measured in maternal and umbilical serum, in some cases exceeds that of residents of territories which are internationally recognized as disaster areas, for example the Aral Sea region. Here, due to long-term application of persist-

ent pesticides, very high levels of environmental pollution exist, particularly for DDT and HCH (Muntean *et al.*, 2003), which occur in local foods at levels higher than maximum residue limits established by European Commission (EC, 1997, 1999, 2003). Thus, the geometric means of cord and maternal μ-HCH concentrations in the Chukotka population were found at levels 10-20% higher than those measured in Aral Sea women. DDE cord concentrations in the Kola population occur within ranges similar to those found in the Aral Sea population, while maternal and cord HCB concentrations measured in the coastal population of Chukotka, are likely to be some of the highest ever reported for both the Arctic and Aral Sea regions.

As some pesticides such as Mirex and toxaphenes have never been manufactured or imported into Russia (or into the former Soviet Union), blood serum concentration levels in the indigenous population in the study areas, provide an opportunity to obtain an approximate evaluation of the relative contribution made by global transfer of these substances to the POP exposure experienced by indigenous populations residing in the study area (Figure 10.1).

Given the results for Mirex in Table 10.1, it is assumed that most of the study populations in arctic Russia are exposed to levels of long-range transported persistent toxicants which are from 4 to 100 times less than the population resident in the coastal area of the Chukotka Peninsula.

Population	Geometric means of Mirex concentrations in serum, μg/L	Ratio of concentrations to that of coastal Chukotka, %
Chukotka coastal	0.12	100.0
Chukotka inland (Anadyr)	0.008	6.7
Taymir inland (Khatanga)	0.02	16.7
Taymir inland (Dudinka)	0.02	16.7
Taymir urban (Norilsk)	n.d.	>1
Kola (inland)	0.007	5.8
Pechora River Basin	0.03	25.0
Aral Sea urban	n.d	>1

Table 10.1. Serum concentrations of Mirex in study populations.
n.d. – not detected

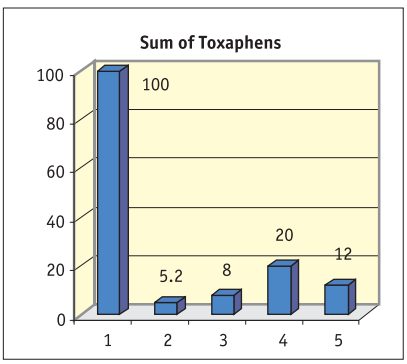


Figure 10.1
Proportion of serum samples containing Toxaphenes and Mirex in the study populations, %

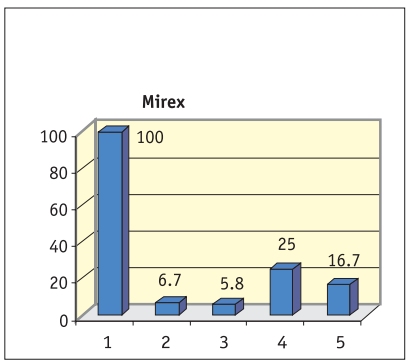
Low-income indigenous families are at greater risk of exposure to POPs due to their significantly higher consumption of local foods, particularly fish and marine mammals of high fat content, which in many cases act as a major source of human exposure to environmental toxicants. Women with low incomes residing in the Chukchi AO, are also more likely than women with high incomes to be either underweight or obese. The prevalence of adverse outcomes of pregnancy increases steadily with a reduction in family monetary income per capita.

As a rule, blood concentrations of organic contaminants are positively correlated with each other, while this is not the case for inorganic contamnants. In pregnant women, a closer relationship is found between total PCBs and HCB (neither of which are pesticides), which presumes a common exposure source. Those organochlorines which are classified as pesticides, are also positively correlated with each other.

Significantly higher blood concentrations of PTS are found in males of indigenous populations compared to females. At a community level, the lowest serum concentrations of POPs are found in pregnant women, probably due to early hospitalization in delivery departments (and thus a change to a very different nutrition pattern). Long-term hospitalization preceding the expected birth is a common practice in prenatal health care in remote Russian Arctic areas.

At variance with commonly accepted views, cord blood concentrations of Pb and total Hg were frequently found to be higher than those measured in maternal blood and are poorly correlated. It is possible therefore, that babies could be at greater risk from inorganic pollutants accumulated by their mothers. In contrast, concentrations of total PCBs and most pesticides measured in maternal serum (expressed as unit of mass per unit of volume) are significantly higher when compared to their concentrations in cord blood and are closely correlated.

POP concentrations measured in blood serum are highly dependent on age. This phenomenon may reflect the impact of past exposure to POPs which, it is assumed, was much greater everywhere in the Arctic (AMAP, 1997).



1. Chukotka coastal
2. Chukotka inland
3. Kola
4. Pechora
5. Taimyr

The number of breast fed children has been also found to be a significant determinant of POP serum concentrations in women. Serum concentrations of lipophilic contaminants is reduced by an increase in parity.

In formal terms, only blood mean PCB and lead concentrations in the adult indigenous population exceed the internationally recognized levels of concern, designed to evoke preventive action. However, statistically significant associations have been found between blood concentrations of total PCBs (Arochlor 1260) and lead and a number of non-specific reproductive and developmental health effects such as prevalence of low birth weight, premature births, stillbirths and major structural malformations (Tables 10.2 and 10.3).

Also, statistical analysis of recorded health problems in connection with blood concentrations of some other pollutants (Hg, Cd and HCHs) indicates possible associations between pollutant levels and the prevalence of certain reproductive and developmental stages as well as with the prevalence of chronic diseases in older people.

Serum concentrations of total PCBs in maternal blood appear to be associated with alterations to the sex ratio. For concentrations of between 2 to 4 µg/L, the frequency of male offspring is found to be higher than the national average. In contrast, for maternal total PCB blood concentrations higher than 4.0 µg/L, there appears to be a strong effect on the prevalence in female offspring. Such a phenomenon has been widely discussed elsewhere in terms of paternal exposure to dioxin and dioxin-like substances (Davis *et al.* 1998; Ryan *et al*, 2002). Given that close correlations among adult members of a family are seen in blood levels of PCBs (see chapter 6) the exposure of fathers (as well as mothers) cannot be ruled out as a possible important risk factor in affecting sex ratios.

Metal	Level of exposure, µg/L	Susceptible populations	Observed effect (RR – relative risk of an effect)	Confounding	Statistical strength
Lead	> 30.0	Pregnant women	Premature birth RR= 2.77 Altered gender ratio RR=2.2	PCB, Cd	Moderate
		Women over 40 of age	Prevalence of chronic diseases RR=3.0	Alcohol	Moderate
Cadmium	> 1.0	Pregnant women	Premature birth RR=2.06	Pb, PCB	Weak
			Low birth weight RR=2.5	PCB, alcohol	Weak
Mercury	> 2.0	Pregnant women of Chukotka	Spontaneous abortions RR=3.1		Moderate

Table 10.2. Summary of possible health effects in indigenous populations associated with exposure of indigenous people to selected metals.

In contrast to information previously obtained from national and global statistics, female babies of indigenous mothers with elevated POP blood concentrations, are exposed to a higher risk of low birth weight and other adverse outcomes of pregnancy when compared to male babies. A similar association was reported for a number of cases where parents had been exposed to organochlorine chemicals.

PCB	Level of exposure, µg/L	Observed effect	Confounding	Statistical strength
Total PCB Arochlor 1260	> 2.0 > 5.0	Altered gender ratio of newborns, RR=3.3	Pb	Moderate
		Premature birth, RR=2.22 In female newborns: RR=2.6	HCH, Low family income, Alkohol	Weak
		Premature birth, RR=2.8	Alkohol, Low family income	Weak/moderate
		Stillbirth and birth defects among female newborns, RR=3.5		Weak
		Increase in prevalence of lifetime adverse outcomes of pregnancies, RR=2.4	Hg, Pb	Weak

Table 10.3. Summary of possible health effects associated with exposure of pregnant indigenous women to PCB.

Any criteria proposed for the limitation of POPs in human blood and tissues necessarily involve a large number of uncertainties, due to the lack of precise toxicological information on the effects of hazardous substances, especially when addressing the most sensitive sub-groups of people (e.g, infants, the elderly and the majority of indigenous people who lack good nutritional) .

10.2. Region-specific priorities for environmental health

A summary of regional environmental health priorities related to the project objectives is given in Table 10.4.

10.3. Evidence of causation

Because causation is a fundamental issue in the epidemiology of reproductive health and developmental disorders, the lines of evidence described in Table 10.2 need further discussion. To show that a causal relationship does exist, a number of tests or criteria have been developed (Hill, 1965; Wynne and Braunwald, 1998; Cotran *et al.*, 1999). These include consistency of results between studies involving different groups; the way in which the results of different studies fit each other (coherence); whether there is a relationship between given definite levels of exposure and the effect or population response ('dose-response relationships') etc. Since very limited information on PTS-induced human reproductive and developmental effects is available, it is not feasible to test the full set of suggested epidemiological criteria of causation.

Study population	Priority contaminants in the environment	Most contaminated local foods [1]	Priority contaminants in human body [2]	Associated Health effects
Coastal areas of the Chukchi AO	Food contamination by PCBs, Hg, toxaphenes	Sea mammal meat fermented in soil (Kopalchen), home-processed and salty dried sea fish, home-made brew (span)	PCBs, Pb, HCB, Hg	Reproductive and developmental, problems; chronic liver diseases
Inland areas of the Chukchi AO	High prevalence of use of household DDT/HCH chemicals	Salmon, home-processed fish		
Taymir AO	Highest use of lead ammunition	Birds, fish	Pb DDT (Norilsk)	
Nenets AO	Highest prevalence of lead paint use			
Kola peninsula	High use of household DDT/HCH chemicals; PCB food contamination	Salmon		Highest maternal/cord contaminant ratio of DDT

Table 10.4. Priority problems for different study regions in the Russian Arctic. [1] – at least one of PTS occurring in concentrations above the national limits; [2] – contaminants either occasionally exceeding international guidelines (level of concern) or are shown to associate with a certain effect

In the meantime, the identification of 38 cases in which the outcome of pregnancy was fatal, 62 cases of reduced birth weight (16 of which were extremely low), 27 cases of premature birth, 8 cases of serious birth defects and 31 spontaneous abortions, supported by life-style, occupational and other information on risk factors, as well as the measurement of a wide range of PTS in the environment, food, indoor materials and blood specimens collected as part of the cross-sectional study presented in this report, provides an opportunity to consider the causal role of exposure of individuals to specific environmental contaminants.

Current evidence supporting the classical causation indicators of plausability, consistency, coherence and analogy is judged to be acceptable for PCBs (Table 10.4), as well as for lead and total mercury exposures, as measured in human blood. It is not possible to properly assess the temporality and/or reversibility of previously reported findings, because the health effects suggested as being associated with PCB exposure, constituted limited population-based reports and were not the outcome of a systematic epidemiological study. However, it should be noted that the inherent weakness of cross-sectional study design and the limited number of pregnant women available for survey purposes (i.e. low power) diminishes the impact of the elevated relative risks and statistically significant p-values of the Chi-Square Test and of Fisher's Test presented in Table 10.2.

After adjustment for major confounders (i.e, smoking and alcohol consumption) the increased risk of adverse outcomes of pregnancies was clearly observable for concentrations of total PCBs in maternal serum over 2.0 µg/L, which is significantly lower than the level recommended as a level of concern (5-20 µg/L) and much lower than the level of effects (100 µg/L). The same is broadly true in terms of maternal lead concentrations, for which typical developmental disorders in newborns were manifest at levels of 30 µg/L, when internationally recommended guidelines are currently set at 100 µg/L. There are, however, two possible factors to be considered which are capable of affecting developmental disorders associated with PTS exposure. A first and frequently mentioned circumstance, is that the indigenous people of the Russian North are generally considered to be one of the most susceptible subpopulations due to factors such as malnutrition and an altered traditional diet that has become physiologically inadequate (Panin, 1989). A second uncertainty is that an adverse pregnancy outcome may not be solely the result of maternal exposure. Paternal exposure may also transfer risks to the off-spring. The study design used, however, did not allow the quantification of such risks.

The new evidences obtained suggest that the association between environmental exposure to PCBs, lead and mercury (as measured by blood levels which are considered to be relatively common for indigenous populations of the Russian Arctic) and health effects such as the prevalence of low birth weight, reduced gestational age, fatal outcomes of pregnancy and the prevalence of chronic diseases in women, supports a hypothesis of causation.

Statistical associations for the observed effects may be further improved by analysis of the remaining blood samples taken during the surveys, which are currently deep frozen (within the framework of the project, only 255 of the 348 maternal blood samples collected were randomly selected and analyzed). In a preliminary check of the 93 remaining sample donors, it was found that they include mothers recorded as having 14 cases of adverse pregnancy outcomes.

10.4. Application of the precautionary principle

Even though the lines of evidence for the causal role of PTS with respect to health effects are generally not complete and there are a number of uncertainties to accommodate before establishing reliable causation, it is important to note that the anticipated health effects associated with PTS exposure as experienced by vulnerable groups of indigenous populations are likely to be serious, and include birth defects and fatal outcomes of pregnancy. For this reason, it is suggested that two approaches are taken in addressing these uncertainties when considering recommendations and planning public health action.

Causation Indicator	Description	References
Temporality	No evidence	
Plausibility	Similar effect of PCBs has been demonstrated in a large number of animal experiments. Holzman strain of rats treated with commercial PCB mixtures showed that developmental toxicity can occur in the absence of overt signs of maternal toxicity as evidenced by reduced fetal weight and viability.	Spencer, 1982
	Reduced birth weight and postnatal growth reported in Wistar rats administered with PCB;	Hany *et al.*, 1999
	Impaired ability to conceive and decreased fetal survival are well-documented in female monkeys following repeated oral exposures to Arochlor.	Arnolds *et al.*, 1997, 1998
Consistency	Identical symptoms were observed in women consuming contaminated fish. Lower birth weight, smaller head circumference, and shorter gestational age were positively correlated with consumption of fish and levels of total PCBs in cord serum; however, when the two populations were divided according to the cord serum levels, the great majority in the low-level group were fish-eaters, suggesting that fish consumption rates were poor indicators of PCB exposure. Fish consumption during pregnancy only did not predict either birth size or gestational age.	Michigan study Fein *et al.*, 1984b
	PCB 153 in maternal blood used as a biomarker of exposure to PCBs, found an increase in the risk of a low birth weight at maternal blood PCB 153 concentrations of 300 and 400 ng/g (ppb, lipid basis).	Swedish cohort study. Rylander *et al.*, 1998
	Dutch general population cohort, prenatal exposure to PCBs (PCBs in cord blood) was associated with a reduced birth weight, but not with head circumference or height at 10 days of age.	Patandin *et al.*, 1998
	Parental exposure to dioxin and dioxin- like chemicals are manifested by increase of female offspring.	Devis et al., 1998; Mocarelli *et al.*, 2000; Ryan *et al.*, 2002
	Danish case-control study showed a strong association between low fertility and an excess of females compared to males among offspring.	Møller, 1998.
	The Yusho accident female victims who consumed PCB-contaminated oil had 2 stillbirths out of 11.	Masuda, 1994
Statistical Strength	An association between the prevalence of low birth weight, shorter gestational age of newborn, all fatal outcomes of pregnancies (adjusted for alcohol consumption) and total PCB concentrations in maternal serum over 2.0 µg/L (Arochlor 1260 over 5.0 µg/L) is from weak to moderate.	This report.
Specificity	Being of high sensitivity, the reproductive and developmental effects associated with PCB exposure are not considered to be specific ones.	This report
Dose-response	Dose-response relationship has been demonstrated through elevating serum concentrations of total PCB or Arochlor 1260 steadily, followed by increasing prevalence of reproductive and developmental effects including altered sex-ratio.	This report
Coherence	The known endocrine disrupting effects of PCBs, both the oestrogen-like and oestrogen receptor binding activity, might result in fetal damage and impact on its growth.	Arnold *et al.*,1998 Kester *et al*, 2000
	Prenatal exposure of mothers to a background level of PCB was shown to affect thyroid hormone metabolism related to developmental disorders	Koopman-Esseboom *et al.*, 1994
Reversibility	No evidence	
Analogy	Health effects in wildlife includes the following: mortality in piscivorous birds; reproductive impairment in monkeys, minks, ring doves, and American kestrels; immunotoxicity in monkeys and birds; endocrine and neurobehavioral effects in birds;	EPA, 1978
	Mink that were fed by fish contaminated with PCBs showed reproductive toxicity.	Hornshaw *et al.*, 1983
	A variety of other health effects have since been evaluated in wildlife, some of which may be relevant to human health.	AMAP, 2002
Study design	Cross-sectional study; Inherent weakness to establish causation	Hill, 1965; Beaglehole *et al.*, 1993

Table 10.5. Rules of causation applied to the prevalence of low birth weight and reduced gestational age of newborns in arctic indigenous women; experience of higher environmental exposure to PCBs is definite, with maternal serum concentrations exceeding 2.0 µg/L (or 300ng/g lipids).

From the project perspective, it is believed that a precautionary principle (PP) which addresses the avoidance of potential harm, should be applied in two basic situations encountered in the environment or workplace.

A. When there is a lack of regulation and lack of human data, but sufficient animal data.

B. When concern arises about an existing regulation in the light of new evidence of an adverse effect becoming available.

A number of basic factors or criteria associated with the application of the PP have gained both national and international requirements:

1. The size of the population affected;
2. The higher susceptibility of certain subgroups (e.g. children, pregnant women, individuals with poor health or malnutrition);
3. The seriousness of the anticipated effects (e.g. irreparable or irreversible impairments which significantly compromise human health);
4. The transparency and disclosure of potential risks ('right to know' of the public);
5. The consideration of inputs other than scientific evidence (e.g. a high level of public anxiety);
6. The implementation of temporary precautionary exposure levels;
7. The implementation of interim measures to reduce exposure to levels as low as possible/reasonable;
8. The need to apply PP on a case-by-case basis; a single conceptional framework not necessarily being suited to all situations;
9. When failure to apply precautions may engender liability in the future.

The establishment of exposure limits in Russia, constitutes, in many cases, an application of the precautionary principle. However, in the absence of such limits and guidelines for blood concentrations of PTS and also of limits for foodstuffs, it is clear that the potential seriousness of the anticipated effects and their general consistency with current knowledge regarding the specific toxicity of the PTS in question, argues for the application of the precautionary principle (at least on a 'case-by-case' basis) as some babies may be at excessive risk from pollutants taken up by their mothers.

Overall conclusions and recommendations

The main conclusion of the first AMAP assessment (AMAP, 1997) clearly stated that the well-known benefits of breast milk and traditional food definitely outweighed the risks to human health risks from contaminants. The social, cultural, spiritual and physical health of Arctic indigenous peoples, depends on the collection and consumption of country foods. The consumption of local fish, meat, wild greens and berries is important in providing the necessary dietary intake of most nutrients, vitamins, essential elements and minerals. Based on these conclusions, the AMAP assessment recommended that:

- Consumption of traditional food continues, with recognition that there is a need for dietary advice to Arctic peoples so they can make informed choices concerning the foods they eat;
- Breast milk should continue to be promoted.

These basic conclusions and recommendations have received full acknowledgement and support within the framework of this project. At the same time, a number of important findings made during the period of project implementation have promoted the development of conclusions and recommendations specific for Arctic Russia, and for the objectives of the project.

1. A close partnership has been successfully achieved between researchers and indigenous organizations and communities in accordance with internationally recognized practices, as well as effective co-operation in developing remedial actions to reduce health risks resulting from the contamination of the environment and traditional food sources. The project has been implemented with the active participation of the Russian Association of the Indigenous Peoples of the North, Siberia and Far East (RAIPON) and its regional branches. RAIPON representatives acted as equal partners with the scientific teams in all project activities and phases, including the development of project recommendations. Achieving the project objectives would not have been possible without close collaboration with the Russian executive authorities, and particularly the administrations of the regions where the project was undertaken.

2. Project implementation has enhanced the position of the Russian Federation in international negotiations to reduce the use of PTS, and empowered RAIPON to participate actively and fully in these negotiations. The signing of the Stockholm Convention on Persistent Organic Pollutants by the Russian Federation, the active role played by RAIPON, in line with other International Organizations of the Arctic Indigenous Peoples, and the full-scale participation of Russian federal executive agencies and RAIPON in the development and implementation of the Arctic Council Action Plan to eliminate pollution in the Arctic are good, but not the only, indicators of attaining relevant project objectives.

3. The existing system in Russia for statistical reporting of environmental releases do not cover most persistent toxic substances, and in particular, those covered by the Stockholm Convention on Persistent Organic Pollutants.
   In this respect, it is recommended that new forms of state statistical reports on industrial atmospheric emissions, waste water discharges and solid wastes, be developed and approved, which should be adequate for the requirements of the Stockholm Convention on Persistent Organic Pollutants and other international treaties and agreements aimed at the limitation of environmental and human health effects of persistent toxic substances. In this, it is recommended that experience gained in the development and use of registers for emissions of contaminants and transport be used.

4. From experience gained during project implementation, existing data and information on PTS pollution sources available to federal and local environmental and human health authorities does not adequately reflect the actual situation in the Russian Arctic regions. Studies and surveys within the project framework have documented the environmental impact of unknown local PTS sources. In particular, there is evidence of relatively fresh environmental releases of contaminants such as DDT and PCB.
   Taking into account the objectives aimed at implementation of the Environmental Doctrine of the Russian Federation and the Fundamentals of the State Policy in Chemical Safety, it is recommended that a source inventory system be developed and implemented in the Arctic administrative territories inhabited by the indigenous peoples, that covers both former and current releases of PTS from all economic activities.

5. PCBs can be considered as one of the most serious environmental and human health risk factors for the areas covered by the project , which cannot be adequately explained by long-range transport and existing information on local sources. According to the Russian PCB inventory, 53,000 out of 180,000 tonnes of PCB produced in the former USSR, were used for the production of paints, varnish, lubricants and other products, i.e, they have been used in open systems. Although this type of PCB use could not be taken into account by the inventory, it is likely that some of the PCB- related problems mentioned above also resulted from contamination from such sources.
   Within the framework of the Russian National Action Plan on implementation of the Stockholm Convention, it is recommended that a special section on the rehabilitation of PCB-contaminated sites, including land and housing be developed and implemented. With respect to this issue, spe-

cial attention should be paid to land and settlements inhabited by Arctic indigenous peoples, taking into account their lifestyle and social vulnerability.

6. A significant proportion of total global PTS in the Arctic environment, is determined by their long-range transport. For example, the pesticide, Mirex has not been produced and used in either the USSR orRussia. However, levels of Mirex in the blood of the indigenous population residing in the Russian Arctic, particularly in coastal Chukotka, are found at clearly detectable levels, albeit lower than in some other parts of the Arctic, such as Arctic Canada. At the same time, the validity of long-range atmospheric transport and deposition estimates is limited by the scarcity of data on remote sources, and a lack of comprehensive source inventories.
   It is recommended that the Government of the Russian Federation, in cooperation with the other member countries of the Arctic Council, take active measures in the international arena to ensure the reduction, and in the future, the full elimination of environmental and human health threats from global PTS. In particular, it is recommended that the Russian Federation ratifies the Stockholm Convention on Persistent Organic Pollutants, and joins the Aarhus Persistent Organic Pollutants and Heavy Metals Protocols of the UN-ECE Convention on Long-range Transboundary Air Pollution.

7. Environmental aspects of human health, particularly those associated with PTS exposure of indigenous peoples, are closely linked to the economic and social status of indigenous families. In this respect, a significant reduction in the effects of PTS on human health cannot be successfully achieved without improvement in the economic and social conditions of the Russian Arctic indigenous peoples.
   It is recommended that, the National Plan of Economic and Social Development of the Northern Territories of the Russian Federation, which, it is envisaged, is to be developed or reconsidered following the Meetings of the State Council Board of the Russian Federation and of the President of the Russian Federation with the representatives of the northern territories of the Russian Federation in Salekhard, 28-29 April, 2004; should fully address improvements to the social and economic conditions of the Russian Arctic indigenous peoples. This action should be undertaken with the full involvement of the indigenous peoples.

8. In general, PTS levels in the natural environment and biota of the Russian Arctic are at moderate levels compared to other Arctic regions. This presents a means to significantly reduce PTS intake by indigenous peoples without intervening in their basic traditional lifestyle and cultural identity, through the implementation of protection and remedial actions, including improvement of sanitary conditions in the indigenous settlements and by implementation of household and dietary recommendations developed as a result of the findings of this report.
   As a follow-up to this project, it is recommended that the Russian federal executive human health and environmental authorities, in close collaboration with the Russian Association of Indigenous Peoples of the North, Siberia and Far East and regional and local administrations, develop a set of practical activities aimed at achieving, in full acknowledgement and respect of the traditional lifestyle and cultural identity of the Russian Arctic indigenous peoples, a significant reduction in their PTS intake. These measures, which should be an integral part of the National Plan of Social and Economic Development of the Russian Northern Territories, should include actions required at the federal, regional and local levels, taking into account the circumstances of each area. More specific regionally-based recommendations, addressed to the indigenous peoples should be presented in special publications in Russian.

9. The levels of human exposure to PTS in the Russian Arctic, specifically to HCB and HCH, and, in some cases, also to DDT and PCB, is one of the highest reported for all of the Arctic regions. In some cases, exposure has been shown to exceed levels assessed for residents of territories, which are internationally recognised as disaster areas, such as the Aral Sea region, due to long-term use of persistent pesticides. In the areas of the Russian Arctic studied, practically every indigenous family consumes a significant amount of traditional food. Families with low incomes rely to a greater extent on the local, fat-rich traditional diet. As a consequence, low-income indigenous families are at greater risk of exposure to POPs.
   It is recommended that the human health authorities and administrations of the territories of the Russian Arctic inhabited by indigenous peoples, in close collaboration with the regional branches of RAIPON and in full acknowledgement of the importance of the traditional diet for nutrition and preservation of the national and cultural identity of the indigenous peoples, as part of their lifestyle, develop appropriate targeted measures to reduce PTS intake with traditional food, based on specific recommendations, the improvement of social and economic conditions and the raising of awareness about existing problems.

10. The highest PTS exposures and associated health risks are documented for the coastal areas of Chukotka, where the traditional diet of the indigenous population is largely based on marine mammals and fish. This corresponds to previous information obtained concerning the Greenlandic and coastal Canadian indigenous populations.
    It is recommended that, in the development of practical follow-up measures, special attention should be paid to the situation in the Chukchi AO, taking into account both, the social and economic status of the indigenous peoples in this region of Russia, and the health risks associated with PTS intake. On the basis of data obtained within the framework of the project, the coastal areas of the Chukchi AO are of main concern with respect to human health risks.

11. Indoor and occupational sources of PTS, including contamination of dwellings, are likely to be a significant contributor to blood contamination among indigenous peoples of the Russian Arctic. It was found that all of the houses of indigenous people studied during the targeted surveys, were contaminated by POPs, mostly by PCB and DDT. Levels of indoor PCB contamination correlate to levels of PCB measured in the blood of indigenous families living in these houses.
It is recommended that remedial action to remove PTS contamination from the houses of indigenous families, should be an important and urgent action, aimed at e improving the social and economic status of indigenous communities.

12. It was found that the labelling of chemicals produced and retailed for household protection against insects and rodents, often does not correspond to their actual chemical composition, and that these chemicals sometimes contain toxic substances in high concentrations, particularly DDT and PCB.
It is recommended that proposals for amendments to the Federal Law "On safe handling of pesticides and agrochemicals" be developed, to ensure implementation of strict and efficient control measures over the production and trade of pesticides and other chemicals for private use, particularly those used for protection against insects and rodents, which would ensure a complete ban on the use of PTS in these chemicals.

13. In a number of cases, home-made local food contains higher levels of PTS contamination than raw products obtained from the natural environment. It has been shown that additional contamination of food by PTS can take place when food is stored, processed, and/or cooked in a contaminated household environment.
It is recommended that the local human health authorities, in close collaboration with regional branches of RAIPON, work out an efficient action plan to improve sanitary conditions in indigenous houses. These measures should be integrated with communication with indigenous families and efforts to raise awareness about the health risks associated with contamination of home-processed food.

14. POP concentrations measured in blood serum are highly dependent on age. This phenomenon may reflect past exposure to POPs. The number of breast fed children has also been found to be a significant determinant of POPs serum concentrations in women. Serum concentrations of lipophilic contaminants are reduced by an increase in parity. Statistically significant associations have been found between blood concentrations of total PCBs (Arochlor 1260), lead and a number of non-specific reproductive and developmental health effects such as the prevalence of low birth weight, premature births, stillbirths and major structural malformations. Serum concentrations of total PCBs in maternal blood also appear to be associated with impacts on newborn sex ratios. In contrast with both national and global statistics, female babies of indigenous mothers with elevated POP blood concentrations, have a higher risk of low birth weight and other adverse outcomes of pregnancy when compared to male babies.
It is recommended that the Russian human health authorities implement internationally recognized levels of concern for PTS blood concentrations. It is further recommended that dietary safety advice based on the benefits of traditional food are made an important component of prenatal care and of family planning strategies for the indigenous communities at risk.

15. A close correlation between PTS levels in blood and breast milk has been documented for indigenous women of the Chukchi AO.
It is recommended that the international and Russian national health and environmental protection authorities develop recommendations for the assessment of human PTS intake, based on levels of these contaminants in blood and breast milk, taking into account the advantages and drawbacks of using these indicators for different groups within the population.

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