Chapter 19
Environmental Health in the Changing Arctic

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Abstract Human health and well-being are the result of complex interactions among genetic, social, cultural and environmental factors. Especially in the Arctic regions, where the climate and living conditions are demanding, the environment and nature are important elements for good and safe every-day life. Changes in the environment and climate have huge impacts on life in the Arctic areas. The Arctic has been contaminated by chemicals resulting from human activities and natural processes, mostly from distant sources via the atmosphere, rivers and ocean currents. Arctic environment is now in great change with the melting of permafrost and ice, which may release some of the accumulated contaminants into water and air. The results of the multidisciplinary ArcRisk research project show that the contaminants may re-circulate in the food-webs and concentrate in food items. The processes and pathways between environmental compartments are very complex, and influenced by many factors, like weather conditions, temperature and ice cover. The future Arctic will be more urbanized, with a more elderly population and closer connections to the other parts of the globe. All of this will be a big challenge for the health and well-being of the different populations, indigenous and non-indigenous, living in rural and urban areas. It is important to focus on living conditions, including clean air, water and food, which all will support good life in the Arctic. The results of the ArcRisk project provide important information for the decision-makers on how to meet the future needs of the changing Arctic.

Keywords Environmental health • Contaminants • Climate change • Monitoring programs • Quality of life

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19.1 Introduction

The living conditions and health of indigenous peoples have been a specific research focus during the last years. Indigenous peoples comprise 10 % of the whole population living in the Arctic, ranging from 0 % in Iceland up to 90 % in Greenland. The disparities in health still exist when compared to other countries, especially among the indigenous populations in Canada and Russia. During the last decades, there has been migration to towns and cities. For instance, at the moment half of the Arctic Russian population is concentrated in nine big cities. This phenomenon is seen in all of the Arctic countries. The migration of the new Northerners, the people working either temporary or more permanently in the Arctic, has already started; and the warming climate may attract more people to move to the North. The overall trends of human development are presented in the Arctic Human Development Report –II (Larsen and Fondahl 2014).

At the moment, the economic interest is increasingly focused on the warming Arctic due to its huge resources and possibilities for the shipping and mining industries. However, the warming climate poses some threats to human health, such as worsening food and water security, new infectious diseases and the increased risk of contaminants. Changing climate conditions, together with permafrost melting, also disrupt the transportation routes and destroy other infrastructure in communities. The changes in the livelihoods and ways of living cause stress and mental problems to the local populations. There have been conflicts between the mining and tourism industries and the traditional livelihoods, like reindeer herding, fishing and hunting. One alarming sign is the increase of suicides and depressions in young reindeer. herders, who do not perceive a future for their work. The preservation of cultural heritage plays a central role in the health and well-being of the indigenous communities.

Several international organizations and monitoring programs are promoting the health and well-being of different populations living in the Arctic countries. During the last 20 years there have been successful circumpolar monitoring programs and projects of human health established by the Arctic Council (http://www.arctic-council.org/index.php/en/). These projects are based on the development of international collaboration in data collection, management and dissemination. Excellent examples include the human health assessment reports of the Arctic Monitoring and Assessment Programme (AMAP), the International Circumpolar Surveillance of Infectious Diseases (ICS), the Circumpolar Health Observatory (CircHOB, http://circhob.circumpolarhealth.org/) and the Survey of Living Conditions in the Arctic (SLiCA). In all of these, the traditional way of life of the indigenous peoples is included as an important part of the surveys. The major focus of this chapter is on the effects of climate change on persistent contaminants in the environment and on human health.

19.2 Monitoring Contaminants in the Circumpolar North

The Arctic Monitoring and Assessment Programme (AMAP, http://www.amap.no/) is one of the six Working Groups of the Arctic Council. It is focused on monitoring and assessing the status of the Arctic region with respect to pollution and climate change issues since 1991. It has published several science-based and policy-relevant assessments and reports about the levels, trends, and processes of persistent organic pollutants and heavy metals, and on their impact on ecosystems and humans. The actions of AMAP, together with other international frameworks, like those of United Nations and EU, support the work to reduce the global threat imposed by pollution and climate change. The monitoring regions of AMAP are shown in Fig. 19.1.

AMAP also regularly publishes reports on human health and on the trends of environmental contaminants and heavy metals in the environment, traditional/local foods and humans (AMAP 2009; see http://www.amap.no).

Due to globalization and climate change, there are many new challenges for individuals and communities in the Arctic. The Arctic is already and will continue to be less isolated than in the past. However, in case of contaminant transfer, the Arctic has been tightly connected to the other parts of the globe. Without borders, the persistent organic pollutants (POPs), like pesticides, dioxins and mercury, are transferred by air and water streams to the North from where they have been produced and used. Humans are exposed to POPs and mercury through food, drinking water and, to a minor extent, via inhalation.

Figure 19.2 shows one of the most important and followed-up POPs, DDT. DDT (and its metabolite DDE) still exists all around the Arctic regions, where it is transported from other parts of the globe. DDT was synthesized in 1874, and it has been used against malaria and as an agricultural insecticide. DDT was found to be toxic to humans and animals, and was consequently banned in agricultural use. Although the ban was implemented 40 years ago, DDT is still used in limited quantities, e.g. in South Africa. DDE is the main metabolite, which is formed from DDT in human body and in the environment. It is excreted into human breast milk, which may expose fetuses to the substance during the pregnancy. The levels of DDE in pregnant women and women in child-bearing age are still rather high, and there are only some regions where the trend is lowering (Fig. 19.2).

Human health and climate change have been the topic of several joint research and educational projects, such as the multidisciplinary EU-funded ArcRisk project led by AMAP (*EU7PW;* Arctic Health Risks: Impacts on health in the Arctic and Europe owing to climate-induced changes in contaminant cycling, www.arcrisk.eu), which aims to determine how climate-mediated changes in the environmental fate of contaminants affect the exposure of human populations via the food-web, both now and in the future.

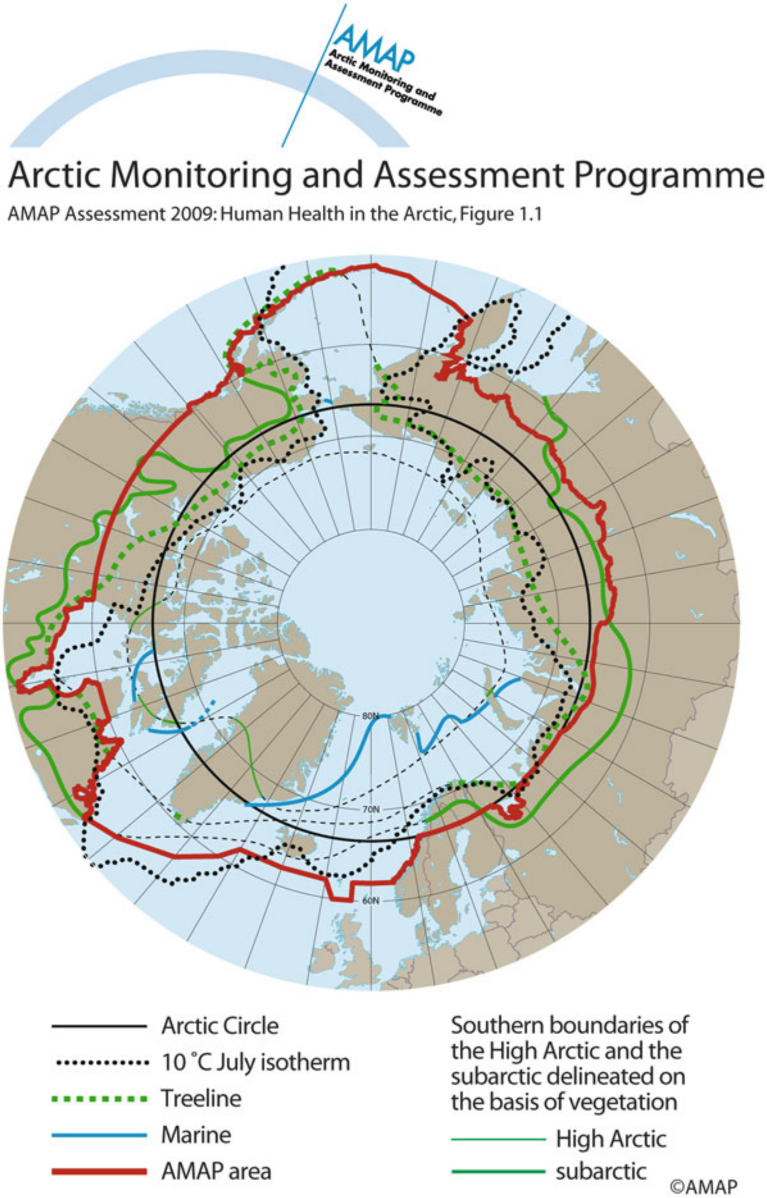

Fig. 19.1 Geographical boundaries of the Arctic by AMAP (Copyright: AMAP 2014)

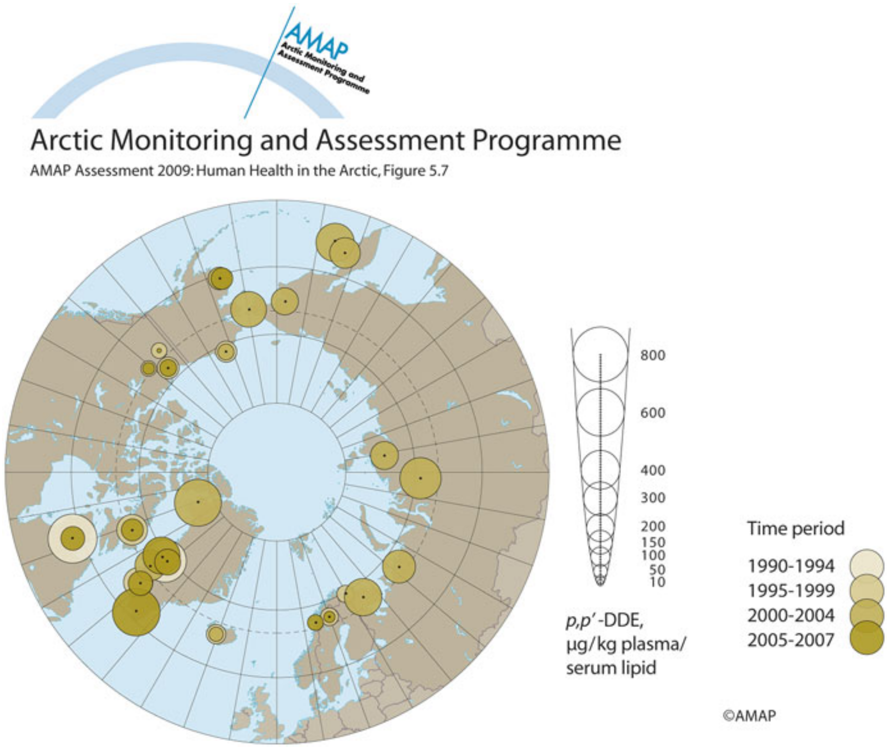

Fig. 19.2 DDE concentrations in blood of mothers, pregnant women and women of child-bearing age in the circumpolar countries (www.amap.no)

19.3 Effects of Climate Change on Contaminant Transfer and Human Health

The main focus of the ArcRisk project was to develop climate change adaptation and prevention strategies for the different regions in the Arctic, but also for the EU and global contexts. The research was divided into three parts: (1) the sources and origin of long-range transported contaminants, which reach the Arctic ecosystems; (2) the levels of contaminants in Arctic biota and ecosystems; and (3) levels of contaminants in humans exposed. The main results of the project were the development of new models to study the impacts of climate change on pollutant transport and fate in the Arctic, and their accumulation in the food chains. The estimation of the future levels of contaminants is very much dependent on the transfer between the atmosphere, marine and terrestrial ecosystems and the uptake into food chains. Primary emissions of many banned POPs (like dioxins, DDT) will decrease in the future, but the effects of the warming climate may increase the volatility of POPs. Models showed that climate change can affect future levels of concentrations of POPs, either increasing or decreasing depending on the chemical properties of the POP. There are also differences between geographical regions.

Mercury and one of the dioxins, PCB153, were selected as case studies in the ArcRisk project. During the project, all the possible information concerning these two contaminants was collected and future scenarios (until 2100) were made. Mercury emissions result from both man-made and natural sources (like volcanic eruptions). Very high mercury levels have been found in marine mammals and fish species (top of the food chain) in the Arctic Canada and Greenland. Especially indigenous populations, who consume those animals as a part of their diet, have been heavily exposed. At the moment, the levels of mercury in populations in the Arctic are slightly decreasing, but there are notable differences between the regions, populations and individuals. There is regional variation in the atmospheric deposition of mercury in the Arctic within the climate change scenario. According to the results of the ArcRisk project, the atmospheric deposition decreases over the Arctic Ocean, but increases over the continents due to changes in ice cover and ozone concentrations. The processes and pathways between environmental compartments are very complex and difficult to estimate, as they are influenced by many factors, such as weather conditions, temperature and ice cover.

One of the main tasks of the ArcRisk project was to study the effects of climate change on dietary exposure and human health in the Arctic, and to compare these results to those observed in the Mediterranean region. Seafood is the major source for mercury in human diets. However, fish is also a very important source of nutrients, and eating fish has been shown to promote good health. Thus, the risks and benefits must be taken into consideration when giving dietary recommendations, especially for the most vulnerable groups, pregnant women and children. The results of the ArcRisk project showed that the concentrations of mercury in human blood and hair were at the same level in the Mediterranean and the Arctic populations. There are several mother-child cohorts in the Arctic, especially in Faroe Islands, where children, who have been heavily exposed during the pregnancy, have been followed up. Several harmful effects on their health were discovered. Due to the dietary recommendation not to use the most contaminated food items during pregnancy, the levels of mercury exposure are now lower. However, in the Mediterranean countries higher fish consumption during pregnancy was associated with higher cognitive and language developmental performance.

Mercury levels in fish vary according to species. There are also differences between wild caught and farmed fish, with wild catches typically having higher levels of mercury. Due to harvesting and climate change, the number of fish species will decrease, and recommendations to increase fish consumption may not be possible in the future. The discussion about mercury levels in food items and human body will continue. Especially those indigenous populations who use traditional food, e.g. marine mammals, continue to be at risk. The benefits of fish consumption are clear, but the question as to what is the acceptable amount of contaminants and toxic metals in food items, remains difficult to answer. Follow-up studies and further research into the causes for the high inter-individual variations of contaminant levels in the Arctic populations and biological mechanisms behind methyl mercury are needed. There may also be other important sources of mercury exposure, like elemental mercury through inhalation and inorganic mercury in food, which should be taken into account.

What are the main health effects of POPs and toxic metals on human health? It is very difficult to find a straightforward answer. It depends on the chemical and the time of exposure (fetuses and children are the most sensitive), as well as on individuals and their behavioural habits (like smoking, diet and alcohol consumption). Mercury is undoubtedly toxic, but the question is, what is the lowest level at which it will start to have harmful effects on the human body? There are only a few contaminants concerning which we can give straightforward answers. The association between concentrations of lead in human body and the adverse effects found in central nervous system and malformations are among the most known examples. In the cases of other environmental contaminants, it is difficult to find evidence-based toxicological data about the correlation between health outcomes and exposure to one or more contaminants, since the individual study designs and methods used vary from one study to another. It is important to harmonize study protocols so that the results are comparative. In this way, it would be possible to draw more powerful conclusions and estimate the cut-off levels for one contaminant and even for mixtures of contaminants. It is also important to follow up on those population groups that have had the most exposure to contaminants. Climate may change the present trend, where pollutants in the Arctic are on the decline. Human exposure levels to POPs and mercury should be followed also in the future. The levels of the old environmental pollutants are mainly decreasing in the environment and in humans in the circumpolar regions, but there are differences among regions and among contaminants. In the Russian North, it has been found that there are new "hot spot" areas, where increased quantities of environmental contaminants and heavy metals, especially mercury, are being released from the frozen soil and contaminate drinking water.

Multidisciplinary research projects, like ArcRisk, will provide important information for future monitoring activities and offer insight into the effects of climate change. This information is relevant not only for the vulnerable population groups, but also for the decision-makers in the circumpolar North and across the globe (Table 19.1).

Table 19.1 Key findings of the ArcRisk project

Levels of legacy POPs in human tissues are declining in many regions of the circumpolar Arctic. New sources and patterns are being seen in Arctic Russia
Levels of mercury in human tissues are declining in several Arctic regions. Inuits continue to have the highest exposure levels of mercury in the Arctic and most often exceed blood guidelines
Traditional foods are an important source of nutrients for many Arctic residents. These foods are also the main source of exposure to contaminants
New evidence indicates that contaminants and toxic metals may affect human health; especially fetuses and children are at risk
Climate change may increase the mobilization of POPs and mercury, and lead to higher releases of contaminants within the Arctic

19.4 Food and Water

The changing climate causes permafrost melting, reduced ice cover, as well as floods and storms. All of these phenomena affect food and water security in the Arctic, an issue that was taken as one of the priority themes during the Swedish chairmanship of the Arctic Council (2011–2013). The joint circumpolar project was started to identify indicators relevant to monitoring food and water security in the Arctic areas. Following an extensive literature research and critical review, 12 candidate indicators for future monitoring were selected jointly by the Sustainable Development Working Group's (SDWG) Arctic Human Health Expert Group and the Arctic Monitoring and Assessment Programme's (AMAP) Human Health Assessment Group (Nilsson et al. 2013). These 12 indicators (including contaminants in food and water) are based on existing WHO and FAO indicators, and they will be the starting point for monitoring both indigenous and non-indigenous populations in rural and urban areas of the Arctic (Table 19.2).

A more detailed description of the promoted measures regarding food security are provided in Chap. 16.

During the last twenty years there has been a dietary transition from traditional and local foods to a Western type of diet. This shift has already led to increased rates of obesity, diabetes and cardiovascular diseases. There is less physical activity, as modern technology, such as snowmobiles and motorbikes, are used in activities like reindeer herding. The store-bought food is often cheaper than the traditional and local food, and climate change may decrease the possibilities for hunting and fishing. Dietary recommendations have been made to ensure a balanced and nutritious diet. However, the transportation costs are high, and the hunting equipment, fuel, and vehicles are more expensive in the North than in the southern parts of the same country. All of these factors contribute to the emergence of more unhealthy dietary patterns.

Table 19.2 Indicators of food and water security (Nilsson et al. 2013)

Healthy weight (BMI, ratio >30, also for children)
Self-estimated proportion of traditional food in diet
Non-monetary food accessibility
Monetary food accessibility
Food-related contaminants
Food borne diseases
Per capita renewable water
Accessibility of running water
Waterborne diseases
Drinking water contaminants
Authorized water quality assurance
Water safety plans

19.5 Good Life in the Changing Arctic

The increasing economic interest in the Arctic will produce new jobs and new Northerners. Demographic changes, including aging, will put strain on the infrastructure in many parts of the Arctic. Support is needed to secure the health and wellbeing of older people. Both globalization and climate change will affect environment and every-day life. What are the dimensions or parameters of good life in the Arctic? Are those the same in the circumpolar North as elsewhere? Are they the same for the indigenous and the non-indigenous peoples? According to the United Nations' Human Development Index, the parameters for good life are health (Infant mortality and Life expectancy), education (Educational attainment) and income (Gross Domestic Product). From the health point of view, the Arctic regions are divided into four groups: Nordic countries; Alaska, Yukon and North West Territories; Greenland and Nunavut; and the Russian Arctic. Almost all health, education and income parameters have improved during the last 5–10 years, but there are notable differences between the populations, sub-groups, regions and genders.

Life in the Arctic has its specificities, and there has been an attempt to develop indicators that can be used for Arctic, but also for more global, comparison (see more, Larsen and Fondahl 2014; and Arctic Social Indicators by Larsen et al. 2010, 2015). At the moment, several studies are being conducted on measuring subjective or community well-being or quality of life in different parts of the Arctic, and their results will be used to build a common set of indicators for the circumpolar area.

Close environmental relationship will also be important for the future Northerners. To ensure a clean and safe environment, global, national and Arctic strategies and decisions are needed. We must work towards restricting the use and release of chemicals, which will transfer and accumulate in the sensitive Arctic environment, and take care of the health and well-being of the populations in the North.

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