Swedish Society for Nature Conservation
Naturskyddsföreningen

IPEN International POPs Elimination Network

A survey of mercury content in the hair of delegates at the first UN negotiating meeting for a global mercury treaty

Swedish Society for Nature Conservation[1] and International POPs Elimination Network (IPEN)[2], Stockholm, Sweden 2010.

Authors in alphabetical order: Beeler B.[2], Dahl U.[1], DiGangi J.[2], Lloyd-Smith M.[2], Patton S.[2], Prevodnik A.[1], and Wickens J.[2].

Photo: Roshan Singh

[1]Swedish Society for Nature Conservation (SSNC, Naturskyddsföreningen) is a non-profit environmental member-based organization with 181,000 members. SSNC has the power to make changes by spreading knowledge, mapping environmental threats, creating solutions, and influencing politicians and governments both nationally and internationally. SSNC is also the owner of the world's most advanced Eco-label: Good Environmental Choice (www.naturskyddsforeningen.se/)

[2] International POPs Elimination Network (IPEN) is a global network of over 700 health and environmental organizations in more than 100 countries working together for a Toxics-Free Future (www.ipen.org/hgfree)

Summary of results

This survey found mercury in the hair of delegates and other persons from 40 countries, indicating the global nature of methyl mercury contamination. Mercury levels in participants from developing countries and countries with economies in transition (CEIT) were on average approximately twice as high as levels found in participants from developed countries. In addition, the average level of mercury in hair from developing countries and CEIT participants exceeded the US National Research Council mercury reference dose of 1000 ug/kg. Mercury is released to the environment from many sources such as mercury-containing products and devices, product manufacturing sites, industrial processes, mining activities, metal refining, coal combustion, cement kilns, waste dumps and incinerators, contaminated sites, crematoria and many others. Products that contain mercury are widely produced and globally traded even though substitutes and alternatives are available for most of them, including thermometers, blood pressure measuring devices, barometers, batteries, electrical switches and many types of electronic equipment. The mercury treaty that is under negotiation is fundamental for millions of people who eat fish as a source of protein. Removing the skin of the fish does not remove mercury, as is sometimes believed, as mercury is distributed throughout the fish in protein tissue. Mercury-contaminated fish is a poisoned food source. The survey underscores the urgency of implementing a global mercury treaty that eliminates all anthropogenic sources of mercury.

Introduction

In 2009, the Governing Council of the United Nations Environment Programme (UNEP GC) decided to develop a global legally binding instrument on mercury to reduce risks to human health and the environment (UNEP GC25/5). The mercury treaty will be negotiated in a series of five meetings and Sweden agreed to host the first intergovernmental negotiating committee meeting (INC1) in June 2010 with delegates from more than 100 countries participating.

The UNEP GC noted that mercury is a substance of global concern due to its long-range transport, persistence, ability to bioaccumulate, and toxicity (for more information on mercury toxicity, please see Annex 3). In the environment, mercury is converted to methylmercury which is the form that bioaccumulates in living organisms. In humans, methylmercury is incorporated into hair[1]. Therefore, hair is widely accepted as a matrix for reliable estimations of the body burden of methylmercury, which likely comes from the diet[2, 3, 4, 5]. Since INC1 is a global meeting with participants from all over the world, we surveyed e.g. interested delegates from all UN regions for mercury content in hair to raise awareness and illustrate the global nature of mercury contamination in humans.

Survey design

A total of 58 samples were analyzed including 45 government delegates and 8 representatives of NGOs and Indigenous Peoples. In addition, 4 Swedish members of Swedish parliamentary parties, Andreas Carlgren (Minister of Environment, the Center Party), Göran Hägglund (Social Minister Party Leader, Christian Democrats), Mona Sahlin (Party Leader, Social Democrats) and

Maria Wetterstrand (Party Leader, The Greens), and 1 Swedish Olympic Game Gold Winner, Anja Pärson, also participated for showing their engagement on environmental issues and global solidarity. Participants were tested from the following 40 countries: Argentina, Armenia, Australia, Bahrain, Brazil, Cambodia, Canada, Cook Islands, Czech Republic, Finland, Germany, Haiti, Indonesia, Japan, Jordan, Kenya, Kiribati, Madagascar, Malaysia, Mali, Mauritius, Mexico, Netherlands, Nigeria, Norway, Palestine, Philippines, Poland, Russia, Saint Lucia, St. Vincent and the Grenadines, Sweden, Switzerland, Syria, Tanzania, Thailand, United Kingdom, Uruguay, United States of America, and Yemen (see the map in Figure 1 for the geographical extent of the survey, and the pie chart in figure 2 for the composition of survey participants from UN regions). The survey participants answered questions of potential relevance to the mercury body burden (see Annex 4). The hair samples were placed in sealable polyethylene bags and sent to the Department of Applied Environmental Science (ITM), Stockholm University, for determination of mercury according to the method "Mercury in solids and solutions by thermal decomposition, amalgamation, and atomic absorption spectrophotometry" (Swedish EPA Method Nr7473). A t-test was performed to compare population means between participants from developed countries and developing countries and CEIT. The identities of the survey participants were kept confidential, except for the members of Swedish parliamentary parties and for the Swedish Olympic Game Gold Winner.

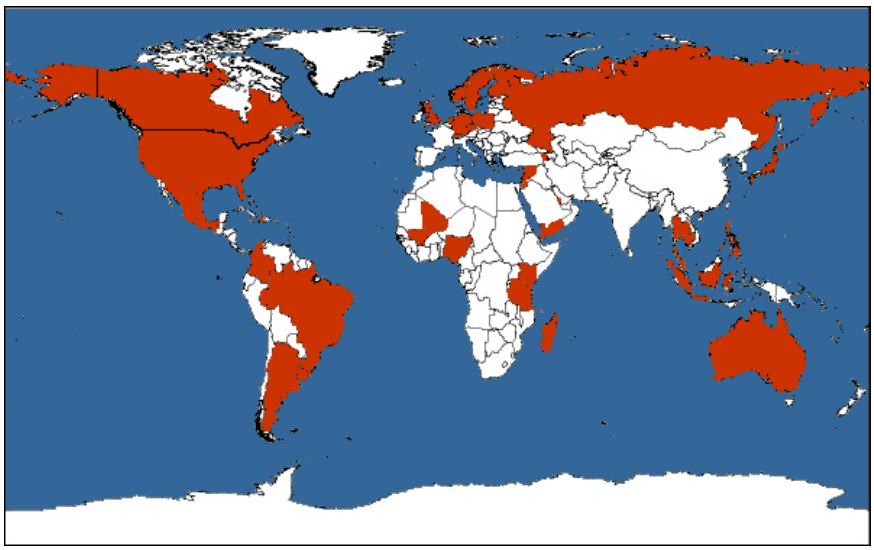

Figure 1: Map with countries of origin of survey participants highlighted in red.

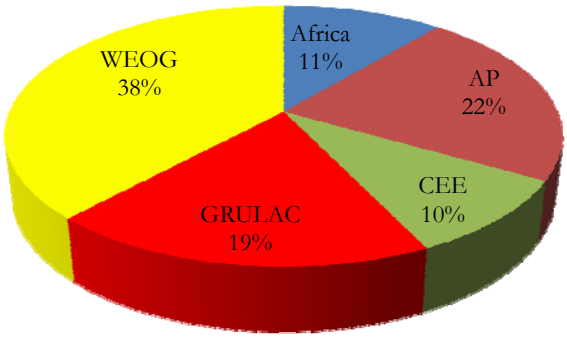

Figure 2. Composition of survey participants from UN regions. Abbreviations: AP, Asia-Pacific; CEE, Central and Eastern Europe; GRULAC, Group of Latin American and Caribbean Countries; WEOG, Western Europe and Others Group.

Results and discussion

The survey detected mercury in 100% of the participants. Mercury levels in human hair ranged from 93 ug/kg to 2956 ug/kg (Figure 3). One sample contained more than 20,000 ug/kg mercury which grossly exceeded the benchmark dose limit of 10,000 ug/kg set by the World Health Organization (WHO) in 1990[6]. This data point has not been used in any graphs or statistical analysis of the survey.

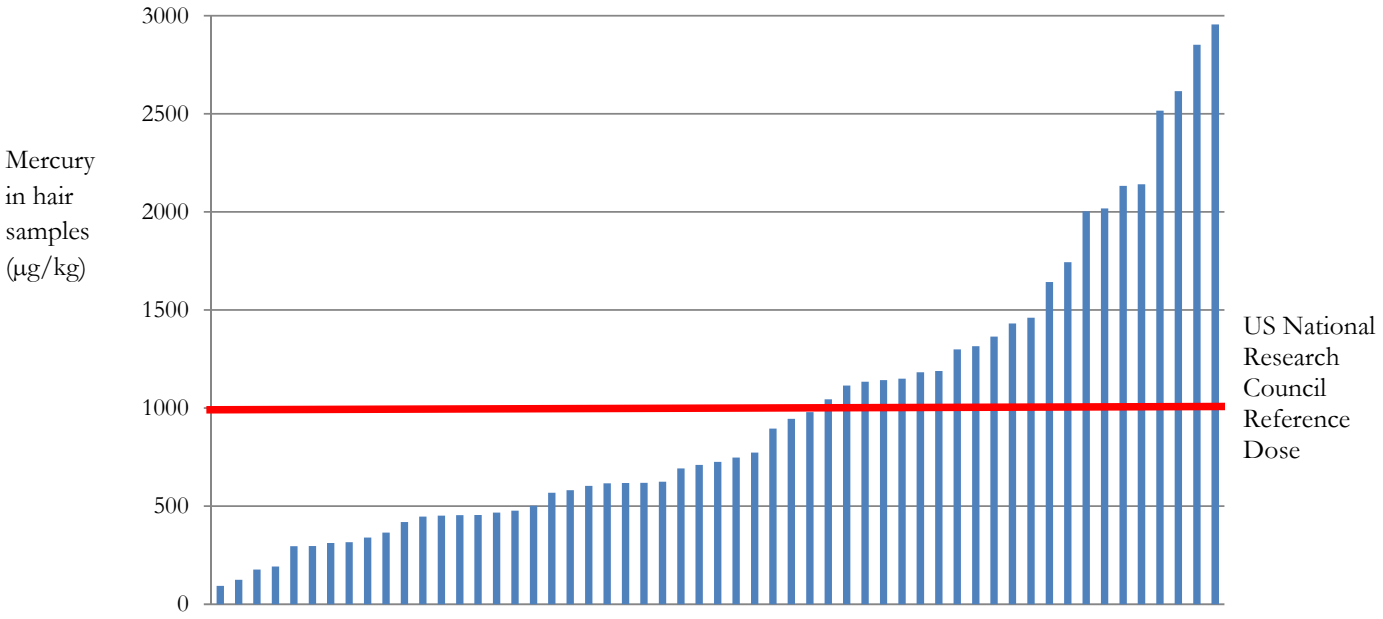

Figure 3. Mercury in hair samples (ug/kg). As the participation was confidential, only staples are shown for indication of trends.

To test the hypothesis that delegates might differ in their human body burden of mercury, the data was separated into two groups; participants from developed countries and those from developing countries and CEIT (Table1). Interestingly, a statistical analysis of the data shows that average mercury levels in hair of participants from developing countries and CEIT was approximately twice as high as levels found in participants from developed countries ($p < 0.005$). In addition, the average level of mercury in hair from developing countries and CEIT participants slightly exceeded the US National Research Council mercury reference dose of 1000 ug/kg[7].

Table 1. Comparison of mercury levels in hair in delegates from developed countries and developing countries and CEIT.

Country	No. Samples	No. Countries	Average mercury level (ug/kg)	Std dev
Developed	20	11	669	338
Developing and CEIT	33	29	1182	847

Abbreviations: No., number; Std dev, standard deviation; CEIT, countries with economies in transition.

All together, 22 samples (38%) exceeded the US National Research Council mercury reference dose of 1000 ug/kg with respect to possible nerve damage[7] (Figure 3). Of these 22 samples, 17 (81%) were from developing country and CEIT participants. Seven of the 22 samples exceeding the reference dose were women (32%). Exposure of women at reproductive age (<40 years) is particularly problematic, since mercury is transferred from mothers to their offspring prenatally. Studies in Iraq suggested there is a 5% chance of adverse fetal brain development effects when maternal mercury hair concentrations were 10,000-20,000 ug/kg[8]. This is an unacceptably high risk. With a safety factor of 10, i.e. a dose corresponding to that of the US National Research Council, adverse fetal brain development effects could be avoided according to the scientific knowledge today[7]. However, subtle nerve damage in adults, such as parasthesia (a feeling of "pins and needles" or "limb falling asleep"), cannot be ruled out[7].

Effects from chronic exposure to low levels of mercury are less well understood than acute effects from high levels. Therefore, chronic low level mercury exposure is a high-priority area of research, as many people are exposed to methylmercury at levels not high enough to cause any obvious signs of poisoning[9]. In this respect it is important to distinguish individual risks from population risks. Subtle neurological effects, e.g., too small to be clinically significant for an individual, may be quite important when a population as a whole is considered[12]. The population at risk for subtle effects from mercury may be very large. Recent data, in fact, suggest that nerve damaging effects of methylmercury exposure may extend significantly lower than the US National Research Council reference dose (1000 μg/kg)[13]. So far, there are no official

methylmercury reference doses for immunological and cardiovascular toxicities, but they are suspected to be even lower than the US National Research Council reference dose for nerve damage (see e.g. 11).

Many other surveys have established a link between fish consumption and hair mercury content (see e.g. refs. 12 and 13). Non fish-eaters in Sweden have less than 100 μg mercury/kg hair (personal communication, Gerd Sällsten at Gothenburg University, 2010). All but one participant stated in the questionnaire that they eat fish, and all samples contained more mercury than the Swedish background level. This is yet another confirmation, even though based on a small sample, that fish is a source of mercury to the general population. However, in this survey no clear pattern with respect to the frequency of fish meals per week was observed. The position of a fish species in a food web may influence how much methylmercury it contains. Predatory fish usually contain the highest levels of mercury[14]. As the species of fish consumed and their trophic statuses (positions in food webs) were not considered in this survey, it could not be concluded how the frequency of fish influences the mercury content in the participants.

An interesting observation in the survey is that the average mercury levels in hair of participants from developing countries and CEIT was approximately twice as high as levels found in participants from developed countries (see Table 1).

This survey did not aim to identify the reasons for the increased levels in delegates from developing countries and CEIT. Generally speaking, historical uses, industrial practices, lack of public awareness and ineffective laws could contribute to mercury in the environment in developing countries though. In addition, many countries in Asia-Pacific and Africa are also dependent upon fish as a major protein source (see, e.g., ref. 15), especially in the island states.

The full extent of human exposure to mercury globally is still unknown. A recent EU assessment suggested that as much as 1-5% of the general population of Central and Northern Europe (3-15 million people), and people in coastal areas of the Mediterranean, have levels near the US National Research Council reference dose (1000 μg/kg)[11]. Even more alarming is the fact that members of some Mediterranean, Arctic and Amazonian fishing communities may have mercury concentrations more than ten times as high as the US National Research Council reference dose[14,15]. Such doses exceed the level when adverse fetal brain development effects can be expected[8].

Mercury is released to the environment from many sources including: mercury-containing products and devices, product manufacturing sites, industrial processes, mining activities, metal refining, coal combustion, cement kilns, waste dumps and incinerators, contaminated sites, crematoria and many others. Products that contain mercury are widely produced and globally traded even though substitutes and alternatives are available for most of them, including thermometers, blood pressure measuring devices, barometers, batteries, electrical switches and many types of electronic equipment.

In conclusion, this survey indicates global contamination of methylmercury in humans, since it was found in all tested delegates from all UN regions, even in those from countries far from major sources of mercury. The survey results underscore the importance of eliminating all

anthropogenic sources of mercury to prevent further contamination of fish and other food sources. The mercury treaty being negotiated could be of fundamental value for millions of people who eat fish as a source of protein. Removing the skin of the fish does not remove mercury, as sometimes thought, as mercury is distributed throughout the fish in protein tissue. Mercury-contaminated fish is a poisoned food source. The results suggest that the treaty should eliminate the anthropogenic sources of mercury globally and also establish mechanisms for evaluating its effectiveness, including global monitoring of mercury in the environment, fish, and humans.[1] The survey underscores the urgency of implementing such a global mercury treaty.

Acknowledgment

SSNC and IPEN would like to thank all the participants of this survey for helping to promote increased public awareness of mercury body burden in humans. We would also like to thank the Department of Applied Environmental Science (ITM) at Stockholm University, with a special thanks to Ann-Marie Johansson and Pia Kärrhage, who performed the hair mercury analysis for us on a holiday, so that we would have the results in time.

[1] For views on a global mercury treaty please see Annex 2

Annex 1: Levels of mercury in hair, and comments from participants of the study

Andreas Carlgren, Swedish Environmental Minister, 773µg/kg:
The survey illustrates the need to tackle the mercury problem, because mercury is present in all of us and it shouldn't be a part of our bodies! To eliminate all sources of mercury, I and the Swedish government want an effective global legally binding instrument on mercury in place soon – the ongoing negotiations is our chance to make a real difference for coming generations.

Mona Sahlin, leader of the Social democrats Party in Sweden, 452µg/kg:
The numbers are alarming. We must limit the amount of mercury and other heavy metals in industrial products. It's especially important that products that we know often will end up as waste in nature is free from heavy metals. Therefore we must make the European legislation tougher to phase out the use of heavy metals. We should start with mercury. We Social democrats also demand a stop of all exports of hazardous waste from European countries to poor countries around the world. We must take responsibility for the environmental problems we create ourselves.

Anja Pärson (Gold winner in the Olymics), 748µg/kg:
With my sample, I hope to make the Nordic countries and the rest of the world aware of the problems with mercury. We have to start to take responsibility, and I see it as a duty to my family, and our next generation, to do the best I can!

Maria Wetterstrand (leader of the Green Party), 692 µg/kg.

Göran Hägglund (Social Minister, Leader of the Christian Democrats), 1189µg/kg.

Annex 2. Brief Statement of IPEN and SSNC Views of a Global Mercury Treaty

Mercury is a substance of global concern

- Fish in all regions are contaminated with mercury at levels that threaten human health and the environment; rice and other crops may also be an important pathway for mercury exposure.
- Mercury-contaminated fish and other foods are particularly harmful to mothers and children.
- Two-thirds of the mercury in the environment comes from human activities.
- Mercury in the environment travels long distances and spreads out globally even to remote places.
- Mercury is released to the environment from many sources including: mercury-containing products and devices, product manufacturing sites, certain industrial processes, mining activities, metal refining and recycling, coal combustion, cement kilns, waste dumps and incinerators, contaminated sites, crematoria and many others.
- Mercury and most of its compounds are extremely toxic. The most toxic forms of mercury are its organic compounds, such as methylmercury. However, inorganic compounds, are also highly toxic by ingestion or inhalation of the dust. Mercury can cause both chronic and acute poisoning.

Objective, scope, and implementation

- The goal of the global mercury treaty should be to protect human health, wildlife and ecosystems by eliminating anthropogenic sources of mercury.
- The treaty should have a broad scope and address the entire mercury life-cycle.
- It should recognize particularly vulnerable populations such as children, women of child bearing age, indigenous peoples, Arctic communities, island and coastal dwellers, fisherfolk, small-scale gold miners, the poor, workers**,** and others.
- The treaty should include provisions that will enable it to be expanded at a future date to also control other pollutants of similar global concern, without compromising the robustness of the mercury treaty.
- It should require each Party to establish and implement a National or Regional Treaty Implementation Plan; include in the plans inventories of mercury supplies, sources, releases to all media, wastes and contaminated sites.
- Civil society should have an active role in the development and implementation of the treaty including the opportunity to participate in the development and implementation of National or Regional Implementation Plans.
- The treaty should establish mechanisms for evaluating its effectiveness, including global monitoring of mercury in the environment and in fish and humans.

Supply

- Ban primary mercury mining; mandate permanent, secure, monitored storage for existing mercury stockpiles and all mercury that is recovered from chlor-alkali plants; restrict trade in mercury generated from remaining sources.
- In some cases, there may be need for transition assistance and/or other aid to specific groups of workers or communities who currently depend for their livelihood on activities that release mercury to the environment.

Demand

- Use elimination-based control measures subject to possible limited, time-bound exemptions to phase-out all products and processes that contain or use mercury.
- Promote research and development on sustainable, non-toxic, alternatives to products and processes that contain or use mercury with special emphasis on addressing the needs of developing countries and countries with economies in transition.

Trade

- Establish effective controls on international trade in mercury and mercury-containing products.
- While the treaty may recognize that mercury control and international trade law are mutually supportive, it must not contain language suggesting that its provisions are subservient to international trade law.

Atmospheric emissions

- Establish Best Available Techniques (BAT) and Best Environmental Practices (BEP) for coal-fired power plants, cement kilns, and other combustion processes that release mercury to the environment with an agreed schedule for its phased-in application; aim to phase-out any of these sources when good alternatives are feasible, available and affordable from a societal point of view.

Waste and contaminated sites

- A mechanism should be established to identify, manage and remediate mercury contaminated sites. This may include appropriate compensation for affected workers and communities.
- Responsibility for mercury-related phase-outs and clean-ups should be consistent with the Polluter Pays Principle where costs are shared by responsible parties with special attention to the private sector.

Awareness-raising

- The treaty should provide for public information, awareness and education, especially for women, children, workers, small-scale gold miners, the poor, marginal people and the least educated. It should also provide this for indigenous peoples, Arctic communities, islanders, coastal people, fisherfolk and others who rely on fish or other mercury-contaminated foods for their nutrition.
- The public should receive timely access to relevant governmental and private sector data on mercury hazards, mercury sources, and alternatives to mercury-containing products.

Capacity building and technical and financial assistance

- Establish an adequately funded and predictable financial mechanism with new and additional resources sufficient to enable developing countries and countries with economies in transition to fulfill their treaty obligations without compromising their poverty reduction goals.
- Establish mechanisms for capacity-building and technology transfer.

Compliance

- Establish effective monitoring, reporting, and review mechanisms to promote transparency and ensure compliance with treaty obligations.

Annex 3: Mercury toxicity

Like all metals, mercury cannot degrade once released into the environment. Deep-sea sediments are the only known long-term sink for removal of mercury from the biosphere (the biological part of ecosystems)[16], and only in the very long run it may be reabsorbed into the earth's crust via loss of ocean floor at subduction zones. Mercury is a unique metal, as it appears in four different forms: as a liquid metal at room temperature (elemental form), as gas (elemental form) at room temperature, ions and in organic forms. The organic forms of mercury are formed by microbial action in oxygen poor aquatic environments[17]. As a gas, it can disperse long distances in the atmosphere. Exposure to elemental mercury can occur through inhalation of contaminated air, e.g., near mercury mines, hazardous waste sites, landfills, or by occupational exposure, e.g., in dental offices where mercury containing amalgam is used for tooth filling[18]. As a metal and in its organic forms, mercury is fat soluble and thus accumulates in foodwebs of ecosystems[16]. Fish is a prime source of organic mercury exposure for the general public[19].

Mercury has no known biological function and it is highly toxic, particularly its organic forms, methylmercury being the most toxic[20]. Methylmercury is classified as a potential carcinogen[21]. The prime target for methylmercury is the nervous system[17, 22], with complications such as loss of cognitive capacity and memory[3], and impaired neuro-muscular coordination as a result[3]. Fetuses and children are particularly sensitive to mercury, as their brain and nervous system is under development[23]. Mercury has the ability to cross the placenta[22], and is excreted in milk[24]. This is why in many countries pregnant and breast feeding women are recommended to not eat certain species of fish. There are also other, less known and sometimes diffuse, complications that appear to be associated with exposure to mercury, although in many cases existing epidemiological data is insufficient to establish a causal link for certain. These complications range from cardiovascular problems[25, 26], impaired kidney function[27] to certain forms of cancer [28, 29].

Mercury has many industrial applications – particularly in medical and electronic devices. Coal combustion[30, 31], waste incineration[32, 33], metal mining, refining, and manufacturing[34, 35, 36], and chlorine-alkali production[37, 38] are currently major emission sources for mercury in the industrialized countries. Mercury is also used in small scale gold mining in many countries. Gold mining activities create local or regional problems. That is why the Amazonian basin is highly contaminated with mercury[8], and similar problems are also found in African and Southeast Asian countries.

Annex 4: Questionnaire

Sample number: _____

Participant ID Code: _____

Swedish Society for Nature Conservation
Naturskyddsföreningen

IPEN
INTERNATIONAL POPs ELIMINATION NETWORK

QUESTIONNAIRE FORM FOR SAMPLING OF HG IN HAIR

The results from this test will be compiled and included as data in a press material fact sheet on mercury exposure and contamination in humans, for raising awareness of mercury body burden in the people preparing the initiative of a global legally binding instrument on mercury. **The right of confidentiality is granted to each individual participant unless she/he voluntarily waives it.**

Privacy & Anonymous Samples: Each participant will receive a Participant ID Code, to be utilized in collecting results and to conceal the names of participants.

1. Date:	
2. Name or Participant ID Code:	
3. Country:	
4. Gender:	Female ( ) Male ( )
5. Age:	
6. Do you want to be contacted by email to know your personal Hg burden? NOTE: Participates who wish to provide anonymous hair samples, can collect results by emailing (ulrika.dahl@naturskyddsforeningen.se), providing their ID Code and set password.	Yes ( ) No ( ) Email Address:
7. Do you eat fish?	Yes ( ) No ( )

8. If you eat fish, what is your favorite or top two favorite kind of fish to eat?	

9. Approximately how many meals of fish are you eating every week?	No fish ( ) ≤ 1 ( ) 2 ( ) 4 ( ) 6 ( ) ≥8 ( )
10. Do you avoid or limit your fish consumption because of concerns for mercury?	Yes ( ) No ( )
11. Do you think you will take measures to reduce your mercury exposure after participating in this hair activity?	Yes ( ) No ( ) I already take measures ( )

Note: There are more than one type of mercury, organic and inorganic. Sampling hair for mercury illustrate organic mercury in the body. However, you may be exposed to inorganic mercury by sources like dental amalgam filling ("silver fillings"), skin cream or by occupation.

12. Are you aware of the different routs of mercury exposures?	Yes ( ) No ( )

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