Assessing hair mercury levels of women of childbearing age in 9 countries:

A civil society pilot project

zero Hg
mercury working group

Report prepared by:
Michael T. Bender, MS, Director
Mercury Policy Project (MPP), a project of the Tides Center
1420 North St.
Montpelier, Vermont, USA
www.mercurypolicy.org

Technical analysis provided by:
Lynda M. Knobeloch, Ph.D.,
consultant in toxicology and public health policy,
Mount Dora, FL, U.S.

For

Zero Mercury Working Group (ZMWG)
c/o European Environmental Bureau (EEB)
34, Boulevard de Waterloo
B-1000, Brussels,
Belgium
www.zeromercury.org

ACKNOWLEDGEMENTS

Mercury Policy Project, the European Environmental Bureau, and the Zero Mercury Working Group (MPP, EEB, ZMWG) acknowledge financial support provided by: The Garfield Foundation, and the Sills Family Foundation (for general support) and the German Government and the Swedish public development co-operation aid through the Swedish Society for Nature Conservation (SSNC) (for general support, layout and printing), but none of the above are responsible for any use that may be made of information contained therein. The sole responsibility for the content lies with Mercury Policy Project, the European Environmental Bureau, and the Zero Mercury Working Group (MPP, EEB, ZMWG).

Photos: Cover Page Ginny Warner, Page 2 & 5 www.sxc.hu, Page 6,8 and 20 Hemsing Hurrynag, Pesticide Action Network, Mauritius. Page 12, Shahriar Hossain, Ph.D., Ecologist, Journalist & Social Justice Advocate, Dhaka, Bangladesh; Page 13 Dominique Bally KPOKRO, MSc., Head of Chemistry, Biodiversity and Health Dpt. Jeunes Volontaires pour l'Environnement, Côte d'Ivoire, Page 14 Mohamed Aly.

Reviewers included: Professor Philippe Grandjean, MD, University of Southern Denmark; Peter Maxson, Director, Concorde East/West, Brussels, Belgium; Professor Lars Hylander, Swedish University of Agricultural Science; Edward Groth III of Pelham, NY, U.S.; Susan Keane, Natural Resources Defense Council, Washington, DC, U.S. and Elena Lymberidi-Settimo, European Environmental Bureau, Belgium, Brussels; Lynda M. Knobeloch, Ph.D., consultant in toxicology and public health policy, Mount Dora, FL, U.S.

The mercury analyses were carried out at the Department of Environmental Medicine, University of Southern Denmark, as a student project with Ranja Bjerring as the responsible technician and under the supervision of Professor Philippe Grandjean, MD.

The hair sampling protocol in Annex A was provided courtesy of the Health and Environment Alliance (HEAL), Brussels, Belgium.

Formatting- Layout: Rebecca Lagunsad / Ban Toxics! Philippines

Non-governmental Organizations (NGOs) participating in the project included:

- Armenian Women for Health and Healthy Environment (Armenia);
- Center for Public Health and Environmental Development (Nepal);
- Citizens Against Chemicals Pollution (Japan);
- Ecologistas en accion or Ecologists in Action (Spain);
- Environment and Social Development Organization (Bangladesh);
- groundWork (South Africa);
- Jeunes Volontaires pour l'Environnement (Côte d'Ivoire);
- Pesticide Action Network (Mauritius); and
- Toxics Link (India).

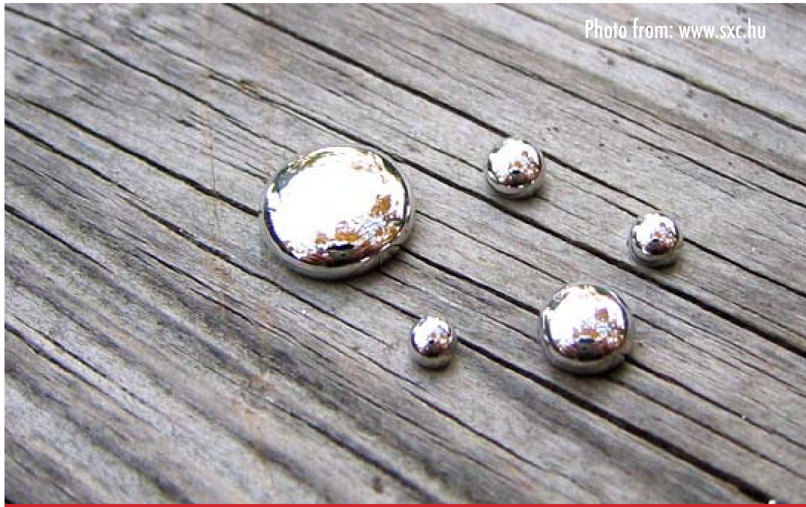


Photo from: www.sxc.hu

CONTENTS

EXECUTIVE SUMMARY

The *Minamata Convention on Mercury* highlights the global need to take further concrete measures to better ascertain and reduce human exposure to mercury. Specifically, biomonitoring programs are needed to measure mercury levels in people, as well as in commonly eaten fish. Such initiatives will provide the information needed to develop and monitor effective mercury exposure reduction strategies such as national fish consumption advisories and restrictions on the production, use, trade and environmental release of mercury. Biomonitoring can also be used as a mechanism to evaluate the Convention's progress toward reducing human exposure to mercury over time.

While most exposure studies have been conducted in developed countries, much less is known about exposures in other regions of the world. To improve worldwide understanding of the extent of mercury pollution and its impact on human health and development, it is imperative to expand capacity to assess global exposure variations among people. Hair analysis is a well-documented method that can be used to assess recent exposure to methylmercury - the organic form of mercury that contaminates fish. It is also an exposure assessment project that lends itself well to citizen participation.

There are two important findings of this study. First, non-governmental organizations from nine countries voluntarily and successfully conducted this mercury exposure assessment and reduction awareness raising pilot project with limited support and donated technical and laboratory testing services. This project clearly demonstrates the capacity of civil society groups everywhere to conduct similar projects in the future, especially in light of the special access and relationships of civil society groups to communities in widely different cultures around the globe.

Second, while it is not surprising that hair mercury concentrations were found to vary widely from one community/country to another, our findings identified a significant number of individuals with mercury exposure levels that were high enough to signal a risk of adverse effects, especially to any developing fetus. Such high exposure levels are typically associated with frequent consumption of the types of fish and seafood that tend to have elevated mercury contamination.

Specifically, our study found that hair mercury concentrations ranged from 0.01 to 8.05 micrograms per gram (µg/g) (median 0.44 µg/g) among individuals in the 9 countries tested, and were highest in samples provided by women of childbearing age in Spain and Japan. Study results also show that women of childbearing age in several countries. Overall, nearly one-quarter (24%) of the samples exceeded the widely recognized U.S. Environmental Protection Agency (EPA) guideline of 1 µg/g.

Furthermore, in 4 of the 9 countries a high percentage (defined as more than 20%) of all samples from women of child bearing age exceeded this threshold, specifically :

- 71% of those tested in Japan;
- 64% of those tested in Spain;
- 36% of those tested in Mauritius; and
- 23% of those tested in Côte d'Ivoire.

Mercury hair sampling event in La Chaux Social Welfare Centre, Mahebourg, Mauritius, 11 June 2013

Based on the report findings, the Zero Mercury Working Group makes the following assessments and recommendations:

1. The U.S. EPA guideline, which was adopted in 2001, is intended to prevent subtle developmental delays that have been linked to prenatal exposure to methylmercury. However, recent scientific evidence suggests that adverse effects on fetal development can occur at levels below the current guideline. If so, our study findings may underestimate the percentage of women in this sample with hair mercury concentrations of concern.

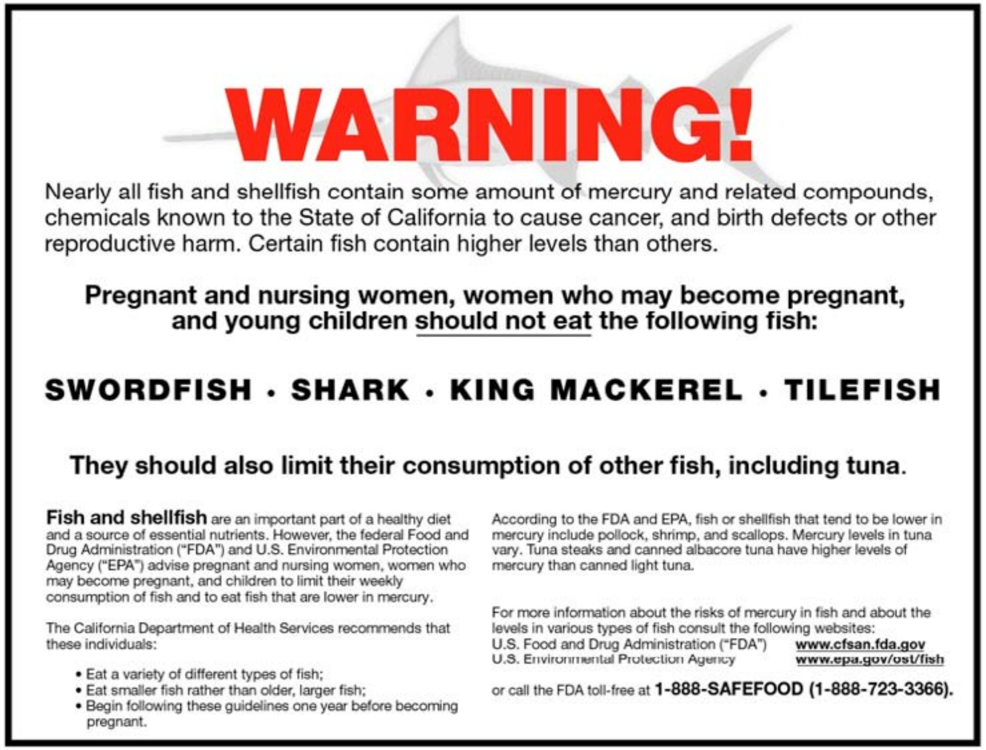
2. Since it may take several years to update existing exposure guidelines to reflect the changing body of epidemiological evidence, an extra degree of caution about prenatal methylmercury exposure is warranted, increasing the urgency of the Convention's objective of reducing anthropogenic mercury emissions. These facts should compel countries to ratify the Convention soon and by 2015 if possible, and to take steps to reduce human exposure to mercury immediately.

3. The primary short-term strategy for reducing methylmercury exposure in people is to reduce frequent consumption of fish with medium and high mercury concentrations. Women who are pregnant or who are planning a pregnancy should include fish in their diets, but they should also be encouraged to select fish that are low in mercury and other contaminants.

4. The situation from country to country is highly variable and seems to be affected by multiple factors, including (as enumerated in the report) amounts of fish consumed, types of fish consumed, access to coastal fisheries, family income, and other things. Countries should therefore conduct their own exposure assessments for mercury and determine levels of human exposure to mercury. Governments should measure concentration of mercury in frequently consumed fish and issue advisories especially to protect women of childbearing age, children and those who eat large quantities of fish.

5. Civil society organizations can play a critical role in helping to identify populations at risk and promoting mercury exposure reduction awareness. It is therefore recommended that civil society groups everywhere be encouraged to conduct similar projects, especially in light of the special access of civil society groups to communities in widely different cultures around the globe.

6. Hair mercury analysis in humans can provide a useful biomarker for mercury exposure. Therefore, it is recommended that the new Convention and the interim Intergovernmental Negotiation Committee process leading up to its ratification should work closely with the World Health Organization in building a global database of mercury levels in human hair in countries worldwide to use as a baseline to evaluate progress in reducing human exposure to mercury over time.



From the state of California , USA

1. INTRODUCTION

The adoption of the new Minamata Convention on Mercury has highlighted the need across the world to develop biomonitoring capabilities that can target efforts to reduce human exposure to mercury. Specifically, biomonitoring is necessary to assess mercury levels in people and the fish most frequently consumed in order to enable countries to develop fish consumption advisories for mercury and implement effective risk communication strategies to reduce human exposure. Biomonitoring can also be used to evaluate the Convention's progress toward reducing levels of exposure over time.

Since most studies of human exposure to mercury have been conducted in developed countries and less is known about exposure levels in other regions, one of the key objectives of this study is to assess global variations in mercury exposure among women of childbearing age by testing hair samples for mercury. In biological monitoring, hair strands have been used as an indicator for environmental exposure and this kind of an exposure assessment project lends itself well to citizen participation.

Hair analysis is a well-documented and relatively inexpensive method that can be used to assess recent exposure to mercury including methylmercury. Although our study results are widely variable, findings identify individuals that have concerning levels of exposure to methylmercury through frequent consumption of mercury-contaminated fish and seafood.

Measuring hair mercury concentrations is a routine analysis at many research laboratories, particularly in developed countries. However, with a one-time investment of $30,0000 (USD) for specialized testing equipment, a scale to weigh the sample, trained personnel and small operating expense, a government agency or health clinic can have the capacity to analyze up to 50 hair samples per day. Alternatively, samples may be sent to an accredited lab for mercury analysis at a cost of as little as $20 (USD) per sample, although in some cases (like this project) the testing was generously donated.

The primary goal of this project was to demonstrate the feasibility of testing hair samples in widely different cultures around the globe, and to assess the ability of civil society to responsibly and credibly conduct such sampling. This research is needed in multiple mercury hotspots around the globe, especially where fish with medicum to high levels of mercury is consumed frequently, in order to determine current (and future) exposure levels, evaluate changes over time and promote exposure reduction and prevention efforts targeted at:

- populations at risk of exposure due to local pollution sources,
- coastal populations,
- indigenous peoples,
- fishing communities, and
- other heavy fish eaters.

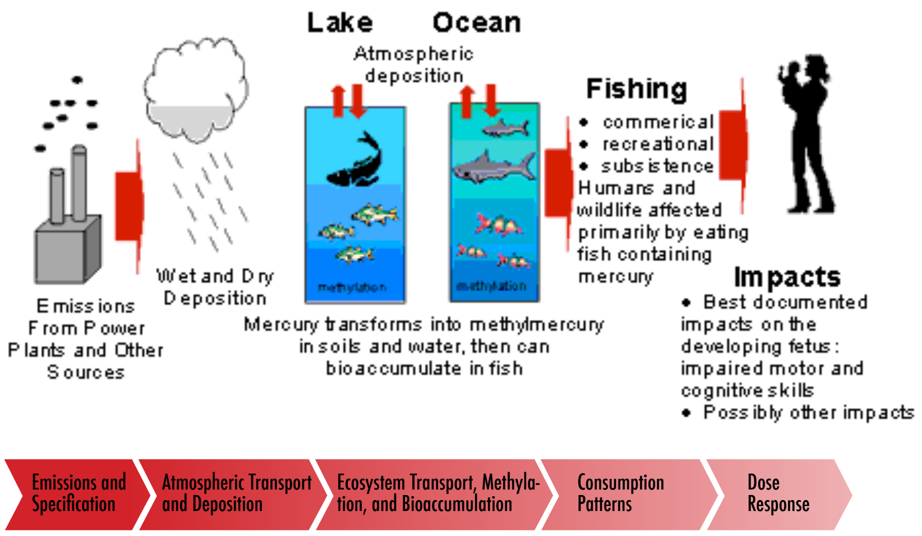
In the report methodology section and in the annexes, instructions are presented to conduct mercury hair testing; analyze the results; and inform participants and the general public about the findings and any health risks resulting from exposure risks.


Mercury hair sampling event in La Chaux Social Welfare Centre, Mahebourg, Mauritius, 11 June 2013

2. BACKGROUND

Mercury is a neurotoxin that presents a health risk because of its global dissemination, persistence, toxicity, and bioaccumulative nature and is a problem even in remote locations such as the Arctic. Even with measures put into place to reduce emissions, anthropogenic mercury pollution from historical and on-going mercury releases continues to build up and is projected to persist in the environment for decades to come, necessitating additional actions to protect human health into the foreseeable future. The major (non-occupational) route of exposure of methlymercury to humans is via consumption of fish that become contaminated through the aquatic food web, as demonstrated by the following flow chart in Figure 1. [ii]

Figure 1. How mercury enters the environment



Risk of adverse health effects in children following in utero methylmercury exposures is well documented and rises as maternal exposure increases. [iv] Studies have associated prenatal methylmercury exposure with impaired development of sensory, motor, and cognitive functions in children, resulting in learning difficulties, poor coordination, and inability to concentrate.[v] The importance of brain functions means that even a small deficit, whether measured as a decrease in IQ points or otherwise, is likely to impact an individual's quality-of-life, academic success and economic prospects. [vi] Adult exposures have also been linked to increased rates of cardiovascular disease. [vii]

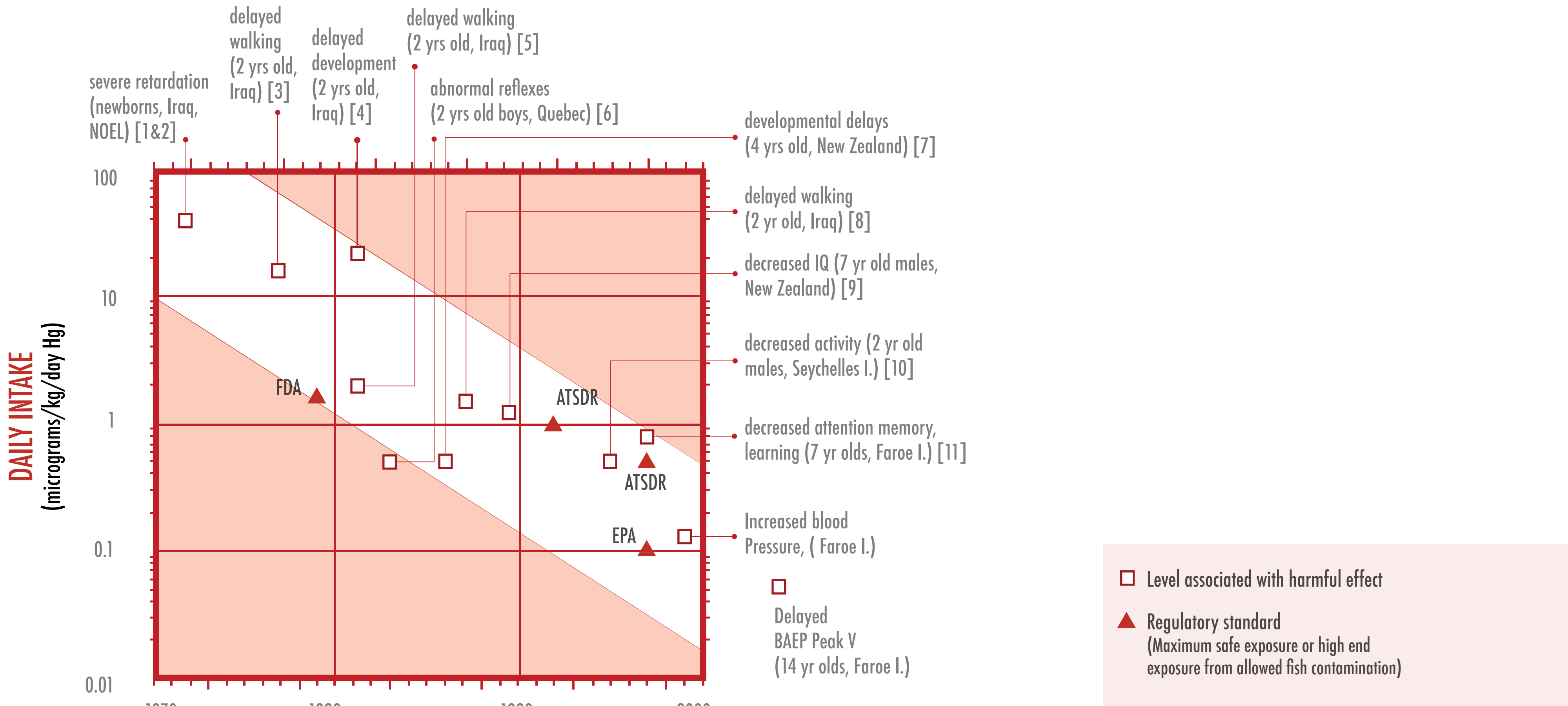
Children and adults who consumed frequent meals of mercury-contaminated fish have experienced adverse effects on mental processes and neuromuscular coordination." [viii] According to the World Health Organization, this includes:

> "...people who are regularly exposed (chronic exposure) to high levels of mercury (such as populations that rely on subsistence fishing or people who are occupationally exposed). Among selected subsistence fishing populations, between 1.5/1000 and 17/1000 children showed cognitive impairment (mild mental retardation) caused by the consumption of fish containing mercury. These included populations in Brazil, Canada, China, Colombia and Greenland." [ix]

The public health challenges posed by methylmercury in fish are complex. While fish consumption provides important nutritional benefits, the risk posed by higher concentrations of mercury in some species is undeniable. Depending on the age, diet and habitat of fish species, their mercury levels may vary by as much as 100-fold. About 70 percent of tested commercially caught fish consumed in the U.S., and a similar fraction estimated in other parts of the world [x] contains relatively low levels of mercury. Long-lived, larger predatory fish such as tuna, swordfish, shark, king mackerel, pike, walleye, barracuda, scabbard, tilefish, orange roughy, and marlin have typically higher concentrations. [xi]

The Table[xii] below (from 2002) reveals historically what was generally considered "safe thresholds" for methlymercury that have been continuously revised downward over time as scientific knowledge advances, and that trend continues. Research carried out over the past decade has found adverse effects of prenatal methylmercury exposure at very low doses, at least an order of magnitude below exposures known to be harmful a decade ago.[xiii] Furthermore, these studies found no threshold level below which prenatal methylmercury exposure has no adverse effects.

Table 1. Exposure risks to methlymercury increasing over time

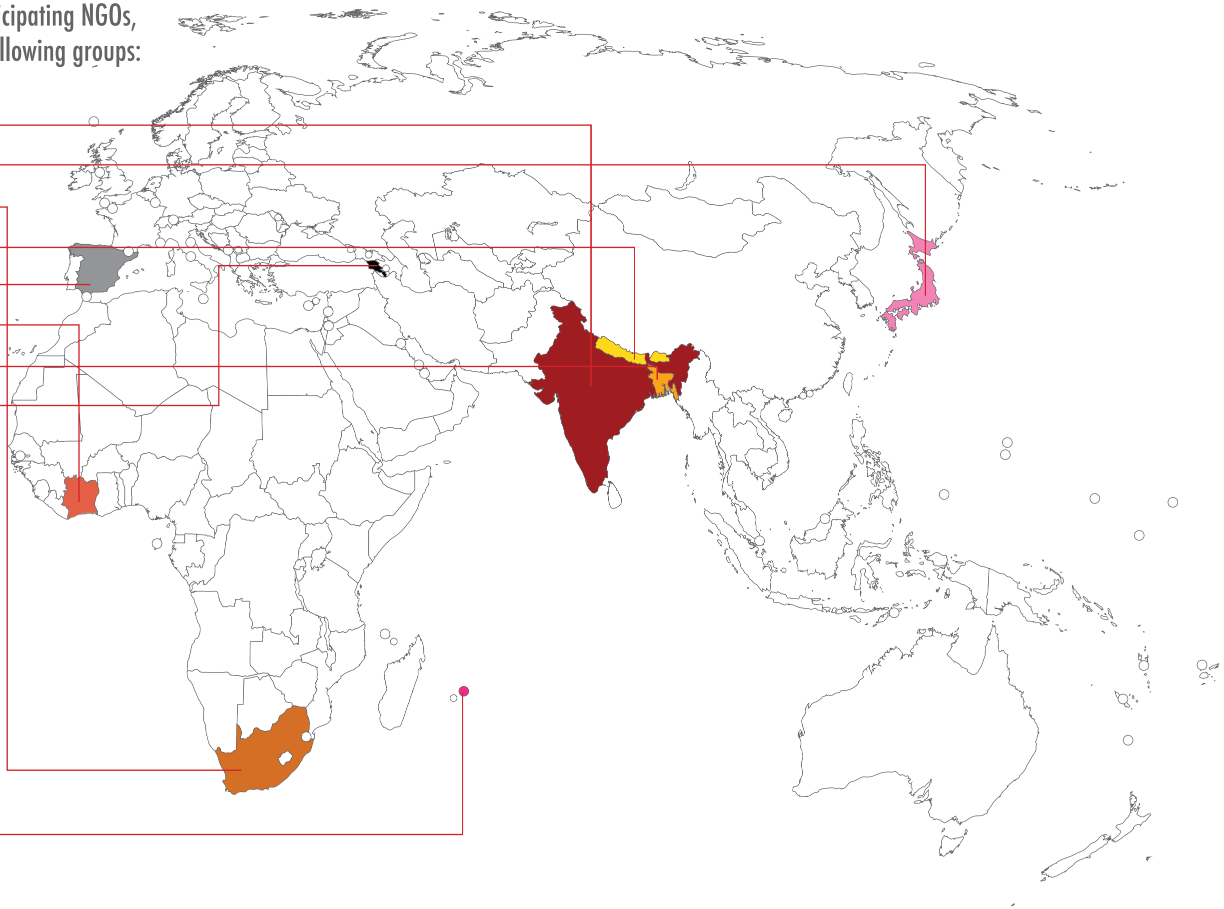


From: In Harm's Way, 2002

3. METHODOLOGY

Selection of countries for sampling mercury levels in hair was based solely on the presence and willingness of civil society non-governmental organizations (NGOs) to participate in the study. Women of childbearing age who were willing to voluntarily donate hair samples were recruited by public interest NGOs with experience in working on social and environmental issues in their countries. Participating NGOs, who are also affiliated with the Zero Mercury Working Group (ZMWG), included the following groups:

1. Toxics Link (India);
2. Citizens Against Chemicals Pollution (Japan);
3. groundWork (South Africa);
4. Center for Public Health and Environmental Development (Nepal);
5. Ecologistas en accion or Ecologists in Action (Spain);
6. Jeunes Volontaires pour l'Environnement (Côte d'Ivoire);
7. Environment and Social Development Organization (Bangladesh);
8. Armenian Women for Health and Healthy Environment (Armenia); and
9. Pesticide Action Network (Mauritius).



Collection sites were widely dispersed around the world, with the numbers on the map corresponding to the country of the NGOs list above.

NGOs were provided with an overview and rationale for the project, and then presented with the protocol for collecting hair samples (*see Annex A*). NGOs were provided with a 3 month time period in mid-2013 for collecting hair samples and asked to seek out women of child-bearing age (between 18-49 years), who ate fish frequently and would be willing to volunteer to participate. Subsequently, some NGOs (but not all) hosted a community event and circulated a notice (*see template for notice in Annex B*) announcing it in advance.

Prior to collecting hair samples, the responsible NGO representative was asked to explain to interested participants the purpose of the mercury hair testing project and also to ascertain that the participant understood the project; that their participation was voluntary; and that all information was to be kept strictly confidential. Before proceeding, participants were asked to sign two informed consent forms (*see Annex C*) agreeing to donate a hair sample to the project. One of the forms was provided to the participant and the other was kept by the NGO.

In addition, participants were asked to respond to a question regarding how much fish they consumed per week over a three-month period, and the recorded response and the coded hair sample were subsequently packaged for mailing to the lab. Participants were informed that, once tested, their hair sample would be destroyed, and that they would be provided with the results of their mercury hair test once the project was completed.

Figure 3. Hair sampling project in Bangladesh by Environment and Social Development Organization.

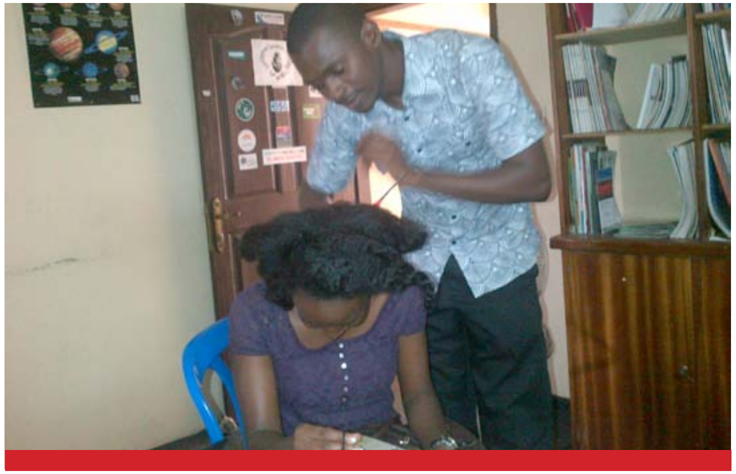


Figure 4. Hair sampling project in Côte d'Ivoire by Jeunes Volontaires pour l'Environnement

Hair samples, along with age and fish intake information, were collected from 220 women who ranged in age from 17 to 53 years. The variation in NGO selection of participants is explained in Table 2.

Table 2. Characterization of the participants and their environment

Country	Selection of participants	Description of participants' living environment	Other notes
Bangladesh	Samples collected from three community meetings	City dwellers and country dwellers	Samples from 3 different locations
India	Individuals selected randomly	City dwellers	Samples from 3 different locations
Côte d'Ivoire	Individuals solicited from NGO list	City dwellers living on the coast	Samples from one city
Japan	Individuals solicited from CACP advertised for individuals to volunteer list	General in Japan	
Mauritius	Samples collected from two community meetings	Villagers living along the coast	Samples from 2 different locations
Nepal	Samples collected from group meeting, individuals	City dwellers	Samples from 1 location
S.Africa	Samples collected from individuals	Majority were city dwellers	Samples from several locations
Spain	Samples collected from pupils of a teacher and her daughter's friends	City and country dwellers	Samples from 1 location

Generally, there was a high level of interest in participation, in some cases with some women asking if their children could also be tested. Of the women approached, the participation rate ranged between 80%-95%.

The hair samples were sent to the University of Southern Denmark's Environmental Medicine laboratory for testing. The protocol utilized by the laboratory was as follows.

> "From the hair samples, 2-cm segments closest to the root (thus representing the exposure during recent months) were cut with laboratory scissors and placed on a micro-scale. Samples of about 20 mg were needed for accurate mercury analysis. After dissolution in nitric acid, measurement of mercury was carried out by amalgamation of mercury vapor on a gold filter followed by atomic absorption detection. Blank samples, standards and reference materials were included in every analytical series."[xiv]

4. RESULTS

Hair mercury concentrations ranged from 0.01 to 8.05 micrograms per gram (µg/g) (median 0.44 µg/g) among all of the countries tested (see results by country in Annex D.) Hair mercury concentrations and fish intake, by country, are summarized in Table 3.

Table 3. Summary of Hair Mercury Concentration and Fish Intake by Country for 220 Women of Child-Bearing Age

	N	Mean	Median	Min	Max	% Results > 1 ug/g	Mean Age	Mean no. fish meals per week
Armenia	25	0.08	0.06	0.01	0.37	0	33.9	1.4
Bangladesh	40	0.45	0.36	0.16	2.12	5	27.2	2.9
India	23	0.23	0.13	0.03	0.97	0	30.9	3.2
Côte d'Ivoire	26	0.90	0.68	0.22	3.20	23	28.4	NA
Japan	24	1.66	1.37	0.60	4.11	71	33.1	2.7
Mauritius	25	1.10	0.76	0.19	8.05	36	34.2	1.6
Nepal	20	0.30	0.25	0.11	1.00	0	28.9	0.4
S.Africa	9	0.37	0.32	0.11	0.98	0	28.7	1.3
Spain	28	1.70	1.45	0.31	6.38	64	37.4	6.7
Total	220	0.78	0.44	0.01	8.05	24	31.4	2.8*

*N = 194

Fish intake was generally determined as the average number of fish meals consumed per week. However, women from Côte d'Ivoire reported the number of hours or days that had elapsed since their last fish meal. Because this data could not reliably be converted to units of servings/week, it was not included in our comparison of fish intake to women's ages or hair mercury concentrations.

5. DISCUSSION

Fish consumption and mercury intake were significantly positively associated with hair mercury. Among the 220 women who participated in this study, 24% had a hair mercury level that exceeded the U.S. Environmental Protection Agency (EPA) guideline level of 1 µg/g. This guideline approximately corresponds to the EPA's reference dose and is intended to be protective against the prenatal neurotoxic effects of methylmercury.[xv]

Of greatest concern were two individuals' results from two different countries with mercury hair concentrations of over 5 ppm; one from Spain and the other from Mauritius.

In 4 of the 9 countries, a significant percentage (defined as more than 20%) of the samples of hair from women of childbearing age exceeded the 1 µg/g U.S. EPA guideline, including:

- 71% of those tested in Japan;
- 64% of those tested in Spain;
- 36% of those tested in Mauritius; and
- 23% of those tested Côte d'Ivoire.

Mercury concentrations were the highest in the wealthier countries. Also noteworthy is that while the number of mean meals per week in Spain were more than double those consumed in Japan, a larger percentage of Japanese women's hair mercury levels exceeded the U.S. EPA guideline. This suggests that the mercury concentrations of the fish consumed in Japan may, on average, be higher than what is consumed in Spain.

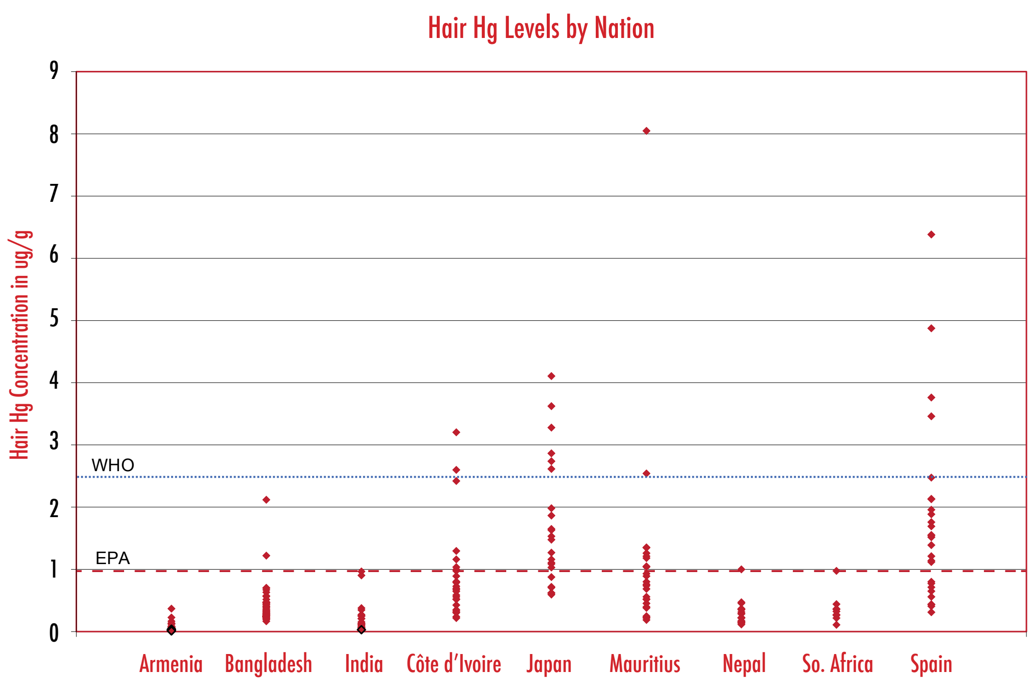


Figure 4. Scatter-plot of hair mercury levels by nation of residence. The U.S. EPA guideline value of 1 µg /g is shown in red, while the WHO guideline value of 2.5 µg/g is shown in blue. 24% and 7% of the hair mercury levels exceeded the EPA and WHO guidelines, respectively.

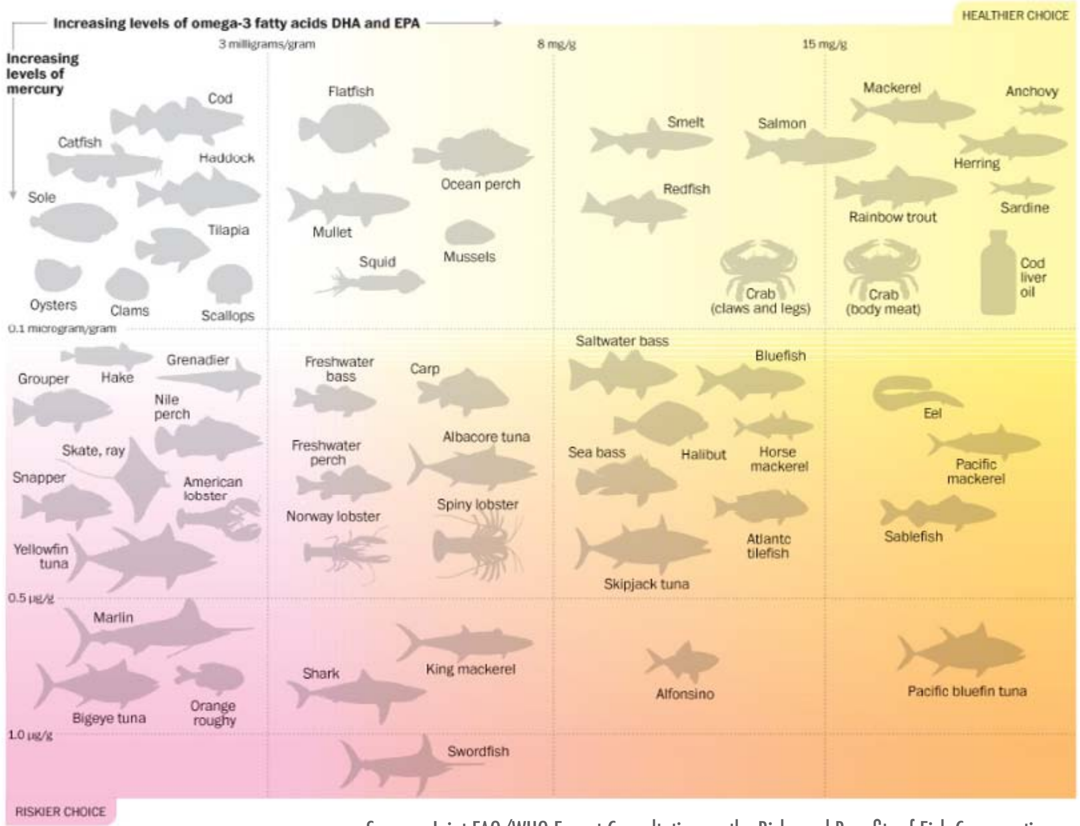
The number of samples that exceeded the U.S. EPA guideline were also significant in two African countries tested: Mauritius and Côte d'Ivoire. Given that these two countries, along with Spain and Japan have long coastal areas, this could also be a factor in the higher percentage exceedence rate of the guideline due to proximity to sea-dwelling species that could have higher mercury concentrations.

In contrast, mercury levels were much lower and samples above the guideline were rare in less wealthy nations such as Bangladesh, Armenia, India and Nepal. These differences are not entirely explained by self-reported fish intake. For example, women whose hair was tested in Bangladesh and Japan reported approximately the same average weekly fish intake, but had very different hair mercury levels suggesting either that the mercury content in the fish eaten in Bangladesh was lower, or that the quantity of fish eaten at each meal was lower there. A possible lower mercury content in the fish eaten could be due to different species consumed such as more predatory species in the countries with higher hair mercury levels or a lower mercury content of the same species but of different geographical origin.

While the study did not seek information on specific fish species, another possible explanation for the lower exposure levels could be due to the likelihood of more frequent intake of less costly freshwater fish as opposed to imported (mainly frozen) seafood in Armenia and perhaps other countries. This would also be consistent with the findings of Mahaffey et al. in 2008, which showed elevated blood mercury levels "occurred more commonly among women of childbearing age (~one in six) living in coastal areas of the U.S." and that "Asian women and higher income women ate more fish and had higher blood mercury levels."[xvi]

Our findings should be interpreted cautiously due to the limited sample size and because the nations and women who participated in this study were not randomly selected to be representative of any geographic region or population. Despite these weaknesses, our results suggest that exposure to methylmercury, the primary form of mercury in the hair, is relatively common in many parts of the world.

Seafood: The choice is yours



Source: Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption. Washington Post, Published on April 2, 2012

6. CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the Zero Mercury Working Group makes the following assessments and recommendations:

1. The U.S. EPA guideline, which was adopted in 2001, is intended to prevent subtle developmental delays that have been linked to prenatal exposure to methylmercury. However, recent scientific evidence suggests that adverse effects on fetal development can occur at levels below the current guideline. If so, our study findings may underestimate the percentage of women in this sample with hair mercury concentrations of concern.

2. Since it may take several years to update existing exposure guidelines to reflect the changing body of epidemiological evidence, an extra degree of caution about prenatal methylmercury exposure is warranted, increasing the urgency of the Convention's objective of reducing anthropogenic mercury emissions. These facts should compel countries to ratify the Convention soon and by 2015 if possible, and to take steps to reduce human exposure to mercury immediately.

3. The primary short-term strategy for reducing methylmercury exposure in people is to reduce frequent consumption of fish with medium and high mercury concentrations. Women who are pregnant or who are planning a pregnancy should include fish in their diets, but they should also be encouraged to select fish that are low in mercury and other contaminants.

4. The situation from country to country is highly variable and seems to be affected by multiple factors, including (as enumerated in the report) amounts of fish consumed, types of fish consumed, access to coastal fisheries, family income, and other things. Countries should therefore conduct their own exposure assessments for mercury and determine levels of human exposure to mercury. Governments should measure concentration of mercury in frequently consumed fish and issue advisories especially to protect women of childbearing age, children and those who eat large quantities of fish.

5. Civil society organizations can play a critical role in helping to identify populations at risk and promoting mercury exposure reduction awareness. It is therefore recommended that civil society groups everywhere be encouraged to conduct similar projects, especially in light of the special access of civil society groups to communities in widely different cultures around the globe.

6. Hair mercury analysis in humans can provide a useful biomarker for mercury exposure. Therefore, it is recommended that the new Convention and the interim Intergovernmental Negotiation Committee process leading up to its ratification should work closely with the World Health Organization in building a global database of mercury levels in human hair in countries worldwide to use as a baseline to evaluate progress in reducing human exposure to mercury over time.

ANNEX A*: Hair sampling protocol

Please carefully read through these instructions before you begin and make sure you have all the necessary materials.

For each individual hair sample, you will need the following

- a small envelope for hair sample
- a large mailing envelope
- a questionnaire (please do not forget to fill it in and include the code number)
- two copies of a consent form (please make sure that the participant signs both copies)

Before collecting the hair sample, please ask the participant to:

1. Answer the question, with the interviewer writing down the response
2. Sign their name to two copies of the informed consent form, with one copy for the participant and the other to be kept on file by the local NGO
3. Take a copy of the "mercury fact sheet," which includes their code number and information on how to contact the local NGO to get hair test

Instructions for obtaining hair sample

The best place to remove hair (the least obvious area) would be in the middle of the back of the head. The sample of hair should be approximately 50 hairs.

If the volunteer has long hair, the sample should be at least 8 cm in length and be about the size of this square:

If the volunteer has short hair, it will be necessary to cut from a larger patch, for example about 2 cm in diameter.

The sample should weigh about 0.50 grams

* This protocol was provided courtesy of the Health and Environment Alliance (HEAL), Brussels, Belgium.

STEP BY STEP INSTRUCTIONS

1. Grasp hair loosely and pull to top or side of head with a hair clip.

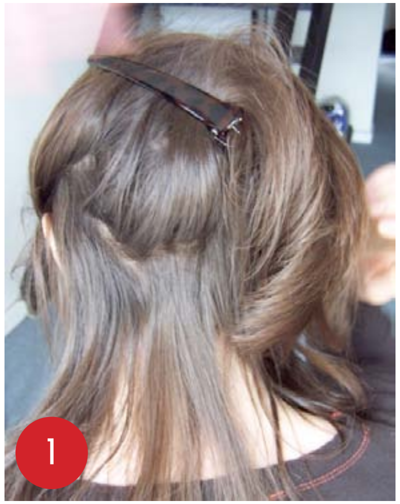
2. Identify sample location and amount of hair to be cut, ideally in the middle of the back of the head close to the neck.

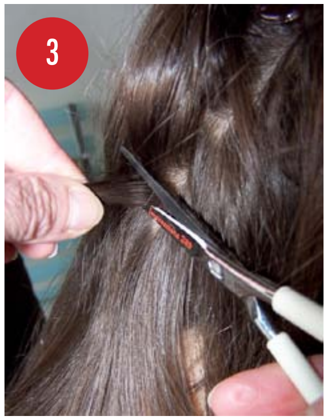
3. Cut sample as close to the scalp as possible. A cotton thread should be wound tightly around the hair sample close to the scalp end so that the first 2-3 cm can be used for the analysis. The hair sample is ideal, because the proximal end of the hair is easily identified (the yellow arrow).

4. Place entire hair sample in a small paper envelope that has individual's code number on it, along with the completed questionnaire from that individual and place both into a bigger envelope for mailing.

   Please label the envelope with the following information:
   Project name or number
   Subject name and/or code
   Date of sampling
   Sampling number (if appropriate)

5. Mail the complete questionnaire and the coded hair sample to the ZMWG, and we will forward it to the lab.





ANNEX B: Draft Notice of Mercury Awareness Raising Event for Women of Childbearing Age

Who: The event will be hosted by [the local NGO] who has worked on reducing mercury pollution and exposure both within the country and globally

What: Information will be presented about young children and women's exposure to mercury and the health risk that it poses. Pregnant women, nursing mothers and young children are most at risk from exposure to mercury, primarily from fish contaminated with mercury. The event will provide important information for parents of young children and women of childbearing age on ways to reduce their exposure to mercury.

When: [Date to be announced]

Where: [Local community hall location to be announced]

Why: Mercury poses a threat both locally and globally. Although mercury is released by natural sources, additional releases from anthropogenic sources have led to increases in environmental deposition and exposure to mercury around the globe. Because mercury is recognized as a global pollutant, the United Nations has recently agreed on a new treaty to reduce mercury exposure internationally. In the coming years, countries around the world will be taking steps to reduce exposure to mercury, and the event being sponsored will contribute to this effort.

Mercury hair sampling event in La Chaux Social Welfare Centre, Mahebourg, Mauritius, 11 June 2013

ANNEX C: Informed consent form

This mercury hair testing project has been explained to me and I voluntarily agree to participate. I give permission to have my hair cut and tested for mercury. I understand that the hair testing data will be kept anonymous.

I have answered the questionnaire regarding my age and fish consumption and have had a chance to ask questions and the responses have been satisfactory.

Should I decide to request my mercury hair testing results, I have been provided with instructions on how to access this information.

______________________ ______________________ __________

Print name | Sign name | Date

Receipt of the signed consent form by the local NGO:

Name : .... Date : ....

Signature : ....

ANNEX D: Mercury hair testing results, by country

Nation	Number	Fish/week	Age	Hair Hg
Côte d'Ivoire	1		24	0.24
Côte d'Ivoire	2		26	0.56
Côte d'Ivoire	3		28	2.60
Côte d'Ivoire	4		27	0.67
Côte d'Ivoire	5		35	0.52
Côte d'Ivoire	6		18	0.65
Côte d'Ivoire	7		21	0.98
Côte d'Ivoire	8		23	0.73
Côte d'Ivoire	9		25	0.52
Côte d'Ivoire	10		38	0.31
Côte d'Ivoire	11		43	3.20
Côte d'Ivoire	12		29	1.00
Côte d'Ivoire	13		29	0.81
Côte d'Ivoire	18		17	1.30
Côte d'Ivoire	19		19	1.04
Côte d'Ivoire	20		25	0.59
Côte d'Ivoire	21		26	0.89
Côte d'Ivoire	22		31	0.33
Côte d'Ivoire	23		27	0.31
Côte d'Ivoire	24		31	1.16
Côte d'Ivoire	25		36	0.35
Côte d'Ivoire	26		33	0.79
Côte d'Ivoire	27		31	0.43
Côte d'Ivoire	28		31	0.70
Côte d'Ivoire	29		30	2.42
Côte d'Ivoire	30		36	0.22
Spain	61	4	43	1.52
Spain	62	8	39	1.54
Spain	63	8	40	0.56
Spain	64	16	37	6.38
Spain	65	16	41	3.76
Spain	66	3	48	0.44
Spain	67	8	38	1.69
Spain	68	8	38	1.14
Spain	69	12	20	0.65
Spain	70	8	40	1.39
Spain	71	4	47	0.71
Spain	72	4	22	0.80
Spain	73	4	19	1.21
Spain	74	8	37	2.48
Spain	75	4	35	0.77
Spain	76	4	43	4.87
Spain	77	4	33	0.44
Spain	78	4	35	2.13
Spain	79	4	36	1.12
Spain	80	4	45	0.31
Spain	81	12	37	3.46
Spain	82	4	34	0.44
Spain	83	4	18	2.13
Spain	84	4	45	1.76
Spain	85	12	35	1.96
Spain	86	1	49	0.41
Spain	89	8	49	1.55
Spain	90	8	43	1.88
Armenia	151	1	36	0.14
Armenia	152	2	20	0.02
Armenia	153	1	47	0.02

Nation	Number	Fish/week	Age	Hair Hg
Armenia	154	1	33	0.07
Armenia	155	1	34	0.13
Armenia	156	3	37	0.01
Armenia	157	2	43	0.07
Armenia	158	1	36	0.03
Armenia	159	2	18	0.08
Armenia	160	1	49	0.09
Armenia	161	1	36	0.12
Armenia	162	1	22	0.03
Armenia	163	4	31	0.23
Armenia	164	2	27	0.05
Armenia	165	1	35	0.03
Armenia	166	2	24	0.04
Armenia	167	1	35	0.01
Armenia	168	1	49	0.05
Armenia	169	1	47	0.06
Armenia	170	1	48	0.06
Armenia	171	1	24	0.08
Armenia	172	1	47	0.17

Nation	Number	Fish/week	Age	Hair Hg
Armenia	173	1	19	0.07
Armenia	174	1	18	0.03
Armenia	175	1	32	0.37
Japan	241	3	35	1.48
Japan	242	3	40	1.63
Japan	243	1	32	0.62
Japan	244	1	31	0.62
Japan	245	2	31	1.65
Japan	246	2	33	0.88
Japan	247	3	31	2.74
Japan	248	4	31	1.16
Japan	249	3	29	1.98
Japan	250	2	34	0.72
Japan	251	1	33	1.86
Japan	252	2	33	3.62
Japan	253	5	39	3.28
Japan	254	2	32	0.71
Japan	255	1	34	1.27
Japan	256	2	31	2.87

Nation	Number	Fish/week	Age	Hair Hg
Japan	257	3	28	0.62
Japan	258	4	35	4.11
Japan	259	1	36	1.11
Japan	260	2	34	2.61
Japan	261	3	33	1.09
Japan	262	10	25	1.53
Japan	263	3	39	1.03
Japan	264	0.5	36	0.60
South Africa	301	1	24	0.11
South Africa	302	3.5	26	0.37
South Africa	303	1	24	0.27
South Africa	304	1	31	0.32
South Africa	305	1	37	0.36
South Africa	306	2	24	0.98
South Africa	307	0.5	37	0.22
South Africa	308	1	24	0.26
South Africa	309	1	31	0.44
Bangladesh	421	4	21	0.28
Bangladesh	422	3	25	0.35

Nation	Number	Fish/week	Age	Hair Hg
Bangladesh	423	3	21	0.19
Bangladesh	424	1	23	0.46
Bangladesh	425	4	22	0.39
Bangladesh	426	4	24	0.27
Bangladesh	427	1	22	0.63
Bangladesh	428	3	23	0.47
Bangladesh	429	3	24	0.70
Bangladesh	430	3	24	0.57
Bangladesh	431	3	19	0.70
Bangladesh	432	2	19	0.20
Bangladesh	433	2	20	0.32
Bangladesh	434	4	23	0.31
Bangladesh	435	4	23	0.44
Bangladesh	436	3	18	0.41
Bangladesh	438	2	22	0.35
Bangladesh	439	4	42	1.22
Bangladesh	440	4	18	0.28
Bangladesh	441	2	22	0.46
Bangladesh	442	2	26	0.16

Nation	Number	Fish/week	Age	Hair Hg
Bangladesh	444	3	53	0.67
Bangladesh	447	5	40	2.12
Bangladesh	448	1	28	0.52
Bangladesh	450	2	25	0.41
Bangladesh	451	2	25	0.24
Bangladesh	453	2	25	0.23
Bangladesh	454	3	28	0.35
Bangladesh	459	4	19	0.47
Bangladesh	460	2	26	0.28
Bangladesh	461	3	28	0.26
Bangladesh	462	3	28	0.26
Bangladesh	463	2	32	0.29
Bangladesh	464	3	20	0.30
Bangladesh	465	4	38	0.26
Bangladesh	466	4	35	0.33
Bangladesh	467	2	28	0.43
Bangladesh	468	3	42	0.37
Bangladesh	469	3	37	0.46
Bangladesh	470	3	51	0.57

Nation	Number	Fish/week	Age	Hair Hg
Mauritius	91	1	37	2.54
Mauritius	92		23	0.93
Mauritius	93	1	45	0.25
Mauritius	94	0.5	21	1.05
Mauritius	95	1.5	48	1.04
Mauritius	96	3	39	0.89
Mauritius	97	1	36	0.80
Mauritius	98	3	28	0.52
Mauritius	99	1	37	1.18
Mauritius	100	0.2	32	0.52
Mauritius	101	1	48	8.05
Mauritius	102	0.5	25	1.26
Mauritius	103	2	24	1.35
Mauritius	104	4	38	0.22
Mauritius	105	4	44	0.38
Mauritius	106	2	30	0.45
Mauritius	107	2	38	1.21
Mauritius	108	1	34	0.69
Mauritius	109	0.6	39	0.19

Nation	Number	Fish/week	Age	Hair Hg
Mauritius	110	1.3	19	0.23
Mauritius	111	1.5	33	0.56
Mauritius	112	2	29	0.40
Mauritius	113	1	30	0.76
Mauritius	114	1	30	0.74
Mauritius	115	1	48	1.35
India	181	1	34	0.12
India	182	1	46	0.07
India	183	2	20	0.05
India	184	2	30	0.06
India	185	2	39	0.21
India	186	2	20	0.07
India	187	2	20	0.03
India	188	3	40	0.12
India	189	3	30	0.09
India	190	1	40	0.13
India	191	7	32	0.90
India	192	4	24	0.25
India	193	4	23	0.25

Nation	Number	Fish/week	Age	Hair Hg
India	194	5	30	0.26
India	195	7	31	0.27
India	196	7	31	0.38
India	197	4	34	0.35
India	198	4	31	0.11
India	199	1	27	0.21
India	200	3	26	0.16
India	201	7	30	0.97
India	202	1	31	0.13
India	203	1	42	0.07
Nepal	126	0.3	29	0.11
Nepal	138	0.3	32	0.14
Nepal	125	0.2	28	0.14
Nepal	132	0.3	33	0.16
Nepal	136	0.2	29	0.16
Nepal	133	0.1	17	0.17
Nepal	139	1	21	0.22
Nepal	127	0.3	31	0.22
Nepal	131	0.3	37	0.22

Nation	Number	Fish/week	Age	Hair Hg
Nepal	129	0.3	35	0.22
Nepal	137	0.1	23	0.28
Nepal	140	0.3	33	0.29
Nepal	124	0.7	35	0.29
Nepal	128	0.3	23	0.32
Nepal	123	0.8	32	0.35
Nepal	134	0.1	20	0.36
Nepal	121	0.4	30	0.37
Nepal	130	0.3	24	0.46
Nepal	135	0.3	32	0.47
Nepal	122	0.3	31	1.00

ENDNOTES

[i] Maag, J., Maxson, P. and Tuxen, A. Global Mercury Assessment, United Nations Environment Program, Chemicals Directorate, UNEP Technology, Industry & Environment Division, Geneva, Switzerland (2002).

[ii] Cone, M., Silent Snow: The Slow Poisoning of the Arctic. Glover PressNY p. 80 (2005), p.45.

[iii] U.S. Environmental Protection Agency, How Mercury Enters the Environment (accessed 15 September 2013) http://www.epa.gov/hg/exposure.htm

[iv] Mergler, D et al, Methylmercury Exposure and Health Effects on Humans: A Worldwide Concern, Ambio Vol.36, No.1 (February 2007); and National Academy of Sciences, Toxicological Effects of Methylmercury, National Academy Press, Washington, DC, International Standard Book Number 0-309-07140-2 (2000).

[v] Bakir F, Damluji SF, Amin-Zaki L. Methlymercury poisoning in Iraq, Science 1973; 180:230-41, Julvez J. et al, Epidemiological Evidence of Methylmercury Neurotoxicity,Chapter 2, Methylmercury and Neurotoxicity, (Eds.) S. Ceccatelli; M. Aschner (2012) XI, 373, p.59, 15 in color., Hardcover ISBN: 978-1-4614-2382-9.

[vi] Written testimony by Philippe Grandjean, MD, PhD, Mercury MACT Rule Hearing
sponsored by Rep. Tom Allen, Maine State House, Augusta, Maine (March 1, 2004).

[vii] Salonen JT, Seppänen K, Lakka TA, Salonen R, Kaplan GA. Mercury accumulation and accelerated progression of carotid atherosclerosis: a population-based prospective 4-year follow-up study in men in eastern Finland. Atherosclerosis. 2000; 148: 265–273.

[viii] Genuis SJ. Toxicant exposure and mental health–individual, social, and public health considerations. J Forensic Sci. 2009;54(2):474-477 doi: 10.1111/j.1556-4029.2008.00973.x. Epub 2009 Jan 31; Hightower JM. Diagnosis Mercury: Money, Politics, and Poison. Washington, DC: Island Press/Shearwater Books;2009; Knobeloch, L., D. Steenport, C. Schrank and H. Anderson (2006), Methylmercury exposure in Wisconsin: A case study series. Environmental Research 101: 113-122; Korns, F. (1972) The Frustrations of Bettye Russow, Nutrition Today, 7(6): 21-23; Risher, J.F. (2004) Too much of a good thing (fish): Methlymercury case study. J Environmental Health 67(1):9-14, 28; Carta P, Flore C, Alinovi R, Ibba A, Tocco MG, Aru G, Carta R, Girei E, Mutti A, Lucchini R, and Randaccio FS, Sub-clinical neurobehaviorial abnormalities associated with low level of mercury exposure through fish consumption. Neurotoxicology (2003) 24(4-5):617-623.

[ix] Mercury and health, Fact sheet N°361, WHO (April 2012) http://www.who.int/mediacentre/factsheets/fs361/en/index.html

[x] Evers, D et al, Report on Mercury in the Global Environment: Patterns of Global Seafood Mercury Concentrations and their Relationship with Humans. Biodiversity Research Institute. (December, 2012)
http://www.zeromercury.org/index.php?...bri-report-mercury-in-the-global-environment

[xi] Report of the Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption, FAO Fisheries and Aquaculture Report No. 978 FIPM/R978(En) (2010).

[xii] Schettler, T et al, In Harm's Way: Toxic Threats to Child Development, A Report by Greater Boston Physicians for Social Responsibility (May 2002); Table updated by Professor Philippe Grandjean, MD. (December 2012)

[xiii] Boucher, O., Jacobson, S.W., et al., 2012. Prenatal methylmercury, postnatal lead exposure, and evidence of Attention Deficit/Hyperactivity Disorder among Inuit children in arctic Quebec. Environ. Health Perspect.120: 1456-61; Freire, C., Ramos, R., Lopez-Espinosa, M.J., et al., 2010.Hair mercury levels, fish consumption and cognitive development in preschool children from Granada,Spain. Environ. Res. 110(1): 96-104; Jedrychowski, W., et al., 2006. Effects of prenatal exposure to mercury on cognitive and psychomotor function in one-year-old infants: Epidemiologic cohort study in Poland. Annals of Epidemiology 16(6): 439-447.Also available as doi: 10.1016/j.annepidem.2005.06.059; Lederman, S.A., Jones, R.L., Caldwell, K.L., Rauh, V.,Sheets, S.E., Tang, D., et al., 2008. Relation between cord blood mercury levels and early childhood development in a World Trade Center cohort. Environ.Health Perspect. 116, 1085-1091; Murata, K., Weihe, P., Budtz-Jørgensen, E., Jørgensen,P.J., and Grandjean, P., 2004. Delayed brainstem auditory evoked potential latencies in 14-year-old children exposed to methylmercury. J. Pediatrics 144: 177-183; Oken, E., Wright, R.O., Kleinman, K.P., Bellinger, D Amarasiriwardena, C.J., Hu, H., et al., 2005. Maternal fish consumption, hair mercury, and infant cognition in a U.S. cohort. Environ. Health Perspect. 113, 1376-1380; Oken, E., Radesky, J.S., Wright, R.O., Bellinger, D.C., Amarasiriwardena, C.J., Kleinman, K.P., et al., 2008. Maternal fish intake during pregnancy, blood mercury levels, and child cognition at age 3 years in a US cohort. Am. J. Epidemiol. 167, 1171-1181; Sagiv, S.K., Thurston, S.W., et al., 2012. Prenatal exposure to mercury and fish consumption during pregnancy and Attention Deficit/Hyperactivity Disorderrelated behavior in children. Archives of Pediatric andAdolescent Medicine. Published online: http://doi:10.1001/archpediatrics.2012.1286; http://archpedi.jamanetwork.com/article.aspx?articleid=1377487; Suzuki, K., et al. (2010), Neurobehavioral effects of prenatal exposure to methylmercury and PCBs, and seafood intake: Neonatal behavioral assessment scale results of the Tohuku study of child development. Environmental Research 110:699-704.

[xiv] Personal communication from Professor Philippe Grandjean, MD (12 September 2013)

[xv] US Environmental Protection Agency, Reference Dose (RfD): An estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark dose, with uncertainty factors generally applied to reflect limitations of the data used. Generally used in EPA's noncancer health assessments. (Accessed 15 September 2013) http://www.epa.gov/hg/exposure.htm

[xvi] Mahaffey, et al, Adult Women's Blood Mercury Concentrations Vary Regionally in the USA: Association with Patterns of Fish Consumption (NHANES 1999-2004), Environmental Health Perspectives, (25 August 2005)

Zero Mercury Working Group
c/o European Environmental Bureau
34, Boulevard de Waterloo
B-1000, Brussels, Belgium
www.zeromercury.org