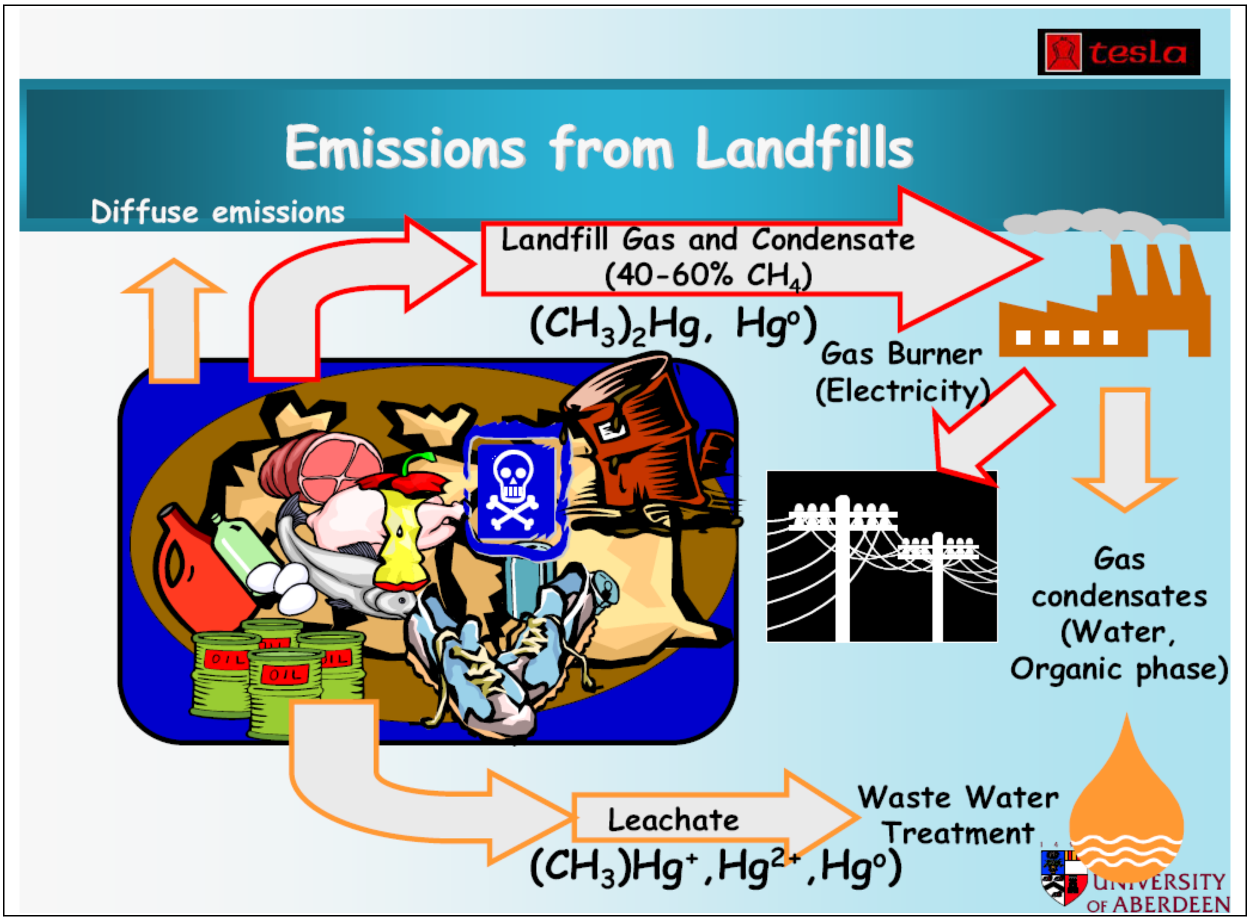
United Nations Environment Programme

# Management of Mercury and Mercury-Containing Waste

## Final Project Report




**UNEP/DTIE**
**Chemicals Branch**
**June 2010**

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Photo on title page: Courtesy of Dr. Jörg Feldmann, Trace Element Speciation Laboratory (Tesla), University of Aberdeen

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# Mercury Waste Management Project

# Final Report

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# Abbreviations and Acronyms

| | |
|---|---|
| Ar | Argon |
| ASGM | Artisanal small-scale gold mining |
| BAT | Best available techniques |
| BKF | Burkina Faso |
| CHL | Chile |
| CV-AFS | Cold-vapor atomic fluorescence spectrometry |
| ESM | Environmentally sound management |
| HCl | Hydrochloric acid |
| Hg | Mercury |
| $Hg^{2+}$ | Mercury ion |
| HgLab | Mercury laboratory |
| GC | Governing Council (of UNEP) |
| $H_2O$ | Water |
| $HNO_3$ | Nitric acid |
| INC | Intergovernmental negotiating committee |
| IC | International Consultant |
| ICP-MS | Inductively coupled plasma-Mass spectrometry |
| KHM | Cambodia |
| $MeHg^+$ | Methylmercury ion |
| MOE | Ministry of Environment |
| NGO | Non-governmental organisation |
| PAK | Pakistan |
| PHL | Philippines |
| SBC | Secretariat of the Basel Convention |
| Sn | Tin |
| $SnCl_2$ | Tin chloride |
| SOP | Standard operational procedure |
| SSFA | Small-scale funding agreement |
| T-Hg | Total mercury |
| TESLA | Trace Analytical Laboratory of Aberdeen University |
| UN | United Nations |
| UNEP | United Nations Environment Programme |

| | |
|---|---|
| UNITAR | United Nations Institute for Training and Research |
| WHO | World Health Organisation |
| yr | Year |

**Units**

| | |
|---|---|
| kg | kilogram |
| g | gram |
| mg | milligram |
| µg | microgram |
| ng | nanogram |
| mL | milliliter |
| µL | microliter |
| $m^3$ | cubic meter |
| ppm | parts-per-million |

# Summary

This 5-country project on “Mercury Waste Management” was implemented from 5 November 2008 until 30 June 2010. The project included four countries – Burkina Faso, Cambodia, Pakistan and Philippines - that were financed by the Government of Norway. The participation of Chile was made possible with funds from the Mercury Trust Fund.

This project deals with the management of mercury and mercury-containing waste and will contribute to the UNEP priority area on harmful substances and hazardous waste under its Medium Term Strategy with the ultimate goal of minimizing the impact of harmful substances and hazardous waste to the environment and human beings.

The objectives of this project were to address mercury issues where mercury in any of its forms – metallic or ionic – enters the waste stream. All participating countries had developed initial mercury inventories, which were taken as a starting point. The inventories were further refined and the applicability of the Draft Basel Technical Guidelines on the Environmental Sound Management of Waste Consisting of Mercury, Containing or Contaminated with Mercury was tested.

The project was successfully implemented and resulted in waste management plans in five countries in all five countries. The project started and was concluded with two “global” workshops where a common workplan was agreed at the onset of the project and finally the results were presented and discussed in context. The plans constitute an initial step for national action identified as priorities through stakeholder consultations and underlined through analysis of relevant samples for total mercury content. Typically, countries have identified three priorities for mercury waste management that warrant further action. Most plans include components that a country can resolve at national level, others need international support. In general, governments are faced with the assessment of all steps in the mercury life-cycle from source identification and quantification to final disposal whereby the options and criteria for the long-term safe disposal for waste consisting of elemental mercury, waste containing or contaminated with mercury need to be defined.

An additional component of this project has supported countries in their technical capacity to carry out field work, and collect environmental samples (including human hair) to determine the concentrations of mercury at selected sites. Preliminary analytical results have provided countries with an indication of potential hot spots or sources that need specific environmental management practices aimed at risk reduction. However, in some cases the technical and analytical infrastructure is quite limited and not sufficient to conduct comprehensive field studies and sampling activities. In such cases, countries relied on external support to obtain data and analytical results.

Issues for future work under action plans, include:

(a) Further reviews of the national mercury emissions inventory;

(b) Analysis and update of existing regulation for mercury and mercury waste;

(c) Promote a mandate for shared responsibility and cooperation among institutions

(d) Develop and implement national guidelines for mercury waste management (e.g. by taking advantage of the BC technical guidelines for mercury waste);

(e) Build/strengthen institutional capacity and infrastructure for mercury waste management;

(f) Develop and implement risk communication programmes and awareness raising activities;

(g) Leverage resources for the implementation of activities under national action plan for mercury waste, and

(h) Promote cleaner production schemes and other voluntary schemes with the industrial sector, among others.

These preliminary actions were fundamental to move forward and develop a national action plan for mercury and mercury waste. While countries participating in this project show several differences in mercury issues within the national context, several elements of the action plans appeared to be shared by all countries. One of the main aspects that are incorporated in these plans is the need to assess and review existing legislation on chemicals and hazardous waste management. This is a necessary step that should be followed by an in depth analysis aimed to identify and cover gaps, to later ensure that mercury and mercury waste are covered under national environmental legislation with a life cycle approach.

# 1 INTRODUCTION

Governments initiated partnership activities addressing mercury at Governing Council 23 and have subsequently strengthened the role of partnerships to effectively deliver mercury activities. Governing Council 25/5 specified the UNEP Global Mercury Partnership as one of the main mechanisms for the delivery of immediate actions on mercury during the negotiation of the global mercury convention.

Scientific evidence of mercury accumulation in the environment has been available for well over a century. It has been well documented that the exposure of people to mercury poses serious health risks. Once released in the atmosphere or released through river systems and watersheds, mercury can travel hundreds and thousands of miles and accumulates in the food chain, with potentially serious effects for people far from the source. The only way to limit these effects from mercury, and to ensure that mercury is not affecting environmental sustainability, is to decrease or eliminate releases of mercury from our activities now. The measures necessary to deal with mercury are many and varied – some require us to work together while others may be things that each of us needs to do individually. Some measures will be implemented through legal obligations and others may be more practically implemented through a cooperative approach.

The management of mercury and mercury-containing waste is the last step in the product life-cycle. The elimination of mercury in products and processes may be the most efficient way to avoid the presence of any form of mercury in waste. While mercury is being phased down from products and processes, there is still a need to manage mercury from this end of the product life-cycle. This project is included into the business plan of the Waste Management Partnership Area.

UNEP/DTIE Chemicals Branch is executing the project "Management of Mercury and Mercury Containing Waste" with the objective to increase the capacity of developing countries and other stakeholders in assessing, managing, and reducing the risks to human health and the environment posed by mercury and mercury-containing waste. The Norwegian Government is funding this project, which will be implemented in Burkina Faso, Cambodia, Pakistan, and the Philippines. Chile is also participating through additional funds from the UNEP Mercury Programme.

The project's activities will build upon the national mercury inventories the participating countries had already developed. Another important element in the project will be the testing of the Draft Technical Guidelines on the Environmentally Sound Management of Mercury Waste developed by the Secretariat of the Basel Convention.

The components of this global mercury waste management project can be briefly summarized as follows:

1. Review of quantitative and qualitative data from the national inventory for mercury sources;
2. Prioritization of mercury sources and the corresponding sectors;
3. Development of a national mercury waste management plan;
4. Environmentally sound management (ESM) application in selected sources and sectors;
5. Sampling and mercury analysis of environmental and human samples; and
6. Final national reports and final project report (including evaluation and lessons learned).

# 2 Institutional Arrangements

This global project on mercury waste management was implemented by the United Nations Environment Programme (UNEP), Chemicals Branch of the Division of Technology, Industry and Economics (DTIE).

The project was implemented at a global level, whereby funding was directed towards the five participating countries at equal level to allow implementation of the national activities, towards an experienced mercury laboratory for the analysis of national samples form developing countries, towards an International Consultant to assist the participating countries as well as UNEP with expertise in the project. Two global workshops, one at the onset of the project and a final results workshop were funded as well. The activities, main actors together with the dates of implementation are detailed in Chapter 5 - Chemical Analysis of Mercury.

The total project costs were USD 430,000 from the Government of Norway with additional USD 50,000 from the Mercury Trust Fund to allow the participation of Chile and USD 43,000 for the organization of the final results workshop. The project had substantial in-kind contribution from all participating countries, the International Consultant and the Expert Laboratory, the Secretariat of the Basel Convention, and UNEP Chemicals, which has not been budgeted.

The project was implemented from 5 November 2008 until 30 June 2010.

Participating countries and institutions included:

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# 3 Related or Complementary Activities

## 3.1 Intergovernmental Negotiations for Legally Binding Instrument on Mercury

With GC decision 25/5 III, adopted on 20 February 2009, UNEP agreed to elaborate a legally binding instrument on mercury (Chemicals management, including mercury). The GC requested the Executive Director of UNEP to convene an intergovernmental negotiating committee (INC) with the mandate to prepare that instrument, commencing its work in 2010 with the goal of completing it prior to the twenty-seventh regular session of the Governing Council/Global Ministerial Environment Forum, in 2013.

Five meetings of the INC are scheduled as follows:

| | | |
|---|---|---|
| INC1 | 7-11 June 2010 | Stockholm, Sweden |
| INC2 | 24-28 January 2011 | Tokyo, Japan |
| INC3 | 31 October – 4 November 2011 | (Africa) |
| INC4 | June 2012 | (Montevideo, Uruguay |
| INC5 | (4-8 or 18-22 February) 2013 | TBD<br>(just before GC27, end of February) |
| Diplomatic Conference | 3rd quarter 2013 | (still to be identified) |

At the talks, governments from around the world will begin a formal process to address the need to protect human health and the global environment from the serious, adverse effects of mercury and its compounds through legally binding obligations.

The instrument is to be a comprehensive and suitable approach to mercury, which will cover supply and storage, demand for use in products and processes, international trade, atmospheric emissions, waste and remediation of contaminated sites, increasing knowledge, capacity building and technical and financial assistance and compliance. Substantive articles may include the following:

1. The objectives of the instrument
2. To reduce the supply of mercury and enhance capacity for its environmentally sound management
3. To reduce the demand for mercury in products and processes
4. To reduce international trade in mercury
5. To reduce atmospheric emissions of mercury
6. To address mercury-containing waste and remediation of contaminated sites
7. To increase knowledge through awareness-raising and scientific information
8. To specify arrangements for capacity-building and technical and financial assistance, recognizing the ability of developing countries and countries
9. To address compliance

Further reading:
http://www.unep.org/hazardoussubstances/MercuryNot/MercuryNegotiations/tabid/3320/language/en-US/Default.aspx

## 3.2 Global Mercury Partnership

The Global Mercury Partnership is the primary vehicle for immediate action on mercury, contributing to the overall global mercury solution. The importance and urgency of immediate actions on mercury through the Global Mercury Partnership is clearly recognized by the UNEP Governing Council.

Partnership activities have been on-going since 2005; the Global Mercury Partnership was formalized through the development of the Overarching Framework in 2008, following extensive consultation with partners and stakeholders, and now operates through seven partnership areas that reflect the major mercury source categories.

The Partnership currently has seven identified Priorities for Action (or partnership areas) that are reflective of the major source categories:

- Reducing Mercury in Artisanal and Small-Scale Gold Mining
- Mercury Control from Coal Combustion
- Mercury Reduction in the Chlor-alkali Sector
- Mercury Reduction in Products
- Mercury Air Transport and Fate Research
- Mercury Waste Management
- Mercury Supply and Storage

It is clear that there are many important and strategic on-going actions that are contributing to the reduction of mercury in the environment today. The Global Mercury Partnership is implementing pilot projects, encouraging innovation, building scientific and guidance materials as well as raising awareness.

Further reading:
http://www.unep.org/hazardoussubstances/Mercury/GlobalMercuryPartnership/tabid/1253/language/en-US/Default.aspx

## 3.3 Mercury-related Issues under the Basel Convention

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal establishes a global framework for the control of transboundary movements of hazardous wastes and other wastes as well as for the environmentally sound management (ESM) of such wastes, including hazardous waste and other waste generated at the national level. The main principles guiding the implementation of the Basel Convention are *i)* transboundary movements of hazardous wastes should be reduced to a minimum consistent with their ESM; *ii)* the generation of hazardous waste should be reduced to a minimum; *iii)* hazardous wastes should be treated and disposed of as close as possible to their source of generation.

In the last decade, the norm-creating process on ESM has received increasing attention. Technical guidelines for the ESM of various waste streams have been developed. These documents have a special value since they were not only developed by highly specialized experts from various countries, organizations, the private sector and the civil society represented in the technical working groups, but were also later adopted by the Conference of the Parties to the Basel Convention.

Mercury under the Basel Convention is listed under Y29 in Annex I to the Basel Convention. In addition, mercury wastes are also covered in Annex VIII under the following codes:

A1010 metal and metal-bearing waste;

A1030 wastes having as constituents or contaminants of mercury and mercury compounds;

A1180 waste electrical and electronic assemblies or scrap containing components such as mercury switches or contaminated with mercury;

By its decision VIII/33, the eighth meeting of the Conference of the Parties (COP-8) agreed to include a new Strategic Plan focus area on mercury wastes. Under the mercury waste programme, COP8 instructed the Secretariat, in cooperation with UNEP, to:

i) develop partnerships around the theme of environmentally friendly technologies and awareness raising regarding avoidance, use and disposal of mercury wastes;

ii) develop capacity-building and technical assistance programmes to reduce and prevent pollution from mercury;

iii) develop guidelines on ESM of mercury wastes with emphasis on the development of sound disposal and remediation practices.

Following the Basel Convention's COP-8 decision VIII/33, UNEP Chemicals and the Secretariat of the Basel Convention have developed a work plan comprised of the following two components:

Component I: To develop and finalize draft texts for the technical guidelines on the Environmentally Sound Management (ESM) of mercury wastes in close consultation with the Open-ended Working Group of the Basel Convention; and

Component II: Implementation of pilot projects on Environmentally Sound Management (ESM) of mercury wastes in selected countries.

The Technical Guidelines on the Environmentally Sound Management of Mercury Wastes will provide guidance to Parties and other stakeholders on the ESM of mercury containing waste, including sources and types of mercury waste, chemical analysis of mercury in waste, ESM criteria and practices, a legislative and regulatory framework, prevention and minimization, handling, collection and transportation, treatment and recovery processes, long-term storage and disposal of mercury waste, remediation, public awareness and participation and policy development. A first draft version of the Technical Guidelines on the Environmentally Sound Management of Mercury Wastes was presented for consideration by the Open-ended Working Group of the Basel Convention at its sixth meeting (OEWG-6) in September 2007 in Geneva. As of June 2010, under the leadership of the Government of Japan, the fifth draft of the Technical Guidelines for the Environmentally Sound Management of Wastes Consisting of Elemental Mercury, Containing or Contaminated with Mercury was developed with contributions by interested stakeholders (see http://www.chem.unep.ch/mercury/Sector-Specific-Information/Docs/waste/Basel_wastes_010110.doc ). The review process is ongoing with the objective of submission to COP-10, tentatively scheduled for October 2011.

# 4 GLOBAL WORKSHOPS AND BASELINE AT PROJECT START

At the start of the project and close to the project's termination date, two global workshops were held to bring together all participating countries. Also present were the mercury expert laboratory and the international consultant in order to learn to know each other, facilitate good information exchange and smooth implementation of the project. Further, the face-to-face meetings were very much appreciated to establish networks and a "family feeling" among countries and staff with similar problems.

## 4.1 Inception Workshop, March 2009

The inception workshop took place from 4 to 6 March 2009 at the City Angkor Hotel in Siem Reap, Kingdom of Cambodia. The workshop was organized by the Ministry of Environment, Government of Cambodia. The objective of the workshop was to bring together all participating countries, the international consultant and the back-up expert laboratory to set a common basis for the execution of the project. The inception workshop reached its objectives and all participants welcomed the opportunity to learn to know each other better in a face-to-face meeting, to discuss details of the project implementation, and to agree on a workplan and a timetable.

The countries presented their baseline assessment as a starting point for the project; *i.e.*, their national mercury release inventories. The aggregated results in terms of total releases but also normalized to population equivalent (*per capita*) to allow some comparison between countries is shown in Table 4-1.

Table 4-1: Summary of mercury emissions presented as national totals and *per capita* equivalents

| | Burkina Faso | Cambodia | Chile | Pakistan | Philippines |
|---|---|---|---|---|---|
| Min (kg Hg $yr^{-1}$) | | 769 | 361,007 | 10,842 | 133,856 |
| Max (kg Hg $yr^{-1}$) | 4,498 | 14,845 | 416,821 | 36,898 | 234,031 |
| Population (*mio) | 15.26 | 14.24 | 16.7 | 172.8 | 94.0 |
| Min (g Hg $person^{-1}$ $yr^{-1}$) | 0 | 0.05 | 21.62 | 0.06 | 1.42 |
| Max (g Hg $person^{-1}$ $yr^{-1}$) | 0.29 | 1.04 | 24.96 | 0.21 | 2.49 |

## 4.2 Final Workshop, June 2010

The final workshop took place from the $21^{st}$ to $23^{rd}$ of June 2010 at the King's College of the University of Aberdeen (Scotland, UK). The workshop included a laboratory visit at the Trace Element Speciation Laboratory Aberdeen (TESLA) and a demonstration of trace analysis of mercury in hair. The objectives of the workshop were to report country specific activities during the project, to discuss the sampling strategies to assist the assessment of mercury related activities and their implementation into a national waste management plan, and to provide an insight into the analytical chemistry involved in trace mercury analysis of biological and environmental samples.

Each participating country (excl. Burkina Faso, who could not attend due to visa problems) presented the outcomes describing their activities during the duration of the project related to the assessment of a country-specific mercury inventory. The countries provided the mercury expert laboratory with a series of samples listed above. The sampling strategies and the analytical data were presented and their interpretation was discussed. The practical part of the workshop included the visit of TESLA, where the theoretical and practical aspects of sample preparation and analysis using “high end” state of the art analytical methodologies, as well as field-deployable and affordable methods were discussed and demonstrated. Finally the participants presented their national waste management plans with regards to mercury and mercury-related waste and their mitigation strategies. The international consultant reflected on the activities of the individual countries, put them into an international context and discussed the lessons learnt from this project.

# 5 CHEMICAL ANALYSIS OF MERCURY

## 5.1 Sampling strategies

In order to assess mercury release into the environment and the extent of mercury exposure of people, the participating countries were given the opportunity to analyze biological and/or environmental samples for their mercury concentration. The budgetary limitations did not allow for a full quantitative assessment of the nation-wide mercury inventory, and an assessment of the exposure of people working or living in potential hot spots of mercury contamination. The sample amount was restricted to less than 72 samples for an entire country, therefore careful planning of the sampling strategy was needed in order to maximize the utilization of the results for identification of potential contaminations and related potential health risks.

Each country involved has decided on different strategies, all valid in their own right and focused on dedicated subjects. While some have focused on particular hot spots, others wanted to generate some baseline values which would have covered the major potential sources of mercury and mercury containing waste.

### 5.1.1 Thorough investigation of one potentially mercury-related contamination source

Chile has identified a major mercury containing waste stream (mining waste generated by small and large gold mines) and wanted to identify the extent of mercury contamination and the homogeneity of a typical waste dump in a residential area. The dump contained waste from different gold mining activities, which potentially stretched over more than several decades or even centuries. It was important to thoroughly identify the stratification of the waste and the homogeneity of the waste dump surface. Several sample cores were taken from the waste dump in order to gain stratification information which indirectly may give information of two processes. At first the waste can be characterized with respect to its mercury concentration from the different phases of the gold mining operations, and secondly the mercury mobilization on the surface of the dump may have lead to potentially smaller concentration on the surface compared to the core of the dump. The rational of sampling the soil surface with a tight grid was in this case the potential exposure risk of people living near the dump since the surface was bare soil surface without vegetation and wind can re-suspend soil particles into the atmosphere. Major concern was whether or not local residents may have been exposed to elevated mercury due to the exposure to the surface soil. It is important to illustrate whether mercury is mobilized on the surface or not and this may be deduced from the topographical information of the sampling location and the mercury concentration in the surface soil. Furthermore, Chile provided 1 kg of each sample, which was milled and homogenized. It can be described as a pooled sample, which is representative for the sampled soil. This reduces the variability and reduces the number of analysis significantly.

In order to sample one dump thoroughly, the Chilean Government may use the data to identify not only a potential source of mercury but can identify environmental processes surrounding this mercury source. In follow-up studies, the knowledge gained from this sampling exercise may assist in the risk assessment of other mining dumps using less tight sampling grids, thus reducing the amount of analyses required.

### 5.1.2 Thorough investigation of mercury exposure near a mercury source

The countries Burkina Faso and Pakistan have identified the baseline assessment of major potential mercury sources in their countries and focused on identification of the extent of the mercury exposure to people. A direct measure of mercury exposure is the concentration of mercury in blood, since this is the proportion of mercury which is cycling through the body and thus can interact with the biological system at the moment of sampling. This methodology is excellent when short term exposure needs to be investigated. Mercury in blood is however subject to variation with time of the exposure, especially in the case of a single exposure event, and can therefore only deliver a snapshot of mercury exposure of the individual. Where information concerning long-term exposure of people is concerned, blood sampling would need to be replicated very often for one person. Therefore, this approach is not applicable for this exercise. Another problem with blood sampling is that it is invasive and can often only be done by nurses and medical doctors, thus raising the cost for sampling personnel. Additionally, the administration regarding storage and transport of samples increases vastly, since blood is a potential carrier of infectious diseases. The fact that mercury in the form of methylmercury is not released into the urine but rather excreted into keratinous tissue makes sampling of hair and nail ideal tissues to assess direct and long-term exposure to mercury. Sampling a certain length of hair gives a more integral value (long-term effect) of mercury exposure, and in addition, spatially resolved mercury determination in a length of hair may give information about the variability of mercury exposure in time. Furthermore, the analysis of hair is easier, since hair concentrations are at least two orders of magnitude higher than mercury concentrations in blood.

Burkina Faso addressed the question whether the workers in an ASGM are more exposed to mercury than the people living in the vicinity of the mines. This was addressed by sampling the hair of more than 30 people of which ⅔ were working in the mines and ⅓ was not directly exposed to mercury during the day. Since individual differences in working tasks and life style have an influence on the mercury in hair, at least more than ten people needs to be sampled to gain the statistical power to compare the two groups of people.

Pakistan had more samples to be analyzed and was able to study the exposure of workers at different potential sources such as dental clinics and chlor-alkali plants. Again, in order to have statistical power, the hair of at least ten people was sampled per group of people and compared them with control groups. Control groups are necessary in order to assess the baseline exposure to mercury excluding occupational exposure. Since relevant control groups are difficult to find, questionnaires were used to identify potential mercury sources of the volunteers such as number of amalgam fillings, rice and marine fish consumption per week, smoking and age and occupational tasks related to potential mercury exposure.

### 5.1.3 Identification of exposure pathways

This approach was partly taken by Cambodia when they wanted to answer the question whether or not the people working in the ASGM sector are exposed to volatile mercury and its proportion of bioavailability. One disadvantage to use hair as a sample tissue to assess mercury exposure directly is the fact that mercury in hair cannot only be the result of mercury inhalation or ingestion with subsequent accumulation in the keratinocytes of the hair. Mercury in hair can also result from direct exposure to elemental mercury vapor, which might be bioavailable by inhalation but might also be directly accumulated externally. If people are potentially exposed to elemental mercury vapor it would be advisable to identify whether this is the case by sampling unexposed keratinous tissue such as toe nails (assuming people wearing shoes while working). Cambodia chose to look at hair and nail samples from 12 volunteers living and working in the ASGM. The sample set made it possible to identify the importance of potentially external mercury accumulation in some volunteers. Nail is similar to hair easy to sample and is not considered as infectious tissue, hence it limits the administration of sample storage and transport. Furthermore, hair and nail give average integral concentrations, which may be termed as pooled sample rather than snapshots which reduce the sample numbers significantly.

### 5.1.4 Identification of potential mercury sources

If the extent of mercury contamination at the different potential sources is known, the first step would be a screening analysis in which samples are taken and then pooled to get an average mercury concentration which would indicate elevated mercury concentration without extensive sample acquisition and analysis. Cambodia used this approach to identify the extent of mercury release into the public drainage system of the capital from potential sources such as hospitals and dental clinics. Instead of sampling individual sewage waters, the sludge samples were taken from the drainage system at different points from the potential sources. This has the disadvantage that no direct inventory can be made for the potential mercury sources since no knowledge is available what is transported as soluble/colloidal mercury in the water and what is the contribution of each individual source over time. The advantage of taking sludge from the drainage system is that sludge is a sink of mercury due to the chemistry of mercury in a sulphur-rich anaerobic sewer. Mercury becomes easily immobilized due to its insolubility of mercury sulphide. Sampling sludge from the drainage system gives not only an average of the different sources but also an average over time, which is for the establishment of baseline values essential. Cambodia sampled sludge at different points of the drainage system near potential mercury sources at three different points in order to address the heterogeneity of the sludge. Furthermore, Cambodia investigated the mercury of the different waste products from ASGM and municipal waste dumps by taking “topsoil” samples.

In conclusion, all countries asked different questions which can be answered by taking a very selective suite of samples which help them to assess the exposure of people to mercury in their country, identifying important environmental processes in mercury distribution of mercury-containing waste and establishing baseline values for the different sources of mercury release.

### 5.1.5 Lessons to be learnt from the sampling exercise

In order to minimize the number of samples it is important to identify the aim of the analysis and to exactly define the question, which should be answered by the analytical data. Emphasis should be laid on the identification of the statistical power needed to answer the question and to think about pooled samples which give an average value over time and space rather than gaining detailed information. It is important to follow the sampling protocol to minimize problems with the analysis. It is also important to take samples, which are relevant but also easy to administer (easily stored, stable samples, homogenous, small sample size preferred and easy to get to, and also easy to transport to different countries including legal import/export conditions, minimizing costs by sending small and lightweight sample volumes).

## 5.2 Analytical methodology and analysis performed

### 5.2.1 Analytical procedures

The samples were analyzed according to SOPs for the different matrices (procedures can be found in the annex). Briefly, hair and nail samples were weighed and then washed before digestion using conc. nitric acid, while sludge and soil samples were directly digested in conc. nitric acid using microwave-assisted heating without any pre-treatment. Aim of this sample preparation is to transfer all molecular forms of mercury into $Hg^{2+}$ and bring all mercury in solution. All samples were digested two or three times (duplicate or triplicate).

As analytical procedure, mainly cold-vapor atomic fluorescence spectrometry (CV-AFS) was used to determine the mercury concentrations in the digests. Every digest was measured three times, resulting in 6 to 9 measurement per sample. The instrument was calibrated daily before and after a series of measurement. For method validation, Inductively Coupled Plasma- Mass Spectrometry (ICP-MS) was used on selected samples. The same measurement procedure was applied as for CV-AFS, daily produced calibration standards run before and after a set of samples.

### 5.2.2 Quality controls

The calibration solutions were made from certified mercury solution standards and parallel to every batch of samples QC samples were measured in order to determine the accuracy of the analysis. In order to validate the method for accuracy and precision, spiked samples were analyzed for total mercury. After the digestion, three subsamples were analyzed: one without spike, one spiked with a known amount of inorganic mercury (from 100 µg/kg $Hg^{2+}$ solution) and one spiked with a known amount of organic mercury (from 100 µg/kg $MeHg^{+}$ solution). Each subsample was analyzed in triplicate and the values obtained for the spiked samples were compared with that obtained from the non spiked one. Additional certified standard reference materials (NIES No 13 & IAEA 085) were analyzed as well and for all samples recovery rates between 95 % and 102 % were achieved. Blank samples were always measured and found below the limit of detection of 0.02 ng/mL.

In order to identify weather or not CV-AFS gives unbiased results, two different methods were used on selected samples (a) gold trapping CV-AFS and (b) inductively-coupled plasma mass spectrometry (ICP-MS). While the gold trapping CV-AFS method is based on the same principal than the CV-AFS but one order of magnitude more sensitive (limit of detection is about 0.002 ng/mL), ICP-MS is as sensitive as CV-AFS but less prone to matrix effects. In ICP-MS $MeHg^{+}$ and $Hg^{2+}$ give the same response. Both methods gave the same results within the variability of the sub-samples which was ±10 %.

# 6 PROJECT ACTIVITIES BY COUNTRY OR ACTOR

The main activities took place at national level from April 2009 until June 2010. Countries were assisted by the International Consultant (IC).

This section summarizes the main activities at national level as well as the observations by the International Consultant and the Mercury Laboratory. Detailed reports were authored by the national project coordinator and her/his team and other project support staff; they are annexed in Chapter

The project implementation according to activity and country is summarized in Table 6-1. The Workplan had been developed during the inception workshop. As expected, some changes did occur during implementation but overall the activities were successfully completed.

Table 6-1: Summary table for activities within the project on Management of Mercury Waste
BKF=Burkina Faso, KHM=Cambodia, CHL=Chile, PAK=Pakistan, PHL=Philippines; IC=International Consultant, HgLab=Mercury lab

| | Activity | Country/Actors | Date | Objective / Remarks |
|---|---|---|---|---|
| **1** | Set-up project management structure and enter into agreement with countries, IC, and HgLab | UNEP | | SSFAs between UNEP Chemicals and the five countries and HgLab were signed. Following the general approval to extend the Norway-funded project by six months until 30 June 2010, amendments to the agreement were made. IC was contracted to assist the participating countries and UNEP. |
| **2** | Global inception workshop | BKF, KHM, CHL, PAK, PHL; IC; HgLab | 4-6 Mar 2009 Cambodia | Project kick-off, review of inventories, introduction to methodologies, agree on workplan, timetable, networking |
| **3** | Set-up national project management structure: Assignment of nat'l personnel, review of relevant information, identification of stakeholders | BKF | | Project team identified, contracts not yet |
| | | KHM | Mar-Apr 2009 | Project team formed |
| | | CHL | | Project team identified, contracts not yet |
| | | PAK | | Nat'l team and stakeholders identified |
| | | PHL | | Nat'l project mgt structure established, stakeholders identified, ToRs under development |
| **4** | National stakeholders' meeting and orientation on the Draft Technical Guidelines on ESM of Mercury Waste; criteria, prioritization, and drafting of a national mercury waste management plan | BKF | | |
| | | KHM | Jun 2009 | |
| | | CHL | Jul 2009 | |
| | | PAK | Late Apr 09 | |
| | | PHL | Apr-Jun 09 | |
| **5** | Sector-specific activities and awareness-raising activities on the TG application | BKF | | Back-to-back with WS; total of 1 week to start |
| | | KHM | Nov 2009-Jan 2010 | Together with (4), random activities, 1 month, combining sites, includes sampling |
| | | CHL | | Together with (4) |
| | | PAK | | Together with (4); combined with site visit |
| | | PHL | | Together with (4), total of 1 wk |
| **6** | Development of national mercury waste management plan | BKF | | Priority sectors included Artisanal gold mining; Products containing of Hg (thermometers, piles and batteries, tensiometer, lamps, *etc.*);Dental amalgam; Waste. |

| | Activity | Country/Actors | Date | Objective / Remarks |
|---|---|---|---|---|
| | | KHM | 2009-Feb 2010 | Desk study on Hg-wastes management related issues, communicated with relevant stakeholders, collection information on Hg-wastes management practices, and development of first draft and second draft of National Action Plan on Mercury Wastes Management in Cambodia |
| | | CHL | | Waste management plan was developed |
| | | PAK | | Three priority sectors were identified: Chlor-alkali, health sector and lights |
| | | PHL | Nov 2009 | Development of waste management plan |
| **7** | Collection of relevant human and environmental samples and shipment to HgLab (including consultation with and notification to HgLab) (including survey on existing national capacity) | BKF | Apr-May 2010 | Hair samples were collected from ASGM workers and people living in the vicinity of the ASGM but are not directly involved in the mining activities and sent to HgLab |
| | | KHM | Jan-Mar 2010 | Soil and biota samples collected at ASGM sites, dumping sites, dental care and public sewage systems. In total, 60 samples were collected and sent for analyses to Aberdeen, Scotland. |
| | | CHL | Mar 2010 | Samples from tailings were sent to the HgLab and analyzed |
| | | PAK | Oct 2009 | Human hair samples from two chlor-alkali factories and from non-exposed population was collected and sent to HgLab. Additional samples from Mg-containing products are to be analyzed by national lab. |
| | | PHL | | No samples were sent to the HgLab |
| | | HgLab | Oct 2009-Jun 2010 | Analysis of hair, nail, soil, and sludge samples using ICP-MS and/or AFS |
| **8** | Communication of Hg analysis results to countries | HgLab | Mar 2010 | Report sent to PAK |
| | | | Apr 2010 | Report sent to CHL |
| | | | Jun 2010 | Report sent to KHM |
| | | | Jun 2010 | Report sent to BKF |
| **9** | 2nd national stakeholder meeting to finalize management plan and communicate results | BKF | May 2010 | National action plan finalized |
| | | KHM | 10-11 Jun 2010 | Hg Waste Management Action Plan finalized |
| | | CHL | 15 Jun 2010 | National action plan developed |
| | | PAK | 19 May 2010 | National action plan for three priority sectors finalized |
| | | PHL | May 2010 | National action plan finalize |
| **10** | Global final project results workshop, | BKF, KHM, CHL, PAK, | 21-23 Jun 2010, Aberdeen, UK | Presentation of results, discussion of final report, lessons learned |

| | Activity | Country/Actors | Date | Objective / Remarks |
|---|---|---|---|---|
| | | PHL; IC; HgLab | | |
| **11** | Submission of final technical and financial national reports to UNEP | BKF, KHM, CHL, PAK, PHL; IC; HgLab | Jun 2010 | Electronically from country, IC, HgLab to UNEP Chemicals |
| **12** | Project final report published | UNEP | 30 Jun 2010 | Web-accessible at http://www.unep.org |

Full weblink for this project including final report and its annexes:
http://www.unep.org/hazardoussubstances/Mercury/InterimActivities/Partnerships/WasteManagement/WasteManagementProject/tabid/3538/language/en-US/Default.aspx

## 6.1 Burkina Faso

**Component 1.** Review of quantitative and qualitative data from the national inventory of mercury sources

The national inventory of the sources of mercury was carried out by the Project Team with the aim of bringing up to date the inventory of fixtures of the sources of use, emissions and releases of mercury in the environment. The data gathering related to the discussions with the people working within the structures of management of waste, of use of mercury in its organic or inorganic form. These exchanges made it possible to assess the level of mercury use in the country. During the inventory work, the project team encountered certain difficulties like:

- Non co-operation of certain structures in sharing information;
- Non availability of certain structures;
- The absence of data in certain branches of industry;
- The lack of information or sensibilization on the dangers of mercury.

**Component 2.** Prioritization of mercury sources and the corresponding sectors:

The sources of mercury and the corresponding sectors classified by set of priorities are:

- Artisanal gold mining;
- Products containing of Hg (thermometers, piles and batteries, tensiometer, lamps, *etc.*);
- Dental amalgam;
- Waste.

**Component 3.** Development of a national mercury waste management plan:

A national plan of Mercury and Mercury-containing Wastes Management was developed by the Project Team starting from the inventory results. Further, samples of human hair were analysed in order to take measures for reducing the transfers of mercury as well as their impact on the human health and environment. The purpose of this plan is to set a base for an ecologically rational management of the emission sources of mercury. With this intention several tasks must be carried out.

- The realization of a consolidated inventory;
- Reinforcement of the capacities of the various actors;
- Regulation of mercury during all the phases of the life cycle;
- The sensitizing of the stakeholders;
- The implementation of environmental management of the production, distribution and use of mercury or mercury-containing products;
- The implementation of the technical infrastructures of production, storage, control and disposal of mercury waste.

**Component 4.** ESM application in selected sources and sectors:

The sources and the sectors chosen for the implementation of a system of environmental management are:

- The management of urban and industrial waste;
- Phasing out the use of products containing mercury (thermometers, batteries);
- Artisanal gold mining.

**Component 5.** Sampling and mercury analysis of environmental and human samples:

The sampling was carried out by the project team with the help of a guide on the site of gold washing of Bagassi (a village in Burkina Faso). The team initially proceeded to a meeting with the gold washers in order to sensitize them for the sampling. Hair samples were taken and shipped in plastic bags for analysis at the Aberdeen University.

## 6.2 Cambodia

Mercury waste issues became a major concern in Cambodia soon after the UNEP mercury wastes project was introduced. Some of the initiatives that have been undertaken to address mercure waste include: a a dry batteries collection project (2007-2008), implemented by the Phnom Penh Environmental Department in collaboration with Phnom Penh Municipality. The main objective of this pilot project was the promotion of environmentally sound management of hazardous wastes and raising public awareness on the risk associated with hazardous wastes contained in consumer products. In addition, the development and adaptation of a governmental ordinance on "globally harmonized system on classification and labeling of chemicals" (issued in October 2009), an E-waste project, and the introduction of "Pollutants Release and Transfer Register" (PRTR) system's initiative, have all contributed to the sound management of chemicals, including mercury.

Under the UNEP's Mercury Waste Management Project, Cambodia has achieved major outputs including establishment of project implementation mechanism, development of national action plan on mercury wastes management, development of technical guideline on ESM of mercury wastes, and organization of national workshops to gather information for action plan and guideline development and reviewing them and adaptation. Last but not least, biota and non-biota samples have been collected and sent for analysis to Aberdeen University, Scotland.

The project team to undertake UNEP's mercury waste project had been established by the Ministry of Environment right after the Global Inception Workshop Project on the Management of Mercury and Mercury Containing Wastes, which was held in Siem Reap, from 04$^{th}$ to 06$^{th}$ March 2009. There are four project team member nominated and selected: the Project Coordinator, an Assistant to Project Coordinator, an Administration and Financial Officer, and a National Consultant. Project Office is located at the Department of Environmental Pollution Control, Ministry of Environment.

After forming the project team, major works has been done to accomplish the UNEP's mercury waste project as well as addressing Cambodia hazardous wastes management initiative activities, particularly ESM of mercury and its wastes. In this regards, desk study on Hg-wastes management related issues had been carried out, communication with relevant stakeholders undertaken, and collection of information on Hg-wastes management practices had been done, of which enable project team to develop the first draft and second draft of National Action Plan on Mercury Wastes Management in Cambodia. The first drafts had been reviewed by the UNEP's consultant and all feedbacks and comments have been elaborated into second draft. Then the second draft was introduced to the national consultation workshop to be finalized and adopted before submitted to the Minister for the Environment for final approval.

Beside the national action plan on mercury wastes management in Cambodia, a **Technical**

**Guideline on ESM of Mercury Wastes** was also developed based on information obtained in previous activities. Similar approach to action plan formulation, this guideline was also submitted to UNEP's consultant for comments and all feedbacks had been elaborated into the development of second draft. Then the second draft technical guideline has been introduced together with the second draft of action plan to the national consultation workshop held in June 2010, aiming to revised and adopted by the relevant stakeholders for final draft formulation before submitting to the Minister for the Environment for final approval. Now, the final draft of national action plan and technical guideline have been developed and waiting for submission to the Minister for the Environment to endorse, hopefully, will granted the approval in the third quarter of 2010.

Concerning workshops, two national workshops have been conducted. The first workshop was done in June 2009 aiming to introduce the UNEP's mercury waste project and identification of relevant issues related to the development of action plan and guideline. The second workshop was done in June 2010 with objectives to revise the second draft of action plan and technical guideline on ESM of mercury wastes in Cambodia, and get adaptation by all stakeholders who participated in this workshop.

Finally, through the UNEP's mercury waste project, Cambodia able to collect samples both biota and environmental samples for analysis of mercury contaminated in our environment. Sampling activities conducted at gold mining sites (both Ratanakiri and Kratie provinces), hospitals, dental care facilities, and public sewage systems. There were 60 samples collected, of which 23 samples are biota (nails and hairs) and the remaining 37 samples were non-biota (ore, tailing sludge, sewage sludge, and soils). Based on analytical results, there was clear understanding that Cambodia's environment is exposed to mercury, some of them exceeded the health risk level according to WHO guideline. Therfore, ESM of mercury and mercury containing wastes shall be taking into account from the time being in order to avoid further serious risk to human health and the environment.

In conclusion, based on the project implementation, we got feedbacks that all stakeholders are enthusiastic about the mercury waste project carried out in Cambodia and they fully support action plan and guideline prepared by the MOE. Last but not least, other suggestions to seek further assistance from development partners, *i.e.,* UNEP, UNITAR and other UN agencies and donor countries were also addressed.

Lesson Leaned from project implementation:

- It is an essential project ever had in Cambodia which enable us taking in to account the ESM of Chemicals waste generating from end of life of products including mercury. The Action Plan and Guideline on Mercury and Mercury-Containing Waste would become official papers for ESM of mercury.
- Legal instruments as well as guideline on ESM of Hg waste management are insufficient,
- Responsibility and cooperation of concerning institutions related to Hg waste management do not identified or mandated yet,
- Implementation plan and guideline on Mercury waste management are still inadequate,
- Capacity building of project team is very limited for implementation the Hg waste project in term of development action plan and guideline on ESM of Hg and Hg containing wastes
- Public awareness on Hg wastes and its risk to human health the environment is absent, resulting in dumping of Hg-containing wastes without consideration,
- Resources (technical and financial) for implementation of existing or new initiatives related to Hg and Hg wastes management is limited,

- Need strengthening capacity of officers for effectively implementing Hg-waste management instruments (legal, action plan and guideline),
- Need assistance from development partners for enhancing the implementation of Hg-wastes management initiatives,

Need demonstration activities for ESM of Hg-waste management in dental care sector or consumer products (Hg-based lamps): Pilot project on the implementation of technical guideline on Hg-waste management,

**Component 1.** Review of quantitative and qualitative data from the national inventory of mercury sources

- It is acknowledged that dada obtained from the Inventory Report on Mercury releases in Cambodia can be regarded appropriately. However the input factors seem to be reflecting circumstances pertaining to developed countries rather than developing countries like Cambodia, factor from waste categories seemed to be high.
- Some output data seemed to be over or underestimated due to input data obtained for calculation of mercury release are taken from secondary sources or estimation method
- Therefore, full inventory must be taken in accompany with lab analyses which regarded as based lines data for the country.

**Component 2.** Prioritization of mercury sources and the corresponding sectors:

- Capacities of project team and national consultant are considered limited in terms of mercury issues and mercury related risks.
- The understanding of mercury issues by (national workshop) participants was limited. Information and comments provided by them did not respond to priorities that could be included in an action plan or guideless.
- National reference data was not available and only the mercury releases inventory was used as a baseline to identify needs for the development of an action plan and technical guidelines.

**Component 3.** Development of a national mercury waste management plan:

- Capacities of project team and national consultant are considered limited in terms of mercury issues and mercury related risks.
- Difficulties in communication between international consultant and stakeholders due to translation constraints into Khmer language.
- Limited funds to hold additional meetings or conduct site visits to collect additional data, required to formulate an action plan and guidelines.

**Component 4.** ESM application in selected sources and sectors:

- Sources and sectors selected by task team for mercury waste project were either broad or had several gaps, which in turn affects a good development of the action plan for the implementation of ESM guidelines. This was due to insufficient information provided by stakeholders.

**Component 5.** Sampling and mercury analysis of environmental and human samples:

- Lack of basic technical identification of sampling site/sources.
- Analytical results can be used as baseline date to establish a national profile.

**Component 6.** Final national reports and final project report; evaluation

## 6.3 Chile

**Component 1.** Review of quantitative and qualitative data from the national inventory of mercury sources:

- The review of data from the national inventory was a task conducted by a national committee. This instance provided input from the Mining Ministry and the private sector (mining industry) with regards of their concerns related to an overestimation of data from copper mining. Results from these discussions included an activity in the action plan, to develop national emission factors with input from several mining industries that expressed interest.

**Component 2.** Prioritization of mercury sources and the corresponding sectors:

- The priority sectors include artisanal gold mining and consumption products. These sectors provided important details regarding these activities. CONAMA coordinated the prioritization process and was also responsible for raising awareness among working groups. In addition, this task is considered as a key element to assess the needs for financing this programme during the coming years.

**Component 3.** Development of a national mercury waste management plan:

- The development of a national waste management plan was an activity coordinated by CONAMA through a participative working process. The action lines for the plan were defined in terms of information update, and for the development of national guidelines to sample and analyze mercury in priority sectors. Additional tasks include awareness raising in all relevant institutions; and, implementing environment management instruments such as a policy for the management of contaminated sites.

**Component 4.** ESM application in selected sources and sectors:

- The review of ESM provided a general overview of several waste management actions that can be easily applied in the country. Translation of the ESM guidelines into Spanish are required.

**Component 5.** Sampling and mercury analysis of environmental and human samples:

- The sampling process was conducted by Fundacion Chile (consulting company) and the analytical work was done by the National Environment Center. Samples were taken from a mining tailing site in Andacollo city, northern Chile. This site is emblematic due to the artisanal gold mining activities and the related human health and environmental concerns expressed by the local authorities. Soil samples were also analyzed by the University of Aberdeen. Additional technical information is required for sampling processing and analytical techniques.

## 6.4 Pakistan

**Component-1: Review of quantitative data from the national inventory of mercury sources.**

- Basic data about the inventory of mercury and mercury products in Pakistan was developed to identify the mercury exposure resources in the country and to identify the groups of people at more risk. This also created awareness in the general public regarding the toxicity of mercury.

**Component-2: Prioritization of mercury sources and the corresponding sectors:**

- In prioritization exercise of mercury sources and the corresponding sectors, Apart from the administrative and regulatory measures, the awareness plays pivotal role to sensitize all key players and the members of civil society to implementation National Mercury Waste Management Plan in a real sense. The possible awareness activities and practices should focus on waste minimization, segregation at source, handling, collection, storage, transportation and disposal. The main awareness campaign should be through leaflets, brochures, workshops and banners etc.

**Component-3: Development of a national mercury waste management plan:**

- After prioritization exercise, a national mercury waste management plan was developed. The plan was designed to cover mercury waste prevention and minimization, collection, storage, treatment and disposal of mercury waste including fresh and existing legislations and reuse , recycle and recovery of mercury waste and also suggest that the management should encourage the certified and skilled personnel to address the mercury waste issue in a befitting manner. The government should encourage developing alternate equipment and materials of Mercury and supporting the initiative on mercury free products at national level. The National Waste Management Plan for mercury give such a lesson to improve the quality of life of people of Pakistan by reducing mercury releases to environment through ensuring provision for mercury alternatives at all levels at an affordable cost and in an equitable, efficient and sustainable manner.

**Component-4: ESM application in selected sources and sectors**

Environmentally Sound Management system for mercury disposal should engage in different private and public sources and sectors. As in national draft plan discussed the three priority sectors identified are:

- **Chlor-alkali plants/sectors:** Industry should have a good understanding of its mercury waste situation. how much mercury waste is generated, what type of waste (sludge’s, filter cake, tailings, ash, slag, etc.) as generated, what is the approximate mercury content of the different types of waste, as under what conditions may waste be stored?

- **Health** sector**:** Mercury containing medicines should be avoided and if they are essential then these medicines must be labeled. Beside the manufacture, import and sale of unlabeled and mercury-containing health care products must be regulated

- **Light product/sources sector:** Use of yellow light energy savers should be encouraged and the industrial sector should be given incentives on the manufacture of yellow light energy savers like reduced GST.

**Component 5: Sampling and mercury analysis of environmental and human samples:**

- Most of the hair samples (T-Hg concentration) group exceed the normal value (2.0 mg/kg) recommended by the WHO (1990). This can be attributed to the exposure of the participants to mercury vapour. Obviously, the more exposed the participants are too many, the more the concentration of total mercury (T-Hg) found in their hair samples. Further, the results of mercury in Products like pesticides, paints, battery cell, skin lightening creams etc are under submission for analysis.

## 6.5 Philippines

**Component 1. Review of quantitative and qualitative data from the national inventory of mercury sources**

The following are the issues or experiences and lessons learned on the quantification and qualification of data on the national inventory of mercury sources:

- There is no available centralized database or information network on the types and quantities of mercury and mercury-containing wastes. The Initial inventory only gives estimate on the levels of mercury releases but not on the amount and type of wastes generated from process, product, or use of such product.
- Data on other uses of crude oil such as in the polymerization process or in the manufacture of plastic products are not considered including data on mercury emissions from mining of metals. Data are limited only to gold, silver, copper, and lead.
- The calculation for mercury in thermometers, both clinical and industrial, needs refinement because the initial calculation was based only on the number of hospitals and schools and do not include industrial facilities. Likewise, data on the importation and production of thermometers in the Philippines is not available
- Data on the production and importation of mercury to verify the validity of the total consumption of mercury in the country is not available. The levels for chlor-alkali production are under the assumption that the existing process uses mercury cell technology, which in fact is not the case.
- There was a double accounting of mercury emissions in pulp and paper production because its emission source is due to the production of one of its primary raw material – caustic soda, which is already accounted for in the chlor-alkali production
- In the national inventory, the following are the other potential sources of mercury that were not considered:
  - Other coal combustion
  - Mineral oil extraction, refining, and use

- Other fossil fuels extraction and use
- Biomass fired power and heat production
- Coal Mining
- Limestone quarrying
- Other production of chemicals and polymers with mercury compounds as catalysts
- Batteries containing mercury
- Biocides and pesticides containing mercury
- Mercury in paint
- Pharmaceuticals for human and veterinary uses containing mercury
- Rituals and folklore medicine
- Recycled mercury production (secondary production)
- Recycled ferrous metals production (iron and steel)
- Other recycled metals production
- Incineration was not considered in the inventory because of the "incineration ban" but some hospitals were given permit for medical wastes incineration
- Informal local disposal of industrial production wastes
- Informal general waste dumping

**Component 2. Prioritization of mercury sources and the corresponding sectors:**

Based on the results of the national inventory conducted on mercury sources, the following are experienced:

- Ranking of priority sources must be restricted on the current extensive application or uses of mercury, either in the process or products. It must be based on the perceived or potential risk of its intentional and unintentional release.
- Artisanal gold mining (with emphasis on small-scale mining), light industry, and clinical and industrial use or applications of mercury are the sectors that must be given priority.
- Other uses and applications of mercury can not be considered due to absence of information or recorded data on the quantity and sources from the identified sectors despite of the existence of the national regulatory compliance requirements.

**Component 3. Development of a national mercury waste management plan:**

The development of the Philippine National Mercury Waste Management Plan was done through the conduct of an Inter-Agency Meetings and seminars discussing the importance of coming up with a cohesive and harmonized actions that will result to the prevention of releases and contamination of the environment. The following are the lessons learned during the development of the Plan:

- Information sharing or presentation of the environmental and health impacts on the exposure to mercury must be done because not all of the representatives from the invited sectors or stakeholders or agencies are aware of the risks posed by such exposure.
- Review of the different regulatory mandates and functions must be conducted in order to harmonize priority actions and activities that must be included in the management plan and to identify the gaps and issues that needs to be resolved.
- Identification of the primary actors or stakeholders or exposure groups must be considered, identified and involved in the development of the management plan in order to

come up with a near perfect and progressive actions and activities addressing the major issues and concerns that may be raised or popped out.

- Regular and continual meetings of the inter-agency (technical working group) must be conducted to assess and evaluate the progress and results of activities implemented by each member agency.
- Identification of options on the collection, storage, treatment and disposal of mercury and mercury containing wastes must be carefully done especially on the selection of best available techniques (BAT) and best environmental practices (BEP) appropriate and applicable in the Philippine setting.

**Component 4. ESM application in selected sources and sectors:**

The following are the experiences and lessons learned on this component:

- Awareness is insufficient or lacking in the application of environmentally sound management of mercury and mercury-containing wastes especially in healthcare institutions and the communities that are identified to be the foremost source of mercury releases both intentional and unintentional.
- The importance on developing a local or tailor-fit guidelines on the ESM of mercury must be done in the Philippines in order to come up with a doable or implementable action plan and if possible by source and sector.
- The Technical Guideline on the Environmentally Sound Management of Mercury and Mercury-containing products and wastes prepared and developed by the Secretariat of the Basel Convention (SBC) must be widely disseminated or circulated to the major sources and sectors in order to provide them with the procedures or steps toward preventing the potential release into the environment of mercury and for easy gathering of data and information.

**Component 5. Sampling and mercury analysis of environmental and human samples**

Sampling and analysis of mercury fro environmental and human samples for the project had not been conducted in the Philippines due to time and administrative constraints. However, during the survey and meetings conducted for the preparation of the National Action Plan, capability and capacity to carry-out sampling and analysis of mercury in environmental and human samples is not totally new in the Philippines. The following are the experiences and lessons learned:

- Willingness of potential identified subject for human samples especially blood is difficult to get due to the consequences may result or how the result will be given or divulge to the subject.
- There are existing laboratories that can carry-out analysis of mercury human samples as shared by the representatives of agencies present during the conduct of national consultation meeting and stakeholders workshop conducted.

## 6.6 International Consultant

Main activities conducted within this project included developing materials and assisting participating countries with technical training. Capacity building sessions consisted of workshops to introduce the main components of the mercury waste project, with particular emphasis on the Basel Convention Draft Technical Guidelines for Mercury Waste, and on key components for a National mercury waste management plan.

Participation during the technical workshops was active and included representatives of a National multi-stakeholder committee in each country, namely: government decision-makers and other officials involved in environmental protection, agriculture, public health, economic affairs, and international trade. These sessions also included representatives from civil organizations involved in raising awareness on hazardous chemical substances; representatives from industry (for example associations for the electric and electronic sector, chlor-alkali production, mining, among others), and experts from universities and research centers carrying out studies on chemicals and hazardous waste.

Several points for discussion were of particular interest for most stakeholders during the technical workshops. These included the following:

- Gathering information to determine the status of mercury and mercury waste at the National level; for instance, when developing the mercury emissions inventory, sources of information appeared to be either scattered or with limited information for specific sectors. Improving data in these fields can be a challenge, considering the diversity of information required and the possibility that it might not be readily available. However, discussions focused on recommendations for addressing information gaps and how stakeholders can benefit when reliable information is made available for environmental management initiatives. Improved national surveys were mostly considered as an additional an effective mechanism to collect more information.
- National mercury emissions inventories are becoming an increasingly important tool for countries to report on this priority chemical, and are generally considered as a vehicle for public access to information. Inventories can be used as a basic instrument to help establishing management strategies and policies for the sound management of chemicals as they identify major sources of releases and provide estimates of amounts used, released and disposed of.
- Implementation of the BC Draft Technical Guidelines for Mercury Waste was acknowledged as a key issue in order to comply with goals and objectives of this project. Countries generally viewed these guidelines as a relevant tool to support activities set forth in the respective National action plan for mercury waste. There were indications on the need to adapt these guidelines to applicable domestic contexts.
- Research institutes and universities play an important role in the generation of scientific information such as data on levels of hazardous substances in humans and the environment and the risks associated to exposure. These institutions may also be involved in identifying and developing alternatives to toxic chemicals. It is therefore useful to identify research institutes and universities that carry out this type of research. This information may be available through council for research and technology or similar body, which provides information about national research and academic programs and the results of scientific studies carried at universities and research centers.
- Non-governmental organizations (NGOs) that work on environmental and health issues keep a close relationship with communities and can have a better knowledge of a risk in local areas. Studies performed by NGOs can provide evidence of local impacts of

hazardous substances, as well as pilot initiatives for alternatives that may provide with important contribution to the project's implementation.

Concluding remarks with an international perspective include considerations for other projects to be developed and implemented in the near future, as follows:

- Pilot projects that have participation from several countries, and particularly from different regions of the world, can surely provide substantial experience to others who may consider engaging in studies in this field.
- Lessons learned from the technical training workshops and in general from all stages of this project, consisted of recommendations for improvements on environmental management issues related to mercury and mercury waste. For instance, the establishment of voluntary or regulatory instruments that support chemicals and waste management which can be disseminated and shared with countries and regions that face similar problems.
- Many developing countries and countries with economies in transition still lack the technical capacity to fully develop and enforce chemicals management practices. It is therefore important to ensure that specialized training is provided to agencies of the public sector that are responsible for the management of hazardous substances, as well as to other relevant stakeholders in the field.
- Multi-stakeholder participation, outreach and education activities by all actors and partners (for example, industry, NGOs, schools and universities, and worker associations) are critical components to support the effective implementation of these type of projects, and country coordinators should be encouraged to consider relevant activities.

## 6.7 Mercury Expert Laboratory

The Trace Analytical Laboratory of Aberdeen University (TESLA) served as the expert laboratory for this project. TESLA did provide assistance to the countries and to UNEP such as providing standard operational procedures for taking samples in the participating countries, analyzing all samples from this project, and assist with data interpretation.

The number and type of samples that were shipped to TESLA for analysis of total mercury within the project period are shown in Table 6-2.

Table 6-2: Number and type of biological and environmental samples provided by the participating countries

| *Country* | *Type of samples* | *Number of samples* |
|---|---|---|
| Burkina Faso | Hair samples from people working in artisanal gold miners and controls | 31 |
| Cambodia | Soil and sludge from public drainage system near hospitals, dental clinics, municipal waste dumps | 37 |
| | Hair and toenail samples from people working in artisanal gold mines | 23 |
| Chile | Soil samples from a waste dump resulting from gold mining incl. controls | 33 |
| Pakistan | Hair samples from people working at chlor alkali plants, dental clinics and controls | 72 |

In Table 6-3 a summary of analytical data are listed giving information about the country, the type of sample and the range of concentration measured in the number of samples given. Due to the heterogeneity of the sample the median value is given.

Table 6-3: Summary of mercury concentration found in the submitted samples from the different participating countries.

| Country | Type of samples | No of samples | median mg/kg | min-max mg/kg |
|---|---|---|---|---|
| Burkina Faso | Hair samples from people working in ASGM | 17 | 3.95 | 0.41-7.10 |
| | Hair samples from people living in ASGM area but not involved in mining activities | 11 | 0.75 | 0.01-2.50 |
| Cambodia | Soil and sludge from public drainage system near hospitals, dental clinics, municipal waste dumps | 37 | 0.41 | 0.06-6.92 |
| | Toenail samples from people working in ASGM | 11 | 1.28 | 1.05-3.51 |
| | Hair samples from people working in ASGM | 12 | 3.21 | 1.30-5.76 |
| Chile | Soil samples from a waste dump resulting from gold mining | 31 | 0.28 | 0.12-0.92 |
| | Soil samples as controls | 2 | | 0.02-0.04 |
| Pakistan | Hair samples from people working at chlor alkali plant with active amalgam technology | 23 | 177 | 3.3-9,340 |
| | Hair samples from people working at chlor alkali plant at which amalgam was phased out | 9 | 2.30 | 1.7-20.2 |
| | Hair samples from workers in dental clinics | 22 | 2.26 | 0.45-4.86 |
| | Hair samples from control group | 18 | 0.39 | 0.05-4.73 |

# 7 REACH OUT ACTIVITIES AND PUBLICATIONS

This project has been included into the business plan of the Waste Management partnership area and progress reports therein were feeded as appropriate.

A WebPage related to the mercury negotiation process and the UNEP Global Partnership has been set-up and is accessible at http://www.unep.org/hazardoussubstances/Mercury/tabid/434/language/en-US/Default.aspx. Information on this 5-country project can be accessed at http://www.unep.org/hazardoussubstances/Mercury/InterimActivities/Partnerships/WasteManagement/WasteManagementProject/tabid/3538/language/en-US/Default.aspx .


The project was presented at the following events:

- First Meeting of the Waste Management Partnership Area – Tokyo, Japan, 12-13 March 2009

  The presentation can be viewed at http://www.chem.unep.ch/mercury/Sector-Specific-Information/Docs/waste/S2_01UNEP-Mercury-waste-projects.pdf

- Second Meeting of the Waste Management Partnership Area - Tokyo, Japan, 8-9 March 2010

  The presentation can be viewed at http://www.chem.unep.ch/mercury/Sector-Specific-Information/Docs/waste/S1_01_UNEP-Chemicals.pdf

Publications for review in the scientific literature are underway.

# 8 CONCLUSIONS / RECOMMENDATIONS

## 8.1 Technical Conclusions

The project has generated the following outputs:

- Strengthened capacities for the implementation of the Basel Convention Technical Guidelines for Mercury Waste
- Capacity building for sampling and analysis of mercury in selected samples and matrices (human and environmental)
- Awareness raising initiatives and risk communication campaigns
- Multistakeholder participation in support of decision making for the sound management of mercury and mercury waste
- National action plans for mercury waste management ;

Some technical details include the following:

- An in depth analysis of the inventory on mercury releases was achieved by all participating countries. This activity included the prioritization of sectors and identification of main contributors to mercury emissions and mercury waste. Main findings from this technical exercise have been useful in the development phase of the national action plan under this project.
- A detailed review of the BC Technical Guidelines for Mercury Waste has further allowed countries to identify key issues to be addressed in specific sectors of concern. These include, among others, the need to review and/or update current regulation on chemicals management; an assessment of the existing technical infrastructure for mercury waste management and identification of needs to build further capacities. In addition, this review has provided with significant input for the design of the national action plan for mercury waste management.

## 8.2 Results in International Context

The outcomes of this project will feed into the UNEP Global Mercury Partnership and especially the Waste Management Partnership Area and into the negotiations for a legally binding instrument on mercury. As is usual practice, the countries – as potential future parties to the convention – will be charged to make the contributions according to their positions and priorities.

An immediate result of this project is a follow-up project on “Mercury storage and waste” financed by the government of Norway. The project will be implemented during the second half of 2010 with the objective to identify the gaps and overlaps between activities addressing mercury waste management and mercury storage.

It is recognized that there are gaps between these projects and other outputs from Mercury Partnership areas and a need to consider the management of wastes consisting of, containing or contaminated with mercury in a coherent manner. The outcomes and experiences have not been assessed horizontally or as part of overall hazardous waste management planning in participating countries. The project will compile and assess presently available information from the projects and cross-reference the existing guidance. The expected result will be a synthesis report and a handy guidance through practical cases studies that address specific but commonly perceived problems. It is expected that a user-friendly guidance reflecting especially developing country situations be developed and made available for use.

## 8.3 Recommendations/Comments on Draft Basel ESM Guidelines

It has been agreed during the discussions at the Final Workshop, June 2010, that each country will submit its own comments to the Secretariat of the Basel Convention.

# 9 ANNEX: CHEMICAL ANALYSIS AND QUESTIONNAIRE

## 9.1 Sampling Protocols

### 9.1.1 Hair samples

1. Hair samples should be obtained from the occipital area of the head and should include at least 100 strands of hair measuring at least 1.0 cm long (about 50 mg-100 mg in total) cut with scissors at the hair root.

2. Tie the root ends of the sampled hair strands together with a cotton thread or affix to adhesive tape or the like so that the root ends can be identified.

3. Place the sample in a polyethylene bag and label the bags with an arrow indicating the end of hair closest to the scalp

4. Store the polyethylene bags at room temperature.

### 9.1.2 Nail samples

1. Nails should be obtained from all toes (about 500 mg in total if possible) cut with scissors if possible wash the nail.

2. Pool all samples together.

3. Mill the samples with a small ball mill to generate a homogeneous fine powder

4. Store in Eppendorf tubes or polyethylene bags at room temperature.

### 9.1.3 Sludge and soil samples

1. Soil should be taken with regards to place and depth

5. only the < 2 mm soil fraction should be taken

6. Stratification should be considered in particular when core samples are taken

7. Approximately 200 g soil should be taken and homogenized by milling the soil (< 0.02 mm); 500 mg–1000 mg will be taken for each sub sample

8. Air dry the soil

9. Irradiate the soil for sterilisation, which does not change the mercury content but makes the export of soil to other countries easier.

10. Store the soil in polyethylene plastic bags at room temperature

## 9.2 Analytical Methods and Materials

### 9.2.1 Mercury Analysis with Atomic Fluorescence Spectrometry

Cold Vapour Atomic Fluorescence Spectrometry (CV-AFS) was used to determine the total mercury concentration in human hair samples. The instrument used is a Millennium Merlin (PS Analytical, UK). The CV-AFS used is shown in Figure 9-1.

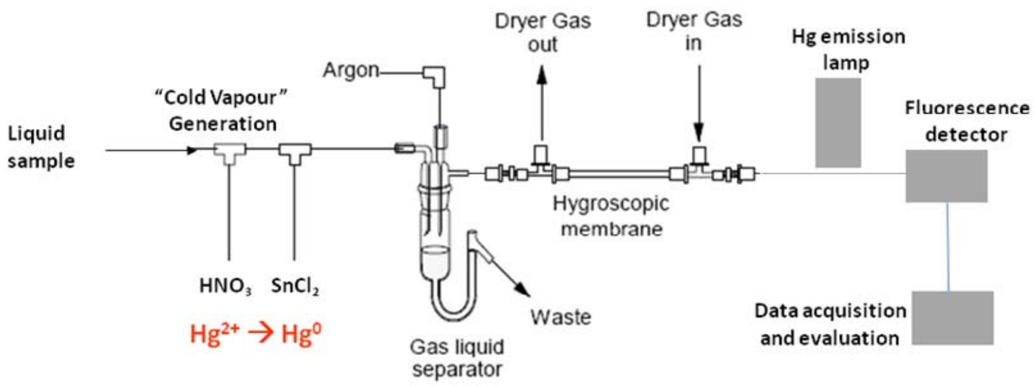



Figure 9-1: Schematic diagram of CV-AFS for mercury determination, modified from PS Analytical 10.125 Millennium Excalibur User Manual, Issue 11, November 2006

In cold vapour (CV) AFS, the digested, liquid sample reacts with acidic stannous chloride to convert Hg (II) present in the samples to $Hg^o$. Sn(II)chloride reacts with mercury and forms highly volatile elemental mercury:

$$Sn^{2+} + Hg^{2+} \rightarrow Sn^{4+} + Hg^o$$

The $Hg^o$ vapour is removed from solution in a gas liquid separator using an inert gas stream (Ar), and via a dryer membrane transported into the Atomic Fluorescence detector, where Hg atomic excitation is achieved using a low-pressure mercury vapour discharge lamp at 253.7 nm. Resonance fluorescence is detected at the same wavelength, using a photomultiplier, data are converted to a digital signal and finally recorded in mV *vs.* time. A typical measurement is shown in Figure 9-2. Liquid sample is aspired for 45 seconds, and the peak area obtained after data integration used for quantification purposes. Atomic fluorescence spectrometry is a commonly used method to analyse very low concentrations of mercury (Hg) due to its high sensitivity and selectivity.

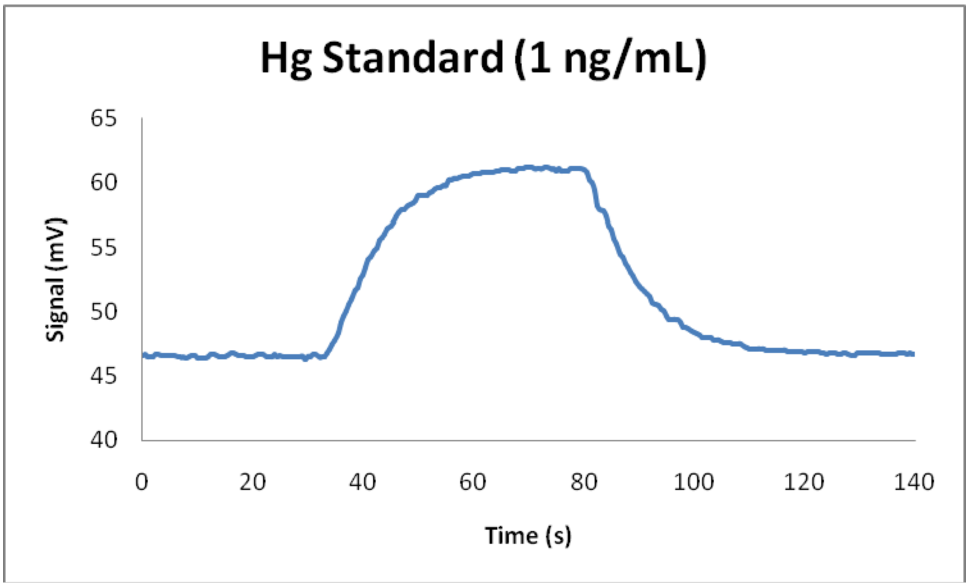



Figure 9-2: Typical transient analytical signal for Hg standard solution @ 1 ng/mL (1 ppb) with CV-AFS

## 9.2.2 Mercury Analysis with gold trapping CV-AFS (PSA Galahad setup)

Gold amalgam sampling for mercury vapor is a highly sensitive technique (more sensitive than CV-AFS) that is widely used for the analysis of mercury in trace amounts.

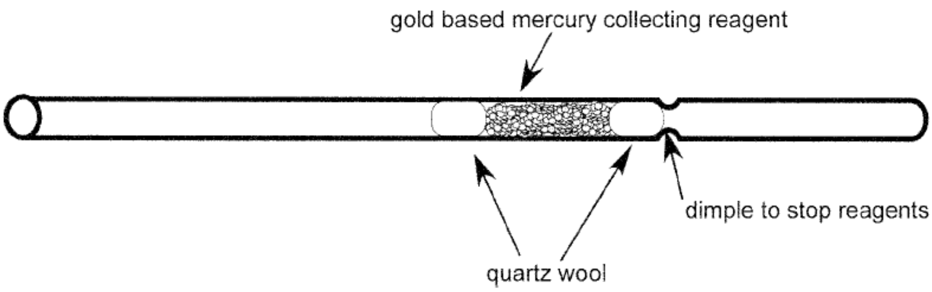



Figure 9-3: Sorbent tube containing a gold containing trap.

The mercury vapor produced is carried into a glass sorbent tube containing a gold amalgam trap. The sorbent tube is then heated at 300 °C in order to release volatile organic compounds that might be present in the collected sample. At this temperature amalgamated mercury is retained on the sorbent tube. After unwanted organic material is driven off, the sorbent tube is heated at 700°C to vaporize retained mercury and the mercury vapor is introduced into the CV AFS detector for measurement. A narrow peak is generated which gives a better signal to noise ratio and therefore a better detection limit for mercury in the solution of about 0.002 ng/mL.

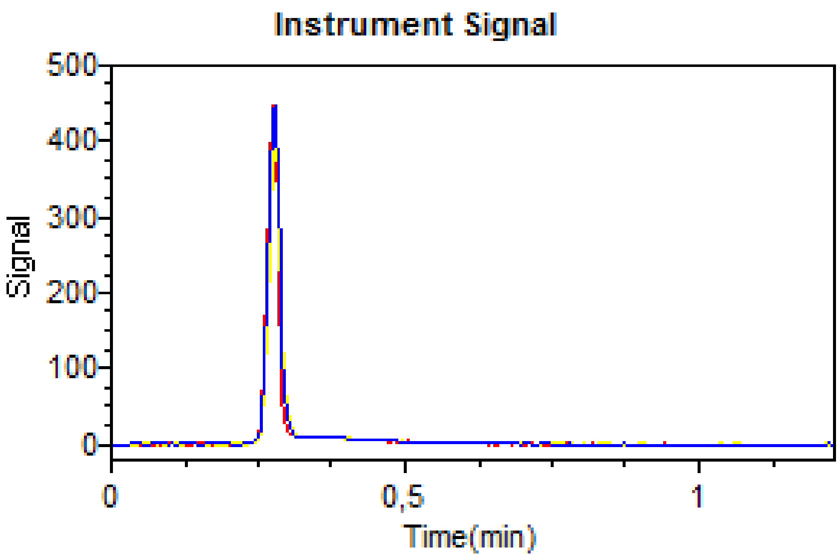



Figure 9-4: Typical peak obtained using the gold trapping method followed by AFS

## 9.2.3 Reagents

All chemicals used were of analytical grade or better quality. Water used for dilution of standards and sample digests was of suprapure quality (18 MΩ, Elga pure water systems, UK). Hydrochloric acid 32 % (Fisher Scientific, UK); Nitric acid, 70% (Analar, BDH, UK); $SnCl_2$* $2H_2O$, 98% (A.C.S, Sigma Aldrich, UK); $H_2O_2$, 30% (trace analysis, Fisher Scientific, UK); 2-Mercapto Ethanol (Sigma Aldrich, UK); Sulphuric acid 98%, (Sigma Aldrich, UK). Double distilled water was used for cleaning of glassware. $SnCl_2$ dihydrate solution was used as a reducing agent and prepared in concentrations of 2 % and 3 % by dissolving 20 g and 30 g of $SnCl_2$*$2H_2O$, respectively, in 100 ml of hot, concentrated HCl for 15 min. The total volume for each solution was completed to one litre using ultra pure water.

## 9.2.4 Standards

Inorganic mercury standard solution: A 10 mg/kg intermediate standard solution was obtained by diluting a 1000 ± 3 mg/kg certified ICP-MS standard solution (Spex, US) in 5 % $HNO_3$. This solution was prepared weekly and stored at 4°C. Working standard solutions at 100 µg/kg were prepared daily by diluting the 10 mg/kg intermediate standard solution with 5% (v/v) $HNO_3$. Methylmercury (MeHg) standard: A 100 µg/kg MeHg as Hg working standard solution was prepared daily by diluting a 81.23 mg/kg MeHg as Hg standard stock solution with 1 % (v/v) HNO3. The stock solution was prepared from MeHgCl salt (99% pure, Strem, UK).

Calibration standards are made up by subsequent dilution from the certified Hg standard solution, typically in a range of 0.1 – 10 µg/kg. All dilutions are made by weight (± 0.1 mg) in 5 % $HNO_3$ and concentrations corrected for exact weights.

A typical calibration curve is shown in Figure 9-5, detection limits (LOD, 3σ) are typically in the range of 10 ng/kg-20 ng/kg (10 ppt-20 ppt), limits of quantification at 30 ng/kg (in

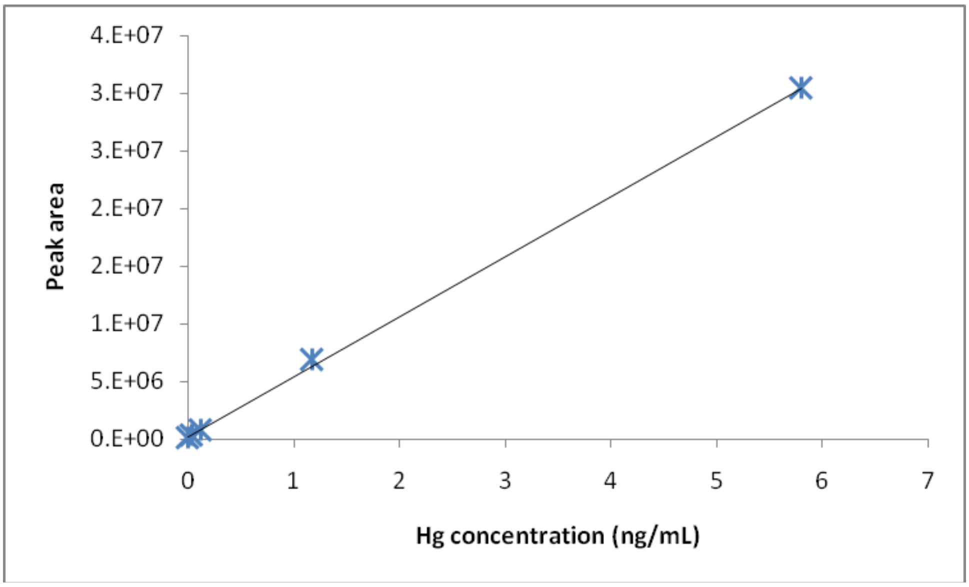



Figure 9-5: Calibration for Hg by CV-AFS, Linear regression: Y = 5,212,453 x + 226,274; $R^2 = 0.99955$

### 9.2.5 Glassware washing procedure

All glassware used for standard and sample preparation is thoroughly cleaned in a multi-step procedure prior to use. This comprises a first cleaning step with a detergent, then twice in 10 % $HNO_3$, once in 10 % HCl and a final washing in ultra pure water, each for one hour assisted by ultrasonication. The cleaned glassware is covered and dried in an oven at about 50°C and stored in ziplok bags in a dust free place until use.

### 9.2.6 Washing of hair samples

Hair samples are weighed into a 150 ml conical flask, and 100 ml of a detergent solution (1% RBS-25 in ultra pure water) added. Samples are shaken for one hour, the detergent solution decanted and the hair washed with 100 mL of ultra pure water 4 times. Excess water is removed, and the cleaned hair samples placed in an oven for overnight drying at 50°C. After drying, the hair containing flasks are placed open in a clean bench for five hours to allow the hair to equilibrate with the atmospheric humidity.

### 9.2.7 Hair and nail digestion method

Analysis of HgT is performed via Atomic Fluorescence Spectroscopy after total wet digestion of the samples and Hg cold vapour generation (CV-AFS). A certified reference material (CRM), IAEA 085, certified for Hg and MeHg in hair, was used to develop and validate the total mercury analysis in hair samples. Approximately 10 mg of certified reference materials (IAEA 085 and NIES 13) are exactly (± 0.1 mg) weighed into a clean 22 mL glass vial with teflon-lined cap. 5 mL of $HNO_3$ are added to the vial, the vials loosely closed and left standing in a fume hood for 20 minutes, then tightly sealed and heated in a water bath at 100 $^{o}C$ for 90 minutes. After cooling to room temperature, the liquid is diluted with ultra pure water at a factor of 25 and then submitted to Hg detection via Hg-CV-AFS.

Table 9-1: Determination of total mercury in CRMs NIES 13 and IAEA -085

| ***Certified reference material*** | ***Total mercury*** | | |
|---|---|---|---|
| | **Certified value (µg/g)** | **Measured value (µg/g) *x ± SD** | **Recovery (%)** |
| NIES No13 | **4.42 ± 0.2 µg/g** | 4.40 ± 0.1 | 99.6 ± 0.05 |
| IAEA 085 | **23.2 ± 0.8 µg/g** | 23.18 ± 0.05 | 99.9 ± 0.05 |

* Results are given as average ± standard deviation (n=3)

The results obtained for the certified reference materials NIES 13 and IAEA 085 show excellent accuracy and precision and prove the validity of the method used. Results were corrected for dry weight, hair samples were dried at 80$^{o}C$ to constancy.

### 9.2.8 Soil and sludge digestion method

Approximately 0.5 g of soil/sludge was placed in a 20 mL vials and the open glass vials were left in the oven at 70 °C for 4 h to remove moisture from the sample. After that 5 mL of $HNO_3$ 69% were added to the dry sample and the vials were sealed and autoclaved in water bath for 90 minutes at 100 °C. The vials were then allowed to cool and the digested samples were weighed. A certain volume of digested samples (1ml, 0.5ml, 100 µl or 50 µl) was transferred and weighed into a 25 mL measuring volumetric flask, and made up to the mark with deionised water (dilution 1:25, 1:50, 1:250, 1:500 v/v respectively). The weights of the empty digestion glass vials, and samples before and after digestion were recorded for calculation. Finally, these diluted samples were ready for analysis with CV AFS. The total mercury (T-Hg) concentrations were determined by external calibration performed by using the blank, 0.02, 0.1, 1.0, 2.5 ng/g $Hg^{2+}$ standards in 5% (v/v) $HNO_3$ for CV-AFS (Millennium Merlin) method and using the blank, 0.005, 0.05, 0.1 ng/g $Hg^{2+}$ standards in 5% (v/v) $HNO_3$ for gold trapping CV-AFS (Galahad method).

Table 9-2: Determination of mercury in spiked soil and sludge samples

| Sample ID | Spiked amount of Hg ng | Determined amount Hg ng | Recovery % | % RSD |
|---|---|---|---|---|
| Contaminated soil spiked with methylmercury | 101 | 96.6 | 95.7 | 1.9 |
| Contaminated soil spiked with inorganic mercury | 104 | 99.3 | 95.5 | 2.0 |
| Soil with low mercury spiked with methyl-mercury | 16.4 | 15.7 | 95.4 | 0.1 |
| Soil with low mercury spiked with inorganic mercury | 16.4 | 15.9 | 96.8 | 2.0 |

In order to validate the method for accuracy and precision, spiked samples were analyzed for total mercury. After the digestion, three subsamples were analyzed: one without spike, one spiked with a known amount of inorganic mercury (from 100 µg/kg $Hg^{2+}$ solution) and one spiked with a known amount of organic mercury (from 100 µg/kg MeHg solution). Each subsample was analyzed in triplicate and the values obtained for the spiked samples were compared with that obtained from the non spiked one.

## 9.3 Questionnaire

The questionnaires is based on the questionnaires developed by Claudia Cascio for the identification of arsenic sources in the food. Some specific questions, which are related to mercury specific exposures were added while arsenic-specific questions were deleted.

# ANONYMOUS QUESTIONNAIRE

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

CODE ____________ DATE ____________________

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| GENDER | MALE □ | FEMALE □ | AGE | | HEIGHT (cm) | | WEIGHT (kg) | | |
| PLACE OF BIRTH | TOWN/CITY……………………… COUNTRY………………………………………………………… | | | | | | | | |
| ARE YOU PREGNANT? | | ARE YOU CURRENTLY MENSTRUATING? | | | | | | | |
| DO YOU HAVE CHILDEN? NO □ YES□ HOW MANY?...................................... | | | | | | | | | |
| ARE YOU TAKING ANY MEDICINES? YES □ NO □<br>If yes, please specify…………………………………………………………………………….. | | | | | | | | | |
| ARE YOU TAKING ANY DIETARY SUPPLEMENTS? YES □ NO □<br>If yes, please specify…………………………………………………………………………….. | | | | | | | | | |
| DO YOU DO ANY PHYSICAL ACTIVITY?<br>……………………………………………………………………………………..<br>If yes, please specify?.............................................HOW MANY HOURS PER WEEK?.............. | | | | | | | | | |
| ARE YOU A SMOKER?<br>YES □ NO □ | | | If yes, how many cigarettes per day?<br>5-10 □ 11-20 □ more than 20 □ | | | | | | |

| |
|---|
| **Do you suffer from any diseases or medical complications?** |
| **Please specify……………………………………………………………………………………….**<br>**………………………………………………………………………………………………** |
| **In the past did you suffer from any disease or medical complication? □ Y □ N** |
| **If yes, how long ago…………………………………….……………………………………**<br>**Please specify the nature of disease/complication……………………………………………..** |

**ETHNIC ORIGIN**

| | | | | | |
|---|---|---|---|---|---|
| WHITE | □ European | | □ British | | □ Other: ………….. |
| BLACK | □ Caribbean | | □ African | | □ Other: ………….. |
| ASIAN | □ Indian | □ Pakistani | □ Chinese | □ Bangladesh | □ Other: ………….. |
| MIXED | ………………………………………………………………………………… | | | | |

**DRINKING HABITS**

**Which kind of water do you usually drink? (ONE OPTION PER LINE PLEASE)**

| | | | | |
|---|---|---|---|---|
| **Bottled (*)** | **always** □ | **mainly** □ | **sometimes** □ | **never** □ |
| **Tap (#)** | **always** □ | **mainly** □ | **sometimes** □ | **never** □ |
| **Well or fountain (@)** | **always** □ | **mainly** □ | **sometimes** □ | **never** □ |

**(*) IF** you drink **BOTTLED** water:

| |
|---|
| How long have you been drinking bottled water? ……………………………………….… |
| What type of drinking water did you used before?.................................................................... |
| Which brand of bottled water do you mainly drink ?……………………………………… |

**(#) IF** you drink **TAP** water:

| |
|---|
| How long have you been consuming tap water? …………………………………..…… |
| What type of drinking water did you used before?..................................................... |

**(@) IF** you drink **WELL or FOUNTAIN** water:

| |
|---|
| Please specify the name/location………………………………………………………… |
| How long have you been consuming this water? ……………………………..………… |
| What drinking water did you used before?................................................................... |

What type of water do you use for cooking? ……………………………………………….

**HOW MUCH WATER DO YOU DRINK DAILY? (PLEASE TICK ONE OPTION ONLY)**

| | | | | | | |
|---|---|---|---|---|---|---|
| Less than 1 Litre □ | 1 Litre □ | 1 Liter and half □ | 2 Litres □ | 2 Litres and half □ | 3 Litres □ | MORE □ Specify ……….. |

| | | | |
|---|---|---|---|
| Do you drink coffee? | How many cups? ……□ | per day; □ | per week |
| Do you drink tea? | How many cups? ……□ | per day; □ | per week |
| Do you drink soft drink? | How many cups? ……□ | per day; □ | per week |
| Do you drink juice? | How many cups? ……□ | per day; □ | per week |

| DO YOU DRINK ALCOHOL? | If yes, how many units* per week? |
|---|---|
| * 1 unit = ½ pint beer, 1.5 unit = 1 single spirit, 1 unit = 1 glass wine, 1 unit = 1 glass sherry | < 1 □ 1-5 □ 6-10 □ 11-20 |

**DIETARY HABITS**

Are you a vegetarian? YES ☐ NO ☐

Do you eat fish? YES ☐ NO ☐ SOMETIMES ☐

Are you a vegan? YES ☐ NO ☐

Do you usually have your breakfast at home? YES ☐ NO ☐

Do you usually have your lunch at home? YES ☐ NO ☐

Do you usually have your dinner at home? YES ☐ NO ☐

Have you eaten fish or shell fish in the last week? YES ☐ NO ☐
if yes, which kind ……………………………………

Have you eaten fresh water fish in the last week? YES ☐ NO ☐
if yes, which kind ……………………………………

Have you eaten chicken in the last week? YES ☐ NO ☐

Have you eaten mushrooms in the last week? YES ☐ NO ☐

**For the following foods please indicate what the usual portion you eat is and how many times do you eat this portion:**

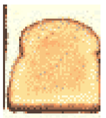
**WHITE BREAD: ROLLS** **Do you eat white roll bread?** **YES** ☐ **NO** ☐

| | | | | |
|---|---|---|---|---|
|  | What is your typical portion? | **50 g** ☐ | **100 g** ☐ | **150 g** ☐ |
| | | **200 g** ☐ | **250 g** ☐ | **More** ☐ |

How many times do you eat the portion?

| **Rarely** | **One per month** | **One per week** | **1-3 times per week** | **4-6 times per week** | **Daily** | **2 times per day** |
|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |

**WHITE BREAD:** SLICES Do you eat white slice bread? YES ☐ NO ☐

| | | | | |
|---|---|---|---|---|
|  | What is your typical portion? | **1-2 Slices** ☐ | **3-4 Slices** ☐ | **5-6 Slices** ☐ |
| | | **7-8 Slices** ☐ | **9-10 Slices** ☐ | **More** ☐ |

How many times do you eat the portion?

| **Rarely** | **One per month** | **One per week** | **1-3 times per week** | **4-6 times per week** | **Daily** | **2 times per day** |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |

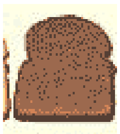
**BROWN BREAD: ROLLS** **Do you eat brown roll bread?** **YES** ☐ **NO** ☐

| | | | | |
|---|---|---|---|---|
|  | What is your typical portion? | **50 g** ☐ | **100 g** ☐ | **150 g** ☐ |
| | | **200 g** ☐ | **250 g** ☐ | **More** ☐ |

How many times do you eat the portion?

| **Rarely** | **One per month** | **One per week** | **1-3 times per week** | **4-6 times per week** | **Daily** | **2 times per day** |
|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |

**BROWN BREAD: SLICES** **do you eat brown slice bread?** **YES** ☐ **NO** ☐

| | | | | |
|---|---|---|---|---|
|  | What is your typical portion? | **1-2 Slices** ☐ | **3-4 Slices** ☐ | **5-6 Slices** ☐ |
| | | **7-8 Slices** ☐ | **9-10 Slices** ☐ | **More** ☐ |

How many times do you eat the portion?

| **Rarely** | **One per month** | **One per week** | **1-3 times per week** | **4-6 times per week** | **Daily** | **2 times per day** |
|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |

**PASTA:** **Do you eat pasta?** **YES** ☐ **NO** ☐

| | | | | |
|---|---|---|---|---|
|  | What is your typical portion? | **50 g** ☐ | **100 g** ☐ | **150 g** ☐ |
| | | **200 g** ☐ | **250 g** ☐ | **More** ☐ |

How many times do you eat the portion?

| **Rarely** | **One per month** | **One per week** | **1-3 times per week** | **4-6 times per week** | **Daily** | **2 times per day** |
|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |

**Do you consume any special type of pasta** (for example, brown pasta or other kind)**?**
**YES** ☐ **NO** ☐

**Which type?.............................................How many times?................................................**

**WHITE RICE:** Do you eat white rice ? **YES** ☐ **NO** ☐

| | | | | |
|---|---|---|---|---|
|  | What is your typical portion (cooked)? | **50 g** □ | **100 g** □ | **150 g** □ |
| | | **200 g** □ | **250 g** □ | **More** □ |

How many times do you eat the portion?

| **Rarely** | **One per month** | **One per week** | **1-3 times per week** | **4-6 times per week** | **Daily** | **2 times per day** |
|---|---|---|---|---|---|---|
| □ | □ | □ | □ | □ | □ | |

**Which kind of white rice do you eat** (indicate type or brand)**?** ………………………………

**BROWN RICE:** Do you eat brown rice ? **YES** □ **NO** □

| | | | | |
|---|---|---|---|---|
|  | What is your typical portion (cooked)? | **50 g** □ | **100 g** □ | **150 g** □ |
| | | **200 g** □ | **250 g** □ | **More** □ |

How many times do you eat the portion?

| **Rarely** | **One per month** | **One per week** | **1-3 times per week** | **4-6 times per week** | **Daily** | **2 times per day** |
|---|---|---|---|---|---|---|
| □ | □ | □ | □ | □ | □ | |

**Freshwater FISH:** Do you eat freshwater fish ? **YES** □ **NO** □

| | | | | |
|---|---|---|---|---|
|  | What is your typical portion (cooked)? | **50 g** □ | **100 g** □ | **150 g** □ |
| | | **200 g** □ | **250 g** □ | **More** □ |

How many times do you eat the portion?

| **Rarely** | **One per month** | **One per week** | **1-3 times per week** | **4-6 times per week** | **Daily** | **2 times per day** |
|---|---|---|---|---|---|---|
| □ | □ | □ | □ | □ | □ | |

**Marine FISH (such as white fish)** Do you eat marine fish ? **YES** ☐ **NO** ☐

| | | | | |
|---|---|---|---|---|
|  | What is your typical portion (cooked)? | **50 g** ☐ | **100 g** ☐ | **150 g** ☐ |
| | | **200 g** ☐ | **250 g** ☐ | **More** ☐ |

How many times do you eat the portion?

| Rarely | One per month | One per week | 1-3 times per week | 4-6 times per week | Daily | 2 times per day |
|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |

**Predatory FISH (such as sword fish, tuna, marlin)**
Do you eat this kind of marine fish ? **YES** ☐ **NO** ☐

| | | | | |
|---|---|---|---|---|
|  | What is your typical portion (cooked)? | **50 g** ☐ | **100 g** ☐ | **150 g** ☐ |
| | | **200 g** ☐ | **250 g** ☐ | **More** ☐ |

How many times do you eat the portion?

| Rarely | One per month | One per week | 1-3 times per week | 4-6 times per week | Daily | 2 times per day |
|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |

**OTHER SEA FOOD:** Do you at other sea food ? **YES** ☐ **NO** ☐

| | | | | |
|---|---|---|---|---|
|  | What is your typical portion (cooked)? | **50 g** ☐ | **100 g** ☐ | **150 g** ☐ |
| | | **200 g** ☐ | **250 g** ☐ | **More** ☐ |

How many times do you eat the portion?

| Rarely | One per month | One per week | 1-3 times per week | 4-6 times per week | Daily | 2 times per day |
|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | |

**Do you eat organic food?** **YES** ☐ **NO** ☐

| | | | | |
|---|---|---|---|---|
| **Organic meat** | **Mainly** ☐ | **Sometimes** ☐ | **Rarely** ☐ | **Never** ☐ |
| **Organic poultry** | **Mainly** ☐ | **Sometimes** ☐ | **Rarely** ☐ | **Never** ☐ |
| **Organic fruit** | **Mainly** ☐ | **Sometimes** ☐ | **Rarely** ☐ | **Never** ☐ |
| **Organic vegetables** | **Mainly** ☐ | **Sometimes** ☐ | **Rarely** ☐ | **Never** ☐ |

| How often do you eat the following food (Please tick one option per line) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Never | Rarely | 1 Time per month | 1 Time per week | 1-3 times per week | 4-6 times per week | Daily | 2 times per day |
| Fresh vegetables | | | | | | | | |
| Olives | | | | | | | | |
| Mushrooms | | | | | | | | |
| Pistachio nuts | | | | | | | | |
| Spinach | | | | | | | | |
| Almonds | | | | | | | | |
| Sweet chestnuts | | | | | | | | |
| Other nuts | | | | | | | | |
| Apples | | | | | | | | |
| Orange/Clementine | | | | | | | | |
| Peach | | | | | | | | |
| Grapes | | | | | | | | |
| Pears | | | | | | | | |
| Banana | | | | | | | | |
| Pineapple | | | | | | | | |
| Beef | | | | | | | | |
| Pork | | | | | | | | |
| Cold meat | | | | | | | | |
| Chicken | | | | | | | | |
| Milk | | | | | | | | |
| Cheese | | | | | | | | |
| Sweets/Dessert | | | | | | | | |
| Eggs | | | | | | | | |
| Wholegrain cereal | | | | | | | | |
| Wholegrain crackers | | | | | | | | |

**GENERAL INFORMATION:**

| WHERE DO YOU LIVE CURRENTLY? | |
|---|---|
| **CITY /TOWN…………………………**<br>**AREA…………………………………** | **HOW LONG HAVE YOU LIVED THERE?........................................** |

**How would you define the place where you live currently?**

**Rural** □ **Semi Rural** □ **Semi Urban** □ **Urban** □

| **WHERE WERE YOU LIVING PREVIOUSLY?** | |
|---|---|
| **CITY /TOWN……………………..………**<br>**AREA………………………………………** | **FROM ……………… TO……..…………….** |
| **CITY /TOWN……………………..………**<br>**AREA………………………………………** | **FROM ……………… TO……..…………….** |
| **CITY /TOWN……………………..………**<br>**AREA………………………………………** | **FROM ……………… TO……..…………….** |
| **CITY /TOWN……………………..………**<br>**AREA………………………………………** | **FROM ……………… TO……..…………….** |
| **CITY /TOWN……………………..………**<br>**AREA………………………………………** | **FROM ……………… TO……..…………….** |

**DO YOU LIVE NEAR TO ANY OF THE FOLLOWING INDUSTRIES?**

**Farm** □ **Mine** □ **Refinery** □ **Chlor-Alkali Plant** □

**Petrochemical Plant** □ **Power Plant** □ **Motorway** □

**What is your job ?** ***(name of your company is not necessary but just the sector, e.g., chemical industry/bank/farm)***

| | |
|---|---|
| **SECTOR OF THE COMPANY…………………………….**<br>**TASK…………………………….……………………..** | **HOW LONG?................** |
| **Do you handle, inhale or have contact with any chemical substance** (such as solvents, paints, pesticides, exposed to metal fumes (mercury) *etc.*) **or radiation ?**<br>**YES** □ **NO** □<br>**SPECIFY ………………………………………………………………………………** | |
| **How many hours per day are you exposed to these substances?.......................................** | |

| | |
|---|---|
| **PREVIOUS JOB……….…..........…………** | **HOW LONG?.......................................** |
| **PREVIOUS JOB……….............…………** | **HOW LONG?.......................................** |

| | |
|---|---|
| **PREVIOUS JOB……….............…………** | **HOW LONG?........................................** |
| **PREVIOUS JOB……….............…………** | **HOW LONG?........................................** |

**Do you dye your hair?** **YES □** **NO □**

**Which kind of color do you use?** **Artificial□** **Natural □**

**Do you have mercury dental fillings ?** **YES □** **NO □**

**If yes, how many? ……………………**

**Do you have any other internal metallic supports? YES □** **NO □**

**THANK YOU FOR YOUR CO-OPERATION**

## CONSENT AND CONFIDENTIALITY

I give my consent for the use of biological samples and information provided in scientific research, which may be published in scientific journals. The information provided will not be used for any other purpose.
I have been informed that the research will be carried out anonymously and that no attempt will be made to match laboratory derived or questionnaire data with individual donors.

**Signed:…………………………………..**

**Date:…………………………………….**