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The Republic of Yemen
Ministry of Water and Environment
Environmental Protection Authority (EPA)

Yemen Mercury Inventory Report

Mercury Release Inventories - Asian Pilot Project

INVENTORY OF MERCURY RELEASES IN Yemen

Preliminary Inventory

September 2008

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General Authority for Environmental Protection (EPA)

Forword:

The Yemen Mercury Inventory Report was written by Mr. Helal Al-Reiashi, National Consultant. Technical support for the project was facilitated by the United Nation Environment Programme (UNEP) and through a mercury pilot project with in-kind contributions from the Yemen Government.

This report is published in Arabic and English by the Environmental Protection Authority (EPA), the Ministry of water and environment, the Government of Yemen to provide ground information mercury release sources and quantity in Yemen. This report is a first outcome of the common chemicals information and data collection in Yemen.
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Preface

All over history, mercury has been known and used for gold and silver processing. In many parts of the world, mercury has been used in batteries, chlor-alkali production, dental amalgam, fluorescent lights, switches, and thermometers. Much of the mercury contained in these end-of-use products.

In 2007, Yemen got assistance from the United Nations Environmental Program (UNEP) to study the mercury releases from all identified sources. In 2007, UNEP-Chemicals provided the workshop training to the inventory team from the Ministry of water and environment Environmental protection Authority (MWOE), Yemen, by indicating a specific need data and information for gathering related to mercury releases.

After training, the inventory team initiated and identified hotspot areas of possibly mercury releases sources based on local knowledge and current activities (as compared with activities mentioned in the UNEP Toolkit for identification and quantification of mercury releases, November 2005). Based on this material, the inventory team decided to select 10 provinces (including municipalities) out of 24 provinces and municipalities through the country. The inventory stage was conducted from Dec. to Feb. 2008 and then by March 2008 was the period of data entry and analysis.

The main purposes of this inventory is to produce based line information on mercury release sources, exposure routes and possible quantities released into the environment. Inventories for such releases form an important tool in the decision process of mitigating environmental impacts from the pollutants. When Yemen has decided that mercury pollution is a potential priority problem that needs to be evaluated further, it will typically need to estimate both the relative and the absolute contributions to mercury releases from the different sources present in the country. This information can be used to determine which release source types are significant and which sources should be addressed through release reduction initiatives.

Combined with additional knowledge of the specific release source types and available options for bringing about release reductions, the most cost-effective reduction measures can be identified for selection in the decision making process. Often, such inventories are also vital in the communication with stakeholders such as industry, trade and the public.

In addition, baseline information on mercury releases, and subsequent up-dates, can be used to monitor progress towards pre-set goals, and thereby identify successful approaches which could serve as examples in other areas, as well as areas where the applied measures do not prove adequate and further attention and initiative is needed.

Official Note of Chairman EPA

This mercury inventory report was the result of field survey at 10 provinces (including municipalities) and the long discussion of different stakeholders from both public and private sectors the consultation workshop in February 19-20, 2008. The inventory report team was sponsored by UNEP-Chemicals Branch.

This mercury inventory report provide based useful information for governmental ministries, private companies, civil society, and stakeholders with responsibilities for the management and using of mercury and help them in promoting improvement of human health care and environment protection in Yemen.

On behalf of the Minister, Minister of Water & Environment, I would like to express my sincere appreciation to UNEP for funding. Specials thanks for our Yemen Inventory Team provide the best outputs, hard works, and strongest commitment for mercury data collection and development of the inventory report. I'm deeply indebted for all views and comments were made by representatives of the governmental institutions, private sector and other stakeholders and all participants at a consultation workshop at the Ministry of water and environment Environmental protection Authority in Sana'a, Yemen in February 19-20, 2008 respectively.

Finally, I would like to announce that, this mercury inventory report was adopted by the Ministry of water and environment Environmental protection Authority as official baseline information for official purposes use.

The Ministry of water and environment Environmental protection Authority
Director of Department of Environmental Pollution Control, Yemen

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Abbreviation

µg Hg/Nm^3	Microgram mercury per normal metric cube
APCS	Air Pollution Control System
MHOP	Ministry of Health and Population Survey
EPA	Environmental Protection Authority
g	gram
GDP	Growth Domestic Products
GEF	Global Environmental Facilities
GoY	Government of Yemen
Hg	Mercury
LPG	Liquefied Petroleum Gas
MIMT	Ministry of Industry, and Trade
mm	Millimeter
Mn	Manganese
MoWE	Ministry of water and environment
NA	Not Available
NGOs	Non-Governmental Organizations
MoPS	Ministry of Planning & Statistics
MoAI	Ministry of Agriculture, and Irrigation
MoC	Chamber of Commerce
UNEP	United Nations Environmental Programme
VCM/PVC	Vinyle-chloride-monomer (for PVC production)/ poly-vinyle-chloride (plastic type)
WB	World Bank

Summary

This report is focused on the preliminary survey on mercury release into atmosphere within Yemen territory and such survey had been undertaken from July to December 2007 throughout Yemen by the mercury task team of the Department of Environmental protection Authority (EPA)of the Ministry of water and environment Environmental protection Authority, which is leaded by a national coordinator. This team had been gone through a two day training course, which is lectured by the international consultant (the UNEP Toolkit author) right-away before the survey took place. The team was also provided questionnaire forms for recording the finding and the inventory had been undertaken within the selected 10 provinces and municipalities, where assumed to have potential mercury releases.

It was remarkably that the products and equipment contained mercury or mercury compound have been used in Yemen, however, there is no official record could confirms when such equipment was first introduced to Yemen. Nevertheless, it is no doubt to state that equipment containing mercury and mercury compound have been imported to Yemen, which resulting mercury release into the environment after disposal of such equipment. In addition to this, extraction of mining activities

Therefore, based on the preliminary survey, it was understood that the total output of mercury in Yemen is approximately 658 Kg in minimum and about 6,944 Kg in maximum per year. The first major source of maximum mercury output into atmosphere is consumer products with intentional use of mercury that cause the release of mercury, followed by disposal of wastes that could output mercury of approximately 6,944 Kg per year. Concerning maximum release, the survey team thought that this amount may be reasonable figure because maximum input factors have been use for calculation for the release of such mercury, which can be assumed that it can be compensated to some fields that unable to obtain information for calculation including electrical and electronic switches, light sources with mercury, biocides and pesticides, paints, pharmaceuticals for human and veterinary uses, cosmetics and related products, etc.

By the ways, regarding the management of mercury release into the environment, yet Yemen has no any specific provision dealing with safe and sound management and use of either products/equipment containing mercury or mercury compounds nor other specific chemicals so far. The existing legislation available is generally focusing on the overall management of chemicals particularly related to pesticides (for agricultural purposes) and waste management (for the environmental purposes). In term of the technical infrastructures, there are three main laboratories available in Yemen, which is belonged to technical ministries but none of those laboratories have capacity in analyzing for mercury due to number of deficiencies.

To sum up, as Yemen is faced with severe constraints related to the national budget and knowledgeable and expertise people in this area, the country requires further assistance in terms of both budget and technical support from GEF/UNEP and other international communities and development partners, in order to undertake further detail inventories as well as designing and implementing mercury management plans. This will assist Yemen in sound management of mercury, which will provide benefits for not only the current generation, but also for the next generations nationally, regionally and globally.

1 Preliminary inventory of mercury use and release in Yemen

1.1 Introduction

Based on investigations and their experiences, developed countries and some developing countries revealed that the production, consumption, and disposal of chemicals and/or chemical compounds, especially for those that are used in industrial and agricultural sectors, created enormous impacts to the atmosphere, biodiversity, soil, water, human health, etc., not merely for this generation, but also for future generations. The devastation results from the environmental impacts posed a great obstacle to socio-economic development. The nightmare of Minamata, Yokkaichi, and Itai-itai Diseases, for example, were widespread in parts of Japan in the mid 1950s to 1960s, causing damage to human health and domestic animals, and also severely polluted water sources and the atmosphere. To eliminate and phase out these catastrophes, the Japanese Government, in taking more efforts, spent tremendous money and took time for surviving whatever was destroyed. The Minamata Bay tragedy in Japan alerted the world to the potentially lethal effects of industrial chemicals that are discharged into the environment without proper treatment. Many western countries' reports have also mentioned other types of adverse environmental impacts that they have confronted because socio-economy development was undertaken without considering the sustainable environment.

The UNEP Governing Council concluded, at its 22nd session in February 2003, after considering the key findings of the Global Mercury Assessment report, that there is sufficient evidence of significant global adverse impacts from mercury to warrant further international action to reduce the risks to humans and wildlife from the release of mercury to the environment. The Governing Council decided that national, regional and global actions should be initiated as soon as possible and urged all countries to adopt goals and take actions, as appropriate, to identify populations at risk and to reduce human-generated releases. This commitment to addressing the global adverse impacts of mercury pollution was reinforced by Governments at the 23rd session of the Governing Council in February 2005. The Governing Council also requested UNEP, in cooperation and consultation with other appropriate organizations, to facilitate and conduct technical assistance and capacity building activities to support the efforts of countries to take action regarding mercury pollution.

In response to the Governing Council's request, UNEP has established a mercury program within UNEP Chemicals, with the immediate objective to encourage all countries to adopt goals and take actions, as appropriate, to identify exposed populations, minimize exposures through outreach efforts, and reduce anthropogenic mercury releases.

This report is considering mercury release into the environment through the use of mercury and mercury contained in products, as well as through use of certain high volume materials with mercury trace concentrations. The calculation of mercury release into the environment is made based on guideline, methods, sources, and factors mentioned in the "***UNEP toolkit for identification and quantification of mercury releases***".

1.2 Mercury release sources identified in Yemen

Major source categories and subcategories of mercury release listed in the UNEP toolkit are listed in table 2. The table also shows which mercury sources exist in Yemen. Due to limitations in data availability and constraints in time and budget, it has not been possible to quantify all mercury release sources present in Yemen; the table shows which sources have been quantified as part of this preliminary inventory work.

Table 1: Classification sources of mercury release

1	**Extraction and use of ful/energy sources**
513	Use of crude oil
513	Use of gasoline, diesel and other distillates
513	Use of gasoline, diesel and other distillates (transportation)
513	LPG
516	Biomass fired power and heat production
3	**Production of other minerals and material with mercury impurities**
531	Cement production
533	Lime production
5	**Consumer products with intentional use of mercury**
551	Thermometers
554	Batteries alkaline
554	Other type batteries
552	Electrical and electronic switches, contacts and relays with mercury
556	Paints
5	**Total 5**
6	**Other intentional product/process uses**
561	Amalgam fillings in capsule
8	**Waste incineration**
583	Incineration of medical waste
9	**Waste /deposition land filling and waste water treatment**
591	Solid waste disposal

Source: UNEP Toolkit, Pilot draft, November 2005

1.3 Pre-Inventory Preparation

For conducting the inventory of the release of mercury at the preliminary survey from various sources including desk study, the responsible survey team was formed and comprised nine members and was recruited by the Project Coordinator namely as follow:

1 -Eng. Helal Ali Al-Reiashi ,	**Deputy General Authority for Environmental Protection**
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3- Ahmed Ali	**Occupational Health and Safety**
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6- Dr. Abdel Fattah Abdul Haq Thabit	**General Administration for Plant Protection**
7- Eng. Abdullah Ahmed Obadi	**Yemen Consumer Society**
8-Dr. Yassin Abdel Warith	**Ministry of Public Health and Population**
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10-Dr. Abdo Al- Subari	**Ministry of Oil and Minerals**
11- Eng. Abdu Ahmed Sinan	**Ministry of Industry and Trade**
12- Dr. Ahmad Al-Aghil	**Agricultural Society**
13- Mehdi Morshed Tarah	**Chamber of Commerce and Industry**

To accomplish the objectives of mercury survey, the Mercury Project Coordinator requested to UNEP/GEF to assist with building capacity of the survey team to be able using the UNEP Toolkit for preparing the inventory throughout the country, as mercury management issue is a new theme for Yemen. Prior to this, Yemen had no experience in preparing an inventory of mercury releases. Knowledge on the inventory process, and concepts and techniques regarding data gathering and analysis is very limited, even though the members of the survey team took part in the two-day training workshop on mercury inventory held at the head quarter of the Environmental protection Authority.

Before conducting the inventory, the survey team had practices questionnaires (Appendix 1) and then identified 10 provinces and municipalities (out of total 10 provinces and municipalities), where expected to have potential release of mercury, based on the above categories release sources and human activities.

1.4 Release factors and sources

Emission factor is a parameter that plays a fundamental role in the calculation of the release of mercury into the environment. If emission factors cannot be assigned values, we cannot effectively calculate the release of mercury. In this regard, the UNEP Toolkit clearly identifies emission factor values according to specific source categories/sub-categories. Although the UNEP Toolkit is a very useful document for the development of a mercury release inventory report, even it mostly seems to be designed for use in developed countries rather than developing countries. This may create some confusion for developing countries with limited experience.

Determining release sources for Yemen mainly depended on the UNEP Toolkit even in a few cases pose some difficulty and complexity. For determining suitable release sources in this case, we considered and elaborately debated with Mr. Jakob Maag, UNEP's international consultant, Denmark, to find available solutions based on the UNEP Toolkit. In this regards and based on local knowledge, the mercury inventory team decided to focus the survey work for primary data on selected sources including:

1. Health sector (hospital, health care, and clinic) for both mercury contained in products (thermometer and amalgam filling) and mercury release from waste incineration,
2. Landfill (municipal waste dumping),

Besides undertaking field survey for primary data production, the inventory team had undertaken desk study on other sources of possibility mercury release including:

3. Secondary ferrous and non-ferrous metal production
4. Energy sources
5. Waste burning (industrial and medial waste)
6. Cremation
7. Cell batteries,
8. Production of lime, etc.

2 Quantification of mercury releases

Information and data gathering from survey and desk study, the estimated amount of mercury use and release in Yemen will be discussed by each category set under UNEP Toolkit as the following description.

2.1 Extraction and use of fuels/energy sources

2.1.1 Mineral oil - extraction, refining and use

2.1.1.1 Power plants

Activity rates

So far, fuel oils are widely consumed in Yemen in the power plants for generating electricity to serve the daily requirement of inhabitants in cities, towns, and rural areas. The General Population Census of Yemen 1995 indicated that lighting is generated from 60.1% electricity; 20.5% private generators 5.5% used acid-lead batteries; 13.9% Kerosene.

The managers of the power plants revealed that both heavy oils and light oils are crucial sources for running the power plants in the cities and provinces because Yemen has not had enough capability to construct a hydropower dam equipped with modern facilities.

Mercury input factors and output distribution factors used

As no specific data on mercury contents of the fuels actually used in Yemen was available, the maximum input factors from the Toolkit were used for preliminary estimation of mercury inputs to society from this sector. As the energy combustion technology used is considered as basic, that is, with no filters retaining mercury, the total input of mercury is considered high as released to the atmosphere with 100 mg mercury per tons for gasoline, diesel, and other distillates. Nevertheless, as no information provided by the toolkit, it is assumed that all types of heavy fuel oil fall to crude oil category, which meant that its input factor is about 10 mg per ton in minimum and about 300 mg mercury per ton in maximum. Resulting mercury release estimates are shown in table 3 below.

Table input and output for cement

No	513
Sub-category	Use of crude oil
Activity rate(t/y)	3 731 818
Input factor min	10 mg/t
Input factor max	300 mg/t
Input (Kg Hg/y) mini	37
Input (Kg Hg/y) max	1 120
Air distribution factor	1
Air output min kg /year	37
Air output max kg/ year	1 120
Total output mini	37
total output max	1 120

2.1.1.2 Transportation

Activity rates

Concerning transportation, the estimation of fuel consumption in Yemen it is known that about 2,546996.60 tons of diesel and gasoline were used in this sector. Out of this amount, about 1,047659.0 tons of fuel oil has been used for engines and it might be contributing to the release of mercury.

So, the total of refined fuel use for transportation is equaled to 1,188430.1 tons and possible mercury release from using such refined oil is shown in table 3.

Mercury input factors and output distribution factors used

Fuel sues for transportation sector is mostly distillated which fall to refined fuel type. According to the energy combustion technology used in Yemen which no filters retaining mercury or other type of pollution controlling system applied, thus the total input factor of mercury release is considered high as released to the atmosphere with 1 mg per ton in minimum and 100 mg per tons in maximum for gasoline, diesel, and other distillates (from UNEP Toolkit).

Resulting mercury release estimates are shown in table 3 below.

Input and output for transportation

No	513
Sub-category	Use of gasoline, diesel and other distillates (transportation)
Activity rate(t/y)	1 188 430
Input factor min	1 mg/t
Input factor max	100 mg/t
Input (Kg Hg/y) mini	1
Input (Kg Hg/y) max	119
Air distribution factor	1
Air output min kg /year	1
Air output max kg/ year	119
Total output mini	1
total output max	119

2.1.1.3 LPG

The fossil fuel used for Yemen household cooking is a gas from national refinery for cooking by using liquefied petroleum g as LPG has been present in Yemen since 1988s for house use .
The fossil fuel used for Yemen household cooking is a gas from national refinery for cooking by using liquefied petroleum g as LPG has been present in Yemen since 1988s for house use .

The amount of gas for use in domestic cooking is about 709, 187 tons (for 2006 according to the Oil Gas and Minerals statistics). According to the estimation of the Department of Custom, about 97% of fuel gas (or 709, 187 tons) is used for domestic cooking, and perhaps 3% is used for other purposes.

To convert the gas from weight to volume, the recommendation from UNEP Toolkit preparation and author (Jakob Maag) indicated that 1 metric ton of natural gas has the

volume of 1265 Nm^3 (normal meter cube, measure at temperature 0 degree Celsius and a pressure of 1013 millibar). So, the total gas of 709, 187 tons equal to 89818533 Nm^3 gas in volume. Based on this conversion, the amount mercury release from this sector can be calculated in table 3 bellows.

No	513
Sub-category	LPG
Activity rate(t/y)	709 187
Input factor min	1 mg/t
Input factor max	100 mg / Ton
Input (Kg Hg/y) mini	1
Input (Kg Hg/y) max	71
Air distribution factor	1
Air output min kg /year	1
Air output max kg/ year	71
Total output mini	1
total output max	71

Mercury input factors and output distribution factors used

For calculation of mercury release, it is necessary to convert the gas from metric ton to metric cube and as mentioned in the UNEP Toolkit, the input factor would be ranged from 0.03 to 0.4 μg Hg/Nm^3 of pipeline gas. For sound management of gas, the maximum input factor has been use for calculating the release of mercury into the atmosphere.

2.1.2 Biomass

Although fuel oil and gas are present in some cities and provinces, woods and charcoals are still popularly used due to their lower cost compared to fuel oil or gas. Wood and charcoal accounts for approximately 90% of the total energy supply in Yemen, especially as the main domestic source of energy for cooking (General Population Census of Yemen 1995). Updated national data and information on consumed woods/charcoals is not available for Yemen so far; the amounts are not expected to have changed much however.

Mercury input factors and output distribution factors used

There is varying mercury input factors addressed country by country as indicated in the UNPE Toolkit. Nevertheless, the toolkit expressed more indicators from Denmark, which can be assumed that such information could be used as model for calculation for least developing country, i.e. Yemen. So, based on the UNEP Toolkit, the mercury content of wood and straw burned in Denmark is in range of 0.007 to 0.03 mg/Kg dry weight.

As no specific data on mercury contents of the fuels actually used in Yemen was available, the minimum and maximum input factors from the Toolkit were used for this preliminary estimation of mercury inputs to society from this sector. As the energy combustion technology used is considered as basic, that is, with no filters retaining mercury, the total input of mercury is considered as released to the atmosphere is about 0.007 mg in minimum and 0.03 mg in maximum mercury per metric ton.

Resulting mercury release estimates are shown in table 3 below.

2.1.3 Summary of results for fuels

As the above description, the total amount of estimated mercury release by this sector (category 1) can be calculated at the below table:

Table 2: Mercury input from energy sources category

Results of inputs with modification

Sub-category	**Activity rate**(t/y)	**Input factor**		**Amount (Kg Hg/y)**	
		Min	**Max**	**Min**	**Max**
Use of crude oil	3 731 818	10 mg/t	300 mg/t	37	1 120
Use of gasoline, diesel and other distillates	2 546 996	1 mg/t	100 mg/t	3	255
Use of gasoline, diesel and other distillates (transportation)	1 188 430	1 mg/t	100 mg/t	1	119
LPG	709 187	1 mg/t	100 mg / Ton	1	71
Biomass fired power and heat production	1 047 569	0.007 mg/t	0.03 mg/t	0,007	0,031
Total release by category 1				**42**	**1 564**

Outputs for use of fuel/energy sources

Sub-category	**Activity rate**(t/y)	**Input factor**		**Amount (Kg Hg/y)**		**Air distribution factor**	**Air output min kg /year**	**Air output max kg/ year**
		Min	**Max**	**Min**	**Max**			
Use of crude oil	3 731 818	10 mg/t	300 mg/t	37	1 120	1	37	1 120
Use of gasoline, diesel and other distillates	2 546 996	1 mg/t	100 mg/t	3	255	1	3	255
Use of gasoline, diesel and other distillates (transportation)	1 188 430	1 mg/t	100 mg/t	1	119	1	1	119
LPG	709 187	1 mg/t	100 mg / Ton	1	71	1	1	71
Biomass fired power and heat production	1 047 569	0.007 mg/t	0.03 mg/t	0,007	0,031	1	0,007	0,031
Total release by category 1				**42**	**1 564**		**42**	**1 564**

2.2 Primary metal production - small scale gold mining

Activity rate and input factor

Yemen is an agricultural based country, so no heavy industry like production of metal from ores materials is existed so far. Based on UNEP Toolkit and reflecting to current situation. (Oil, Gas and Minerals statistics2006)).

Production of primary ferrous metal

No	529
Sub-category	Primary ferrous metal production
Activity rate(t/y)	500
Input factor min	0,05 g/ton
Input factor max	1 g/ton
Input (Kg Hg/y) mini	0,025
Input (Kg Hg/y) max	0,5
Air distribution factor	1
Air output min kg /year	0,025
Air output max kg/ year	0,5

2.3 Production of other minerals and materials with mercury impurities

Activity rate

There are no production activities of other minerals and materials with mercury impurities available in Yemen, except the production of lime and bricks information is not available. Thus, available data/information used in this section are available only for lime production, however and other minerals and materials data are not a available we need more survey .

2.3.1. Lime production

Raw material for producing the lime products is limestone, which is found in the mountains. The limestone mines were dug in different diameters and transported to the kilns for burning. Owners of the lime producing handicrafts revealed that the processing of lime products.

Mercury input factors

Information given by the UNEP Toolkit indicated that an atmospheric emissions factor of 0.055 g of mercury per metric ton of lime output was calculated for lime kiln using a mass balance approach, regardless sources of energy burned. Other input factor is also indicated by the toolkit in which 8 mg to 10 mg of mercury per metric ton of lime produced by the coal/coke-fired rotary kiln. For the natural gas-fired vertical kiln, the results showed an average mercury emission factor of 1.5 mg mercury per metric tons of lime produced

For Yemen case, lime kiln is made of brick on the ground and mainly use firewood as the main source of energy for lime production. As no specific data on mercury contents of the fuels actually used in Yemen was available, the minimum input factor of 0.009 grams per ton and maximum input factors of 0.055 grams per metric ton of lime output (from the Toolkit) was used for preliminary estimation of mercury inputs to society from this sector. As the energy combustion technology used is considered as basic, that is, with no filters retaining mercury, the total input of mercury is considered as released to the atmosphere.

So, the estimation of mercury releases from lime production is indicated in Table 6 below.

Table 3: Input and output for from mineral production category

No	533
Sub-category	Lime production
Activity rate(t/y)	145
Input factor min	0.009 g/t
Input factor max	0.055 g/t
Input (Kg Hg/y) mini	0,01305
Input (Kg Hg/y) max	0,07975

Air distribution factor	1
Air output min kg /year	0,013
Air output max kg/ year	0,080
Total output mini	0,01
total output max	0,08

2.3.2. Cement Production

Certain recoverable materials, as well as fuels that contribute the most significant quantities of mercury, are used in the production of grey cement. However, the lime used in the process also makes a contribution. The quantity of mercury that derives from the raw materials of cement production amounts to about 103 kg/year, and the greater part the mercury contribution comes from the fuels and fly ash we import klinker.

Output and output for cement production

No	531
Sub-category	Cement production
Activity rate(t/y)	525000
Input factor min	0.2 g/t
Input factor max	0.2 g/t
Input (Kg Hg/y) mini	105
Input (Kg Hg/y) max	105
Air distribution factor	0,98
Air output min kg /year	103
Air output max kg/ year	103
Product air distribution factor	0,02
Product output mini	2,1
Product output maxi	2
Total output mini	105
total output max	105

Input for Production of other minerals and materials with mercury impurities

Sub-category	Activity rate(t/y)	Input factor		Amount (Kg Hg/y)	
		Min	**Max**	**Min**	**Max**
Cement production	525000	0.2 g/t	0.2 g/t	105	105
Lime production	145	0.009 g/t	0.055 g/t	0,0131	0,07975
Total 3					

Output for Production of other minerals and materials with mercury impurities

Sub-category	Air distribution factor	Air output min kg /year	Air output max kg/ year	Product air distribution factor	Product output mini	Product output maxi
Cement production	0,98	103	103	0,02	2,1	2
Lime production	1	0,013	0,080			
Total 3		103	103	0,02	2,10	

2.4 Intentional use of mercury in industrial processes

No activities related to the intentional use of mercury in industrial processes in Yemen, because this country is depending much on it agricultural production and tourist sector, thus no data on mercury release available for this category (category 4)

2.5 Consumer products with intentional use of mercury

There are 7 sub-categories addressed in the UNEP Toolkit regarding consumer products with intentional use of mercury including:

Thermometers
Electrical and electronic switches, contacts and relays with mercury
Light sources with mercury
Batteries alkaline
Other type batteries
Paints
Cosmetic and related products

So far, no one knows about the mercury being use in the above described products except thermometers and batteries. Nevertheless, there is no record on about where thermometers and batteries have been used and how many thermometers and batteries have been distributed or dispose of within the country. Based on history, it was understood that such mercury thermometers had been used as medical thermometer, ambient air temperature thermometer, in chemical laboratory, and in industrial equipment, while batteries are being use to power electrical device, i.e. radio throughout the country.

Beside information on thermometer and battery containing mercury, there are no any information related to the quantity of other consumer products i.e. electrical and electronic switches, light source with mercury (fluorescent lamps), biocides and pesticides, paints, pharmaceuticals for human and veterinary uses, and cosmetic and related products been imported to Yemen or been disposed of neither in a yearly basis or in a period of time. So, the calculation of the releases of mercury from these types of products is not known .we need additional fund for analysis.

Considering on sub-categories on consumer products that may release mercury, the survey team undertook survey on thermometers and batteries only and such finding is described below.

2.5.1 Thermometers with mercury

Activity rate

In Yemen, medical thermometer is well known by most people, except its risk to human health, when containing mercury. Such thermometers are generally used at hospital and clinic, and some at home. Unfortunately, the total number of medical thermometers that have been imported, distributed and used in Yemen so far, remain unknown. Therefore, the inventory teams have been undertaking a survey on these matters by contact to selected hospitals and local health clinics (including various sizes of hospitals/clinics). The results showed about 1500 thermometers have been supplied to 20 hospitals within a year, made average of 50 thermometers per hospital per year for big hospital. The detailed results are shown in Appendix 3.

Nevertheless, based on the inventory issue report provided by the Ministry of Health &population, for period from 1st January 2007 to 31st December 2007, indicated that were 1500 thermometers had distributed to health facilities through out Yemen and 200 for Industrials use (See Appendix 3). Most of these thermometers are mercury based, but some of them are alcoholic and digital type thermometers. Unfortunately, the origin or country produced such medical thermometers is varies including EU countries, Japan, China, USA, Canada, Russia, etc. and quantity of imported from those countries also unknown.

On the other hand, there are at least two types of medical thermometers available in Yemen markets: one is mercury type and other one is alcoholic types. So, it is hard to say that all thermometers supplied to health establishments are mercury based thermometers, however, for future sound management of mercury we can be assumed that those supplied thermometers are mercury based. On the other hand, the rough estimate made does not include fever thermometers used in private homes, and may therefore underestimate the actual supply in Yemen.

Mercury input factors used

Mercury input factors for this section is varying from one field to another i.e. medical thermometers, household thermometers, ambient air temperature thermometers, industrial and special application thermometers, laboratory thermometers, and thermometers for testing petroleum products. Nevertheless, for Yemen case, only medical thermometers are commonly used by medical practitioners and could be the most well known one, then followed by household thermometers. The rest thermometers use by other sectors seems very limited, and can be considered none for testing petroleum products.

In this regards and based on thermometer's information available, the mercury input factors provided by the UNEP Toolkit is ranged from a minimum of 0.25 g to a maximum of 2 g per thermometer. This variation standard is followed by the thermometer's made origin including Canada (0.7 g), Denmark (0.25 g), EU (0.5 g to 1.5 g), France (2 g), Russia (1.85 g), and USA (0.61 g). By the way, for calculation mercury release by this sector, the UNEP Toolkit, provide preliminary default mercury input factors for medical thermometer ranged from 0.5 g to 1.5 g per thermometer. In this regards, the maximum input factor (1.5 g per thermometer) has been selected for calculation the release of mercury in Yemen.

Output distribution factors

The contacted hospitals were also asked about the fate of used thermometers, but no answers were obtained on this issue. Through other studies of hospital waste and a field visit to one hospital, it is known however that spent thermometers would generally be disposed with other hospital waste, that is, buried on-site, burned on-site or perhaps in some case be disposed with general waste to landfills. According to information from the field visit, mercury from broken thermometers spilled on the floor would simply be washed out with

water. This water likely ends up in the sewer system or on the ground on-site, depending on local settings.
Accordingly the Toolkit's default output distribution factors for the scenario "No or very limited separate thermometer collection. Missing or informal collection and handling of general waste is widespread" were applied in the calculations, in which, the output distribution factor for this sector is 0.2 for air, 0.3 for water, 0.2 for land, and 0.3 for general waste. So the estimated possible release of mercury and its distribution pathways for this sub-category is shown in the below table 7 and 8.

Table 4: Mercury input and output distribution by pathway for thermometers

No	5,1
Sub-category	Thermometers
Activity rate(t/y)	1700
Input factor min	0.5 g/item
Input factor max	1.5 g/item
Input (Kg Hg/y) mini	0,85
Input (Kg Hg/y) max	2,55
Air distribution factor	0,2
Air output min kg /year	0,17
Air output max kg/ year	0,51
Water distribution factor	0,3
Water output min	0,255
Water output max	0,765
Land distribution factor	0,2
land output mini	0,17
land output max	0,51
General waste distribution factor	0,3
waste output mini	0,255
waste output max	0,765
Total output mini	1
total output max	3

***Note**: Input factors are taken from UNEP Toolkit. For medical thermometer input factor ranged from 0.5 to 1.5 g Hg/item.*

2.5.2 Input and output for Electrical switches and relays with mercury

No	552
Sub-category	Electrical and electronic switches, contacts and relays with mercury
Activity rate(t/y)	17000000
Input factor min	0,25 g/ hab
Input factor max	0,25 g/ hab
Input (Kg Hg/y) mini	4250

Input (Kg Hg/y) max	4250
Air distribution factor	0,3
Air output min kg /year	1275
Air output max kg/ year	1275
Water distribution factor	0,3
Water output min	1275
Water output max	1275
General waste distribution factor	0,4
waste output mini	1700
waste output max	1700

2.5.3 Input and output for Light sources with mercury

No	553
Sub-category	Light sources with mercury
Activity rate(t/y)	17000000
Input factor min	5 per item
Input factor max	15 mg /item
Input (Kg Hg/y) mini	85
Input (Kg Hg/y) max	255
Air distribution factor	0,3
Air output min kg /year	25,5
Air output max kg/ year	76,5
Water distribution factor	0,3
Water output min	25,5
Water output max	76,5
General waste distribution factor	0,4
waste output mini	34
waste output max	102

2.5.4 Batteries with mercury

Activity rates

According to information from Custom Department, it was reported that in 2005 Yemen had imported batteries about 13 tons from different countries. Zinc-air type batteries contribute with 97.96 percent (about 13 tone/y) of total batteries imported,. No batteries explicitly reported as mercury based was recorded by the Custom Department. Detail information obtained from the Custom Department is shown in Appendix 4. Projection of mercury releases by this sub-category is shown in table 13.

Mercury based battery may be used in Yemen, but no official records does not confirm about the use nor other information related to origin of imported, imported quantities, distribution, or disposal management.

Input factors

For general cylindrical alkaline batteries which are normally used in large quantities compared to other battery types, the large globally traded brands today contain no or very

little mercury. Some regionally sold brands may however contain more mercury (reference to Toolkit). As an indication of the potential mercury inputs with these batteries, the Toolkit's input factors for alkaline batteries (0-10 Kg Hg/ton battery) are used in the calculations. By the way, based on information from UNEP's consultant[1] was reported that the revised input factor for zinc-air type batteries is about 0.250 Kg/ton, which can be considered as minimum input factor for this zinc-air type batteries.

For the batteries reported as "others", experience from other countries show that this may most likely be a mix of many battery types reported as "others", because they may have been packed together, or because the importer was not sure of the actual type. As this category may likely include most button cell size battery types which generally do contain mercury, but only parts of them may be the actual mercury-oxide batteries, a mixed input factor range from the Toolkit was used, representing a broader range of button cell battery types: 3.4 - 160 Kg Hg/ton batteries (based on personal consultation with consultant and Toolkit author (Jakob Maag, January 2008). The resulting mercury input estimates are associated with a substantial uncertainty, but do however serve to indicate an order of magnitude of the mercury input to Yemen with batteries.

Output distribution factors

Based on local practice, the out of used batteries have been disposed of with general waste without separation practice, for all urban areas. For people who living in country side, the used batteries are disposed of right away at their back yards, whether burred or burned with general waste. According to information from the field visit,

Accordingly the Toolkit's default output distribution factors for the scenario "No or very limited separate batteries collection. Missing or informal collection and handling of general waste is widespread" were applied in the calculations, in which, the output distribution factor for this sector is 0.25 for air, 0.25 for land, and 0.5 for general waste. So the estimated possible release of mercury and its distribution pathways for this sub-category is shown in the below table 9 and 10.

Table 5: input and outputs for alkaline batteries

No	5,4
Sub-category	Batteries alkaline
Activity rate(t/y)	13
Input factor min	0.1 kg/t
Input factor max	0.250 kg/t
Input (Kg Hg/y) mini	1,3
Input (Kg Hg/y) max	3,25
Air distribution factor	0,25
Air output min kg /year	0,33
Air output max kg/ year	0,81
Land distribution factor	0,25
land output mini	0,325
land output max	0,8125
General waste distribution factor	0,5

waste output mini	0,65
waste output max	1,625
Total output mini	1
total output max	3

Table 6: input and output for other types of batteries

No	5,4,1
Sub-category	Other type batteries
Activity rate(t/y)	3
Input factor min	3.4 kg/t
Input factor max	160 kg/t
Input (Kg Hg/y) mini	10,2
Input (Kg Hg/y) max	480
Air distribution factor	0,25
Air output min kg /year	2,55
Air output max kg/ year	120,00
Land distribution factor	0,25
land output mini	2,55
land output max	120
General waste distribution factor	0,5
waste output mini	5,1
waste output max	240
Total output mini	10
total output max	480

2.5.5 Input and output for Cosmetics and related products

No	558
Sub-category	Cosmetic and related products
Activity rate(t/y)	5
Input factor min	10 kg/ton
Input factor max	50 kg/ton
Input (Kg Hg/y) mini	50
Input (Kg Hg/y) max	250
Water distribution factor	1
Water output min	50
Water output max	250

Input for category 5

Thermometers	1700	0.5 g/item	1.5 g/item	0,85	2,55
Electrical and electronic switches, contacts and relays with mercury	17000000	0,25 g/ hab	0,25 g/ hab	4250	4250
Light sources with mercury	17000000	(5 -15 mg per item	15 mg /item	85	255

Batteries alkaline	13	0.1 kg/t	0.250 kg/t	1,3	3,25
Other type batteries	3	3.4 kg/t	160 kg/t	10,2	480
Paints	5	0.3 kg Hg/t	0.5kg Hg/t	1,5	2,5
Cosmetic and related products	5	10 kg/ton	50 kg/ton	50	250
Total 5				**4398,85**	**5243,3**

2.6 Other intentional products/process uses

Other intentional products use in this category is referring to various products including amalgam fillings, manometers and gauges, laboratory chemicals and equipment, mercury metal use in religious rituals and folklore medicine, and others. For Yemen context, mercury metal use in religious rituals does not exist. Beside this, for mercury use in manometers and gauges, laboratory chemicals and equipment, and other folklore medicines remain we have no information and data, whether of origin and quantity imported, or where supplied to. Nevertheless, it is known that such product have been use in health cares (manometers and gauges) and laboratories.

Dental amalgam fillings could be the only available information to get and this was addressed in this report as the following point.

Source description

Mercury may be released to air, water, and wastes during the use and disposal of amalgam fillings especially during the placing of fillings and the removal of fillings or teeth containing fillings. The releases can be also occurred after the death of a person with fillings, e.g. dental amalgams, are a major source of mercury releases to air from cremation .

In Yemen history on when the dental clinics operated are remains unknown. Most of dental clinics are operated by private sector and few by public sector.

There are several types of tooth filling materials in use in Yemen including amalgam, composite, glass ionomer cement, poly carboxylate cement, oxyde design and ceramic. Yemen people who went to dental clinic prefer to use composite for filling their tooth rather than amalgam. Oxyde design and ceramic materials is favorite use by wealthy people.

According to dentists report, it is known that amalgam is usually supplied in two forms either 1) as pure mercury along with a powder mix of the other metals, which are weighed and mixed in the clinic; or 2) as small capsules where mercury and the metal powder are present in the right proportions and need only to be mixed (in the capsule before opening) in the clinic, prior to filling the cavity in the tooth. Amalgam in capsule form is favorite use by dentist in Yemen compared to the other form currently.

Mercury input

Detailed information on mercury use for dental amalgam was collected from public and private dental clinics in 4 big provinces and two municipality in Yemen.

According to information from the Department of Health, the total number of dental clinics in the country is approximately 3290. Assuming as a very rough estimation that the remaining dental clinics of the country also have an average of two chairs per clinic, the survey made covers approximately 1200. Accordingly, a rough estimate of the national consumption of amalgam capsules is 35000 capsules per year in maximum estimation.

Similarly, a rough estimate of the free metal mercury consumption for dental fillings is 20000-30000 grams or 20. - 30 Kg Hg/year in maximum calculation.

There is no report on mercury contains in each capsule by weight or percentage, which is enable to calculate the total amount of mercury use for tooth fillings nor the emission by media. Nevertheless, to enable for calculation for the release of mercury into the environment, it is assumed that one amalgam capsule contains an average amount of mercury of 0.8g (based on UNEP Toolkit data per filling from Denmark), resulting in a calculated mercury consumption with capsules of 35000 x 0.8 g = 28000 grams or equal to 28.00 Kg Hg/year (around year 2005-2007) in maximum. So that the total amount of mercury use in Yemen for dental fillings can thus be estimated at around 20-30 Kg Hg per year in maximum.

This is a very low input of mercury with dental amalgam compared to western countries (reference to Toolkit). A major reason for this is likely a much lower frequency of dental restorations (restorations are expensive compared to daily economy in Yemen), in combination with the apparently widespread use of other filling materials.

Regarding mercury releases from dental clinics and dental amalgam use, the contacted clinics were asked about their waste management, but no response was received on this issue. Both solid and suspended amalgam drilling waste is most likely lost directly to the sewer/drainage system, or other on-site sewage disposal method. No information was identified indicating special collection of excess amalgam from the insertion of new fillings, or of extracted teeth. As the silver in these materials does represent some value, it is not deemed unlikely that such collection or re-sale could perhaps take place. Even if this is the case, and the metal is re-melted in the country, the mercury content is most likely lost directly to the atmosphere from the furnaces. Quantification of any such processes is deemed beyond the scope of this study considering the lack of actual data on the issue. In conclusion it must be assumed that most of the mercury used in dental amalgam is lost to the environment either directly, or via the disposal of general waste. For larger cities where there is the highest concentration of dental clinics, mercury from dental clinics may likely be detectable in sewer sludge (based on consultation with Jakob Maag, January 2008).

Table 7: input and output for dental amalgam[2]

No	6,1
Sub-category	Amalgam fillings in capsule
Activity rate(t/y)	0.8 g per caps
Input factor min	26000 caps
Input factor max	35000 caps
Input (Kg Hg/y) mini	20,8
Input (Kg Hg/y) max	28
Air distribution factor	0,02
Air output min kg /year	0,42
Air output max kg/ year	12
Water distribution factor	0,14

[2] *Table 5 – 137 of the tool kit page 200*

Water output min	2,912
Water output max	3,92
Product air distribution factor	0,6
Product output mini	12,48
Product output maxi	16,8
General waste distribution factor	0,12
waste output mini	2,496
waste output max	3,36
disposal emission factor	0,12
Output disposal mini	2,496
output disposal max	3,36
Total output mini	21
total output max	39

2.7 Production of recycled metals (secondary metal production)

The category 7 indicates the mercury release from the production of recycled metals regarded as secondary metal production. There are three types of sub-categories considering in this sector including (1) production of recycled mercury, (2) production of recycled ferrous metal (iron and steel) and (3) production of other recycled metals. In Yemen practices, the secondary metal production is available only for scraped iron, aluminum, copper, and lead.

2.7.1 Production of recycled ferrous metal (iron and steel)

It is known that recycled iron production undertaken at small scale handicraft. The iron scrap recycling/production sources comprise 3 locations; and most of them are located in Hodeidah and Aden Province. According to the estimation, the amount of iron annually produced is about 720 tons. The most common recycling kiln is a cylinder with a height of 1 meter and a diameter of 0.7 meters. It is processed by charcoals. The production of iron scrap recycling is made for other products, especially, spare parts for vehicles and any metallic machines. The recycling kiln is generally made of iron on the inside and bricks on the outside. Such handicrafts have no temperature controller or air pollution control system applications applied. Under these conditions, most likely no potentially mercury-containing parts (switches and lights) will actually enter the melting furnace. To the extent cars with mercury containing parts (e.g. older cars from the Europe & Arab Gulf) are present in the Yemen society, these parts may be collected for re-sale as spare parts or be lost to scrap heaps at the car scrappers, or go with general waste to landfills. The charcoal as mercury source is considered accounted for separately above (on an overall national basis).

2.7.2 Production of other recycled metals

The production of other recycled metals refers to the recycle of secondary scraped non-ferrous metals including aluminum, copper and lead. The aluminum recycling at handicrafts is available at 80 locations with the annually rate production of 50,00 tons. Most of them are located in Sana'a and Aden ,Hodeidah and only a few additional provinces. Same as the iron recycling kiln, the kiln for aluminum recycling is simply made of iron inside with the outside protected/covered by bricks. The recycling process is operated by using charcoals. This oven

has no temperature controller. The products of recycled aluminum can make many types of domestic objects, for example, pots, plates, bowls, and other souvenir items.
The copper recycling process operates in 3 small-scale handicrafts, but no data has been disclosed from responsible institutions. However, there is no data available on the annual production of copper, but the survey indicated that copper recycling products can design many products like statues and other souvenir objects, bowls, plates, etc.
As for ferrous metals, no mercury containing parts are expected to be fed to the furnaces; any parts present would likely be scrapped as waste.
For the two recycling sources of iron scraped and aluminum products, as addressed earlier, the release of mercury into the environment could no be calculated (at the below table 12) due to no input factors available (based on UNEP Toolkit).

Table 8: Mercury release from recycled metal production

No	Sub-category	Activity rate(t/y)	Input factor		Amount (Kg Hg/y)	
			Min	Max	Min	Max
7.1	Production of recycled ferrous metal (iron and steel)	720	N/A	N/A		
7.2	Production of other recycled metals (aluminum, copper, etc.)	50	N/A	N/A		
	Total release by category 7					

***Note**: No input factors for this category is provided by UNEP Toolkits*

2.8 Waste incineration

The category 8 (waste incineration) refer to any waste that going to burned down at incinerators regardless with or without air pollution control system. As indicated in the UNEP Toolkit, there are five type of waste incineration sub-categories addressed including: incineration of municipal/general wastes, incineration of hazardous waste, incineration of medical waste, incineration of sewage sludge, and informal incineration (burning) of waste. In this regards and based on Yemen context, the waste incineration in Yemen can be addressed only two types: (1) municipal waste incineration; and (2) medical waste incineration.

2.8.1 Incineration of municipal/general waste

Activity rates

The municipal wastes comprise household wastes, hospital wastes and garment factory wastes. Both types of wastes mostly have similar composition, excluding chemical wastes which are generated from the use of chemicals or chemical compounds in production processes. Most municipal wastes are disposed of at dumping sites contrary to other developing/developed countries that incinerate their wastes in incinerators or ovens. The municipal waste incineration addressed in this report is merely on garment factory wastes[3] that burn in the incinerators for various purposes including: (i) reducing the waste quantity; and (ii) generating a steam for ironing. However, municipal household wastes that are disposed at dumping sites are not necessary to identify in this point, because Yemen does not have so called professional incineration facilities as well as such municipal wastes will be mentioned in the below section 3.9.1.

Input factor

Most of manufacturing establishment in Yemen are soft drinks and garment factories, which their waste are mostly cartons ,plastics cloth and household wastes that can be considered as municipal wastes. All factories' incinerators do no install APCS, which all emission matters

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are gone freely to the atmosphere. So, as an indication of the potential mercury inputs with incineration of municipal wastes, the Toolkit's maximum input factors (input factors ranged from 1 gram to 10 gram Hg/ton waste) are used in the calculations.

Output distribution factors

Accordingly the Toolkit's default output distribution factors for the scenario "None" were applied in the calculations, in which, the output distribution factor for this sector is 1 for air. So the estimated possible release of mercury and its distribution pathways for this sub-category is shown in the below table 14.

2.8.2 Incineration of medical waste

Activity rates

Medical wastes account for approximately 2% of total waste production, and is composed of needles, syringes, glass bottles, glasses, surgical wastes, and other pharmaceutical wastes. Currently, the medical waste is generally reasonably managed in terms of waste classification, collection, storage, and disposal/burning and the remaining composed with municipal wastes.

Input factor

All medical waste incinerators do no install APCS, which all emission matters are gone directly into the atmosphere. So, as an indication of the potential mercury inputs with incineration of medical wastes, the Toolkit's maximum input factors (input factors ranged from 8 Kg to 40 Kg Hg/ton waste) are used in the calculations.

Output distribution factors

Accordingly the UNEP Toolkit, the default output distribution factors for incineration of medical waste shall follow the default output distributors for incineration of municipal wastes. Thus default output distributions factors for the scenario "None" were applied in the calculations, in which, the output distribution factor for this sector is 1 for air. So the estimated possible release of mercury and its distribution pathways for this sub-category is shown in the below table 14.

Table 9: input and output for incineration of medical waste

No	8,2
Sub-category	Incineration of medical waste
Activity rate(t/y)	400.00 t/y
Input factor min	8 g/t
Input factor max	40 g/t
Input (Kg Hg/y) mini	3,2
Input (Kg Hg/y) max	16
Air distribution factor	1
Air output min kg /year	3
Air output max kg/ year	16
Water distribution factor	
Total output mini	3
total output max	16

2.9 Waste deposition/land filling and waste water treatment

The category 9 (waste disposal) refer to any waste that going to disposal of at landfill or backyard. As indicated in the UNEP Toolkit, there are five type of waste deposition and waste water treatment sub-categories addressed including: controlled landfills/deposit, diffuse deposition under some control, informal local disposal of industrial production waste, informal dumping of general waste, and waste water treatment. In this regards and based on Yemen context, the waste deposition in Yemen can be addressed in three types: (1) controlled landfill; (2) waste water treatment, and (3) informal waste disposal. The informal wastes disposal is unable to describe in this report for the calculation of mercury release due to no reliable information or data supports. So, only two subcategories can be addressing in this report as the following.

2.9.1 Controlled landfills/deposits

Up to the present, solid waste disposal is still a big issue in Yemen, although efforts by the Netherlands, especially MoPR, urge stakeholders to apply environmentally sound management of wastes. Among cities and provinces, Sana'a & Aden certainly are the only cities that has its dumping site (Dumpsite) which is being improved under the support of German Government and. This dumpsite mostly accepts solid wastes collecting from urban areas, but in rural areas of Amran where waste collecting vehicles cannot access, solid wastes are untidily disposed of in low lands, drainages, canals, natural ponds, on/along the roads, and so on.

In nearly all cities and provinces, solid wastes generated from houses, commercial centers, hospitals, industrial handicrafts, etc. are disposed at the above mentioned sources, and kept to decompose under weather conditions, or sometimes is burned. Significantly, dumping sites exist in cities and provinces that are very simple without any monitor/protection system[4], and furthermore, domestic animal and scavengers can freely access these to find food and salable materials.

Besides Dumping Site, all dumpsites in the cities and provinces, in general, are being used without high technology and are only open and/or lower lands located close to or far away from residential area, and many of them are close to wadies. Currently, over 95% of dumpsites are simple without installing a collection system for water, gases, and leachate.

Activity rates

Nevertheless, through information obtained from the Solid Waste and Hazardous Substances Management of Office of the Ministry of water and environment Environmental protection Authority recorded that the amount of solid waste collected and dumped throughout the country in 2006 is approximately 474,556 tons. So, based on this waste amount we can estimate the generation of mercury and its release into the environment as indicated in the table 15 below. Detail information of wastes generated by each province and municipality is shown on Appendix 6.

Input factors

All collected general (municipal) wastes are goes to dumping site, where wastes have been burning frequently by natural and/or human activities (waste compacted activities, scavengers burned, etc.). So, as an indication of the potential mercury inputs factor for this subcategory, the Toolkit's input factors are ranged from 1 gram to 10 gram mercury per ton waste are used in the calculations.

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2.9.2 Waste water system/treatment

Yemen does not have a waste water/sewage treatment center and the construction study of wastewater treatment plant has not been undertaken yet, except a few cities and provinces have received loans from WB and *KFW* (Germany) for wastewater treatment.

Sewerage and drainage systems in Sana'a and in some other cities and provinces play a crucial role in releasing rain water and waste water, and reducing flooding in residential areas, villages, etc., and finally run off to receiving water bodies.

The situation in provinces and cities does not differ from Sana'a, Aden, Ibb, and Hajah, where wastewaters from various generating sources are being discharged into waterways or other receiving sources without treatment, and then stored in these areas. Some waterways or water storage areas are currently being studied for improving their flow or storage capacity.
Based on input factor provided by UNEP Toolkit and the above description figures, thus the amount of mercury release by this category is shown in table 15.

Table 10: input and output for waste disposal[5]

No	9.1
Sub-category	Solid waste disposal
Activity rate(t/y)	474,556
Input factor min	1 g/t
Input factor max	10 g/t
Input (Kg Hg/y) mini	474,556
Input (Kg Hg/y) max	4745,56
Output disposal mini	
output disposal max	
Total output mini	0
total output max	0

***Note**: Input factors are taken from UNEP Toolkit. For general wastes, default input factor ranged from 1 to 10 g Hg/t and for waste water input factor ranged from 0.5 to 10 mg Hg/m^3.*

2.10 Crematoria and cemeteries

N.A

Input factors

As an indication of the potential mercury inputs factor for this subcategory, the Toolkit's input factors are ranged from 1 gram to 4 gram mercury per corpse are used in the calculations.

Table 11: Mercury release from cremation category

No	Sub-category	Activity rate (corpse/y)	Input factor		Amount (Kg Hg/y)	
			Min	Max	Min	Max
10.1	Cremation	N/A				

[5] *The output are not recorded for this category considering they should be recorded in others categories*

	Total release by category 10					

***Note**: Input factors are taken from UNEP Toolkit. For cremation, input factor ranged from 1 to 4 gram Hg/corpse and for burial input factor also ranged from 1 to 4 gram Hg/corpse.*

2.11 Identification of potential hot-spots

The potential hot-spots of mercury release identified by the UNEP Toolkit refer to post or abandon sites of chemical production, pulp and paper manufacturing, chlor-alkali production, etc. which classified as the following:

- Closed/abandoned chlor-alkali production sites
- Other sites of former chemical production where mercury compounds were produced (pesticides, biocides, pigments etc.), or mercury or compounds were used as catalysts (VCM/PVC etc.)
- Closed production sites for manufacturing of thermometers, switches, batteries and other products
- Closed pulp and paper manufacturing sites (with internal chlor-alkali production or former use of mercury-based slimicides)
- Tailings/residue deposits from mercury mining
- Tailings/residue deposits from artisanal and large scale gold mining
- Tailings/residue deposits from other non-ferrous metal extraction
- Sites of relevant accidents
- Dredging of sediments
- Sites of discarded district heating controls (and other fluid controls) using mercury pressure valves
- Sites of previous recycling of mercury ("secondary" mercury production)

Besides tailings from gold mining dealt with above, it can be assumed that there is no potential hot-spot of mercury release could be identified or addressed in this category, by the time being.

2.12 Overview of the Inventory Results

Although Yemen has a different and complex situation[6] regarding the use and release of mercury compared to some other developed and developing countries. Nevertheless, Yemen still can estimate the possible release of mercury into the environment based on the UNEP Toolkit. While the outcome of the survey and calculation of mercury releases does not deem to be 100 percent accurate, it is the immense pride of Yemen that to have the ability to show the release scale of mercury to the world as well as to other countries in the region. The results of the survey were elaborated in the above are summarized data only in table 17 below.

Table 12: Summary of mercury input from all categories

No	Sub-category	Activity rate(t/y)	Input factor min	Input factor max	Input (Kg Hg/y) mini	Input (Kg Hg/y) max
			Min	Max	Min	Max
1	**Extraction and use of ful/energy sources**					
513	Use of crude oil	3 731 818	10 mg/t	300 mg/t	37	1 120
513	Use of gasoline, diesel and other distillates	2 546 996	1 mg/t	100 mg/t	3	255
513	Use of gasoline, diesel and other distillates (transportation)	1 188 430	1 mg/t	100 mg/t	1	119
513	LPG	709 187	1 mg/t	100 mg / Ton	1	71
516	Biomass fired power and heat production	1 047 569	0.007 mg/t	0.03 mg/t	0,007	0,031
1	**Total release by category 1**				**42**	**1 564**
2	**Primary metal production**					
529	Primary ferrous metal production	500	0,05 g/ton	1 g/ton	**0,03**	**0,50**
3	**Production of other minerals and material with mercury impurities**					
531	Cement production	525000	0.2 g/t	0.2 g/t	105	105
533	Lime production	145	0.009 g/t	0.055 g/t	0,01305	0,07975
3	**Total 3**				**105**	**105**
5	**Consumer products with intentional use of mercury**					
551	Thermometers	1700	0.5 g/item	1.5 g/item	0,85	2,55
552	Electrical and electronic switches, contacts and relays with mercury	17000000	0,25 g/ hab	0,25 g/ hab	4250	4250
553	Light sources with mercury	17000000	(5 -15 mg per item	15 mg /item	85	255
554	Batteries alkaline	13	0.1 kg/t	0.250 kg/t	1,3	3,25
554	Other type batteries	3	3.4 kg/t	160 kg/t	10,2	480
556	Paints	5	0.3 kg Hg/t	0.5kg Hg/t	1,5	2,5
558	Cosmetic and related products	5	10 kg/ton	50 kg/ton	50	250
5	**Total 5**				**4398,85**	**5243,3**
6	**Other intentional product/process uses**					
561	Amalgam fillings in capsule	26000 caps	0.8 g per caps	0.8 g per caps	20,8	20,8
562	Manometers and gauges with mercury	3000	1 g per item	1g per item	3	3
6	**Total 6**				**24**	**24**
8	**Waste incineration**					
583	Incineration of medical waste	400.00 t/y	8 g/t	40 g/t	3,2	16
8	**Total 8**				**3,2**	**16**
9	**Waste /deposition land filling and waste water treatment**					
591	Solid waste disposal	474,556	1 g/t	10 g/t	474,556	4745,56

9	**Total 9**				**475**	**4 746**
1 - 9	**Total 1 to 9**				**5 047**	**11 698**

Result of inputs and outputs

Sort per max input

No	Sub-category	Input (Kg Hg/y) mini	Input (Kg Hg/y) max
591	Solid waste disposal	474,56	4 745,56
513	Use of crude oil	37,32	1 119,55
554	Other type batteries	10,20	480,00
553	Light sources with mercury	85,00	255,00
513	Use of gasoline, diesel and other distillates	2,55	254,70
558	Cosmetic and related products	50,00	250,00
513	Use of gasoline, diesel and other distillates (transportation)	1,19	118,84
531	Cement production	105,00	105,00
513	LPG	0,71	70,92
561	Amalgam fillings in capsule	20,80	20,80
583	Incineration of medical waste	3,20	16,00
554	Batteries alkaline	1,30	3,25
562	Manometers and gauges with mercury	3,00	3,00
551	Thermometers	0,85	2,55
556	Paints	1,50	2,50
529	Primary ferrous metal production	0,03	0,50
533	Lime production	0,01	0,08
516	Biomass fired power and heat production	0,01	0,03

Sort per total out put

No	**Sub-category**	**total output max**
1.1	Use of crude oil	1 119,55
5,4	Other type batteries	480,00
1.2	Use of gasoline, diesel and other distillates	254,70
1.3	Use of gasoline, diesel and other distillates (transportation)	118,84
3,1	Cement production	105,34
1,3	LPG	70,92
6,1	Amalgam fillings in capsule	39,09
8,2	Incineration of medical waste	16,00
5,4	Batteries alkaline	3,25
5,1	Thermometers	2,55
3,2	Lime production	0,0798
1.5	Biomass fired power and heat production	0,0314
5,2	Electrical and electronic switches, contacts and relays with mercury	0.1375

5,6	Paints	2.5
9.1	Solid waste disposal	0

Sort per max output air

No	Sub-category	Air output max kg/ year
513	Use of crude oil	1 119,55
513	Use of gasoline, diesel and other distillates	254,70
554	Other type batteries	120,00
513	Use of gasoline, diesel and other distillates (transportation)	118,84
531	Cement production	103,28
553	Light sources with mercury	76,50
513	LPG	70,92
583	Incineration of medical waste	16,00
562	Manometers and gauges with mercury	1,80
554	Batteries alkaline	0,81
551	Thermometers	0,51
529	Primary ferrous metal production	0,50
561	Amalgam fillings in capsule	0,42
533	Lime production	0,08
516	Biomass fired power and heat production	0,03
556	Paints	
558	Cosmetic and related products	

Sort per max output water

No	Sub-category	Water output min	Water output max
552	Electrical and electronic switches, contacts and relays with mercury	1275	1275
558	Cosmetic and related products	50	250
553	Light sources with mercury	25,5	76,5
561	Amalgam fillings in capsule	2,912	2,912
562	Manometers and gauges with mercury	0,9	0,9
551	Thermometers	0,255	0,765

Sort per max output land

No	Sub-category	land output mini	land output max
554	Other type batteries	2,55	120
562	Manometers and gauges with mercury	0,6	1,8
554	Batteries alkaline	0,325	0,8125
551	Thermometers	0,17	0,51

Summary of results

Designation	Toaux Min	Totaux Max
Input (Kg Hg/y)	797,21	7 448,28
Outputs		
Air output kg /year	177,85	1 883,94
Water output	174,48	1 276,38
land output	98,56	1 072,23
Product output	16,08	14,98
waste output	328,13	3 195,12
Output disposal	2,50	2,50
Total output	**794,57**	**7 443,06**

3 Conclusion

It is the first time for Yemen in preparing a report on the use and release of mercury throughout the country for use as a key paper for global sound management of mercury release and reduction as requested by UNEP. To achieve the goal of reporting in this area, the responsible survey team in cooperation with concerned ministries, their line agencies, and local authorities conducted survey on mercury use and release sources in 10 selected provinces and municipality.

While carrying out the survey at the concerned ministries, provincial departments, local authorities, etc. and various sites, the survey team faced many problems regarding critical gaps in making and keeping statistical records, such as shortage of reliable data and information from the various generating/releasing sources. In this regard, most data/information was obtained by estimations made by local line institutions (i.e. amalgam filling, thermometers, Hg for extracting gold, etc.) and as a result, the survey team had some difficulty in calculating actual levels of the release of mercury into the environment. Despite these challenges, through the survey activities stakeholders become more aware of mercury issues and related harmful effects to human health and the ecosystem.

Nevertheless, the survey team tried their best in obtaining and calculation for the release of mercury to the environment and they can conclude that the total release of mercury in Yemen is approximately **797 Kg in minimum** and about **7,443 Kg** in maximum per year. Concerning maximum release, the survey team thought that this amount may be reasonable figure because maximum input factors have been use for calculation for the release of such mercury, which can be assumed that it can be compensated to some fields that unable to obtain information for calculation including electrical and electronic switches, light sources with mercury, biocides and pesticides, paints, pharmaceuticals for human and veterinary uses, cosmetics and related products, etc.

This findings and conclusion is made by the inventory team for its preliminary survey on the release of mercury throughout the country, without present this results to concerned ministries, stakeholders, and civil societies for reflecting, comments and update data and information, if applicable. So, it is recommended that, a full inventory on the release of mercury shall be carried out in the near future, which will enable Yemen to prepare proper plan for sound management of mercury release, basically dealing with sound management

of release sources. For such a full inventory it will be necessary to collect all information from various sectors fields as specified in categories and sub-categories addressing in the UNEP Toolkit, which reflecting to Yemen context.

As Yemen is faced with severe constraints related to the national budget and knowledgeable people in this area, the country requires further assistance in terms of both budget and technical support from GEF/UNEP and other international communities and donors, in order to perform such further inventories and management plans. This will assist Yemen in sound management of mercury, which will provide benefits for not only the current generation, but also for the next generations though out the globe.

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5 Appendix

Appendix 1

Firms consulted during the inventory
The Minister of Youth and Sports
The Minister of Public Works and Roads
The Minister of Oil and Minerals
The Minister of Legal Affairs
The Minister of Public Health and Population
The Minister of Industry and Trade

- The Minister of Agriculture and Irrigation
- The Minister of State for Parliament and Shura
- Undersecretary of the Ministry of Finance
- President of the Customs Authority
- The President of the General Authority for Standardization and Metrology.

6 Appendix

6.1 Appendix 1: Questionnaires used using mercury inventory activities

6.1.1 Questionnaire to hospital and health care centre

Name of hospital/health care: .....
Address: .....
Telephone: .....
Number of bed: ..... Number of patients per week/year: .....
Number of thermometers supplied per annum: .....
Number of gauge supplied per annum: .....
Number of amalgam filling used by dental clinic per annum: .....
What measures to be taken when mercury thermometer broken? .....
.....
What kind of management of waste containing mercury? .....
.....
.....
.....
Quantity of wastes generated per day / week / month in tons: .....
Quantity of wastes incinerated per day / week / month in tons: .....
Types of waste incinerated: .....

.....
.....
Types of incinerator:.....
Processing of waste incineration:.....
Bottom ash management:.....
.....
General understanding on mercury and its hazard:.....
.....
.....
Brief observation assessment: .....
.....
.....
.....

Issued at: ……. on dated: ……/ ……./
2007
Sign of interviewer

6.1.2 Questionnaire to dental clinics

Name of clinic:.....
Address:.....
Telephone:.....
Number of chair: ..... Number of patients per week/month:.....
Type of dental filling materials used by clinic: .....
Number of amalgam filling purchased by dental clinic per month / annum:.....
Number of amalgam filling used by dental clinic per week / month:.....
What should be done with amalgam waste after teeth/tooth filling? .....
.....
.....
What should be done with used amalgam removing from filled tooth/teeth?.....
.....
.....
.....
.....
What should be done to the removing tooth/teeth that filed with amalgam?.....
.....
.....
.....
Is the dental clinic having filter for separating amalgam or treated liquid waste containing amalgam? .....
.....
.....
.....
General understanding on mercury and its hazard:.....
.....
.....

Brief observation assessment: .....
.....
.....

Issued at: ……. on dated: ……/ ……../
2007
Sign of interviewer

6.1.3 Questionnaire to Gold Mining

Name of gold miner or company: .....
Address:.....
Telephone:.....
Number of miners: .....
.....
Size, characteristic and situation of gold mining:.....
Processing of gold mining:.....
Raw materials and chemicals used for extracting gold:.....
.....
.....
In case of mercury uses, please specify:

- Number of mercury used per month / year (in weight, Kg): .....
- Number of mercury purchased for use per month / year (in weight, Kg): .....
- Purchased source in country:.....
- Origin of import:.....

Quantity of gold extracted in gram per month / year:.....
Number month or year of dig-able period:.....
Percentage of miners that use jar/pot for melting mercury amalgam: .....
Percentage of miners that inject mercury to extract gold from mining hole: .....
Is there any mercury concentration actually have before injection mercury amalgam? .....
.....
Management of solid and liquid waste containing mercury:.....
.....
.....
.....
General understanding on mercury and its hazard:.....
.....
Brief observation assessment: .....
.....

Issued at: ……. on dated: ……/ ……../
2007
Sign of interviewer

6.1.4 Questionnaire to waste disposition/landfilling

Name of landfill: .....
Under authorization of: .....
Address: .....
Telephone: .....
Size and technical preparation of landfill: .....
Quantity of wastes entered landfill, ton/day: .....
Sources and type of wastes collected for landfill: .....
.....
.....
.....
.....
.....
Quantity of waste burned at landfill, ton/day: .....
Management of leaches (liquid waste generated by landfill): .....
Numbers of landfills exist in province/municipality: .....
Brief observation assessment: .....
.....
.....
.....

Issued at: ……. on dated: ……/ ……./
2007
Sign of interviewer

6.1.5 Questionnaire to Provincial Hospital Department

Name of interviewee:.....
Working for provincial/municipal department of health:.....
Telephone:.....
Number of hospital in province/municipality: .....
Number of health center in province/municipality: .....
Number of dental clinic in province/municipality:.....
Information related to the use and distribution of mercury thermometers and gauges pressures (number per year):.....
.....
.....
.....
Information related to the use of amalgam for filling teeth/tooth, and the use and distribution for particular hospital and provincial/municipality's health care center (quantity per month/year):.....
.....
.....
Information related to the used of mercury in pharmaceutical sector by hospital and health care center (if yes, please quote quantify and imported origin): .....
.....
.....
.....
Information related to the principle of management of waste containing mercury:.....
.....
General understanding on mercury and its hazard:.....
.....
.....
Brief observation assessment: .....
.....
.....

Issued at: ……. on dated: ……/ ……./
2007
Sign of interviewer

6.1.6 Questionnaire to waste disposition/landfilling

Name of landfill: .....
Name of interviewee:.....
Under authorization of:.....
Address:.....
Telephone:.....
Size and treatment technical preparation and processing and capacity of treatment: .....
.....
.....
.....
.....

Type and quantity of chemicals used for treatment process: .....
.....
.....
.....
Quantity of liquid wastes collected for treatment facility, m3/day:.....
Quantity of liquid wastes treated per day, m3/day:.....
Sources and types of liquid waste collected for treatment facility:.....
.....
.....
.....
Quantity of waste burned at landfill, ton/day: .....
Management of leaches (liquid waste generated by landfill):.....
Quantity of sludge from treatment process, in ton/day:.....
Management of sludge from treatment processing: .....
.....
.....
.....
General understanding on mercury and its hazard:.....
.....
.....
Brief observation assessment: .....
.....

Issued at: ……. on dated: ……/ ……./
2007
Sign of interviewer

6.1.7 Questionnaire to Industry & Trade

Name of interviewee:.....
of provincial/municipality Department of Industry, ...
Telephone:.....
Location of mining in province:.....
.....
.....
Number of existing metal mining exploration company:.....
Number of miners exist in the province:.....
Estimated metal production from mining:.....
.....
Information related to the use of mercury for extracting metal (indicated in Kg/year): .....
.....
.....
.....
Information related to origin of imported: .....
.....
.....
.....
Information related to the principle of management of waste containing mercury:.....
.....
.....

.....
General understanding on mercury and its hazard:.....
.....
.....
Brief observation assessment: .....
.....
.....
.....

Issued at: ……. on dated: ……/ ……./
2007
Sign of interviewer

6.2 Appendix 3: Number of thermometers used by healthcare centers

Source: Central Pharmaceutical Warehouse, Ministry of Health, February, 2008
Note: Most thermometers are mercury based products
Appendix 4: Types and quantity of batteries imported, 2005

6.3 Appendix 5: Number of amalgam use for dental filling

6.3.1 Number of mercury amalgam use by surveyed provinces, 2007

Inventory Issue Report: Amalgam Gs Powder A Non Gamma, 250g***Source: Central Pharmaceutical Warehouse, Ministry of Health, February, 2008***
Note: Each bottle contain 250 grams of amalgam Gs Powder A Non Gamma

Appendix 6: Number of solid wastes collected and dumped by provinces
Source: Department of Environmental Monitoring, Ministry of water and environment Environmental protection Authority, 2008