# Kingdom of Cambodia

(2)

## Ministry of Environment

# Cambodia Mercury Inventory Report


**MINISTRY OF ENVIRONMENT**
**Mercury Pilot Project**
**In collaboration with**
**UNITED NATIONS ENVIRONMENT PROGRAM (UNEP)**
**Chemicals Branch**

**Phnom Penh, February 2008**

MOE

UNEP

Ministry of Environment
Department of Environmental
Pollution Control

UNEP

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The Cambodia Mercury Inventory Report was written by Mr. Kan Vibol, National Consultant. Technical support for the project was facilitated by the United Nation Environment Programme (UNEP) and financed by the Global Environment Facility (GEF) through a mercury pilot project with in-kind contributions from the Royal Government of Cambodia.

This report is published in Khmer and English by the Department of Environmental Pollution Control, the Ministry of Environment, the Royal Government of Cambodia to provide ground information mercury release sources and quantity in Cambodia. This report is a first outcome of the common chemicals information and data collection in the Kingdom of Cambodia.

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# Official Speech of H.E. Heng Nareth

This mercury inventory report was the result of field survey at 12 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 Cambodia.

A background document entitled for preparation of the mercury inventory report is in the UNEP Toolkit for identification and quantification of mercury releases, November 2005 and the worth guidance from **H.E. Dr. Mok Mareth**, Senior Minister, Minister for the Environment.

On behalf of the My Senior Minister, Minister of Environment, I would like to express my sincere appreciation to UNEP for funding. Specials thanks for our Cambodian 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 Environment in Phnom Penh, Cambodia in February 19-20, 2008 respectively.

Finally, I would like to announce that, this mercury inventory report was adopted by the Ministry of Environment as official baseline information for official purposes use.

**Phnom Penh, February 28, 2008**

**H.E. Heng Nareth**

Advisor for the Ministry of Environment
Director of Department of Environmental
Pollution Control, Cambodia

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## Abbreviation

| | |
|---|---|
| µg Hg/$Nm^3$ | Microgram mercury per normal metric cube |
| ADB | Asian Development Bank |
| APCS | Air Pollution Control System |
| CIPS | Cambodia Intercensal Population Survey |
| DEPC | Department of Environmental Pollution Control |
| EU | European Communities |
| g | gram |
| GDP | Growth Domestic Products |
| GEF | Global Environmental Facilities |
| GoC | Government of Cambodia |
| Hg | Mercury |
| JICA | Japan International Cooperation Agency |
| Kg | Kilogram |
| KoC | Kingdom of Cambodia |
| LPG | Liquefied Petroleum Gas |
| MIME | Ministry of Industry, Mine and Energy |
| mm | Millimeter |
| Mn | Manganese |
| MoE | Ministry of Environment |
| NA | Not Available |
| NGOs | Non-Governmental Organizations |
| NIS | National Institute of Statistics |
| POPs | Persistent Organic Pollutants |
| PPM | Phnom Penh Municipality |
| RGC | Royal Government of Cambodia |
| SEDP II | Second Socio-Economic Development Plan |
| UNEP | United Nations Environmental Programme |
| VCM/PVC | Vinyle-chloride-monomer (for PVC production)/ poly-vinyle-chloride (plastic type) |
| WB | World Bank |

# 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 can be recycled; however, only a small amount of the mercury used is recycled.

Mercury is a liquid metal, occurs naturally in a number of geologic environments, may be obtained as a by-product from precious metals mining, and is found in trace amounts in coal. Much of this mercury may be used and recycled; however, mercury used for gold production and mercury released from coal-fired power-plants, broken fluorescent lamps, battery production, and other sources is not recovered to any high degree and becomes a global environmental and human health concern. Minamata disease is an excellence example of mercury impact to the environment and human health in Japan, which brought a global concern of its release to the environment and seeking cooperation among countries for sound management of its release.

In 2007, Cambodia 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 Environment (MOE), Cambodia, 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 12 provinces (including municipalities) out of 24 provinces and municipalities through the country. The inventory stage was conducted from August to November 2007 and then by December 2007 was the period of data entry and analysis.

The main purposes of this inventory are 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 Cambodia 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.

# Summary

This report is focused on the preliminary survey on mercury release into atmosphere within Cambodia territory and such survey had been undertaken from July to December 2007 throughout Cambodia by the mercury task team of the Department of Environmental Pollution Control of the Ministry of Environment, which is leaded by a national coordinator. This team had been gone through a three day training course (including field study), 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 12 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 Cambodia, however, there is no official record could confirms when such equipment was first introduced to Cambodia. Nevertheless, it is no doubt to state that equipment containing mercury and mercury compound have been imported to Cambodia, which resulting mercury release into the environment after disposal of such equipment. In addition to this, extraction of mining activities (i.e. gold extraction, lime production, etc.) and other manufacturing, processing and combustion activities could cause the release of mercury into the atmosphere as well.

Therefore, based on the preliminary survey, it was understood that the total release of mercury in Cambodia is approximately **769.51 Kg** in minimum and about **14845.178 Kg** in maximum per year. The first major source of maximum mercury release into atmosphere is consumer products with intentional use of mercury that cause the release of mercury of about 8485.362 Kg, followed by disposal of wastes that could release mercury of approximately 4665.56 Kg and then the third source of mercury release is gold extraction that emitted mercury into the environment of about 1182 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 Cambodia 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 six main laboratories available in Cambodia, 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 Cambodia 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 Cambodia 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 National Background Information

## 1.1 Country profile

### 1.1.1 Physical Geography

Cambodia is a tropical country situated in South East Asia between latitudes 10º to 15º north and longitudes 102º and 108º east, where the length from north to south is 480 km and the length from west to east is 580 km. It shares borders with Laos to the North, Thailand to the North and West, and Vietnam to the East and South. Cambodia has a total area of 181,035 $Km^2$ territories with a coastline of about 435 Km. Cambodia composed of 20 provinces and four municipalities, four of which have relatively short maritime boundary and extensive mangrove forests, some of which are relatively undisturbed.

Cambodia has a tropical monsoon climate with pronounced wet and dry seasons. The wet season lasts from May to October, with rainfall derived from the southwest monsoon drawn landward from the Indian Ocean. The dry season, from November to April, is associated with the northeast monsoon, which brings cooler air. From late July there may be periods without significant rainfall for ten or fifteen days or more at a time, referred to as the short dry season.

Most of Cambodia can be described as under sub humid climate. The wet season accounts for 80% of the annual rainfall. The average annual rainfall varies considerably across the country. Rainfall in the central area, covering the Tonle Sap Basin and Lower Mekong valley, averages 1,200 mm. The heaviest rainfall, over 3,000 mm per year, occurs along the coastal lowland in the west. Precipitation also varies widely from year to year.

Cambodia's topography comprises 4 main areas: the mountainous, plateau, floodplain and coastal zones. The mountainous area is situated at the border, mostly at the west and northern parts of the country, while the plateau area is located in north-east. The floodplain area is situated in the central part of the country surrounding the Tonle Sap great lake and Mekong River, while the coastal zone is located in the south-west.

### 1.1.2 Population

The population projection for Cambodia in 2006 is 14.0 million, according to official population projection based on the 1998 general population census and the 2004 Cambodia Intercensal Population Survey (CIPS). The population increased by 2.0 percent from 13.8 million in 2005. The average population density for Cambodia is 82 persons per square kilometer. Around 51.4 percent of the population is females, and the population is growing at an estimate rate around 1.7 percent per annum.

The population growth rate is continuing to decline and is expected to fall to 1.6 percent by 2011. In term of future population growth, Cambodia’s population is projected to increase to 14.0 million in 2006, 14.8 million by 2009 and 15.3 million by 2010.

## 1.2 Sectoral profile

### 1.2.1 Agricultural profile

Cambodia is an agricultural economy. Between 80% and 85% of the labor force is engaged in agriculture and related sub-sectors (fisheries and forestry), which contribute to about half of the country's GDP. Cambodia's main agricultural crop is rice, which is growing on over 90% of the currently cropped area. The second most important crop is rubber. However, favorable prospects are believed to exist for the production of other crops such as maize, soybeans, mung-bean, pepper and tobacco. Two main types of farming systems can be distinguished: rice-based systems and multi cropping systems. Five major rice growing systems exist in Cambodia: rain fed lowland rice system, dry season flood recession rice system, floating rice system, dry season lowland irrigated rice system, and upland rice system. Multi cropping systems predominate among the agricultural systems near the Mekong River, the upland brown and red soils systems, the black clay systems and the slash-and-burn systems.

The agricultural sector has much potential and provides the basis for the country's development. Wise management of Cambodia's rice and natural resource base is crucial for sustainable and equitable development. The principal goals of the government in the agricultural sector are the following: to

ensure available food at both the national and household levels; to produce surpluses for export; to expand rubber production for increased foreign exchange earnings; to encourage the production of raw materials for local agro-industries; and to improve the well-being and income of the rural population.

The status of agricultural cultivation areas and yields including crops, livestock and poultries, fisheries, and rubber are shown in the below table.

**Table 1: Crops production and area, 2003-2006**

| Products | Area (Ha) | | | | Production (Tons) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2003 | 2004 | 2005 | 2006 | 2003 | 2004 | 2005 | 2006 |
| **Crops** | | | | | | | | |
| *Rice* | *2,315,853* | *2,374,175* | *2,443,530* | *2,541,432* | *4,710,957* | *4,170,284* | *5,986,179* | *6,264,030* |
| *Maize* | *93,362* | *91,203* | *90,732* | *109,200* | *314,601* | *256,665* | *247,760* | *376,939* |
| *Yellow Maize* | *73,039* | *69,689* | *67,046* | *68,759* | *287,484* | *223,656* | *191,561* | *326,378* |
| *Cassava* | *25,740* | *22,749* | *30,032* | *96,905* | *330,649* | *362,050* | *535,623* | *2,182,043* |
| *Sweet Potato* | *8,717* | *7,316* | *8,479* | *9,625* | *34,897* | *35,138* | *39,142* | *45,285* |
| *Vegetable* | *36,090* | *32,604* | *35,762* | *44,276* | *139,626* | *179,050* | *172,399* | *222,893* |
| *Mung Bean* | *44,940* | *39,089* | *60,570* | *83,334* | *31,815* | *45,253* | *45,041* | *59,899* |
| *Pea Nut* | *14,563* | *19,213* | *17,237* | *14,438* | *18,483* | *21,543* | *22,629* | *23,811* |
| *Soya Bean* | *53,064* | *84,886* | *118,760* | *75,053* | *63,188* | *110,305* | *179,096* | *98,289* |
| *Sugar Cane* | *9,581* | *6,788* | *79,250* | *8,368* | *173,105* | *130,363* | *56,711* | *141,704* |
| *Sesame* | *33,991* | *64,470* | *5,993* | *56,051* | *21,957* | *54,954* | *90,193* | *24,789* |
| *Tobacco* | 6,407 | *1,708* | 8,177 | *8,768* | 7,601 | *2,479* | 14,143 | *14,231* |
| *Jute* | 490 | *633* | 514 | *449* | 561 | *880* | 826 | *575* |
| **Total** | **2,715,837** | **2,822,523** | **2,966,082** | **3,116,658** | **6,134,924** | **5,592,620** | **7,581,303** | **9,780,866** |
| **Rubber** | | | | | | | | |
| *Rubber* | *-* | *23 786.93* | *-* | *20,583.33* | *-* | *26,056.03* | *-* | *21,389.501* |
| **Livestock and poultry** | | | | | | | | |
| *Cattle (heads)* | | | | | *2,985,416* | *3,039,945* | *3,184,146* | *3,344,742* |
| *Buffalo (heads)* | | | | | *660,493* | *650,572* | *676,646* | *724,378* |
| *Pig (heads)* | | | | | *2,304,248* | *2,428,566* | *0* | *2,740,815* |
| *Poultry (heads)* | | | | | *16,013,713* | *13,990,592* | *0* | *15,136,065* |
| **Total** | | | | | **21,963,870** | **20,109,675** | **3,860,792** | **21,946,000** |
| **Fisheries** | | | | | | | | |
| *Inland Fishery Capture* | | | | | *308,750* | *250,000* | *324,000* | *422,000* |
| *Marine Fishery Capture* | | | | | *54,750* | *55,800* | *60,000* | *60,500* |
| *Aquaculture* | | | | | *13,085* | *20,835* | *26,000* | *34,200* |
| **Total** | | | | | **376,585** | **326,635** | **410,000** | **516,700** |

***Source**: Annual Conference Report 2006-2007, Ministry of Agriculture, Forestry and Fisheries, April 2007*

### 1.2.2 Industrial profile

According to the National Institute of Statistic of the Ministry of Planning (Statistic Year Book 2006) approximately 29,230 manufacturing establishments were operating in Cambodia in 2005, up 2.4 percent compared to 28,546 establishments in 2004. Of the establishments in 2005, 483 were large establishments and 28,747 medium to small establishments. By comparison, there were 415 large establishments and 28,131 medium to small establishments or handicraft business registered up to 2004.

Most large establishments were involved in the manufacture of textiles, wearing apparel and footwear (77.4. percent), followed by the manufacture of food, beverages, and tobacco (8.9 percent), chemicals, petroleum, coal, rubber, and plastics (4.1 percent), fabricated metal products (3.5 percent), and non-metallic mineral products (2.3 percent).

Most medium to small establishments were involved in the manufacture of food, beverages, and tobacco (81.2 percent), followed by manufacture of fabricated metal products (7.7 percent), textiles, wearing apparel and footwear (5.8 percent), non-metallic mineral products (2.5 percent), and other manufacturing (2.1 percent)..

**Table 2: Number of large manufactures, 2002-2005**

| Manufacturing sectors | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|
| 1. Food, beverage, tobacco | 31 | 34 | 39 | 43 |
| 2. Textile, wearing apparel, and leather products | 255 | 283 | 320 | 374 |
| 3. Wood products including furniture | 07 | 07 | 07 | 07 |
| 4. Paper products, printing and publishing | 03 | 05 | 05 | 10 |
| 5. Chemicals, petroleum, coal, rubber and plastic | 16 | 18 | 20 | 20 |
| 6. Non-metallic mineral products | 11 | 11 | 11 | 11 |
| 7. Manufacturing of basic metal | 0 | 0 | 0 | 0 |
| 8. Fabricated metal products | 12 | 12 | 12 | 17 |
| 9. Other manufacturing | 01 | 01 | 01 | 01 |
| ***Total*** | ***336*** | ***371*** | ***415*** | ***483*** |

***Source**: Statistical Yearbook. National Institute of Statistic, Ministry of Planning, 2006*

### 1.2.3 Health Profile

According to statistic year book 2006, indicated that the total number of registered public health personnel decreased 0.07 percent from 17,137 in 2004 to 17,125 in 2005. The number of doctors decreased 0.6 percent to 2,079; pharmacists decreased 2.8 percent to 377; registered dentists decreased from 233 to 220; and nurses increased 0.6 percent to 7,091; registered midwifes increased 1.1 percent to 2,850; and labs also increased 0.9 percent to 435. The number of other health personnel decreased 2.4 percent to 1,759. The ratio of doctors to the general population was 1:6,638 in 2005, compared to 1:6,453 in 2004, and 1:7,374 in 1997.

The number of health establishments has decreased 8.5 percent to 1,086 in 2005 compared 1,187 in 2004, and was down 13.8 percent compared to 1,260 establishments in 1997. The number of medical beds available was down to 7,599 compared to the previous year, and down 31.5 percent compared to the 11,100 beds available in 1997.

### 1.2.4 Religious profile

Buddhism was constituted as a national religion of the Kingdom of Cambodia and most people up to about 95% follow Buddhist principle and they go to pagoda for celebrating traditional events including cremation. In Cambodia, there are about 4000 pagodas spreading though out the country, most of them installed crematoriums, some contain one chamber and some contains two-chambers. Crematoria practice are common across Cambodia, whether apply at pagodas or at nearby home or at field. The amount of chambers vary depending on the pagoda demand and/or the decisions of monk's principal. In PPM and some provinces, crematoriums are located in pagodas, but in remote/rural areas crematoriums are located in pagodas or areas close to villages. The processes of burning dead bodies generally use wood and in some cases used tires instead.



***Figure 1: Overview of crematoria chambers: general one-chamber crematoriums in rural area (top three) and common two-chamber crematorium***

In rural and remote areas, the burning processing of dead bodies is generally more careless than in the urban/town areas. The burning practices can be classified into two types: (i) burning in crematorium; and (ii) open burning. Crematoriums in rural/remote areas are commonly small with one chamber and a low chimney or without a chimney. In some areas, dead bodies were burnt in open areas close to the villages/forest areas. In 2003, the data taking from the inventory report on unintentionally produced POPs in Cambodia indicated that about 30,616 death bodies were burnt in crematories and 9,980 dead bodies were burnt in open areas.

# 2 Preliminary inventory of mercury use and release in Cambodia

## 2.1 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***".

## 2.2 Mercury release sources identified in Cambodia

Major source categories and subcategories of mercury release listed in the UNEP toolkit are listed in table 3. The table also shows which mercury sources exist in Cambodia. Due to limitations in data availability and constraints in time and budget, it has not been possible to quantify all mercury relase sources present in Cambodia; the table shows which sources have been quantified as part of this preliminary inventory work.

**Table 3: Classification sources of mercury release**

| No. | Categories and sub-categories of mercury release courses | Cambodia source |
|---|---|---|
| **1** | **Extraction and use of fuels/energy sources** | |
| 1.1 | Coal combustion in large power plants | × |
| 1.2 | Other coal use | × |
| 1.3 | Mineral oils - extraction, refining and use | ✓ |
| 1.4 | Natural gas - extraction, refining and use | ✓ |
| 1.5 | Other fossil fuels - extraction and use | × |
| 1.6 | Biomass fired power and heat production | ✓ |
| 1.7 | Geothermal power production | × |
| **2** | **Primary (virgin) metal production** | |

| No. | Categories and sub-categories of mercury release courses | Cambodia source |
|---|---|---|
| 2.1 | Mercury (primary) extraction and initial processing | × |
| 2.2 | Gold and silver extraction with mercury amalgamation processes | ✓ |
| 2.3 | Zinc extraction and initial processing | × |
| 3.4 | Copper extraction and initial processing | × |
| 2.5 | Lead extraction and initial processing | × |
| 2.6 | Gold extraction and initial processing by methods other than mercury amalgamation | × |
| 2.7 | Aluminum extraction and initial processing | × |
| 2.8 | Other non-ferrous metals - extraction and processing | × |
| 2.9 | Primary ferrous metal production | × |
| **3** | **Production of other minerals and materials with mercury impurities** | |
| 3.1 | Cement production | × |
| 3.2 | Pulp and paper production | × |
| 3.3 | Production of lime and light weight aggregates | ✓ |
| **4** | **Intentional use of mercury in industrial processes** | |
| 4.1 | Chlor-alkali production with mercury-technology | × |
| 4.2 | VCM production with mercury catalyst | × |
| 4.3 | Acetaldehyde production with mercury catalyst | × |
| 4.4 | Other production of chemicals and polymers with mercury | × |
| **5** | **Consumer products with intentional use of mercury** | |
| 5.1 | Thermometers with mercury | ✓ |
| 5.2 | Electrical switches and relays with mercury | × |
| 5.3 | Light sources with mercury | × |
| 5.4 | Batteries with mercury | ✓ |
| 5.5 | Biocides and pesticides with mercury | × |
| 5.6 | Paints with mercury | × |
| 5.7 | Cosmetics and related products with mercury | × |
| **6** | **Other intentional product/process use** | |
| 6.1 | Dental mercury-amalgam fillings | ✓ |
| 6.2 | Manometers and gauges with mercury | × |
| 6.3 | Laboratory chemicals and equipment with mercury | × |
| 6.4 | Mercury metal use in religious rituals and folklore medicine | × |
| 6.5 | Miscellaneous product uses, mercury metal uses, and other sources | × |
| **7** | **Production of recycled metals ("secondary" metal production)** | |
| 7.1 | Production of recycled mercury ("secondary production") | × |
| 7.2 | Production of recycled ferrous metals (iron and steel) | ✓ |
| 7.3 | Production of other recycled metals | ✓ |
| **8** | **Waste incineration** | |
| 8.1 | Incineration of municipal/general waste | ✓ |
| 8.2 | Incineration of hazardous waste | × |
| 8.3 | Incineration of medical waste | ✓ |
| 8.4 | Sewage sludge incineration | × |
| 8.5 | Informal waste incineration | × |
| **9** | **Waste deposition / land-filling and waste water treatment** | |
| 9.1 | Controlled landfills/deposits | ✓ |
| 9.2 | Diffuse disposal under some control | × |
| 9.3 | Informal local disposal of industrial production waste | × |
| 9.4 | Informal dumping of general waste | ✓ |
| 9.5 | Waste water system/treatment | ✓ |
| **10** | **Crematoria and cemetaries** | |
| 10.1 | Crematoria | ✓ |
| 10.2 | Cemetaries | × |
| **11** | **Potential hotspots** | × |

***Source: UNEP Toolkit, Pilot draft, November 2005***

## 2.3 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. | Mr. Sarun Sambor, Chief Officer, MoE | Project Coordinator |
| 2. | Mr. Kan Vibol, Free land consultant | Reporter |
| 3. | Mr. Chap Yuthy, Vice Chief Officer, MoE | Member |
| 4. | Mr. Chin Sothon, Vice Chief Officer, MoE | Member |
| 5. | Mr. Phay Chanthy, Vice Chief Officer, MoE | Member |
| 6. | Mr. Nget Bol, Technical staff, MoE | Member |
| 7. | Mr. Chap Marith, Technical staff, MoE | Member |
| 8. | Mr. Ive Sophal, Technical staff | Member |
| 9. | Ms. Heng Heap, Vice Chief Officer Officer | Member (Administrative work) |

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 Cambodia. Prior to this, Cambodia 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 three-day training workshop on mercury inventory held at the head quarter of the Ministry of Environment, from 10 to 12 July 2007.

Before conducting the inventory, the survey team had practices questionnaires (Appendix 1) and then identified 10 provinces and 2 municipalities (out of total 24 provinces and municipalities), where expected to have potential release of mercury, based on the above categories release sources and human activities. Those 10 provinces are: Battambang, Kampot, Kampong Cham, Kampong Chhnang, Kampong Thom, Kraties, Pousat, Ratanakiri, Svay Rieng, and Takeo, and other 2 (largest) municipalities are Phnom Penh and Sihanoukville.

## 2.4 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 Cambodia 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),
3. Gold mining,

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

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

# 3 Quantification of mercury releases

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

## 3.1 Extraction and use of fuels/energy sources

### 3.1.1 Mineral oil - extraction, refining and use

#### *3.1.1.1 Power plants*

**Activity rates**

So far, fuel oils are widely consumed in Cambodia 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 Cambodia 1998 indicated that lighting is generated from 15.1% electricity; 3.5% used acid-lead batteries; 79.9% Kerosene; and 1.5% other sources.

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 Cambodia has not had enough capability to construct a hydropower dam equipped with modern facilities, although Cambodia has tremendous water resources, especially the Mekong River and its tributaries.

It is complex and difficult for Cambodia to calculate mercury releases from the fossil fuel power plant sector, while the national data for specific fossil fuel types and quantity seems to be unclear and inadequately stated, and sometime, annual data on fossil fuel unavailable for researchers.

Based on the secondary data from the "***Inventory Report on Unintentionally produced POPs in Cambodia, 2004***", it is understood that there are four types of refined fuel imported to Cambodia to be using as energy sources for electricity and lighting with total amount of 427,092.87 tons, of which 25,015 tons for kerosene, 14,425.91 tons for gasoline, 146,903.96 tons for diesel, and 240,748 tons for heavy fuel oil.

**Mercury input factors and output distribution factors used**

As no specific data on mercury contents of the fuels actually used in Cambodia 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 4 below.

#### *3.1.1.2 Transportation*

**Activity rates**

Concerning transportation, the estimation of fuel consumption in Cambodia it is known that about 187,302.60 tons of diesel and about 97,435.25 tons of gasoline were used in this sector. Out of this amount, about 58,461.15 tons of gasoline has been used for the 4-stroke engines and 38,974.10 tons for the 2-stroke engines and it might be contributing to the release of mercury.

So, the total of refined fuel use for transportation is equaled to 284737.85 tons and possible mercury release from using such refined oil is shown in table 4.

**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 Cambodia 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 4 below.

### 3.1.2 Natural gas - extraction, refining and use

**Activity rates**

The fossil fuel used for Cambodian household cooking is a gas imported from Thailand, Malaysia, Singapore, and Vietnam. Cooking by using liquefied petroleum gas (LPG) has been present in Cambodia since 1990s.

The amount of imported gas for use in domestic cooking is about 27,016.65 tons (for 2002 according to the National Profile). According to the estimation of the Department of Custom, about 97% of fuel gas (or 26,206.15 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 27,016.65 tons equal to 34,176,062.25 $Nm^3$ gas in volume. Based on this conversion, the amount mercury release from this sector can be calculated in table 4 bellows.

**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.

### 3.1.3 Biomass

Household cooking biomass, for example, woods and charcoals, are the traditional household cooking materials and are widely consumed throughout the country. 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 Cambodia, especially as the main domestic source of energy for cooking (General Population Census of Cambodia 1998). Updated national data and information on consumed woods/charcoals is not available for Cambodia so far; the amounts are not expected to have changed much however.

The 1995 survey on energy supplies in Cambodia conducted by the MIME under ADB support indicated that the total energy supply for final consumers comprised 84% wood and other biomass; 14% petroleum products; 1.2 % charcoals; and 0.9% electricity.

As we could not find any updated data, the calculation of mercury release from biomass is based on the 1995 survey data; it is known that the total amount of biomass used for household cooking is about 5,511,201 tons per annum. Out of this amount, firewood consists of 5,360,060 tons, charcoal consists of 37,841 tons and other biomass consists of 113,300 tons.

**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. Cambodia. 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 Cambodia 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 4 below.

### 3.1.4 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 4: Mercury release from energy sources category**

| No | Sub-category | Activity rate(t/y) | Input factor | | Amount (Kg Hg/y) | |
|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Max |
| 1.1 | Use of crude oil (Power plant) | 240748 t/y | 10 mg/t | 300 mg/t | 2.407 | 72.224 |
| 1.2 | Use of gasoline, diesel and other distillates (Power plant) | 186344.87 t/y | 1 mg/t | 100 mg/t | 0.186 | 18.634 |
| 1.3 | Use of gasoline, diesel and other distillates (transportation) | 284737.85 t/y | 1 mg/t | 100 mg/t | 0.285 | 28.474 |
| 1.4 | Use of pipeline gas (consumer quality) | 34176062.25 $Nm^3$ | 0.03 $\mu g/Nm^3$ | 0.40 $\mu g/Nm^3$ | 0.001 | 0.014 |
| 1.5 | Biomass fired power and heat production | 5,511,201 t/y | 0.007 mg/t | 0.03 mg/t | 0.039 | 0.165 |
| | **Total release by category 1** | | | | **2.918** | **119.511** |

## 3.2 Primary metal production - small scale gold mining

**Activity rate and input factor**

Cambodia 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, the gold extraction activity could be considered as primary metal production in Cambodia. Such gold extraction is made by local people in small scale or at family level. No, commercial activity (company level) related to gold extraction is permitted so far, except the gold study companies that have been allowed to explore for the ores (reported by the officer of the Ministry of Industry, Mines and Energy, (MINE)).

Based on report written by Mr. Sieng Sotham, Director of the Department of Geology of MIME (Small scale gold mining in Cambodia: A situation assessment, July 2004), addressed that there are 19 known gold deposits in Cambodia with employment labor between 5000 to 6000 miners during the peak mining season, which begins in November and finishes in May, (considered as dry season in Cambodia). The report also indicated that such gold extraction is operated in small scale manner or so called family level, and most of gold extraction activities are took place at the north-east part of the country.

As far as gold extraction at family level is considered as primary metal production, the survey team had undertaken interviewed with 36 families who do gold extraction activities at the north east part of the country in three provinces. Currently, no official report exist on the precise number of families and study companies doing gold extraction or other information related to the precise location occupied by those families through out the country. Nevertheless, based on information provided by provincial departments of MIME of respected provinces, it was reported that there are 200 miners in Ratanakiri, 85 miners in Kratie, and 1310 miners in Kampong Thom provinces being undertaken gold extraction at the north-east part of the country. List of interviewed families is shown in Appendix 2.

Among the families who are doing gold extraction, 36 families were randomly selected for interviews. Among these 12 families (or 48 miners) live in Kampong Thom province, 12 families (61 miners) live in Kratie province and 12 families (66 miners) live in Ratanakiri province. Based on this interview, it was recorded that most goal mining families living at Ratanakiri province (10 families (or 54 miners) among the 12 interviewed families) use mercury with amount of 32.5 Kg a year and they can extract 21.476 Kg of gold. Only one family (6 miners) lives in Kratie province use mercury (about 2 Kg a year) to extract gold with amount of about 0.685 Kg a year. So, in total, there are 34.5 Kg of mercury have been used for a year to extract gold of about 22.161 Kg. The survey also observed that gold miners use the same method or practice to extract gold from ore, i.e. most miners in Ratanakiri use mercury to extract gold while miners in the other provinces use mechanical method to extract gold.

The rest of gold mining families (live in Kampong Thom and Kratie Province and two families live in Ratanakiri province) use other method for extracting gold, basically mechanic facilities and other chemicals, and they can extract gold of about 6.866 Kg in a year. Based on calculation, it can be derived that an average extraction of 1 Kg of gold requires the use of 1.557 Kg mercury. Mixed gold and mercury amalgam then go through a melting process to evaporate the mercury and have almost pure gold remaining. No mercury recovery measures are in place for gold extraction, thus it meant that all mercury with amount of 34.5 Kg use for extracting gold by these 36 families (representing 175 miners) escape into the environment. As conclusion, one miner may use 0.197 Kg mercury per year to extract gold.

As mentioned, the total number of families/companies applying mercury for gold extraction is not known. For the use of this inventory, preliminary very rough estimates of total mercury use in this sub-category shall however be made, in order to provide the best background for consideration of the need for additional investigation and/or reduction measures for mercury use. Small scale gold mining activities is considered to be or have been existing in 12 of Cambodia's provinces. As there most certainly are more families using mercury for small scale mining (SM) than the actual 11 identified, the 34.5 kg shall here be taken as an absolute minimum consumption.

A very uncertain, yet illustrative, maximum can be derived assuming that the prevalence of mercury usage in the remaining 1595 miners in the three visited provinces equal the average use in the 36 interviewed families (representing 175 miners); and that the same conditions apply in the remaining 9 provinces with possible existence of small scale gold mining. By simple extrapolation this yields a calculated mercury consumption of some 1182 kg Hg/year.

While the derived consumption interval, 34.5 - 1182 kg mercury/year is highly uncertain, it does illustrate a possible order of magnitude of the mercury usage for small scale mining in Cambodia. The minimum of the interval is most likely significantly underestimating the actual consumption. The derived maximum of the interval may overestimate the actual consumption, but is - based on the weak evidence used - not necessarily as high as the real consumption.

*Pure mercury to be used for extracting gold from gold-ore*

*Miner washes the dirt out to obtain gold with mercury-amalgam*

*Interviews with gold miners at gold-mining site, Kampong Thom Province*

***Figure 2: Gold mining activities and surveyed overview at gold mining site***

**Output distribution factors and calculates releases**

Accordingly the Toolkit's default output distribution factors for the scenario "Extraction of gold with mercury amalgamation processes" were applied in the calculations, in which, the output distribution factor for this sector is 0.6 for air, 0.2 for water, 0.2 for land, and unknown to product and general waste. So the estimated possible release of mercury and its distribution pathways for this sub-category is shown in the below table 5 and 6.

**Table 5: Estimated mercury release from gold extraction**

| No | Sub-category | Activity rate(t/y) | Input factor | | Amount (Kg Hg/y) | |
|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Max |
| 2.1 | Maximum mercury use per year | 6000 miners | N/A | N/A | 34.5 | 1182 |
| | **Total release by category 2** | | | | **34.5** | **1182** |

**Table 6: Estimated mercury output distribution by pathway**

| Phase in life cycle | Air | Water | Land | Product | General waste | Sector specific treatment/ disposal |
|---|---|---|---|---|---|---|
| Default output distribution factors, share of mercury input | 0.6 | 0.2 | 0.2 | ? | | |
| Output distribution by pathway | 709.2 | 236.4 | 236.4 | | | |

## 3.3 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 Cambodia, except the production of lime and bricks. Thus, available data/information used in this section are available only for lime production, however, for other productions including cement, pulp and paper, and other minerals and materials, data are not available.

The information taking from the Inventory Report of Unintentionally Produced POPs in Cambodia, (inventory report, 2004) indicated that, in Cambodia, the production of lime is possible only in Kampot Province. Presently, four lime producing handicrafts are operated there. These handicrafts are located in areas close to the forest as it is easy to get fuel woods for processing the lime kilns. Remarkably, coal material is used at the commencing of burning and afterwards they use woods only. The lime kilns were commonly made of brick.

Raw material for producing the lime products is limestone, which is found in the mountains. The limestone mines were dug in diameters of 20-30 cm and transported to the kilns for burning. Owners of the lime producing handicrafts revealed that the processing of lime products can take place for 6 months per year during the dry season. The average lime process takes place once per month in the amount of 10 tons per each handicraft, which made total production of lime per annum is about 240 tons.

**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 Cambodia 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 Cambodia 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 7 below.

**Table 7: Mercury release from mineral production category**

| No | Sub-category | Activity rate(t/y) | Input factor | | Amount (Kg Hg/y) | |
|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Max |
| 3.1 | Lime production | 240 | 0.009 g/t | 0.055 g/t | 0.002 | 0.013 |
| | **Total release by category 3** | | | | **0.002** | **0.013** |

## 3.4 Intentional use of mercury in industrial processes

No activities related to the intentional use of mercury in industrial processes in Cambodia, 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)

## 3.5 Consumer products with intentional use of mercury

There are 8 sub-categories addressed in the UNEP Toolkit regarding consumer products with intentional use of mercury including:

1. Thermometers with mercury
2. Electrical and electronic switches, contacts and relays with mercury
3. Light sources with mercury
4. Batteries containing mercury
5. Biocides and pesticides
6. Paints
7. Pharmaceuticals for human and veterinary uses
8. Cosmetics 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 Cambodia 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 available.

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.

### 3.5.1 Thermometers with mercury

**Activity rate**

In Cambodia, 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 Cambodia 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 178 thermometers have been supplied to 14 hospitals within a year, made average of 13 thermometers per hospital per year. The detailed results are shown in Appendix 3.

Nevertheless, based on the inventory issue report (code QB0560) provided by the Ministry of Health, for period from 1$^{st}$ January 2007 to 31$^{st}$ December 2007, indicated that were 6141 thermometers had distributed to health facilities through out Cambodia (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 Cambodia 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 fewer thermometers used in private homes, and may therefore underestimate the actual supply in Cambodia.

**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 Cambodia 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 Cambodia.

**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 8 and 9.

**Table 8: Mercury release from consumer product: thermometers**

| No | Sub-category | Activity rate(t/y) | Input factor | | Amount (Kg Hg/y) | |
|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Max |
| 5.1.1 | Thermometers | 6141 items/y | 0.5 g/item | 1.5 g/item | 3.071 | 9.212 |
| | **Total release by category 5** | | | | **3.071** | **9.212** |

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

**Table 9: Mercury output distribution by pathway**

| Phase in life cycle | Air | Water | Land | General waste | Sector specific treatment/disposal |
|---|---|---|---|---|---|
| Default output distribution factors, share of Hg input | 0.2 | 0.3 | 0.2 | 0.3 | |
| Output distribution by pathway | 4.11 | 6.17 | 4.11 | 6.17 | |

### 3.5.2 Batteries with mercury

**Activity rates**

According to information from Custom Department, it was reported that in 2005 Cambodia had imported batteries about 648.850 tons from different countries. Zinc-air type batteries contribute with 97.96 percent (about 635.599 tons) of total batteries imported, and the rest is other type batteries (about 13.251 tons). 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 10.

Before civil war, it was though that mercury based battery may be used in Cambodia, but no official records confirm about the use nor other information related to origin of imported, imported quantities, distribution, or disposal management.

**Input factors**
For general cylindrical zinc-air 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 Cambodia 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 10 and 11.

**Table 10: Mercury release from consumer product: batteries**

| No | Sub-category | Activity rate(t/y) | Input factor | | Amount (Kg Hg/y) | |
|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Max |
| 5.2.1 | Batteries | 635.599 | 0.25 Kg/t | 10 Kg/t | 158.900 | 6355.99 |
| 5.2.2 | Other type batteries | 13.251 | 3.4 Kg/t | 160 Kg/t | 45.053 | 2120.16 |
| | **Total release by category 5** | | | | **203.953** | **8476.15** |

**Table 11: Mercury output distribution by pathway (batteries)**

| Phase in life cycle | Air | Water | Land | General waste | Sector specific treatment/disposal |
|---|---|---|---|---|---|
| Default output distribution factors, share of Hg input | 0.25 | | 0.25 | 0.5 | |
| Minimum output distribution by pathway | 50.988 | | 50.988 | 101.977 | |
| Maximum output distribution by pathway | 2119.037 | 0 | 2119.037 | 4238.075 | |

## 3.6 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 Cambodia 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

[1] *Yves GUIBERT, UNEP' consultant*

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, which is the common religious practice in Cambodia.

In Cambodia history on when the dental clinics operated are remains unknown. Most of dental clinics are operated by private sector and few by public sector. Most dental clinics have from one to four chairs in operation and other few dental clinics may up to 10 chairs. Based on inventory undertaken in 8 provinces, it was observed that there are 15 clinics with total chairs of 27 (in average each clinic occupy 2 chairs). The annual number of patients going to these clinics is 11340 persons.

There are several types of tooth filling materials in use in Cambodia including amalgam, composite, glass ionomer cement, poly carboxylate cement, oxyde de zine and ceramic. Cambodian people who went to dental clinic prefer to use composite for filling their tooth rather than amalgam. Oxyde de zine 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 Cambodia compared to the other form currently.

*Mercury amalgam in capsule*

*Interviewed with dentist*

***Figure 3: Inventory team conducted mercury survey activities at dental clinic***

**Mercury input**

Detailed information on mercury use for dental amalgam was collected from public and private dental clinics in 8 provinces and one municipality in Cambodia. The detailed results are shown in Appendix 5. The annual consumption of about 2790 dental capsules besides a total of 0.991 Kg of metal mercury used by private dental clinics was reported. These data include response from 14 dental clinics representing a total of 22 dental chairs and about 127 capsules per chair and 45 grams per chair regarding it average.

Beside this, based on inventory issue report provided by the Central Pharmaceutical Warehouse of the Ministry of Health (code: NI0010) indicated that there are 19 bags (each bag contain amalgam about 250 g) of amalgam Gs powder A Non Gamma were distributed to all public health facilities through out Cambodia for the period of time from 1$^{st}$ January to 31$^{st}$ December 2007. So, the total amalgam distributed to public health facilities is about 4750 grams or 4.750 Kg. (See appendix 5)

According to information from the Department of Health, the total number of dental clinics in the country is approximately 556. 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 1112. Accordingly, a rough estimate of the national consumption of amalgam capsules is 141224 capsules per year in maximum estimation. Similarly, a rough estimate of the free metal mercury consumption for dental fillings is 50040 grams or 50.040 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 141224 x 0.8 g = 112979.2 grams or equal to 112.979 Kg Hg/year (around year 2005-2007) in maximum. So that the total amount of mercury use in Cambodia for dental fillings can thus be estimated at around 163.019 Kg Hg per year in maximum.

In conclusion, the total free metal mercury consumption for dental fillings is about 5.741 Kg in minimum for both the public health facilities (4.750 Kg) and private dental clinics (0.991 Kg). In addition, minimum amalgam filling in weight converting from capsules use is approximately 2.232 Kg. Thus, the total amalgam filling used by public and private dental sectors is approximately 7.973 Kg in minimum in 2007.

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 Cambodia), 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 12: Mercury release from other intentional use products category**

| No | Sub-category | Input factor | Activity rate | | Amount (Kg Hg/y) | |
|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Max |
| 6.1.1 | Amalgam fillings in capsule | 0.8 g per capsule | 2790 capsules | 141224 capsules | 2.232 | 112.979 |
| 6.1.2 | Free metal mercury consumption | | 5.741 Kg | 50.040 Kg | 5.741 | 50.040 |
| | **Total release by category 6** | | | | **7.973** | **163.019** |

## 3.7 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 Cambodia practices, the secondary metal production is available only for scraped iron, aluminum, copper, and lead.

### 3.7.1 Production of recycled ferrous metal (iron and steel)

Based on information from the Inventory Report of Unintentionally Produced POPs in Cambodia, (inventory report, 2004) it is known that recycled iron production undertaken at small scale handicraft.

The iron scrap recycling/production sources comprise 16 locations; and most of them are located in Phnom Penh Municipality and Kandal Province. According to the estimation, the amount of iron annually produced is about 8,358.80 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 (APCS) 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 USA) are present in the Cambodian 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).

### 3.7.2 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 13 locations with the annually rate production of 2,197 tons. Most of them are located in Phnom Penh 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 or APCS. The products of recycled aluminum can make many types of domestic objects, for example, pots, plates, bowls, and other souvenir items. (The Inventory Report of Unintentionally Produced POPs in Cambodia, 2004)

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 13) due to no input factors available (based on UNEP Toolkit).

**Table 13: 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) | 8,358.80 | N/A | N/A | | |
| 7.2 | Production of other recycled metals (aluminum, copper, etc.) | 2,197 | N/A | N/A | | |
| | **Total release by category 7** | | | | | |

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

## 3.8 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 Cambodia context, the waste incineration in Cambodia can be addressed only two types: (1) municipal waste incineration; and (2) medical waste incineration.

### 3.8.1 Incineration of municipal/general waste

**Activity rates**

Again, information from the Inventory Report of Unintentionally Produced POPs in Cambodia, 2004 addressed that the municipal wastes comprise household 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, such as Singapore, Malaysia, etc. The municipal waste incineration addressed in this report is merely on garment factory wastes[2] 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 Cambodia does not have so called professional incineration facilities as well as such municipal wastes will be mentioned in the below section 3.9.1.

Up to the present, six incinerators owned by factories are burning their wastes, of which five incinerators are for burning rags and/or disable cloths in garment factories for processing the steam ovens (at 249.60 tons annually), and one incinerator burns other industrial wastes at 3,276 tons annually. There are no reports on the burning temperatures for respective incinerators. Remarkably, the onsite incinerators are operated with low technology without air pollution control systems (APCS). In total, solid waste of about 3,525.60 tons are burned in factories' incinerators. Based on this waste burning amount we can estimate the generation of mercury and its release into the environment as indicated in the Table 14 below.

**Input factor**
Most of manufacturing establishment in Cambodia are garment factories, which their waste are mostly cloth and household wastes that can be considered as municipal wastes. All factories' incinerators do no install APCS, which all emission matters 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 15.

### 3.8.2 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.

According to the Inventory Report of Unintentionally Produced POPs in Cambodia, 2004, the medical waste incinerators in Cambodia are classified into three types: (i) local medical waste incinerator; (ii) SICIM incinerator; and (iii) modern incinerator. These incinerators are mostly operated with the burning of fuel, woods or other biomass. There is estimated that about 676 local medical waste incinerators, 25 SICIM incinerators, and 2 modern incinerators are being operated within the public health sector.

The 2004 inventory report has shown that the medical waste of about 801.82 tons is burned every year. So, based on this waste burning amount we can estimate the generation of mercury and its release into the environment as indicated in the table 14 below.

**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

[2] These wastes include rags or disable cloths.

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 15.

**Table 14: Estimated the release of mercury from waste incineration category**

| No | Sub-category | Activity rate (t/y) | Input factor | | Amount (Kg Hg/y) | |
|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Max |
| 8.1 | Incineration of municipal/ general waste | 3,525.60 t/y | 1 g/t | 10 g/t | 3.526 | 35.256 |
| 8.2 | Incineration of medical waste | 801.82 t/y | 8 g/t | 40 g/t | 6.415 | 32.073 |
| | **Total release by category 8** | | | | **9.941** | **67.329** |

**Table 15: Estimated mercury output distribution by pathway**

| Subcategory | Distribution pathway | | | | | |
|---|---|---|---|---|---|---|
| | Air | Water | Land | Product | General waste | Sector specific treatment/ disposal |
| Emission reduction devices (None) | 1 | | | | | |
| Incineration of municipal/general waste | 35.256 | | | | | |
| Incineration of medical waste | 32.073 | | | | | |

*Interviewed with health care officer to obtain information on medical wastes disposal of*

*A type of medical waste incineration facilities operating in Cambodia*

*Left picture: Overview of general wastes dump at open-landfill of Kampong Cham Province*

***Figure 4: Mercury inventory team conducted survey at health care facilities and landfills***

## 3.9 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 Cambodia context, the waste deposition in Cambodia 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.

### 3.9.1 Controlled landfills/deposits

Up to the present, solid waste disposal is still a big issue in Cambodia, although efforts by the RGC, especially MoE, urge stakeholders to apply environmentally sound management of wastes. Among cities and provinces, PPM certainly is the only city that has its dumping site (Stueng Meanchey Dumpsite) which is being improved under the support of Japanese Government and JICA Study Team. This dumpsite mostly accepts solid wastes collecting from urban areas, but in rural areas of PPM 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[3], and furthermore, domestic animal and scavengers can freely access these to find food and salable materials.

Besides Stung Meanchey 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 water sources. 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 Environment recorded that the amount of solid waste collected and dumped throughout the country in 2006 is approximately 466,556 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 16 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.

### 3.9.2 Waste water system/treatment

Cambodia 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 ADB for wastewater treatment.

Sewerage and drainage systems in PPM and in some other cities and provinces play a crucial role in releasing rain water and waste water, and reducing flooding in residential areas, hospitals, business centers, etc., and finally run off to receiving water bodies. In PPM, the drainage systems of Boeng Trabek, Boeng Salang, and Stung Meanchey, from year to year, has become increasingly shallow due to high sediment loads, suspended particles, and sludge. For the last three decades, these drainage systems were not dredged (to remove bottom sludge).

The situation in provinces and cities does not differ from PPM, 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 16.

[3] The systems that have functions in control of infiltration of water, gases, and leachate and collection.

**Table 16: Mercury release from waste disposal category**

| No | Sub-category | Activity rate(t/y) | Input factor | | Amount (Kg Hg/y) | |
|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Max |
| 9.1 | Solid waste disposal | 466556 | 1 g/t | 10 g/t | 466.556 | 4665.56 |
| 9.2 | Waste water treatment | N/A | 0.5 mg/$m^3$ | 10 mg/$m^3$ | 0 | 0 |
| | **Total release by category 9** | | | | **466.556** | **4665.56** |

***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/$m^3$.*

## 3.10 Crematoria and cemeteries

The practices of burning dead bodies can be classified into two types: (i) burning in crematory; and (ii) open burning. Crematories in rural/remote areas are commonly small with one chamber and a low chimney or without a chimney. In some areas, dead bodies were burnt in open areas close to the villages/forest areas (see figure below). On the other hand, in urban areas dead bodies were burnt in crematoriums located at pagodas with high chimney, some of which have twin-chambers.

Based on the Inventory Report of Unintentionally Produced POPs in Cambodia, 2004, it is known that, in 2003 about 30,616 bodies were burnt in crematoriums and about 9,980 dead bodies were burnt in open areas. In conclusion, the total dead bodies for 2003 were 40596 corpses. To date, there is no statistic data on mortality figures updated, however, based on data in 2003, the amount of mercury release on that year is shown in the below table 17. With the prevalent burning conditions, some of the mercury may remain in ashes, while most is expected to be emitted to the atmosphere.

**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 17: 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 | 40596 | 1g/corpse | 4 g/corpse | 40.596 | 162.384 |
| | | | | | | |
| | **Total release by category 10** | | | | **162.384** | **162.384** |

***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.*

## 3.11 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.

## 3.12 Overview of the Inventory Results

Although Cambodia has a different and complex situation[4] regarding the use and release of mercury compared to some other developed and developing countries. Nevertheless, Cambodia 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 Cambodia 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 18 below.

**Table 18: Summary of mercury release from all categories**

| No | Category and Sub-category | Activity rate | Input factor | | Amount (Kg Hg/y) | |
|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Max |
| **1** | **Extraction and use of fuel/energy sources** | | | | | |
| 1.1 | Use of crude oil (Power plant) | 240748 t/y | 10 mg/t | 300 mg/t | 2.407 | 72.224 |
| 1.2 | Use of gasoline, diesel and other distillates (Power plant) | 186344.87 t/y | 1 mg/t | 100 mg/t | 0.186 | 18.634 |
| 1.3 | Use of gasoline, diesel and other distillates (transportation) | 284737.85 t/y | 1 mg/t | 100 mg/t | 0.285 | 28.474 |
| 1.4 | Use of pipeline gas (consumer quality) | 34176062.25 $Nm^3$ | 0.03 $\mu g/Nm^3$ | 0.40 $\mu g/Nm^3$ | 0.001 | 0.014 |
| 1.5 | Biomass fired power and heat production | 5,511,201 t/y | 0.007 mg/t | 0.03 mg/t | 0.039 | 0.165 |
| **2** | **Primary metal production** | | | | | |
| 2.1 | *Maximum mercury use per year* | 6,000 miners | N/A | N/A | 34.5 | 1182 |
| **3** | **Production of other minerals and materials with mercury impurities** | | | | | |
| 3.1 | Lime production | 240 | 0.009 g/t | 0.055 g/t | 0.002 | 0.013 |
| **4** | **Intentional use of mercury in industrial purposes** | | | | N/A | N/A |
| **5** | **Consumer products with intentional use of mercury** | | | | | |
| 5.1 | *Thermometers* | 6141 items/y | 0.5 g/item | 1.5 g/item | 3.071 | 9.212 |
| 5.2.1 | *Batteries* | 635.599 t/y | 0.25 Kg/t | 10 Kg/t | 158.900 | 6355.99 |
| 5.2.2 | *Other type batteries* | 13.251 t/y | 3.4 Kg/t | 160 Kg/t | 45.053 | 2120.16 |
| **6** | **Other intentional products/process uses** | | | | | |
| 6.1.1 | Amalgam fillings in capsule | 0.8 g per capsule | 2790 capsules | 141224 capsules | 2.232 | 112.979 |
| 6.1.2 | Free metal mercury consumption | | 5.741 Kg | 50.040 Kg | 5.741 | 50.040 |
| **7** | **Production of recycled metals (secondary metal production)** | | | | | |
| 7.1 | *Production of recycled ferrous metal (iron and steel)* | 8,358.80 t/y | N/A | | 0 | 0 |
| 7.2 | *Production of other recycled metals (aluminum, copper, etc.)* | 2,197 t/y | N/A | | 0 | 0 |
| **8** | **Waste incineration** | | | | | |
| 8.1 | *Incineration of municipal/general waste* | 3,525.60 t/y | 1 g/t | 10 g/t | 3.526 | 35.256 |
| 8.2 | *Incineration of medical* | 801.82 t/y | 8 g/t | 40 g/t | 6.415 | 32.073 |

[4] The development processes in Cambodia proceeds slowly by using outdated/low cost facilities and technologies.

| No | Category and Sub-category | Activity rate | Input factor | | Amount (Kg Hg/y) | |
|---|---|---|---|---|---|---|
| | | | **Min** | **Max** | **Min** | **Max** |
| | *waste* | | | | | |
| **9** | **Waste deposition/land filling and waste water treatment** | | | | | |
| 9.1 | *Solid waste disposal* | 466,556 t/y | 1 g/t | 10 g/t | 466.556 | 4665.56 |
| 9.2 | *Waste water treatment* | N/A | 0.5 mg/$m^3$ | 10 mg/$m^3$ | 0 | 0 |
| **10** | **Crematoria and cemeteries** | | | | | |
| 10.1 | *Cremation* | 40,596 corpse/y | 1g/corpse | 4g/corpse | 40.596 | 162.384 |
| **11** | **Identification of potential hot-spots** | | | | N/A | N/A |
| | **Total release from all categories** | | | | **769.51** | **14845.178** |

# 4 Conclusion

It is the first time for Cambodia 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 8 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 Cambodia is approximately **769.51 Kg in minimum** and about **14845.178 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 Cambodia 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 Cambodia context.

As Cambodia 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 Cambodia 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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# 6 Appendices

## 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 Questionnaires to Gold Mining, Requested to Local Authorities

Name of interviewee representing village/commune/district: .....
Position: .....
Telephone: .....
Address: Village..... Commune: .....
District: ..... Province: .....
Number of miners per village/commune/district (persons or families): .....
Number of gold mining company: .....
Quantity of gold extracted per year, in gram: .....
Quantity of mercury used for extracting gold (in weight, Kg/year): .....
Purchased source: .....
Origin of import: .....
Management of leaches (liquid waste generated by landfill): .....
Numbers of landfills exist in province/municipality:
General understanding on mercury and its hazard: .....
.....
.....
Brief observation assessment: .....
.....
.....
.....

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

### 6.1.8 Questionnaire to Provincial Industry Mine and Energy Department

Name of interviewee:.....
of provincial/municipality Department of Industry, Mines, and Energy: .....
Telephone:.....
Location of gold mining in province: .....
.....
.....
Number of existing gold mining exploration company:.....
Number of miners exist in the province: .....
Estimated gold production from gold mining: .....
.....
Information related to the use of mercury for extracting gold (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 2: List of interviewed gold miners, family level

| No | Name Of Province | Interviewed code | Number of Miner | Hg (Kg) | Other chemicals | Amount of Gold Products g/year | Remark |
|---|---|---|---|---|---|---|---|
| 1. | Kompong Thom | QKT-01 | 3 | | | 36.8 | In Family |
| 2. | Kompong Thom | QKT-02 | 3 | | | 32 | in Family |
| 3. | Kompong Thom | QKT-03 | 4 | | | 184 | In Family |
| 4. | Kompong Thom | QKT-04 | 4 | | | 210 | In Family |
| 5. | Kompong Thom | QKT-05 | 5 | | | 176 | In Family |
| 6. | Kompong Thom | QKT-06 | 2 | | | 96 | In Family |
| 7. | Kompong Thom | QKT-07 | 4 | | | 360 | In Family |
| 8. | Kompong Thom | QKT-08 | 4 | | | 376 | In Family |
| 9. | Kompong Thom | QKT-09 | 4 | | | 210 | In Family |
| 10. | Kompong Thom | QKT-10 | 5 | | | 280 | In Family |
| 11. | Kompong Thom | QKT-11 | 6 | | | 272 | In Family |
| 12. | Kompong Thom | QKT-12 | 4 | | | 238 | In Family |
| 13. | Kratoe | QKR-01 | 6 | 2 | | 685 | In Family |
| 14. | Kratoe | QKR-02 | 6 | | 0.5 | 225 | in Family |
| 15. | Kratoe | QKR-03 | 4 | | 0.5 | 100 | In Family |
| 16. | Kratoe | QKR-04 | 7 | | 0.5 | 190 | In Family |
| 17. | Kratoe | QKR-05 | 3 | | 0.5 | 90 | In Family |
| 18. | Kratoe | QKR-06 | 4 | | 0.5 | 120 | In Family |
| 19. | Kratoe | QKR-07 | 4 | | 0.5 | 210 | In Family |
| 20. | Kratoe | QKR-08 | 5 | | 0.5 | 225 | In Family |
| 21. | Kratoe | QKR-09 | 10 | | 0.5 | 270 | In Family |
| 22. | Kratoe | QKR-10 | 2 | | 0.5 | 270 | In Family |
| 23. | Kratoe | QKR-11 | 3 | | | 260 | In Family |
| 24. | Kratoe | QKR-12 | 7 | | | 680 | Use 2 machines |
| 25. | Ratanakiri | QRK-01 | 4 | 2 | | 1026 | |
| 26. | Ratanakiri | QRK-02 | 8 | 2.5 | | 6400 | |
| 27. | Ratanakiri | QRK-03 | 4 | 3 | | 1856 | In Family |
| 28. | Ratanakiri | QRK-04 | 6 | 3 | | 600 | |
| 29. | Ratanakiri | QRK-05 | 5 | 3 | | 1170 | |
| 30. | Ratanakiri | QRK-06 | 3 | 3 | | 2475 | |
| 31. | Ratanakiri | QRK-07 | 8 | 3 | | 300 | |
| 32. | Ratanakiri | QRK-08 | 4 | 4 | | 900 | |
| 33. | Ratanakiri | QRK-09 | 4 | 4 | | 562 | |
| 34. | Ratanakiri | QRK-10 | 8 | 5 | | 6187 | |
| 35. | Ratanakiri | QRK-11 | 4 | | 0.5 | 405 | In Family |
| 36. | Ratanakiri | QRK-12 | 8 | | | 1350 | |
| | **Total** | | **175** | **34.5** | **5** | **29026.8** | |

## 6.3 Appendix 3: Number of thermometers used by healthcare centers

### 6.3.1 Number of thermometers used by surveyed health centers

| No | Province and Municipality | Name of healthcare centre | Number of patient per year | Number of used thermometer per year | Number of used thermometer per patient |
|---|---|---|---|---|---|
| 1 | Battambang | Chamkar Samrong | 24,000 | 50 | 480 |
| 2 | Kampong Chhnang | Chrey Bak | 4,800 | 5 | 960 |
| 3 | Kampong Chnnang | Kompong Chnnang | 54,750 | 20 | 2738 |
| 4 | Kampot | Tray Koh | 7,200 | 10 | 720 |
| 5 | Kampot | Trapieng Sragniar | 3,000 | 15 | 200 |
| 6 | Kompong Cham | Ampil | 420 | 3 | 140 |
| 7 | Pursat | Snam Preah | 4,800 | 8 | 600 |
| 8 | Pursat | Prey Gni | 6,000 | 20 | 300 |
| 9 | Seam Reap | Chreav | 9,000 | 10 | 900 |
| 10 | Seam Reap | Kandet | 7,440 | 4 | 1860 |
| 11 | Sihanouk Ville | Sihanouk | 1,000 | 3 | 333 |
| 12 | Sihanouk ville | Khleang Leou | 9,600 | 10 | 960 |
| 13 | Takeo | Rakar Krouv | 6,000 | 5 | 1200 |
| 14 | Takeo | Ang Tasom | 480 | 15 | 32 |
| | **Total** | | **138490** | **178** | |

### 6.3.2 Inventory Issue Report: Thermometer Oral/Rectal (Code: QB0560)

| No | Code | Facility Name | Unit | Quantity | Date Activate |
|---|---|---|---|---|---|
| 1. | 1501 | Bakan | Piece | 12 | 05-Jan-07 |
| 2. | 9704 | Kossamak | Piece | 36 | 05-Jan-07 |
| 3. | 9706 | National Pediatric | Piece | 120 | 05-Jan-07 |
| 4. | 0104 | Ochrov | Piece | 24 | 05-Jan-07 |
| 5. | 2002 | Romeas Hek | Piece | 36 | 05-Jan-07 |
| 6. | 1502 | Sampov Meas | Piece | 24 | 05-Jan-07 |
| 7. | 2201 | Samrong | Piece | 24 | 05-Jan-07 |
| 8. | 0103 | Thmor Puok | Piece | 24 | 05-Jan-07 |
| 9. | 1704 | Angkor Chun | Piece | 12 | 12-Jan-07 |
| 10. | 0204 | Battambang | Piece | 24 | 12-Jan-07 |
| 11. | 1701 | Kralanh | Piece | 12 | 12-Jan-07 |
| 12. | 0202 | Mong Russey | Piece | 24 | 12-Jan-07 |
| 13. | 0203 | Sampov Luon | Piece | 12 | 12-Jan-07 |
| 14. | 0402 | Kampong Tralach | Piece | 36 | 18-Jan-07 |
| 15. | 9708 | MCH | Piece | 24 | 18-Jan-07 |
| 16. | 0702 | Chhouk | Piece | 48 | 26-Jan-07 |
| 17. | 0704 | Kampot | Piece | 12 | 26-Jan-07 |
| 18. | 0602 | Kampong Thom | Piece | 24 | 01-Feb-07 |
| 19. | 0301 | Chamcar Leu-Stung Trang | Piece | 24 | 09-Feb-07 |
| 20. | 0303 | Kampong Cham-Kampong Sie | Piece | 24 | 09-Feb-07 |
| 21. | 0305 | Memut | Piece | 36 | 09-Feb-07 |
| 22. | 0306 | O Reang Ov- Koh Sotin | Piece | 12 | 09-Feb-07 |
| 23. | 0503 | Oudong | Piece | 36 | 09-Feb-07 |
| 24. | 0307 | Ponhea Krek-Dam Be | Piece | 48 | 09-Feb-07 |
| 25. | 0308 | Prey Chhor-Kang Meas | Piece | 24 | 09-Feb-07 |
| 26. | 1801 | Sihanouk Ville | Piece | 20 | 09-Feb-07 |
| 27. | 0901 | Smach Mean Chey | Piece | 24 | 09-Feb-07 |
| 28. | 0309 | Srey Santhor-Kang Meas | Piece | 12 | 09-Feb-07 |
| 29. | 0802 | Kean Svay | Piece | 96 | 13-Feb-07 |
| 30. | 2101 | Ang Rokar | Piece | 36 | 28-Feb-07 |

| No | Code | Facility Name | Unit | Quantity | Date Activate |
|---|---|---|---|---|---|
| 31. | 0403 | Baribo | Piece | 30 | 28-Feb-07 |
| 32. | 2104 | Kirivong | Piece | 120 | 28-Feb-07 |
| 33. | 1002 | Kratie | Piece | 60 | 28-Feb-07 |
| 34. | 1404 | Neak Loeung | Piece | 60 | 28-Feb-07 |
| 35. | 1301 | Preah Vihear | Piece | 60 | 28-Feb-07 |
| 36. | 9902 | Ministry Of National Defence | Piece | 20 | 12-Mar-07 |
| 37. | 1101 | Sen Monorom | Piece | 12 | 12-Mar-07 |
| 38. | 9708 | MCH | Piece | 24 | 23-Mar-07 |
| 39. | 0102 | Preah Net Preah | Piece | 36 | 23-Mar-07 |
| 40. | 2002 | Romeas Hek | Piece | 36 | 23-Mar-07 |
| 41. | 2201 | Samrong | Piece | 24 | 23-Mar-07 |
| 42. | 2003 | Svay Rieng | Piece | 48 | 23-Mar-07 |
| 43. | 0103 | Thmor Puok | Piece | 24 | 23-Mar-07 |
| 44. | 9703 | Khmer-Soviet Friendship | Piece | 300 | 27-Mar-07 |
| 45. | 9704 | Kossamak | Piece | 24 | 27-Mar-07 |
| 46. | 0403 | Baribo | Piece | 24 | 30-Mar-07 |
| 47. | 9706 | National Pediatric | Piece | 240 | 05-Apr-07 |
| 48. | 0601 | Baray-Santuk | Piece | 24 | 30-Apr-07 |
| 49. | 0704 | Kampot | Piece | 24 | 30-Apr-07 |
| 50. | 1801 | Sihanouk Ville | Piece | 28 | 30-Apr-07 |
| 51. | 1801 | Sihanouk Ville | Piece | 20 | 30-Apr-07 |
| 52. | 0303 | Kampong Cham-Kampong Sie | Piece | 36 | 11-May-07 |
| 53. | 0306 | O Reang Ov- Koh Sotin | Piece | 24 | 11-May-07 |
| 54. | 0307 | Ponhea Krek-Dam Be | Piece | 48 | 11-May-07 |
| 55. | 0902 | Sre Ambel | Piece | 12 | 11-May-07 |
| 56. | 0801 | Ang Snuol | Piece | 24 | 31-May-07 |
| 57. | 0802 | Kean Svay | Piece | 36 | 31-May-07 |
| 58. | 1002 | Kratie | Piece | 24 | 31-May-07 |
| 59. | 0805 | Muk Kam Poul | Piece | 24 | 31-May-07 |
| 60. | 1301 | Preah Vihear | Piece | 48 | 01-Jun-07 |
| 61. | 9703 | Khmer-Soviet Friendship | Piece | 240 | 21-Jun-07 |
| 62. | 2104 | Kirivong | Piece | 120 | 21-Jun-07 |
| 63. | 9704 | Kossamak | Piece | 36 | 21-Jun-07 |
| 64. | 0101 | Mongkol Borei | Piece | 24 | 21-Jun-07 |
| 65. | 1404 | Neak Loeung | Piece | 48 | 21-Jun-07 |
| 66. | 1405 | Peareang | Piece | 12 | 21-Jun-07 |
| 67. | 1101 | Sen Monorom | Piece | 48 | 21-Jun-07 |
| 68. | 0103 | Thmor Puok | Piece | 24 | 21-Jun-07 |
| 69. | 9708 | MCH | Piece | 24 | 29-Jun-07 |
| 70. | 9706 | National Pediatric | Piece | 100 | 29-Jun-07 |
| 71. | 2002 | Romeas Hek | Piece | 24 | 29-Jun-07 |
| 72. | 0204 | Battambang | Piece | 24 | 23-Jul-07 |
| 73. | 0402 | Kampong Tralach | Piece | 48 | 23-Jul-07 |
| 74. | 9703 | Khmer-Soviet Friendship | Piece | 30 | 23-Jul-07 |
| 75. | 1701 | Kralanh | Piece | 24 | 23-Jul-07 |
| 76. | 1901 | Stung Treng | Piece | 60 | 23-Jul-07 |
| 77. | 0601 | Baray-Santuk | Piece | 24 | 24-Jul-07 |
| 78. | 9902 | Ministry Of National Defence | Piece | 30 | 24-Jul-07 |
| 79. | 1601 | Rattanakiri | Piece | 48 | 24-Jul-07 |
| 80. | 0301 | Chamcar Leu-Stung Trang | Piece | 36 | 10-Aug-07 |
| 81. | 0702 | Chhouk | Piece | 48 | 10-Aug-07 |
| 82. | 0703 | Kampong Trach | Piece | 48 | 10-Aug-07 |
| 83. | 0307 | Ponhea Krek-Dam Be | Piece | 48 | 10-Aug-07 |
| 84. | 0308 | Prey Chhor-Kang Meas | Piece | 12 | 10-Aug-07 |
| 85. | 0310 | Tbong Khmum-Kroch Chmar | Piece | 24 | 10-Aug-07 |
| 86. | 0801 | Ang Snuol | Piece | 24 | 20-Aug-07 |
| 87. | 0802 | Kean Svay | Piece | 50 | 20-Aug-07 |
| 88. | 9804 | Ministry Of Health | Piece | 3 | 20-Aug-07 |
| 89. | 1601 | Rattanakiri | Piece | 30 | 20-Aug-07 |

| No | Code | Facility Name | Unit | Quantity | Date Activate |
|---|---|---|---|---|---|
| 90. | 0807 | Saang | Piece | 50 | 20-Aug-07 |
| 91. | 1002 | Kratie | Piece | 60 | 28-Aug-07 |
| 92. | 2101 | Ang Rokar | Piece | 30 | 30-Aug-07 |
| 93. | 2104 | Kirivong | Piece | 120 | 30-Aug-07 |
| 94. | 06 | Kampong Thom PHD | Piece | 72 | 31-Aug-07 |
| 95. | 1402 | Kampong Tralach | Piece | 30 | 11-Sep-07 |
| 96. | 1404 | Neak Loeung | Piece | 96 | 11-Sep-07 |
| 97. | 1405 | Peareang | Piece | 12 | 11-Sep-07 |
| 98. | 1101 | Sen Monorom | Piece | 30 | 11-Sep-07 |
| 99. | 1702 | Siem Reap | Piece | 100 | 11-Sep-07 |
| 100. | 2201 | Samrong | Piece | 30 | 14-Sep-07 |
| 101. | 1501 | Bakan | Piece | 20 | 27-Sep-07 |
| 102. | 0101 | Mongkol Borei | Piece | 50 | 27-Sep-07 |
| 103. | 0102 | Preah Net Preah | Piece | 20 | 27-Sep-07 |
| 104. | 1502 | Sampov Meas | Piece | 12 | 27-Sep-07 |
| 105. | 0103 | Thmor Puok | Piece | 24 | 27-Sep-07 |
| 106. | 9706 | National Pediatric | Piece | 100 | 08-Oct-07 |
| 107. | 0401 | Kampong Chhang | Piece | 20 | 18-Oct-07 |
| 108. | 9708 | MCH | Piece | 24 | 18-Oct-07 |
| 109. | 9703 | Khmer-Soviet Friendship | Piece | 140 | 22-Oct-07 |
| 110. | 9704 | Kossamak | Piece | 20 | 22-Oct-07 |
| 111. | 2401 | Pailin Ville | Piece | 12 | 22-Oct-07 |
| 112. | 1704 | Angkor Chun | Piece | 24 | 25-Oct-07 |
| 113. | 0204 | Battambang | Piece | 24 | 25-Oct-07 |
| 114. | 1701 | Kralanh | Piece | 14 | 25-Oct-07 |
| 115. | 1203 | Lech | Piece | 12 | 25-Oct-07 |
| 116. | 0202 | Mong Russey | Piece | 30 | 25-Oct-07 |
| 117. | 2002 | Romeas Hek | Piece | 20 | 25-Oct-07 |
| 118. | 1901 | Stung Treng | Piece | 50 | 25-Oct-07 |
| 119. | 2003 | Svay Rieng | Piece | 60 | 25-Oct-07 |
| 120. | 0702 | Chhouk | Piece | 40 | 05-Nov-07 |
| 121. | 0703 | Kampong Trach | Piece | 50 | 05-Nov-07 |
| 122. | 0602 | Kampong Thom | Piece | 20 | 14-Nov-07 |
| 123. | 0302 | Choeung Prey-Batheay | Piece | 12 | 20-Nov-07 |
| 124. | 0303 | Kampong Cham-Kampong Sie | Piece | 60 | 20-Nov-07 |
| 125. | 0305 | Memut | Piece | 48 | 20-Nov-07 |
| 126. | 9706 | National Pediatric | Piece | 200 | 20-Nov-07 |
| 127. | 0306 | O Reang Ov- Koh Sotin | Piece | 24 | 20-Nov-07 |
| 128. | 0307 | Ponhea Krek-Dam Be | Piece | 120 | 20-Nov-07 |
| 129. | 0308 | Prey Chhor-Kang Meas | Piece | 12 | 20-Nov-07 |
| 130. | 1601 | Rattanakiri | Piece | 60 | 20-Nov-07 |
| 131. | 0309 | Srey Santhor-Kang Meas | Piece | 12 | 20-Nov-07 |
| 132. | 2104 | Kirivong | Piece | 120 | 30-Nov-07 |
| 133. | 1002 | Kratie | Piece | 60 | 30-Nov-07 |
| 134. | 0808 | Takhmao | Piece | 100 | 30-Nov-07 |
| 135. | 1402 | Kampong Trabek | Piece | 20 | 20-Dec-07 |
| 136. | 1404 | Neak Loeung | Piece | 60 | 20-Dec-07 |
| 137. | 1404 | Peareang | Piece | 12 | 20-Dec-07 |
| 138. | 1502 | Sampov Meas | Piece | 10 | 20-Dec-07 |
| 139. | 1101 | Sen Monorom | Piece | 50 | 20-Dec-07 |
| | **Total** | | **Piece** | **6141** | |

***Source: Central Pharmaceutical Warehouse, Ministry of Health, February, 2008***
*Note: Most thermometers are mercury based products*

## 6.4 Appendix 4: Types and quantity of batteries imported, 2005

| No. | Company code | lithium | Zinc-Air | Zinc-Carbon | Mn | Hg | Silver | Other-Battery | Total Imported (kg) |
|---|---|---|---|---|---|---|---|---|---|
| | Products code | 8506.60.10 | 8506.80.11 | 8506.1 | 8506.3 | 8506.4 | 8506.8 | | |
| 1 | 1000153 | | 2.00 | | | | | | 2.00 |
| 2 | 1001914 | | 31.78 | | | | | | 31.78 |
| 3 | 1002683 | | 8,013.60 | | | | | | 8,013.60 |
| 4 | 1017159 | | 32,828.00 | | | | | | 32,828.00 |
| 5 | 1017195 | | 7,620.00 | | | | | | 7,620.00 |
| 6 | 1031604 | | 4,000.00 | | | | | | 4,000.00 |
| 7 | 1037027 | | - | | | | | 3,201.00 | 3,201.00 |
| 8 | 1037093 | | 45.00 | | | | | | 45.00 |
| 9 | 1052143 | | - | | | | | 150.00 | 150.00 |
| 10 | 1061539 | | 17.00 | | | | | | 17.00 |
| 11 | 1067809 | | 4,005.00 | | | | | | 4,005.00 |
| 12 | 1070890 | | 83.00 | | | | | | 83.00 |
| 13 | 1080252 | | 572,300.22 | | | | | | 572,300.22 |
| 14 | 1091802 | | 175.20 | | | | | | 175.20 |
| 15 | 1092099 | | - | | | | | 9,900.00 | 9,900.00 |
| 16 | 1120879 | | 2,200.00 | | | | | | 2,200.00 |
| 17 | 1123442 | | 2,003.00 | | | | | | 2,003.00 |
| 18 | 1142860 | | 0.10 | | | | | | 0.10 |
| 19 | 1170890 | | 2,275.00 | | | | | | 2,275.00 |
| | Total (Kg) | 0.00 | 635,598.90 | 0.00 | 0.00 | 0.00 | 0.00 | 13,251.00 | 648,849.90 |

***Source: Custom Department, 2005***

## 6.5 Appendix 5: Number of amalgam use for dental filling

### 6.5.1 Number of mercury amalgam use by surveyed provinces, 2007

| No | Clinic Code | Province | Number of chairs | Number of patient person/year | Amalgam use, tablets/y | Amalgam use, g/y |
|---|---|---|---|---|---|---|
| 1. | CC-01 | Battambang | 1 | 720 | 180 | |
| 2. | CC-02 | Battambang | 3 | 1200 | 360 | |
| 3. | CC-03 | Kampot | 1 | 180 | | 1 |
| 4. | CC-04 | Kampot | 2 | 240 | | |
| 5. | CC-05 | Kompong Cham | 2 | 600 | 360 | |
| 6. | CC-06 | Kompong Cham | 1 | 480 | 300 | |
| 7. | CC-07 | Kompong Chnnang | 1 | 3000 | 300 | |
| 8. | CC-08 | Kompong Chnnang | 1 | 1800 | 240 | |
| 9. | CC-09 | Phnom Penh | 5 | 364 | | |
| 10. | CC-10 | Phnom Penh | 1 | 72 | 60 | |
| 11. | CC-11 | Phnom Penh | 6 | 960 | | |
| 12. | CC-12 | Phnom Penh | 5 | 1800 | | |
| 13. | CC-13 | Phnom Penh | 5 | 600 | | |
| 14. | CC-14 | Pursat | 1 | 1080 | | **240** |
| 15. | CC-15 | Pursat | 1 | 1200 | 240 | |
| 16. | CC-16 | Seam Reap | 4 | 720 | 360 | |
| 17. | CC-17 | Seam Reap | 2 | 240 | 300 | |
| 18. | CC-18 | Sihanouk Ville | 1 | 120 | 90 | |
| 19. | CC-19 | Sihanouk Ville | 1 | 180 | | |
| 20. | CC-20 | Takeo | 2 | 240 | | 750 |
| 21. | CC-21 | Takeo | 3 | 600 | | |
| | **Total** | | **49** | **16396** | **2790** | **991** |

### 6.5.2 Inventory Issue Report: Amalgam Gs Powder A Non Gamma, 250g (Code: NI0010)

| No | Code | Facility Name | Unit | Quantity | Date Activate |
|---|---|---|---|---|---|
| 1 | 9701 | Ang Doung | Bottle | 5 | 18-Jan-07 |
| 2 | 2102 | Bati | Bottle | 2 | 28-Feb-07 |
| 3 | 2103 | Don Keo | Bottle | 3 | 28-Feb-07 |
| 4 | 2102 | Bati | Bottle | 1 | 30-Aug-07 |
| 5 | 9703 | Khmer-Soviet Friendship | Bottle | 5 | 22-Oct-07 |
| 6 | 0704 | Kampot | Bottle | 2 | 05-Nov-07 |
| 7 | 2102 | Bati | Bottle | 1 | 30-Nov-07 |
| | **Total** | | Bottle | **19** | |
| | **Total in weight** | | Weight | **4750 grams** | |

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

## 6.6 Appendix 6: Number of solid wastes collected and dumped by provinces

| No | Location | Unit | Quantity of waste disposed of |
|---|---|---|---|
| 1 | Bateay Meanchey | **ton/year** | 7,738.00 |
| 2 | Battmbang | **ton/year** | 12,593.00 |
| 3 | Kampong Speu | **ton/year** | 1,752.00 |
| 4 | Kampong Thom | **ton/year** | 4,215.00 |
| 5 | Kampot | **ton/year** | 11,275.00 |
| 6 | Kandal | **ton/year** | 4,431.00 |
| 7 | Kep town | **ton/year** | 1,022.00 |
| 8 | Koh Kong | **ton/year** | 1,642.00 |
| 9 | Kompong Cham | **ton/year** | 9,819.00 |
| 10 | Kompong Chnnang | **ton/year** | 3,011.00 |
| 11 | Kratie | **ton/year** | 1,825.00 |
| 12 | Mondulkiri | **ton/year** | 730.00 |
| 13 | Oddor Meanchey | **ton/year** | 182.00 |
| 14 | Pailin | **ton/year** | 730.00 |
| 15 | Phnom Penh | **ton/year** | 324,159.00 |
| 16 | Preah Vihear | **ton/year** | 365.00 |
| 17 | Prey Veng | **ton/year** | 3,942.00 |
| 18 | Pursat | **ton/year** | 1,825.00 |
| 19 | Ratanakiri | **ton/year** | 2,555.00 |
| 20 | Seam Reap | **ton/year** | 36,500.00 |
| 21 | Sihanoukville | **ton/year** | 32,850.00 |
| 22 | Stung Treng | **ton/year** | 2,190.00 |
| 23 | Svay Rieng | **ton/year** | 475.00 |
| 24 | Takeo | **ton/year** | 730.00 |
| | **Total** | **ton/year** | **466,556.00** |

***Source: Department of Environmental Pollution Control, Ministry of Environment, 2008***

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