



National Assessment Report on Mercury in Cambodia

Prepared by: Department of Hazardous Substance Management, General Directorate of
Environmental Protection, Ministry of Environment

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Executive Summary

In October 2013, Cambodia endorsed the notification of signatory of Minamata Implementation Plan for the UNEP Global Mercury, currently under implementation process. This plan is an indication of a new effort by Cambodia to provide additional guidance in the form of specific goals, objectives and actions for the sound management of mercury.

In the Kingdom of Cambodia, the use of hazardous substances, especially the mercury substances are not normally managed in an environmentally sound manner and there is no specific government institution responsible for mercury management. Therefore, management of mercury and mercury-containing wastes in Cambodia is a collaboration of various ministries within a government. Governmental institutions manage hazardous chemicals in according to their roles and responsibilities regulated by governmental ordinances. The governmental institutions fulfill their mandates in managing hazardous chemicals by building safety into the chemicals production processes, chemicals trade, and by ensuring the prevention and/or mitigation of impacts on people's health, especially user health, and protect the environment and biodiversity. This section gives an overview of important ministries, agencies and institutions related to mercury along with their responsibilities, authorities and mandate. Responsibilities for the management of hazardous chemicals such as Mercury are designated to governmental ministries including: Ministry of Environment, Ministry of Agriculture Forestry and Fisheries, Ministry of Mines and Energy, Ministry of Industry and Handicraft, Ministry of Health, Ministry of Commerce (Department of CAMCONTROL), Ministry of Economic and Finance (Department of Customs), and Ministry of Interior (National Authority for Controlling Drugs).

In 2007, Cambodia got assistance from the United Nations Environmental Program (UNEP) to study the mercury releases from all identified sources. These sources were identified 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 the preliminary survey, it was understood that the total release of mercury in Cambodia was 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 was consumer products with intentional use of mercury that caused 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. 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.

There are a lot of victims from mercury in mining activity and there is case study on human data currently ties mercury exposure to cancer in Cambodia, but the data available are limited by each province and location. Cambodia, small-scale mining especially the kind of illegal mining cause much of the risks to mining's workers are the result of poor equipment and technical.

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Abbreviations and Acronyms

ADB	:	Asian Development Bank
ASGM	:	Artisanal and Small-Scale Gold Mining
CDC	:	The Council for Development of Cambodia
EIA	:	Environmental Impact Assessment
EPA	:	Environmental Protection Agency
Hg	:	Mercury
JICA	:	Japan International Cooperation Agency
Kg	:	Kilogram
LPG	:	Liquefied Petroleum Gas
MAFF	:	Ministry of Agriculture, Forestry and Fisheries
MIH	:	Ministry of Industry and Handicraft
MIME	:	Ministry of Industry, Mine and Energy
MME	:	Ministry of Mines and Energy
MOC	:	Ministry of Commerce
MOE	:	Ministry of Environment
MEF	:	Ministry of Economy and Finance
MOH	:	Ministry of Health
MOI	:	Ministry of Interior
MPWT	:	Ministry of Public Work and Transport
MOWRAM	:	Ministry of Water Resource and Meteorology
MSDS	:	Material Safety Data Sheet
NGOs	:	Non-Government Organizations
PCD	:	Pollution Control Department
SAICM	:	The Strategic Approach to International Chemicals Management
SDG	:	Sustainable Development Goals
UNEP	:	United Nations Environmental Programme
WB	:	World Bank

1. Background

In October 2013, Cambodia endorsed the notification of signatory of Minamata Implementation Plan for the UNEP Global Mercury, currently under implementation process. This plan is an indication of a new effort by Cambodia to provide additional guidance in the form of specific goals, objectives and actions for the sound management of mercury. Due to the utilizing of mercury has risen in many factors such as in power source (battery) dentist preparation, in cosmetic and artisanal gold mining, there have been some increasing need for sustainable development models that promote environmental protection while enhancing the contribution of these activities to poverty alleviation. Artisanal mining provides a critical sources of income for an estimated 15 million poverty driven miners around the world, many in Africa, Asia and Latin America. In case of Cambodia, it is understood that the total release of mercury, is approximately 769.51 Kg as a minimum, and about 14845.178 Kg as a maximum per year. The first major source of maximum mercury release into atmosphere is consumer products (thermometers and batteries), which contributed to the release of 8485.362 Kg of mercury per annum, followed by disposal of wastes (dumpsites) which contains mercury substances that could release of approximately 4665.56 Kg of mercury, followed by gold extraction (small scale gold mining) that emitted approximately 1182 Kg of mercury per year. However, its environment impacts are often extensive, with mercury pollution posing major threats to human health and diver ecosystems.

Involving to the above guidance information of releasing of mercury to atmosphere per year and environmental impact of mercury in Cambodia, a national assessment report on mercury shall be developed from the prioritization exercise and from stakeholder inputs. The report will cover an existing legal framework which focus on any legislative law which Cambodia has for chemical substance especially the mercury substances, institutional framework which focus on any ministry which involves to the chemical substances especially the Mercury substances, consumption of mercury which introduce about the utilization of mercury especially the small scale gold mining in Cambodia, and impact of mercury which introduce about the effectiveness of mercury in environment and human health. Moreover, the report will be contributing to the country's national poverty reduction strategies, development plans, their equivalent or their concentration on mercury substance.

2. Legislative Framework

Pollution is endemic in many parts of the developing world, where a lack of regulations and enforcement have left legacies of pollution in many dense urban centers. These problems affect upward of one billion people, and result in an increased burden of disease, reduced quality of life, and reduced life expectancy. Active facilities provide continuous sources of pollutants to water and air. Even when shut down or re-configured to reduce emissions, old facilities often leave behind a legacy of toxic materials that continue to poison local populations. Industrial and mining pollution imposes a particularly heavy burden on health, especially children's health. Heavy metals such as lead, mercury, chromium and cadmium cause developmental problems such as mental retardation, as well as various cancers and other diseases.

The main environment and health threats arising from current practices are the releasing of hazardous substances, especially the composition of these substances which contains

mercury particles into the air, water and soil. Mercury enters the environment as a result of normal breakdown of minerals in rocks and soil through exposure to wind and water. Release of mercury from natural sources has remained fairly the same over the years. Still mercury concentrations in the environment are increasing; this is ascribed to human's activity. Most of the mercury released from human activities is released into air, through fossil fuel combustion, mining, smelting and solid waste combustion. Some forms of human activity release mercury directly into soil or water, for instance the application of agricultural fertilizers and industrial wastewater disposal. All mercury that is released in the environment will eventually end up in soils or surface waters.

2.1 National Legal Framework

2.1.1 National Regulation

In the Kingdom of Cambodia, the use of hazardous substances, especially the mercury or mercury substances are not normally managed in an environmentally sound manner and there is no specific government institution responsible for mercury management. The existing legislations such as constitution, royal degree or law, sub-decree and prakas which are related to environmental protection, pollution prevention and control, as well as chemical and mercury related management and control could be found below.

Constitution of Cambodia which involves to the environmental impacts are stated within under article 59, describing that “the State shall protect the environment and balance of abundant natural resources and establish a precise plan of management of land, water, air, wind, geology, ecological system, mines, energy, petrol and gas, rocks and sand, gems, forests and forestry products, wildlife, fish and aquatic resources” and article 64 stated that “the State shall ban and severely punish those who import, manufacture, and sell illicit drugs and counterfeit and expired goods which affect the health and life of the consumer”. The purpose of this national constitution under article 59 and 64 denote clearly on the environmental protection and health care respectively, meaning that any activities or chemical substances which could pollute to environment or effect on human's health have to punish or forbidden.

Law on Environmental Protection and Natural Resources Management was adopted by the National Assembly on 24 December 1996. This law contains 11 chapters and 27 articles, but it does not intend to provide specific environmental management systems, codes and standards. However, it is a fundamental framework for the development of environmental regulation such as sub-decrees, ministerial declarations, circulations, codes and standards for environmental quality protection and natural resources management in the Kingdom of Cambodia. The main purposes of this law are to protect environmental quality from pollution by chemicals and other hazardous wastes through inventory and environmentally sound management of pollutants. This law also focuses on the sustainable management of natural resources in order to promote the socio-economic development of the country. Furthermore, the law on environmental protection and natural resources management also mentions some points related to the marine environmental management including coastal resources management.

Sub-degree on Solid Waste Management was adopted by the National Assembly on 27 April 1999. The main purposes of this sub-decree are to regulate the solid waste

management with proper technical manner and safe way in order to ensure the protection of human health and protection of environment such as the conservation of bio-diversity. Furthermore, this sub-decree applies to some activities related to disposal storage collection, transport, recycling, dumping of garbage and hazardous waste. This sub-decree contains 6 chapters and 32 articles. In chapter 3 denotes about the hazardous waste management and at article 11 and 12, state that the Ministry of Environment shall establish guidelines on the management of hazardous waste to ensure the safe management and shall issue Prakas on the standard of quantify of toxin or hazardous substances contained in the hazardous waste which could be allowed to be disposed in order to ensure the human health and environmental quality protection and bio-diversity conservation. Even though this law does not intend to provide specific hazardous management which focus on the mercury and mercury substance. However, it is a fundamental framework for the development of environmental regulation such as sub-decrees, ministerial declarations, circulations, codes and standards for environmental quality protection, mercury and mercury substances' standard to environment in the Kingdom of Cambodia.

Besides, there are dozens of legislation which are more related to the management of chemical, hazardous substances and environmental quality in the Kingdom of Cambodia. The details of these related legislations is shown in the below table.

Table 1: Legislation related to mercury or chemical substances and related residues management in Cambodia

No.	Legislation's Title	Year of Approval	Responsible Institution	Review Resulted
Constitution				
1	The Constitution of the Kingdom of Cambodia	1993	All	A part of the Law aims to protect and maintain the environmental quality from any kinds of pollution. It might be indirectly impact to mercury and chemicals management, including its wastes.
Relevant Laws				
2	The Law on Environmental Protection and Management	1996	MOE	A part of the objective law is to protect and maintain the environmental quality from any kinds of pollution. It might be indirectly impact to mercury and chemicals management, including its wastes
3	Law on Pharmaceutical Management	1996	MOH	The aim of this law is focus on pharmaceutical management which control the drug uses of chemical substances, bio-produce and plant product for health care.
4	Law on the Management of Quality and Safety of Products and Service	2000	MOC	This legislation is not concentrated directly to the chemical substance or mercury but focus on all the produced goods and service which are effect to the public health (Article 6)

5	The Law on Administration of Factory and Handicraft	2006	MIME ¹	Some articles of the law may not involve to the management of hazardous substances such as mercury but are article 29 states of using the dangerous chemical.
6	The Law on Water Resources Management in the Kingdom of Cambodia	2007	MOWRAM	The disposal pollutant was managed including the wastes, due to endanger human, animal and plant health which states in article 22.
7	The Law on The Management of Pesticides and Fertilizers	2012	MAFF	The Law is considered to directly impact to the management of pesticides and relevant chemicals, but it specific stipulation on mercury has not highlighted.
Relevant Sub-Decrees				
8	Sub-Decree on Standards and Management of Agricultural Materials	1998	MAFF	Some stipulations of the Sub-Decree may directly manage pesticides which is produced by hazardous chemical substances, where these have been banned
9	Sub-Decree on Water Pollution Control	1999	MOE	The Sub-Decree may directly involve the environmental sound management of chemical wastes including hazardous wastes, as mentioned in annexes
10	Sub-Decree on Solid Waste Management	1999	MOE	The Sub-Decree may directly involve the environmental sound management of industrial and hazardous wastes including mercury wastes, as mentioned in annexes
11	Sub-Decree on EIA Process	1999	MOE	The Sub-Decree may indirectly involve in managing POPs chemicals and related residues due to its objectives aim at protecting and conserving the environment and natural resources.
12	Sub-Decree on Air Pollution and Noise Disturbance	2000	MOE	It has a purpose to protect the environments quality and public health from air pollutants and noise pollution through monitoring, curb and mitigation activities (Anex2 max-standards of hazardous substances which could exist in air and Anex3 max-standard of hazardous substances which could expose from mobile source to the atmosphere).
13	Sub-decree on the Classification of Poisonous Substances for the Health Sector	2000	MOH	This Sub-Decree aims to strengthen the effectiveness of control and use of poisonous drug or chemical substances or chemical compounds or chemical plan which can cause hazard to human or

¹The Ministry has divided in two Ministries, namely, "Ministry of Industry and Handicraft", and "Ministry of Mine and Energy"

				animal health.
14	Sub-Decree on Industrial Standards of Cambodia	2001	MIME ¹	It may not directly involve the management of mercury or hazardous substances, but a part of article 21 states an inspection to the using materials or chemical substances which do suspect to illegal standard.
15	Sub-Decree on the Implementation of the Amendment to the Law on Investment of the Kingdom of Cambodia	2005	CDC	The Sub-Decree is evaluated to be indirectly linked to the management of chemical products or mercury containing in articles.
16	Sub-Decree on the Establishment and Management of the Special Economic Zone	2005	CDC	It is commonly indirectly linked to management of mercury substance or hazardous substances containing in articles within various activities of trades and other developments
17	Sub-decree on the Facilitation of Trade Through Risk Management	2006	MOC	The Sub-Decree may indirectly involve with the control of mercury substance, through control the import-export of chemicals, chemical substances at check-points.
18	Sub-decree on the enforcement of the list of prohibited and restricted goods	2007	MEF and relevant ministries	The sub-decree aims to prohibit and to limit the quantity of 1537 goods, including Mercury substances, to be imported to and exported from Cambodia
19	Sub-decree on Cosmetic Product Control	2008	MOH	The sub-decree aims to protect, prevent the production, circulation, importation of counterfeit cosmetic products, cosmetic products of damaged quality, illegal cosmetic products to ensure quality and safety for consumers and to facilitate the trade of cosmetic products.
20	Sub-Decree on Classification and Labelling Chemicals	2009	MOE and relevant ministries	The Sub-Decree commonly addresses the management of chemicals, hazardous substances including their wastes. It is recognized to directly impact to mercury substances management too
21	Sub-Decree on the Organization and Functioning of the Ministry of Industry and Handicrafts	2013	MIH	The Sub-Decree may indirectly involve in setting up the standard and labeling the chemical substance used in industrial sector as stipulated in point No. 8 of article 19
22	Sub-Decree on E-Waste Management	2016	MOE and relevant ministries	The purpose to this legislation is to manage effective electronic and electrical waste. Especially prohibited the burning or breaking of electronic and electrical waste causing hazards to the environment or public health (article 7).

Relevant Regulations				
23	Guideline on Urging the Carrying out of Sub-Decree on Solid Waste Management, MOE 1999	1999	MOE	It may directly involve the management of mercury wastes through industrial and hazardous waste management.
24	Prakas on Procedures and Issuance of Certification of Items and Quantities of Chemical Substance Use	2012	MIME	The aims of this Prakas to strengthen the effectiveness of control and use of chemical substance, which is an important raw material serving the industrial sector and to facilitate the private sector businesses in supplying, distributing, and using chemical substances based on items in compliance with the law
25	Prakas on Management of Health Care Waste in the Kingdom of Cambodia	2009	MOH	This one aims to strengthen the effectiveness of health care services, to require for identify waste, label, and list of waste in order to response for technical separation, collection, storing, transportation, treatment and dispose of waste from health center in kingdom of Cambodia.
26	Prakas on Industrial Waste Collection and Transportation in Phnom Penh Municipality	2002	MOE	This Prakas has not specified mercury substances or waste, but its objective is to manage industrial and hazardous waste as a whole
27	Announcement on the Halting of Industrial Waste Selling, Providing and Burning	2003	MOE	It has not specified mercury substances or waste, but its objective aim at managing industrial and hazardous waste as a whole.
28	The Joint Declaration Ministry of Interior and Ministry of Environment on "Solid Wastes and Litter Management in Cambodia"	2003	MOI and MOE	It is not clearly mentioned to the management of mercury or mercury substance or its wastes.
29	Prakas on Management and Storage of Battery Waste	2007	MOE	It aims to manage battery waste to ensure good environmental quality and protect human health.
30	Prakas on Waste Management from Healthcare Services in the Kingdom of Cambodia	2008	MOH & MOE	It is indirectly involved mercury or its wastes' management, which might be generated by health sector.
31	Prakas on Procedure and Requirement for Pesticides Registration	2012	MAFF	It is not clearly engaged with the management of mercury or mercury substances or its waste.
32	Prakas on List of Pesticides in the	2012	MAFF	This Prakas aims to identify the list of pesticide, classification of forbidden

	Kingdom of Cambodia			pesticides, type of permit pesticide which can be used and the effective management of pesticide in Cambodia.
33	Prakas on Procedure of Management of Pesticides in Trade	2013	MAFF	This Prakas aims to strengthen the effectiveness of strategy for agriculture pesticides using which chemical substances were made.
34	Prakas on Organization and Functioning of Department of Standards Regulatory	2014	MIH	It may indirectly involve in mercury or mercury substance management, which is relevant to chemical substances management and usage standards for industrial sector
35	Prakas on Standard Using of Concentration of Poisonous or Chemical Substances which Permit for Disposing	2015	MOE	This Prakas may directly involve in standard disposing the poisoning, hazardous or hazardous waste to protect human health and Environment which allowed into the safety land fill (as in annex).
36	Prakas on Establishment of Clean Environment Committee	2016	MOE	It may not directly to mercury or chemical substance management but it involves to a competition of all industry in whole country which accompanied to a sound environment.
Relevant Draft Law/Sub-Decree				
37	Environmental Code	Under the drafting process	MOE and relevant ministries	The purpose of this legislation is to compile all regular law of MOE to one Code for implementation as sound environment management.
38	Draft Law on Chemicals Management	Under the drafting process in discussing with line ministries	MOE and relevant key ministries	The Law is considered to directly impact to the all chemical substance management, including their wastes but this law was inserted to the Environmental Code
39	Draft Law on Environmental Pollution Control	Under the drafting process in discussing with line ministries	MOE	The Law is considered to directly impact to the management of POP related wastes.
40	Draft Law on Environmental Impact Assessment	Under the drafting process in discussing with line ministries	MOE	This legislation aims to manage pollutant, especially the chemical substances from any business source to maintain the environmental sound management.
41	Draft Sub-Decree on Water Quality Management	Being submitted to the Council of Ministers for approval	MOWRAM	It is indirectly addressed to mercury or hazardous substance management and their waste management.
42	Draft Sub-Decree on	Under the	MOE	This Sub-Degree involves to the

	Sewage Management	drafting process in discussing with line ministries		chemical substances which are forbidden to be disposed into the water or drawn into the sewage water
43	Draft Prakas on Battery Management	Being finalized and get approval from minister of environment	MOE	This prakas aims to manage battery waste and battery to be reused to protect quality of environment. It covers on all activities related to battery waste and battery to be reused in Cambodia.

2.1.2 National Policy and Action Plan

Besides the above laws and regulations, the Royal Government of Cambodia also has policies for managing mercury as well as the environmental quality in Cambodia. Those policies are:

- Strategic Plan on Management of Mercury in Artisanal and Small Scale Gold Mining in Cambodia 2012-2016(MOE, 2011a)
- National Mercury Waste Management Plan(DEPC, 2010)
- Action Plan on the Management of Releasing Mercury in Cambodia (2008-2010) (MOE, 2011a)
- Technical Guideline on Environmentally Sound Management of Mercury Waste (MOE, 2011a)
- Rectangular Strategy Phase III (2014-2018) (RGC, 2013)
- Cambodia Industrial Development Policy 2015-2025 (COM, 2015)
- National Policy on Green Growth (NCGG, 2013)
- National Strategy Development Plan 2014-2018 (RGC, 2014)
- National Poverty Reduction Strategy (NPRS) 2003-2005 (CSD, 2002)

2.1.2.1. *Strategic Plan on Management of Mercury in Artisanal and Small Scale Gold Mining in Cambodia 2012-2016 (SPASGM)*

This strategic plan has been developed for environmentally sound management (ESM) of mercury and mercury- contaminated waste generated from artisanal and small scale gold mining activities in Cambodia. This strategic plan promotes the use of alternative substances for gold extraction, the ESM of intentional mercury use, as well as mercury waste minimization and disposal, with provisions for recovering mercury.

This strategic plan is reflected on various concerns on safe use and sound management of intended mercury in Artisanal and Small Scale Gold Mining (ASGM). This SPASGM assists in implementation of existing legal frameworks, national strategies, action plans and many other technical papers locally and internationally. It also identified framework needs, risk reduction measures, and potential funding sources to be able to implement, sustain, and expand ESM of mercury waste. Moreover, the plan will reflect the country's national poverty reduction strategies, development plans, or their equivalents.

Three main components is identified under this strategic plan, which aims to achieve a comprehensive management of mercury and mercury containing wastes in ASGM in Cambodia including: (i) Legal framework and institutional strengthening; (ii) Research and development; and (iii) Vocational training, awareness raising and environmental consideration.

Out of these three components, there are 07 specific objectives and 25 programs of work (proposed activities) is established for the sound management of mercury and mercury containing wastes in ASGM activities.

2.1.2.2. National Mercury Waste Management Plan (NMWMP)

This management plan was developed in response to the commitment of the Royal Government of Cambodia for environmentally sound management of chemicals through live cycle management of mercury and its wastes. There are five main components identified under this management plan, which aims to achieve a comprehensive management of mercury and mercury containing wastes in Cambodia including: (i) Mercury management in process and products; (ii) Mercury waste management approaches; (iii) Research, monitoring, modeling, assessment and inventories; (iv) Communication and awareness raising; and (v) Implementation and compliance. Out of these five components, there are 15 specific objectives and 45 programs of work (proposed activities) were identified for sound management of mercury and mercury containing wastes.

2.1.2.3. Action Plan on the Management of Releasing Mercury in Cambodia (2008-2010)

This action plan was developed with aims at providing for the Ministry of Environment with a framework that consists of a path forward in joint efforts to reduce the exposure of Cambodia's population and ecosystems to mercury application, especially in artisanal and small scale gold mining (ASGM) activities, through the prevention and reduction of anthropogenic releases of mercury to the environment.

This Action Plan on the Management of Releasing Mercury provides an overview of pilot action of inventory and proposed three years action plans (2008-2010) related to the mercury. It is general in nature and is intended as a pilot phase of the project on inventory of mercury in Cambodia and introduction to the problems solving regarding existing legislation, policy, institutional capacity, public awareness, and participation in implementation of the mercury reduction and management action.

This Action Plan contained of 8 (eight) components including updating regulation, capacity building, full inventory, mercury emission reduction, mercury waste management, education and awareness raising, monitoring and research. The most important actions are strengthening capacity for all and mercury emission reduction and management through providing technical training promote awareness raising and education programs.

2.1.2.4. Technical Guideline on Environmentally Sound Management of Mercury Waste

The guideline is a second framework for safe and sound management of mercury and mercury-containing wastes in Cambodia was developed. This technical guideline is a great action that helps promote public health and environmental quality in Cambodia. It will also help Cambodia fulfill her obligation under the Agenda 21 and 2020 vision of the World Summit on Sustainable Development (WSSD) by stated that “chemicals are used and produced in ways that lead to the minimization of significant adverse effects on human health and the environment.”

This technical guideline provides instruction for the environmentally sound management (ESM) of mercury-containing wastes. There are numbers of sources of mercury wastes generated, however, this paper focusing only three main sources including mercury wastes generated from light sources, healthcare facilities (mercury based devices), and dental care facilities (dental amalgam filling). This technical guideline also elaborates procedures to be followed by the users and operators, procedures for collection, transportation, and disposal of mercury-contaminated wastes, and other frameworks to be followed by the competent agencies and institutions.

2.2 International Commitment

Cambodia became members to some of international conventions, treaties or agreements with aim to protect Cambodia's environment from chemicals pollution and prevent adverse effects on human health and the environment. Some of those most relevant to chemical management including mercury are:

2.2.1 Basel Convention

The Basel Convention on the Control of Trans-Boundary Movements of Hazardous Wastes and their disposal was adopted on 22 March 1989. The Kingdom of Cambodia had already ratified the Basel Convention since 2 March 2001. The Ministry of Environment is a National Leading Agency to this Convention. This is the Convention that was developed under the auspices of UNEP in response to the growing worldwide awareness of the problem of international traffic in hazardous wastes. It regulates the trans-boundary movement of hazardous wastes and other wastes and obligates the Parties to ensure that such waste is managed in an environmentally sound manner especially during the disposal process. The “environmentally sound management” is defined under Article 2.8.

2.2.2 Rotterdam Convention

The Convention on Prior Informed Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, strives to reduce health and environmental hazards posed by chemicals and pesticides. It obliges a party that plans to export a chemical that is either banned or severely restricted for use within its territory, to inform the importing party that such an export will take place. It requires clear labelling of chemicals to be exported and it requires an exporting party to ensure that an up to date materials safety data sheet (MSDS) is sent to the importer when exporting chemicals that are to be used for occupational

purposes.

There are a total of 47 chemicals listed in Annex III, 33 are pesticides (including 4 severely hazardous pesticides formulations) and 14 industrial chemicals. The Kingdom of Cambodia has ratified and became a 151 party member of the said Convention in May 2013. The Ministry of Agriculture, Forestry and Fisheries is a National Designated Authority to the Convention.

2.2.3 Minamata Convention

On 10 October 2013, Cambodia endorsed the notification of signatory of Minamata Implementation Plan for the UNEP Global Mercury, currently under implementation process. This plan is an indication of a new effort by Cambodia to provide additional guidance in the form of specific goals, objectives and actions for the sound management of mercury.

2.2.4 The Strategic Approach to International Chemicals Management (SAICM)

Adopted by the International Conference on Chemicals Management (ICCM) on 6 February 2006 in Dubai, United Arab Emirates, the Strategic Approach to International Chemicals Management (SAICM) is an international voluntary policy framework to foster the sound management of chemicals. Its aim is to support the achievement of the goal agreed at the 2002 Johannesburg World Summit on Sustainable Development of ensuring that, by the year 2020, chemicals are produced and used in ways that minimize significant adverse impacts on the environment and human health. A major driving force for the establishment of the Strategic Approach has been the recognition of the growing gaps between the capacities of different countries to manage chemicals safely, the need to improve synergies between existing instruments and processes and the growing sense of urgency regarding the need to assess and manage chemicals more effectively to achieve the 2020 goal articulated in the Johannesburg Plan of Implementation.

2.2.5 ILO Chemicals Convention 1990, No. 170

The Convention represents one of the most far-reaching international agreements in the area of chemicals management and specifically addresses the protection of workers from harmful effects of chemicals at the workplace. It applies to all branches of economic activity in which chemicals are used, covers all chemicals and provides specific measures in respect of hazardous chemicals. The Convention requires that classification systems be established and that all chemicals should be marked to indicate their identity. Hazardous chemicals should be labelled to provide essential information on their classification, their hazards and safety precautions to be observed. Because of the tri-partite composition of the ILO under whose jurisdiction the Convention was negotiated, governments, suppliers, employers and workers all have responsibilities for the safe management and handling of chemicals. Governments are required to develop national policies on safety in the use of chemicals at work and that may include measures to prohibit and/or restrict the use of certain chemicals. Suppliers, which may include manufactures, importers and distributors, are required to ensure that chemicals are properly classified and labelled and that safety data sheets are provided to employers.

Employers have an obligation to ensure that workers are not exposed to chemicals exceeding national or international limits, that they are provided with safety data sheets and that they are trained on all aspects of safety in the use of chemicals in the workplace. Employers are also required to assess the risks associated with use the use of chemicals and identify options to protect workers throughout all stages of the life-cycle of the chemical. Workers have an obligation to co-operate with their employers and to take all reasonable steps to minimize or avoid risk.

Within the above national legal laws are applied by various ministries in Cambodia and international legal instruments are adopted, ratified and signatory by the Royal Government of Cambodia with aim to protect Cambodia's environment from chemicals pollution and prevent adverse effects on human health, wildlife and the environment. Due to the lacking of a legislative law about management of mercury substances and mercury waste, especially the lacking of human resource to improve or develop some regulation and chemical management in Cambodia, the disposing and spreading or emitting hazardous compounds such as mercury to environment could not control.

3. Institutional Framework

3.1 Roles and Responsibilities of Central Government

Mercury is classified as a hazardous chemical that can pose adverse impacts on public health and the environment. Therefore, management of mercury and mercury-containing wastes in Cambodia is a collaboration of various ministries within a government. Governmental institutions manage hazardous chemicals in according to their roles and responsibilities regulated by governmental ordinances. The governmental institutions fulfill their mandates in managing hazardous chemicals by building safety into the chemicals production processes, chemicals trade, and by ensuring the prevention and/or mitigation of impacts on people's health, especially user health, and protect the environment and biodiversity. This section gives an overview of important ministries, agencies and institutions related to mercury along with their responsibilities, authorities and mandate.

Responsibilities for the management of hazardous chemicals such as Mercury are designated to governmental ministries including:

- 1) Ministry of Environment
- 2) Ministry of Agriculture Forestry and Fisheries
- 3) Ministry of Mines and Energy
- 4) Ministry of Industry and Handicraft
- 5) Ministry of Health
- 6) Ministry of Commerce (Department of CAMCONTROL)
- 7) Ministry of Economic and Finance (Department of Customs)
- 8) Ministry of Interior (National Authority for Controlling Drugs)

Table 2: Roles and Responsibilities of Relevant Ministries

Governmental Agencies	Stages of Chemicals Life-Cycle
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	Importation	Production	Storage	Transportation	Distribution/ Marketing	Uses and Handling	Emergencies	Disposal
Ministry of Environment	X	X	X	X	X	X	X	X
Ministry of Agriculture Forestry and Fisheries	X	X	X	X	X	X	X	X
Ministry of Mines and Energy	X		X			X	X	X
Ministry of Industry and Handicraft	X		X			X	X	X
Ministry of Health	X	X	X	X	X	X	X	X
Ministry of Commerce	X				X			
Ministry of Economic and Finance	X							
Ministry of Interior	X	X	X	X	X	X	X	X

The governmental agencies described above have different roles and responsibilities for managing hazardous chemicals and its wastes determined by the Royal Government of Cambodia. Below are the summary role and responsibilities of those governmental institutions:

3.1.1 Ministry of Environment

Ministry of Environment (MOE) cooperates with other governmental institutions, national and international organizations, non-governmental organizations, and private sectors. It is responsible for monitoring environmental quality (water, soil, and air), controlling environmental pollutants release, and participates in collecting, compiling, and managing data related to toxic and hazardous chemicals, and managing all kinds of waste in terms of a safe environment.

Ministry of Environment is the primary regulatory agency designated by law for the protection the environment and public health from hazardous chemicals and its wastes including mercury and mercury-containing wastes in the Cambodia.

3.1.2 Ministry of Agriculture, Forestry and Fisheries

Ministry of Agriculture, Forestry, and Fisheries (MAFF) has large responsibilities for the management through controlling import and use of chemicals in agricultural sectors including chemical fertilizers, pesticides, and veterinary drugs. It has obligations to develop agricultural chemicals management policy and legal frameworks, and promote public awareness in the safe use of agricultural chemicals in order to improve agricultural productivity, food safety, food security, and public welfare.

3.1.3 Ministry of Mine and Energy

The Ministry of Mines and Energy (MME) is playing an important role in attracting private investment in resources exploration and development through the provision of geo-scientific information on minerals and energy resources, and management of an equitable and secure titles systems for the mining, petroleum and geothermal industries. It also carries prime responsibility for regulating these extractive industries in the country, including the collection

of royalties, and ensuring that safety; health and environmental standards of using hazardous chemicals are consistent with the relevant legislation and regulations

3.1.4 Ministry of Industry and Handicraft

The Ministry of Industry and Handicraft (MIH) is responsible for promoting development of industrial activities, and industrial chemicals production and use in terms of national industrial chemicals management. Most importantly, the Ministry has the obligation to create the development of legislation, policy, and planning related to industrial aspects including industrial chemical management.

3.1.5 Ministry of Health

Ministry of Health (MOH) is responsible for developing overall health policy direction, regulation and legislation based on the governmental policy goals to improve health, to manage pharmaceutical production, business and distribution of medical and paramedical equipment to all private and public units, and to examine and control of food safety and cosmetics products.

3.1.6 Ministry of Commerce

Ministry of Commerce (MOC) has established General Directorate of CAMCONTROL that has key role and responsibility for controlling the quality, quantity of imported and exported goods and carrying out the repression of fraud related to product quality, except pharmaceutical products, medical equipment, and cosmetics.

3.1.7 Ministry of Economic and Finance

Ministry of Economic and Finance (MEF) has established General Directorate of Customs and Excise that has key role and responsibility for managing import-export regulated goods; to carry out prevention measures and confiscation of goods smuggled; control, monitor, and manage import-export regulated goods.

3.1.8 Ministry of Interior

Ministry of Interior (MOI) has established National Authority for Drugs Control that is responsible for gathering information and operational action against the cultivation of narcotic plants, their production, use, and distribution and the trade/trafficking of drugs. It facilitates drugs control activities in cooperation with other agencies in order to ensure effective and safe drugs control.

3.1.9 Inter-Ministerial Mechanisms for Hazardous Chemicals Management

In order to promote effective implementation of chemicals management policy and technique, coordination mechanisms for managing chemicals are established under two forms: the inter-ministerial commissions and technical working groups.

Inter-ministerial commissions and other coordination mechanisms are established to promote cooperation between governmental institutions, civil organizations, and

stakeholders and for facilitating effective chemicals management. The inter-ministerial commissions have three main functions:

- a) Facilitate and assist line ministries in managing chemicals and other procedures;
- b) Facilitate, review, and advise line ministries in preparing a national chemicals management plan; and
- c) Facilitate chemicals management information and technological exchange among governmental institutions, civil organizations, and stakeholders.

Three inter-ministerial committees are established by the government to facilitate and assist relevant ministries in managing of hazardous chemicals including:

- Inter-Ministerial Committee for the Management of Quality and Safety of Products and Services.
- Inter-Ministerial Technical Committee for Industrial Standard.
- Inter-Ministerial Steering Committee in charge of Facilitation and Implementation of the Basel, Vienna, and Stockholm Conventions.

The inter-ministerial committees and coordination mechanisms described above is established under the national central level, and the members of these inter-ministerial committees and coordination mechanisms consists of relevant governmental institutions, NGOs, and other national institutes. The inter-ministerial committees have a permanent mandate and the membership of each member in each committee is also permanently valid except it is subject to any request for change from the line ministries or from the inter-ministerial committees.

In order to assist the inter-ministerial committees and coordination mechanisms on technical aspects, technical working groups is also established with the participation of relevant agencies, which are thought to be key to the management of hazardous chemicals.

Inter-ministerial committees and coordination mechanisms' responsibilities for management of hazardous chemicals is defined by the governmental ordinance (sub-decree) or by the ministerial ordinance (declaration).

3.2 Gap Analysis

Although structured mechanism exists for the management of mercury and other hazardous chemicals, institutions' roles and responsibilities are not clearly defined. Overlapping responsibilities are often occurred in the performance and enforcement in management of mercury and other hazardous chemicals during the inspection and controlling activities.

Unclear responsibility designation for governmental institutions can result in negative impacts on the effectiveness of each agency' performances in the management of hazardous chemicals and sometimes can cause conflicts among institutions. In order to enhance effectiveness of hazardous chemical management and to avoid conflicts, clear responsibilities should be provided for relevant ministries.

The lack of human and financial resources and insufficient coordination amongst various ministries and organizations are also the main challenge for the sound management of chemicals such as mercury. Absence of a mechanism for receiving public comments as well as feedback from the stakeholders in chemicals management policy development and decision making process is also reducing the effectiveness of management of hazardous chemicals such as mercury and its wastes. From experiences show that unless chemical importers and users are engaged in dialogue with the government in management of mercury and other hazardous chemicals, they will tend to do all in their power to ignore the government programme and initiatives.

4. Mercury Use and Emission in Cambodia

According to the literature review on the existing information concerning the mercury use and emission in Cambodia, there is only a government report on the Cambodia Mercury Inventory in 2008 (MoE, 2008) that provide a comprehensive data on the mercury use and emission to the environment. The following part (4.1) is a summary of the important information found out in the inventory report.

4.1 Cambodia Mercury Inventory in 2008

In 2007, Cambodia got assistance from the United Nations Environmental Program (UNEP) to study the mercury releases from all identified sources. These sources were identified 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). The inventory was conducted in 12 provinces (including municipalities) out of 24 provinces and municipalities throughout the country from August to November 2007. The main purposes of the inventory were to produce baseline information on mercury release sources, exposure routes and possible quantities released into the environment.

Major source categories and subcategories of mercury release listed in the UNEP toolkit are listed in table 1. The table also shows which mercury sources exist in Cambodia.

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	x
1.2	Other coal use	x
1.3	Mineral oils - extraction, refining and use	✓
1.4	Natural gas - extraction, refining and use	✓
1.5	Other fossil fuels - extraction and use	x
1.6	Biomass fired power and heat production	✓
1.7	Geothermal power production	x
2	Primary (virgin) metal production	
2.1	Mercury (primary) extraction and initial processing	x
2.2	Gold and silver extraction with mercury amalgamation processes	✓
2.3	Zinc extraction and initial processing	x
2.4	Copper extraction and initial processing	x
2.5	Lead extraction and initial processing	x
2.6	Gold extraction and initial processing by methods other than mercury amalgamation	x

No.	Categories and sub-categories of mercury release courses	Cambodia source
2.7	Aluminum extraction and initial processing	x
2.8	Other non-ferrous metals - extraction and processing	x
2.9	Primary ferrous metal production	x
3	Production of other minerals and materials with mercury impurities	
3.1	Cement production	x
3.2	Pulp and paper production	x
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	x
4.2	VCM production with mercury catalyst	x
4.3	Acetaldehyde production with mercury catalyst	x
4.4	Other production of chemicals and polymers with mercury	x
5	Consumer products with intentional use of mercury	
5.1	Thermometers with mercury	✓
5.2	Electrical switches and relays with mercury	x
5.3	Light sources with mercury	x
5.4	Batteries with mercury	✓
5.5	Biocides and pesticides with mercury	x
5.6	Paints with mercury	x
5.7	Cosmetics and related products with mercury	x
6	Other intentional product/process use	
6.1	Dental mercury-amalgam fillings	✓
6.2	Manometers and gauges with mercury	x
6.3	Laboratory chemicals and equipment with mercury	x
6.4	Mercury metal use in religious rituals and folklore medicine	x
6.5	Miscellaneous product uses, mercury metal uses, and other sources	x
7	Production of recycled metals ("secondary" metal production)	
7.1	Production of recycled mercury ("secondary production")	x
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	x
8.3	Incineration of medical waste	✓
8.4	Sewage sludge incineration	x
8.5	Informal waste incineration	x
9	Waste deposition / land-filling and waste water treatment	
9.1	Controlled landfills/deposits	✓
9.2	Diffuse disposal under some control	x
9.3	Informal local disposal of industrial production waste	x
9.4	Informal dumping of general waste	✓
9.5	Waste water system/treatment	✓
10	Crematoria and cemeteries	
10.1	Crematoria	✓
10.2	Cemeteries	x
11	Potential hotspots	x

4.1.1 Extraction and use of fuels/energy sources

It was estimated that the total emission of mercury from the extraction and use of fuels/energy source was range from 2.918 in minimum to 119.511 in maximum. The largest emission of mercury from these was use of crude oil (power plant) which is about 2.407 to 72.224 in minimum and maximum, respectively.

4.1.1.1 Mineral oil - extraction, refining and use

A.1. Power plants

Fuel oils were widely consumed in Cambodia in the power plants for generating electricity to serve the daily requirement of inhabitants in cities, towns, and rural areas which was about 15.1% of the total population. Both heavy oils and light oils were crucial sources for running the power plants in the cities and provinces. There were four types of refined fuel imported to Cambodia to be used as energy sources for electricity and lighting with total amount of 427,092.87 tons, of which 25,015 tons was kerosene, 14,425.91 tons was gasoline, 146,903.96 tons was diesel, and 240,748 tons was heavy fuel oil. The total emission of mercury was shown in table 4 below.

A.2. Transportation

Concerning transportation, the estimation of fuel consumption in Cambodia was about 187,302.60 tons of diesel and about 97,435.25 tons of gasoline. Out of this amount, about 58,461.15 tons of gasoline were 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. Therefore, total of refined fuel use for transportation was equaled to 284737.85 tons. The total emission of mercury was shown in table 4 below.

4.1.1.2 Natural Gas - extraction, refining and use

The fossil fuel used for Cambodian household cooking was a gas imported from Thailand, Malaysia, Singapore, and Vietnam. Cooking by using liquefied petroleum gas (LPG) was presented in Cambodia since 1990s. The amount of imported gas for use in domestic cooking was about 27,016.65 tons in which about 97% of fuel gas (or 26,206.15 tons) was used for domestic cooking, and perhaps 3% was used for other purposes. This amount was equivalent to 34,176,062.25 Nm³ gas in volume. The total emission of mercury was shown in table 4 below.

4.1.1.3 Biomass

Household cooking biomass, for example, woods and charcoals, were the traditional household cooking materials and were widely consumed throughout the country. The 1995 survey on energy supplies in Cambodia conducted by the MIME under ADB support indicated that the total energy supplies for final consumers comprised 84% wood and other biomass; 14% petroleum products; 1.2 % charcoals; and 0.9% electricity. 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. The total emission of mercury was shown in table 4 below.

Table 4: Mercury release from energy sources category

No	Sub-category	Activity rate	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	186344.87 t/y	1 mg/t	100 mg/t	0.186	18.634

	plant)					
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)	34176062.25Nm ³	0.03 µg/Nm ³	0.40 µg/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

4.1.2 Primary Metal Production – small scale artisanal gold mining

Gold extraction activities were considered as primary metal production in Cambodia. Such gold extraction was made by local people in small scale or at family level. No commercial activity (company level) related to gold extraction was permitted so far, except the gold study companies that was allowed to explore for the ores.

The inventory revealed that there were 19 known gold deposits in Cambodia with employment labor between 5000 to 6000 miners during the peak mining season, which began in November and finished in May. Such gold extraction was operated in small scale manner or so called family level, and most of gold extraction activities were took place at the north-east part of the country. Mercury was used to extract gold from the ores. It was estimated that 34.5 - 1182 kg mercury/year was magnitude of the mercury usage for small scale mining in Cambodia.



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 1: Gold mining activities and surveyed overview at gold mining site

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 uses 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			

4.1.3 Production of other minerals and materials with mercury impurities

There were 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 were available only for lime production, however, for other productions including cement, pulp and paper, and other minerals and materials, data were not available.

The production of lime was possible only in Kampot Province. Raw material for producing the lime products was limestone, which was found in the mountains. The average lime process took place once per month in the amount of 10 tons per each handicraft, which made total production of lime per annum was about 240 tons.

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

4.1.4 Intentional use of mercury in industrial processes

There were no activities related to the intentional use of mercury in industrial processes in Cambodia, because this country was depending much on its agricultural production and tourist sector, thus no data on mercury release was available for this category (category 4)

4.1.5 Consumer products with intentional use of mercury

There were 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 knew about the mercury being use in the above described products except thermometers and batteries. Nevertheless, there was no record on where thermometers and batteries were used and how many thermometers and batteries were 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 were being use to power electrical device, i.e. radio throughout the country.

4.1.6 Thermometers with mercury

Based on the inventory issue report (code QB0560) provided by the Ministry of Health, for period from 1st January 2007 to 31st December 2007, indicated that were 6141 thermometers had distributed to health facilities throughout Cambodia. Most of these thermometers were mercury based, but some of them were alcoholic and digital type thermometers. On the other hand, there were at least two types of medical thermometers available in Cambodia markets: one was mercury type and other one was alcoholic types. So, it was hard to say that all thermometers supplied to health establishments are mercury based thermometers, however, for future sound management of mercury we could assumed that those supplied thermometers were mercury based.

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	

4.1.7 Batteries with mercury

In 2005 Cambodia had imported batteries about 648.850 tons from different countries. Zinc-air type batteries contributed about 97.96 percent (about 635.599 tons) of total batteries imported, and the rest was other type batteries (about 13.251 tons). No batteries explicitly reported as mercury based was recorded by the Custom Department.

Before civil war, it was though that mercury based battery might 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.

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	

4.1.8 Other intentional products/process uses

Other intentional products use in this category was 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 did not exist. Beside this, for mercury use in manometers and gauges, laboratory chemicals and equipment, and other folklore medicines remained no information and data, whether of origin and quantity imported, or where supplied to. Nevertheless, it was known that such products were used in health cares (manometers and gauges) and laboratories. Dental amalgam fillings could be the only available information to get.

4.1.8.1 Mercury use as amalgam

Mercury might 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 could also occur after the death of a person with fillings, e.g. dental

amalgams, were a major source of mercury releases to air from cremation, which was the common religious practice in Cambodia.

There were 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 preferred to use composite for filling their tooth rather than amalgam. Oxyde de zine and ceramic materials was favorite use by wealthy people. Amalgam was usually supplied in two forms either 1) as pure mercury along with a powder mix of the other metals, which were weighed and mixed in the clinic; or 2) as small capsules where mercury and the metal powder were present in the right proportions and needed only to be mixed (in the capsule before opening) in the clinic, prior to filling the cavity in the tooth. Amalgam in capsule form was favorite use by dentist in Cambodia compared to the other form currently.



Mercury amalgam in capsule



Interviewed with dentist

Figure 2: Inventory team conducted mercury survey activities at dental clinic

A rough estimate of the national consumption of amalgam capsules was 141224 capsules per year in maximum estimation. Similarly, a rough estimate of the free metal mercury consumption for dental fillings was 50040 grams or 50.040 Kg Hg/year in maximum calculation. It was assumed that one amalgam capsule contains an average amount of mercury of 0.8g, resulting in a calculated mercury consumption with capsules of $141224 \times 0.8 \text{ g} = 112979.2 \text{ grams}$ 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 could thus be estimated at around 163.019 Kg Hg per year in maximum.

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

4.1.9 Production of recycled metals (secondary metal production)

There were 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 was available only for scraped iron, aluminum, copper, and lead.

4.1.9.1 Production of recycled ferrous metal (iron and steel)

It was known that recycled iron production undertaken at small scale handicraft. The iron scrap recycling/production sources comprised 16 locations; and most of them were located in Phnom Penh Municipality and Kandal Province. According to the estimation, the amount of iron annually produced was about 8,358.80 tons.

4.1.9.2 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 was 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.

The copper recycling process operated in 3 small-scale handicrafts, but no data was disclosed from responsible institutions.

As for ferrous metals, no mercury containing parts were expected to be fed to the furnaces; any parts present would likely be scrapped as waste.

4.1.10 Waste incineration

There were 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 could be addressed only two types: (1) municipal waste incineration; and (2) medical waste incineration.

4.1.10.1 Incineration of municipal/general waste

The municipal wastes comprised household wastes and garment factory wastes. Both types of wastes mostly had similar composition, excluding chemical wastes which were generated from the use of chemicals or chemical compounds in production processes. Most municipal wastes were disposed of at dumping sites. The municipal waste incineration addressed in this report was merely on garment factory wastes that was burned in the incinerators for various purposes including: (i) reducing the waste quantity; and (ii) generating a steam for ironing.

Six incinerators owned by factories were burning their wastes, of which five incinerators were for burning rags and/or disable cloths in garment factories for processing the steam ovens (at 249.60 tons annually), and one incinerator burned other industrial wastes at 3,276 tons annually. In total, solid waste of about 3,525.60 tons were burned in factories'

incinerators.

4.1.10.2 Incineration of medical waste

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

The 2004 inventory report has shown that the medical waste of about 801.82 tons is burned every year. The estimated possible release of mercury and its distribution pathways for this sub-category is shown in the below table.

Table 13: 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 14: 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					

4.1.11 Waste deposition/land filling and waste water treatment

There were five type of waste deposition and waste water treatment sub-categories addressed in UNEP toolkit 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 could be addressed in three types: (1) controlled landfill; (2) waste water treatment, and (3) informal waste disposal. The informal wastes disposal was unable to describe in the inventory report for the calculation of mercury release due to no reliable information or data supports. So, only two subcategories could be addressed.

4.1.11.1 Controlled landfills/deposits

Among cities and provinces, Phnom Penh Municipality certainly was the only city that had its dumping site (Stueng Meanchey Dumpsite) which was being improved under the support of Japanese Government and JICA Study Team. Besides Stung Meanchey Dumping Site, all dumpsites in the cities and provinces, in general, were being used without high technology and were only open and/or lower lands located close to or far away from residential area, and many of them were close to water sources. Over 95% of dumpsites were simple without installing a collection system for water, gases, and leachate.

4.1.11.2 Waste water system/treatment

Cambodia did not have a waste water/sewage treatment center, except a few cities and provinces received loans from WB and ADB for wastewater treatment. Based on input factor provided by UNEP Toolkit, the amount of mercury release by this category was shown in below table.

Table 15: 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/m³.

4.1.12 Crematoria and cemeteries

The practices of burning dead bodies could be classified into two types: (i) burning in crematory; and (ii) open burning. Crematories in rural/remote areas were 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.

In 2003 about 30,616 bodies were burnt in crematoriums and about 9,980 dead bodies were burnt in open areas. The total dead bodies for 2003 were 40596 corpses. With the prevalent burning conditions, some of the mercury might remain in ashes, while most was expected to be emitted to the atmosphere.

Table 16: 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.

4.1.13 Identification of potential hot-spots

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

In summary, based on the preliminary survey, it was understood that the total release of mercury in Cambodia was 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 was consumer products with intentional use of mercury that caused 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. 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.

Table 17: 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 µg/Nm ³	0.40 µg/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	<i>Maximum mercury uses per year</i>	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					
5	Consumer products with intentional use of mercury					
5.1	<i>Thermometers</i>	6141 items/y	0.5 g/item	1.5 g/item	3.071	9.212
5.2.1	<i>Batteries</i>	635.599 t/y	0.25 Kg/t	10 Kg/t	158.900	6355.99
5.2.2	<i>Other type batteries</i>	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	<i>Production of recycled ferrous metal (iron and steel)</i>	8,358.80 t/y	N/A		0	0
7.2	<i>Production of other recycled metals (aluminum, copper, etc.)</i>	2,197 t/y	N/A		0	0
8	Waste incineration					
8.1	<i>Incineration of municipal/general waste</i>	3,525.60 t/y	1 g/t	10 g/t	3.526	35.256
8.2	<i>Incineration of medical waste</i>	801.82 t/y	8 g/t	40 g/t	6.415	32.073
9	Waste deposition/land filling and waste water treatment					
9.1	<i>Solid waste disposal</i>	466,556 t/y	1 g/t	10 g/t	466.556	4665.56
9.2	<i>Waste water treatment</i>	N/A	0.5 mg/m ³	10 mg/m ³	0	0
10	Crematoria and cemeteries					
10.1	<i>Cremation</i>	40,596 corpses/y	1g/corpse	4g/corpse	40.596	162.384
11	Identification of potential hot-spots					
	Total release from all categories				769.51	14845.178

Source: PCD (2008)

4.2 Present Status of Mercury Use and Emission in Cambodia

Up to now, besides the mercury inventory in 2008, there is no other available comprehensive information regarding mercury use and emission in Cambodia. Even though, there are some updated information regarding possible sources of mercury uses and emission in the primary metal production and artisanal gold mining have been recorded.

4.2.1 Primary Metal Production

Cambodia's mineral industry is still largely undeveloped and most mining companies are small-scale quarries that produce such construction materials as limestone, sand and gravel, and other construction aggregates. There are also a large number of artisanal miners, running very small operations mining for gold and other minerals.

In recent years there have been a large number of exploration licenses granted to both local and international companies. As of 2010, the Ministry of Industry, Mines and Energy (presently named Ministry of Mines and Energy) has granted 77 mineral exploration licenses to local and foreign companies. Three years later, by 30 November 2013, mineral exploration licenses increased to 106 for both local and international companies from Australia, China, Russia, Korea, Vietnam and Canada. Those were including of 132 licenses for metallic minerals, 2 licenses for bauxite, 2 licenses for white sand, and 11 licenses for coal (Sau, 2012).

Table 18: Some of Metallic Minerals Exploration Concessionaires

No	Company Name	Type of Mineral	Concession Areas
1	(Cambodia) Metal Work Co., Ltd	NA	Somlout, Ratanakmondul District, Battambang Province
2	Alex Corporation	NA	Pacharada, Mondulkiri Province
3	Alumina Co., Ltd. (Cambodia-Vietnam)	Bauxite	Mondulkiri
4	Angkor Metal Coporation Co., Ltd	NA	Kuleng District, Preah Vihear Province
5	Angkor Wat Cement Limited	NA	BonTeay Ampill District, Otdar Meanchey Province
6	Angkor Wat Minerals Ltd	NA	TbangMeanChey District, OtdarMeanChey Province
7	Angkor Gold (Canadian)	Gold	
8	An Mady Group Co., Ltd.	Coal	Siem Pang, Stung Treng and Kratie
9	Asia Pacific Gold & Copper Company Limited	NA	Santouk District, Kampoung Thom Province and Sambo, Prek Prasab District, Kratie Province
10	Astra Mining	Gold	
11	C.I.M.G (Cambodia International Mining Group)	NA	Sambo District, Kratie Province
12	Cambo Cana Kiri Development Ltd	NA	Angdoun Meas District, Ratanakiri Province
13	Cambodia Ws Mining Industry Holding Limited	NA	Roveang Khag Lech District Preah Vihear Province
14	Cambodian China International Mines Resources Exploration Co., Ltd	NA	Lompat District, Rattanakiri Province
15	Cambodian Hua Yi Mining Co., Ltd	NA	Chey Sen District, Preah Vihear
16	Cambodian International Investment Development Group Co., Ltd	NA	Senmonorom District, Mondulkiri Province
17	Cambodian Iron and Steel Mining Industry	NA	Roveang District, Preah Vihear Province

	Group		
18	Cambodia LEL Mine Resources Development Co., Ltd.	Iron	Ratanakiri
19	Capital Mineral Resources Investment Co., Ltd	NA	Thalaborivat District, Steung Treng Province
20	Capital Mining Ratanakiri Project	Gold	
21	China Northern Mining (Cambodia) Co., Ltd	NA	Vealveng District, Pursat Province
22	Delcom Cambodia Pte., Ltd.	NA	Ro Vieng District, Preah Vihear Province
23	Donghua Group Corporation Limited	NA	Chey Sen District, Preah Vihear Province
24	Five Tigers (Cambodia) Mines Co., Ltd	NA	Phnomsrock District Banteay Mean Chey Province
25	Future Environment	NA	Aoral District, Kampong Speu
26	General Gold Metal Group Plc	NA	PaCheada, Mondulkiri Province
27	Gold Metal Group Co., Ltd	NA	Pheck Chenda District, Mondulkiri Province
28	Golden Resource Development Co.,Ltd	NA	Chep District, Preah Vihear Province
29	Guangxi Nonferrous Metal Group (Cambodia) Co., Ltd	NA	Roveang District, Preah Vihear Province
30	Guangzhou Donghua Enterprise Co	Gold	
31	Hoang Anh-Ratanakiri Co., Ltd (Branch company of Hoang Anh Gia Lai Joint Stock Vietnamese company)	Iron	Borkoe. Aouchom, Ouyadav District, Ratanakiri Province
32	Indochine Resource Ltd	Gold, Copper Iron	Siempang District, StungTrang Province, Ta Veang and VaunSay District Ratanakiri Province, SanDan District Kampong Thom Province, Sambour District Kratie Province and Pheck Chenda, Keo Seyma District Mondulkiri
33	Ji Zhou Co., Ltd	NA	Kratie District, Kratie Province
34	Jiang Seng Co., Ltd	NA	Siembang Steung Treng Province
35	Kenertec Co., Ltd	NA	Cheab, Sangkum Thmey, Chey Sen, Preah Vihear and Thalab Vivath District, Steung Treng Province
36	Khov Primsec Co., Ltd	NA	Sampaov Loun, Phnom Prach Battambang Province
37	Kingdom Mining Co., Ltd	NA	Chep, Cheam Kasang District, Preah Vihear Province
38	Kingdom Resources Co., Ltd	NA	Sangkum District, Preah Vihear Province
39	Liberty Mining International Limited, MAXUM METAL Co., Ltd. and Transol	Iron	Ratanakiri, Preah Vihear and Mondulkiri
40	Liberty Mining International PTY	NA	Ban lung District, Ratanakiri Province and ThmorPouk, PhnomSrok District, Banteay Mean Chey Province and Banteay Ampil, ChungKal District OtdarMeanChey Province
41	Lohak Samnor (Cambodia) Co., Ltd	NA	Sambo District, Kratie Province
42	Mekong Mining Investment	NA	Chep District, Preah Vihear Province
43	Mekong Mining Investment Co., Ltd	NA	Aoun Doung Meas District, Ratanakiri Province
44	Mekong Mining Investment Co.,Ltd	NA	Cheysen, Chep District, Ratanakiri Province
45	Michelle Corporation	NA	Svay Lea District, Siem Reap Province
46	Ming Hong Xin Co., Ltd	NA	Sambo District, Kratie Province
47	Mulit-Mineral Development (Cambodia) Co., Ltd.	NA	ChungKal District, OtdarMeanchey
48	NIM Meng Group Co.,Ltd	NA	Chekreng District Siem Reap Province
49	Oxiana & DZ	NA	Koh Ngek, Mondulkiri Province
50	Oxiana and Shin Ha Mining Company Limited	NA	Kaev Seima District, Mondulkiri Province
51	OZ Minerals Okvau Deposit	Gold	
52	P S M Global Trading Co., Ltd	NA	Snoul District Kratie Province, Keosema District Mondulkiri Province
53	Phu Yang (Cambodia) Co., Ltd	NA	Pailin Province and Battambang
54	Power Mining Pte Ltd	NA	Borkeo, Aouchom, Lophat District, Rattanakiri

			Province
55	Ratanakiri Consultancy Company Pte Ltd	NA	Siempang District Steung Treng Province, Veang Sai Ratanakiri Province
56	Renaissance Minerals	Gold	
57	Rong Cheng Industrial Investment (Cambodia) Co.,Ltd.	NA	Kaev Seima District, Mondulkiri Province
58	Shino Sun Mineral Resource Co., Ltd.	NA	Memot District, Kampong Cham Province
59	SINH YI Co., Ltd	NA	Keo Sema District, Mondulkiri Province
60	Sino-Create (Cambodia) Investment Co., Ltd.	NA	SamBour District, Kratie Province
61	Sophorn Theary Peanich Co., Ltd	NA	Svay Le District, Siem Reap Province
62	Southern Gold (Cambodia) Ltd	Gold Iron	Snoul and Kraie District, Kratie Province and Keo Sema, Koun Kramon District and Mondulkiri Province and Sambo District Kratie Province
63	Summer Gold Investment PVT Ltd.	Iron Gold	Ouyadav District, Rattanak Kiri Pronice and Pech Chenda District, Mondulkiri
64	Sun International Investment Co.,Ltd	NA	Peachea Da District, Ratanakiri Province
65	Sun Hill Minerals Co., Ltd.	Iron	Mondulkiri
66	The Steung Treng Mineral Join Venture Company (VINACOMIN of Vietnam, Try Pheap Mining Co., Ltd. of Cambodia and MOM Good Luck Mining Co., Ltd.)	Iron	Thala Barivat District, Stung Treng Province
67	Transol Mining and Exploration Company Pty Ltd	NA	Ouyadav District Ratanakiri Province
68	U B E Development Co., Ltd	NA	Samroung Choung Kal District, Preah Vihear Province
69	United Khmer Group Co., Ltd	NA	Srokthorbang, Sreaumbal, Koh Kong Province
70	Xing Yuan Kanng Yeak Co., Ltd	Gold	Sambo District, Kratie Province
71	Ya Long (Cambodia) Mining Co., Ltd	NA	Phnomsrok District Banteay Mean Chey Province

Source: (PPS, 2011; SES, 2016)

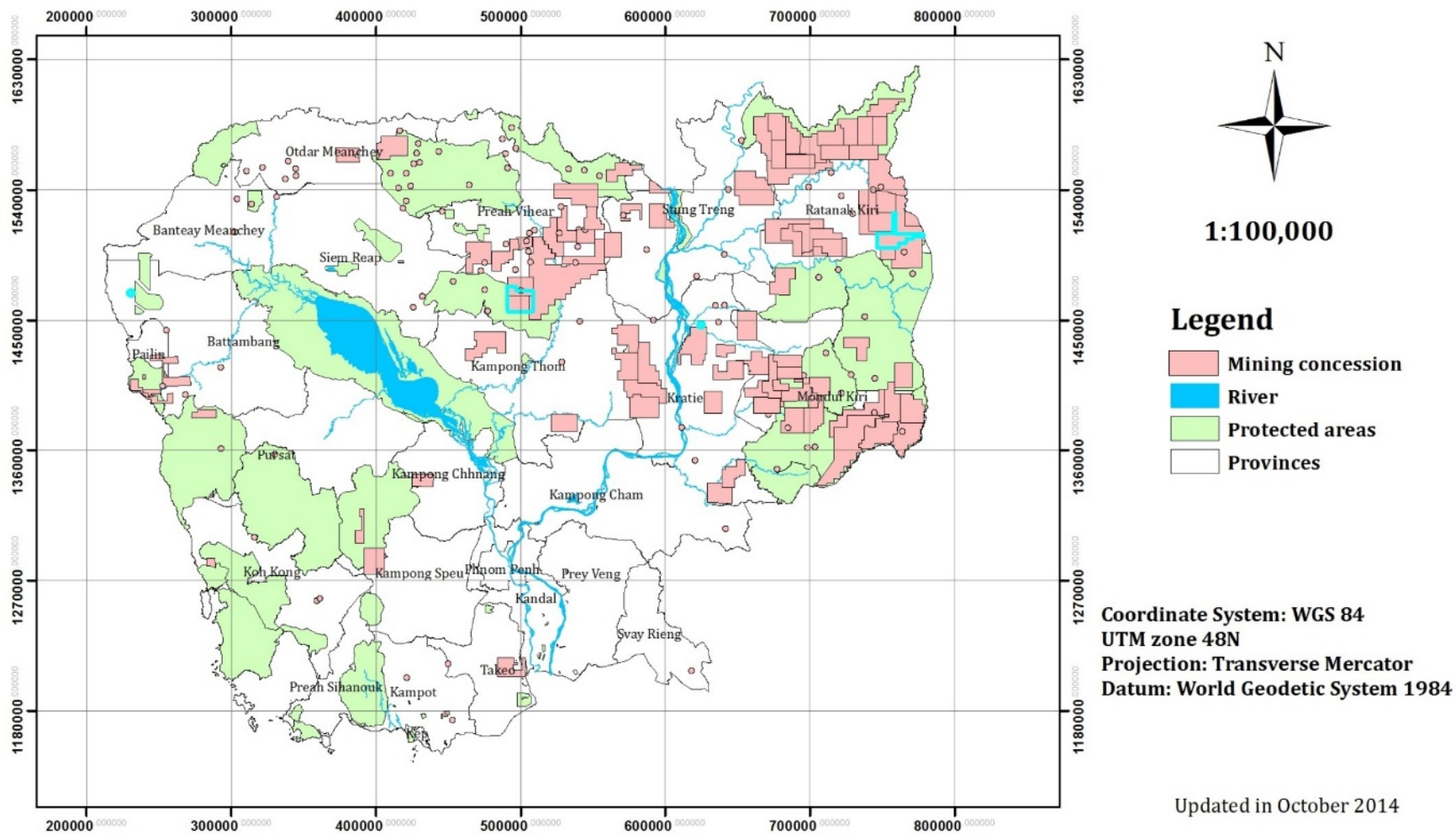


Figure 3: Mineral Investment Projects in Cambodia (Houn, 2015)

4.2.1.1 Large-Scale Gold Mining

The leading commercial gold works in Cambodia was the Okvau Working deposit owned by OZ Minerals. The Okvau working deposits was discovered in 2010 and has produced great optimism about the potential of gold deposits in the country. It is located in Mondul Kiri province about 260km to the North east of the Cambodian capital and it is estimated to contain about 600,000 ounces of gold. Another gold deposit is located in Phum Syau which was owned by the Angkor gold corp. It is likely to be the first commercial gold mine in Cambodia. However, there is no information about the gold deposit in the area because the company was conducting exploration since 2012 over the area of 1448 square kilometers (RGN, 2016).

There is no information about the methods to be used for extracting gold; therefore, there is no conclusion about the use of mercury from this sector.

4.2.1.2 Artisanal Small-scale Gold Mining (ASGM)

Artisanal gold mining was reported that provided direct job to local people about 5000 to 6000 (Lay, 2015) as cited in (Spiegel & Hoeung, 2011). ASGM is officially classified to be an illegal mining activities in Cambodia based on Law on Mineral Resource Management and Exploitation (2001) of Cambodia. Mercury is commonly used for extracting gold from the mineral owing to cheap price of mercury in the market and the low awareness of the impacts of mercury on health and environment. To stop people from using mercury in their gold mining activities was so much difficult (Lay, 2015). In the effort to improve the management of mercury used in this ASGM, the government of Cambodia through the Ministry of Environment developed the Strategic Plan on Management of Mercury in Artisanal and Small Scale Gold Mining in Cambodia 2012-2016 (Spiegel & Hoeung, 2011) as well as National Mercury Waste Management Plan (MoE, 2010a) , Action Plan on the Management of Releasing Mercury in Cambodia (2008-2010) (MoE, 2011b) and Technical Guideline on Environmentally Sound Management of Mercury Waste (MoE, 2010b).

Most of ASGM locate in Preah Vihear, Mondul Kiri, Battambang, Kratie, Rattanakiri, Kampong Thom (Houn, 2015; MoE, 2008; Spiegel & Hoeung, 2011)

Regarding the amount of mercury to be used in this ASGM activities, there is no any comprehensive studies or records have been conducted instead of the information found in the mercury inventory in 2008 above.



Figure 4: *Artisanal Gold Mining Activities in Cambodia (Lay, 2015)*

5. Impact of Mercury

The toxicity of mercury depends on its chemical form, and thus symptoms and signs are rather different in exposure to elemental mercury, inorganic mercury compounds, or organic mercury compounds (notably alkyl mercury compounds such as methyl mercury and ethyl mercury salts, and dimethyl mercury). The sources of exposure are also markedly different for the different forms of mercury. For alkyl mercury compounds, among which methyl mercury is by far the most important, the major source of exposure is diet, especially fish and other seafood. For elemental mercury vapor, the most important source for the general population is dental amalgam, but exposure at work may in some situations exceed this by many times. For inorganic mercury compounds, diet is the most important source for the majority of people. However, for some segments of populations, use of skin-lightening creams and soaps that contain mercury, and use of mercury for cultural/ritualistic purposes or in traditional medicine, can also result in substantial exposures to inorganic or elemental mercury.

While it is fully recognized that mercury and its compounds are highly toxic substances for which potential impacts should be considered carefully in Cambodia, there is ongoing research on how toxic these substances, especially methyl mercury. Regarding to new findings from various research center during the last decade indicate that toxic effects may be taking place at lower concentrations than previously thought, and potentially larger parts of the global population may be affected. As the mechanisms of subtle toxic effects and proving whether such effects are taking place are extremely complex issues, a complete

understanding has so far not been reached on this very important question.

5.1 Human Health Effects of Exposure to Mercury

Mercury is a neurotoxin. Human's health may be affected by an exposure to mercury depends on a number of factors:

- The form of mercury (for example, methyl mercury or elemental (metallic) mercury)
- The amount of mercury in the exposure;
- The age of the person exposed (the fetus is the most vulnerable)
- Person is exposed breathing, eating, skin contact, etc.
- The health of the person exposed.

There are a lot of victims from mercury in mining activity and there is case study on human data currently ties mercury exposure to cancer in Cambodia, but the data available are limited by each province and location. In very high doses, some forms of mercury have caused increases in several types of tumors in rats and mice. Moreover, regarding to U.S. Centers for Disease Control and Prevention (CDC) data show that most people have blood mercury levels below levels associated with possible health effects. Methyl mercury, however, is a powerful neurotoxin, and people exposed to high levels may experience adverse health effects. If you are concerned about your exposure to methyl mercury, you should consult your physician. Possible symptoms of methyl mercury poisoning may include:

- Loss of peripheral vision
- "Pins and needles" feelings, usually in the hands, feet, and around the mouth
- Lack of coordination of movements
- Impairment of speech, hearing, walking
- Muscle weakness

Cambodia, small-scale mining especially the kind of illegal mining cause much of the risks to mining's workers are the result of poor equipment and technical. Often these individuals are not aware of the nature of these risks or of the simple steps that can be taken to reduce the risks. Those engaged in ASM are already some the poorest people and are therefore likely to have inadequate sanitation, with little access to clean water or basic health care. There is also poor awareness of mining related health issues in rural health services, such as recognition of mercury poisoning and appropriate treatment. In some cases, working and living areas overlap, and numerous studies have suggested that it is especially important to ensure that the location for gold processing activities is separate from the locations where mining communities live. Although, such settlements may be recognized and accepted as regular activities, children can be exposed to multiple disease threats, including malaria, cholera, tuberculosis and other parasitic and infectious diseases. Various studies emphasize that governments should consider practical steps to build local capacities to adopt improved gold extraction methods and avoid safety and health risks by improving the working conditions of the mineworkers (According to ILO, 1999). Moreover, the negative impact on economic to families who are working as mining worker also included to human health impact from mercury in mining activities too.

5.2 Impacts of Mercury on Environment

Mercury occurred and can be used in mining activities, agriculture sector and especially in health sector etc., but it will provides with negative impact to human health, economic development and environment when people lack of knowledge on how to use it properly and to manage it for final disposal.

Moreover, regarding to the poor understanding of workers in mining activities of negative impact from mercury, especially the final dispose of mercury to environment, a very important factor in the impacts of mercury to the environment is its ability to build up in organisms and up along the food chain. Although all forms of mercury can accumulate to some degree, methyl mercury is absorbed and accumulates to a greater extent than other forms. Inorganic mercury can also be absorbed, but is generally taken up at a slower rate and with lower efficiency than is methyl mercury. The bio magnification of methyl mercury has a most significant influence on the impact on animals and humans. Fish appear to bind methyl mercury strongly, nearly 100 percent of mercury that bio accumulates in predator fish is methyl mercury. Most of the methyl mercury in fish tissue is covalently bound to protein sulfhydryl groups. This binding results in a long half-life for elimination (about two years). As a consequence, there is a selective enrichment of methyl mercury (relative to inorganic mercury) as one moves from one trophic level to the next higher trophic level.

The mercury concentrations are lowest in the smaller, non-predatory fish and can increase many-fold on the way up the food chain. Apart from the concentration in food, other factors affect the bioaccumulation of mercury. Of most importance are the rates of methylation and demethylation by mercury methylation bacteria (e.g., sulphate reducers). When all of these factors are combined, the net methylation rate can strongly influence the amount of methyl mercury that is produced and available for accumulation and retention by aquatic organisms. As described in chapter 2, several parameters in the aquatic environment influence the methylation of mercury and thereby its bio magnification. While much is generally known about mercury bioaccumulation and bio magnification, the process is extremely complex and involves complicated biogeochemical cycling and ecological interactions. As a result, although accumulation/magnification can be observed, the extent of mercury bio magnification in fish is not easily predicted across different sites.

At the top levels of the aquatic food web are fish-eating species, such as humans, seabirds, seals and otters. The larger wildlife species (such as eagles, seals) prey on fish that are also predators, such as trout and salmon, whereas smaller fish-eating wildlife (such as kingfishers) tend to feed on the smaller forage fish. In a study of fur-bearing animals in Wisconsin, the species with the highest tissue levels of mercury were otter and mink, which are top mammalian predators in the aquatic food chain. Top avian predators of aquatic food chains include raptors such as the osprey and bald eagle. Thus, mercury is transferred and accumulated through several food web levels (US EPA, 1997). Aquatic food webs tend to have more levels than terrestrial webs, where wildlife predators rarely feed on each other, and therefore the aquatic bio magnification typically reaches higher values.

Furthermore, among the most important environmental issues related to small-scale mining are the use of mercury for gold amalgamation and the use of cyanide, sometimes in combination with mercury. The Artisanal and Small-Scale Mining (ASM) sector is the world's

largest source of mercury pollution from intentional uses (the second largest emission source after coal-fired power plants) and hundreds of sites in the Asia-Pacific Region have been identified as mercury hotspots. Mercury use is the common method for gold extraction because it is simple, cheap and easily available. Assessments conducted in developing countries included Cambodia have noted that new programs are urgently needed to be able to tackle the threats of mercury pollution and build capacity of mining communities. Past experiences have indicated that convincing miners to completely eliminate mercury use can be difficult due to the importance of amalgamation to the ASM process and their immediate livelihood. However, numerous practical strategies exist that can substantially reduce the use of mercury and eliminate the most serious occupational and environmental health risks.

Environmental impacts often arise because of a lack of awareness, and education programs are important because impacts of mercury use are often invisible in the short term. Past experiences show that educating mining communities can lead to important reductions in mercury use. Although various low cost methods to reduce mercury use exist, in many cases, governments have only invested minimally in programs to provide education and training services in mining communities. Lack of capacity within government departments has often been identified as a key challenge in regulating and monitoring ASM activities.

Artisanal and small-scale gold mining contributes to poverty alleviation in the short term period for areas where very few other means of livelihood exist. It also serves as the main source of income for approximately 6,000 people who are living in the north-east and north-west parts of the country, i.e. Ratanakiri, Mondulkiri, Stung Treng, Kratie, Phrea Vihear, and Oddor Meanchey provinces. Their daily incomes vary from unskilled migrant workers (USD1.5 to USD2.5 per day) to skilled workers who can earn slightly more, and wealthy miners who have their own machinery or excavation earning (USD10 to USD15 per day) more than skilled workers. Even if ASGM can offer job opportunities and income to the poor, artisanal and small scale gold mining activities still lead to some serious long-term environmental and health impacts on those who are living at, adjacent to, or downstream from operational sites. In this regard, there is a need to promote sustainable practices (i.e. the use of gravity separation and cyanidation, which could be promoted as alternatives to mercury, or mercury recycling technologies such as retorts) at small scale gold mining sites with an aim to protect human health and environment from the negative impacts of mercury and mercury containing wastes while continuing to ensure the income of the miners. The promotion of sustainable practices can be done through legalization and administering of ASGM, and proper professional mining skills for miners shall be provided.

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