NATIONAL **INVENTORY OF MERCURY RELEASES** IN SURINAME 2019

REPUBLIC OF SURINAME

2019

National Inventory of Mercury Releases in Suriname 2019

This inventory was done under the GEF Enabling Activity: Minamata Initial Assessment for Suriname (project number 00095987) and was prepared by Drs. Jan Quik and Vanessa Sabajo MSc.

This inventory was performed in accordance with UN Environment's "Toolkit for identification and quantification of mercury releases", Inventory Level 2 (version 1.04, January 2017, or newer).
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List of Abbreviations

ASGM	Artisanal and Small Scale Gold Mining
GMD	Geologische en Mijnbouwkundige Dienst
OGS	Ordening Goud Sector
SBB	Stichting Bosbeheer en Bostoezicht
SHMR	Stichting Houders Mijnbouw Rechten

Executive Summary

Introduction

NIMOS on behalf of the government of Suriname made this inventory based on the decision taken by the government to become party to the Minamata Convention. This decision was approved in the National Assemblée of the 8th of March 2018

This inventory was developed in 2018. Data for the year 2015 have been used in the inventory, when available. For some data types, more recent data or year averages were used. The year for all data given is noted with the data in question in the relevant sections of this report.

This mercury release inventory was made with the use of the "Toolkit for identification and quantification of mercury releases" made available by the Chemicals Branch of the United Nations Environment Programme (UN Environment Chemicals). The Toolkit is available at UN Environment Chemicals' website:

http://web.unep.org/chemicalsandwaste/what-we-do/technology-and-metals/mercury/toolkit-identification-and-quantification-mercury-releases

This inventory was developed on the Toolkits Inventory Level 2. The Toolkit methodology is based on mass balances for each mercury release source sub-category.

See further description of these estimations in the relevant source type sections.

Results and discussion

An aggregated presentation of the results for main groups of mercury release sources is presented in Figure 1.1 - 1.6 and Table 1.1 below. Explanation of notes can be found after Figure 1.6

Figure 1-1 Mercury releases to air.

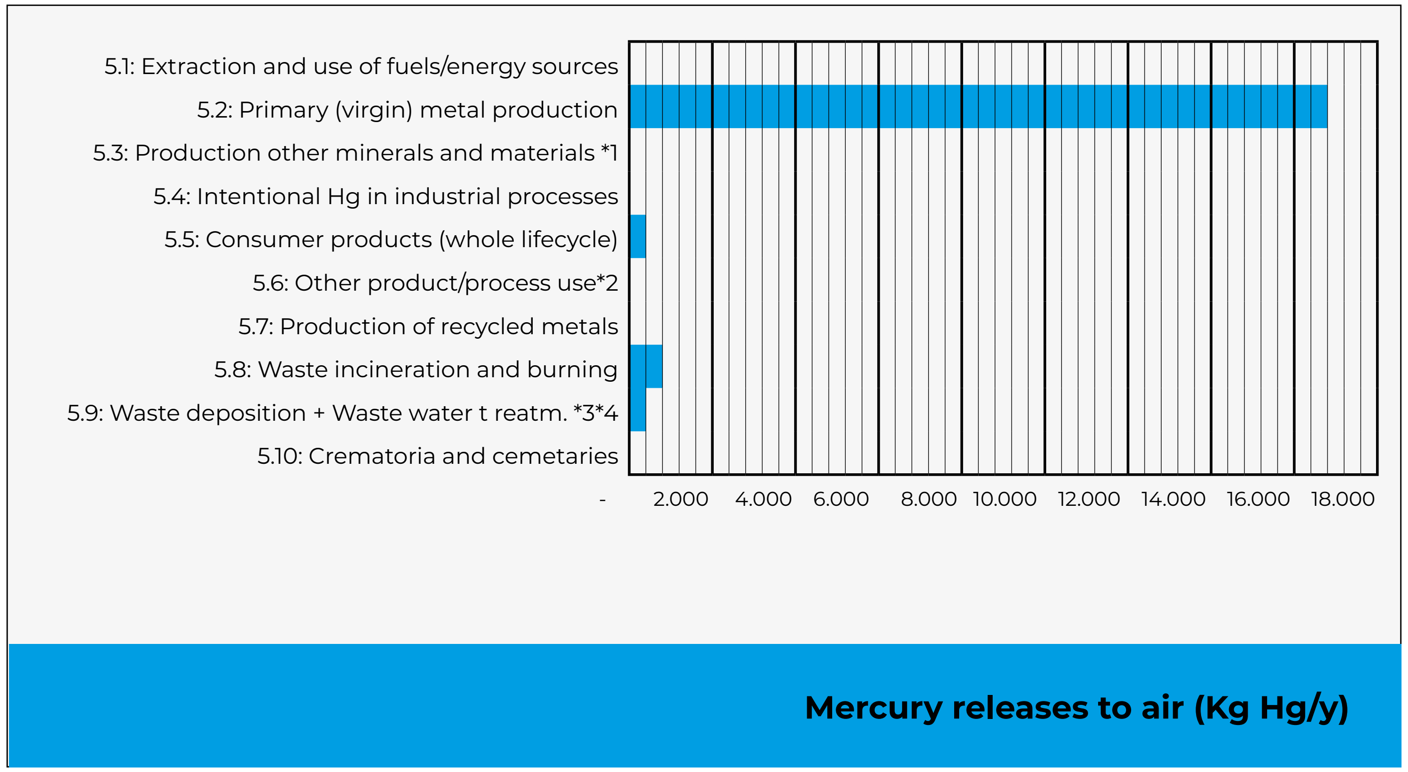


Figure 1-2 Mercury releases to water

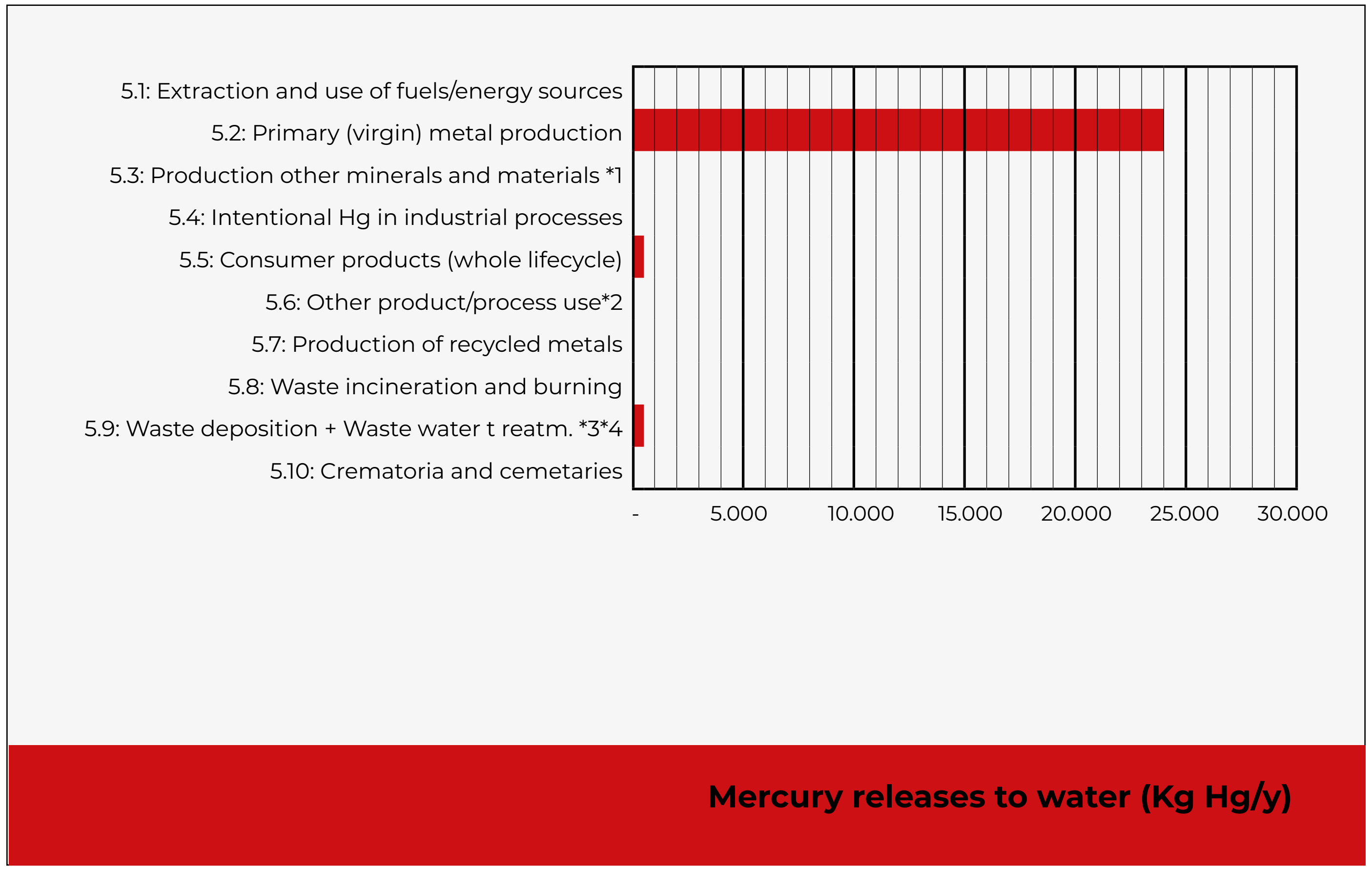


Figure 1-3 Mercury releases to land

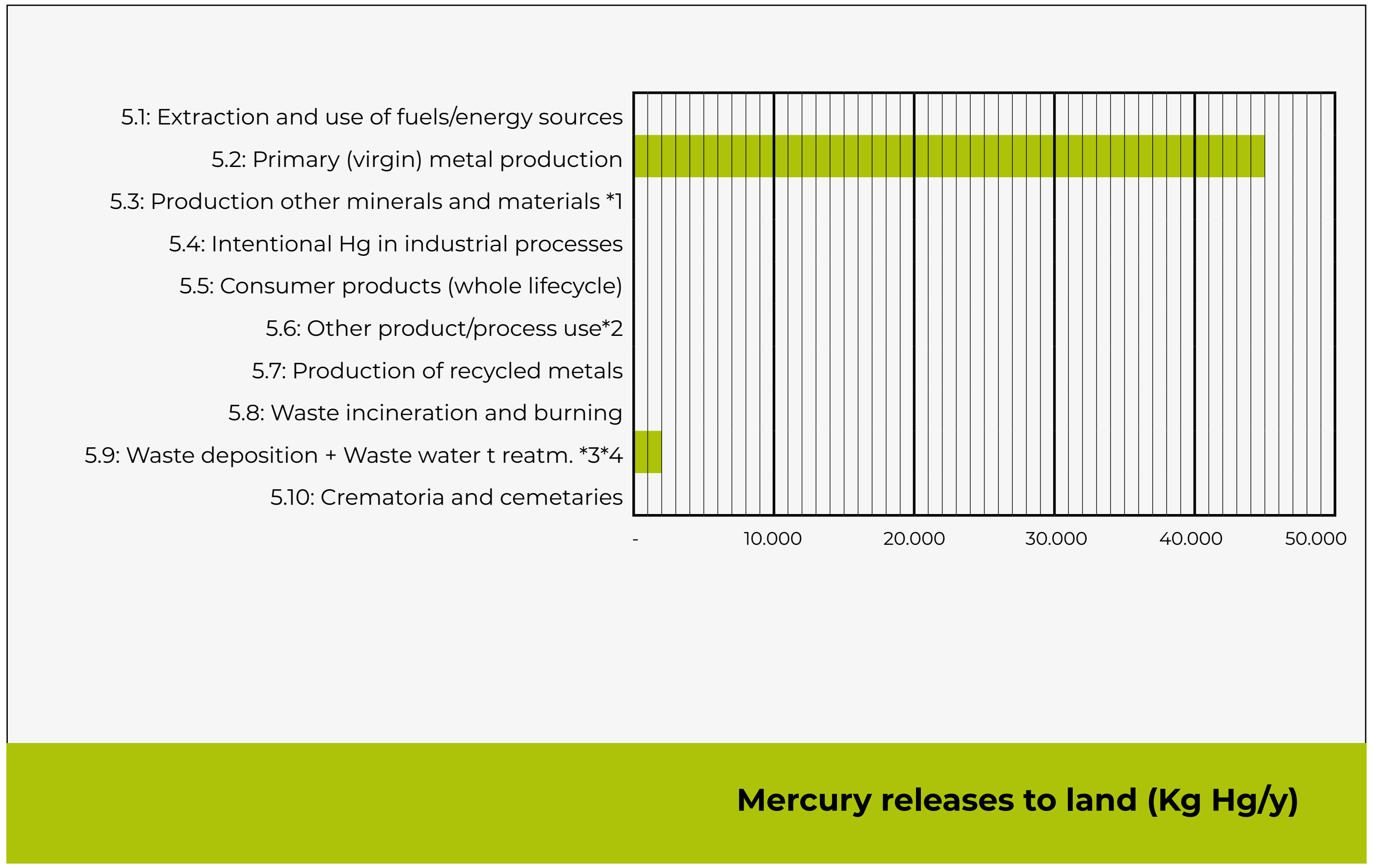


Figure 1-4 Mercury outputs to by-products and impurities

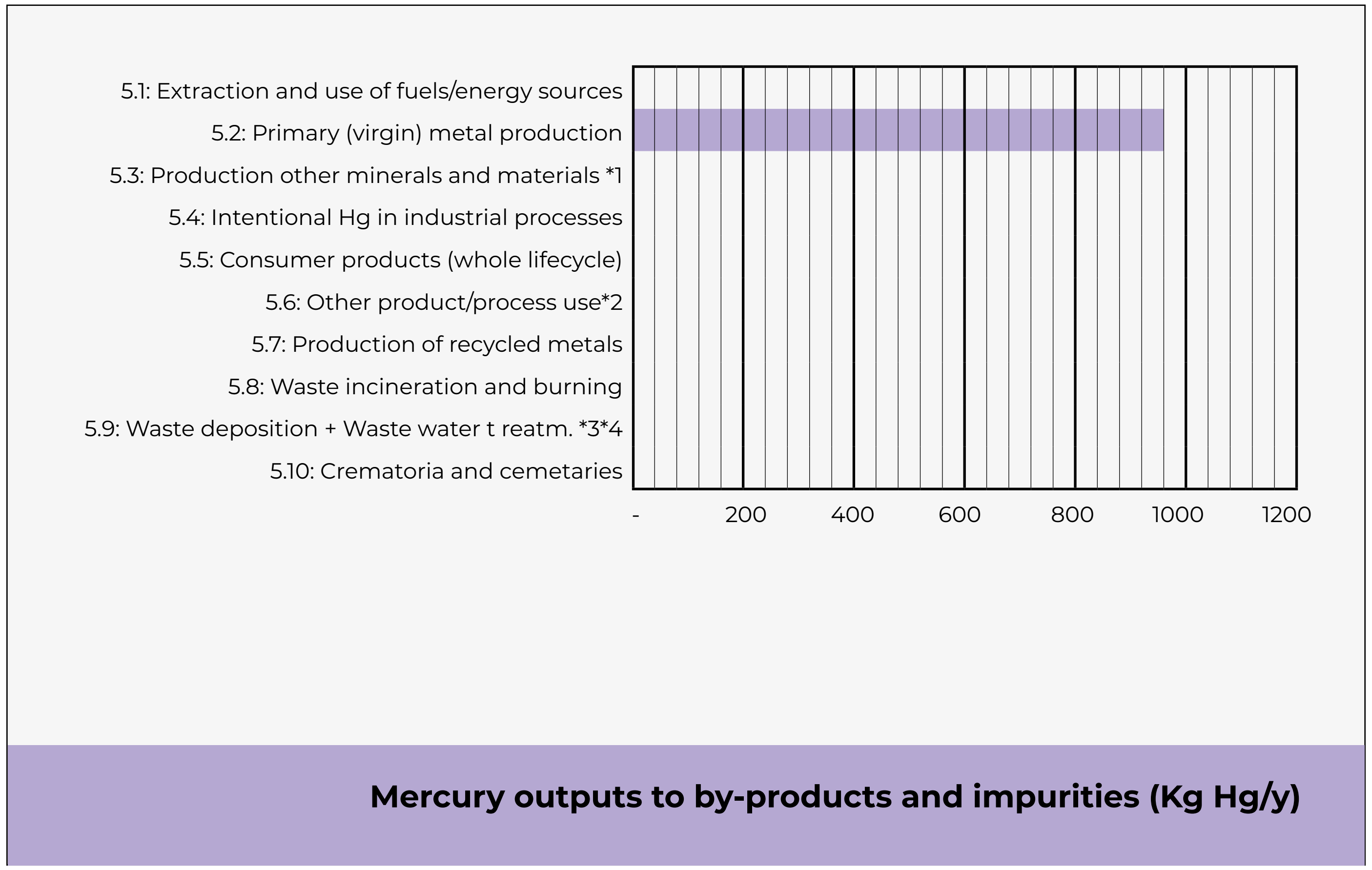


Figure 1-5 Mercury releases to general waste

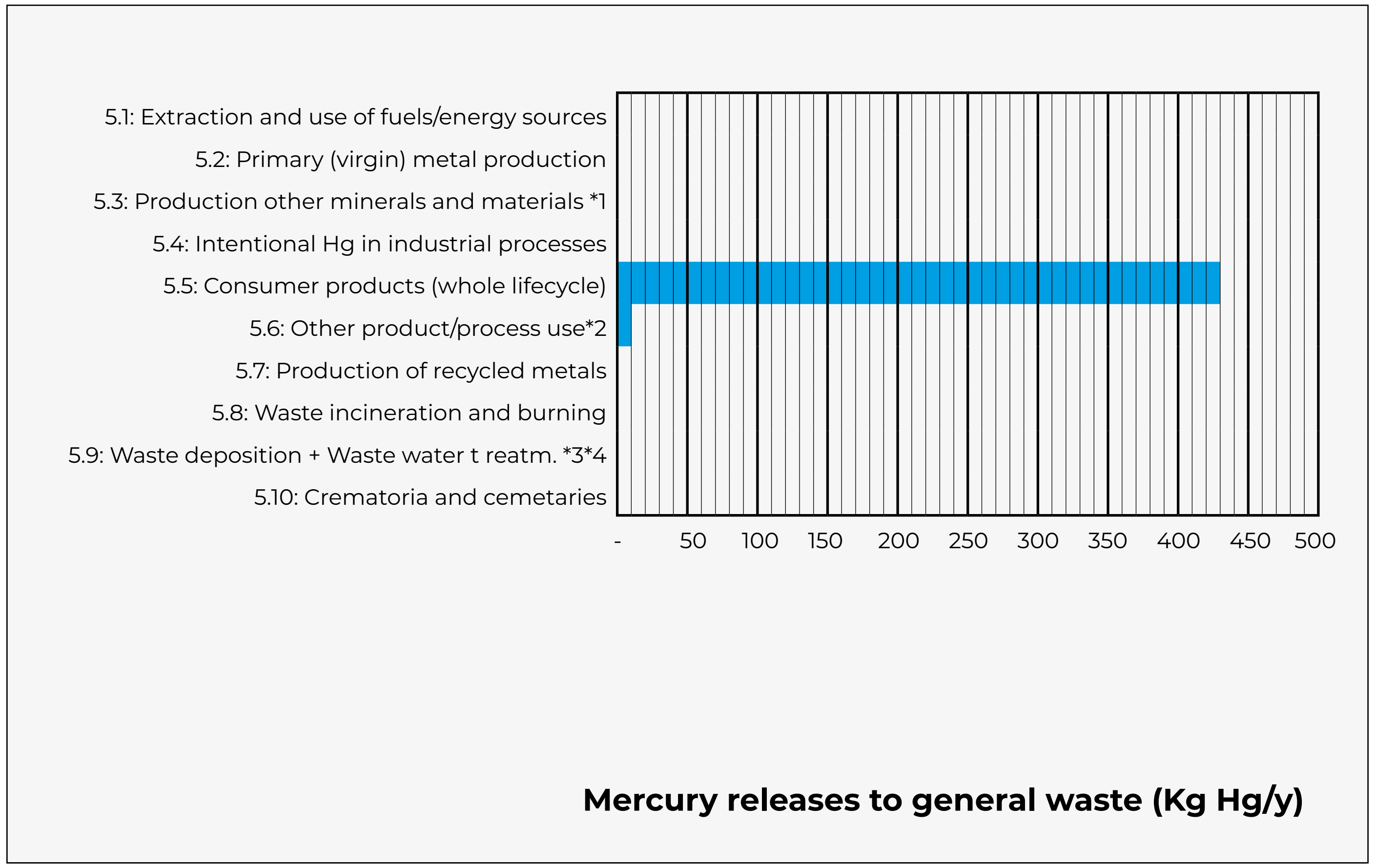
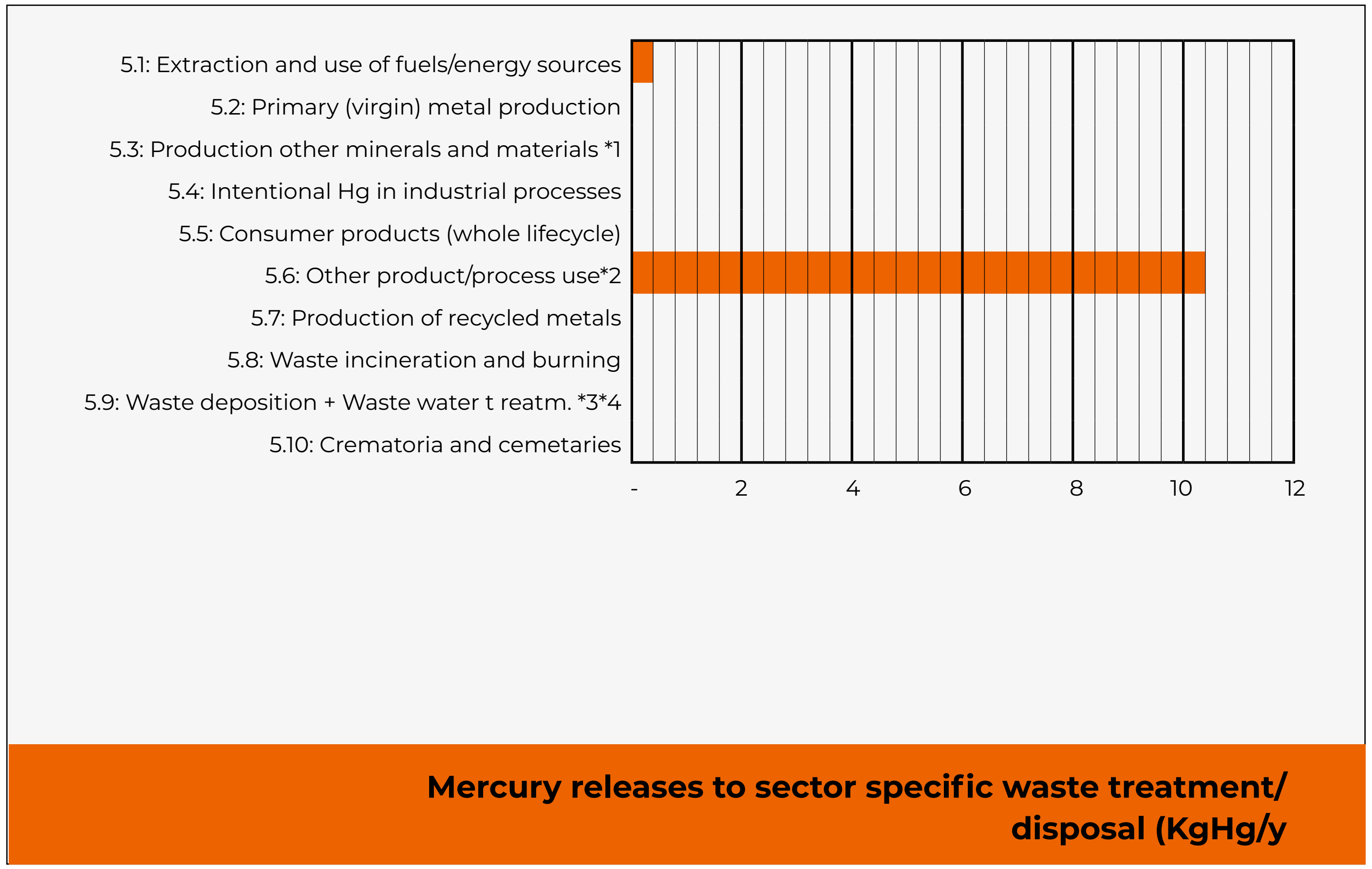


Figure 1-6 Mercury releases to sector specific waste treatment/disposal



Notes:
**1 Includes production of cement, pulp and paper, lime and light weight aggregates.*
**2 Includes dental amalgam fillings, manometers and gauges, lab chemicals and equipment, Hg use in religious rituals and folklore medicine, and miscellaneous product uses.*
**3 The estimated quantities include mercury in products which has also been accounted for under each product category.*
To avoid double counting, the release to land from informal dumping of general waste has been subtracted automatically in the data used in this chart.
**4 The estimated input and release to water include mercury amounts which have also been accounted for under each source category.*
To avoid double counting, releases to water from waste water system/treatment have been subtracted automatically in the data used in this chart.

Table 1-1 Summary of mercury inventory results

Source category	**Calculated Hg output Kg/year**							
	Air	Water	Land	By-products and impu-rities	Gen-eral waste	Sector specific treatment / disposal	Total releases by source category	Percent of total releases *3 *4
5.1: Extraction and use of fuels/ energy sources	22.3	0.7	-	0.3	-	0.4	24	0.0%
5.2: Primary (virgin) metal production	16.869.3	23.829.7	44.563.4	962.6	-	-	86.225	97.0%
5.3: Production of other minerals and materials with mercury impurities *1	-	-	-	-	-	-	-	0.0%
5.4: Intentional use of mercury in industrial processes	-	-	-	-	-	-	-	0.0%
5.5: Consumer products with inten-tional use of mercury (whole life cycle)	274.9	291.3	284.5	-	430.9	-	1.282	1.4%
5.6: Other intentional product/ process use *2	0.5	16.4	2.6	1.6	10.9	10.4	42	0.0%
5.7: Production of recycled metals	-	-	-	-	-	-	-	0.0%
5.8: Waste incineration and burning	867.1	-	-	-	-	-	867	1.0%
5.9: Waste deposition/landfilling and waste water treatment *3 *4	207.7	350.7	1661.4	-	-	-	2.220	0.9%
5.10: Crematoria and cemeteries	2.1	-	7.1	-	-	-	9	0.0%
SUM OF QUANTIFIED RELEASES *3 *4	18.244	24.346	44.858	965	442	11	88.864	100%

Notes:
**1 Includes production of cement, pulp and paper, lime and light weight aggregates.*
**2 Includes dental amalgam fillings, manometers and gauges, lab chemicals and equipment, Hg use in religious rituals and folklore medicine, and miscellaneous product uses.*
**3 The estimated quantities include mercury in products which has also been accounted for under each product category.*
To avoid double counting, the release to land from informal dumping of general waste has been subtracted automatically in the TOTALS.
**4 The estimated input and release to water include mercury amounts which have also been accounted for under each source category. To avoid double counting, releases to water from waste water system/treatment have been subtracted automatically in the TOTALS.*

The individual mercury release sub-categories contributing with the highest mercury releases to the atmosphere were

1. Gold and silver extraction with the mercury-amalgamation process (89%)
2. Informal waste burning and Informal dumping of general waste (6%)
3. Gold extraction and initial processing by other processes than mer-cury amalgamation (3%)

The individual mercury release sub-categories contributing with the highest inputs of new mercury were

1. Gold and silver extraction with the mercury-amalgamation process (70%)
2. Gold extraction and initial processing by other processes than mer-cury amalgamation (27%).

The origin of mercury in waste and waste water produced in the country is mercury in products and materials. Waste fractions and waste water do therefore not represent original mercury inputs to society (except imported waste). Waste and waste water may however represent substantial flows of mercury through society. The following were found to be the major flows of mercury with waste and waste water: Informal dumping of general waste and Waste water system/treatment.

In this inventory, default input factors were used for the estimation of mercury releases from general waste treatment. The default factors were based on literature data of mercury contents in waste, and these data were only available from developed countries. The calculations made indicate that the default input factors for general waste may over-estimate the mercury releases from this source (see the section on waste data in this report). This may be of priority in follow-up work, as feasible.

Detailed presentation of mercury inputs and releases for all mercury release source types present in the country are shown in the following report sections.

The Toolkit spreadsheets used in the development of this inventory are posted along with this report, or can be submitted upon request.

Major points sources of mercury releases identified are listed in each of the relevant source sub-category sections below.

No single major contaminated site has been identified, but all land areas were gold extraction with the mercury-amalgamation process has taken place, can be considered as contaminated sites. See more details about these contaminated sites in section 5 in this report.

Data gaps and recommendations for follow-up

It should be noted that the default input factors used in the level 2 assessment, are estimates and associated with substantial uncertainties. They primarily serve to raise awareness that mercury can be released during the process, and that this mercury can eventually end up in the atmosphere, water, land, products, general waste or sector specific treatment/disposal.

Major data gaps encountered during the level 2 assessment included the following:

1. Insufficient analytical data were available of actual mercury content in a wide range of products, such as oil, fuel, gas, biomass burned, general waste and waste water.
2. For the main contributors to mercury release - mining and pro-cessing of gold - insufficient data were available of actual mercury content in raw ore, mercury flows and mass balances in both ASGM and LSGM operations. This is reflected in uncertainty in the input factors used to predict mercury release.
3. Import data on consumer products containing mercury were not sufficiently specified by our Customs Department. The CET codes used did not provide the requested detail, making it difficult to recognize and quantify mercury containing products.

More detailed descriptions of these data gaps are given in each category sub-section in the report. Some recommendations for follow-up, related to gold mining, are:

1. Improvements in both estimating mercury input and release into the environment and in suc cessful efforts to reduce these mercury emissions, can only be realized with the full involvement and support of the gold miners and their organizations, such as the Federation of small scale goldminers and the foundation Suriname Houders Mijnbouw Rechten (SHMR). Also the large gold mining companies should be involved. A start has been made to involve OGS, GMD, SHMR and Newmont Suriname LLC in estimating mercury inputs, but this should be further expanded and systematized.
2. The quality of data compiled so far and presented, first in the level 1 MIA and now in the level 2 MIA needs to be continually improved. The level 2 assessment already made adjustments and differentiations in the input factors used to calculate mercury input. This process should continue and be expanded with pilot studies in different types of ASGM and LSGM operations (using different techniques and procedures). The pilot studies should produce quantitation of mercury flows and mass balances, based on measurements and actual chemical analysis of processed ore, tailings and air for mercury content. These studies should be performed with internationally accepted quality assurance and quality control procedures.
3. A driving force in realizing change towards reducing and eventually eliminating use of mercury in gold mining, are legal and regulatory tools and their enforcement. This in combination with working together with the miners in gradually improving their mining techniques, will lead to results.
4. Health concerns, both of the miners for their own health and for the health of nearby inhabitants of villages, should be further substanti-ated and monitored by Human Biomonitoring programs to establish the degree of human exposure to mercury. HBM studies are already being carried out, but regular screening should be made available for both miners (occupational exposure) and villagers (environmental exposure). For the villagers exposure takes primarily place through inges tion of fish contaminated with methyl mercury. Most vulnerable groups are young children and pregnant women.
5. In order to monitor the effectiveness of mercury mitigating measures something like a National Reference Centre could be designated where all data could be stored and evaluated.

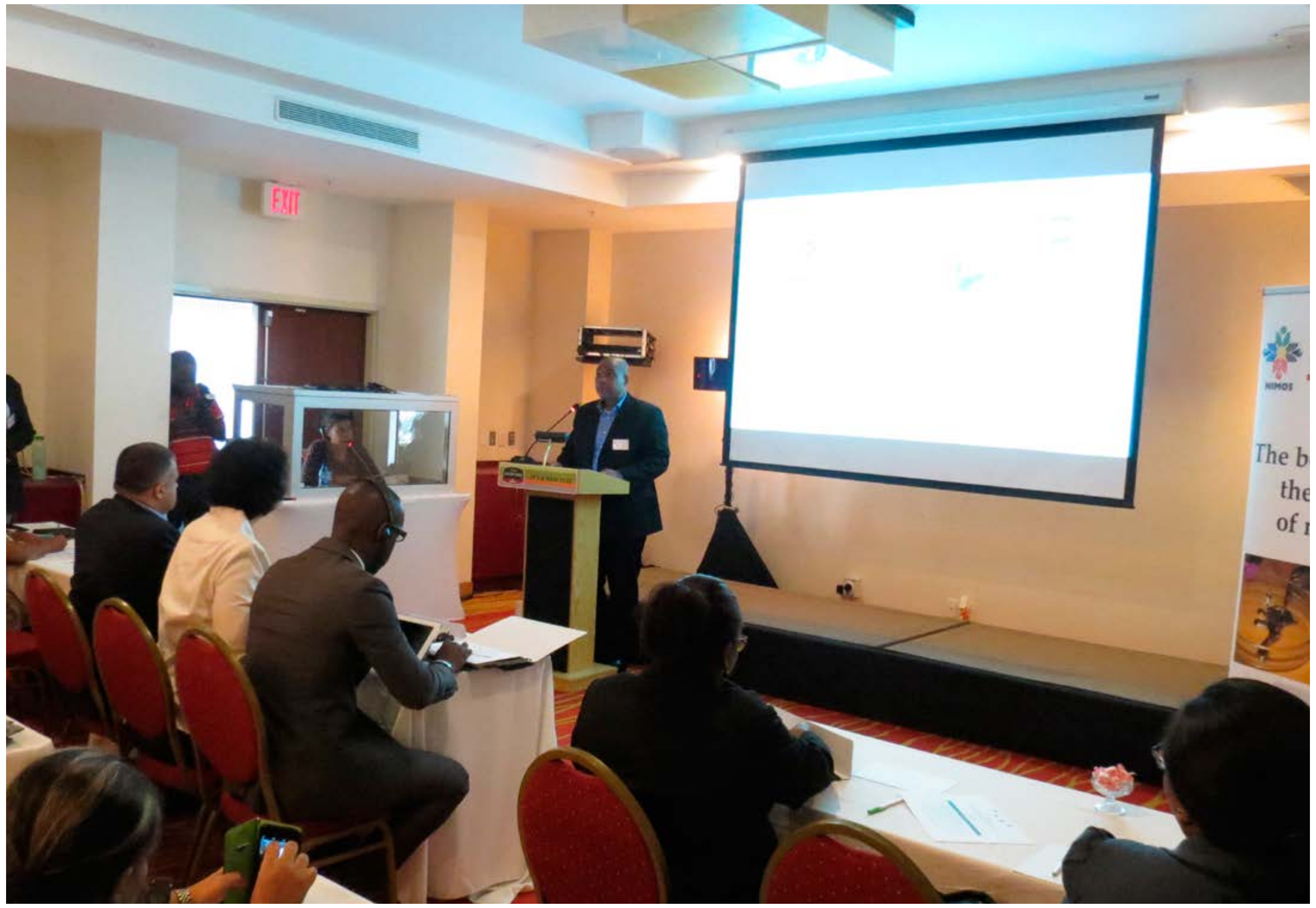
In order to improve the data quality of imported consumer goods with mercury it is recommended that the capacity of Suriname's Customs Department is strengthened, so that sufficiently specific import data can be provided.

1. Mercury release source types present

Table 2-1 shows which mercury release sources were identified as present or absent in the country. Only source types positively identified as present are included in the quantitative assessment.

Table 2-1 Identification of mercury release sources in the country; sources present (Y), absent (N), and possible but not positively identified (?)

Cat. no.	Source category	Source pres-ence (y/n/?)
5.1	**Main category - Extraction and use of fuels/energy sources**	
5.1.1	Coal combustion in large power plants	N
5.1.2	Other coal combustion	N
5.1.3	Extraction, refining and use of mineral oil	Y
5.1.4	Extraction, refining and use of natural gas	Y
5.1.5	Extraction and use of other fossil fuels	N
5.1.6	Biomass fired power and heat production	Y
5.1.7	Geothermal power production	N
5.2	**Main category - Primary (virgin) metal production**	
5.2.1	Primary extraction and processing of mercury	N
5.2.2	Gold and silver extraction with the mercury-amalgamation process	Y
5.2.3	Zinc extraction and initial processing	N
5.2.4	Copper extraction and initial processing	N
5.2.5	Lead extraction and initial processing	N
5.2.6	Gold extraction and initial processing by other processes than mercury amalgamation	Y
5.2.7	Aluminium extraction and initial processing	N
5.2.8	Extraction and processing of other non-ferrous metals	N
5.2.9	Primary ferrous metal production	N
5.3	**Main category - Production of other minerals and materials with mercury im-purities**	
5.3.1	Cement production	N
5.3.2	Pulp and paper production	N
5.3.3	Lime production and light weight aggregate kilns	N
5.3.4	Others minerals and materials	N
5.4	**Main category – Intentional use of mercury as an auxiliary material in indus-trial processes**	
5.4.1	Chlor-alkali production with mercury-technology	N
5.4.2	VCM (vinyl-chloride-monomer) production with mercury-dichloride ($HgCl_2$) as catalyst	N
5.4.3	Acetaldehyde production with mercury-sulphate ($HgSO_4$) as catalyst	N
5.4.4	Other production of chemicals and polymers with mercury compounds as cata-lysts	N
5.5	**Main category - Consumer products with intentional use of mercury**	
5.5.1	Thermometers with mercury	Y
5.5.2	Electrical and electronic switches, contacts and relays with mercury	Y
5.5.3	Light sources with mercury	Y
5.5.4	Batteries containing mercury	Y
5.5.5	Polyurethane with mercury catalysts	Y
5.5.6	Biocides and pesticides	N
5.5.7	Paints	?
5.5.8	Pharmaceuticals for human and veterinary uses	N
5.5.9	Cosmetics and related products	Y



Cat. no.	Source category	Source presence (y/n/?)
5.6	**Main category - Other intentional products/process uses**	
5.6.1	Dental mercury-amalgam fillings	Y
5.6.2	Manometers and gauges	Y
5.6.3	Laboratory chemicals and equipment	Y
5.6.4	Mercury metal use in religious rituals and folklore medicine	Y
5.6.5	Miscellaneous product uses, mercury metal uses and other sources	Y
5.7	**Main category - Production of recycled metals**	
5.7.1	Production of recycled mercury ("secondary production)	N
5.7.2	Production of recycled ferrous metals (iron and steel)	Y
5.7.3	Production of other recycled metals	N
5.8	**Main category – Waste incineration**	
5.8.1	Incineration of municipal/general waste	N
5.8.2	Incineration of hazardous waste	N
5.8.3	Incineration of medical waste	Y
5.8.4	Sewage sludge incineration	N
5.8.5	Informal waste burning	Y
5.9	**Main category - Waste deposition/landfilling and waste water treatment**	
5.9.1	Controlled landfills/deposits	N
5.9.2	Diffuse deposition under some control	Y
5.9.3	Informal local deposition of industrial production waste	?
5.9.4	Informal dumping of general waste	Y
5.9.5	Waste water system/treatment	Y
5.10	**Main category - Cremation and cemeteries**	
	Crematoria	Y
	Cemeteries	Y
	Main category - Potential hot spots	
	Closed/abandoned chlor-alkali production sites	?
	Other sites of former chemical production where mercury compounds are/were produced (pesticides, biocides, pigments etc.), or mercury or compounds were used as catalysts (VCM/PVC etc.)	N
	Closed production sites for manufacturing of thermometers, switches, batteries and other products	N
	Closed pulp and paper manufacturing sites (with internal chlor-alkali production or former use of mercury-based slimicides)	N
	Tailings/residue deposits from mercury mining	N
	Tailings/residue deposits from artisanal and large scale gold mining	Y
	Tailings/residue deposits from other non-ferrous metal extraction	Y
	Sites of relevant accidents	N
	Dredging of sediments	N
	Sites of discarded district heating controls (and other fluid controls) using mercury pressure valves	?
	Sites of previous recycling of mercury ("secondary" mercury production)	N

2. Summary of mercury inputs to society

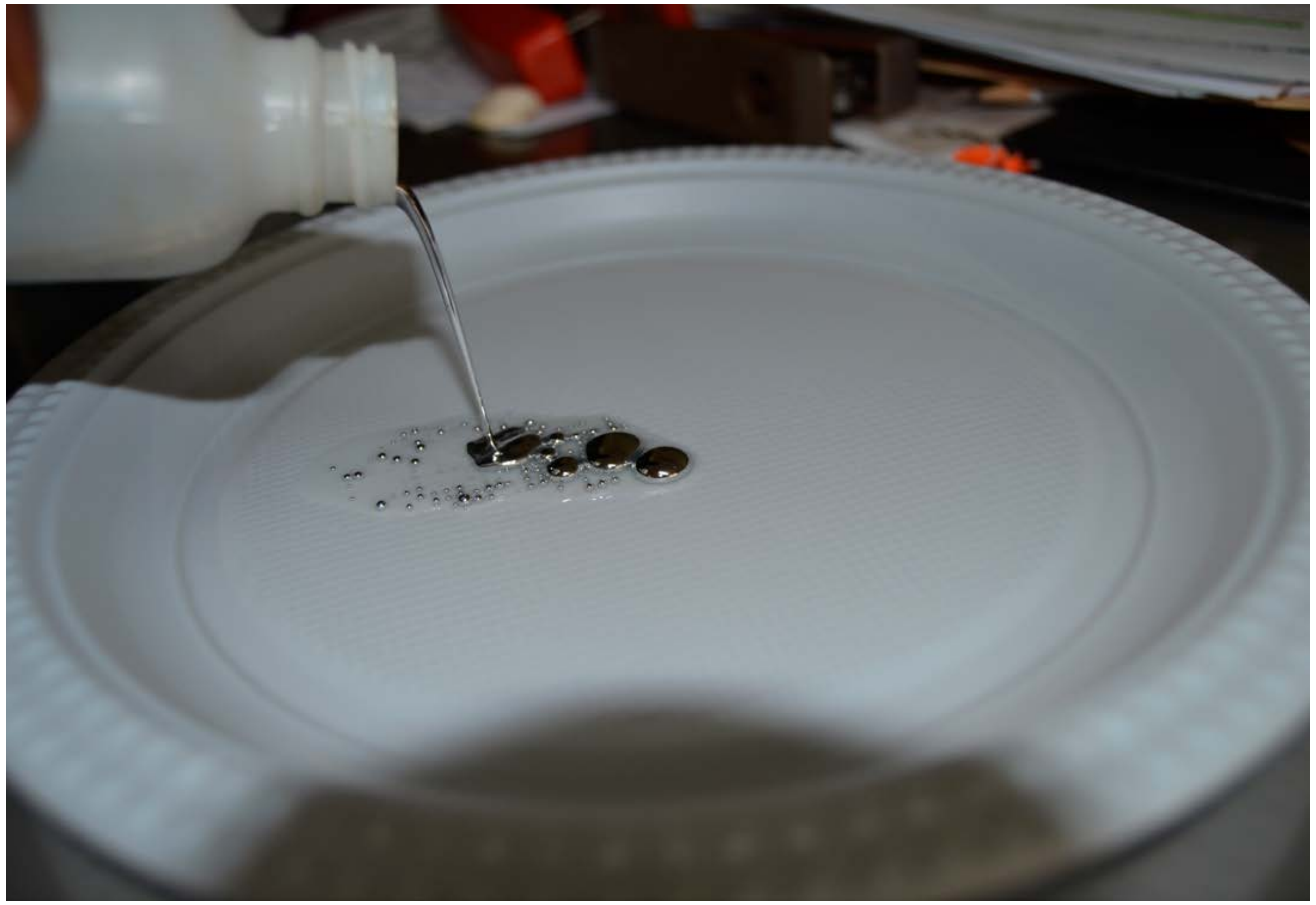
Mercury inputs to society should be understood here as the mercury amounts made available for potential releases through economic activity in the country, such as gold mining. This includes also mercury intentionally used in products such as thermometers, blood pressure gauges, fluorescent light bulbs, etc. It also includes mercury mobilised via extraction and use of raw materials which contain mercury in trace concentrations.

For waste categories, the “inputs” are calculated to show the distribution of mercury in waste through the different waste treatment activities and calculate releases from these activities, though waste is not an original source of input of mercury into society (except in case of waste import). Waste “inputs” are marked in italics.

Table 3.1 summarizes the mercury inputs in society from all different sub-categories identified to be present in Suriname; the inputs are specified for production phase, use and disposal phase.

Table 3-1 Summary of mercury inputs to society.

Cat. no.	**Source category**	**Estimated Hg input, Kg Hg/y, by life cycle phase (as relevant)**		
		Production phase*1	**Use phase**	**Disposal phase**
5.1	**Main category - Extraction and use of fuels/energy sources**			
5.1.3	Extraction, refining and use of mineral oil	5	7	
5.1.4	Extraction, refining and use of natural gas	1	0	
5.1.6	Biomass fired power and heat production		15	
5.2	**Main category - Primary (virgin) metal production**			
5.2.2	Gold and silver extraction with the mercury-amalgamation process	62.159		
5.2.6	Gold extraction and initial processing by other processes than mercury amalgamation	24.066		
5.5	**Main category - Consumer products with intentional use of mercury**			
5.5.1	Thermometers with mercury			966
5.5.2	Electrical and electronic switches, contacts and relays with mercury			67
5.5.3	Light sources with mercury			5
5.5.4	Batteries containing mercury			230
5.5.5	Polyurethane with mercury catalysts			14
5.5.7	Paints			
5.5.8	Cosmetics and related products			
5.6	**Main category - Other intentional products/process uses**			
5.6.1	Dental mercury-amalgam fillings	1	5	27
5.6.2	Manometers and gauges			2
5.6.3	Laboratory chemicals and equipment			24
5.6.4	Mercury metal use in religious rituals and folklore medicine			?
5.6.5	Miscellaneous product uses, mercury metal uses and other sources			
5.7	**Main category - Production of recycled metals**			
5.7.2	Production of recycled ferrous metals (iron and steel)			
5.7.3	Production of other recycled metals			
5.8	**Main category – Waste incineration**			
5.8.3	Incineration of medical waste			2 5
5.8.5	Informal waste burning			8 4 2



Cat. no.	Source category	Estimated Hg input, Kg Hg/y, by life cycle phase (as relevant)		
		Production phase*1	Use phase	Disposal phase
5.9	**Main category - Waste deposition/landfilling and waste water treatment**			
5.9.3	Informal local deposition of industrial production waste			?
5.9.4	Informal dumping of general waste			2,077
5.9.5	Waste water system/treatment			143
5.10	**Main category - Cremation and cemeteries**			
5.10.1	Crematoria			2
5.10.2	Cemeteries			7

Notes:
**1 Production phase includes raw material production.*

Note that the following source sub-categories made the largest contributions to mercury inputs to society:

1. Gold and silver extraction with the mercury-amalgamation process,
2. Gold extraction and initial processing by other processes than mercury amalgamation and
3. Informal dumping of general waste.

The origin of mercury in waste and waste water produced in the country is mercury in products and materials. Waste fractions and waste water do therefore not represent original mercury inputs to society (except imported waste). Waste and waste water may however represent substantial flows of mercury through society. The following were found to be the major flows of mercury with waste and waste water: Informal dumping of general waste and Informal waste burning.

3. Summary of mercury releases

In the Table 4-1 below, a summary of mercury releases from all source categories present is given. The key mercury releases here are releases to air (the atmosphere), to water (marine and freshwater bodies, including via waste water systems), to land, to general waste, and to sector specific waste. An additional output pathway is “by-products and impurities” which designates mercury flows back into the market with by-products and products.

See Table 4-2 below for a more detailed description and definition of the output pathways.

Note that the following source sub-categories made the largest contributions to mercury releases to the atmosphere:

1. Gold and silver extraction with the mercury-amalgamation process (89%)
2. Informal waste burning and Informal dumping of general waste (6%)
3. Gold extraction and initial processing by other processes than mercury amalgamation (3%)

Table 4-1 Summary of mercury releases (overleaf)

C	Sub-C	Source category	Exists? (y/n)	Calculate Hg input to society	Calculated Hg output, Kg/year					
					Air	Water	Land	By-products and impurities	General waste	Sector specific treatment / disposal
5.1		**Source category: Extraction and use of fuels/energy sources**								
	5.1.1	Coal combustion in power plants	n	0	0	0	0	0	0	0
	5.1.2.1	Coal combustion in coal fired industrial boilers	n	0	0	0	0	0	0	0
	5.1.2.2	Other coal use	n	0	0	0	0	0	0	0
	5.1.3	Mineral oils - extraction, refining and use	y	8	7	1	0	0	0	0
	5.1.4	Natural gas - extraction, refining and use	y	1	0	0	0	0	0	0
	5.1.5	Other fossil fuels - extraction and use	n	0	0	0	0	0	0	0
	5.1.6	Biomass fired power and heat production	y	15	15	0	0	0	0	0
	5.1.7	Geothermal power production	n	0	0	0	0	0	0	0
5.2		**Source category: Primary (virgin) metal production**								
	5.2.1	Mercury (primary) extraction and initial processing (a	n	0	0	0	0	0	0	0
	5.2.2	Gold (and silver) extraction with mercury amalgamation processes	y	62.159	16.267	22.988	22.904	0	0	0
	5.2.3	Zinc extraction and initial processing	n	0	0	0	0	0	0	0
	5.2.4	Copper extraction and initial processing	n	0	0	0	0	0	0	0
	5.2.5	Lead extraction and initial processing	n	0	0	0	0	0	0	0
	5.2.6	Gold extraction and initial processing by methods other than mercury amalgamation	y	24.066	603	841	21.659	963	0	0
	5.2.7	Aluminum extraction and initial processing	n	0	0	0	0	0	0	0
	5.2.8	Other non-ferrous metals - extraction and processing	n	0	0	0	0	0	0	0
	5.2.9	Primary ferrous metal production	n	0	0	0	0	0	0	0

C	Sub-C	Source category	Ex-ists? (y/n)	Calculate Hg input to society	Calculated Hg output, Kg/year					
					Air	Water	Land	By-products and impurities	General waste	Sector specific treatment / disposal
5.3		**Source category: Production of other minerals and materials with mercury impurities**								
	5.3.1	Cement production	n	0	0	0	0	0	0	0
	5.3.2	Pulp and paper production	n	0	0	0	0	0	0	0
	5.3.3	Production of lime and light weight aggregates	n	0	0	0	0	0	0	0
5.4		**Source category: Intentional use of mercury in industrial processes**								
	5.4.1	Chlor-alkali production with mercury-technology	n	0	0	0	0	0	0	0
	5.4.2	VCM production with mercury catalyst	n	0	0	0	0	0	0	0
	5.4.3	Acetaldehyde production with mercury catalyst	n	0	0	0	0	0	0	0
	5.4.4	Other production of chemicals and polymers with mercury	n	0	0	0	0	0	0	0
5.5		**Source category: Consumer products with intentional use of mercury**								
	5.5.1	Thermometers with mercury	y	966	193	290	193	-	290	0
	5.5.2	Electrical switches and relays with mercury	y	67	20	0	27	-	20	0
	5.5.3	Light sources with mercury	y	5	1	0	1	-	2	0
	5.5.4	Batteries with mercury	y	230	57	0	57	-	115	0
	5.5.5	Polyurethane with mercury catalysts	y	14	3	1	6	-	4	0
	5.5.6	Biocides and pesticides with mercury	n	0	0	0	0	-	0	0
	5.5.7	Paints with mercury	?	0	0	0	0	-	0	0
	5.5.8	Pharmaceuticals for human and veterinary uses	n	0	0	0	0	-	0	0
	5.5.9	Cosmetics and related products with mercury	y	0	0	0	0	-	0	0
5.6		**Source category: Other intentional product/process use**								
	5.6.1	Dental mercury-amalgam fillings (b	y	16	0	8	2	2	2	2
	5.6.2	Manometers and gauges with mercury	y	2	0	1	0	0	1	0
	5.6.3	Laboratory chemicals and equipment with mercury	y	24	0	8	0	0	8	8
	5.6.4	Mercury metal use in religious rituals and folklore medicine	y	0	0	0	0	0	0	0
	5.6.5	Miscellaneous product uses, mercury metal uses, and other sources	y	0	0	0	0	0	0	0
5.7		**Source category: Production of recycled metals (“secondary” metal production)**								
	5.7.1	Production of recycled mercury (“secondary production”)	n	0	0	0	0	0	0	0
	5.7.2	Production of recycled ferrous metals (iron and steel)	y	0	0	0	0	0	0	0
	5.7.3	Production of other recycled metals	n	0	0	0	0	0	0	0
5.8		**Source category: Waste incineration*3**								
	5.8.1	Incineration of municipal/general waste	n	0	0	0	0	0	0	0
	5.8.2	Incineration of hazardous waste	n	0	0	0	0	0	0	0
	5.8.3	Incineration of medical waste	y	25	25	0	0	0	0	0
	5.8.4	Sewage sludge incineration	n	0	0	0	0	0	0	0
	5.8.5	Informal waste burning	y	842	842	0	0	0	0	0
5.9		**Source category: Waste deposition/ landfilling and waste water treatment**								
	5.9.1	Controlled landfills/deposits*3	n	0	0	0	0	0	0	0
	5.9.2	Diffuse disposal under some control	y	0	-	-	-	-	-	-
	5.9.3	Informal local disposal of industrial production waste	?	0	0	0	0	-	-	-
	5.9.4	Informal dumping of general waste*1*3	y	2.077	208	208	1.661	-	-	-
	5.9.5	Waste water system/treatment*2	y	143	0	143	0	0	0	0
5.10		**Source category: Crematoria and Cemetaries**								
	5.10.1	Crematoria/cremation	y	2	2	0	0	-	0	0
	5.10.2	Cemeteries	y	7	0	0	7	-	0	0
SUM OF QUANTIFIED INPUTS AND RELEASES *1*2*3*4				**88.019**	**18.244**	**24.346**	**44.858**	**965**	**442**	**11**

Notes:
**2: The estimated quantities include mercury in products which has also been accounted for under each product category. To avoid double counting, the release to land from informal dumping of general waste has been subtracted automatically in the TOTALS. *3: The estimated release to water includes mercury amounts which have also been accounted for under each source category. To avoid double counting, release to water from waste water system/ treatment have been subtracted automatically in the TOTALS.*

Table 4-2 Description and definition of the output pathways

Calculation result type	Description
Estimated Hg input, Kg Hg/y	The standard estimate of the amount of mercury entering this source category with input materials, for example calculated mercury amount in the amount of coal used annually in the country for combustion in large power plants.
Air	Mercury emissions to the atmosphere from point sources and diffuse sources from which mercury may be spread locally or over long distances with air masses; for ex-ample from: · Point sources such as coal fired power plants, metal smelter, waste incineration; · Diffuse sources as small scale gold mining, informally burned waste with fluorescent lamps, batteries, thermometers.
Water	Mercury releases to aquatic environments and to waste water systems: Point sources and diffuse sources from which mercury will be spread to marine environments (oceans), and freshwaters (rivers, lakes, etc.). for example releases from: · Wet flue cleaning systems from coal fired power plants; · Industry, households, etc. to aquatic environments; · Surface run-off and leachate from mercury contaminated soil and waste dumps
Land	Mercury releases to soil, the terrestrial environment: General soil and ground water. For example releases from: · Solid residues from flue gas cleaning on coal fired power plants used for gravel road construction; · Uncollected waste products dumped or buried informally · Local un-confined releases from industry such as on site hazardous waste storage/burial · Spreading of sewage sludge with mercury content on agricultural land (sludge used as fertilizer) · Application on land, seeds or seedlings of pesticides with mercury com-pounds
By-products and impurities	By-products that contain mercury, which are sent back into the market and cannot be directly allocated to envi-ronmental releases, for example: · Gypsum wallboard produced from solid residues from flue gas cleaning on coal fired power plants. · Sulphuric acid produced from desulphurization of flue gas (flue gas cleaning) in non-ferrous metal plants with mercury trace concentrations · Chlorine and sodium hydroxide produced with mercury-based chlor-alkali technology; with mercury trace concentrations · Metal mercury or calomel as by-product from non-ferrous metal mining (high mercury concentrations)
General waste	General waste: Also called municipal waste in some countries. Typically household and institution waste where the waste undergoes a general treatment, such as incin-eration, landfilling or informal dumping or burning. The mercury sources to waste are consumer products with intentional mercury content (batteries, thermometers, fluo-rescent tubes, etc.) as well as high volume waste like printed paper, plastic, etc., with small trace concentra-tions of mercury.
Sector specific waste treat-ment / disposal	Waste from industry and consumers which is collected and treated in separate systems, and in some cases recy-cled; for example. · Confined deposition of solid residues from flue gas cleaning on coal fired power plants on dedicated sites. · Hazardous industrial waste with high mercury content which is deposited in dedicated, safe sites · Hazardous consumer waste with mercury content, mainly separately collected and safely treated batte-ries, thermometers, mercury switches, lost teeth with amalgam fillings etc. · Confined deposition of tailings and high volume rock/waste from extraction of non-ferrous metals The country-specific waste treatment/disposal method is described for each sub-category in the detailed report sections below.

4. Identified hot-spots of mercury contamination (contaminated sites)

In the UNEP Guidelines, no specific standard is given to identify a hotspot, only subcategories with primary pathways of releases of mercury and recommended inventory approach is listed. For Suriname several subcategories are identified, that may have led to hot-spots of mercury contamination (See Table 5-1).

Table 5-1 Sub-categories present in Suriname that may have led to hot-spots

Chapter	Sub-Category	Air	Water	Land	Product	Waste/ Residue	Main invento-ry approach
8.2	Closed/abandoned chlor-alkali produc-tion sites	x	x	x		x	PS
7.1 & 7.2	Tailings/residue deposits from artisanal and large scale gold mining	x	x	x		x	PS
7.3	Tailings/residue de-posits from other non-ferrous metal extraction	x	x	x	x	x	PS

Notes:
PS = Point source by point source approach; OW = National/overview approach;
X - Release pathway expected to be predominant for the sub-category;
x - Additional release pathways to be considered, depending on specific source and national situation.

4.1 Closed or abandoned chlor-alkali production sites

The presence of historic chlor-alkali production waste should be verified. One company might have used mercury containing electrodes in its production process. This information has yet to be verified.

4.2 Tailings/residue deposits from artisanal and large scale gold mining

In the ASGM areas the tailings are not controlled and are directly deposited into the environ-ment. Some companies have taken control measures before waste is discharged into the envi-ronment.

For the large scale companies, the waste is collected into a controlled tailing pond, the overflow is discharged into the environment in a controlled matter.

An estimate of the extent of the area affected by ASGM can indirectly be deduced from satellite images (Stichtng Bosbeheer en Bostoezicht SBB, 2018).

Deforestation due to ASGM and Logging
Since 2000 SBB is monitoring deforestation due to ASGM and Logging via satellite images. These images are converted in to GIS programmes what makes combination of information possible. NIMOS produced two maps, showing deforestation and mining concessions, see figure 5.1 and 5.2 (Nationaal Instituut voor Milieu en Ontwikkeling in Suriname (NIMOS), 2018).
The total area of deforestation due to ASGM for the period of 2000 to 2016 is around 700.28 km2 (Nationaal Instituut voor Milieu en Ontwikkeling in Suriname (NIMOS), 2018)

Figure 5-1 Deforestation Map of Suriname in the Greenstone belt

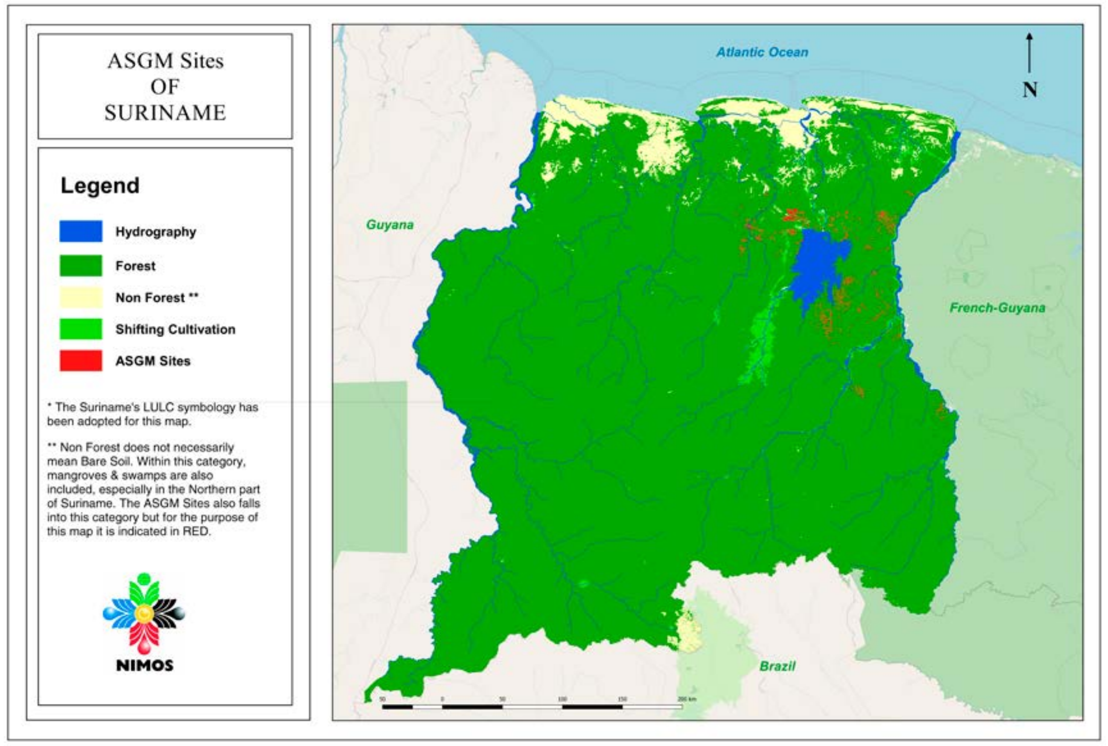
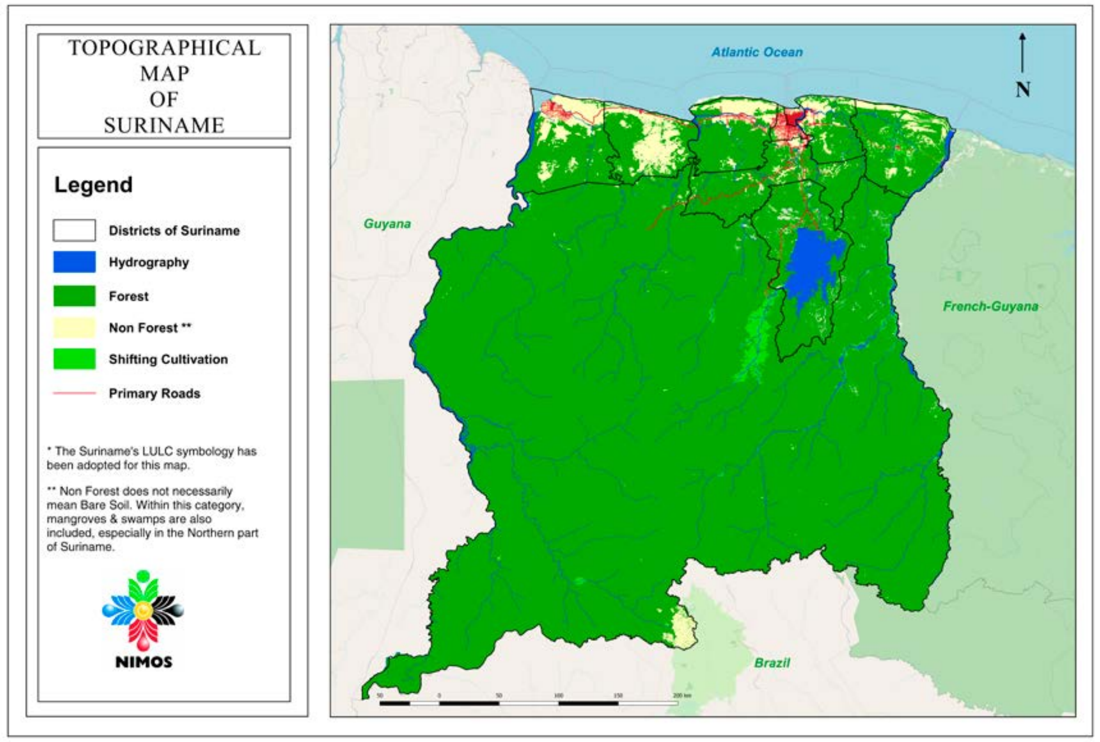


Figure 5-2 Deforestation with Mining Concession Area



Estimation of affected surface area vs amount of mercury released
It was estimated that a total maximum of 62.159 kg of mercury has been released into the environment each year due to ASGM, of which 16.267 kg was released to air, leaving 45.892 kg mercury released to land and water. The total area affected by ASGM was estimated based on deforestation data to be 700 km^2 .
Assuming further that only 10 % of this total area consists of areas where amalgamation took place, or where tailings were stored, we can estimate that 45.892 kg/70 km^2 = 656 kg Hg/km^2 was released each year. Assuming also that these activities have been going on for more than a decade, at least 8560 kg of mercury has been released per km^2 . The concentration of mercury in a top layer of 1 meter of soil would then be 8560 kg Hg/106 m^3 = 8,6 mg Hg/dm^3 . Assuming a density of the soil of 2 kg/dm^3 this would be equivalent to 2 ppm (mg/kg).

Conclusions
Pollution due to use of mercury in ASGM in Suriname can be linked to the fact that there is often no separate collection or treatment of tailings before release into the environment.
It is necessary that standards for permissible levels of mercury in air, water, soil and wastewater are developed at government level.
Furthermore, national guidelines and protocols should be developed on the identification of contaminated areas (hotspots) and the treatment of these areas.

4.3 Tailings/residue deposits from other non-ferrous metal extraction

Bauxite refining was in process up to the 4th quarter of 2015. The residue of the refining is collected in controlled mud lakes. The overflow of storm water is released in the environment in a controlled way. These mud lakes are now being rehabilitated.

4.4 Mercury Pollution research in Suriname

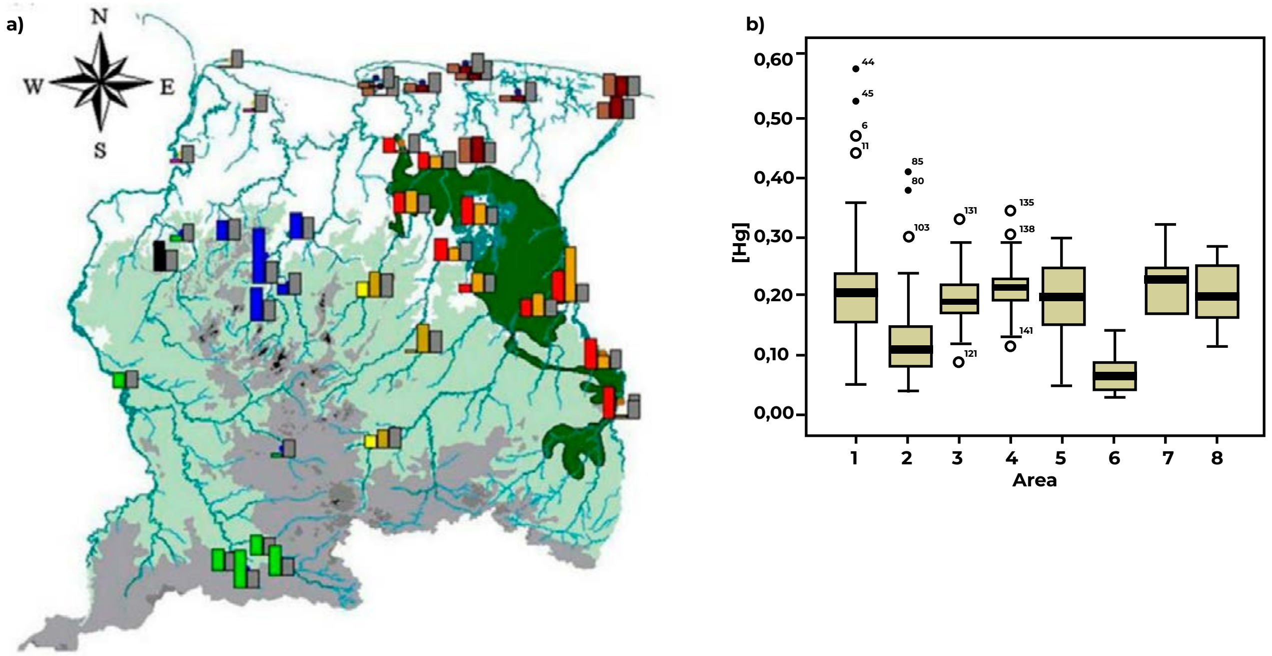
Research was done in Suriname of mercury pollution in air, water, river sediment, human hair and fish.

Some of these studies are:
- Urban mercury pollution in the City of Paramaribo, Suriname (Wip, et al., 2011)
- Community-led Assessment of Risk from Exposure to Mercury by Native Amerindian Wayana in Southeast Suriname (Peplow & Augustine, 2011)
- Review of mercury pollution in Suriname (Ouboter, 2015)

The general outcome of these studies is that there are elevated levels of mercury in air, water, river sediment, human hair and fish.

The following figures from Ouboters' review article (see figure 5.3 and 5.4) show mercury levels in sediment and fish for whole Suriname.

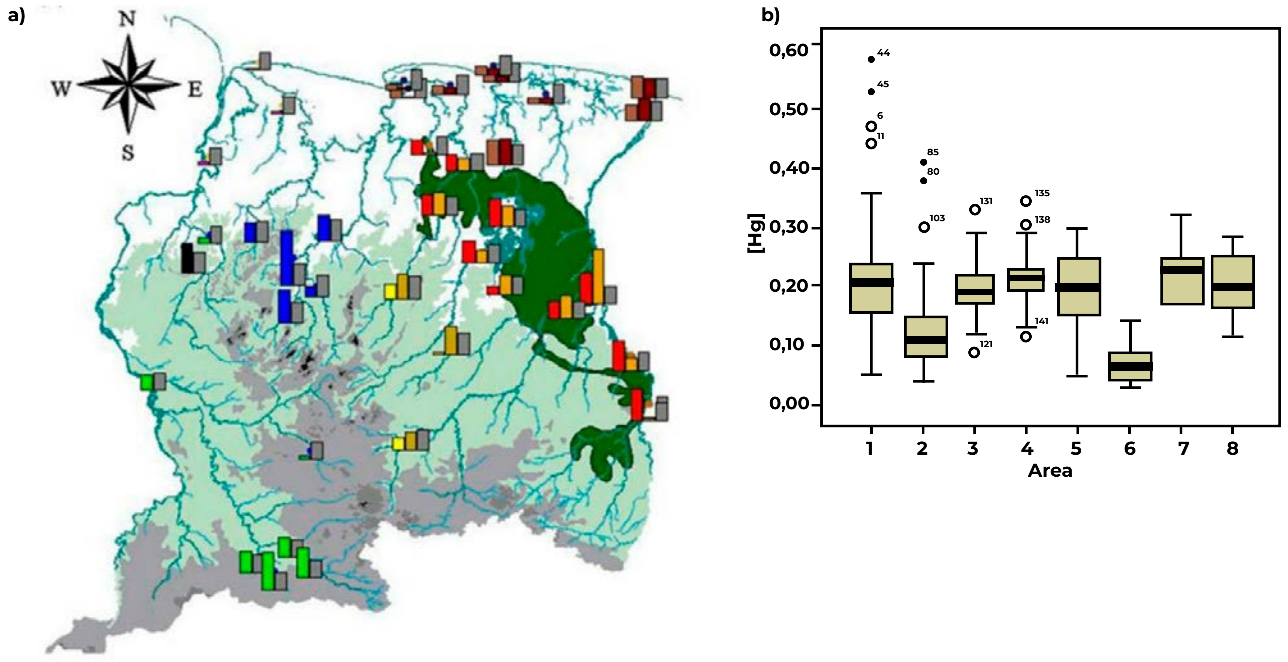
Figure 5-3 Average mercury levels found in sediments in different river systems in Suriname



a. Average mercury levels found in sediments in different river systems in Suriname; Color codes:
   Orange : Gold Mining Area (GMA)
   Yellow : Upstream Gold Mining Area (UGMA)
   Brown : Downstream Gold Mining Area (DGMA)
   Blue : Areas on the weather side of central west mountain range (PWS)
   Black : Areas on the lee side of central west mountain range, not draining the mountain range (PLS)
   Green : West/South-West Suriname (WSW)
   Pink : North West Suriname (NW)

b. Boxplot showing the distribution of mercury levels in sediment, measured in different areas. Codes for areas:
   1= GMA; 2= DGMA; 3= UGMA; 4= Brokopondo Reservoir (BR); 5= WSW; 6= NW; 7= PLS; 8= PWS

Figure 5-4 Average mercury levels found in piscivorous fishes in different river systems in Suriname



a. Average mercury levels found in piscivorous fishes in different river systems in Suriname; Color codes:
   Orange : Gold Mining Area (GMA)
   Yellow : Upstream Gold Mining Area (UGMA)
   Brown : Downstream Gold Mining Area (DGMA)
   Blue : Areas on the weather side of central west mountain range (PWS)
   Black : Areas on the lee side of central west mountain range, not draining the mountain range (PLS)
   Green : West/South-West Suriname (WSW)
   Pink : North West Suriname (NW)

b. Boxplot showing the distribution of mercury levels in piscivorous fishes, measured in different areas. Codes for areas:
   1= GMA; 2= DGMA; 3= UGMA; 4= Brokopondo Reservoir (BR); 5= WSW; 6= NW; 7= PLS; 8= PWS

5. Data and inventory on extraction and use of fuels/energy sources

5.1 Mineral oils-extraction, refining and use

5.1.1 Extraction and Refining of Mineral Oils

Staatsolie N.V. is a State owned oil company which extracts crude oil and refines the crude oil into different products (Heavy Fuel Oil (HFO), Staatsolie Diesel, Premium Diesel and Gasoline).

In its annual report of 2016, the production of crude oil was reported to be 5,98 Million barrels. (Staatsolie, 2018)
This was converted into tons of oil.
1 barrel oil = 0.136 ton oil. (CME group, 2018)
Production of crude oil in 2016 = 5, 98 *10^6 * 0.136 ton oil = 815.825 ton oil.

The calculations of kg Hg/y produced (extraction,)=
input factor (extraction) * year production.
The calculations of kg Hg/y produced from extraction =
3,4 mg Hg/t oil * 10^{-6} kg/mg*815.825 t oil/year = 3 kg Hg/y

The amount of crude oil refined in 2016 was 606.466 t oil (Ravenswaay, 2016)

The calculation of kg Hg/y produced by refining of oil is similar as above.

5.1.2 Use of Heavy oil and petroleum coke

Heavy fuel oil (HFO) is used in Suriname by some large companies with oil combustion facilities (e.g. State Power Company (EBS)) without emission controls. Newmont Suriname also uses HFO for the power plant operation. It is unknown if there are emission control factors incorporated. The amount of HFO used is 3.022.690 l/month= 36.272.280 litres/year HFO (sulphur >1%)= 1008 litres/ton. The amount HFO used per year in tons is: 36.272.280 l/year :1008 l/ton =35.985 ton/year (http://www.eurocbc.org/Standard%20Conversion%20Factors%20dti_converfactors.pdf)
The amount of the different fuels use in the excel file was extracted from the International Energy Agency (IEA) website (International Energy Agency, 2018).
The amount of heavy oil consumption was extrapolated from the “fuel oil” portion of the graph. The graph indicates that 1.5 cm = 100.000 ton oil. For the year 2015 it was calculated to be (4,4cm/1,5cm)*100000 ton oil =293.333 ton oil.

The calculations of kg Hg/y produced by the use of HFO is the same as for extraction and refining of oil, but the default input factor used is 20 mg Hg/t.

5.1.3 Use of Gasoline, diesel, light fuel oil, kerosene, LPG and other light to medium distillates.

These products are used in large companies and the transportation sector.
The amounts for these uses were extracted from the International Energy Agency (International Energy Agency, 2018).

The amount of these lighter fuel products is extrapolated from the IEA graph by combining the amounts of middle distillates, aviation fuels, gasoline and LPG in the graph and for the year 2015 the total amount is calculated to be (6,25/1,5)*100.000 = 411.666 ton oil
The calculations of kg Hg/y produced by the use of lighter oil products is the same as for extraction and refining of oil, but the default input factor used is 2 mg Hg/t

The calculations of mercury releases to air, water or other compartments are:
Input factor (compartment) * calculated kg Hg/y produced(extraction, refining, use).
For instance, the calculation of mercury release to water for the extraction phase is = 0.2* 3kg Hg/y = 0.6 kg Hg/y. Note, that the spreadsheet output sometimes gives a more precise number, due to rounding of number, as in this case it reports 0.55 kg Hg/y.

Data gaps and priorities for potential follow up
No information could be found on mercury content of mineral oil and oil products produced in or imported into Suriname. It is recommended that for future monitoring of mercury releases, these data become available.

Summary of inputs and results
A total of mercury release to air, water and sector specific treat-ment/disposal are respectively 7, 21; 0,58 and 0,31 kg Hg/year.
A summary of the inputs and releases is presented in table 6-1.

Table 6-1 Summary of results for extraction, refining and use of mineral oils

Mineral Oils-extraction, refining and use	Life Cycle Phase-Extraction of Mineral oils	Life Cycle Phase-Refining of mineral oils	Life Cycle Phase-Use of heavy oil and petroleum coke	Life Cycle Phase-Use of Gasoline, diesel, light fuel oil, kerosene, LPG and other light to medium distillates	Sum of releases to pathway from assessed part of life-cycle
Activity rate	815.825 t oil/y	606.466 t oil/y	293.333 t oil/y	411.666 t oil/y	NA
Input factor for phase*1	3,4 mg Hg/t oil	3,4 mg Hg/t oil	20 mg Hg/t oil	2 mg Hg/ t oil	NA
Calculated input for phase *2	3 kg Hg/y	2 kg Hg/y	6 kg Hg/y	1 kg Hg/y	NA
Output distribution factors for*3:					
Air	0	0,25	1	1	NA
Water	0,2	0,01	0	0	NA
Land	0	0	0	0	NA
Products	0	0	0	0	NA
General waste	0	0	0	0	NA
Sector specific treatment/ disposal		0,15	0	0	NA
Calculated out-put/releases to (kg Hg/y):					
Air	0,0	0,52	5,87	0,82	7,21
Water	0,55	0,02	0	0	0,58
Sector specific treatment/ disposal	0,0	0,31	0	0	0,31

Notes:
*NA – not applicable; 1: Level 2 default factor; 2: input = input factor *activity rate; 3: Level 2 default factors*

5.2 Natural gas- extraction, refining and use

Staatsolie produces natural gas for their own use and the production for 2015 is 531.991 SCFD (Standard Cubic Foot per Day) (ABS, 2016)
The conversion of SCF (Standard Cubic Foot per day) to Nm^3 (Normal cubic meter)= 0.0283. (Natural Gas Conversion Guide)
The amount of gas used per year (Nm3/year) is : 531.991 SCFD* 0.0283* 365 days = 5.495.201 Nm^3/year

The calculations of kg Hg/y produced (extraction, refining,) =
Input factor (extraction, refining,) *10^{-9} kg/µg* year production.
The calculations of kg Hg/y produced from use =
100 µg Hg/Nm^3 gas *10^{-9} kg/µg *5.495.201 Nm^3 gas/year = 1 kg Hg/y

The calculations of mercury releases to air, water or other compartments are:
Input factor (compartment) * calculated kg Hg/y produced(extraction, refining).
For instance, the calculation of mercury release to air for the extraction phase is
Input factor (air) * calculated kg Hg/y produced(extraction, refining,)= 0,2* 1kg Hg/y = 0,11 kg Hg/y.

The power company (EBS) imports and distribute gas.
The amount distributed for 2015 is 21.203.013 kg
The amount distributed for 2017 is 24.001.960 kg
19kg LPG= 9.365m^3/atm (20°C)
The conversion from kg to Nm^3 gas/ year =
9,365m^3/atm: 19kg * 21.203.013 kg= 10.450.854 Nm^3 gas/year

This amount was the input for the toolkit excel file. The factors used are from the reference guide of the toolkit.

The calculations of kg Hg/y produced (, use) =
Input factor (, use) * 10^{-9} kg/µg *year production.
The calculations of kg Hg/y produced from use =
0.22 µg Hg/Nm^3 gas *10^{-9} kg/µg *10.450.854 Nm^3 gas/year = 0 kg Hg/y

Data gaps and priorities for potential follow up
No information could be found on mercury content of gas produced in or imported into Suriname. It is recommended that for future monitoring of mercury releases, these data become available.

Summary of inputs and results
A total of mercury release to air, water, product and sector specific treatment/disposal for extraction/refining and use are respectively 1 kg Hg/year and 0 kg Hg/year
A summary of inputs and releases for natural gas is presented in table 6-2.

Table 6-2 Summary of results for natural gas extraction, refining and use

Natural-extraction, refining and use	Life Cycle Phase-Extraction/refining of Natural gas	Life Cycle Phase-Use of gas/ con-sumer quality	Sum of releases to path-way from assessed part of life-cycle
Activity rate	5.495.201 Nm³ gas/y	10.450.854 Nm³ gas /y	N/A
Input factor for phase*1	100 µg Hg/Nm3 gas	0,22 µg Hg/Nm³ gas	N/A
Calculated input for phase *2	1 kg Hg/y	0 kg Hg/y	N/A
Output distribution factors for*3:			
Air	0,2	1	N/A
Water	0,2		N/A
Product	0,5		N/A
Sector specific treatment/ disposal	0,1		N/A
Calculated out-put/releases to (kg Hg/y):			
Air	0,11	0	0,11
Water	0,11	0	0,11
Product	0,270	0	0,270
Sector specific treatment/ disposal	0,05	0	0,05

Notes:
*NA – not applicable; 1: Level 2 default factor; 2: input = input factor *activity rate; 3: Level 2 default factors*

5.3 Biomass fired power and heat production

Wood and charcoal are used for cooking purposes. Wood burning also takes place to produce land for agricultural purposes. The production of biomass and charcoal are respectively 254.315 t/ year and 60.158 t/year (G. Wesenhagen, 2017)

The default factors from the UNEP guideline are used.
The calculations of kg Hg/y produced (wood,) =
(input factor (wood,) * year production) : 1000
The calculations of kg Hg/y produced from wood =
0,03g Hg/t (dry weight) * 254.315 t Biomass(dry weight)/year : 1000 = 8 kg Hg/y

The calculations of kg Hg/y produced (charcoal combustion) =
input factor (charcoal combustion) * year production : 1000
The calculations of kg Hg/y produced from charcoal combustion =
0,12g Hg/t (dry weight) *60,158 t Charcoal(dry weight)/year : 1000 = 7 kg Hg/y
The calculations of releases to air from wood/biomass =
Input factor (air) * calculations kg Hg/y produced (wood).
The calculations of releases to air = 1 * 8kg Hg/y = 7,63 kg Hg/year

The calculations of releases to air from charcoal combustion =
Input factor (air) * calculations kg Hg/y produced (charcoal).
The calculations of releases to air = 1 * 7 kg Hg/y = 7,22 kg Hg/year

Data gaps and priorities for potential follow up
No specific information about mercury content in biomass burned and charcoal is available. It is recommended that for future monitoring of mercury releases, these data become available.

Summary of inputs and results
A total of mercury release to air for heat production based on wood and charcoal combustion are respectively 7,63 and 7,22 kg Hg/year.
A summary of inputs and releases for natural gas is presented in table 6-3.

Table 6-3 Summary of results for this category

Natural gas-extraction, refin-ing and use	Life Cycle Phase-Wood/biomass	Life Cycle Phase-charcoal	Sum of releases to path-way from assessed part of life-cycle
Activity rate	254.315 t biomass (dry weight)/y	60.158 t(dry weight)/y	N/A
Input factor for phase*1	0,03 g Hg/t (dry weight)	0,12 g Hg/t (dry weight)	N/A
Calculated input for phase *2	8kg Hg/y	7 kg Hg/y	N/A
Output distribution factors for*3:			
Air	1	1	N/A
Calculated out-put/releases to (kg Hg/y):			
Air	7,63	7,22	14,85

Notes:
*NA – not applicable; 1: Level 2 default factor; 2: input = input factor *activity rate; 3: Level 2 default factors*

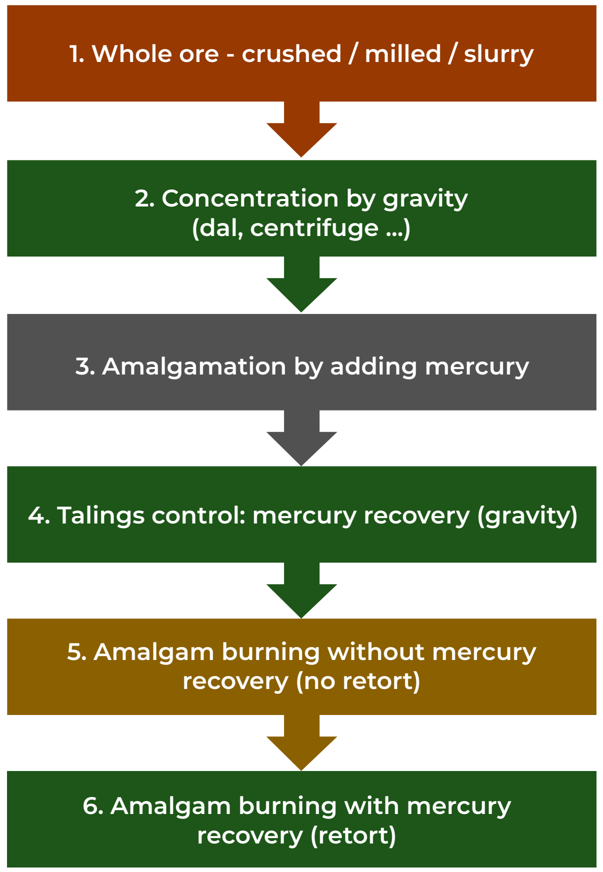
6. Data and inventory on primary (virgin) metal production

6.1 Gold and Silver extraction with mercury amalgamation processes

Artisanal and small-scale gold mining in Suriname (ASGM)
Around 40.000 persons are direct and indirect involved with ASGM activities in Suriname and 7342 persons are registered by OGS as employees directly involved with ASGM activities (OGS, 2018).
The government of Suriname gives concession rights according to the mining decree (E-58, 1986) (Government of Suriname, 2018). An unknown amount of ASGM miners are illegal and do not have concession rights (OGS, 2018) (GMD, 2017).

In the process of gold extraction with mercury amalgamation six steps can be discerned, that are not necessarily all in use or used in the order as presented in Figure 7.1.1. There are many variations of these steps that can differ in detail, technical complexity and effectiveness, but the following is a general description of the process.
The first step is processing the whole ore in order to produce a slurry.

Figure 7-1 Six steps in the process of gold ex traction with the use of mercury



Often excavators are used to collect the ore, which is then crushed and mixed with water to produce a slurry. Another much used technique is to loos-en alluvial material with water and pump the slur-ry to the next stage ('zuig en spuit').
The second step can be concentration of the oreslurry by gravitational forces; gold particles are heavier than other components in the slurry and have the tendency to sink. When the heavier part of the whole ore slurry is isolated from the rest, this is called concentration of the ore. This can be done by using a dal, also called sluice box or by equipment such as sha-king tables or centrifuges. Concentrating the whole ore slurry before adding mercury is considered best practice, but in many cases this is not done.
In order to isolate fine gold particles from other heavy components in the concentrate, the con-centrate is transferred to a separate container and mercury is added to the concentrate in order to bind gold; this is called "concentration amalgama-tion" and is the third step in figure 7-1. Sometimes however mercury is added before a concentra-tion step has taken place; whole-ore slurry is then fed through a container holding mercury. That is called "whole ore amalgamation". The slurry that leaves such a mercury holding container can carry free mercury with the stream; also at other stages in the process tailings are produced that can contain mercury, amal-gam and even gold residues. It depends then on the control measures taken in the operation to contain possible mercury release, how much mercury is lost in the process. These tailings control measures are step 4 in the diagram 7-1.

In order to get the gold, the amalgam (mix of mercury with gold) is isolated, often by using a batea, excess mercury is squeezed from the amalgam, and then the amalgam is heated ("burned") to evaporate the mercury. Practice is that this "burning' takes place in the open air, without using a device to recollect the evaporated mercury, called a retort (step 5 in the diagram). If a retort is used most of the mercury from the amalgam is recovered (step 6 in the diagram).

During their field visits, OGS is registering different equipment and techniques used in the different concession areas; the chosen techniques are based on ore grade and particle size of the ore. Some of these techniques used are:

- "Zuig en Spuit" method combined with a simple dal
- Crusher. Some companies also have other equipment available for extraction purposes next to crushers (e.g. ball mill, sieve) and sometimes they have concentration devices such as centrifuge and shaking table.
- "Isridal" (Seeve system, combined with crusher and/or ball mill to improve particle size)
- "Sumaje" (in stead of a sluice box the slope of a hill is used for gravitational concentration of ore)
- Skalian (Dredging system that mines ore in the rivers)
- Underground mining "Schagt"

Table 7-1 The number of equipment/ techniques registered by OGS

Equipment/ techniques	Number
Zuig en spuit	549
Crusher	656
Isridal	28
Sumaje	13
Excavator	503
Scalian	25

Some of the concession right holders are using different techniques on the same concession. Some of the mining right holders are using a retort to re-use the mercury and also to control mercury emissions. Due to high potential of criminal activities in the gold fields, most ASGM miners do not use a retort. (OGS, 2018).
The ore grade differs in different areas from 0.3- 2.5 g Au/ton ore. (Naarendorp, 2018) (Jbara, 2018) (Naana, 2018).
After the gold amalgam is heated to remove the mercury, the concession holder sells the gold to a gold buyer, who further purifies the received gold if necessary. Some of the gold buyers are also gold exporters. There are 6 gold exporters in Suriname according to a list of the Foreign Currency Commission (Deviezen Commissie) (Nationaal Instituut voor Milieu en Ontwikkeling in Suriname (NIMOS), 2018).
To have an idea of how much gold is sold in this sector, interviews were taken from different gold buyers and exporters (Cheung, 2018) (Issa, 2018) (Isaacs, 2018) (Hoever, 2018) (Tjon & Charles, 2017).
The gold buyers sell the gold to the gold exporter. The gold exporters melt the gold into bars. Some gold buyers/gold exporters already receive gold in bars that do not need melting. An estimated quantity of 10 - 40% of the gold comes from Guyana and/or French Guiana (Cheung, 2018) (Hoever, 2018). At Kaloti Mint House Suriname and Central Bank of Suriname the gold bars are tested for their purity. These gold bars are then exported to Dubai, Europa or Hong Kong.

The Central Bank registers the amount of gold that is exported.
The amount of gold bought by the exporters is between 250-400 kg Au/month/ exporter. This would result in a minimum annual amount of 6*12*250 = 18.000 kg of gold.
The average amount of gold exported registered by the Central Bank over the period (2010-2017) is 19.461 kg / year (Tjon Kie Sim, 2018).
Estimation of gold produced by OGS is 18.000 kg/ year (OGS, 2018).

OGS has a database where 35 areas are registered as gold mining activity areas where they register the number of employers and techniques. The numbers of areas known used for the calculations are 35-3 = 32 areas.
For 3 areas it is unknown what methods are used.
For the UNEP toolkit the extraction techniques are divided into 4 categories:

- Whole ore amalgamation without retort (WOA)
- Whole ore amalgamation with retort (WOAR)
- Concentrate amalgamation without retort (CA)
- Concentrate amalgamation with retort (CAR)

With the expertise of OGS estimations were made of what proportion of the gold extraction in each region falls under each one of these four UNEP categories. The different categories were then summarized and the results are presented in table 7-2. The second column gives the number of areas that use one of the four categories. The next columns express the used category of gold extraction as a percentage of the total areas. In this manner for Suriname's ASGM sector an estimated percentage is available of each of the four possible categories used. Details of this exercise can be found in appendix 2.

Table 7-2 Calculations of percentage of extraction category used in known ASGM areas (OGS, 2018)

Extraction category	# Areas	Percentage total(%) (area/35)*100	Percentage known (%) (area/32)*100
Whole ore amalgamation without retort	16,9	48	53
Whole ore amalgamation with retort	0,9	3	3
Concentrate amalgamation without retort	8,1	23	25
Concentrate amalgamation with retort	6,1	17	19
Unknown	3	9	
Total	**35**	**100**	**100**

The estimated gold production per extraction category is calculated as fol-lows:
Estimated gold production per category = "percentage known" * average yearly gold production (CBvS data)/100. The average yearly gold produc-tion registered at CBvS is 19.461 kg (Tjon Kie Sim, 2018).

The results of these calculations are presented in table 7-1.3

Table 7-3 Calculated yearly gold production per extraction category

Extraction category	Percentage known(%)	Yearly gold production (kg)
Whole ore amalgamation without retort	53	10.278
Whole ore amalgamation with retort	3	547
Concentrate amalgamation without retort	25	4.926
Concentrate amalgamation with retort	19	3.710
Total	**100**	**19.461**

The input factors to calculate kg Hg/ year produced by the different extraction categories and the output distribution factors for air, water and land to calculate the yearly mercury releases to air, water and land of the UNEP toolkit guidelines are used and presented in table 7-4 below

Table 7-4 Input factor and distribution factors for different extraction categories

Extraction category	Input factor (kg Hg/ kg gold produced)	Air distribution factor	Water Distribution factor	Land Distribution factor
Whole ore amalgamation without retort	5	0,2	0,4	0,4
Whole ore amalgamation with retort	4,25	0,06	0,47	0,47
Concentrate amalgamation without retort	1,3	0,77	0,12	0,11
Concentrate amalgamation with retort	0,55	0,45	0,28	0,27

The calculations of the amount of mercury produced per year per extraction category is as follow:
Calculated yearly mercury production per extraction category = input factor * yearly gold production of that extraction category. The results are presented in table 7-5.

Table 7-5 Calculated yearly mercury production per extraction category

Extraction category	Input factor (kg Hg/kg Au)	Yearly gold production (kg/y)	Calculated Yearly mercury procuction (kg Hg/ y)
Whole ore amalgamation without retort	5	10.278	51.390
Whole ore amalgamation with retort	4,25	547	2.324,75
Concentrate amalgamation without retort	1,3	4.926	6.403,8
Concentrate amalgamation with retort	0,55	3.710	2.040,5

The calculations of the amount of mercury releases to air, water and land per extraction category are as follows:
Mercury release to (air, water or land) = Calculated yearly mercury production per extraction category * distribution factor (air, water or land). The results of these calculations are presented in table 7-6

Table 7-6 Calculated mercury releases to air, water and land

Extraction category	Calculated mercury production (kg Hg/ y)	Distribution factor air	Distribution factor water	Distribution factor land	Calculated mercury releases air (kg/y)	Calculated mercury releases water (kg/y)	Calculated mercury releases land (kg/y)
Whole ore amalgamation without retort	51.390	0,2	0,4	0,4	10.278	20.556	20.556
Whole ore amalgamation with retort	2.324,75	0,06	0,47	0,47	139,49	1.092,63	1.092,63
Concentrate amalgamation without retort	6.403,08	0,77	0,12	0,11	4.930,93	768,46	704,42
Concentrate amalgamation with retort	2.040,5	0,45	0,28	0,27	918,23	571,34	550,94

Based on discussions with stakeholders in ASGM (SHMR) it was decided to make some differentiation in the four categories of extraction types. It was noted that a considerable number of miners have some degree of tailings control implemented, in which mercury is recovered. For instance after a dal (sluice box) there is a device in which excess mercury that has not formed an amalgam is recovered; it is often a simple pit or barrel at the end of the dal were mercury is retained by gravity (step 4 in figure 7-1). So instead of the four categories of extraction techniques as used in the level 2 spreadsheet, this number is doubled, depending on presence or absence of this fourth step in the process (see table 7-7). The result of applying tailings control is of course a reduced mercury input into the environment. The recovery of mercury in these simple devices was estimated to be 50% resulting in an decrease of input factors for whole ore amalgamation with 2 kg Hg/kg Au when tailings control is applied and with 0,3 kg Hg/kg Au for concentrate amalgamation with tailings control (see table 7.7). It was estimated (SHMR) that 50 – 70 % of all miners use this tailings control. Using a per-centage of 70 % application of tailings control, the total amount of mercury input of 62.159 kg of mercury is reduced with 27% to 45.190 kg Hg (see table 7-8).

Table 7-7 Subdivision of the four categories of extraction techniques from the UNEP level 2 toolkit

	Categories of extraction techniques							
Steps in ASGM process	**WOA**	**WOA***	**WOAR**	**WOAR***	**CA**	**CA***	**CAR**	**CAR***
1. Whole ore	1	1	1	1	1	1	1	1
2. Concentration	x	x	x	x	2	2	2	2
3. Amalgamation	3	3	3	3	3	3	3	3
4. Tailings control	x	4	x	4	x	4	x	4
5. Burning no retort	5	5	x	x	5	5	x	x
6. Burning with retort	x	x	6	6	x	x	6	6
Input factor (kg Hg/kg Au produced	5	3	4,25	2,25	1,3	1,0	0,55	0,25

WOA = Whole Ore Amalgamation, WOA = Whole Ore Amalgamation with tailings control*
WOAR = Whole ore amalgamation with use of retort; WOAR = whole ore amalgamation with use of retort and tailings control*
CA = concentrate Amalgamation, CA = Concentrate amalgamation with tailings control*
CAR = concentrate amalgamation with use of retort, CAR = concentrate amalgamation with use of retort and tailings control.*

Table 7-8 Calculation of Hg input with adjusted input factors for tailings control. Amount of gold produced per subcategory is based on 70 % of each extraction type uses tailings control.

Category	Input factor	Activity rate	Calculated Hg input
	kg Hg/kg gold produced	Gold produced, kg/y	Kg Hg/y
WOA	5	3.083,4	15,417
WOA*	3	7.194,6	21.583,8
WOAR	4,25	164,1	697,425
WOAR*	2,25	382,9	861,525
CA	1,3	1.477,8	1.921,14
CA*	1	3.448,2	3.448,2
CAR	0,55	1.113	612,15
CAR*	0,25	2.597	649,25
Total		**19.461**	**45.190,49**

Data gaps and priorities for potential follow up

Limited data are available for the amount of Hg used in different operations. Based on the default level 2 input factors an amount of 62.159 kg of mercury is released annually. This value could well be as low as 45.190 kg, when input factors are refined and other mercury recycling actions other than the use of retorts are also taken into account. These refined and lower estimates should be confirmed through field studies. Therefore, for the time being, the high end annual input value of 62.159 kg will be used.

Summary of inputs and results

The total releases to air, water and land from the four main extraction techniques mentioned in the level 2 toolkit are respectively 16.226,64 kg Hg/ year, 22.988,34 kg Hg/ year and 22.903,99 kg Hg/ year.

A summary of inputs and releases for gold extraction with mercury amalgamation is presented in table 7-9

Table 7-9 Summary of results for this category

Gold and silver extraction with mercury amalgamation processes	Life Cycle Phase-Whole ore amalgamation without retort	Life Cycle Phase-Whole ore amalgamation with retort	Life Cycle Phase-Concentrate amalgamation without retort	Life Cycle Phase-Concentrate amalgamation with retort	Sum of releases to pathway from assessed part of life-cycle
Activity rate	10278 kg Au/y	547 kg Au/y	4926 kg Au/y	3710 kg Au/y	N/A
Input factor for phase *1	5 kg Hg/kg Au produced	4,25 kg Hg/kg Au produced	1,3 kg Hg/kg Au produced	0,55 kg Hg/kg Au produced	N/A
Calculated input for phase *2	51.390 kg Hg/y	2.324,75 kg Hg/y	6.403,8 kg Hg/y	2.040,5 kg Hg/y	N/A
Output distribution factors for*3:					
Air	0,2	0,06	0,77	0,45	N/A
Water	0,4	0,47	0,12	0,28	N/A
Land	0,4	0,47	0,11	0,27	N/A
Calculated out-put/releases to (kg Hg/y):					
Air	10.278	139,49	4.930,93	918,23	16.266,64
Water	20.556	1.092,63	768,46	571,34	22.988,43
Land	20.556	1.092,63	702,42	550,94	22.903,99

Notes:
*NA – not applicable; 1: Level 2 default factor; 2: input = input factor *activity rate; 3: Level 2 default factors*

6.2 Gold extraction and initial processing by methods other than mercury amalgamation

There are three gold companies operating in Suriname under this subcate-gory, namely Newmont Suriname LLC, IAMGOLD- Rosebel Gold Mines N.V. and Grassalco.

Newmont Suriname LLC.

The commercial production at Newmont Suriname started on 1 October 2016. In 2017 511.000 troy ounces of gold were produced with a purity of 96-98 % (Graham, 2018).

The amount of ore processed for 2017 is approximately 12 Million tonnes. An online mercury monitor unit is installed in the refinery, which monitors the mercury levels at all times. A Sulphur Impregnated Carbon (SIC) scrub-ber system is attached to the refinery retort and the regeneration kiln. Fur-thermore a hand held mercury analyser is used to monitor the air levels on daily basis. Samples from the refinery sludge (calcine), before and after drying in the retort, are submitted to an external lab in Paramaribo for Mer-cury Analysis.

Systems (Mercury retort and Mercury Scrubbers) are in place to capture Mercury either in metallic form or onto Sulphur Impregnated Carbon (SIC).

Mercury trapped by the SIC scrubber system is analyzed and, if concentra-tions are low (< 100 ppm Hg), this is discharged into the Tailings Storage Facility (TSF). If concentrations are high (> 100 ppm Hg) the mercury load-ed SIC will be collected in 55 gallon steel drum. Metallic mercury will be collected in Mercury Flasks. Storage of both is on site in a secure facility until an appropriate third party disposal solution is identified. No metallic mercury or high mercury concentration SIC has been recovered to-date at Newmont Suriname Process plant. (Graham, 2018)

An ESIA study was conducted in 2013 based on NIMOS guidelines . In that study the area immediately surrounding the concession was identified as an area that has been significantly modified by artisanal and small-scale mining activities. As stated in the ESIA, a baseline study was conducted and the mercury concentrations in several soil and sediment samples were de-ter-mined. The mean mercury concentration of ten soil samples was 231, 1 µg/kg (= 0,231 g Hg/ton), ranging from 0,100 to 0, 357 g/ton. The average mercury concentrations in three different watersheds ranged from 0.2 – 1 g Hg/ton sediment with maximum values of 2 g/ton (SURGOLD - MERIAN, 2012). There are no other data known about mercury contents in ore that is currently being processed at the Merian mine.

The UNEP level 2 toolkit uses a default factor for mercury input of 15 g Hg/ton ore. In light of the data presented in the ESIA it was decided to use an input factor of 1 g Hg/ton ore, which is the minimum amount that the toolkit shows. The amount of ore processed in 2017 is also entered as an input.

The amount calculated mercury input = factor * processed ore/ 1000.

The amount calculated mercury input for Newmont = 1g Hg/t ore used * 12.000.000 tonnes/ year: 1000= 12.000 kg Hg per year.

The distribution factors

Based on studies conducted in USA in different gold mines regarding mercury releases to air, water, land and product the reference report for the toolkit uses the factors as presented in table 7-2.1

Table 7-10 Preliminary default output distribution factors for mercury from extraction of gold from ore without amalgamation.

Phase of life cycle	Air *1	Water *1	Land *1	Product *1	General waste	Sector specific treatment/ disposal *1
Mining and production of gold from ore	0,04	0,02	0,9	0,04	?	?

Notes:
*NA – not applicable; 1: Level 2 default factor; 2: input = input factor *activity rate; 3: Level 2 default factors *1 Mercury retention and deposition of residues will likely vary much between countries and individual facilities. The releases to land may likely be dominating; the distribution of the remai-*
ning mercury outputs on air, water and product (mercury for marketing) is artificial, and is only aimed at raising the signal that substantial mercury amounts may follow these pathways.

Notes:
**1 Based on national data for the USA only; may be associated with substantial uncertainties.*

Due to the fact that Newmont Suriname uses air filters in their production system, the default release factors to air and water were changed from 0,04 and 0,02 into respectively 0.01 and 0.05. The calculations for releases to air, water, land and product are calculated as follow:
To air: air factor * kg Hg calculated /year= 0, 01 *12.000 kg Hg/year =120 kg Hg/ year.

To water: water factor * kg Hg calculated/year = 0, 05 * 12.000 kg Hg/year = 600 kg Hg/ year.

To land: land factor * kg Hg calculated/ year = 0, 9 * 12.000 kg Hg/ year =10.800 kg Hg/year.

To product: product factor * kg Hg calculated / year = 0,04 * 12.000 kg/Hg/year = 480 kg Hg/ year.

IAMGOLD- Rosebel Gold Mines N.V. (RGM)
This gold mining company started commercial production in April 2004.
For 2017 the gold production was 300.000 troy ounces. Before the company was in operation, small scale gold miners were already active in that area. An ESIA study for the initial operation was conducted in September 2002. Later ESIA studies were also done based on NIMOS guidelines.
There is no information available to date, regarding natural mercury concentration in ore, soil or sediment, that could be used to verify the input factor. The presence of mercury emission control systems was reported by RGM, but could not be verified to date.
Although no data of possible mercury content of the processed ore at Rosebel mine are available, the same input factor as for Merian mine is used, namely the 1 g Hg/ton ore instead of the toolkit default input factor of 15 g Hg/ton ore.
The amount of ore processed for 2017 is approximately 12 Million tonnes (IAmGold Rosebel Gold MInes, 2018). The minimum input factor that the toolkit uses and the amount of ore processed in 2017 are used as an input in the toolkit.

The amount calculated mercury input = factor * processed ore/ 1000.
The amount calculated mercury input for RGM = 1g Hg/t ore used
* 12.000.000 tonnes/year : 1000 = 12.000 kg Hg per year

The distribution factors
Based on studies conducted in USA in different gold mines regarding mercury releases to air, water, land and product the reference report for the toolkit uses the factors presented in table 7-2.2.

1 NIMOS Generic and Mining Guidelines, 2009)

Table 7-11 Preliminary default output distribution factors for mercury from extrac-tion of gold from ore without amalgamation.

Phase of life cycle	Air *1	Water *1	Land *1	Product *1	General waste	Sector specific treatment/ disposal *1
Mining and production of gold from ore	0,04	0,02	0,9	0,04	?	?

Notes:
**1 Mercury retention and deposition of residues will likely vary much between countries and individual facilities. The releases to land may likely be dominating (see data above); the distribution of the remaining mercury outputs on air, water and product (mercury for marketing) is artificial, and is only aimed at raising the signal that substantial mercury amounts may follow these pathways.*

Notes:
**1 Based on national data for the USA only; may be associated with substantial uncertainties.*

The calculations for releases to air, water, land and product using the default output distribution factors from table 7-2.2 are calculated as follow:
To air: air factor * kg Hg calculated / year= 0,04 *12.000 kg Hg/year = 480 kg Hg/ year.

To water: water factor * kg Hg calculated / year= 0,02 * 12.000 kg Hg/year = 240 kg Hg/ year.

To land: land factor * kg Hg calculated / year = 0,9 * 12.000 kg Hg/ year =10.800 kg Hg/year.

To product: product factor * kg Hg calculated / year=0,04 * 12.000 kg/Hg/year = 480 kg Hg/ year.

Grassalco (Grasshopper Aluminium Company)
Grassalco is a government owned company. Their gold mining operation is located at Mari-paston (District of Para). Before the company's gold mining activities were in operation small scale gold miners were already active in that area. Until recently the company used the old tailings of these deserted ASGM sites for their operations. No mercury is added in their operation to amalgamate the gold. A crusher, centrifuge, ball mill and shaking table are used to produce the gold concentrate. The captured gold is melted with borax (chemical) into a gold bar. The average amount of ore processed in the operation in 200m^3 ore/ day. This is on a yearly base 66.000 tonnes ore (minus holidays and maintenance). For 2017 the gold production was 4 kg a month. There is no information regarding mercury concentration in ore or creek sediment known. The minimum concentration of mercury in ore used in the toolkit is also used for Grassalco to make the calculations which is 1 g Hg/ton ore. The amount ore processed for 2017 is approximately 66.000 tonne ore (Forster, 2018). The minimum input factor that the toolkit uses and the amount ore processed in 2017 is used as an input in the toolkit.

The amount calculated mercury input = factor * processed or/ 1000.
The amount calculated mercury input for Grassalco =
1g Hg/t ore used * 66.000 tonnes ore / year : 1000= 66 kg Hg per year

The distribution factors
Based on studies conducted in USA in different gold mines regarding mercury releases to air, water, land and product the reference report for the toolkit uses the factors presented in table 7-2.3.

Table 7-12 Preliminary default output distribution factors for mercury from ex-traction of gold from ore without amalgamation.

Phase of life cycle	Air *1	Water *1	Land *1	Product *1	General waste	Sector specific treatment/ disposal *1
Mining and production of gold from ore	0,04	0,02	0,9	0,04	?	?

Notes:
**1 Mercury retention and deposition of residues will likely vary much between countries and individual facilities. The releases to land may likely be dominating (see data above); the distribution of the remaining mercury outputs on air, water and product (mercury for marketing) is artificial, and is only aimed at raising the signal that substantial mercury amounts may follow these pathways.*

Notes:
**1 Based on national data for the USA only; may be associated with substantial uncertainties.*

The calculations for releases to air, water, land and product are calculated as follow:
To air: air factor * kg Hg calculated /year= 0, 04 *66 kg Hg/year =2.64 kg Hg/ year.

To water: water factor * kg Hg calculated/year= 0, 02 * 66 kg Hg/year = 1.32 kg Hg/ year.

To land: land factor * kg Hg calculated/ year = 0, 9 * 66 kg Hg/ year =59.40 kg Hg/year.

To product: product factor * kg Hg calculated / year= 0,04 * 66 kg/Hg/year = 2.64 kg Hg/ year.

Identified point sources of mercury release for gold extraction without amalgamation are presented in table 7-2.4

Table 7-13 Identified point sources for extraction of gold from ore without amalgamation.

Name of specific source	Location	Activity rate	Input factor(s)	Pollution abatement systems	Output distribution factors	Stack height(s) in meter
Newmont Suriname LLC Merian Mine	District Sipaliwini	12.000.000 tonnes/y	For all companies a minimum mercury concentration in ore of 1 g Hg/ ton ore has been used, based on scarce analytical data	Only Newmont proved presence of mercury recovery system. All have tailing pond and dry stack-ing of ore over-burden	Default releases factors for air and water for Newmont Suriname is changed to respectively 0.01 and 0.05 due to air filter in production system. Default factors were used for the other companies, as well as for other compartments	No information available
Iamgold Rosebel Gold Mines NV	District Brokopondo	12.000.000 tonnes/y				No information available
Grassalco	District Para	66.000 tonnes/y				No information available

Data gaps and priorities for potential follow up
It should be noted that the input factors used are estimates and associated with substantial uncertainties. They primarily serve to raise awareness that mercury can be released during the process, and that this mercury can eventually end up in the atmosphere, water, land, products, general waste or sector specific treatment/disposal.

No data were available for Hg concentration in ore for IAMGold and Grassalco operations. Also no actual mercury concentrations of ore processed at Newmont mine were provided. Even when mercury recovery systems are in place, these should be monitored since they are seldom 100 % efficient.

In order to provide a better insight in real mercury input and distribution factors it is suggested that scientifically based, good quality quantitative data on mercury streams during large gold extraction operations are generated. This should preferably be done on an international scale, compiling data from different countries.

Summary of inputs and results
A summary of total input and releases to air, water, land and product from all 3 production plants are presented in Table 7-2.5.

Table 7-14 Summary of results for extraction of gold from ore without amalgamation.

Gold extraction and initial pro-cessingby methods other than mercury amalgamation	Point source			Sum of releases to pathway from assessed part of life-cycle
	Newmont Suriname LLC	IAmGold RGM	Grassalco	
Activity rate Input factor for phase *1 Calculated input to phase *2	12.000.000 t ore used/ year 1g Hg/ t ore used 12.000 kg Hg/ year	24.000.000 t ore used/ year 1g Hg/ t ore used 12.000 kg Hg/ year	66.000 t ore used/ year 1g Hg/ t ore used 66 kg Hg/ year	N/A N/A N/A
Output distribution factors for phase *3: - Air - Water - Land - Products - General waste treatment - Sector specific waste treatment	 0,01 0,05 0,9 0,04 N/A N/A	 0,04 0,02 0,9 0,04 N/A N/A	 0,04 0,02 0,9 0,04 N/A N/A	 N/A N/A N/A N/A N/A N/A
Calculated outputs/releases to (kg Hg/ year): - Air - Water - Land - Products	 120 600 10.800 480	 480 240 10.800 480	 2,64 1,32 59,40 2,64	 602,64 841,32 21.659,40 962,64

Notes:
*N/A – not applicable; 1: Level 2 default factor; 2: input = input factor *activity rate; 3: Level 2 default factors*

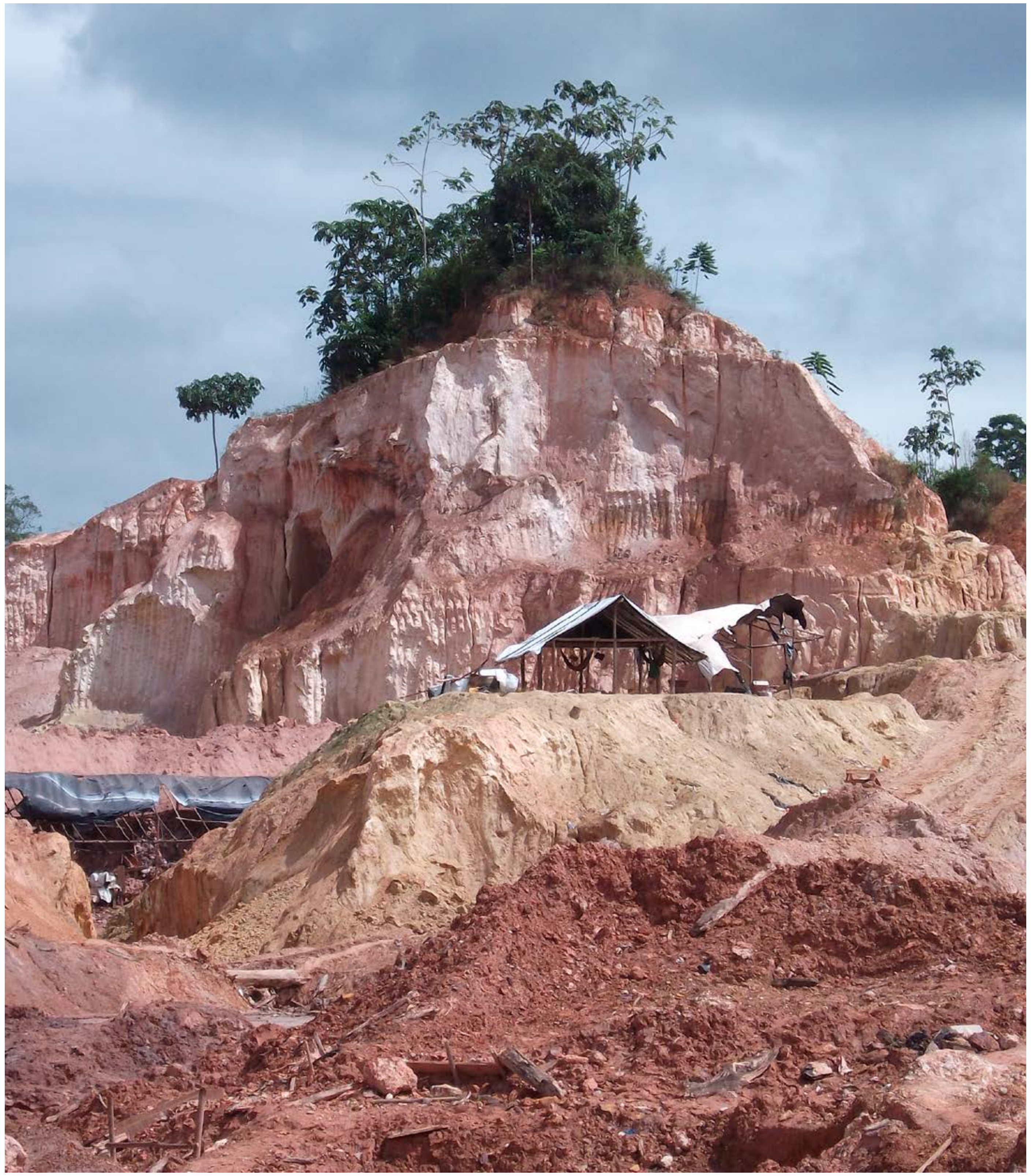
6.3 Aluminium extraction and Initial Processing

6.3.1. Alumina production from bauxite
Alumina production from Bauxite took place from the 1960's until 2015, when the plant of Suralco LLC, a subsidiary of Alcoa LLC, closed its production. At that time mercury was partially recovered and exported to Europe and USA (Emanuels, 2018) and partially settled in the mud lakes. At this moment rehabilitation of the mud lakes is in process. These old mud lakes could be identified as possible hotspots (see Chapter 5)
In table 7-3.1 data are presented of the production of bauxite and alumina and also the alumina export for the period 2011-2015 (Algemeen Bureau voor de Statistiek, 2016).

Table 7-15 Overview bauxite and alumina production in metric tons(mt)

Production	2011	2012	2013	2014	2015
Bauxite	3.236	2.874	2.671	2.708	1.854
Alumina	1.421	1.203	1.149	1.149	780
Alumina export	1.411	1.202	1.146	1.161	769

6.3.2. Alumina production from alumina
During the 1960's until 1990's, there was also an aluminium plant which produced aluminium. Spent pot linings are buried in a controlled land fill of Suralco LLC .



7. Data and inventory on intentional use of mercury in industrial processes

7.1 Production of other minerals and materials with mercury impurities

7.1.1 Cement Production

Currently there are five (5) Surinamese cement production companies, without lime combustion. The only activities that take place in their production processes are the mixing of raw materials, such as clinker, gypsum and other materials and packaging. For the purposes of this Inventory lime combustion is identified as the required process for mercury releases according to the Toolkit guidelines. The amount of the imported materials for the year 2017 are given below in table 8-1. (Inspectie der Invoerrechten en Accijnzen, 2018)

Table 8-1 Import data of raw materials for cement production for 2017

HS_Code	Net_Mass(kg)	Description
25210000	161.980	Limestone flux; ... used for manu-facture of lime or cement
25231000	39.744.505 *	Cement clinkers
25232100	141687	White cement
25233000	125	Aluminous cement
25239000	11195	Other hydraulic cements

** From this amount 134 kg cement clinker was exported in 2017.*

7.1.2 Pulp and Paper Production

In Suriname there are no large paper production facilities, most paper products are imported. There may be one active paper recycling company, this could not yet be verified.

Data gaps and priorities for potential follow up

Presence and used processes of paper recycling facility must be checked.

7.2 Intentional use of mercury in production processes

7.2.1 Chlor-alkali production with mercury technology

There are two companies in Suriname that produce chlorine bleach. Based on information received from one company (Consolidated Industries Corporation, CIC) there is no use of mercury within their production processes (Healy, 2017). From the other company (H.J. de Vries) no information was received.

8. Data and inventory on consumer products with intentional use of mercury

Production
In Suriname no consumer products are produced with intentional use of mercury. Only use and disposal of such products takes place.

8.1 Thermometers with mercury

Use and disposal
According to the registered import information from the Customs Department (Inspectie der Invoerrechten en Accijnzen, 2018), two types of thermometers were imported in 2017, see table 9-1. It must be noted, that the Harmonised System (HS) Codes on the requested data list is not equal to the currently in CARICOM used Common External Tariff Codes CET 2007. The specifically requested HS codes for mercury filled thermometers were sub-categories of the CET 2007 codes, namely 9025.1120, 9025.1180, 9025.1920 and 9025.1980. Therefore the imported amount of thermometers probably includes all types, both mercury filled or filled with other liquids (see table 9-1). Also no additional data could be extracted from these import data about ambient air thermometers and industrial and special thermometers.

Table 9-1 Customs Department data of imported thermometers in 2017

Caricom External Tariff code 2007	Amount imported in kg	Description of goods
90251100	509	Thermometers, liquid filled (clinical, veterinary)
90251900	1.869	Other thermometers, liquid filled

Since the shift from mercury containing thermometers to other types of thermometers is already in process, both in medical use and in laboratory use, for further calculations of mercury input and release, an estimate must be made of what proportion of the total amount of imported thermometers contain mercury. A cautious estimate is that still 80% of imported thermometers contain mercury.

The spreadsheet uses as input the number of thermometers imported, so based on the estimated mass of a thermometer the amount of items imported was calculated. For medical thermometers one item has a mass of 8 gram and including the plastic cover of 15 gram. Based on this a minimum and maximum amount of items was calculated, as well as an average amount. This average amount of items was used as activity rate input in the spreadsheet.

For laboratory thermometers a net average mass was determined (Mangre, 2018) of 24,7 gram and a gross mass including packaging is estimated to be 50 gram.

The minimum amount of thermometers is 0.8 * imported amount (kg) divided by gross mass of a thermometer in kg.

The maximum amount of thermometers is 0.8 * imported amount (kg) divided by the net mass of a thermometer in kg.

The activity rate used is the average amount of items, calculated by adding minimum and maximum amount and dividing by two. The results of these calculations are shown in table 9-2

Table 9-2 Calculation of activity rate for thermometers

CET code	Amount imported (kg)	Percentage Hg containing (kg)	Min. Amount of items	Max amount of items	Average amount = input in spreadsheet
90251100	509	407	50850	27120	38985
90251900	1869	1495	60543	29908	45226

When default values for input factors are used in the spreadsheet, combined with the above estimated input rate, the annual amount of mercury input into the environment is calculated. In order to verify these estimates and assumptions, another calculation was made of the amount of mercury output, based on mass percentage of mercury in a thermometer. For medical thermometers the mass percentage is 1g Hg/8 g * 100 = 12,5 %. For lab thermometers the amount of mercury per thermometer was estimated to be 1 ml which equals 1 ml * 13,546 g/ml = 13,546 g of mercury, resulting in an average mass percentage of 13,546 g Hg/24,74 g * 100 = 55 %.

Results of both ways of calculating mercury input from thermometers is presented in table 9-3. Both calculations are of the same order of magnitude.

Table 9-3 Verification of estimated mercury input from thermometers

CET code	Amount imported (kg)	Percentage Hg containing (kg)	Min. Amount of items	Max amount of items	Average amount = input in spreadsheet
90251100	509	407	38985	39	51
90251900	1869	1495	45226	927	822

When thermometers break or have become unusable, usually there is no special waste disposal procedure, so it is expected that it ends up mixed with general waste. Therefore for disposal the option "(a2) No separate collection. Informal waste handling widespread" has been used.

Data gaps and priorities for potential follow up
There were a number of uncertainties in determining the input rate for thermometers as described above.

More specific import data are needed, according to the HS codes, to know precisely how many mercury containing thermometers are imported. Also assumptions on net mass and gross mass of these thermometers need to be established more precisely in order to estimate amounts of mercury released.

Also import data over more years are needed to see if the import data for 2017 were similar to other years.

Summary of inputs and results
Summary of inputs and results are presented in Table 9-4.

Table 9-4 Summary of inputs and results for Thermometers with mercury

Thermometers with mercury	Medical use and disposal	Other use and disposal	Sum of releases to pathway from assessed part of life-cycle
Activity rate	38.985 items/yr	45.226 items/yr	-
Input factor for phase	1 g Hg/item	20,5 g Hg/item	-
Calculated input to phase	39 kg Hg/yr	927 kg Hg/yr	-
Output distribution factors for phase:1)			
- Air	0,2	0,2	NA
- Water	0,3	0,3	NA
- Land	0,2	0,2	NA
- Products	0	0	NA
- General waste treatment	0,3	0,3	NA
- Sector specific waste treatment	0	0	NA
Calculated outputs/ releases in kg/yr to:			
- Air	7,8	185,43	193,22 kg/yr
- Water	11,7	278,14	289,84 kg/yr
- Land	7,8	185,43	193,22 kg/yr
- Products			0
- General waste treatment	11,7	278,14	289,84 kg/yr
- Sector specific waste treatment			0

1) for category "(a2) No separate collection. Informal waste handling widespread"

8.2 Electrical switches and relays with mercury

Use and disposal
Electrical switches and relays can contain mercury. As activity rate the UNEP Toolkit level 2 spreadsheet uses the amount of inhabitants after a correction is made for the percentage of the population with access to electricity. The estimated mid-year population of 2015 is 567.291 inhabitants (Algemeen Bureau voor de Statistiek, 2016) and according to the country specific data in Appendix 8.4 of the Reference report for the Level 2 toolkit, 84 % of the population in Suriname has access to electricity (UN Environment, 2017).

Default activity rate, corrected for the national electrification rate of 84% and an input factor of 0,14 g Hg/(y*inhabitant) are used to calculate an amount of 67 kg of mercury released into the environment. Since Suriname does not have a sound waste management system, default output distribution factors are used for category "(a2) No separate collection. Informal waste handling widespread".

Mercury input is calculated according to the following formula:

Mercury input = (Input factor * activity rate)/1000 *
(Percent of population with access to electricity)/100

Data gaps and priorities for potential follow up
No data gaps were identified.

Summary of inputs and results
Summary of inputs and results are presented in Table 9-5.

Table 9-5 Summary of input and results for Electrical switches and relays with mercury

Electrical switches and relays with mercury	Use and disposal	Sum of releases to pathway from assessed part of life-cycle
Activity rate Input factor for phase Calculated input to phase	567.291 inhabitants 0,14 g Hg/(y*inhabitant) 67 kg/yr	- - -
Output distribution factors for phase:1) - Air - Water - Land - Products - General waste treatment - Sector specific waste treatment	 0,3 0,4 0,3 0	 NA NA NA NA NA NA
Calculated outputs/ releases in kg/yr to: - Air - Water - Land - Products - General waste treatment - Sector specific waste treatment	 20,01 kg/yr 0 26,69 kg/yr 0 20,01 kg/yr 0	 20,01 kg/yr 0 26,69 kg/yr 0 20,01 kg/yr 0

1) for category "(a2) No separate collection. Informal waste handling widespread"

8.3 Light sources with mercury

Use and disposal

According to the registered import information from Customs Department (Inspectie der Invoerrechten en Accijnzen, 2018), four types of light sources are imported in 2017, see table 9-6. It must be noted, that the HS Codes on the requested data list is not equal to the currently used CET 2007 commodity codes. The specifically requested HS codes for mercury containing light sources were sub-categories of the CET 2007 codes, namely 85393110, 85393190, 89393210, 85393900, 85394910 and 85394930, see table 9-7. In table 9-8 is shown how the reported import data were merged in the requested categories of the spreadsheet.

Table 9-6 Customs Department data of imported light sources with mercury in 2017

Caricom External Tariff code 2007	Amount imported in kg	Description of goods
85393100	9122	Fluorescent, hot cathode
85393200	360	Mercury or sodium vapour lamps; metal halide lamps
85393900	47806	Other
85394900	3663	Ultra-violet or infra-red lamps ; arc-lamps

Table 9-7 Specification of requested HS codes for mercury containing light sources

HS codes requested	Description of goods
85393110	Fluorescent, hot cathode, with double ended cap
85393190	Fluorescent, hot cathode, excl with double ended cap
85393210	Mercury vapour lamp
85393900	Discharge lamps (excl of other mentioned categories)
85394910	Ultraviolet lamps
85394930	Infrared lamps

Table 9-8 Data filled into the spreadsheet for light sources

Categories in spreadsheet	CET code 2007	Mass of imported goods kg
Fluorescent tubes (double end)	85393100	9.122
Compact fluorescent lamp (CFL single end)	85393900	4.7806
High pressure mercury vapour	85393200	360
High pressure sodium lamps		0
UV light for tanning	85394900	3.663
Metal halide lamps		0

For the calculation of number of items out of mass, the following method was used.
The mass of a regular fluorescent tube is 130 g and of a long tube equals 230 g; dividing imported mass by weight gives a minimum and maximum value for amount of imported fluorescent tubes. The average number of these two is then used as activity rate in the spreadsheet.
A similar calculation was done for the other types of light sources; for lack of data similar minimum and maximum weights per lamp type were as-sumed.

Mercury input is then calculated as follows:
Calculated Hg input = (average items/yr) * input factor (mg) /1.000.000 kg
Results are shown in table 9-9

Table 9-9 Calculation of activity rate for light sources and Hg input for the spreadsheet

Time	Max items/yr	Min items/yr	Average items/yr	input factor mg/item	calculated Hg input in kg
85393100	70103	39623	54863	25	1,4
85393200	2765	1563	2164	30	0,1
85393900	367740	207853	287796	10	2,9
85394900	28177	15926	22052	15	0,3

Total mercury release into the environment due to use and disposal of light sources is 4,6 kg which is reported in the spreadsheet as 5 kg.

Since Suriname does not have a soundwaste management system, default output distribution factors are used for category "(a2) No separate collection. Informal waste handling widespread".

Data gaps and priorities for potential follow up

Because Customs Department does not yet have a detailed registration according to the HS codes mentioned above, several assumptions and estimations had to be made, resulting in some uncertainty in the calculated data.

Summary of inputs and results

A summary of inputs and releases to different phases are presented in table 9-10.

Table 9-10 Summary of inputs and results for light sources with mercury

Lightsources with mercury	Use and disposal several categories	Sum of releases to pathway from assessed part of life-cycle
Activity rate Input factor for phase Calculated input to phase	2.164 – 287.796 items/yr 10 – 30 mg/item 5 kg Hg	- - -
Output distribution factors for phase:1) - Air - Water - Land - Products - General waste treatment - Sector specific waste treatment	 0,3 0 0,3 0 0,4 0	 NA NA NA NA NA NA
Calculated outputs/ releases in kg/yr to: - Air - Water - Land - Products - General waste treatment - Sector specific waste treatment	 1.39 kg/yr 0 1.39 kg/yr 0 1.86 kg/yr 	 1.39 kg/yr 0 1.39 kg/yr 0 1.86 kg/yr 0

1) for category "(a2) No separate collection. Informal waste handling widespread"

ww8.4 Batteries with mercury

Use and disposal

According to the registered import information from Customs Department (Inspectie der Invoerrechten en Accijnzen, 2018), seven types of batteries are imported in 2017, see table 9-11. It must be noted, that the HS Codes on the requested data list are not equal to the currently in CARICOM used CET 2007 commodity codes. The specifically requested HS codes for batteries are presented in table 9-12.

Table 9-11 Customs Department data of imported batteries in 2017

Caricom External Tariff code 2007	Amount imported (kg)	Type of battery
85061000	48693	Mangane dioxide cells, a.o.
85063000	415	Mercuric oxide cells
85064000	59	Silver oxide cells
85065000	4981	Lithium cells
85066000	7051	Air-zinc cells
85068000	629123	Other primary cells and primary batteries / dry zinc-carbon batteries
85069000	1406	Parts of primary cells and batteries

Table 9-12 Specification of requested HS codes for mercury containing batteries

Toolkit references
5.5 Consumer products with intentional use of mercury
5.5.4 Batteries with mercury

The articles which do not contain mercury (mentioned in the custom tariff) should be analyzed.

8506 10 11	Manganese dioxide cells and batteries, alkaline, in the form of cylindrical cells (excl. spent)
8506 10 15	Manganese dioxide cells and batteries, alkaline, in the form of button cells (excl. spent)
8506 10 19	Manganese dioxide cells and batteries, alkaline (excl. spent, and in the form of cylindrical cells and button cells)
8506 10 91	Manganese dioxide cells and batteries, non-alkaline, in the form of cylindrical cells (excl. spent)
8506 10 95	Manganese dioxide cells and batteries, non-alkaline, in the form of button cells (excl. spent)
8506 10 99	Manganese dioxide cells and batteries, non-alkaline (excl. spent, and in the form of cylindrical cells and button cells)
8506 30 10	Mercuric oxide cells and batteries, in the form of cylindrical cells (excl. spent)
8506 30 30	Mercuric oxide cells and batteries, in the form of button cells (excl. spent)
8506 30 90	Mercuric oxide cells and batteries (excl. spent, and in the form of cylindrical or button cells)
8506 40 10	Silver oxide cells and batteries, in the form of cylindrical cells (excl. spent)
8506 40 30	Silver oxide cells and batteries, in the form of button cells (excl. spent)
8506 40 90	Silver oxide cells and batteries (excl. spent, and in the form of cylindrical or button cells)
8506 50 10	Lithium cells and batteries, in the form of cylindrical cells (excl. spent)
8506 50 30	Lithium cells and batteries, in the form of button cells (excl. spent)
8506 50 90	Lithium cells and batteries (excl. spent, and in the form of cylindrical or button cells)
8506 60 10	Air-zinc cells and batteries, in the form of cylindrical cells (excl. spent)
8506 60 30	Air-zinc cells and batteries, in the form of button cells (excl. spent)
8506 60 90	Air-zinc cells and batteries (excl. spent, and in the form of cylindrical or button cells)
8506 80 05	Dry zinc-carbon batteries of a voltage of > = 5,5 V but < = 6,5 V (excl. spent)
8506 90 00	Parts of primary cells and primary batteries, n.e.s.

Activity rates for the different types of batteries included in the level 2 spreadsheet were based on the Customs Department import data (see Table 9-11). Because these data were not specified to the required HS code levels, and therefore may include other types of batteries with less or no mercury, the resulting activity rates may be overestimated.

Table 9-13 Activity rates for batteries in relation to Customs Department import data.

Caricom External Tariff code 2007	Amount imported (kg)	Type of battery	Level 2 spreadsheet categories	Activity rate (t/yr)
85061000	48693	Mangane dioxide cells, a.o.	Alkaline, other than button cell shapes	48,693
		not specified	Alkaline button cells	
85063000	415	Mercuric oxide cells	Mercury oxide (all sizes); also called mercury-zinc cells	0,415
85064000	59	Silver oxide cells	Silver oxide button cells	0,059
85065000	4981	Lithium cells	not included in spreadsheet	
85066000	7051	Air-zinc cells	Zinc-air button cells	7,051
85068000	629123	Other primary cells and primary batteries / dry zinc-carbon batteries	not included in spreadsheet	
85069000	1406	Parts of primary cells and batteries	not included in spreadsheet	

Mercury input is then calculated as follows:
Calculated Hg input = activity rate (ton batteries/yr) * input factor (kg Hg/ton batteries) kg Hg/yr
Results are shown in table 9-14

Table 9-14 Calculation of a Hg input for different types of batteries

Level 2 spreadsheet categories	Activity rate (t batteries/yr)	Input factor (kg Hg/t batteries)	Calculated Hg input (kg/yr)
Mercury oxide (all sizes); also called mercury-zinc cells	0,415	320	133
Zinc-air button cells	7,051	12	85
Alkaline button cells	0	5	0
Silver oxide button cells	0,059	4	0
Alkaline, other than button cell shapes	48,693	0,25	12

Data gaps and priorities for potential follow up
Because Customs Department does not yet have a detailed registration according to the HS codes mentioned above, several assumptions and estimations had to be made, resulting in some uncertainty in the calculated data.

Summary of inputs and results
A summary of mercury inputs and releases from batteries to different phases are presented in table 9-15.

Table 9-15 Summary of inputs and results for batteries with mercury

Batteries with mercury	Use and disposal	Sum of releases to pathway from assessed part of life-cycle
Activity rate	0.059 – 48,693 t batteries/yr	-
Input factor for phase	0,25-23 kg Hg/t batteries	-
Calculated input to phase	0,2 – 133 kg Hg/yr	-
Output distribution factors for phase:1)		
- Air	0,25	NA
- Water		NA
- Land	0,25	NA
- Products		NA
- General waste treatment	0,5	NA
- Sector specific waste treatment		NA
Calculated outputs/ releases in kg/yr to:		
- Air	57,46 kg/yr	57,46 kg/yr
- Water	0	0
- Land	57,46 kg/yr	57,46 kg/yr
- Products	0	0
- General waste treatment	114,91 kg/yr	114,91 kg/yr
- Sector specific waste treatment	0	0

1) for category "(a2) No separate collection. Informal waste handling widespread"

8.5 Polyurethane with mercury catalysts

Use and disposal
In two-component polyurethanes, for many applications, the catalysts of choice for catalysing the reaction between a polyol and an isocyanate composition, i.e., for hardening or curing the polyurethane (PU) materials, have long been organic mercury compounds. The polyurethane products are used for a wide range of end-products including rollers, flooring, gaskets, encapsulation of electronic components, shoe soles, shock absorption and repair of industrial installations. (UN Environment, 2017).

To assess the amount of mercury input the Level 2 toolkit uses as activity rate the number of inhabitants which is then corrected for the percentage of the population with access to electricity. The estimated mid-year population of 2015 is 567.291 inhabitants (Algemeen Bureau voor de Statistiek, 2016) and according to the country specific data in Appendix 8.4 of the Reference report for the Level 2 toolkit, 84% of the population in Suriname has access to electricity (UN Environment, 2017). The corrected activity rate is then 567.291*0.84 = 476,527 inhabitants. Input factor in the calculation is 0.03 g Hg/(y*inhabitant)

Mercury input is calculated according to the following formula;

Mercury input = (Input factor * activity rate)/1000 * (Percent of population with access to electricity)/100 = ((0,03 g Hg/y*inhabitant * 567.291 inhabit-ants)/1000) * (84 %/100) = 14,295733 kg Hg/yr.

Since Suriname does not have a sound waste management system, default output distribution factors are used for category "(a2) No separate collection. Informal waste handling widespread".

Data gaps and priorities for potential follow up
Activity rate was number of inhabitants and electrification rate. No specific data.

Summary of inputs and results
A summary of mercury inputs and releases from use and disposal of polyurethane polymers with mercury catalysts are presented in table 9-16.

Table 9-16 Summary of inputs and results for polyurethane with mercury catalysts

Polyurethane with mercury catalysts	Use and disposal	Sum of releases to pathway from assessed part of life-cycle
Activity rate	567.291 inhabitants	-
Acces to electricity	84%	
Corrected activity rate	476.527 inhabitants	
Input factor for phase	0.03 g Hg/(y*inhabitant)	-
Calculated input to phase	14,295733 kg Hg/yr	-
Output distribution factors for phase:1)		
- Air	0,2	NA
- Water	0,1	NA
- Land	0,4	NA
- Products		NA
- General waste treatment	0,3	NA
- Sector specific waste treatment		NA
Calculated outputs/ releases in kg/yr to:		
- Air	2,86 kg/yr	2,86 kg/yr
- Water	1,43 kg/yr	1,43 kg/yr
- Land	5,72 kg/yr	5,72 kg/yr
- Products	0	0
- General waste treatment	4,29 kg/yr	4,29 kg/yr
- Sector specific waste treatment	0	0

1) for category "(a2) No separate collection. Informal waste handling widespread"

8.6 Biocides and pesticides with mercury

Use and disposal
Although in the past biocides and pesticides with mercury have been used, such as calomel, these substances are no longer imported or used (Dijk, 2018).

8.7 Paints with mercury

Use and disposal
Suriname has several companies that import or produce paints. Varossieau Suriname, subsidiary of PPG-USA, is one of the two companies that produce paints and this firm is not importing or using any mercury containing ingredients in its paint (Koemar, 2018). No information is available from the other producing company (H.J. de Vries).

There are no data about the other imported paints available.

Data gaps and priorities for potential follow up
Limited information was available.

Summary of inputs and results
N.A.

8.8 Pharmaceuticals for human and veterinary uses

Use and disposal
No mercury containing medicines or pharmaceuticals are imported by the main provider, Bedrijf Geneesmiddelen Voorziening Suriname (BGVS). However there are still old stocks of mercury containing raw materials, probably from the 1950's or 60's. These are stored in quarantine, waiting for disposal. The laboratory of BGVS is using some mercury containing reagents in small quantities. BGVS is not importing pharmaceuticals for veterinary use, but veterinarians use sometimes products for human use from BGVS (Balraadjsing, 2018).

No data from the Pharmaceutical Inspection were received about other imports of pharmaceuticals that might contain mercury.

Data gaps and priorities for potential follow up
Although it is well known that cosmetic products containing mercury are used by some women to whiten their skin and these products are for sale in several shops, no quantitative data are available.

It is also reported in the past that some vaccines used in Suriname contain preservatives with mercury, such as thiomersal (Gajadien, 2016). No amounts of these vaccines used were reported. Use of thiomersal is allowed to continue under the Minamata Convention.

8.9 Cosmetics and related products with mercury

Use and disposal
Although it is well known that cosmetic products containing mercury are used by some women to whiten their skin and these products are for sale in several shops, no quantitative data are available.

Data gaps and priorities for potential follow up
It is suggested that the whitening crèmes that are being sold in Suriname are analysed to quantify their mercury content, since their use can pose a health risk.

It is advised to check if HS codes for mercury containing cosmetics exist.

9. Data and inventory on other intentional product/process uses

9.1 Dental mercury-amalgam fillings

In Suriname there are 46 practising dentists (Yazdani, 2018) and between 50 and 70 active personnel of the foundation for youth dental care JTV "Jeugd Tand Verzorgers" (Vijent, 2018). For the Level 2 spreadsheet the total number of available dentists was estimated at 46 + 65 = 111, resulting in a dentist rate per 1000 inhabitants of 111/567,291 = 0,1957.

Production
JTV has stopped to use silver amalgam for filling holes in teeth since 2000. The services of JTV are not any more solely aimed at school children but the general public is now served daily from 7.30 till 13.30 and some clinics are even open until 19.30 hrs. (Vijent, 2018). The Surinamese Association of Dentists (STV) has also mostly abandoned the use of amalgam fillings (Yazdani, 2018).

Although mention was made by the interviewees of STV and JTV that use of amalgam fillings has stopped for quite a while, it is estimated that 5 % of all dental workers are still using amalgam fillings as an option.

The input factor for the production phase was calculated as follows:
Default input factor is 0,2 g Hg/(y*inhabitants).
The number of dentists per 1000 inhabitants for Suriname is 111/567,291 = 0,1957
Reference dentist rate = 0,829191
Input factor is (0,2*0,1957)/(1000*0,829191) = $4{,}72.10^{-5}$

It is assumed that at this moment 5% of the dentists still use amalgam fillings, so the production phase input factor is adjusted as follows: $0{,}05*4{,}71.10^{-5} = 0{,}236.10^{-5}$

The total mercury input in the production phase is then $0{,}236.10^{-5}$ *567.291 = 1 kg Hg.

Use and disposal
The amalgam fillings that were laid in the past release mercury to the environment during regular dental services. For the Level 2 calculations it is assumed that in the period from 2003 – 2013 20% of all dental workers used amalgam fillings and that in the period 1998 – 2008 all dentists used amalgam fillings.

The input factor for the use phase was calculated as follows:
Default input factor is 0,2 g Hg/(y*inhabitants)
The number of dentists per 1000 inhabitants for Suriname is 111/567,291 = 0,1957
Reference dentist rate = 0,829191
Input factor is (0,2*0,1957)/(1000*0,829191) = $4{,}72.10^{-5}$

It is assumed that 20% of the dentists used amalgam fillings in the period 2003-2013, so the use phase input factor is adjusted as follows: $0{,}2*4{,}71.10^{-5} = 0{,}944.10^{-5}$
The total mercury input in the use phase is then $0{,}944.10^{-5}$ * 567.291 = 5 kg Hg.

Only a few clinics are equipped with high efficiency amalgam filters and mercury from old fillings usually ends up in the drain.

So for the disposal phase the following calculations were made:

Default input factor is 0,2 g Hg/(y*inhabitants)
The number of dentists per 1000 inhabitants for Suriname is 111/567,291 = 0,1957
Reference dentist rate = 0,829191
Input factor is (0,2*0,1957)/(1000*0,829191) = $4{,}72.10^{-5}$
It is assumed that 100% of the dentists used amalgam fillings in the period 1998-2008, so the disposal phase input factor is $4{,}72.10^{-5}$
The total mercury input in the disposal phase is then $4{,}72.10^{-5}$ *567.291 = 27 kg Hg.
For the release factors default values of the Level 2 spreadsheet are used.

Data gaps and priorities for potential follow up

No information was available about the amount of imported mercury containing capsules for amalgam fillings or old stocks of these items.

Summary of inputs and results

A summary of results and inputs for dental amalgam fillings is presented in Table 10-1.

Table 10-1 Summary of inputs and results for dental amalgam fillings

Dental amalgam fillings	Unit	Production	Use	Disposal	Sum of releases to pathway from assessed part of life-cycle
Activity rate	inhabitants	567291	567291	567291	-
Input factor for phase	g Hg/(y*inhabitant)	$0{,}236*10^{-5}$	$0{,}944*10^{-5}$	$4{,}72*10^{-5}$	-
Calculated input to phase	Kg Hg	1	5	27	-
Output distribution factors for phase:1)					
- Air		0,02	0	0	-NA
- Water		0,14	0,02	0,28	-NA
- Land		0	0	0,08	-NA
- Products		0	0	0,06	-NA
- General waste treatment		0,12	0	0,08	-NA
- Sector specific waste treatment		0,12	0	0,08	-NA
Calculated outputs/ releases in kg/yr to:					
- Air	Kg Hg	0,03	0	0	0,03
- Water	Kg Hg	0,19	0,11	7,5	7,79
- Land	Kg Hg	0	0	2,14	2,14
- Products	Kg Hg	0	0	1,61	1,61
- General waste treatment	Kg Hg	0,16	0	2,14	2,14
- Sector specific waste treatment	Kg Hg	0,16	0	2,14	2,14

Notes:
*NA – not applicable; 1: calculation formulas are described in section 10.1 under heading 'use and disposal'; 2: input = input factor *activity rate; 3: Level 2 default factors*

9.2 Manometers and gauges with mercury

Production

No production of manometers or gauges with mercury takes place in Suriname.

Use and disposal

Since there are no specific data available about the amounts of these items, the Level 1 approach is used to estimate mercury input and release.

Summary of inputs and results

Summary for inputs and results for manometers and gauges is presented in table 10-2.

Table 10-2 Summary of inputs and results for manometers and gauges with mercury

Manometers and gauges with mercury	Use and disposal – manometers and gauges with mercury	Sum of releases to pathway from assessed part of life-cycle
Activity rate	567291 inhabitants	-
Input factor *1	0,005 g Hg/y*inhabitant	-
Adjustment factor for electrification rate	84% of population	-
Calculated input *2	2 kg Hg/y	
Output distribution factors for phase:*3		
- Air	0,2	NA
- Water	0,3	NA
- Land	0,2	NA
- Products	0	NA
- General waste treatment	0,3	NA
- Sector specific waste treatment	0	NA
Calculated outputs/releases in kg/yr to:		
- Air	0,48 Kg Hg	0,48 Kg Hg
- Water	0,71 Kg Hg	0,71 Kg Hg
- Land	0,48 Kg Hg	0,48 Kg Hg
- Products	0,0	0,0
- General waste treatment	0,71 Kg Hg	0,71 Kg Hg
- Sector specific waste treatment	0,0	0,0

Notes:
*NA – not applicable; 1: Level 2 default factor; 2: input = input factor *activity rate; 3: Level 2 default factors*

9.3 Laboratory chemicals and equipment with mercury

Use and disposal

Since there are no specific data available about the amounts of these items, the Level 1 approach is used to estimate mercury input and release, based on the number of inhabitants and electrification rate of the population in Surname.

Summary of inputs and results

Summary for inputs and results for laboratory chemicals and equipment is presented in table 10-3.

Table 10-3 Summary of inputs and results for laboratory chemicals and equipment with mercury

Laboratory chemicals and equipment with mercury	Use and disposal – lab. chemicals and equipment with mercury	Sum of releases to pathway from assessed part of life-cycle
Activity rate	567291 inhabitants	-
Input factor for lab. Chemicals *1	0,01g Hg/y*inhabitant	-
Input factor for lab. equipment l *1	0,04 g Hg/y*inhabitant	-
Adjustment factor for electrification rate	84 % of population	
Calculated input to chemicals *2	4,77 kg Hg/y	
Calculated input to equipment *2	19,06 kg Hg/y	
Output distribution factors for phase: *3		
- Air	0	NA
- Water	0,33	NA
- Land	0	NA
- Products	0	NA
- General waste treatment	0,33	NA
- Sector specific waste treatment	0,34	NA
Calculated outputs/releases to:		
- Air	0	0
- Water	7,86 Kg Hg	7,86 Kg Hg
- Land	0	0
- Products	0	0
- General waste treatment	7,86 Kg Hg	7,86 Kg Hg
- Sector specific waste treatment	8,10 Kg Hg	8,10 Kg Hg

Notes:
*NA – not applicable; 1: Level 2 default factor; 2: input = input factor *activity rate; 3: Level 2 default factors*

9.4 Mercury metal use in religious rituals and folklore medicine

Use and disposal
It is known that some tribal communities of African descent use mercury as a talisman. Other ethnic groups also have this custom. No specific data are yet available.

Summary of inputs and results
Since accidents resulting in the spilling of liquid mercury can take place, it is advised to investigate these uses further.

10. Data and inventory on production of recycled metals

10.1 Production of recycled mercury

Apart from some recovery and reuse of mercury by some gold miners using a retort and gold buyers, secondary production of mercury by recycling facilities is not taking place in Suriname**.**

10.2 Production of recycled ferrous metals (iron and steel)

One company (COBO) is smelting secondary iron into bars for export. It is unlikely that vehicles are smelted, without being stripped. Scrap metal is ex-ported by several companies and the amount is presented in table 11-1.

Table 11-1 Export data of scrap metals

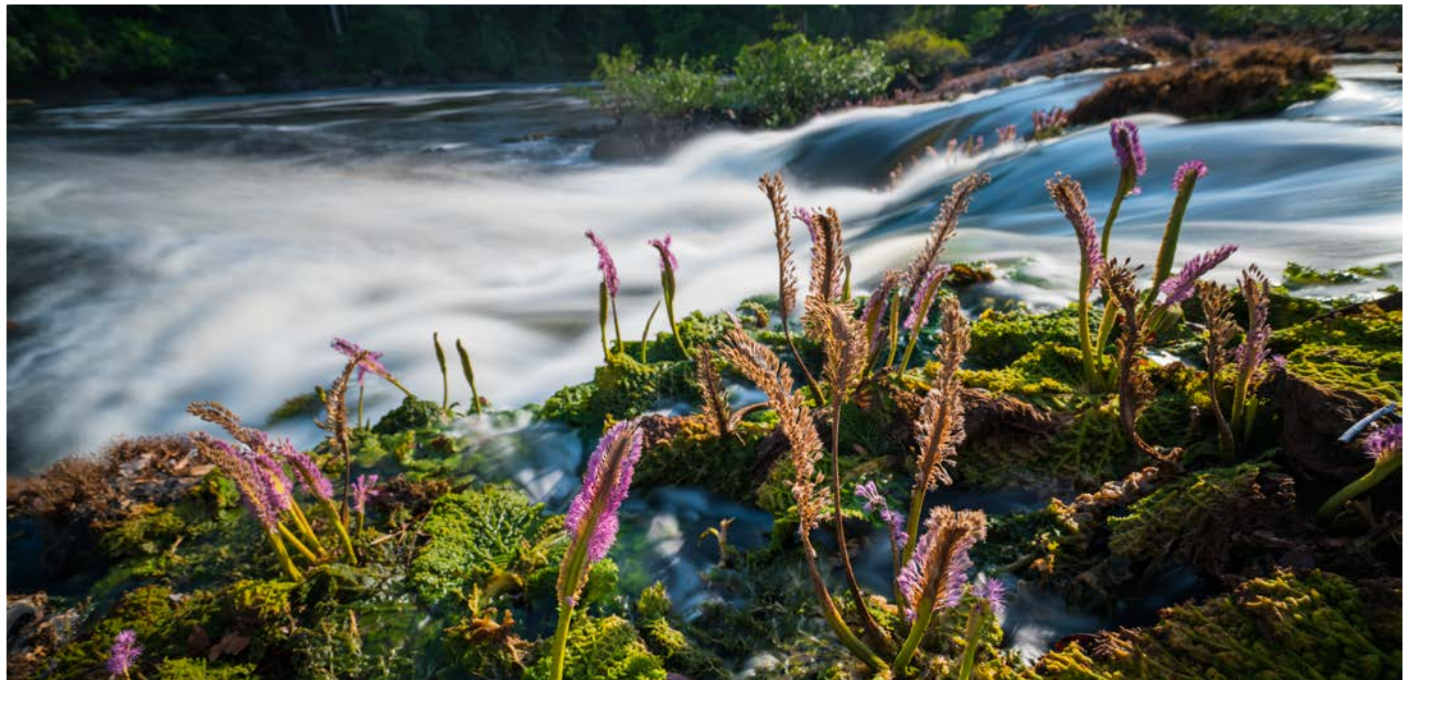
Metaal soort/Kind of Metal	**2011**	**2012**	**2013**	**2014**	**2015**
Ijzer scrap / Iron Scrap (Fe)	14,370.81	49,723.34	41,561	38,333	16,916
Aluminium scrap / Aluminium Scrap (Al)	1,898.00	1,321	1,533	1,643	869
Koper scrap / Copper Scrap (Cu)	397.00	394.87	306	338	217
Lood / Lead (Pb)	1,347.40	1,596.2	1,886.50	1,692	503
Totaal / Total	**18,013.21**	**53,035.41**	**42,286.50**	**42,006**	**18,505**

Bron/Source: Bauxiet Instituut Suriname/ Bauxiet Institute Suriname

Data gaps and priorities for potential follow up
No data could be traced about the number of old cars being smelted in Suriname.

10.3 Production of other recycled metals

In the past aluminium may have been recycled. No data could be found.



11. Data and inventory on waste incineration and burning

11.1 Incineration of municipal/general waste

In Suriname there are no installations for incineration of municipal/general waste. All the products which are included in this category such as electrical appliances, batteries, fluorescent lamps etc are dumped at Ornamibo (uncontrolled combustion). Some household products are burned in the open air (Wesenhagen, 2017).

11.2 Incineration of hazardous waste

This category includes incineration of commercial chemicals, pesticides and other hazardous materials. At present, Suriname does not have a dedicated facility to store or dispose of hazardous waste. Some of these wastes are currently dumped at uncontrolled open sites or at Ornamibo. (Wesenhagen, 2017). In 2015, 6.552 m3 of hazardous waste was dumped at Ornamibo (Algemeen Bureau voor de Statistiek, 2016). Some hazardous waste is exported for disposal according to the rules of the Basel Convention (NIMOS, 2018).

11.3 Incineration of medical waste

Suriname has a total of 7 incinerator facilities: four incinerators for medical waste are located in Paramaribo and one in Nickerie. Another 2 incinerators operate in the Greater Paramaribo area. The Animal shelter in Paramaribo has a small electric furnace for animal carcasses (Wesenhagen, 2017).

Approximately 3.000 kg medical waste is produced daily from mainly hospitals, policlinics, dentists and laboratories (Algemeen Bureau voor de Statistiek, 2016). The amount of medical waste produced per year (350 days) is estimated to be 1,050,000 kg (Wesenhagen, 2017).

Data gaps and priorities for potential follow up
No data gaps were identified.

Summary of inputs and results
Summary for inputs and results for incineration of medical waste is presented in table 12-1.

Table 12-1 Summary of inputs and results for incineration of medical waste

Incineration of medical waste	Life cycle phase – incineration of medical waste	Sum of releases to pathway from all phases of life-cycle
Activity rate	1050 t/y	-
Input factor for phase *1	24 g Hg/t waste incinerated	-
Calculated input to phase *2	25 kg Hg/y	-
Output distribution factors for phase: *3		
- Air	1	NA
- Water	0	NA
- Land	0	NA
- Products	0	NA
- General waste treatment	0	NA
- Sector specific waste treatment	0	NA
Calculated outputs/releases to:		
- Air	25,20 Kg Hg	25,20 Kg Hg
- Water	0	0
- Land	0	0
- Products	0	0
- General waste treatment	0	0
- Sector specific waste treatment	0	0

Notes:
*NA – not applicable; 1: Level 2 default factor; 2: input = input factor *activity rate; 3: Level 2 default factors*

11.4 Sewage sludge incineration

The companies in the coastal zone which are nearby the Suriname river, have their own closed drainage system and their own sewage water treatment plant, but incineration is not involved. Therefore, this activity cannot be rated as practiced in Suriname. The sludge has no particular application; it is being deposited (Wesenhagen, 2017).

11.5 Informal waste burning (open fire waste burning on landfills and informally)

During the period between 2010 and 2016, regular burning of dumped waste occurred on the landfill at Ornamibo. It is cautiously assumed that 25% of the waste going to the landfill is burned.

In 2015 an amount of 204.960 m^3 waste was dumped at Ornamibo landfill (Algemeen Bureau voor de Statistiek, 2016). Assuming that 1 m^3 of waste is equivalent to 2,41 tons the total amount of waste dumped is 204.960 x 2,41 = 493.953,6 t of which 25% is burned resulting in
25 % x 493.953,6 t = 123.488,40 t waste burned at Ornamibo (Wesenhagen, 2017).

It is also estimated (Wesenhagen, 2017) that for the total of Suriname 89.775,35 tons of domestic waste is not dumped at Ornamibo landfill, but elsewhere. When assuming that 50% of this waste is burned, this adds another 44.887,675 tons of waste burned. This results in a total amount of 168.376,1 tons waste burned in 2015.

Data gaps and priorities for potential follow up
Burning of biomass including slash and burn practices and agricultural byproducts such as rice husks, is not included here. In future inventories this can be further investigated.

Specific data on mercury content of general waste that could be used to verify the default input factor use, is not available. Public awareness of the risks associated with informal burning of waste, namely release of both mercury and POPs, should be further promoted.

Summary of inputs and results
Summary for inputs and results for informal waste burning is presented in table 12-2.

Table 12-2 Summary of inputs and results for informal waste burning

Informal waste burning	Life cycle phase – waste dumping	Sum of releases to pathway from all phases of life-cycle
Activity rate	168.376,1 t/y	-
Input factor for phase *1	5 g Hg/t waste	-
Calculated input to phase *2	842 kg Hg/y	-
Output distribution factors for phase: *3		
- Air	1,0	NA
- Water	0	NA
- Land	0	NA
- Products	0	NA
- General waste treatment	0	NA
- Sector specific waste treatment	0	NA
Calculated outputs/releases to:		
- Air	841,88 kg Hg	841,88 kg Hg
- Water	0	0
- Land	0	0
- Products	0	0
- General waste treatment	0	0
- Sector specific waste treatment	0	0

Notes:
*NA – not applicable; 1: Level 2 default factor; 2: input = input factor *activity rate; 3: Level 2 default factors*

11.6 Test of waste and wastewater default factors

In this inventory, default input factors were used for the estimation of mercury releases from general waste treatment. The default factors were based on literature data of mercury contents in waste, and these data were only available from developed countries. The following test of the results was performed to qualify the results for these sources.

The test made for general waste compares the calculated inputs to all four general waste sub-categories with the sum of general waste outputs from intentional mercury uses in products plus processes as follows, using data from the Inventory Level 2 spreadsheet:

In the (unaltered) Level 2 spreadsheet the test was done as follows: See tab “Level 2-Summary” in the spreadsheet:

(E62+E66+E68+E71) > 2*(J24 + ∑(J37 to J55)).

Filling in the values gives: (0+842+0+2077) > 2*(0 + 442)
Resulting in: 2919 > 884

Which is correct (positive).

The calculations made indicate that the default input factors for general waste treatment may over-estimate the mercury releases from this source. This may be of priority in follow-up work, as feasible.

The test made for wastewater compares the calculated inputs to wastewater treatment with the sum of outputs to water from intentional mercury uses in products plus processes as follows, using data from the Inventory level 2 spreadsheet:

In the Level 2 spreadsheet the test was done as follows: tab “Level 2-Summary”:

E72> 2*(G24 + ∑(G37 to G55)).
Filling in the values gives: 143 > 2* (22.988 + 308)

Which is not correct (negative).
The calculations made indicate that the default input factors for wastewater treatment do not necessarily over-estimate the mercury releases from these sub-categories.

12. Data and inventory on waste disposal, deposition/landfilling

12.1 Controlled landfills/deposits

In Suriname there are no controlled landfills or deposits at this moment.

12.2 Diffuse disposal under some control

This source category is expected to be covered under the original sources of the mercury containing material, under the output path “sector specific treatment/disposal accompanied by a descriptive note; e.g. solid residues from waste incineration or metal extraction.

12.3 Informal local disposal of industrial production waste

It is possible that to some extent informal local disposal of industrial production waste takes place at the landfill at Ornamibo or at other locations. There is however no specific information.

12.4 Informal dumping of general waste

In Suriname general waste is dumped at several sites, without control or management system. There are dump sites in each district, but the main ones are Ornamibo for greater Paramaribo area and Nickerie. At the Ornamibo site, which is an uncontrolled landfill, mostly domestic waste is dumped, but it is likely that other types of waste are also dumped there.

In 2015 a total of 204.960 m^3waste of which 86 % was domestic waste was dumped, presumably at Ornamibo (Algemeen Bureau voor de Statistiek, 2016) which corresponds to 493.953,6 tons of waste (assuming 1 m^3 waste is equivalent to 2,41 tons (Wesenhagen, 2017). Since it was assumed (see par. 12.5) that 25% of this waste, which amounts to 123.488,4 t, is burned, this amount should be subtracted from the total of 493.953,6 tons, in order to avoid double counting. In paragraph 12.5 it is also mentioned that 89.775,35 tons waste are dumped elsewhere in the country of which it was estimated that 50% is burned, leaving 44.887,675 tons waste dumped. This means that the resulting activity rate for informal dumping of general waste is then 493.953,6 – 123.488,4 + 44.887,675 = 415.351,875 t/yr

Data gaps and priorities for potential follow up
No specific data are available for the different locations were waste is dumped. Although in the spreadsheet the default release factors are used, it is to be expected that a greater proportion of the mercury input will be released to air, since the dumpsite is set on fire incidentally. This is however included in the paragraph 12.5 (spreadsheet section 5.8.5) informal waste burning.

Summary of inputs and results
Summary for inputs and results for informal dumping of general waste is presented in table 13-1

Table 13-1 Summary of inputs and results for informal dumping of waste

Informal dumping of general waste	Life cycle phase – waste dumping	Sum of releases to pathway from all phases of life-cycle
Activity rate Input factor for phase *1 Calculated input to phase *2	415351,875 t/y 5 g Hg/t waste 2.077 kg Hg/y	- - -
Output distribution factors for phase: *3 - Air - Water - Land - Products - General waste treatment - Sector specific waste treatment	 0,1 0,1 0,8 0 0 0	 NA NA NA NA NA NA
Calculated outputs/releases to: - Air - Water - Land - Products - General waste treatment - Sector specific waste treatment	 207,68 kg Hg 207,68 kg Hg 1.661,41 kg Hg 0 0 0	 207,68 kg Hg 207,68 kg Hg 1.661,41 kg Hg 0 0 0

Notes:
*NA – not applicable; 1: Level 2 default factor; 2: input = input factor *activity rate; 3: Level 2 default factors*

12.5 Waste water

No waste water treatment systems for municipal households are present in Suriname. Industrial waste water facilities are not included here.
The amount of waste water is estimated to be equal to the amount of water delivered to households in 2015 (Algemeen Bureau voor de Statistiek, 2016).

Data gaps and priorities for potential follow up
The default input factor of 5,25 mg Hg/m^3 wastewater – equivalent to 5,25 µg/l – seems rather high for household waste water, but was maintained because small companies and laboratories drain their wastewater in the same way as households. No specific data were available about amount of waste water produced by industry and small companies that do not have their own waste water treatment. It is advised to gather analytical data in order to verify the input factor of household waste water.

Summary of inputs and results
Summary for inputs and results for waste water is presented in table 13-2.

Table 13-2 Summary of inputs and results for waste water

Waste water	Life cycle phase – waste water	Sum of releases to pathway from all phases of life-cycle
Activity rate Input factor for phase *1 Calculated input to phase *2	27.240.100 m3/y 5,25mg Hg/m3 waste water 143,01 kg Hg/y	- - -
Output distribution factors for phase: *3 - Air - Water - Land - Products - General waste treatment - Sector specific waste treatment	 0 1 0 0 0 0	 NA NA NA NA NA NA
Calculated outputs/releases to: - Air - Water - Land - Products - General waste treatment - Sector specific waste treatment	 0,0 143,01 kg Hg 0,0 0,0 0,0 0,0	 0,0 143,01 kg Hg 0,0 0,0 0,0 0,0

Notes:
*NA – not applicable; 1: Level 2 default factor; 2: input = input factor *activity rate; 3: Level 2 default factors*

13. Data and inventory on crematoria and cemeteries

13.1 Crematoria/cremation

There are two crematoria in Paramaribo. Corpses are also cremated ac-cording to Hindu rituals at facilities at the seaside. An average of 828 corpses is cremated yearly (Wesenhagen, 2017)

Data gaps and priorities for potential follow up
No specific data were sought for each locality where cremations take place.

Summary of inputs and results
Summary for inputs and results for crematoria is presented in table 14-1.

Table 14-1 Summary of inputs and results for Crematoria/cremation.

Crematoria/cremation	Life cycle phase – cremation	Sum of releases to pathway from all phases of life-cycle
Activity rate	828 corpses cremated/year	-
Input factor for phase *1	2,5 g Hg/corpse	-
Calculated input to phase *2	2,07 kg Hg/year	-
Output distribution factors for phase: *3		
- Air	1,0	NA
- Water	0	NA
- Land	0	NA
- Products	0	NA
- General waste treatment	0	NA
- Sector specific waste treatment	0	NA
Calculated outputs/releases to:		
- Air	2,07 kg Hg	2,07 kg Hg
- Water	0,0	0,0
- Land	0,0	0,0
- Products	0,0	0,0
- General waste treatment	0,0	0,0
- Sector specific waste treatment	0,0	0,0

Notes:
*NA – not applicable; 1: Level 2 default factor; 2: input = input factor *activity rate; 3: Level 2 default factors*

13.2 Cemeteries

In the period 2013-2015 an average of 3653 persons in Suriname died (Algemeen Bureau voor de Statistiek, 2017), part of whom were cremated (828 corpses) and the remaining (2825) were buried.

Data gaps and priorities for potential follow up
No specific data were sought for geographical distribution of areas with cemeteries.

Summary of inputs and results
Summary for inputs and results for cemeteries is presented in table 14-2

Table 14-2 Summary of inputs and results for Cemeteries.

Cemeteries	Life cycle phase – cemeteries	Sum of releases to pathway from all phases of life-cycle
Activity rate	2825 corpses buried/year	-
Input factor for phase *1	2,5 g Hg/corpse	-
Calculated input to phase *2	7,0625 kg Hg/year	-
Output distribution factors for phase: *3		
- Air	0	NA
- Water	0	NA
- Land	1,0	NA
- Products	0	NA
- General waste treatment	0	NA
- Sector specific waste treatment	0	NA
Calculated outputs/releases to:		
- Air	0,0	0,0
- Water	0,0	0,0
- Land	7,06 kg Hg/year	7,06 kg Hg/year
- Products	0,0	0,0
- General waste treatment	0,0	0,0
- Sector specific waste treatment	0,0	0,0

Notes:
*NA – not applicable; 1: Level 2 default factor; 2: input = input factor *activity rate; 3: Level 2 default factors*

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Appendix 1
Inventory Level 2 calculation spreadsheet

NOTE

This appendix is digitally available as a pdf file on www.nimos.org.

For printed copies of the report, please contact NIMOS.

The digital spreadsheet in Excel format will not be shared.

Appendix 2
Raw data of OGS about ASGM

A. By OGS identified and monitored ASGM areas

Brokopondo	
Alimonie 1 en 2	Koffie kamp en omgeving
Bewojo	Kriki negi
Bisumbhar/Musapasi	Krikimofo
Dam 10	Kwangoe
Djegekreek	Maripaston
Drepada en Tapoeripa	Matawai gebied Villa brasil en Dran oso
Eurobergie	Sarakreek en omgeving
Irene val	White House
Koemboe	Witikreek

Marowijne	
Ampoma gebied	Nassau gebied en Grankreek
Banagron	Oelemarie
Benzdorp en Jaw passie	Sabajo hill
Mamadjuka	Tossokreek
Meriam	Tumatu

Sipaliwini	
Goliath	Oelemarie rivier
Gunsi	Stuwmeer(Brokopondo)
Lawa	Tapanahony
Marowijne rivier te Langatabiki	

B. OGS inventory per area. Numbers of these areas do not correspond with the list in appendix 2A. The areas are anonymized.

	Number of units for each technique/equipment identified in an area							Estimated fraction of operations in an area working according to one of the four categories			
Anonimized area	Zuigspuit	Isridal	Crushed	Sumaje	Excavator	Scaliante	# Workers	Whole ore amalgamation without retort	Whole ore amalgamation with retort	Concentrate amalgamation without retort	Concentrate amalgamation with retort
1	3						18	0,5		0,5	
2			11	1	4		38	1			
3	1		1	1			33	0,5		0,5	
4	1		11	1			96	0,9		0,1	
5	5						60	0,7		0,3	
6	6		14	1	5		30	0,2	0,6	0,2	
7	1		1	1			10		0,3		0,7
8	3		26	1	10		150	0,9		0,1	
9	3	20	3	1	42		170	0,9		0,1	
10	10	1			12		48	0,6		0,4	
11	15		4	1	10		112	0,5		0,5	
12	8						48	0,5		0,5	
13	1		2				15	0,7		0,3	
14			1				5	1			
15	1						6	0,5		0,5	
16	35		70	1			500	0,8		0,2	
17	40		70	1			600	0,6		0,4	
18	6		48				300	0,8		0,2	
19	3						18	0,5		0,5	
20	3			1			18	0,5		0,5	
21	1				2		10	0,5		0,5	
22	?		?	1			?	?		?	
23	7	6	?	1			35	0,8		0,2	
24	?						?	?		?	
25	5		2		6		42	0,6		0,4	
26	?						?	?			
27	375		375		400		4518	0,3		0,3	0,4
28	15		12		10		138	0,7		0,3	
29	6		4				50	0,7		0,3	
30	2	1	1		2		23	0,7		0,3	
31						2	16				1
32						10	80				1
33						6	48				1
34						2	16				1
35						5	40				1
Total	**556**	**28**	**656**	**13**	**503**	**25**	**7291**	**16,9**	**0,9**	**8,1**	**6,1**

The Beginning of
the Ending of Mercury