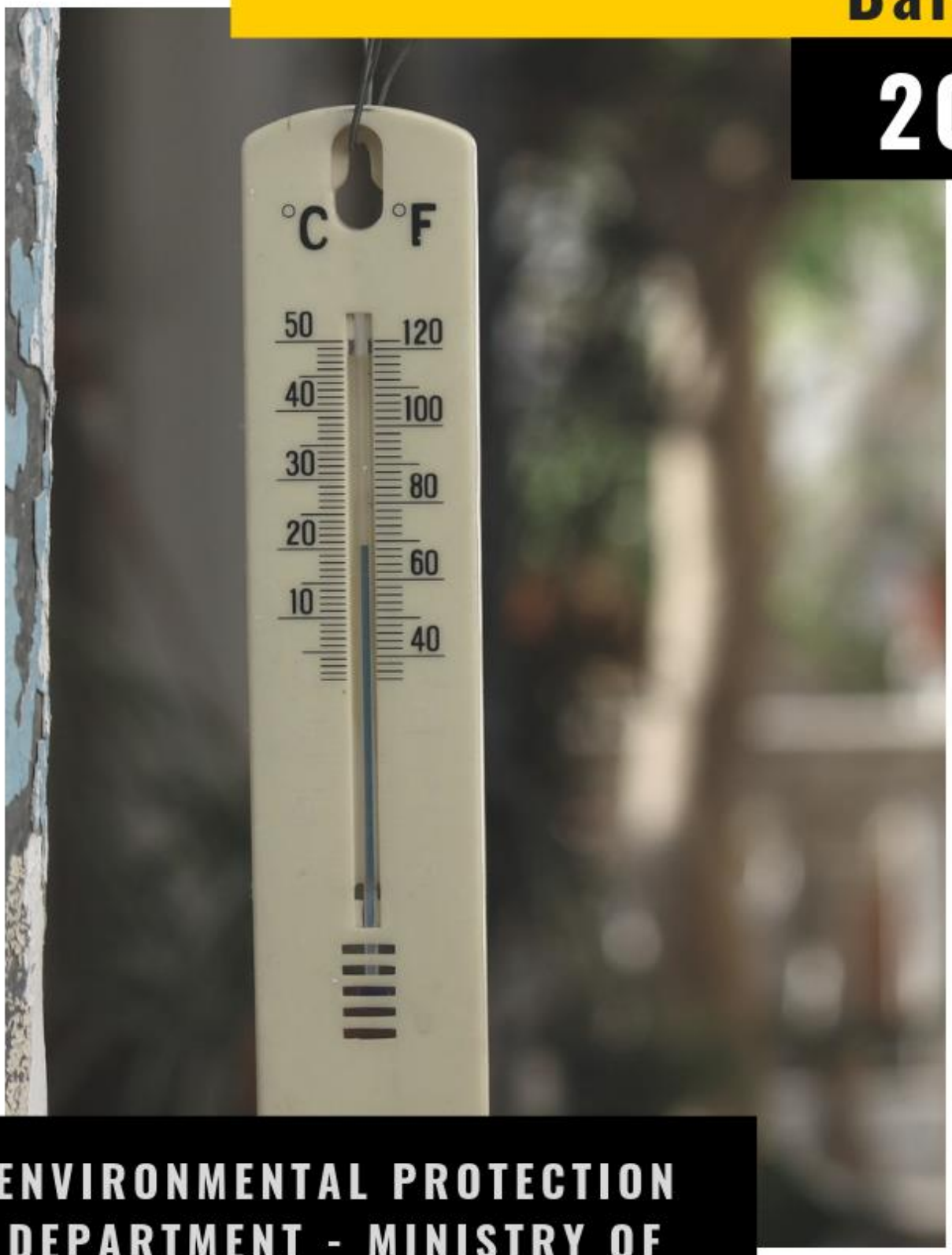
National Inventory of Mercury Releases Barbados

2019



ENVIRONMENTAL PROTECTION DEPARTMENT - MINISTRY OF ENVIRONMENT & NATIONAL BEAUTIFICATION

INVENTORY OF MERCURY RELEASES IN BARBADOS (Draft)

Contact point responsible for this inventory	
Full name of institution	Environmental Protection Department, Ministry of Environment and National Beautification
Contact person	Anthony Headley
E-mail address	anthony.headley@epd.gov.bb or epd.secretary@epd.gov.bb
Telephone number	(246) 535-4600
Fax number	(246) 228-7103
Website of institution	
Report issuing date	2019

This inventory was performed in accordance with UN Environment's "Toolkit for identification and quantification of mercury releases", Inventory Level 1 (version 1.02, April 2013 or newer)

Table of Contents

1. Executive summary

1.1. Introduction

This report, developed in 2018, provides an inventory of the annual distribution of goods and materials containing mercury in Barbados and estimates the quantities of mercury released to various media.

Data for the period 2013-2017 were used to provide five-year averages. For the categories where data for the five-year period were not available, any available information was used. The period under consideration for all data given is noted in the relevant sections of this report.

This mercury release inventory was made using 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 original Toolkit from which this one has been adapted 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 using the Toolkit's Inventory Level 1. The Toolkit is based on mass balances for each release source type. Inventory Level 1 works with pre-determined factors referred to as default input factors and default output distribution factors; these factors are used in the calculation of mercury inputs to society and releases to the environment. These factors were derived from data on mercury inputs and releases from the relevant mercury source types from available literature and other relevant data sources.

Further description of estimations are noted in the relevant sections below.

For the mercury source sub-category "Incineration of municipal/general waste", the presence of mercury controls was taken into consideration when calculating the various emissions.

1.2 Results and discussion

Figures 1 - 7[i] and table 1[ii] below present the results for estimated mercury inputs and mercury releases to various output pathways.

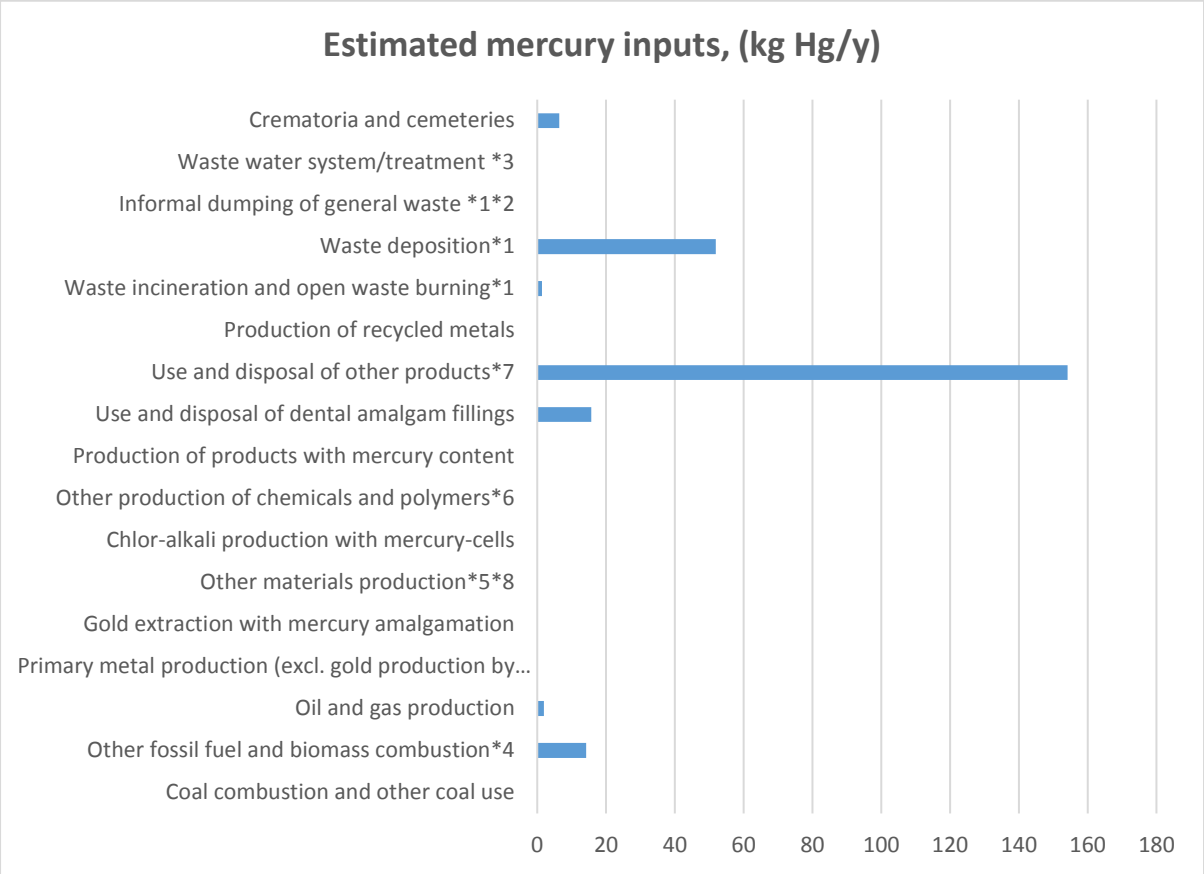


Figure 1: Average Mercury Inputs in Barbados for the period 2013-2017 (kg Hg/y)

Source sub-category with the highest estimated mercury inputs per year:

Use and disposal of other products, which contain mercury.

Source sub-category with the lowest estimated mercury inputs per year:

Waste incineration and open waste burning

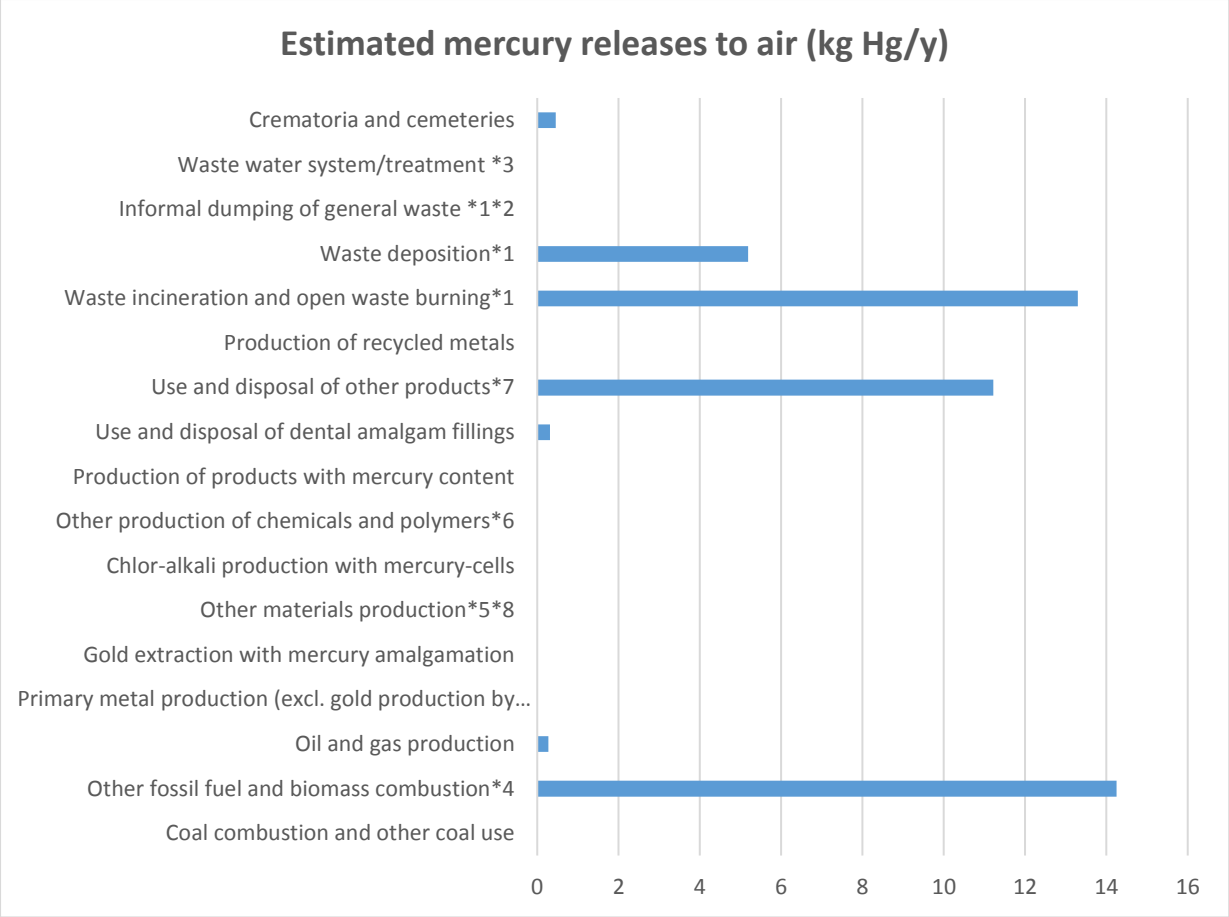


Figure 2: Estimated Mercury Releases into the Air in Barbados, 2013-2017 (kg Hg/y)

Source sub-categories with the highest estimated mercury releases to air per year:

Waste incineration and open burning

Other fossil fuel and biomass combustion

Source sub-category with the lowest estimated mercury releases to air per year:

Oil and gas production

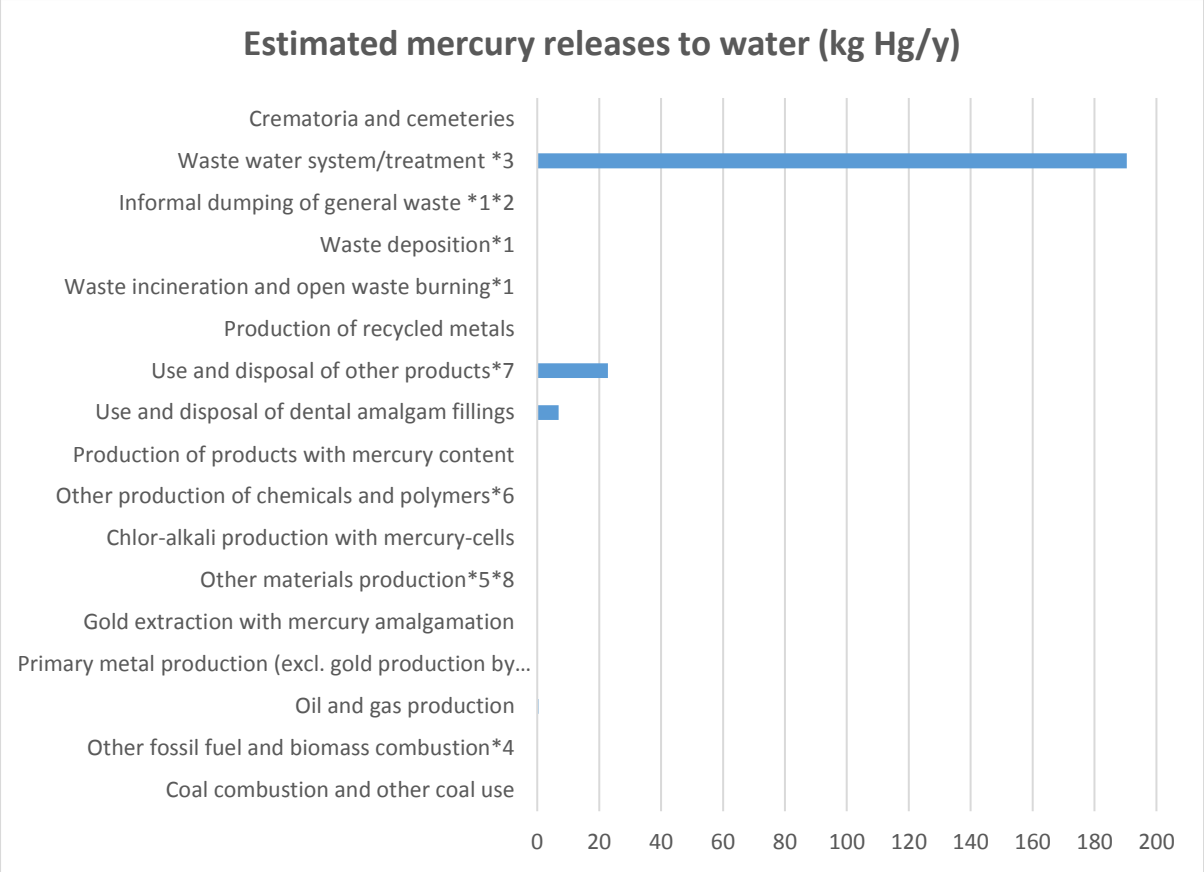


Figure 3: Estimated Mercury Releases into water in Barbados, 2013-2017 (kg Hg/y)

Source sub-category with the highest estimated mercury releases to water per year:

Wastewater system/treatment

Source sub-category with the lowest estimated mercury releases to water per year:

Use and disposal of dental amalgam fillings

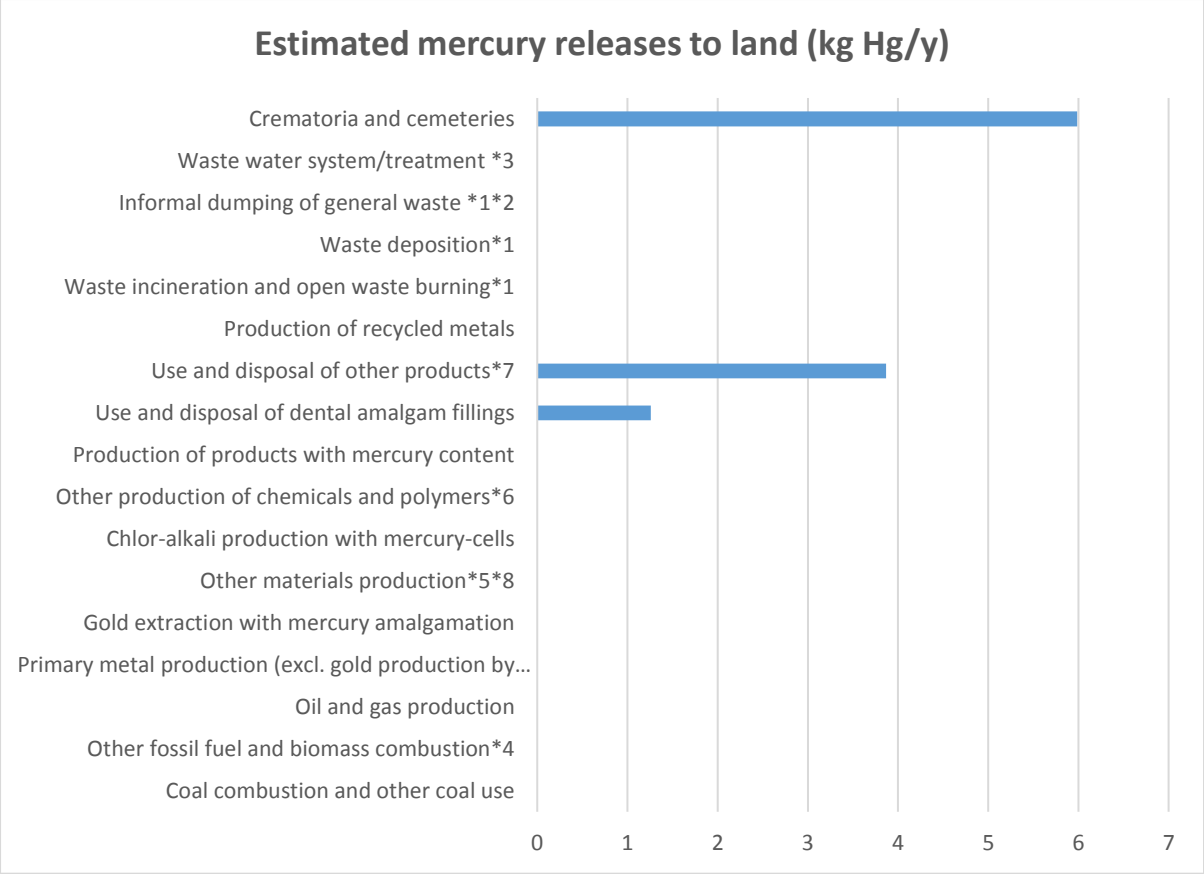


Figure 4: Estimated Mercury Releases to Land in Barbados, 2013-2017 (kg Hg/y)

Source sub-category with the highest estimated mercury releases to land per year: Crematoria and cemeteries

Source sub-category with the lowest estimated mercury releases to land per year: Use and disposal of dental amalgam fillings

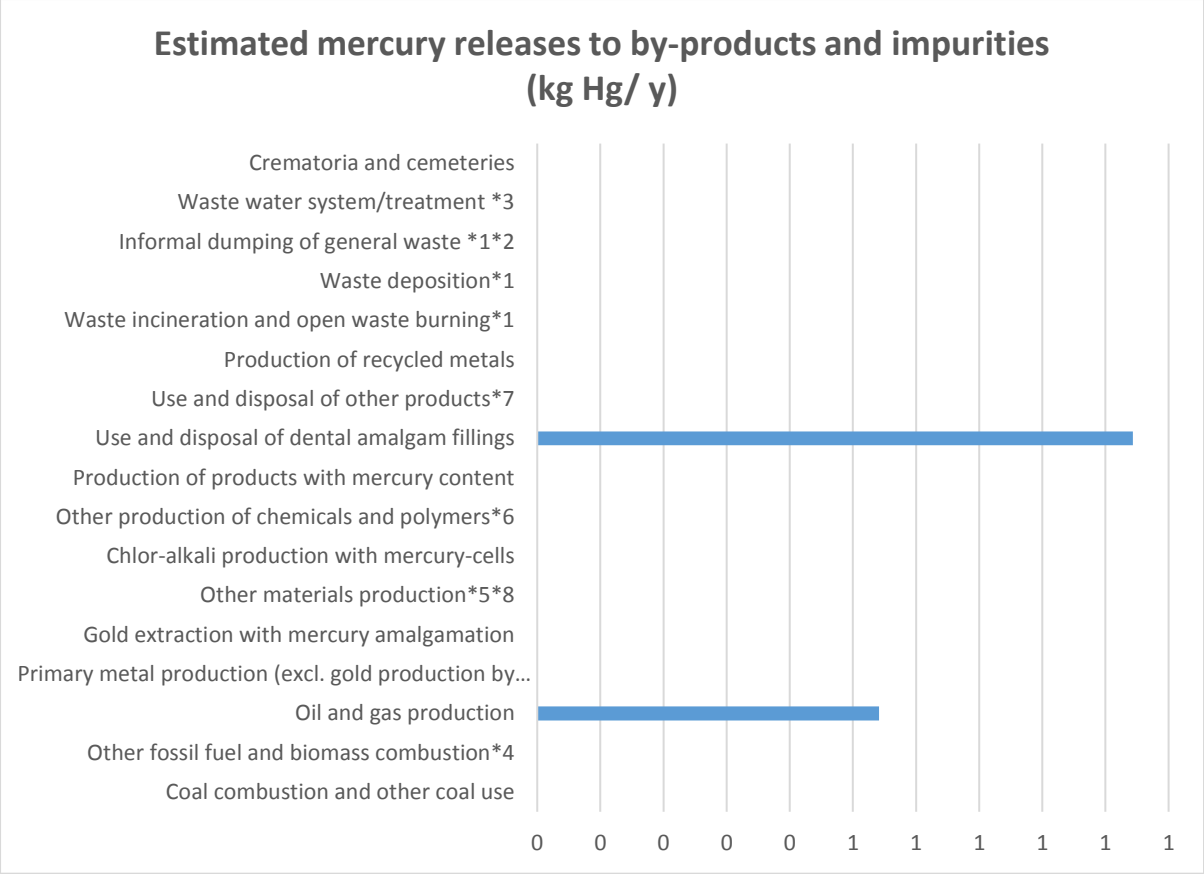


Figure 5: Estimated Mercury Outputs to By-products and Impurities in Barbados, 2013-2017 (kg Hg/y)

Source sub-category with the highest estimated mercury outputs to by-products and impurities per year:

Use and disposal of dental amalgam fillings

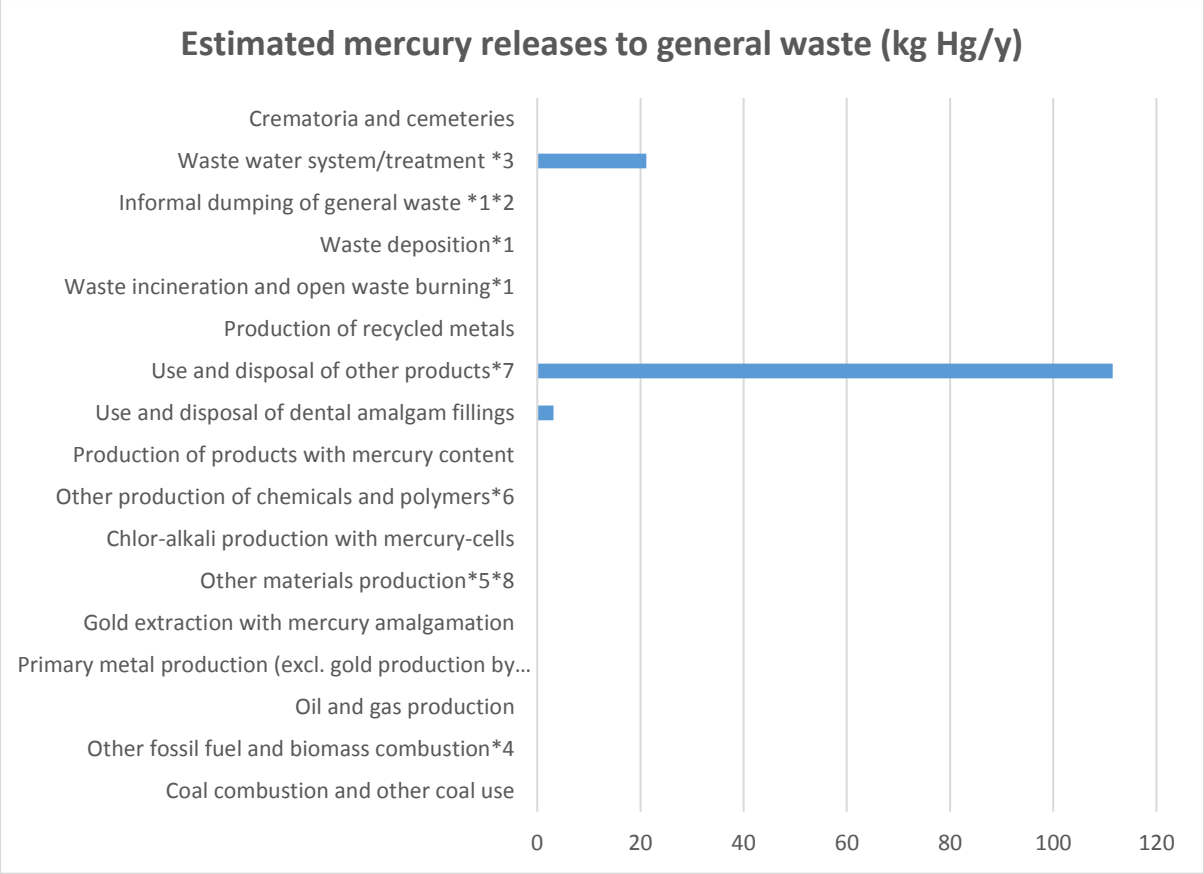


Figure 6: Estimated Mercury Releases to General Waste in Barbados, 2017 (kg Hg/y)

Source sub-category with the highest estimated mercury releases to general waste per year:

Use and disposal of other products, which contain mercury

Source sub-category with the lowest estimated mercury releases to general waste per year:

Use and disposal of dental amalgam fillings

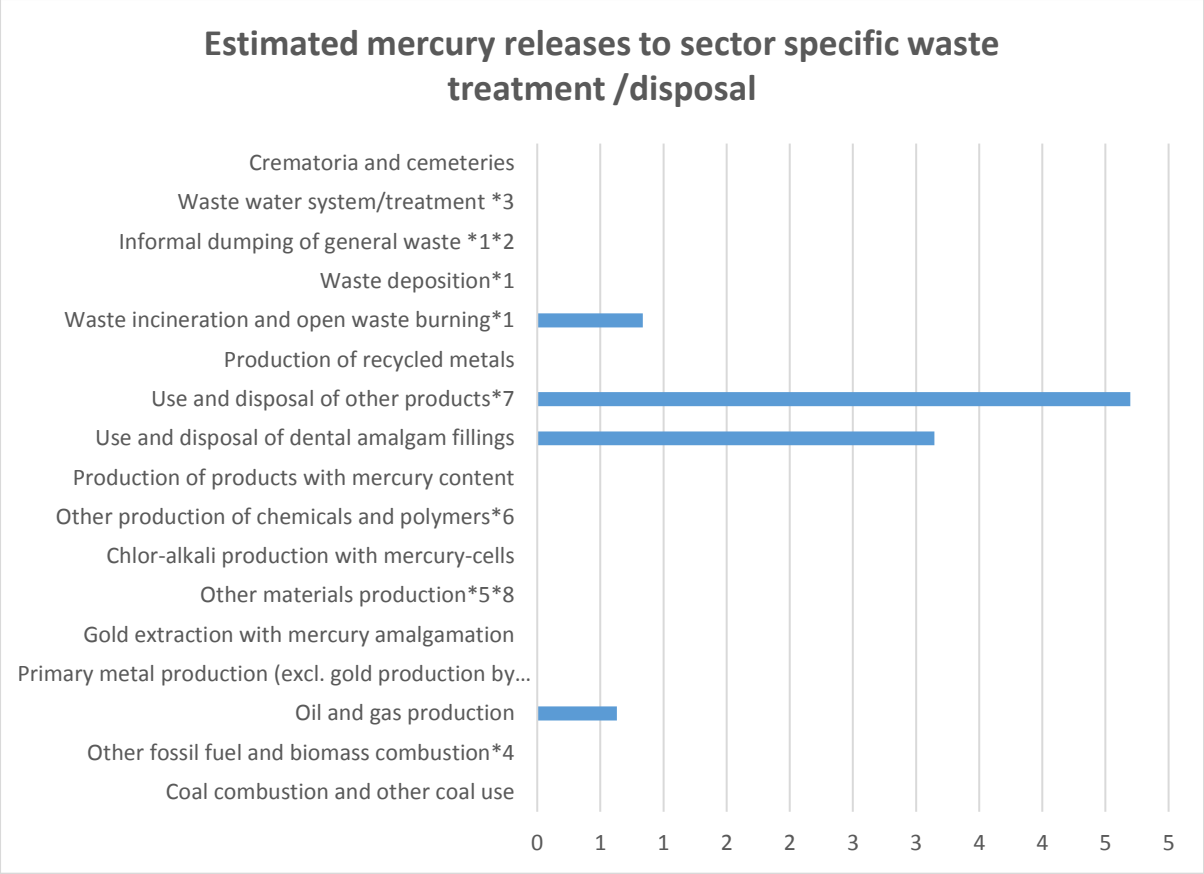


Figure 7: Estimated Mercury Releases, sector specific waste in Barbados, 2013-2017 (kg Hg/y)

Source sub-categories with the highest estimated mercury releases to sector specific waste per year:

Use and disposal of other products

Source sub-category with the lowest estimated mercury releases to sector specific waste per year:

Oil and gas production

Table 1 Summary of mercury inventory results

Source category	Estimated Hg input, kg Hg/y	Estimate Hg releases, standard estimated, kg Hg/y							Percent of total releases *3*4
		Air	Water	Land	By-products and impurities	General waste	Sector specific waste treatment /disposal	Total releases *3*4*5	
Coal combustion and other coal use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Other fossil fuel and biomass combustion	14.2	14.2	0.0	0.0	0.0	0.0	0.0	14.2	6%
Oil and gas production	1.9	0.3	0.4	0.0	0.5	0.0	0.6	1.8	1%
Primary metal production (excl. gold production by amalgamation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Gold extraction with mercury amalgamation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Other materials production*6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Chlor-alkali production with mercury-cells	-	-	-	-	-	-	-	0.0	0%
Other production of chemicals and polymers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Production of products with mercury content*1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Application, use and disposal of dental amalgam fillings	15.7	0.3	6.9	1.3	0.9	3.1	3.1	15.7	7%
Use and disposal of other products	154.2	11.2	22.9	3.9	0.0	111.5	4.7	154.2	67%
Production of recycled metals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Waste incineration and open waste burning*2	14.1	13.3	0.0	0.0	0.0	0.0	0.8	14.1	6%
Waste deposition*2	518.9	5.2	0.1	0.0	-	-	-	5.2	2%
Informal dumping of general waste *2*3	?	?	?	?	?	?	?	0.0	0%
Waste water system/treatment *4	211.6	0.0	190.4	0.0	0.0	21.2	0.0	21.2	9%
Crematoria and cemeteries	6.4	0.5	0.0	6.0	0.0	0.0	0.0	6.4	3%
TOTALS (rounded) *1*2*3*4*5*6	**250.0**	**40.0**	**30.0**	**10.0**	**0.0**	**140.0**	**10.0**	**230.0**	**101%**

1.3 Summary of mercury inventory results

Below are the source sub-categories present in Barbados contributing to the highest estimated mercury inputs.

Energy consumption	1. Combustion/use of petroleum coke and heavy oil 2. Combustion/use of LPG and other light to medium distillates
Fuel production	1. Extraction and processing of natural gas
Use and disposal of products containing mercury	1. Thermometers 2. Batteries with mercury 3. Electrical switches and relays with mercury
Waste incineration	1. Incineration of municipal/general waste
Waste deposition/landfilling and waste water treatment	1. Controlled landfills/deposits 2. Waste water system treatment
Crematoria and cemeteries	1. Cemeteries

Mercury in waste and wastewater produced in Barbados was found to have originated from mercury contained in products and materials. Waste fractions and wastewater therefore do not represent original mercury inputs to society. With respect to waste and wastewater, controlled landfill deposits and wastewater treatment were the major contributors to mercury flows.

Default input factors were used in this inventory for the estimation of mercury releases from general waste treatment and wastewater treatment. The default factors were based on literature regarding mercury content of waste and wastewater; however, data was only available from developed countries. Default input factors calculations may overestimate mercury releases from these sources (see the section on waste data in this report). If feasible, this may be of priority in follow-up work.

Following sections present a detailed presentation of mercury inputs and releases for all mercury release source types present in Barbados.

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

---

[i] **Notes on figures 1-7:**

*1: Waste is not an original source to mercury input to society. To avoid double counting of mercury inputs from waste and products in the graphs, only 10% of the mercury input to waste incineration, waste deposition and informal dumping is included in the chart for mercury inputs. These 10% approximately represents the mercury input to waste from materials not quantified individually in Inventory Level 1 of this Toolkit. See Appendix 1 to the Inventory Level 1 Guideline for more explanation.

*2: Waste is not an original source to mercury input to society. The estimated quantities include mercury in products that have also been accounted for under each product category. To signal the importance of this release pathway, the release to land from informal dumping of general waste has NOT been subtracted in the charts.

*3: Wastewater is not an original source to mercury input to society. The estimated input and release to water include mercury amounts that have also been accounted for under each source category. To avoid double counting, input to waste water system/treatment have been subtracted automatically in the charts. To signal the importance of this release pathway, releases to water via waste water system/treatment has NOT been adjusted in the charts in spite of double counting.

*4: Includes petroleum coke, heavy oil, diesel, gasoil, petroleum, kerosene, natural gas, charcoal and other biofuels.

*5: Includes production of cement and pulp and paper.

*6: Includes production of VCM and acetaldehyde

*7: Includes thermometers, electrical switches and relays, light sources, batteries, polyurethane with Hg catalyst, paints and skin creams with Hg, blood pressure gauges and other manometers, lab chemicals, and other lab and medical uses.

[ii] **Notes to table 1:**

*1 To avoid double counting of mercury in products produced domestically and sold on the domestic market (including oil and gas), only the part of mercury inputs released from production are included in the input TOTAL.

*2: To avoid double counting of mercury inputs from waste and products in the input TOTAL, only 10% of the mercury input to waste incineration, waste deposition and informal dumping is included in the total for mercury inputs. These 10% represent approximately the mercury input to waste from materials that were not quantified individually in Inventory Level 1 of the Toolkit.

*3: The estimated quantities include mercury in products that have 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 that have also been accounted for under each source category. To avoid double counting, input to, and release to water from, waste water system/treatment have been subtracted automatically in the TOTALS.

*5: Total inputs do not necessarily equal total outputs due to corrections for double counting (see notes*1-*3) and because some mercury follows products/metal mercury which are not sold in the same country or in the same year.

1.4 Data gaps

The major difficulties encountered were identifying and obtaining the data necessary to estimate mercury releases from products that intentionally contain the heavy metal. The Barbados Statistical Services (BSS) provided a commendable amount of data on several types of the abovementioned products listed in the inventory. The BSS provided import records for the period 2013-2018; however, some category descriptions provided with the Harmonized System (HS) such as "*thermometers and pyrometers, liquid filled, for direct reading*" did not specifically state whether the specified products contained mercury. Consequently, mercury release estimates for this category may be overestimated.

However, it was found that data for many relevant sources were lumped under a single HS category/code. For example, in the category "*mercury or sodium vapour lamps; metal halide lamps"* each type of lamp is not described in separate categories, so although it is known that each of these lamps may have been imported based on figures provided, the exact quantity of each type of article imported remained unknown. Another category that presented a similar challenge was sphygmomanometers – *"other instruments used to measure or check the flow of other variables of liquids or gases (including manometers)"*. Consequently, it was difficult to determine import data for each product in the category. Therefore, it was assumed that the entire category represented the mercury-containing product; this may have resulted in mercury releases being overestimated. Although hospitals and clinics contacted stated that the use of mercury containing sphygmomanometers was halted in previous years, further research on the use of this equipment and the method of disposal following the cessation of use is necessary.

There is room for improvement when collecting data for the source category products that intentionally contain mercury. In order to develop a more comprehensive assessment, further research could be undertaken with local suppliers to capture the level of usage of such products by the public and private sectors based on consumption/purchasing patterns.

Up to the time of publication, no data were obtained for the occurrence of the following activities and products known to occur or be used in Barbados:

1) Medical waste incineration, this is due to a lack of record keeping by the Queen Elizabeth Hospital; and
2) The use of products such as electrical switches and skin lightening creams and soaps because the relevant entities contacted did not respond to the request for information.

1.5 Main priorities for further assessment and/or action

Products that intentionally contain mercury was found to be the leading contributor to the use and prevalence of mercury in the environment, and therefore had the greatest impact on the volume of emissions estimated. The quality of the data provided for various sections determines the overall accuracy of the Level 1 inventory and its representation of the current situation regarding the presence and emissions of mercury in the environment. Therefore, any data collection improvements should be prioritised or can be focused on in a Level 2 inventory, if feasible. The Level 2 inventory is an advanced version of the Level 1 inventory, which can be used to expand on any sources or activities where further investigation may be necessary. Some of the intentionally used products that should be emphasised for further research are thermometers, sphygmomanometers, mercury vapour lamps and metal halide lamps. Other products and activities that should be considered are:

Electrical switches: Electrical switches may be used locally at some industrial facilities such as the Portvale Sugar Factory. Further investigation into other facilities using these switches would be necessary to determine releases via this source.

Skin lightening creams/soaps: The mercury content of skin lightening creams and soaps and the volume of such products imported annually should be researched due to the lack of information available for this category. Skin lightening creams and soaps containing mercuric compounds are sold in local cosmetic stores; however, the stores contacted were not able to provide annual import data due to a lack of record keeping and the constant change in demand for various brands of products.

Paints: Paints containing mercury is another area where it is necessary to determine the quantities of these paints imported or manufactured in order to produce more accurate mercury release estimates. Up to the time of publishing, no data were provided from the hardware stores contacted.

Releases from incineration of medical waste: Obtaining information for this category proved difficult as the Queen Elizabeth Hospital (QEH) had no record of the volume of medical waste incinerated annually. For future inventories, it may be important to liaise with the QEH to implement a system that will ensure that the volumes of medical waste incineration is recorded and available upon request.

Cement Production: Further investigation is needed to confirm probable mercury releases from the Arawak Cement Company Limited's Portland cement production activities. Even though the data collection form received from the company indicated that mercury was not detected in any of the raw materials nor final product sold or distributed, other verifiable information should be ascertained.

2. Mercury release source types present

Table 2 shows the mercury release sources identified as present or absent in the Barbados. Only source types positively identified as present were included in the quantitative assessment.

The presumably minor mercury release source types shown in Table 2 are not included in the detailed source identification and quantitative assessment.

Table 2 Identification of mercury release sources in Barbados[iii]

Source category	**Source present?**
	Y/N/?
Energy consumption	
Coal combustion in large power plants	N
Coal combustion in coal fired industrial boilers	N
Other coal uses	N
Combustion/use of petroleum coke and heavy oil	Y
Combustion/use of diesel, gasoil, petroleum, kerosene, LPG and other light to medium distillates	Y
Use of raw or pre-cleaned natural gas	N
Use of pipeline gas (consumer quality)	Y
Biomass fired power and heat production	Y
Charcoal combustion	N
Fuel production	
Oil extraction	Y
Oil refining	N
Extraction and processing of natural gas	Y
Primary metal production	
Mercury (primary) extraction and initial processing	N
Production of zinc from concentrates	N
Production of copper from concentrates	N
Production of lead from concentrates	N
Gold extraction by methods other than mercury amalgamation	N
Alumina production from bauxite (aluminium production)	N
Primary ferrous metal production (pig iron production)	N
Gold extraction with mercury amalgamation - from whole ore	N
Gold extraction with mercury amalgamation - from concentrate	N
Other materials production	
Cement production	Y
Pulp and paper production	N
Production of chemicals	
Chlor-alkali production with mercury-cells	N
VCM production with mercury catalyst	N
Acetaldehyde production with mercury catalyst	N
Production of products with mercury content	
Hg thermometers (medical, air, lab, industrial etc.)	N
Electrical switches and relays with mercury	N
Light sources with mercury (fluorescent, compact, others: see guideline)	N
Batteries with mercury	N
Manometers and gauges with mercury	N
Biocides and pesticides with mercury	N

Paints with mercury	?
Skin lightening creams and soaps with mercury chemicals	N
Use and disposal of products with mercury content	
Dental amalgam fillings ("silver" fillings)	Y
Thermometers	Y
Electrical switches and relays with mercury	Y
Light sources with mercury	Y
Batteries with mercury	Y
Polyurethane (PU, PUR) produced with mercury catalyst	Y
Paints with mercury preservatives	N
Skin lightening creams and soaps with mercury chemicals	Y
Medical blood pressure gauges (mercury sphygmomanometers)	Y
Other manometers and gauges with mercury	Y
Laboratory chemicals	Y
Other laboratory and medical equipment with mercury	Y
Production of recycled of metals	
Production of recycled mercury ("secondary production")	N
Production of recycled ferrous metals (iron and steel)	N
Waste incineration	
Incineration of municipal/general waste	Y
Incineration of hazardous waste	N
Incineration / burning of medical waste	Y
Sewage sludge incineration	N
Open fire waste burning (on landfills and informally)	?
Waste deposition/landfilling and waste water treatment	
Controlled landfills/deposits	Y
Informal dumping of general waste *1	?
Waste water system/treatment	Y
Crematoria and cemeteries	
Crematoria	Y
Cemeteries	Y

Source category	Source present?
	Y/N/?
Combustion of oil shale	N
Combustion of peat	N
Geothermal power production	N
Production of other recycled metals	N
Production of lime	?
Production of light weight aggregates (burnt clay nuts for building purposes)	?
Production of other chemicals (than chlorine and sodium hydroxide) in Chlor-alkali facilities with mercury-cell technology	N
Polyurethane production with mercury catalysts	N
Seed dressing with mercury chemicals	N
Infra red detection semiconductors	N
Bougie tubes and Cantor tubes (medical)	?
Educational uses	?
Gyroscopes with mercury	?
Vacuum pumps with mercury	?
Mercury used in religious rituals (amulets and other uses)	N
Mercury used in traditional medicines (ayurvedic and others) and homeopathic medicine	N
Use of mercury as a refrigerant in certain cooling systems	N
Light houses (levelling bearings in marine navigation lights)	?
Mercury in large bearings of rotating mechanic parts in for example older waste water treatment plants	?
Tanning	N
Pigments	N
Products for browning and etching steel	N
Certain colour photograph paper types	N
Recoil softeners in rifles	N
Explosives (mercury-fulminate a.o.)	?
Fireworks	Y
Executive toys	Y

[iii] Key for the above tables: present (Y), absent (N), and possible but not positively identified (?).

3. **Summary of mercury inputs to society**

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

Table 3 Summary of estimated mercury inputs in Barbados

Source category			**Estimated Hg input, kg Hg/y**
	Activity rate	**Unit**	**Standard estimate**
Energy consumption			
Combustion/use of petroleum coke and heavy oil	192102	Oil product combusted, t/y	11
Combustion/use of diesel, gasoil, petroleum, kerosene, LPG and other light to medium distillates	393623	Oil product combusted, t/y	2
Use of pipeline gas (consumer quality)	18048000	Gas used, Nm^3/y	0
Biomass fired power and heat production	50469	Biomass combusted, t/y	2
Fuel production			
Oil extraction	32820	Crude oil produced, t/y	0
Extraction and processing of natural gas	18048000	Gas produced, Nm^3/y	2
Use and disposal of products with mercury content			
Dental amalgam fillings ("silver" fillings)	276302	Number of inhabitants	16
Thermometers	8968	Items sold/y	58
Electrical switches and relays with mercury	276302	Number of inhabitants	39
Light sources with mercury	710509	Items sold/y	11
Batteries with mercury	33.27	t batteries sold/y	23
Polyurethane (PU, PUR) produced with mercury catalyst	276302	Number of inhabitants	8
Other manometers and gauges with mercury	276302	Number of inhabitants	1
Laboratory chemicals	276302	Number of inhabitants	3
Other laboratory and medical equipment with mercury	276302	Number of inhabitants	11
Waste incineration			
Incineration of municipal/general waste	2827	Waste incinerated, t/y	14
Waste deposition/landfilling and waste water treatment			
Controlled landfills/deposits	103789	Waste landfilled, t/y	519
Waste water system/treatment	40306468.8	Waste water, m3/y	212
Crematoria and cemeteries			
Crematoria	183	Corpses cremated/y	0
Cemeteries	2394	Corpses buried/y	6
TOTAL of quantified inputs*1*2*3*4			**250**

Estimated mercury input figures for the best and worst-case scenarios in table 4 are based on two standard deviations from the mean/average most estimated activity rates. Two standard deviations provide a 95.45% confidence interval, that is, 95.45% of all possible values lie within this range. Standard deviation values could not be computed for the following sources due to the default activity rate formulas in the inventory; the use and disposal of: dental amalgam fillings, electrical switches and relays, laboratory chemicals, other laboratory equipment, other manometers and gauges and polyurethane produced with mercury catalyst.
A standard deviation value was also not computed for wastewater system/treatment where data was obtained for one year (2018) only.
Table 4 Summary of estimated mercury inputs (most likely scenario, best-case scenario and worst-case scenario)

Source category			**Estimated Hg input, kg Hg/y**		
	Activity rate	**Unit**	**Most Likely Scenario**	**Best Case Scenario**	**Worst Case Scenario**
Energy consumption					
Combustion/use of petroleum coke and heavy oil	192102	Oil product combusted, t/y	11	9	12
Combustion/use of diesel, gasoil, petroleum, kerosene, LPG and other light to medium distillates	393623	Oil product combusted, t/y	2	2	3
Use of pipeline gas (consumer quality)	18048000	Gas used, Nm^3/y	0	0	0
Biomass fired power and heat production	50469	Biomass combusted, t/y	2	1	2
Fuel production					
Extraction and processing of natural gas	18048000	Gas produced, Nm^3/y	2	1	2
Use and disposal of products with mercury content					
Dental amalgam fillings ("silver" fillings)	276302	Number of inhabitants	16	16	16
Thermometers	8968	Items sold/y	58	0	251
Electrical switches and relays with mercury	276302	Number of inhabitants	39	39	39
Light sources with mercury	710509	Items sold/y	11	3	27
Batteries with mercury	33.27	t batteries sold/y	23	1	77
Polyurethane (PU, PUR) produced with mercury catalyst	276302	Number of inhabitants	8	8	8
Other manometers and gauges with mercury	276302	Number of inhabitants	1	1	1
Laboratory chemicals	276302	Number of inhabitants	3	3	3
Other laboratory and medical equipment with mercury	276302	Number of inhabitants	11	11	11
Waste incineration					
Incineration of municipal/general waste	2827	Waste incinerated, t/y	14	10	18
Waste deposition/landfilling and waste water treatment					
Controlled landfills/deposits	103789	Waste landfilled, t/y	519	464	574
Waste water system/treatment	40306468.8	Waste water, m3/y	212	212	212
Crematoria and cemeteries					
Crematoria	183	Corpses cremated/y	0	0	1
Cemeteries	2394	Corpses buried/y	6	5	7
TOTAL of quantified inputs*1*2*3*4			**250**	**150**	**520**

Figure 8 illustrates the source sub-categories that made the largest contributions of mercury inputs to society in each inventory category.

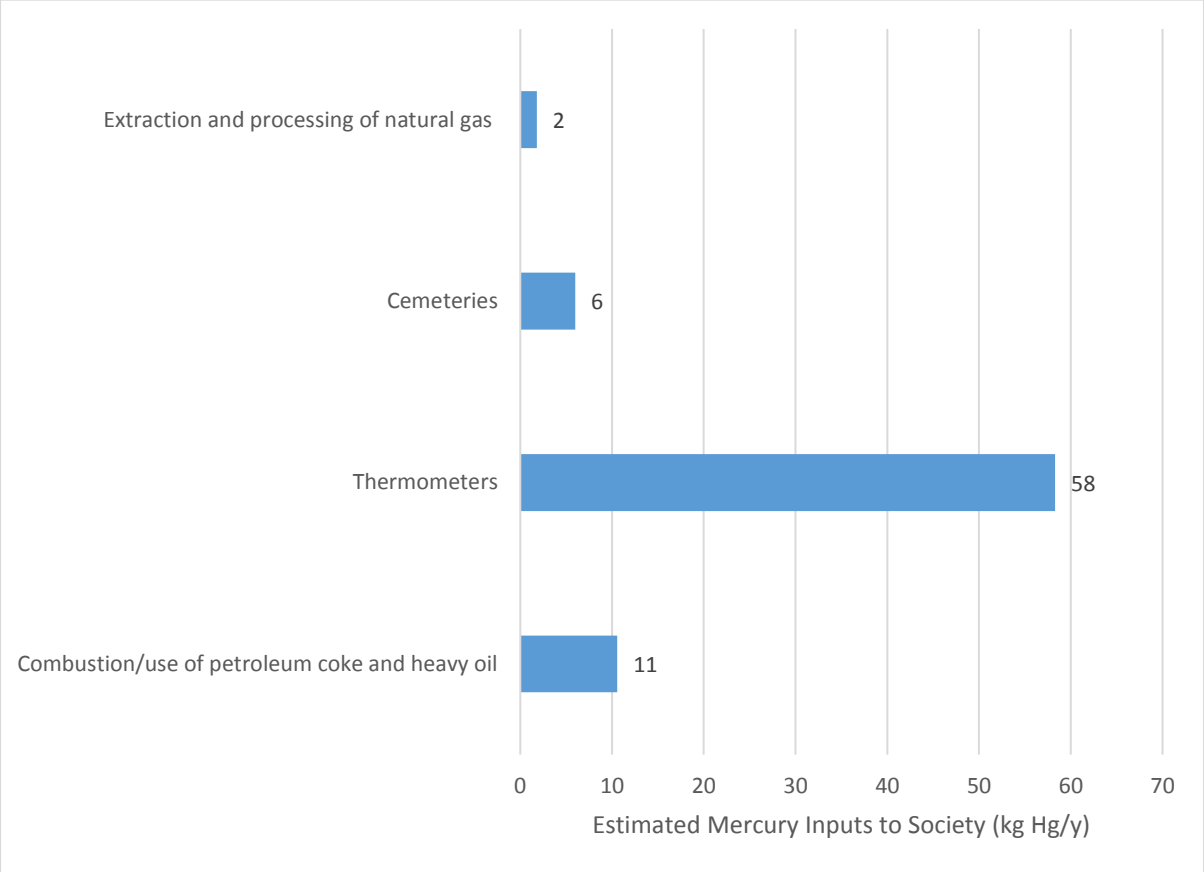


Figure 8 Summary of largest mercury contributions to society

Figure 9 shows the estimated mercury inputs from the use and disposal of products that intentionally contain mercury.

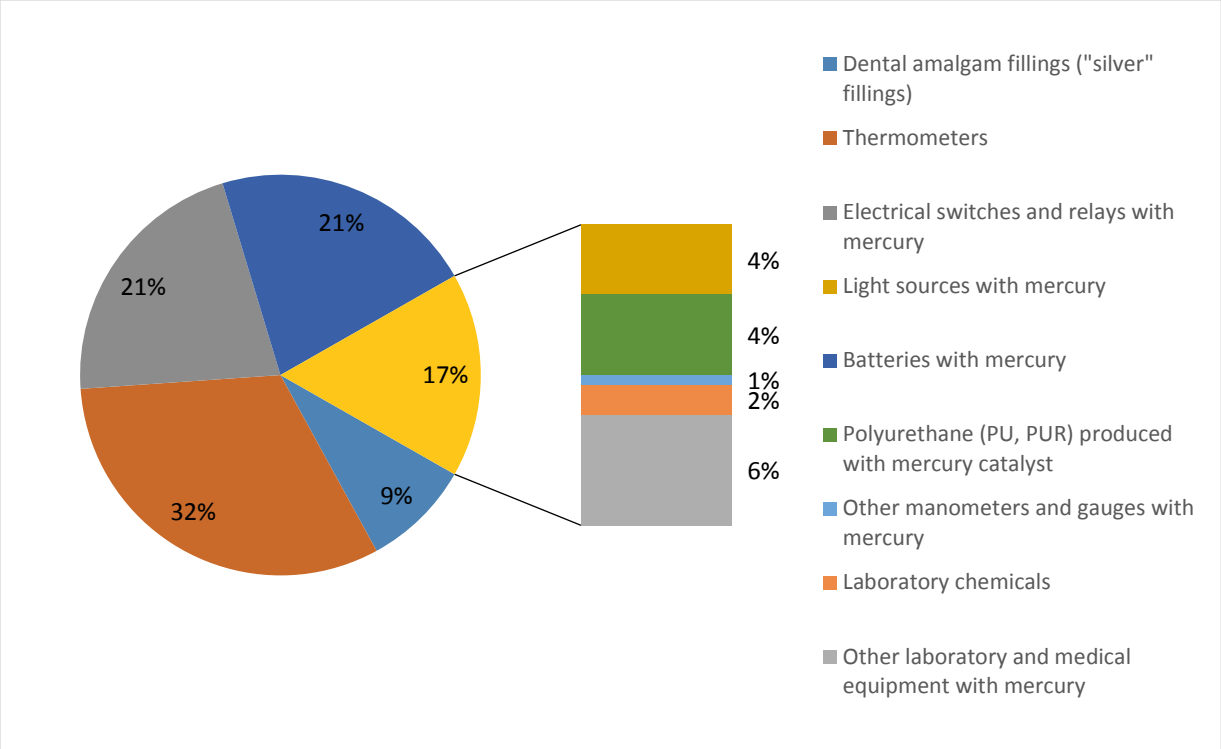


Figure 9 Estimated mercury inputs from products that intentionally contain mercury, kg Hg/year

Highest contributor – Thermometers

Lowest contributor – Other manometers and gauges with mercury

Figure 10 shows the distribution of mercury inputs from sources in the energy consumption category.

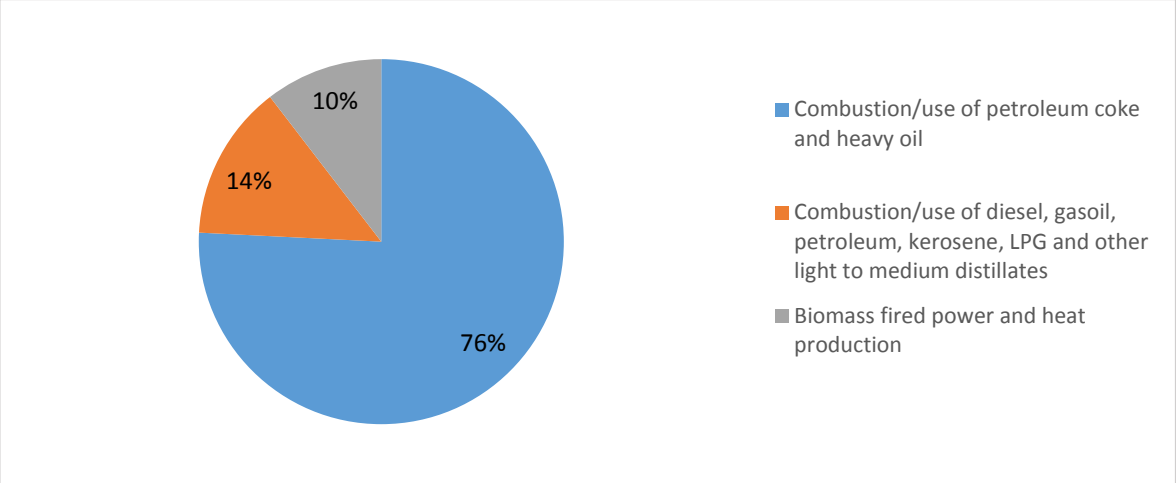


Figure 10 Estimated mercury inputs from energy consumption in Barbados, kg Hg/year

Highest contributor – Combustion/use of petroleum coke and heavy oil

Lowest contributor – Biomass fired power and heat production

4. Summary of mercury releases

Table 5 below provides a summary of mercury releases from all source categories present. The key mercury releases presented are releases to air (the atmosphere), and to water (marine and freshwater bodies, including via wastewater systems), to land, to general waste, and to sectors specific waste treatment. An additional output pathway is "by-products and impurities" which directs mercury flows back into the market via by-products and products where mercury does not play an intentional role for example, sulphuric acid produced from desulphurization of flue gas (flue gas cleaning) in non-ferrous metal plants with mercury present in trace concentrations. See Table 8 for a detailed description and definition of the output pathways.

Table 5 Most likely scenario of estimated mercury releases

Source category	**Estimated Hg releases, standard estimates, Kg Hg/y**					
	Air	**Water**	**Land**	**By-products and impurities**	**General waste**	**Sector specific waste treatment /disposal**
Energy consumption						
Combustion/use of petroleum coke and heavy oil	10.6	0.0	0.0	0.0	0.0	0.0
Combustion/use of diesel, gasoil, petroleum, kerosene, LPG and other light to medium distillates	2.2	0.0	0.0	0.0	0.0	0.0
Use of pipeline gas (consumer quality)	0.0	0.0	0.0	0.0	0.0	0.0
Biomass fired power and heat production	1.5	0.0	0.0	0.0	0.0	0.0
Fuel production						
Extraction and processing of natural gas	0.3	0.4	0.0	0.5	0.0	0.6
Use and disposal of products with mercury content						
Dental amalgam fillings ("silver" fillings)	0.3	6.9	1.3	0.9	3.1	3.1
Thermometers	5.8	17.5	0.0	0.0	35.0	0.0
Electrical switches and relays with mercury	3.9	0.0	3.9	0.0	30.9	0.0
Light sources with mercury	0.6	0.0	0.0	0.0	10.5	0.0
Batteries with mercury	0.0	0.0	0.0	0.0	22.7	0.0
Polyurethane (PU, PUR) produced with mercury catalyst	0.8	0.4	0.0	0.0	7.0	0.0
Other manometers and gauges with mercury	0.1	0.4	0.0	0.0	0.8	0.0
Laboratory chemicals	0.0	0.9	0.0	0.0	0.9	0.9
Other laboratory and medical equipment with mercury	0.0	3.6	0.0	0.0	3.6	3.8
Waste incineration						
Incineration of municipal/general waste	13.3	0.0	0.0	0.0	0.0	0.8
Waste deposition/landfilling and waste water treatment						
Controlled landfills/deposits	5.2	0.1	0.0	-	-	-
Waste water system/treatment *2	0.0	190.4	0.0	0.0	21.2	0.0
Crematoria and cemeteries						
Crematoria	0.5	0.0	0.0	-	0.0	0.0
Cemeteries	0.0	0.0	6.0	-	0.0	0.0
TOTAL of quantified releases*1*2*3	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**

Table 6 Worst-case scenario of estimated mercury releases[iv]

Source Category	Estimated Hg releases, standard estimates, Kg Hg/y					
	Air	Water	Land	By-products and impurities	General waste	Sector specific waste treatment /disposal
Energy consumption						
Combustion/use of petroleum coke and heavy oil	12.25	0.00	0.00	0.00	0.00	0.00
Combustion/use of diesel, gasoil, petroleum, kerosene, LPG and other light to medium distillates	2.53	0.00	0.00	0.00	0.00	0.00
Use of pipeline gas (consumer quality)	0.01	0.00	0.00	0.00	0.00	0.00
Biomass fired power and heat production	2.45	0.00	0.00	0.00	0.00	0.00
Fuel production						
Oil extraction	0.00	0.02	0.00	0.00	0.00	0.00
Extraction and processing of natural gas	0.35	0.47	0.00	0.70	0.00	0.82
Use and disposal of products with mercury content						
Dental amalgam fillings ("silver" fillings)	0.31	6.92	1.26	0.94	3.14	3.14
Thermometers	25.11	75.32	0.00	0.00	150.63	0.00
Electrical switches and relays with mercury	3.87	0.00	3.87	0.00	30.95	0.00
Light sources with mercury	1.36	0.00	0.00	0.00	25.91	0.00
Batteries with mercury	0.00	0.00	0.00	0.00	77.48	0.00
Polyurethane (PU, PUR) produced with mercury catalyst	0.83	0.41	0.00	0.00	7.05	0.00
Other manometers and gauges with mercury	0.14	0.41	0.00	0.00	0.83	0.00
Laboratory chemicals	0.00	0.91	0.00	0.00	0.91	0.94
Other laboratory and medical equipment with mercury	0.00	3.65	0.00	0.00	3.65	3.76
Waste incineration						
Incineration of municipal/general waste	17.18	0.00	0.00	0.00	0.00	1.08
Waste deposition/landfilling and waste water treatment						
Controlled landfills/deposits	5.74	0.06	0.00	-	-	-
Waste water system/treatment *2	0.00	190.45	0.00	0.00	21.16	0.00
Crematoria and cemeteries						
Crematoria	0.70	0.00	0.00	-	0.00	0.00
Cemeteries	0.00	0.00	6.51	-	0.00	0.00
TOTAL of quantified releases*1*2*3	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**

Table 7 Best-case scenario of estimated mercury releases[v]

Source category	Estimated Hg releases, standard estimates, Kg Hg/y					
	Air	Water	Land	By-products and impurities	General waste	Sector specific waste treatment /disposal
Energy consumption						
Combustion/use of petroleum coke and heavy oil	8.9	0.0	0.0	0.0	0.0	0.0
Combustion/use of diesel, gasoil, petroleum, kerosene, LPG and other light to medium distillates	1.8	0.0	0.0	0.0	0.0	0.0
Biomass fired power and heat production	0.6	0.0	0.0	0.0	0.0	0.0
Fuel production						
Extraction and processing of natural gas	0.2	0.3	0.0	0.4	0.0	0.4
Use and disposal of products with mercury content						
Dental amalgam fillings ("silver" fillings)	0.3	6.9	1.3	0.9	3.1	3.1
Thermometers	0.0	0.0	0.0	0.0	0.0	0.0
Electrical switches and relays with mercury	3.9	0.0	3.9	0.0	30.9	0.0
Light sources with mercury	0.2	0.0	0.0	0.0	3.3	0.0
Batteries with mercury	0.0	0.0	0.0	0.0	0.8	0.0
Polyurethane (PU, PUR) produced with mercury catalyst	0.8	0.4	0.0	0.0	7.0	0.0
Other manometers and gauges with mercury	0.1	0.4	0.0	0.0	0.8	0.0
Laboratory chemicals	0.0	0.9	0.0	0.0	0.9	0.9
Other laboratory and medical equipment with mercury	0.0	3.6	0.0	0.0	3.6	3.8
Waste incineration						
Incineration of municipal/general waste	9.4	0.0	0.0	0.0	0.0	0.6
Waste deposition/landfilling and waste water treatment						
Controlled landfills/deposits	4.6	0.0	0.0	-	-	-
Waste water system/treatment *2	0.0	190.4	0.0	0.0	21.2	0.0
Crematoria and cemeteries						
Crematoria	0.2	0.0	0.0	-	0.0	0.0
Cemeteries	0.0	0.0	5.5	-	0.0	0.0
TOTAL of quantified releases*1*2*3	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**

Table 8 Description of Release/Output Pathways

Calculation result type	Description
Estimated Hg input, Kg Hg/y	The standard estimated amount of mercury entering a specific source category with input materials, for example calculated mercury amount in 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 example from: Point sources such as heavy fuel oil power plants, waste incineration; Diffuse sources such as informal burning of waste with fluorescent lamps, batteries, thermometers
Land	Mercury releases to the terrestrial environment: General soil and groundwater. For example releases from: Uncollected waste products dumped or buried informally Dumping of sewage sludge with mercury content on land Application on land, seeds or seedlings of pesticides with mercury compounds
By-products and impurities	By-products that contain mercury, which are sent back into the market and cannot be directly allocated to environmental 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 incineration, landfilling or informal dumping. The mercury sources to waste are consumer products with intentional mercury content (batteries, thermometers, fluorescent tubes, etc.) as well as high volume waste like printed paper, plastic, etc., with small trace concentrations of mercury.
Sector specific waste treatment /disposal	Waste from industry and consumers which is collected and treated in separate systems, and in some cases recycled; 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 batteries, thermometers, mercury switches, lost teeth with amalgam fillings, etc. Confined deposition of tailings and high volume rock/waste from extraction of non-ferrous metals

[iv] Figures for estimated mercury releases in table 6 are based on two standard deviations from the mean/average of all estimated activity rates except wastewater system/treatment since the data provided for that category was not conducive to finding the standard deviation. Two standard deviations provides a 95.45% confidence interval, that is, 95.45% of possible values lie within this range. Therefore, the worst-case scenario shows the highest possible mercury emissions one should expect.

[v] Figures for estimated mercury releases in table 7 are based on two standard deviations from the mean/average of all estimated activity rates except wastewater system/treatment since the data provided for that category was not conducive to finding the standard deviation. Two standard deviations provides a 95.45% confidence interval, that is, 95.45% of possible values lie within this range. Therefore, best-case scenario highlights the lowest possible mercury emissions that should expect.

5. Data and inventory on energy consumption and fuel production

Energy consumption and fuel production covers the use of fossil fuels and plant matter (biomass) for production of electricity and heat. Fossil fuels and biomass naturally contain trace concentrations of mercury, which is usually released when the fuel is burned. Most of this mercury is released to the atmosphere, but some is captured by flue gas cleaning systems and ends up in residues from this system. Mercury concentrations in fuel vary depending on the fuel source and the fuel type. The sections below highlight inventory data for source subcategories consuming energy and or producing fuel. Figure 12 shows the distribution of mercury emissions to the air from sources in this category. See appendix A for activity rate calculation tables for all source sub-categories in this section.

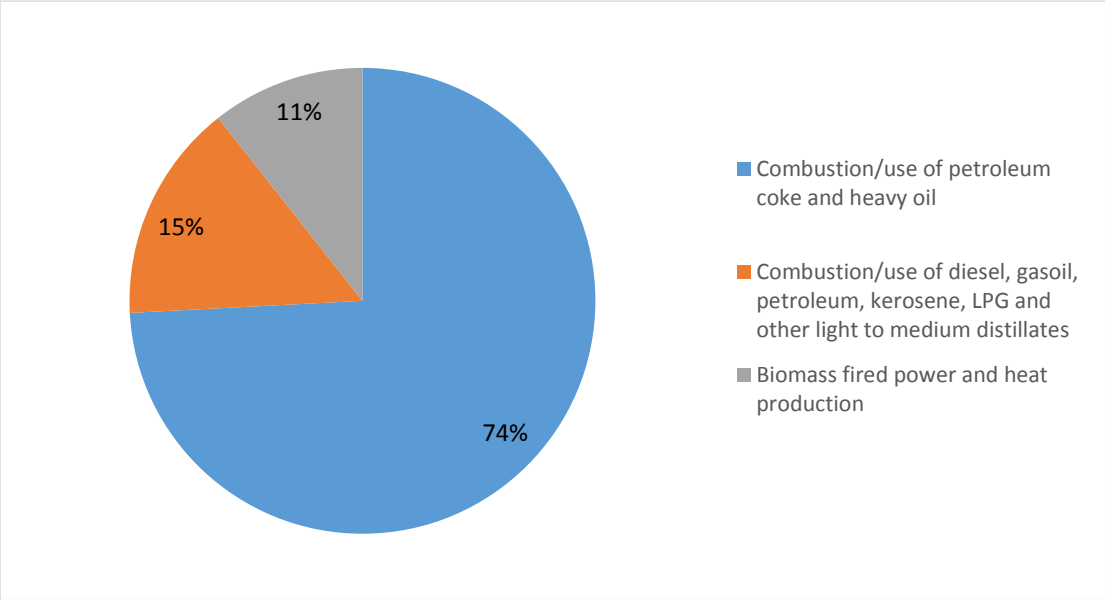


Figure 11 Estimated mercury releases to air from energy consumption, Kg Hg/year

Highest estimated releases – Combustion/use of petroleum coke and heavy oil

Lowest estimated releases – Biomass fires power and heat production

5.1 Combustion/use of petroleum coke and heavy oil

Barbados primarily uses heavy fuel oils (mainly imported from Trinidad and Tobago) for power/electricity generation. Barbados' sole electricity provider is the Barbados Light and Power Company Limited (BL&P). Data for this category were based on 2013-2017 consumption figures provided by BL&P for the following heavy fuel oil products: heavy fuel oil no. 6 (Bunker C) and heavy vacuum gas oil. The activity rate for this category (192,102 ± 15,284 t/y) represents the average amount of heavy fuel oil no. 6 and heavy vacuum gas oil used annually over the period 2013-2017.

5.2 Combustion/use of light to medium distillates

The activity rate for this category (393,623 ± 32,980 t/y) represents the average amount of light oils distributed by BNTCL (gasoline, diesel, and fuel oil) and the light oils used by BL&P (jet A1 fuel and diesel) annually for the period 2013-2017. The figures provided by BNTCL were converted from barrels to metric tonnes using the CME Group's conversion (CME Group 2019).

5.3 Fuel Production (Oil Extraction, Extraction and Processing of Natural Gas)

Natural gas extraction and processing does occur in Barbados and is carried out by BNOCL, according the data received from the Barbados Statistical Service, minimal quantities of natural gas are imported. The natural gas extracted is processed and distributed to various districts around the island to be used as cooking gas. Data for this category were provided by BNOCL for the period 2013-2017, data were converted from thousand cubic feet (mcf) to terajoules using Kyle's Converter, an online conversion calculator (Kyle's Converter 2009), and then converted to normal cubic meters (Nm^3) using the toolkit's conversion calculator. The activity rate for this category (18,048,000 ± 52,736,000 Nm^3) represents the average amount of natural gas extracted by BNOCL annually for the 2013-2017 period, assuming that all of the natural gas extracted within a year is utilised within that particular year.

5.4 Biomass Fired Power and Heat Production

According to (Division of Energy and Communication 2018), Barbados' sugar cane bagasse has been used for cogeneration for years; bagasse derived from sugarcane juice extraction is burned in broilers at sugar factories to generate steam and electricity for the plant. Portvale Sugar Factory, Barbados sole operating sugar factory, provided data for this sub-category. The activity rate (50,469 ± 15,597 t/y) represents the average amount of bagasse burned annually by the factory for the period 2013-2017, and the average amount of fuel wood consumed in Barbados for the period 2013-2017 according to the 2016 Food and Agriculture Organization Forestry Yearbook (Food and Agriculture Organization of the United Nation 2016). The figures from the yearbook were converted from cubic meters to metric tonnes using conversion factors from the Forest Research, a United Kingdom government website (Forest Research n.d.).

6. Data and inventory on domestic production of metals and raw materials

Domestic production of metals and raw materials covers three groups of activities: 1) industrial mining and primary processing of metals where mercury is present in trace concentrations in the ore material; 2) small scale gold mining with mercury amalgamation, where mercury is added to extract the gold; and 3) industrial production of the large volume materials cement and paper.

Based on research and input from some members of staff at the Environmental Protection Department, the conclusion was drawn that the only activity covered in this section that occurs in Barbados is cement production. However, the Arawak Cement Plant did not submit production information as their data collection form indicated that none of their raw materials or final products contain mercury.

6.1 Cement Production

The sole Portland cement producer in Barbados is Arawak Cement Company Limited (Arawak), the cement manufactured is sold and distributed locally and exported. The raw materials used for the production of Portland cement are limestone, shale, iron ore, pozzolan, gypsum, bunker C, diesel and petroleum coke.

Based on information provided in the data collection form from Arawak Cement Company Limited, the Portland cement produced by the company contains no detectable amounts of mercury, as it is not detected in the raw materials used for production. The company also noted the cessation of lime production (Arawak 2018), which could have been a possible contributor to mercury releases.

However, the 2015 Minerals Yearbook for Caribbean Islands published by the U.S. Geological Survey, noted that Arawak has an annual cement production capacity of 360,000 tonnes, which corresponds to approximately 47 kg of mercury releases annually according to the inventory Toolkit (Soto-Viruet 2019). Further study is therefore recommended, as this could be a significant source of mercury releases for Barbados.

7. Data and inventory on domestic production and processing with intentional mercury use

7.1 Production of Chemicals

Production of chemicals covers the industrial production of chemicals with mercury catalyst such as chlor-alkali, vinyl chloride monomer and acetaldehyde. However, based on research and input from some members of staff at the Environmental Protection Department, there was no information to suggest that any of chemical production activities mentioned above occur in Barbados.

7.2 Production of Products with Containing Mercury

Production of products covers the industrial production of products containing mercury such as thermometers, light sources, manometers/gauges, biocides & pesticides, batteries, paints or skin lightening creams and soaps. However, there was no information to suggest that Barbados produces any products containing mercury such as the ones listed above.

8. Data and inventory on waste handling and recycling

Waste handling and recycling includes all types of waste treatment, landfilling, incineration, dumping, open burning and recycling activities. See appendix B for activity rate calculation tables for all source sub-categories in this section.

The overall questions about the overall waste treatment setup in Barbados were answered as follows:

a) More than 2/3 (two thirds = 67%) of the general waste is collected and deposited on lined landfills ~~or incinerated in closed incinerators~~.
b) Less than 1/3 (one third = 33%) of the waste from mercury-added products is safely collected and treated separately

8.1 Incineration of municipal/general waste

Estimated releases for this category was based on data for waste incineration at the Grantley Adams International Airport (GAIA) for the period 2013-2017, and the Barbados Port Inc. (BPI) for 2018 only. GAIA uses a wet scrubber to control air emissions. Waste is delivered to GAIA in both loose and compacted forms, compacted waste accounts for 80-85% of the waste processed (GAIA 2018). The waste incinerated at the BPI includes waste from shipping vessels, businesses, BPI and wooden skids (BPI 2019). The activity rate (2827 ± 413 t/y) represents the weighted average of the amount of waste incinerated by BPI and GAIA annually over the 2013-2018 period. Figure 13 shows that mercury emissions from municipal/general waste incineration were distributed to output pathways as follows: 94% air and 6% sector specific waste treatment/disposal.

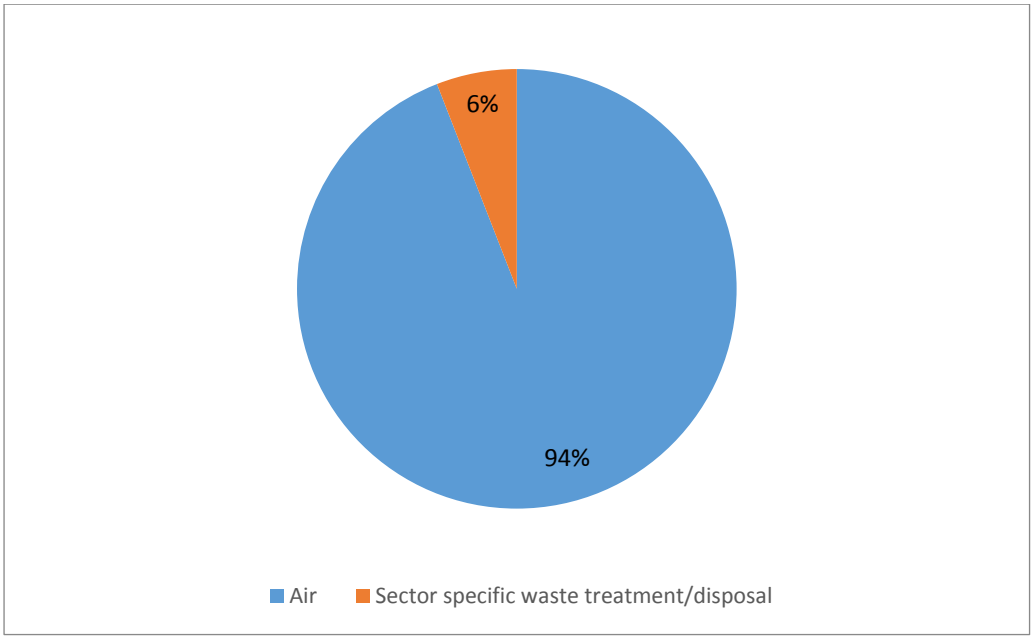


Figure 12 Estimated mercury releases from municipal/general waste incineration

The percentage of waste incinerated by GAIA (59.19 %) was used to calculate mercury emissions from waste incinerated at a facility with an emission control feature. The assumption was made that an electrostatic precipitator has a similar removal efficiency as a wet scrubber, hence the option "PM reduction, simple ESP, or similar" was used to compute releases.

The distribution of the activity rate based on the conjectural use of an electrostatic precipitator by GAIA is outlined below.

Relevant pollution abatement options	No emission reduction devices	PM reduction, simple ESP, or similar
Percent of total activity rate:	40.81	59.19

8.2 Incineration of Hazardous Waste

Barbados does not currently incinerate hazardous waste. The Mangrove Pond Landfill is the engineered landfill site currently in use; it is assumed that most collected refuse is deposited here.

8.3 Incineration and open burning of medical waste

According to data received from Bayview Hospital (Bayview) and Queen Elizabeth Hospital (QEH), it is confirmed that medical waste incineration does occur on island. Bayview's data collection form indicated that all of the medical waste generated by their facility is taken to QEH to be incinerated (Bayview 2018). However, data on the amount of waste incinerated at the QEH is unknown, as records were not kept (QEH 2018).

8.4 Sewage Sludge Incineration

Sewage sludge incineration is not known to take place in Barbados. Sludge from the Barbados Water Authority sewage treatment facility is occasionally deposited at a specific location in Spencers, St. Philip.

8.5 Open Fire Waste Burning (on landfills and informally)

The majority of municipal/general waste in Barbados is collected and taken to the Mangrove Pond Landfill where there is no intentional open burning; however, spontaneous ignition may occur periodically. It can be noted however that open burning is a common practice in various communities across the island, but quantifying this activity poses difficulty and uncertainty, as persons do not typically record the amount of waste burnt. According to Wiedinmeyr et al, 2014, 24,550 tonnes of mercury is emitted annually from the burning of waste globally. Consequently, this is an area for further investigation as it was not included in the inventory.

8.6 Controlled Landfills/Deposits

The activity rate for controlled landfills/deposits (103,789 ± 5,501 t/y) is the average amount waste deposited at the Mangrove Pond Landfill annually for the period 2013-2017.

According to figure 14, an estimated 99% of mercury emissions during that period went to air while 1% went to water.

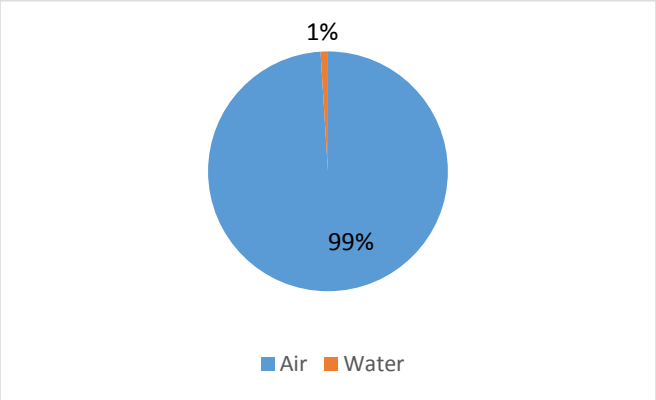


Figure 13 Estimated mercury releases from controlled landfills/deposits

8.7 Waste Water System/Treatment

Barbados has two sewage treatment plants: the South Coast and Bridgetown Waste Water Treatment Plants. The Bridgetown Plant carries out the secondary waste treatment while the South Coast Plant employs primary treatment only.

Water production figures were provided for the year 2018 from the island's main water supplier, Barbados Water Authority (BWA). The water supply is derived from 25 water-pumping stations across the island. An assumption was made that 80% of the water supplied domestically and commercially ultimately ends up as wastewater (NPTEL n.d.). The activity rate for wastewater (40,306,468.80 m^3/y) was therefore calculated as 80% of the total amount water produced in 2017 (50,383,086 m^3/y).

Figure 15 shows that mercury releases from wastewater treatment were distributed to output pathways as follows: 90% water and 10% general waste.

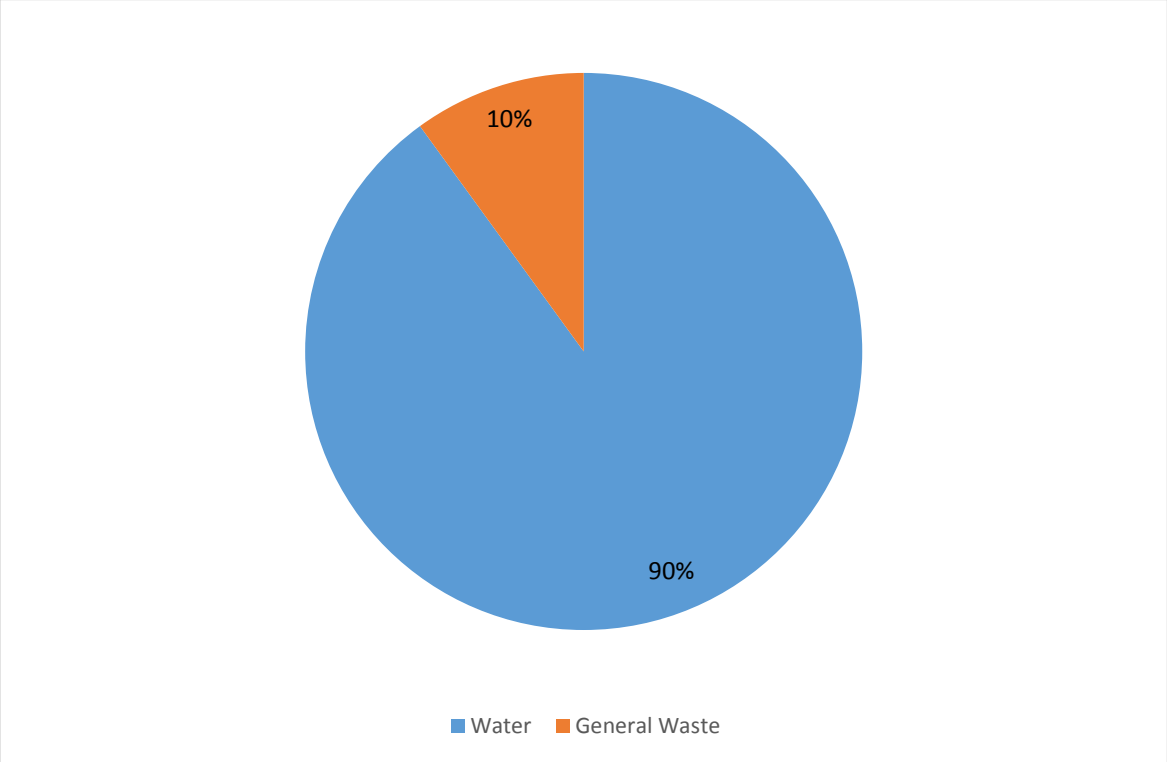


Figure 14 Estimated mercury releases from wastewater treatment,

.

9. Data and inventory on general consumption of products containing mercury as a metal or a mercury containing substance

General consumption of products containing mercury as a metal or a mercury containing substance covers Barbados' consumption of a wide variety of consumer products such as thermometers and fluorescent light bulbs, and products where mercury must be added for its function such as dental amalgam and certain manometers.

Figure 17 shows that the lowest contributors of mercury releases to water in this category were the use and disposal of polyurethane produced with mercury catalyst, 1% and other manometers and gauges, 2%. According to figure 18, the largest contributor of mercury releases to land was the use and disposal of electrical switches and relays, 75%; however, the lowest contributor was the use and disposal of dental amalgam fillings, which accounted 25% or releases. As outlined in figure 19, the use and disposal of other manometers and gauges and laboratory chemicals accounted for the least amount of mercury releases to land, 1%. See appendix C for activity rate calculation tables for all source sub-categories in this section.

Table 6 Source sub-categories with an activity rate and estimated release calculations based on Toolkit calculations for population, electrification rate and density of dental personnel

Sub-category	Data types used as activity rates
Dental amalgam fillings ("silver" fillings)	Population, density of dental personnel
Electrical switches and relays with mercury	Population, electrification rate (percent of population with access to electricity)
Polyurethane (PU, PUR) produced with mercury catalyst	Population, electrification rate (percent of population with access to electricity)
Other manometers and gauges with mercury	Population, electrification rate (percent of population with access to electricity)
Laboratory chemicals	Population, electrification rate (percent of population with access to electricity)
Other laboratory equipment with mercury	Population, electrification rate (percent of population with access to electricity)

Table 7 Background data for default inventory calculations

Background Data for Default Calculations and Range Test			
Country	**Population in 2010 (or as recent as available data allow; UNSD, 2012)**	**Dental personnel per 1000 inhabitants**	**Electrification rate, % of population with access to electricity**
Barbados	276,302	0.236	100

The background data above was provided as part of the Toolkit. The data shown is based on authoritative international data sources (population data: UNSD; Dental data: WHO; Electrification data: IEA). If data from these sources were not available, other sources were used as described in the Toolkit Reference Report's Annex 8.4.

The Barbados Statistical Services (BSS) provided 2013-2018 data on various imported products possibly containing mercury; the products were select based on guidelines the Inventory Level 1 Toolkit.

Below are Harmonized System categories from the BSS used to determine the product's description:

HS code description	Associated HS code
Thermometers and pyrometers, liquid-filled for direct reading	9025.11.00
Other instruments to measure or check the flow of other variables of liquids or gases (including manometers) - Medical blood pressure gauges (Sphygmomanometers)	9026.80.00
Primary cells and primary batteries, of mercuric oxide	8506.30.00
Primary cells and primary batteries, of air-zinc and primary cells and batteries, of silver oxide	8506.60.00 and 8506.64.00
Primary cells and primary batteries, of manganese dioxide	8506.10.00
Primary cells and primary batteries, of silver oxide	8506.40.00
Other electrical discharge lamps other than ultra-violet lamps	8539.39.00
Fluorescent, hot cathode lamps	8539.31.00
Portable electric lamps (functioning by their own source of energy)	8513.10.00
Mercury or sodium vapour lamps; metal halide lamps	8539.32.00
Arc-lamps	8539.41.00
Ultra-violet or infra-red lamps	8539.49.00

9.1 Thermometers

This category includes medical thermometers, others glass mercury thermometers and engine control mercury thermometers.

The Harmonized System (HS) code used for thermometers was "*thermometers and pyrometers, liquid-filled for direct reading"* as there is no category for mercury containing thermometers specifically. The code also includes alcohol-filled thermometers; for simplicity all were considered as mercury-containing thermometers. This likely results in an overestimation. According to the Inventory Level 1 Toolkit Guideline, the assumption was made that 50% of the thermometers in that category were medical thermometers while the other 50% were other glass thermometers (air, laboratory, dairy etc.).

The total activity rate for this category was (8,968 ± 14,827 thermometers/y imported); this represented the average amount of thermometers under the above HS code imported annually for the period 2013-2017. Since the total activity rate was divided based on a 50:50 basis, an estimated 4,484 of the thermometers imported were medical thermometers and the other 4,484 were thermometers for other uses (air, laboratory, dairy, etc.). Figures 16, 17 and 19 below show that thermometer use and disposal accounted for the highest mercury emissions to air 52%, water 59% and general waste 27%.

9.2 Medical blood pressure gauges (*Sphygmomanometers)*

There was no reference in the Harmonized System (HS) codes for sphygmomanometers. There was however a HS code description "*Other instruments to measure or check the flow of other variables of liquids or gases (including manometers)"* but it was unclear if sphygmomanometers were included in this category. Hospitals and clinics contacted stated that electronic blood pressure gauges have been in use by them for a number of years; however, they were not able to provide data on the number of blood pressure gauges containing mercury used as it was not recorded.

9.3 Batteries containing mercury

This category includes the following types of batteries: mercury oxide, zinc-air and other batteries that may contain mercury (plain cylindrical, alkaline, permanganate etc.).The Harmonized System (HS) codes used for this category are outlined in table 8 below.

The activity rates for this category are based on the average amount of batteries imported annually for the period 2013-2017 under the HS categories outlined above. An estimated 33 tonnes of batteries were imported during the five-year period. However, of the 33 tonnes of batteries imported, 0.04 ± 0.07 tonnes were mercuric oxide batteries, 0.23 ± 0.18 were zinc-air, alkaline button or silver oxide and 33 ± 15 tonnes were "other batteries" (plain cylindrical alkaline, permanganate, etc.). The figures for this category were converted from kg to tonnes according to the Toolkit's units. According to figure 19, the use and disposal of batteries with mercury accounted for the largest mercury releases to general waste, 32%.

Table 8 Import data for batteries containing mercury

	2013	**2014**	**2015**	**2016**	**2017**
Mercury Oxide Cells (tonnes)					
Primary cells and primary batteries, of mercuric oxide HS Code: 8506.30.0000	0.001	0.007	0	0.014	0.141
Total (tones): 0.163					
Other Button Cells (tonnes)					
Primary cells and primary batteries, of silver oxide HS Code: 8506.40.0000	0.15	0.006	0.025	0.026	0.024
Primary cells and batteries, of air-zinc HS Code: 8506.60.0000	0.038	0.017	0.482	0.153	0.192
Total (tonnes)	**0.188**	**0.023**	**0.507**	**0.179**	**0.216**
Other Batteries with Mercury (tonnes)					
Primary cells and primary batteries, of manganese dioxide HS Code: 8506.10.0000	24.342	12.889	34.718	45.338	46.748
Total Imports: 33.28 tonnes ~ 33 tonnes					

9.4 Light sources with mercury

This category includes the following types of light sources with mercury: fluorescent tubes (double-end), compact fluorescent lamps (single-end) (CFL) and other light sources based on the Toolkit guidelines. The HS descriptions used for this category are *outlined in table 9 below.*

Table 9 Import data for light sources containing mercury

HS descriptions	Activity rates (items imported/year)
Fluorescent, hot cathode lamps **(fluorescent tubes)** HS Code: 8539.31.0000	179,471 ± 50,396
Other electrical discharge lamps other than ultra-violet lamps **(compact fluorescent lamps)** HS Code: 8539.39.0000	429,759 ± 643,597
Portable electric lamps (functioning by their own source of energy), mercury or sodium vapour lamps; metal halide lamps arc lamps and ultra-violet or infra-red lamps) **(other Hg containing light sources)** HS Codes: 8513.10.0000, 8539.32.0000, 8539.41.0000 and 8539.49.0000	101,279 ± 18,245

The activity rates under this category were based on the average amount of light sources imported annually for the period 2013-2017 under each HS code category outlined above. The total activity rate for this category is (710,509 light sources imported/y).

The activity rate for fluorescent tubes (179,471 ± 50,396 items imported/year) represents the average amount of items imported annually under the HS category *"fluorescent, hot cathode lamps"* for the period 2013-2017. However, the activity rate for compact fluorescent lamps (CFL's) is the average amount of items imported under the HS category *"other electrical discharge lamps other than ultra-violet lamps"* (429,759 ± 643,597 items imported/year).

To calculate that activity rate for other light sources, the Toolkit suggested using data from the following categories to find the activity rate for other light sources: *"portable electric lamps (functioning by their own source of energy), "mercury or sodium vapour lamps; metal halide lamps", "arc-lamps"* and *"ultra-violet or infra-red lamps".* The activity rate for this category (101,279 ± 18,245 items imported/y) was the average amount of items imported annually for the period 2013-2017 under the categories outlined above.

9.5 Cosmetics with mercury

This category covers skin lightening creams and soaps. It should be noted that labels on various skin lightening products in some local beauty supply stores did indicate that these products contain mercury; however, up to the time of publishing, import/sales data from these stores were not submitted. The BSS had no import data available for skin lightening creams and soaps specifically; as such, an activity rate could not be calculated for this category. This presence of mercury in these items is significant both in terms of volume of mercury in these within and in terms of direct population exposure; therefore, it can be considered in greater detail in the future.

An overview of the results for mercury-added products is given below in figures 16-19.

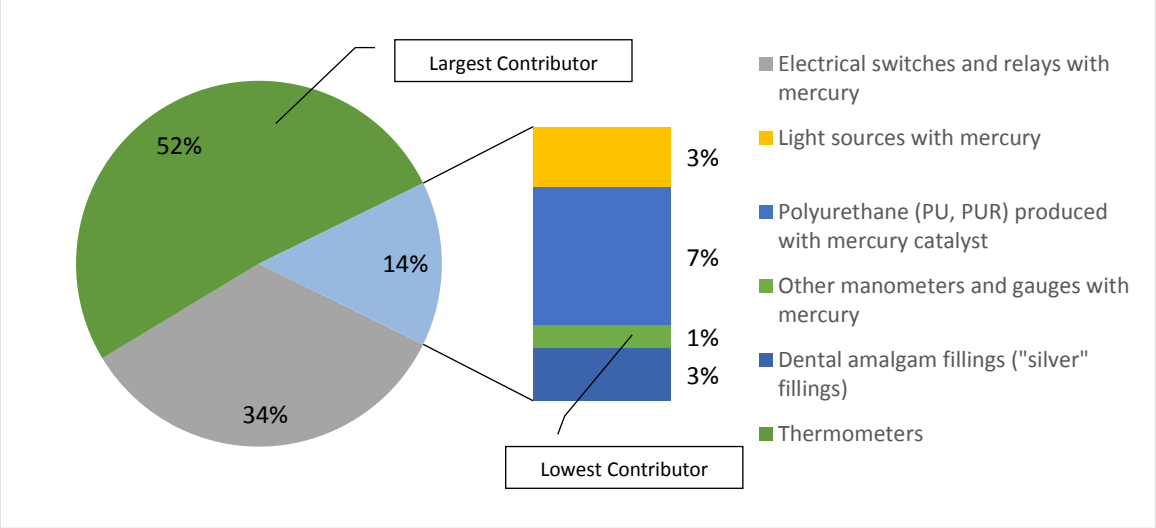


Figure 15 Estimated mercury releases to air from intentional use products

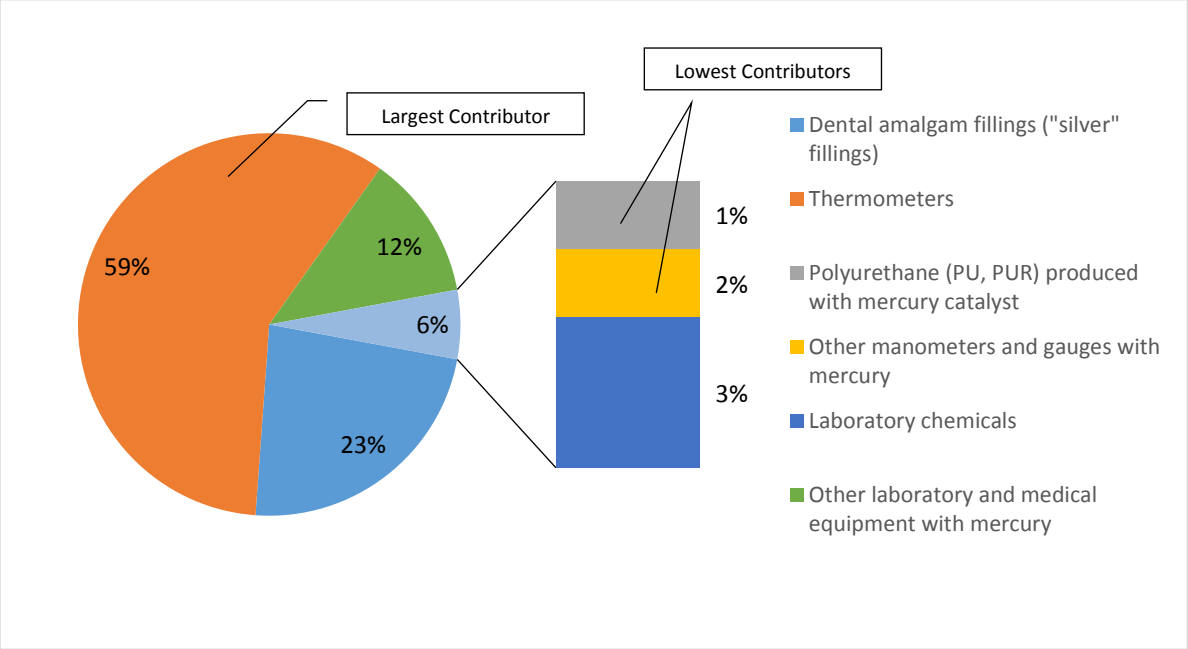


Figure 16 Estimated mercury releases to water from intentional use products

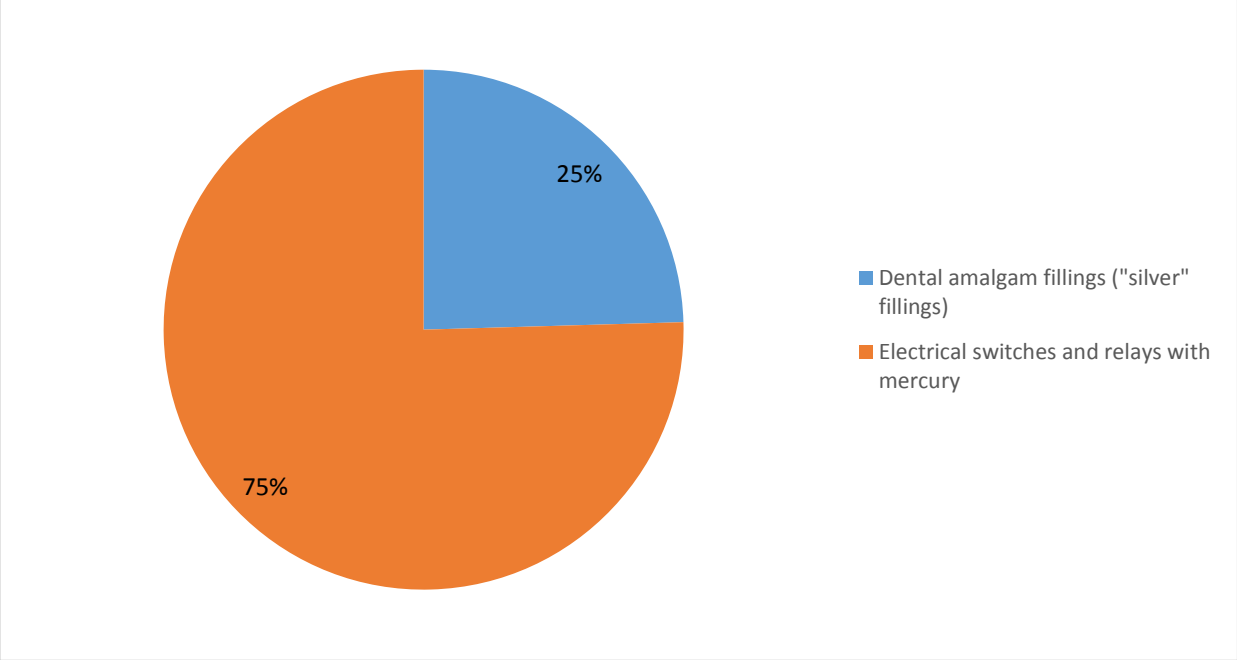


Figure 17 Estimated mercury releases to land from intentional use products

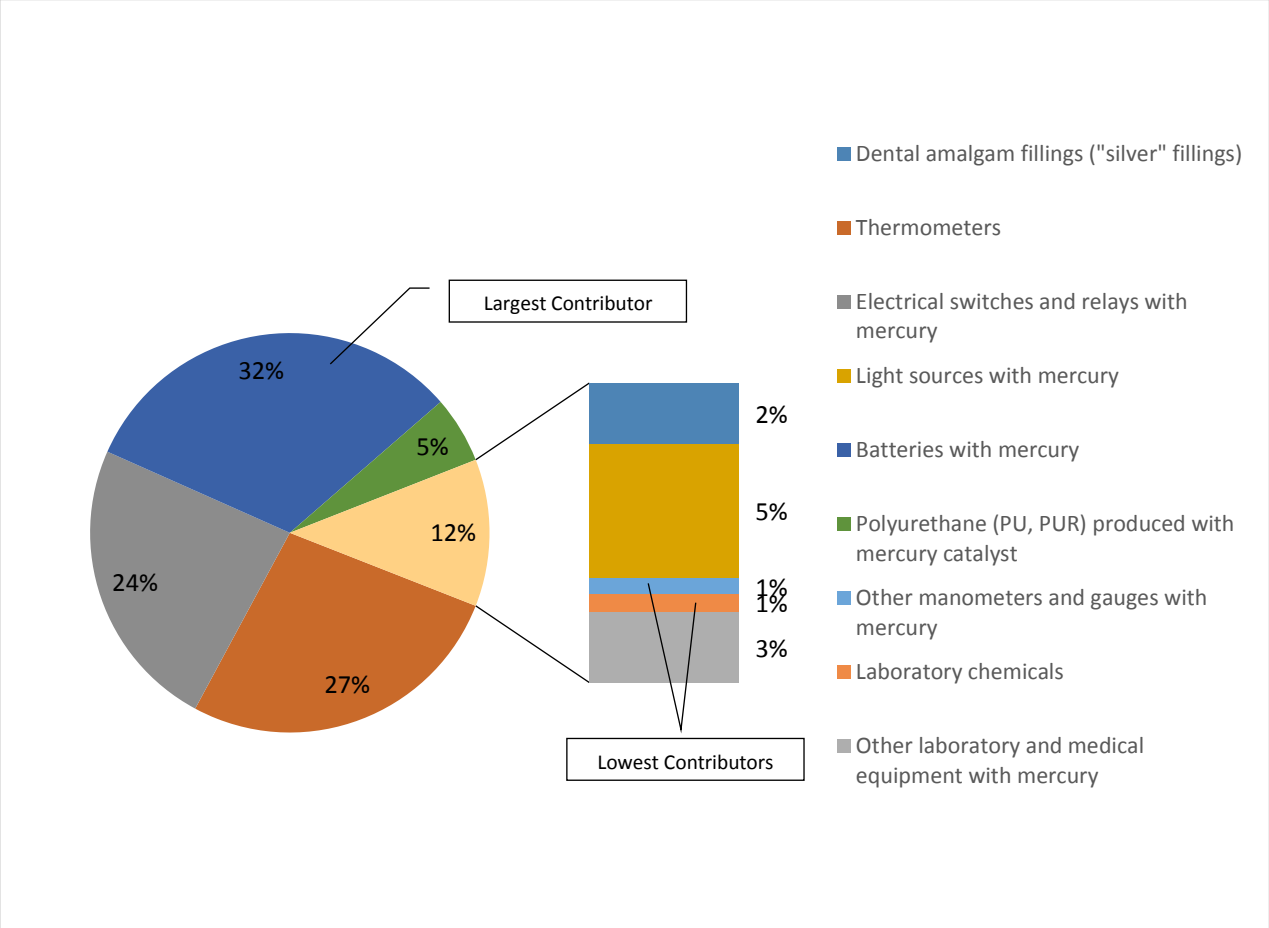


Figure 18 Estimated mercury releases to general waste from intentional use products

10. Data and inventory on crematoria and cemeteries

This category covers burial and cremation activities in Barbados. Figure 20 shows that burials accounted for 93% (6 kg) of the mercury emissions emitted to land. Cremations accounted for 7% (0.5 kg) of mercury emissions in this category which is emitted to air.

Coral Ridge Crematorium is currently Barbados' only crematorium; they provided inventory information for cremations for the period 2013-2018. The activity rate (183 ± 48 bodies cremated) represents the average number of bodies cremated annually for that five-year period.

The Ministry of Health provided information for the inventory on the number of deaths for the period 2013-2018. The activity rate (2394 ± 104 deaths) represents the average number of deaths annually for that period. There are three main large cemeteries on island: Westbury, Mount Pleasant, and Coral Ridge. There are also smaller cemeteries mainly owned by an accompanying church for example, Anglican/parish churches and Catholic churches. See appendix D for activity rate calculation tables for all source sub-categories in this section.

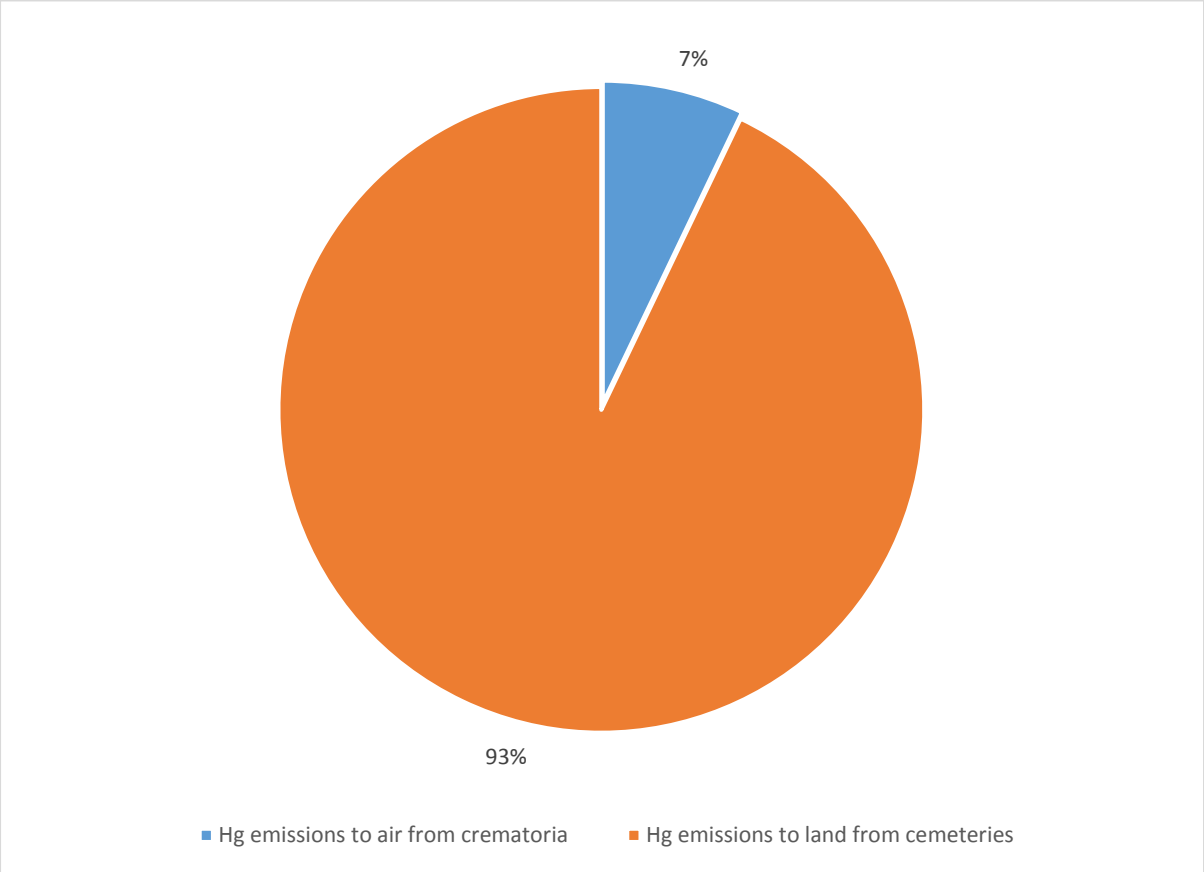


Figure 19 Estimated mercury releases to from cemeteries and crematoria

11. References

Arawak. "2018 Data Collection Form - Arawak Cement Company Limited." 12 17, 2018.

Bayview. "Data Collection Form (2018) - Bayview Hospital." 11 13, 2018.

BPI. "Data Collection Form (2018) - Barbados Port Inc." 1 9, 2019.

CME Group. *Conversion Calculator: CME Group.* 2019. www.cmegroup.com.

Cosmetics Info. "Mercury." *Cosmetic Info: The Science and Safety Behind Your Favourite Products.* 2016. www.cosmeticsinfo.org (accessed February 7, 2019).

Division of Energy and Communication. *Barbados National Energy Policy (2017-2037).* Policy, Division of Energy and Communication, Barbados: Division of Energy and Communication, 2018.

Food and Agriculture Organization of the United Nation. "FAO Yearbook of Forest Products 2016." Annual Report, 2016, 14.

Forest Research. *Conversion Factors.* n.d. www.forestresearch.gov.uk (accessed April 30, 2019).

GAIA. "Data Collection Form (2018) - Grantley Adams International Airport." 12 5, 2018.

Kyle's Converter. *Convert Cubic Feet of Natural Gas to Terajoules: Kyle's Converter.* 2009. www.kylesconverter.com.

NPTEL. "Module 4 - Quantity Estimation of Sewage." The National Programme on Technology Enhanced Learning, n.d. 4.

QEH. "Data Collection Form (2018) - Queen Elizabeth Hospital." 12 12, 2018.

Soto-Viruet, Yadira. "National Minerals Information Centre - Latin America and Canada | North America, Central America, and the Caribbean." *U.S. Geological Survey.* April 2019. (accessed May 2, 2019).

U.S. EIA. "Trends in Lighting Commercial Buildings." *U.S. Energy Information Administration.* n.d. https://www.eia.gov/ (accessed Februay 7, 2019).

Wiedinmyer, Christine , Robert J. Yokelson, and Brian K. Gullet. "Global Emissions of Trace Gases, Particulate Matter, and Hazardous Air Pollutants from Open Burning of Domestic Waste." *Environmental Science & Technology.* 48. American Chemical Society, 2014.

Table 10 Mercury Inventory Stakeholder List

Date of Contact	Institution	Contact
10/3/2018	Arawak Cement Company Limited	Omobamidele Adesegha
6/11/2018	Barbados Community College	Annette Alleyne
3/10/2018	Barbados Light and Power Company	Johann Greaves, Director of Operations
		Rohan Seale, Director-Asset Management
3/10/2018	Barbados National Oil Company Ltd (BNOC)	Patrick Welch
8/10/2018	Barbados National Terminal Company Ltd (BNTCL)	Lekeisha Jordan
24/10/2018	Bayview Hospital	Patricia Mcallister
9/10/2018	Berger Paints	Kenneth Thomas, Production Manager
19/10/2018	Carib Rehab	Managing Director
19/10/2018	Carib Supply (Barbados) Inc.	Clyde Sobers
17/10/18	Carters General Stores	Rian Greaves
24/10/2018	Collins Limited Barbados	Gina Lowhar
3/10/2018	Coral Ridge Memorial	Christine Griffith
6/11/2018	Grantley Adams International Airport (GAIA)	Roger Best
		Morland Williams
	McBrides Caribbean	Prince Forde
10/18/2018	Ministry of Health and Wellness	Mrs. Audrey Lovell-Wickham
24/10/2018	Pharmacy Sales Caribbean Inc.	Donald Emptage
5/10/2018	Portvale Factory	Mr. Raphael Oneal
10/10/2018	Queen Elizabeth Hospital	Ms. Ifill
	Queen Elizabeth Hospital	Dr. Dexter James
21/11/18	Queen Elizabeth Hospital	Paula Agdowu
10/10/2018	Rubis Eastern Caribbean SRL	Nicole McCarthy
		Andrea Gooding
25/10/2018	Sanitation Service Authority	Rosalind Knight
	Sanitation Service Authority/ Mangrove Landfill	Leona Deane
3/10/2018	Sol (Barbados) LTD.	Diane Tull-Knight, Operation Manager
8/10/2018	Statistical Services	Katrina Reid
		Jamar Bellamy

12. Appendix A

Activity Rate Data for Energy Consumption and Fuel Production Source Sub-Categories

Extraction of Crude Petroleum

Extraction of Crude Petroleum					
Oil Type	**2013**	**2014**	**2015**	**2016**	**2017**
Crude Petroleum (barrels)	254,446.00	234,325.00	249,466.00	231,102.00	233,489.00
Crude Petroleum (barrels to metric tonnes)	34,712.96	31,967.94	34,033.56	31,528.24	31,853.89

Average: 32,820

Standard Deviation: 1,448

Worst Case Scenario: 35,716

Best Case Scenario: 29,924

Natural Gas Production

Annual Production of Natural Gas					
Oil Type	**2013**	**2014**	**2015**	**2016**	**2017**
Natural Gas (mcf)	757,617.00	741,716.00	704,450.00	608,964.00	526,861.00
Natural Gas (mcf to cubic feet)	757,617,000	741,716,000	704,450,000	608,964,000	526,861,000
Natural Gas (cubic feet to terajoules)	799.33	782.55	743.23	642.49	555.87

Average: 705

Standard Deviation: 104

Standard Deviation in Nm^3: 52,736,000

Worst Case Scenario: 913

Best Case Scenario: 497

Light Oil Consumption

Light Oil (Metric Tonnes)					
Oil Type	**2013**	**2014**	**2015**	**2016**	**2017**
Gasoline	92,568	88,063	82,502	94,716	89,856
Diesel	104395.15	96619.17	68988.64	58335.37	58591.72
Fuel Oil	172907.1	175184.85	149837.28	186214.2	142864.97
Jet A1	7,244	37,754	41,780	72,688	69,379
Diesel	41,733	17,928	5,838	5,276	6,848
SUM	**418,847.05**	**415,549.10**	**348,946.41**	**417,229.19**	**367,539.67**

Average: 393,623

Standard Deviation: 32,980

Worst Case Scenario: 459,583

Best Case Scenario: 327,663

Heavy Oil Consumption

Heavy Oils (Metric Tonnes)					
Oil Type	**2013**	**2014**	**2015**	**2016**	**2017**
Heavy Fuel Oil No. 6	203,763	190,171	208,382	179,559	174,105
Heavy Vacuum Gas Oil	1,526	1,957	722	149	172
SUM	205,289.00	192,128.00	209,104.00	179,708.00	174,277.00

Average: 192,102
Standard Deviation: 15,284
Worst Case Scenario: 222,670
Best Case Scenario: 161,534

Biomass Power and Heat Production

Biomass Power and Heat Production					
Biomass Type	**2013**	**2014**	**2015**	**2016**	**2017**
Sugar Cane Bagasse (MT/Y)	27,456.14	68,742.53	48,026.65	37,605.69	56,019.73
Annual Use of Bagasse (MT/y) FAO Yearbook 2016 (Forestry)	3623.19	3623.19	3623.19	3623.19	-
Annual Use of Bagasse (MT/y)	**31,079.33**	**72,365.72**	**51,649.84**	**41,228.88**	**56,019.73**

Average: 393,623
Standard Deviation: 32,980
Worst Case Scenario: 459,583
Best Case Scenario: 327,663

13. Appendix B

Activity Rate Data for Waste Handling and Recycling

Municipal Waste Incineration

Municipal Waste Incineration						
	2013	**2014**	**2015**	**2016**	**2017**	**2018**
Yearly amounts (MT)	1276.40	1316.80	1607.20	3093.20	2876.40	4050.21
Weights	0.090	0.093	0.113	0.218	0.202	0.285
Weighted amount (MT)	114.6	121.9	181.6	672.8	581.8	1153.6

Average: 2,371

Weighted Average: 2827

Standard Deviation: 413

Worst Case Scenario: 3653

Best Case Scenario: 2001

Controlled Landfilling

Controlled Landfilling					
	2013	**2014**	**2015**	**2016**	**2017**
Domestic Waste (MT/Y)	112,677.41	104,759.85	102,269.62	98,210.96	101,022.66

Average: 103,789

Standard Deviation: 5,501

Worst Case Scenario: 114791

Best Case Scenario: 92787

Wastewater Treatment

2017 Water Production (M^3)					
Jan	Feb	Mar	Apr	May	Jun
4007864	3563986	4704598	4678687	4967385	3943586
Jul	Aug	Sep	Oct	Nov	Dec
3792821	3930945	4037812	4437928	4448730	3868744
TOTAL (M^3)	50,383,086				
TOTAL (Liters)	50,383,086,000				
Activity Rate (Liters)	**40,306,468,800 (Represents 80% of total water production)**				

14. Appendix C

Activity Rate Data for Products Containing Mercury

Thermometers

Thermometers	2013	2014	2015	2016	2017	Average	Standard Deviation	Worst Case Scenario	Best Case Scenario
All Thermometers and pyrometers liquid filled for direct reading *HS Code 9025110000*	2575	520	4485	35366	1892	8,968	14,827		
Medical thermometers 50%	1287.5	260	2242.5	17683	946	4,484	7,414	19,312	0
Other Thermometers 50%	1287.5	260	2242.5	17683	946	4,484	7,414	19,312	0

Batteries Containing Mercury

Batteries with mercury	2013	2014	2015	2016	2017	Average	Standard Deviation.	Worst Case Scenario	Best Case Scenario
Mercury oxide (button cells and other sizes); also called mercury-zinc cells *HS Code 8506.30.0000*	0.001	0.007	0	0.014	0.141	0.04	0.07	0.18	0
Other button cells (zinc-air, alkaline button cells, silver-oxide) *HS Codes 8506.40.0000 and 8506.60.0000*	0.188	0.023	0.507	0.179	0.216	0.23	0.18	0.59	0
Other primary cells with mercury (plain cylindrical alkaline, permanganate, etc., see guideline) *HS Code 8506.10.0000*	24.342	12.889	34.718	45.338	46.748	33	15	63.00	3

Light Sources with Mercury

Light sources with mercury	2013	2014	2015	2016	2017	Average	Standard Deviation	Worst Case Scenario	Best Case Scenario
Fluorescent, hot cathode-fluorescent tubes (double end) *HS Code 8539.31.0000*	250387	196248	186545	144486	119686	179,471	50,396	280,263	78,679
other electrical discharge lamps other than UV-compact fluorescent lamps (single end) *HS Code 8539.39.0000*	185287	170354	1579239	99941	113971	429,759	643,597		

Other light sources with Hg (based on inventory guideline)	2013	2014	2015	2016	2017	Average	Standard Deviation	Worst Case Scenario	Best Case Scenario

Portable electric lamps (function by own source of energy) *HS Code 8513.10.0000*	41831	34074	29299	32424	42983				
Mercury or sodium vapour lamps, metal halide lamps *HS Code 8539.32.0000*	1212	2171	413	953	1144				
Arc-lamps *HS Code 8539.41.0000*	268	70	55	111	39				
Ultra-violet or infrared lamps *HS Code 8539.49.0000*	44618	58265	56754	73256	86451				
SUM	**87929**	**94580**	**86521**	**106744**	**130617**	**101,279**	**18,245**	**137,769**	**64,789**

15. Appendix D

Activity Rate Data for Cemeteries and Crematoria

	2013	2014	2015	2016	2017	Average	Standard Deviation	Worst Case Scenario	Best Case Scenario
Number of deaths	2490	2684	2491	2682	2533				
Number of bodies cremated	114	167	187	198	245	183	48	279	87
Number of persons buried (Number of deaths - Number of bodies cremated)	2376	2517	2304	2484	2288	2394	104	2602	2186