NATIONAL INVENTORY OF CADMIUM AND LEAD RELEASES IN BARBADOS 2019

ENVIRONMENTAL PROTECTION DEPARTMENT- MINISTRY OF ENVIRONMENT AND NATIONAL BEAUTIFICATION

ENVIRONMENTAL PROTECTION DEPARTMENT

INVENTORY OF CADMIUM AND LEAD RELEASES IN BARBADOS

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1 Executive summary

Introduction
This report provides an inventory of the estimated average releases of Cadmium and Lead in Barbados.

The inventory was developed in *2018*. Data for the years *2013-2017* were used in the inventory when available to provide an average activity rate for the five-year period. For the categories where data was not available for the five-year period, information available for other years was used. The year(s) in consideration for all data given is noted in the relevant sections of this report.

This Cadmium and Lead release inventory was adapted from the "Toolkit for identification and quantification of mercury releases" made available by the Chemicals Branch of the United Nations Environment Programme (UN Environment Chemicals).

This inventory was developed with a methodology inspired by the Mercury Toolkit.

Results and discussion
An aggregated presentation of the results for the main groups of Cadmium and Lead release sources is presented in Figure 1.1 – 2.0 and Table 1.1 below.

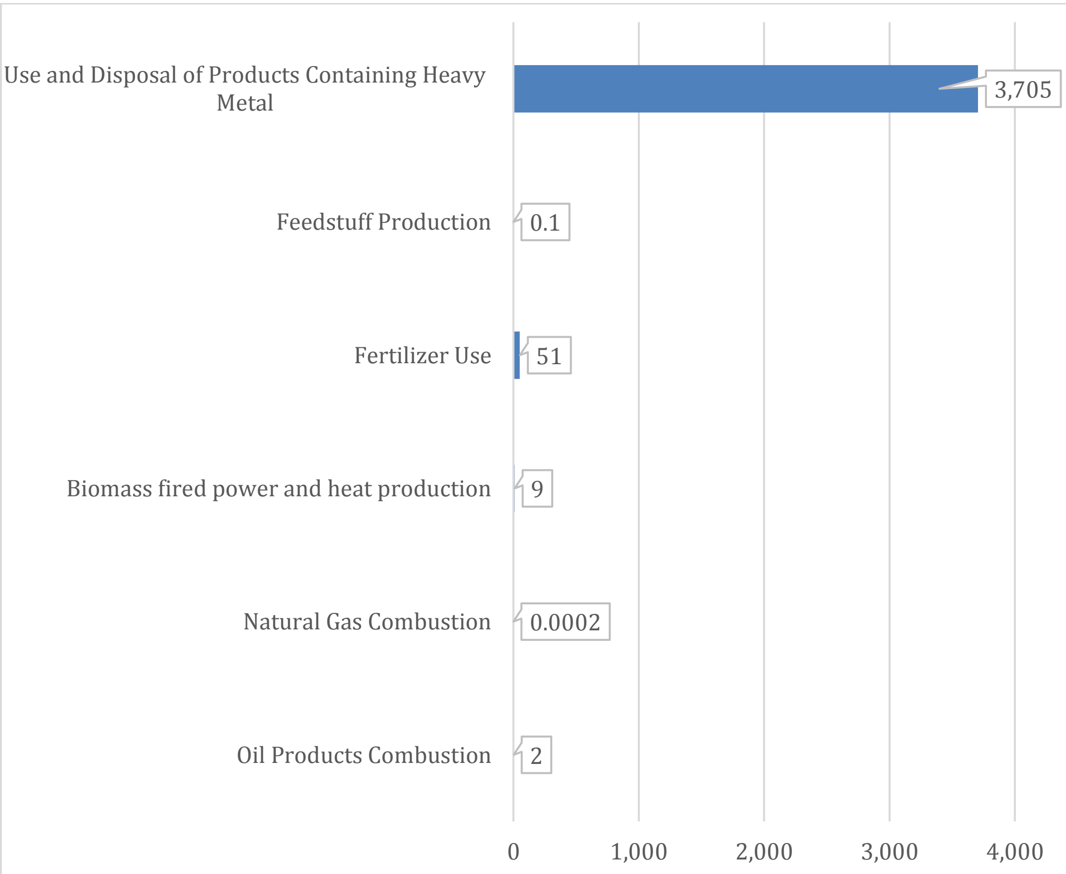

Figure 1.1: Estimated Cadmium inputs (kg of Cadmium per year). This figure shows that the intentional use of products represents the largest release of cadmium with an estimated 3,705 kg of cadmium per year.

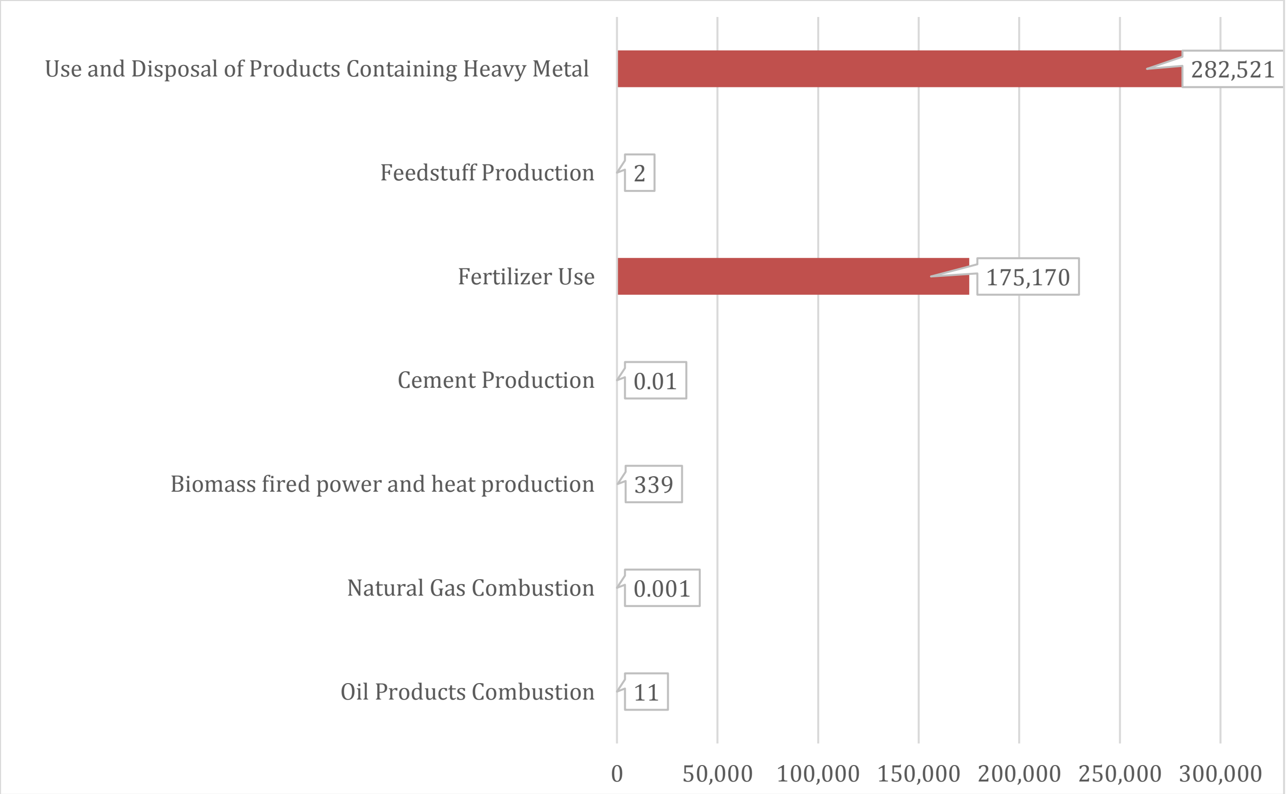

Figure 1.2: Estimated Lead inputs (kg of Lead per year).

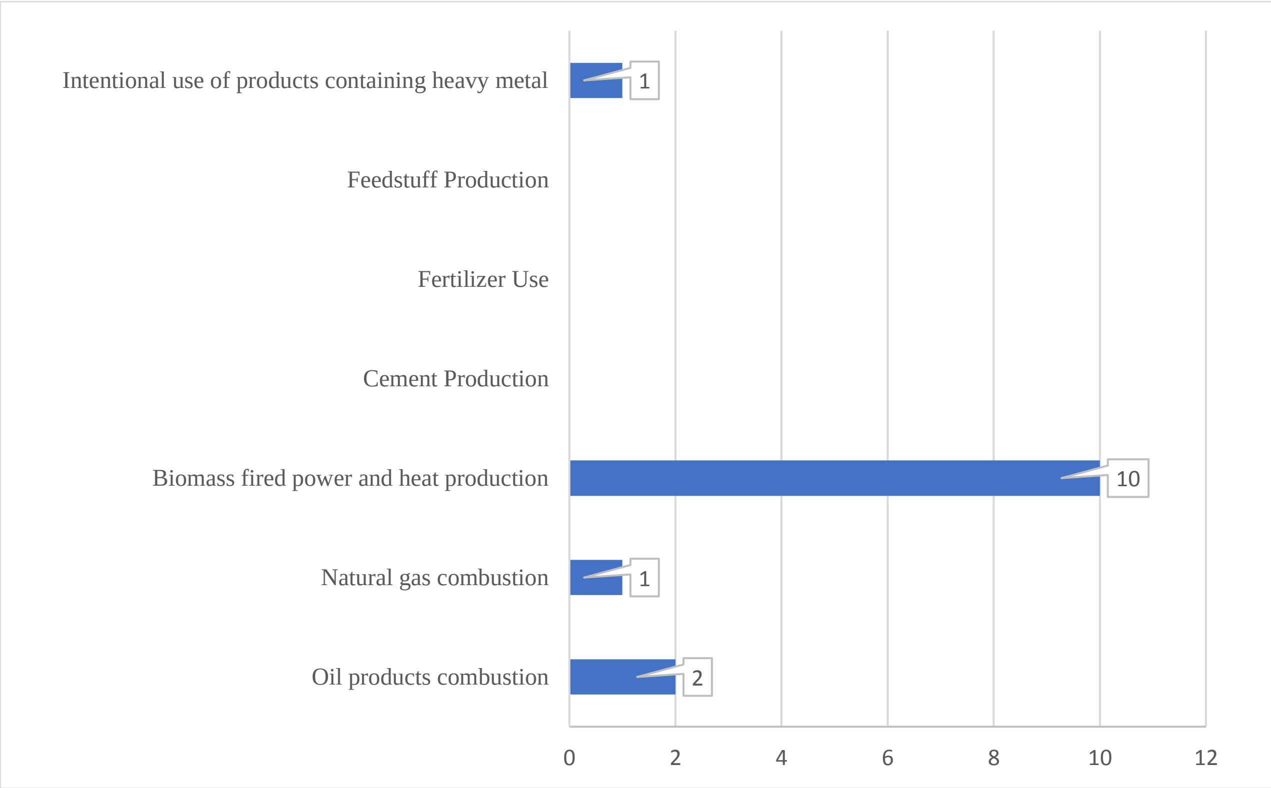

Figure 1.3: Cadmium releases to air, kg Cd/y. Biomass fired power and heat production accounted for the highest releases of cadmium to air with 10 kg Cd annually.

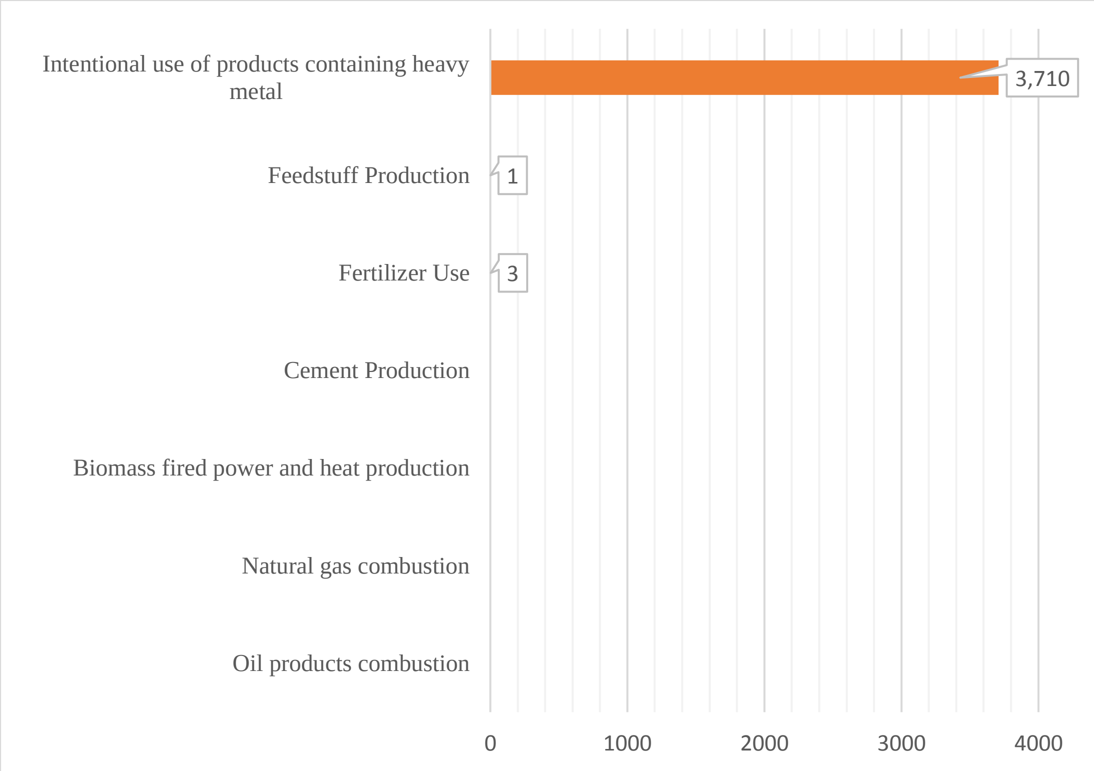

Figure 1.4: Cadmium releases to land, kg Cd/y. Figure shows the intentional use of products containing the metal, was the largest contributor to cadmium emissions onto the land.

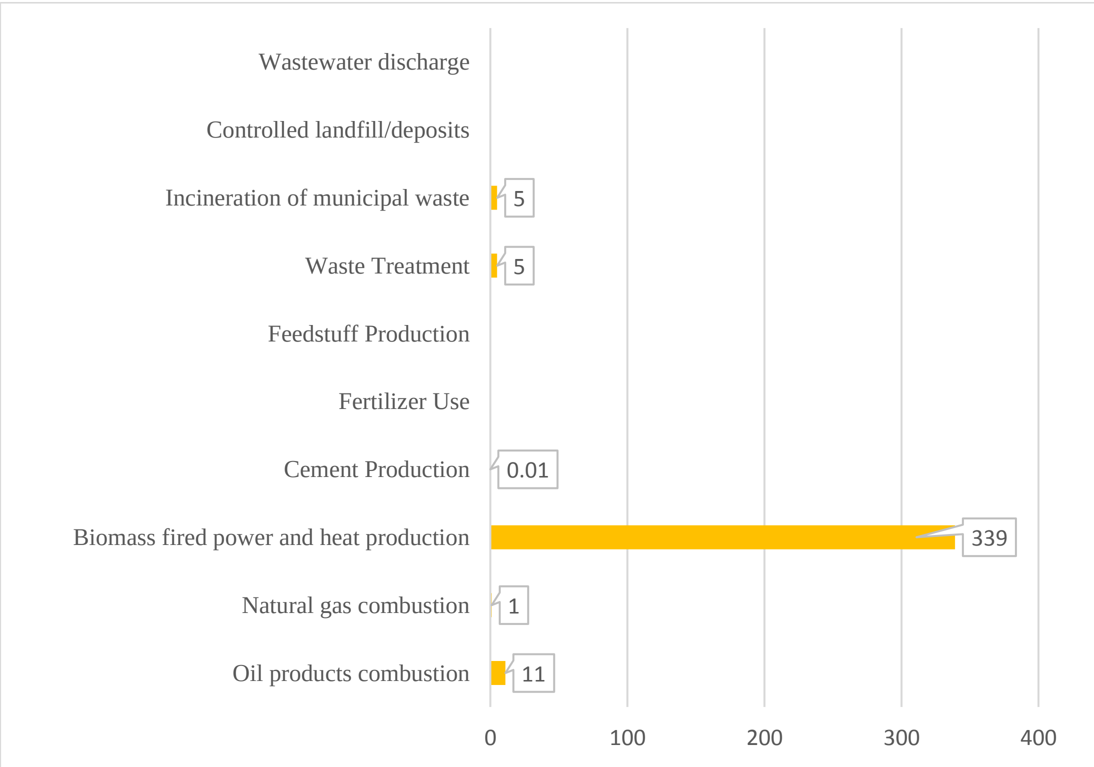

Figure 1.6: Lead releases to air, kg Pb/y. For the estimated lead releases to air, biomass fired power ranked as the major contributor with a total of 339 kg Pb per year.

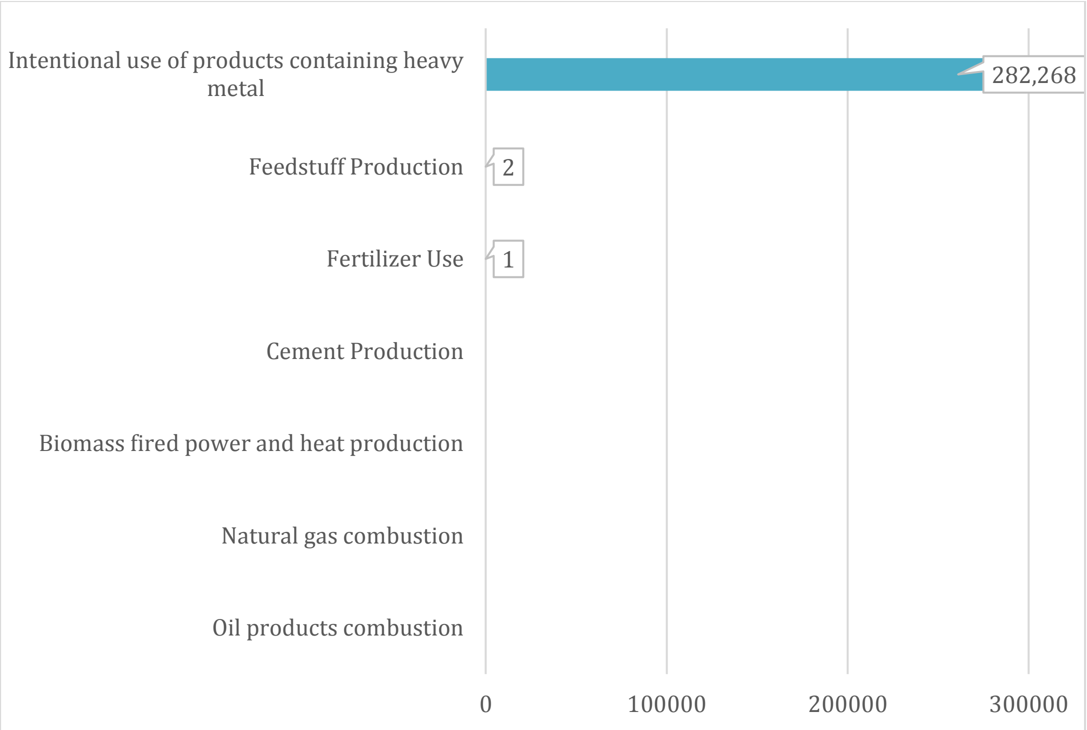

Figure 1.7: Lead releases to land, kg Pb/y. Releases from products that contain lead such as lead-acid starter batteries are the largest contributor to land.

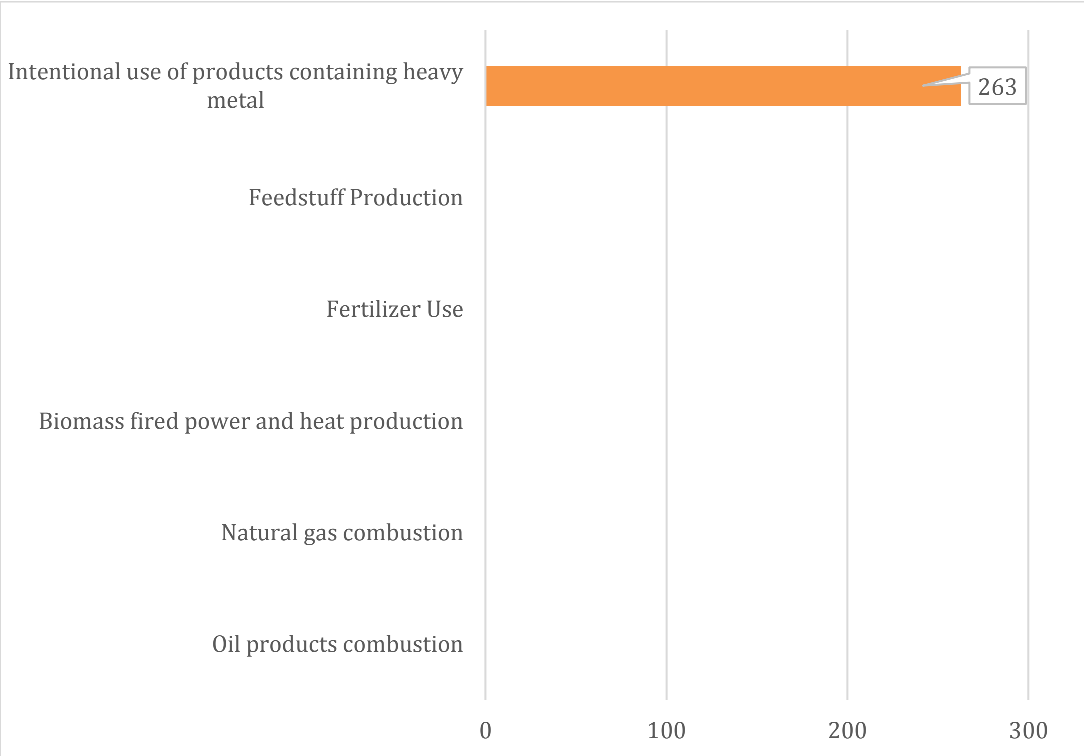

Figure 1.8: Lead releases to water, kg Pb/y. The largest contributor to water, the intentional use of products containing heavy metals, was estimated at 263 kg per year.

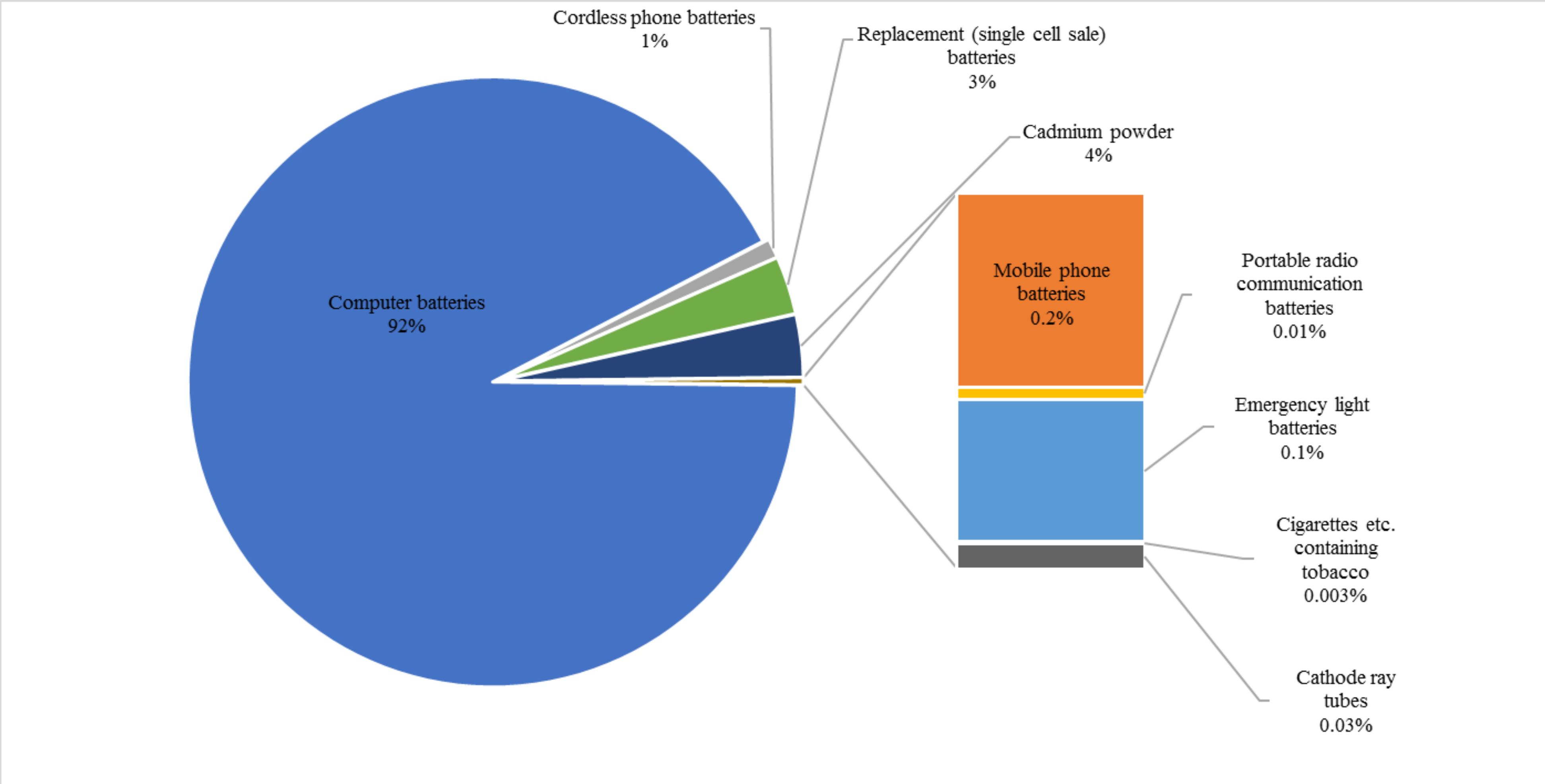

Figure 1.9: Estimated cadmium releases from the intentional use of products containing cadmium

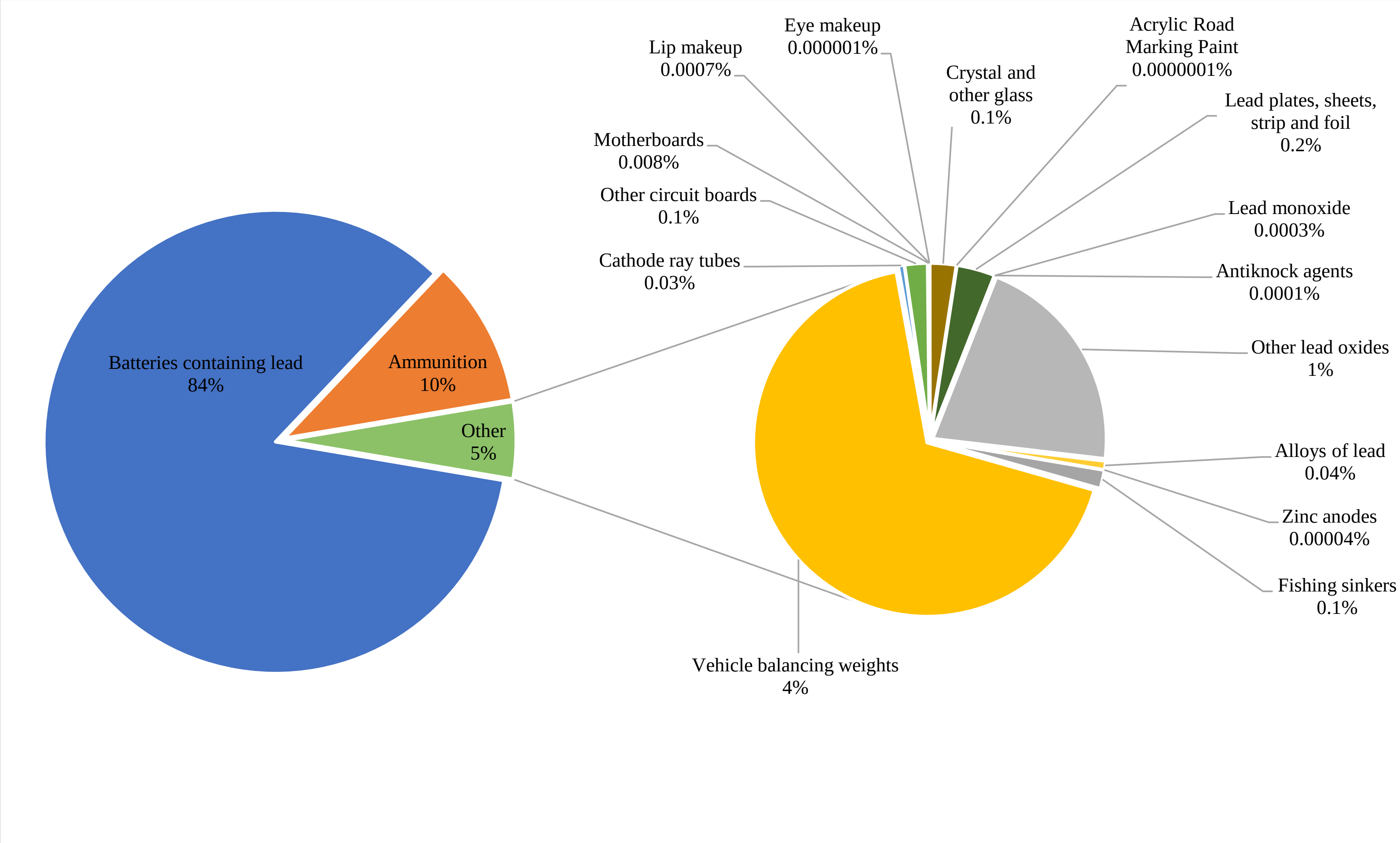

Figure 2.0 Estimated lead releases from the intentional use of products containing lead

Table 1-1 Summary of inventory results

			Oil Products Combustion	Natural Gas Combustion	Biomass fired power and heat production	Cement Production	Fertilizer Use	Feedstuff Production	Use and Disposal of Products Containing Heavy Metal	Waste Incineration	Waste Water Discharge	Controlled Landfill/Deposits
Estimated Releases (kg/y)	**Atmosphere**	**Cadmium**	2	0.0002	10	0	0	0	1	1	0	0
		Lead	11	0.001	339	0.01	0	0	1	5	0	0
	Land	**Cadmium**	0	0	0	0	3	1	3,706	0	0	2,076
		Lead	0	0	0	0	1	0	282,521	0	0	41,516
	Water	**Cadmium**	0	0	0	0	0	0	0	0	605	0
		Lead	0	0	0	0	0	0	262	0	4,031	0

The individual sub-categories contributing to the highest Cadmium and Lead releases were:

	Cadmium	Lead
Atmosphere	Biomass fired power and heat production Oil Products Combustion	Biomass fired power and heat production Oil Products Combustion
Land	Use and Disposal of Products Containing Cadmium Controlled Landfill/Deposits	Use and Disposal of Products Containing Lead Controlled Landfill/Deposits
Water	Waste Water Treatment and Discharge	Waste Water Treatment and Discharge

Detailed presentations of cadmium and lead inputs and releases for all known release source types present in the country are shown in the following report sections.

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

Data gaps

The following section explains the major data gaps encountered:

Products containing intentionally Cadmium and Lead

The major difficulties encountered were identifying and obtaining the data necessary to estimate the emission and releases from intentionally used products containing Cadmium or Lead. The Barbados Statistical Services (BSS) provided a commendable amount of data on several of the intentional products. The BSS provided import records from 2013- 2018, however, category descriptions provided with each Harmonized System (HS) code such as "*other electric accumulators*" do not directly state whether the specific product contains either cadmium or lead. Consequently, estimates of cadmium and lead from this particular category may be overestimated or underestimated.

There is room for improvement regarding the data collection for the intentional use of products of the inventory. For instance, the use of battery operated power tools is one such example where there is little information available on the usage patterns and content of these products. Site visits were undertaken at the largest hardware stores and findings shown that only Lithium ion operated power tools were sold. However, further research could be undertaken with local producers/suppliers to more accurately capture the use of such products to develop a more comprehensive assessment.

Other challenges were encountered where certain products were combined into one HS code category; as a result, it was difficult to determine the exact imports of each product potentially leading to either an overestimation or underestimation of the activity rate and metal content. For example, in the category "Other Cadmium and articles of Cadmium" the types of articles of Cadmium are not described in separate categories, therefore although it is known that these products are imported annually, the exact imports of each type of article is unknown. The categories "Other Lead plates, sheets, strip and foil", "Lip make-up preparations", "eye makeup preparations" and "Nickel-Cadmium electric accumulators" also are other examples as there is a more than one product being included in these categories.

Cathode ray tubes

The use of cathode ray tubes could not be accurately estimated due to the lack of data on imports for tubes found in computer displays, and data on the amount of television sets recovered by recycling companies containing cathode ray tubes. The HS codes for sources containing cathode ray tubes alone were not adequate to provide an accurate representation of the amount of cathode ray tubes used in 2017. A recommendation would be to determine the amount of cathode ray tubes or devices containing cathode ray tubes collected annually by recyclers and imported annually into Barbados, and if available, attain the Lead and or Cadmium content from local distributors and importers. This is one query that can be considered for a more detailed study.

Paints containing Cadmium or Lead

Estimating the amount of paints containing lead involved similar challenges to cathode ray tubes. The amount of paints containing lead was provided from a single source, Berger Paints Caribbean. However, this source may not cover the full scope of lead containing paints such as road marking paints imported annually.

Portable Communication devices

A similar challenge was encountered with acquiring an accurate representation of the amount of portable communication devices that are imported annually because the data provided by Massy Technologies may not be a representation of the total amount imported. Today only Li-ion battery operated devices are being sold by Massy Technologies however some older devices containing Nickel Cadmium batteries may still be in use. An assessment should be carried out to determine if any of these batteries are being recycled.

Aviation Fuel

It should be noted that although annual consumption figures were provided for aviation fuel by the Barbados Light and Power Company Limited (BL&P), additional data that should be sought from other relevant stakeholders. Stakeholders in the fuel distribution sector such as Rubis Eastern Caribbean SRL would be able to provide a more accurate representation of the aviation fuel consumption in Barbados from an a distributors' perspective. Rubis Eastern Caribbean SRL participated in this inventory by providing a safety data sheet for a brand of aviation fuel that is distributed by the company on island, which revealed the presence of tetraethyl lead in the concentration of 0-0.1% by volume. Rubis Eastern Caribbean SRL did not provide the associated amounts of this aviation fuel being sold by the company. This information suggests that there are undocumented amounts of aviation fuel containing the metal.

Lead plates, sheets, strips and foil

Lead plates may be used in roofing or other applications where the lead could be released to land or water, however the uses of lead plates, sheets, strips and foils in Barbados are not known. Research has shown that the major suppliers of roofing material do not retail lead roofing material however there may be other suppliers of this material. There is a need for further research to determine the uses, potential suppliers and potential release pathways of these products.

Other data gaps:

In some categories, data were provided from a single supplier of the product where there were other suppliers that did not provide any data when contacted. In these cases, the activity rates and estimated metal releases are likely underestimated. These categories include fishing sinkers, trace metals used in sacrificial anodes for rust protection, circuit boards, and road marking paints.

No data were obtained at the time of publication for the occurrence of certain activities such as medical waste incineration/burning and the use of products such as rechargeable batteries in power tools & shavers, agriculture and animal waste and radiation shielding. However, these activities and products are may be occurring or used in Barbados.

The units of the figures given for some products or activities were not clearly stated. In cases where the information provider was unable to clarify the exact units sent, an assumption was made about the unit type. As a result, the estimates calculated may be an over or underestimation.

Main priorities for further assessment and/or actions:

The use of products that intentionally contain lead or cadmium was the leading contributor to the introduction of these metals in the society and impact on the amount of emissions estimated. The quality of the data provided for section 5.2 affects the ability of the inventory to portray the actual situation regarding the presence and emissions of these metals in the environment. Therefore, any improvements that can be made towards the provision of data in this section should be prioritised or can be focused on in a more detailed study. The products that should be emphasised for further research are cathode ray tubes, radiation shielding, rechargeable batteries in power tools, cell phones and computers, eye and lip makeup, road marking paints.

Other cases for further research or associate actions are:

Cement Production: The concentrations of lead and cadmium found in soil collected from the local cement facilities and quarry was 16 mg/Kg and 1.3 mg/Kg respectively (AEL, 2019). Cement production takes place at this facility and there is a possibility that the metal content in the soil may be contributed by by-products from the cement production that are being emitted into air. The absence of Lead and Cadmium in locally manufactured cement should be confirmed by further investigation.

Jewellery: Jewellery should be accessed to evaluate whether there is a concentration of Lead or Cadmium present.

Laboratory chemicals containing Cadmium/ *Articles of* Cadmium: The lack of data provided for cadmium chemicals and compounds and the combination of cadmium articles in the HS codes suggests that there is a need for further assessment of the amount of these products imported.

Lead piping: Historically lead pipes were used to distribute the local water supply. Generally, the pipes were used in the past but according to the Barbados Water Authority the pipes have been replaced with pipes made of a material not containing lead.

Makeup: The makeup category requires more investigation with respect to the amount of Lead or cadmium present in various makeup preparations and the quantities of these preparations retailed.

Paints: Road marking paints in particular is another area where there is a need to determine the quantity of these paints retailed locally each year.

Releases from incineration of medical and municipal waste: Another area for further investigation could be acquiring more data for the amounts of medical and municipal waste incinerated and the compositions of those wastes.

2 Cadmium and Lead release source types present

Table 2-1 shows which Cadmium and Lead release sources were identified as present or absent in the Barbados. Only source types positively identified as present are included in the quantitative assessment (see Section 3).

It should be noted however, that the presumably minor Cadmium and Lead release source types shown in Table 2-2 were not included in the detailed source identification and quantification work. These may however be present in some countries.

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

Source category	Present (Y/N/?)
Mobilisation sources (Cadmium **and** Lead**)**	
Oil products combustion	Y
Natural gas combustion	Y
Biomass fired power and heat production	Y
Coal fired combustion	N
Residential and commercial fossil fuel fired boilers	N
Cement production	Y
Iron and steel smelters	N
Mining	N
Zinc and other primary non-ferrous metal production	N
Chemicals production	N
Fertilizers	Y
Trace element in sacrificial anodes	Y
Feedstuffs	Y
Intentional uses (Cadmium**)**	
Power tools batteries	?
Camcorder batteries	?
Computer batteries	Y
Shaver/trimmer/toothbrush batteries	?
Mobile phone batteries	Y
Cordless phone batteries	Y
Portable radio communication (PMR/LMR) batteries	Y
Emergency light batteries	Y
Replacement (single cell sale) batteries	?
Pigments (plastics, ceramics, etc.)	Y
Cd plating of iron and steel, etc.	N
Stabilizers in PVC	?
Solar cells (CdTe type)	N
Other alloys in electrical appliances, etc.	?
Additives in glass and ceramics products	**?**
Articles of cadmium	Y
Cigarettes, cigars, cheroots, and cigarillos	Y
Cathode ray tubes	Y
Eye makeup	Y

Source category	Present (Y/N/?)
Intentional uses (Lead**)**	
Lead-acid starter batteries	Y
Other lead-acid batteries (electric vehicles, UPS systems, etc.)	Y
Lead shot	N
Ammunition	Y
Cable sheathing	?
Lead roofing	?
Lead roof flashing, and other building materials	?
Fishing sinkers	Y
Zinc anodes	Y
Lead-tin alloys (soldering etc.)	?
Balancing weights for vehicles	Y
Balancing weights for ventilator fans	N
Balancing weights for wind turbines	N
Lead piping (for water supply); legacy, generally used	N
Cathode ray tubes in CRT screens (average units)	Y
Eye make-up	Y
Lip make-up	Y
Crystal and other glass	Y
Red lead anti-corrosion paints/coatings	?
Acrylic Road Marking Paint	Y
Pigments (other??)	?
Stabilizers in PVC	?
Glazing (ceramics and enamels)	N
Radiation shielding	?
Fuel additives	N
Lead plates, sheets, strip and foil	Y
Lead grids for electric accumulators	Y
Antiknock agents based on lead compounds	Y
Lead oxides	Y
Lead alloys	Y
Waste treatment	
Incineration of municipal waste	Y
Open waste burning	N
Medical waste incineration/burning	Y
Hazardous waste incineration/burning	N
Sewage sludge dumping	Y
Waste water (treatment/discharge)	Y
Controlled landfill/deposits	Y
Controlled greywater deposits	Y
Agricultural and food wastes from the 1980's	?
Animal wastes, manure from the 1980's	?

Table 2-2 Miscellaneous potential Cadmium and Lead sources not included in the inventory; with preliminary indication of possible presence in the country.

Source category	**Present (Y/N/?)**
Toys	Y
Tyres	Y
Limestone	Y
Shale	Y
Explosives	Y
Fireworks	Y
Executive toys	?

3 Summary of cadmium and lead inputs to relevant sectors

Cadmium and Lead inputs to society should be understood here as the amounts of cadmium and lead made available for potential releases through economic activity in the country. The term turnover may be used as well and this refers to the amount of cadmium/lead that is in play in the sector. This includes Cadmium and Lead intentionally used in products such as batteries/accumulators in the case of Cadmium, and ammunition in the case of lead. It also includes cadmium and lead mobilised via extraction and use of raw materials containing those heavy metals in trace concentrations e.g. fossil fuels and some phosphate fertilizers. Best, most likely and worst case scenarios were constructed for the estimated Cadmium and Lead inputs to society based on the standard deviations of the estimated activity rates and metal releases.

Table 3-0 *Summary of the best case, most likely and worst case scenarios for estimated lead inputs to society*

Source category	Estimated Pb input kg Pb/y		
	Best Case	Most Likely	Worst Case
Mobilisation sources			
Oil products combustion	7.90933E-09	10	0.00000001
Natural gas combustion	0.0007	0.001	0.0014
Biomass fired power and heat production	129	339	548
Cement Production	0	0.01	0
Fertilizers	-	0.7	3
Zinc anodes	0	1	0
Feedstuff:	0	0	0
Swine	1	1	1
Horse	0	0.03	0.05
Cattle	0.2	0.3	0.3
Intentional uses			
Starter batteries (lead acid)	0	63,349	153,526
Lead-acid batteries for starting motor cycles	617	1,357	2,096
Other lead-acid batteries (electric vehicles, UPS systems, etc.)	20,965	173,813	326,662
Ammunition	0	28,931	70,452
Professional fishing sinkers	0	261	0.00
Vehicle balancing weights	0	10,209	0.00
Cathode ray tubes in CRT screens (average units)	205	84	259
Circuit boards	6	319	433
Motherboards	0.001	22	41
Eye make-up	1	0.002	0.003
Lip make-up	0	2	7
Crystal and other glass	0.0002	368	1,522
Road Marking Paint	0	0.0004	0.001
Lead plates, sheets, strip and foil	0	535	1,100
Antiknock agents based on lead compounds	0	0.4	1
Lead monoxide	0	1	0
Other lead oxides	0	3,144	7,434
Alloys of lead:			
Brass	0	2	13
Brass bars, rods & profiles	38	53	67
Brass wire	0	0.1	0.3
Brass plates	6	4	15

Source category	Estimated Pb input kg Pb/y		
Bronze	0	65	262
Waste treatment			
Incineration of municipal waste (No filter)	5	4	111
Waste water (treatment/discharge)	0	4,031	0
Controlled landfill/deposits	37,115	41,516	43,483

Table 3-1 Best Case Scenario of Estimated Lead inputs to society

Source category	Minimum Estimated Activity rate	Unit	Estimated Pb input kg Pb/y
Mobilisation sources			
Oil products combustion	1,839,380	Oil combusted, GJ/y	7.90933E-09
Natural gas combustion	498,462	Natural gas combusted, GJ/y	0.0007
Biomass fired power and heat production	19,275,584	Sugar biomass combusted, kg/y	129
Cement production	-	-	-
Fertilizers	-	Fertilizers used, kg/y	0
Zinc anodes	-	Zinc anodes imported, units/y	0
Feedstuffs:		Feedstuffs produced, kg/y	
Swine	6,233,980		1
Horse	-		0
Cattle	1,509,328		0.21
Intentional uses			
Lead acid starter batteries	-	Batteries imported, kg/y	0.0
Lead acid batteries for starting motorcycles	823	Batteries imported, kg/y	617
Other lead-acid batteries (electric vehicles, UPS systems, etc.)	34,941	Batteries imported, kg/y	20,965
Ammunition	8,097,143	Bullets used, units/y	3,826
Fishing sinkers	-	Sinkers imported, units/y	0
Vehicle balancing weights	-	Weights used, units/y	0
Cathode ray tubes	-	CRTs imported and computer monitors recycled, units/y	0
Circuit boards	20,798	Circuit boards recycled units/year	205
Motherboards	592	Motherboards recycled units/year	6
Eye makeup	21,585	Quantity imported, kg/y	0.001
Lip makeup	16,468	Quantity imported, kg/y	1
Crystal and other glass	-	Quantity imported, kg/y	0
Acrylic Road Marking Paint	2	Paint sold, t/y	0.0002
Lead plates, sheets, strip and foil	-	Sheets imported, unit/y	0
Antiknock agents based on lead compounds	-	Product imported, units/y	0
Lead oxides	-	Quantity imported, kg/y	0
Alloys of lead			
Brass	-	Quantity imported, kg/y	0
Brass bars, rods & profiles	1,664	Quantity imported, units/y	38
Brass wire	-	Quantity imported, units/y	0
Brass plates	-	Quantity imported, units/y	6
Bronze	-	Quantity imported, kg/y	0
Waste treatment			
Incineration of municipal waste	3,653	Municipal waste burned, Mg/y	5
Medical waste incineration/burning	-	Medical waste incineration/burning recycled/year	-
Waste water discharge	-	Waste water discharge, L/y	0
Controlled landfill/deposits	92,787	Waste deposited at controlled landfill, MT/y	37,115

Table 3-2 Most Likely Scenario of Lead inputs to relevant sectors

Source category	Estimated Activity rate	Unit	Estimated Pb input kg Pb/y
Mobilisation sources			
Oil products combustion	2,386,998	Oil combusted, GJ/y	10
Natural gas combustion	704,658	Natural gas combusted, GJ/y	0.001
Biomass fired power and heat production	50,468,700	Sugar biomass combusted, kg/y	339
Cement Production	360,000,000	Cement produced, kg/y	0.01
Fertilizers	263,346	Fertilizers used, kg/y	1
Zinc anodes	1,500	Zinc anodes imported, units/y	1
Feedstuff:		Feedstuffs produced, kg/y	
Swine	6,940,400		1
Horse	368,901		0.03
Cattle	1,804,800		0.3
Intentional uses			
Starter batteries (lead acid)	45,250	Batteries imported, kg/y	63,349
Lead-acid batteries for starting motor cycles	1,392	Batteries imported, kg/y	1,357
Other lead-acid batteries (electric vehicles, UPS systems, etc.)	998,928	Batteries imported, kg/y	173,813
Ammunition	32,281,884	Bullets used, units/y	28,931
Professional fishing sinkers	38,862	Sinkers imported, units/y	261
Vehicle balancing weights	10,260	Weights used, units/y	10,209
Cathode ray tubes in CRT screens (average units)	93	CRTs imported and computer monitors recycled, units/y	84
Circuit boards	32,324	Circuit boards recycled units/year	319
Motherboards	2,353	Motherboards recycled units/year	22
Eye make-up	31,770	Quantity imported, kg/y	0
Lip make-up	37,782	Quantity imported, kg/y	2
Crystal and other glass	3,068	Quantity imported, kg/y	368

Source category	Estimated Activity rate	Unit	Estimated Pb input kg Pb/y
Road Marking Paint	6	Paint sold, t/y	0.0004
Lead plates, sheets, strip and foil	149	Sheets imported, unit/y	535
Antiknock agents based on lead compounds	5	Product imported, units/y	0.4
Lead monoxide	1	Quantity imported, kg/y	1
Other lead oxides	3,455		3,144
Alloys of lead:			
Brass	66	Quantity imported, kg/y	2
Brass bars, rods & profiles	2,317	Quantity imported, units/y	53
Brass wire	19,421	Quantity imported, units/y	0.1
Brass plates	270	Quantity imported, units/y	4
Bronze	431	Quantity imported, kg/y	65
Waste treatment			
Incineration of municipal waste (No filter)	2,827	Municipal waste burned, Mg/y	4
Waste water (treatment/discharge)	40,306,468,800	Waste water discharge, L/y	4,031
Controlled landfill/deposits	103,789	Waste deposited at controlled landfill, MT/y	41,516

Table 3-3 Worst Case Scenario of Estimated Lead inputs to society

Source category	Estimated Activity rate	Unit	Estimated Pb input kg Pb/y
Mobilisation sources			
Oil products combustion	2,934,616	Oil combusted, GJ/y	0.00000001
Natural gas combustion	910,854	Natural gas combusted, GJ/y	0.0014
Biomass fired power and heat production	81,661,816	Sugar biomass combusted, kg/y	548
Cement production	-	-	-
Fertilizers	1,125,893	Fertilizers used, kg/y	3
Zinc anodes	0	Zinc anodes imported, units/y	0
Feedstuffs:			
Swine	7,646,820	Feedstuffs produced, kg/y	1
Horse	782,387		0.05
Cattle	2,100,272		0.3
Intentional uses			
Lead acid starter batteries	219,323	Batteries imported, kg/y	153,526
Lead-acid batteries for starting motor cycles	2,795	Batteries imported, kg/y	2,096
Other lead-acid batteries (electric vehicles, UPS systems, etc.)	544,437	Batteries imported, kg/y	326,662
Ammunition	68,427,540	Bullets used, units/y	70,452
Fishing sinkers	0	Sinkers imported, units/y	0
Vehicle balancing weights	0	Weights used, units/y	0
Cathode ray tubes	285	CRTs imported and computer monitors recycled, units/y	259
Circuit boards	43,849	Circuit boards recycled units/year	433
Motherboards	4,271	Motherboards recycled units/year	41
Eye makeup	41,954	Quantity imported, kg/y	0.003
Lip makeup	59,096	Quantity imported, kg/y	7
Crystal and other glass	6,340	Quantity imported, kg/y	1,522
Acrylic Road Marking Paint	9	Paint sold, t/y	0.0007
Lead plates, sheets, strip and foil	306	Sheets imported, unit/y	1,100
Antiknock agents based on lead compounds	10	Product imported, units/y	1
Lead monoxide	0	Quantity imported, kg/y	0
Other lead oxides	8,169		7,434
Alloys of lead			
Brass	354	Quantity imported, kg/y	13
Brass bars, rods & profiles	2,970	Quantity imported, units/y	67
Brass wire	71,595	Quantity imported, units/y	0.3
Brass plates	1,150	Quantity imported, units/y	15
Bronze	1,749	Quantity imported, kg/y	262
Waste treatment			
Incineration of municipal waste	73,921	Municipal waste burned, Mg/y	111
Medical waste incineration/burning	-	Medical waste incineration/burning, Mg/y	-
Waste water discharge	0	Waste water discharge, L/y	0
Controlled landfill/deposits	108,708	Waste deposited at controlled landfill, MT/y	43,483

Table 3-4 Summary of the best case, most likely and worst case scenarios for estimated cadmium inputs to society

	Estimated Cd input kg Cd/y		
Source category	**Best Case**	**Most Likely**	**Worst Case**
Mobilisation sources			
Oil products combustion	1	1	2
Natural gas combustion	0.0001	0.0002	0.0002
Biomass fired power and heat production	4	9	15
Cement production	-	-	-
Fertilizers	0	2	8
Cattle feed	0.1	0.1	0.2
Intentional uses			
Computer batteries	3,155	3,416	3,676
Mobile phone batteries	0	7	0
Cordless phone batteries	0	38	0
Portable radio communication (PMR/LMR) batteries	0	0.5	2
Emergency light batteries	0	5	0
Replacement (single cell sale) batteries	67	114	162
Articles of cadmium	0	123	0
Cigarettes, cigars, cheroots, and cigarillos containing tobacco	0.1	0.2	0.3
Cathode ray tubes (CRT screens)	0.00002	1	3
Eye makeup	0.00002	0.00004	0.00007
Waste treatment			
Incineration of municipal waste	11	1	20
Medical waste incineration/burning	-	-	-
Waste water discharge	0	605	0
Controlled landfill/deposits	1,856	2,076	2,296

Table 3-5 Best Case Scenario of Estimated Cadmium inputs to society

Source category	Maximum Estimated Activity Rate	Unit	Estimated Cd input kg Cd/y
Mobilisation sources			
Oil products combustion	1,839,380	Oil combusted, GJ/y	1.0
Natural gas combustion	498,462	Natural gas combusted, GJ/y	0.0001
Biomass fired power and heat production	19,275,584	Sugar biomass combusted, kg/y	4
Cement production	-	-	-
Fertilizers	0	Fertilizers used, kg/y	0
Cattle feed	1,509,328	Feedstuffs produced, kg/y	0.1
Intentional uses			
Computer batteries	19,721	Batteries recycled and units sold/year	3,155
Mobile phone batteries	0	Batteries recycled/year	0
Cordless phone batteries	0	Batteries sold/year	0
Portable radio communication (PMR/LMR) batteries	0	Batteries and unites sold, units/year	0
Emergency light batteries	0	Batteries sold/year	0
Replacement (single cell sale) batteries	416	Batteries imported, units/y	67
Articles of cadmium	0	Quantity imported, kg/y	0
Cigarettes, cigars, cheroots, and cigarillos containing tobacco	49,583,000	Cigarettes imported, units/y	0.1
Cathode ray tubes (CRT screens)	0	CRTs imported and computer monitors recycled, units/y	0
Eye makeup	11,400	Quantity imported, kg/y	0.00002
Waste treatment			
Incineration of municipal waste	2,001	Municipal waste burned, Mg/y	11
Medical waste incineration/burning	-	Medical waste incineration/burning, Mg/y	-
Waste water discharge	0	Waste water discharge, L/year	0
Controlled landfill/deposits	92,787	Waste deposited at controlled landfill, MT/y	1,856

Table 3-6 Most Likely Scenario of Cadmium inputs to society

Source category	Estimated Activity Rate	Unit	Estimated Cd input kg Cd/y
Mobilisation sources			
Oil products combustion	2,386,998	Oil combusted, GJ/y	1
Natural gas combustion	704,658	Natural gas combusted, GJ/y	0
Biomass fired power and heat production	50,468,700	Sugar biomass combusted, kg/y	9
Cement production	-	-	-
Fertilizers	263,347	Fertilizers used, kg/y	2
Cattle feed	1,804,800	Feedstuffs produced, kg/y	0.1
Intentional uses			
Computer batteries	21,349	Batteries recycled and units sold/year	3,416
Mobile phone batteries	45	Batteries recycled/year	7
Cordless phone batteries	1,527	Batteries sold/year	38
Portable radio communication (PMR/LMR) batteries	51	Batteries and unites sold, units/year	0.5
Emergency light batteries	73	Batteries sold/year	5
Replacement (single cell sale) batteries	714	Batteries imported, units/y	114
Articles of cadmium	123	Quantity imported, kg/y	123
Cigarettes, cigars, cheroots, and cigarillos containing tobacco	97,895,000	Cigarettes imported, units/y	0.2
Cathode ray tubes (CRT screens)	93	CRTs imported and computer monitors recycled, units/y	1
Eye makeup	31,770	Quantity imported, kg/y	0.00004
Waste treatment			
Incineration of municipal waste	2,827	Municipal waste burned, Mg/y	1
Medical waste incineration/burning	-	Medical waste incineration/burning, Mg/y	-
Waste water discharge	40,306,468,800	Waste water discharge, L/year	605
Controlled landfill/deposits	103,789	Waste deposited at controlled landfill, MT/y	2,076

Table 3-7 Worst Case Scenario of Cadmium inputs to society

Source category	Estimated Activity Rate	Unit	Estimated Cd input kg Cd/y
Mobilisation sources			
Oil products combustion	2,934,616	Oil combusted, GJ/y	2
Natural gas combustion	910,854	Natural gas combusted, GJ/y	0
Biomass fired power and heat production	81,661,816	Sugar biomass combusted, kg/y	15
Cement production	-	-	-
Fertilizers	776,965	Fertilizers used, kg/y	8
Cattle feed	2,100,272	Feedstuffs produced, kg/y	0.2
Intentional uses			
Computer batteries	22,977	Batteries recycled and units sold/year	3,676
Mobile phone batteries	0	Batteries recycled/year	0
Cordless phone batteries	0	Batteries sold/year	0
Portable radio communication (PMR/LMR) batteries	195	Batteries and unites sold, units/year	2
Emergency light batteries	0	Batteries sold/year	0
Replacement (single cell sale) batteries	1,012	Batteries imported, units/y	162
Articles of cadmium	0	Quantity imported, kg/y	0
Cigarettes, cigars, cheroots, and cigarillos containing tobacco	146,207,000	Cigarettes imported, units/y	0.3
Cathode ray tubes (CRT screens)	285	CRTs imported and computer monitors recycled, units/y	3
Eye makeup	52,140	Quantity imported, kg/y	0
Waste treatment			
Incineration of municipal waste	3,653	Municipal waste burned, Mg/y	20
Medical waste incineration/burning	-	Medical waste incineration/burning, Mg/y	-
Waste water discharge	0	Waste water discharge, L/year	0
Controlled landfill/deposits	114,791	Waste deposited at controlled landfill, MT/y	2,296

4 Summary of Cadmium and Lead releases

Table 4-1 below provides a summary of Cadmium and Lead releases from all source categories that were found to be present. The key cadmium and lead releases here are releases to air (the atmosphere), and to water (marine and freshwater bodies, including via wastewater systems) and to land.

Table 4-1 Summary of Best Case Scenario of Lead releases

Source category	Lead **Releases to Air (kg Pb)**	Lead **Releases to Land (kg Pb)**	Lead **Releases to Water (kg Pb)**
Mobilisation sources			
Oil products combustion	0.00000001	0	0
Natural gas combustion	0.0007	0	0
Biomass fired power and heat production	129	0	0
Cement production	0	0	0
Fertilizers	0	0	0
Zinc anodes	0	0	0.00
Feedstuffs:			
Swine	0	1	0
Horse	0	0	0
Cattle	0	0.21	0
Intentional uses			
Starter batteries (lead acid)	0	0	0
Lead acid batteries for starting motorcycles	0	617	0
Other batteries (electric vehicles, UPS systems, etc.)	0	20,965	0
Ammunition	0	3826	0
Fishing sinkers	0	0	0
Vehicle balancing weights	0	0	0
Cathode ray tubes in CRT screens	0	0	0
Circuit boards	0	205	0
Motherboards	0	6	0
Eye makeup	0	0.001	0
Lip makeup	0	1	0
Crystal and other glass	0	0	0
Acrylic Road Marking Paint	0	0	0
Lead plates, sheets, strip and foil	0	0	0
Lead grids for electric accumulators	0	0	0
Antiknock agents based on lead compounds	0	0	0
Lead monoxide	0	0	0
Other lead oxides	0	0	0
Alloys	0	38	0
Waste treatment			
Incineration of municipal waste	5	0	0
Medical waste incineration/burning	-	-	-
Sewage sludge dumping	-	-	-
Waste water discharge	0	0	0.00
Controlled landfill/deposits	0	37,115	0

Table 4-2 Summary of Most Likely Scenario of Lead releases

Source category	Lead **Releases to Air (kg Pb)**	Lead **Releases to Land (kg Pb)**	Lead **Releases to Water (kg Pb)**
Mobilisation sources			
Oil products combustion	10	0	0
Natural gas combustion	0.0011	0	0
Biomass fired power and heat production	339	0	0
Cement production	0.01	-	-
Fertilizers	0	1	0
Zinc anodes	0	0	0.1
Feedstuffs:			
Swine	0	1	0
Horse	0	0.03	0
Cattle	0	0.25	0
Intentional uses			
Starter batteries (lead acid)	0	63349	0
Lead acid batteries for starting motorcycles	0	1357	0
Other batteries (electric vehicles, UPS systems, etc.)	0	173813	0
Ammunition	0	28931	0
Fishing sinkers	0	0	261
Vehicle balancing weights	0	10209	0.00
Cathode ray tubes in CRT screens	0	84	0
Circuit boards	0	319	0
Motherboards	0	6	0
Eye makeup	0	0.002	0
Lip makeup	0	2	0
Crystal and other glass	0	368	0
Acrylic Road Marking Paint	0	0.0004	0
Lead plates, sheets, strip and foil	0	535	0
Antiknock agents based on lead compounds	0.4	0	0
Lead monoxide	0	1	0
Other lead oxides	0	3144	0
Alloys of lead	0	123	0
Waste treatment			
Incineration of municipal waste	4	0	0
Medical waste incineration/burning	-	-	-
Sewage sludge dumping	-	-	-
Waste water discharge	0	0	4031
Controlled landfill/deposits	0	41516	0

Table 4-3 Summary of Worst Case Scenario of Lead releases

Source category	Lead **Releases to Air (kg Pb)**	Lead **Releases to Land (kg Pb)**	Lead **Releases to Water (kg Pb)**
Mobilisation sources			
Oil products combustion	0.000000013	0	0
Natural gas combustion	0.0014	0	0
Biomass fired power and heat production	548	0	0
Cement production	0	0	0
Fertilizers	0	3	0
Zinc anodes	0	0	0
Feedstuffs:			
Swine	0	1	0
Horse	0	0.05	0
Cattle	0	0.3	0
Intentional uses			
Starter batteries (lead acid)	0	153,526	0
Lead acid batteries for starting motorcycles	0	2,096	0
Other batteries (electric vehicles, UPS systems, etc.)	0	326,662	0
Ammunition	0	70,452	0
Fishing sinkers	0	0	0
Vehicle balancing weights	0	0	0
Cathode ray tubes in CRT screens	0	259	0
Circuit boards	0	433	0
Motherboards	0	41	0
Eye makeup	0	0.003	0
Lip makeup	0	7	0
Crystal and other glass	0	1,522	0
Acrylic Road Marking Paint	0	0.0007	0
Lead plates, sheets, strip and foil	0	1,100	0
Antiknock agents based on lead compounds	1	0	0
Lead monoxide	0	0	0
Other lead oxides	0	7,434	0
Alloys of lead	0	358	0
Waste treatment			
Incineration of municipal waste	111	0	0
Medical waste incineration/burning	-	-	-
Sewage sludge dumping	-	-	-
Waste water discharge	0	0	0
Controlled landfill/deposits	0	43,483	0

Table 4-4 Summary of Best Case Scenario of Cadmium releases

Source category	Releases to Air (kg Cd)	Releases to Land (kg Cd)	Releases to Water (kg Cd)
Mobilisation sources			
Oil products combustion	1	0	0
Natural gas combustion	0.0001	0	0
Biomass fired power and heat production	4	0	0
Cement production	-	-	-
Fertilizers	0	0	0
Cattle feed	0	0.1	0
Intentional uses			
Computer batteries	0	3,155	0
Mobile phone batteries	0	0	0
Cordless phone batteries	0	0	0
Portable radio communication (PMR/LMR) batteries	0	0	0
Emergency light batteries	0	0	0
Replacement (single cell sale) batteries	0	67	0
Cadmium powder & other articles	0	123	0
Cigarettes, cigars, cheroots, and cigarillos containing tobacco	0.05	0.05	0
Cathode ray tubes (CRT screens)	0	0.00002	0
Eye makeup	0	0.00002	0
Waste treatment			
Incineration of municipal waste	11	0	0
Medical waste incineration/burning	-	-	-
Waste water discharge	0	0	0
Controlled landfill/deposits	0	1,856	0

Table 4-5 Summary of Most Likely Scenario of Cadmium releases

Source category	Releases to Air (kg Cd)	Releases to Land (kg Cd)	Releases to Water (kg Cd)
Mobilisation sources			
Oil products combustion	1	0	0
Natural gas combustion	0.0002	0	0
Biomass fired power and heat production	9	0	0
Cement production	-	-	-
Fertilizers	0	2	0
Cattle feed	0	0.1	0
Intentional uses			
Computer batteries	0	3,416	0
Mobile phone batteries	0	7	0
Cordless phone batteries	0	38	0
Portable radio communication batteries	0	0.5	0
Emergency light batteries	0	5	0
Replacement (single cell sale) batteries	0	114	0
Cadmium powder	0	123	0
Cigarettes etc. containing tobacco	0	0.1	0
Cathode ray tubes	0	1	0
Eye makeup	0	0.00004	0
Waste treatment			
Incineration of municipal waste	1	0	0
Medical waste incineration/burning	-	0	0
Waste water discharge	0	0	605
Controlled landfill/deposits	0	2,076	0

Table 4-6 Worst Case Scenario of Cadmium releases

Source category	Releases to Air (kg Cd)	Releases to Land (kg Cd)	Releases to Water (kg Cd)
Mobilisation sources			
Oil products combustion	2	0	0
Natural gas combustion	0.0002	0	0
Biomass fired power and heat production	15	0	0
Cement production	-	-	-
Fertilizers	0	8	0
Cattle feed	0	0	0
Intentional uses			
Computer batteries	0	3,676	0
Mobile phone batteries	0	0	0
Cordless phone batteries	0	0	0
Portable radio communication (PMR/LMR) batteries	0	2	0
Emergency light batteries	0	0	0
Replacement (single cell sale) batteries	0	162	0
Articles of cadmium	0	0	0
Cigarettes, cigars, cheroots, and cigarillos containing tobacco	0.1	0.1	0
Cathode ray tubes (CRT screens)	0	3	0
Eye makeup	0	0.00007	0
Waste treatment			
Incineration of municipal waste	20	0	0
Medical waste incineration/burning	-	0	0
Waste water discharge	0	0	0
Controlled landfill/deposits	0	2,296	0

Table 4-7 Summary of largest contributors to releases

The following source sub-categories made the largest contributions to Cadmium and Lead releases to the atmosphere:

	Cadmium	Estimated Releases (kg Cd)	Lead	Estimated Releases (kg Pb)
Atmosphere	Biomass fired power and heat production	10	Biomass fired power and heat production	339
	Oil Products Combustion	2	Oil Products Combustion	11
Land	Controlled Landfills	2,076	Controlled Landfills	41,516
	Use and Disposal of Products Containing Cadmium	3,705	Use and Disposal of Products Containing Lead	282,521
Water	Waste Water Treatment and Discharge	605	Waste Water Treatment and Discharge	4,031

Table 4-8 Description of the types of results

Calculation result type	Description
Estimated input, Kg (Pb/Cd)/y	The estimate of the amount of Cadmium or Lead entering this source category with input materials, for example calculated lead amount in heavy oil used annually in the country for combustion in large power plants.
Air	Cadmium and Lead emissions to the atmosphere from point sources and diffuse sources from which cadmium and lead may be spread locally or over long distances with air masses; for example from: ● Point sources such as heavy fuel oil power plants; ● Diffuse sources such as farming and informal dumping of waste containing cadmium and lead compounds.
Land	Cadmium and Lead releases to the terrestrial environment: General soil and ground water. For example, releases from: ● Uncollected waste products dumped or buried informally ● Application on land, seeds or seedlings of fertilizers with cadmium and lead compounds
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 cadmium and lead sources to waste are consumer products with intentional content (batteries, cathode ray tubes, lead crystal glasses).

5 Data and inventory for Pb/Cd mobilisation sources

The section below provides a description of the calculation of activity rates, metal emission factors used and any assumptions made for mobilization sources of lead and cadmium. Mobilisation sources are those for which the heavy metals in question have not been added intentionally, but are natural trace components of other materials.

Combustion/Use of Petroleum Products (except Natural Gas)

Consumption figures were provided for heavy fuel oil no. 6 (Bunker C), heavy vacuum gas oil, gasoline, diesel, jet a-1 fuel, and crude petroleum by the following sources: Barbados National Terminal Company Limited, Barbados National Oil Company and the Barbados Light and Power Company Limited (Greaves, 2018) for the period 2013-2017. The heavy oils are typically used for power generation. Heavy oil/bunker C fuel is the main heavy fuel combusted for the purpose of energy production in Barbados (DEC, 2017).

The following steps were taken to calculate the activity rate:

1. The average annual consumption figure for the five-year period was first determined. To calculate the average annual oil consumption, oil consumption figures had to be converted from the provided unit (thousand cubic feet (mcf), metric tonnes or barrels) to kilograms
2. The average annual oil consumption figure was converted to Gigajoules using an online energy conversion calculator (KylesConverter.com, 2018).
3. The converted final figure (2,386,998 ± 273,809 GJ/y) was used as the activity rate.

The factor used to calculate the estimated lead releases from oil product production was the lead emission factor for lead emissions released from uncontrolled residual oil-fired boiler using No.6 Bunker Fuel oil with no emission control device (U.S. EPA, 1998). This emission factor was used as the island's only energy provider, The BL&P plant, operates using a similar set-up, the company uses primarily Bunker Fuel oil as fuel. Though the plant utilizes two emission control devices, both electrostatic precipitators (Greaves, 2018), there was no specific emission factor that included this type of emission device so the standard uncontrolled emission factor without an adjustment made for this emission device was used. The emission factor to air was 4.3E-15 kg of lead per joule.

The input factor selected for Cadmium releases to air from oil product combustion was chosen in a similar fashion. The emission factor was 0.53 mg of Cadmium per gigajoule for air emissions released from plants using fuel for heat and energy production (Danish Emission Inventories for Stationary Combustion Plants, 2018) and the emissions were expected to be emitted to the air. For lead, comparatively more residue may end up in solids, of which some may be collected by the electrostatic precipitators. However for simplicity it is assumed that all lead would be released 100% into the atmosphere.

Use of Raw or Pre-cleaned Natural Gas

Barbados mainly extracts natural gas from local sources, and minimal quantities are imported. The natural gas extracted is distributed to various districts around the island and is used primarily as cooking gas. Natural gas extraction figures from 2013 to 2017, provided by the Barbados National Oil Company Limited (BNOCL), were used to calculate the annual activity rate for the five-year period.

The natural gas extraction figures were firstly converted from mcf (thousand cubic feet) to gigajoules using an online energy conversion calculator (KylesConverter.com, 2018) for the purpose of correlation with the unit being used as the input factor/emission factor. To calculate the activity rate for natural gas combustion (704,658 ± 103,098 GJ/y) from natural gas extraction figures an assumption was made that all natural gas extracted annually was combusted. This assumption was based on the use of extracted natural gas residentially for domestic cooking in Barbados (DEC, 2017).

The emission factors for both Lead and Cadmium for this category were derived from literature (U.S. EPA, 1997). The assumption was made that emissions from natural gas combustion will be emitted entirely to air as natural gas combustion produces primarily gaseous emissions and particulate matter. The National Petroleum Corporation noted that natural gas in Barbados is cleaned before it is distributed to households; however, no information was available on the residues or effluents produced from such cleaning steps. The applied factors for lead and cadmium emission releases were estimated annual air emission factors from residential cooking using natural gas based on the local use for natural gas. The emission factor for lead and cadmium emissions were 0.0015 mg of Lead per gigajoules and 0.00025 mg of Cadmium per gigajoule respectively (Trozzi et al., 2016).

Biomass Fired Power and Heat Production

The sugar cane industry in Barbados has used cogeneration for years. Bagasse derived from sugarcane processing is burned in boilers at sugar factories to generate steam and electricity for the plant (Division of Energy and Communication, 2018). Data for this sub-category was provided by the sole operating sugar factory in Barbados, Portvale Sugar Factory. The activity rate (47,570,148 ±15,997,948 kg/y) represents the average annual amount of biomass burned by the factory for the period 2013-2017.

The input factor was based on the amount of Lead and Cadmium releases expected to be emitted to the air when sugar cane is used as fuel for biomass fired power. According to Segura-Muñoz, 2003., 85% of the Cadmium (0.22 mg per kg) and Lead concentration (7.9 mg per kg) found in the roots of sugar cane plants, that were under the direct influence of a landfill and waste-treatment area in Brazil, were found in the stems of the plant. Since the source of fuel used at the Barbados' plant is bagasse from sugar cane stems it is assumed that the heavy metal concentrations found in the local bagasse would be equal to 85% of the root concentrations in the Brazil study, namely 0.19 mg of Cadmium per kg and 6.72 mg of Lead per kg. The emissions from the bagasse would be assumed to be emitted to air when burnt to generate power. There may be an overestimation of the heavy metal content in the bagasse as the input factor was derived from sugarcane that was close to a landfill and waste treatment plant, which is not the case in Barbados. Sugar cane is not planted where it would be subjected to the direct influence of the landfill or waste-treatment plant.

Cement Production

The sole cement producer in Barbados is Arawak Cement Company Limited where Portland Cement is manufactured, sold, 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 Arawak Cement Company Limited data collection form, there are no detectable concentrations of lead or cadmium in the Portland cement produced by the company. It was also reported that there are no detectable concentrations of the metals in the raw products used for cement production. The company had no quick lime production from 2013 to 2017 so there was no information for the metal content in this product (Adesegha, 2018).

However using 2015 cement production rates for the company from the United States Geological Service (USGS) as the activity rate, an estimate of the lead releases that may be produced from cement production was calculated. In 2015, the Arawak Cement Company Ltd had a cement production capacity of 360,000 tonnes (Soto-Viruet 2019). Using an emission factor of 3.75×10^{-5} mg of lead per kg of Portland cement, for cement production using dry process kilns with fabric filters, estimated lead releases were determined. Arawak Cement Company Ltd. uses a simple particle control device such as a fabric filter and the emission factor was chosen based on the assumption that a fabric filter is the type of device used by the company (U.S.EPA, 1998). Air emissions derived from the kiln system are the main emissions expected from cement production as such air was chosen as the pathway for these emissions (Kuenen, 2016). Cadmium concentrations were undetectable in Portland cement based on literature (Cipurkovic et al., 2014; Dorileo et al., 2014).

Use of Fertilizers

Fertilizers are used for domestic and agriculture purposes. The most widely used type of fertilizer in Barbados are fertilizers containing phosphates. Imports for phosphate fertilizers were used to determine the activity rate as studies have shown that Cadmium concentrations in phosphate fertilizers can be high due to the presence of cadmium in the phosphate rock used in the manufacturing of the fertilizer (Lugon-Moulin, 2006). The Barbados Statistical Service provided import data on the below types of phosphate fertilizers imported for the period 2013-2017 (Table 5).

All fertilizers sold/distributed in Barbados are imported, as none is produced locally. The activity rate for the use of fertilizers (263, 347 ±387,011 kg/y) was calculated by finding the average of all phosphate fertilisers imported for the above stated period.

Input factors for this category were derived from literature on the prevalent levels of cadmium and lead present in phosphate fertilizers due to the high local imports of these types of fertilizers.

The Cadmium and Lead content found in several different phosphate fertilizers for tobacco production was used as an estimate of the amount of Cadmium and Lead that could be released from phosphate fertilizers for this category (Lugon-Moulin, 2006) (Table 5). Fertilizers are generally applied to the plant and can be present in the soil. As such, it was assumed that the Cadmium in fertilizers would also accumulate primarily in agricultural soils and that the total Cadmium content released from fertilizers would be transferred completely to the soil as well (Lugon-Moulin, 2006). Cadmium estimated releases in the table below are based on the average amount of cadmium found in the relevant phosphate containing fertilisers from various countries. Therefore, the emission factors were represented as the Cadmium content in the fertilizer that is expected to be emitted to land.

Table 5 The Cadmium and Lead release factors used for the imported fertilizers containing phosphorus

	Associated HS codes	Estimated Cd releases (mg/kg)	Estimated Pb releases (mg/kg)
Phosphate fertilizers (Diammonium phosphate) (DAP)	310530	4.76	2.1
Phosphate fertilizers (Monoammonium phosphate) (MAP)	310540	17.95	1.8
Phosphate fertilizers containing Nitrogen and Phosphorus (NP)	310559	5.32	5.67
Phosphatic fertilizers (P)	*310390*	8.98	0.4
Phosphate fertilizers containing Phosphorus and Potassium (PK)	310560	2.19	1.07

[1](Lugon-Moulin, 2006), (Alkhader, 2015)

The Lead content found in varying phosphate fertilizers was used as an estimate of the amount of lead that could be released, the input factors, from phosphate fertilizers for this category (Table 5). The source of the input factors was a study on the impact of phosphorus fertilizers on heavy metals content of soils and vegetables grown on selected farms in Jordan (Alkhader, 2015).

The same assumption used for cadmium releases regarding the absorption of the metal by the soil was made. These emission factors represented the lead content in the fertilizer that is expected to be emitted to land.

Use/Production of Feedstuff

The sole manufacturer of feedstuff in Barbados is Pinnacle Feeds Ltd. The company provided local animal feed sale figures for the period 2013-2017 in the following categories: poultry feed (broiler/layer/turkey), swine, general purpose, cattle (dairy/beef), small ruminant (sheep/goat), horse and rabbit feed.

The activity rates outlined in the table below were determined using sale figures received from Pinnacle Feeds Ltd. The rates were calculated using the average of the annual averages of feed sold from each feed category over the five-year period. Cadmium and Lead emission factors in the table below are based on a study on heavy metal contamination of animal feed in Texas estimating the amount of Cadmium and Lead expected to be released to the land from the use of the feeds (Dai et al., 2016). According to that study, Cadmium was only detected in cattle/beef; as a result, no other feed types were listed for Cadmium (Table 5.1). As the feed is intended for animal consumption, it was assumed that any of the Cadmium or Lead released from the feeds were released to land on defection.

Table 5.1 Activity rates and input factors for feed types

	Feed Type	Emission Factor *mg/kg of feed*	Activity Rate *kg/y*
Lead	Cattle/beef	0.25	1,804,800 ± 147,736
	Horse	0.03	368,901 ± 206,743
	Swine	-1.25	6,904,400 ± 353,210
Cadmium	Cattle/beef	0.14	1,804,800 ± 147736

Trace metals in sacrificial anodes

The activity rate for lead in sacrificial zinc anodes (1500 anodes used/y) was calculated by using the number of zinc anodes imported by Carters General Stores for the year 2017 only. Sacrificial zinc anodes can contain lead as a trace element and are included in this inventory for that purpose. Data was not provided by the company for the years 2013- 2016. As Carter's General Stores is the largest known supplier of these products, the imported amount provided by the company would therefore be a fair estimate of the quantity of anodes sold in Barbados. However there are other local minor suppliers of sacrificial anodes that were contacted for information.

The data provided by the company was for zinc anodes that are purchased for aquatic use. As such, it was assumed that all of the lead could be released into water during use.

The weight of a single brand of sacrificial zinc anode, was used to aid in the estimation of an input factor. This particular product was selected as this is the larger of the two types of marine anodes seen for sale at Carter's General Store and would have the larger lead content as compared to the other. Zinc sacrificial anodes contain an estimated 0.03 percent of lead (Asturiana de Zinc, 2016), this percentage can be calculated from the weight of a single anode and can represent the lead input factor. The weight of the Yamaha outboard zinc anode was 2.27 kg, assuming that all types of sacrificial anodes sold by the company weighed 2.27 kg then the amount of lead expected to be within each anode would be 0.03% of that net weight. Therefore the input factor was calculated as 0.0003 * 2.27 kg or 0.000681 kg per anode.

5.1 Data and inventory on use of products intentionally containing Cadmium or Lead

Lead

Starter Batteries/Lead-acid Batteries

Data for this category were from the Barbados Statistical Service's (BSS) import records for the period 2013-2017 under the following HS codes: 8507100010, 8507100090, 8507200000 and 85079010. The mass of vehicle lead acid batteries recycled from 2014 to 2017 was provided by Scrapman Recycling Inc.

The data were used to provide the average imports of lead-acid starter batteries. The assumption made was that the figures provided for other lead-acid electric accumulators were for uninterrupted power supply (UPS) batteries only. The activity rate for lead-acid starter batteries (90,499 ± 64412 kg) was calculated by summing the mass of the imported batteries and the mass of the locally made batteries minus the mass of the batteries recycled. To calculate the activity rate (1809 ± 493 kg/y) for motorcycle starter batteries and UPS batteries (289,689 ± 127374 kg/y), the average mass of batteries used annually over the five-year period was calculated.

The input factor for lead-acid starter batteries was estimated as the amount of lead found in a single battery which equates to approximately 75% of the total weight (CenturyYuasa, 2017). It was assumed that the total lead emissions from these batteries would be emitted to land on disposal; hence, a distribution factor of one was applied for land.

The input factor for motorcycle starter batteries and UPS batteries was estimated in the same fashion as for lead-acid starter batteries. Using the weight of a UPS battery, 65 % or 0.65 of this weight was considered the input factor (MHB Battery, 2012). Using a motorcycle starter battery, 75 % of this weight was used as the input factor for each battery (BatteryMegastore, 2018). While some lead-containing battery liquids may be lost to water through the fluids being disposed of either down the drains or directly on the ground, it was assumed that the major lead releases from these batteries would be to land on disposal (to landfills or diffusely).

Ammunition

The BSS provided some of the import data used for the inventory for the following ammunition types: shotgun cartridge, captive bolt/riveting cartridge and other ammunition under the HS codes: 930610, 930621 and 930630.

The other data source was the Barbados Defence Force who provided figures for the following ammunition types: 0.22 inch calibre, 5.56 mm calibre, 9 mm calibre, 0.45-inch calibre, 12 gauge calibre and 7.62 mm calibre. The activity rate for each ammunition type was calculated as the annual average amount of each type of ammunition used over the five year period, 2013-2017 (Table 6). For convenience the activity rates (1,768,499 bullets used/y) for all ammunition was combined for the inventory.

The ammunition imports were converted from mass/quantity of ammunition to units of ammunition where one unit refers to the weight of a single type of ammunition bullet. The weight of most types of ammunition mentioned in the inventory was based on weights provided by the Barbados Defence Force.

The exception was the weight of a shotgun bullet which was based on product information acquired from the National Rifle Association of America (NRAA, 2018).

The input factors used to estimate the emission releases from ammunition were based on the amount of lead found within a single bullet of each ammunition type. The input factor for other ammunition was assumed to be the same as that of 5.56 mm as these bullet was the most popular bullet used by the military (Table 6). Spent ammunition would be spread diffusely in the environment, probably with a big fraction in the earth in shooting ranges, and small but unknown fraction may end up in the sea. For simplicity it is considered to be released to land.

Table 6. Activity rates and estimated input factors for the corresponding ammunition types

Ammunition types	Activity rate; number of bullets used/y	Estimated input factor (kg/unit)
Shot gun	252,240 ± 243,040	0.025
Captive bolt/Riveting	178,077 ± 270,385	0.00003
Other ammunition	3,265,429 ± 5,718,572	0.000245
.22 inch	1,628,462 ± 1,625,770	0.0026
5.56 mm	21,086,286 ± 6,494,572	0.000245
9 mm	5,194,800 ± 3,221,067	0.375
.45 inch	302,215 ± 224,430	0.0149
12 Gauge	20,186	0.028
7.62 mm	345,910 ± 284728	0.0033

2 Reference Barbados Defence Force, the National Rifle Association of America

Fishing Sinkers

The activity rate for fishing sinkers (38,862 sinkers used/y) was calculated by using the number of sinkers imported by Carter's General Stores for the year 2017 only. There are other local suppliers of fishing sinkers that were contacted for information however since only Carter's General Stores provided data there may be an underestimation of the activity rate and releases for this category.

The data provided by the company was for fishing sinkers that were purchased for use in water. It is expected as such, releases from this category are based on the amount of lead that could be lost in water during use. A sales representative from Carter's General Stores noted that the most popular fishing sinkers sold by the company are the 3/8 oz., 1/4 oz. and the 2 oz. egg and hex sinkers.

The unit weight of one type of fishing sinker, the 1/4 oz. egg sinker, was used to aid in the estimation of an input factor. This particular product was selected as this is one of the most affordable and popular types of fishing sinkers seen for sale at Carter's General Store based on the amount imported by the company. According to studies, the average percentage of lead found in lead sinkers is 96.05% (Tateda et al., 2014). Using the estimated egg sinker weight, the input factor was calculated as 96.05% of the sinker's weight, which was 0.01 kg per sinker.

Leaded Vehicle Balancing Weights

The activity rate for vehicle wheel balancing weights (10,260 balancing weights used/y) was calculated based on the assumptions that nine out of ten cars in Barbados have at least 4 wheel balancing weights affixed to the car. The average size of a lead weight affixed to a car based on the three most popular weights used (0.75 oz., 1 oz. and 0.25 oz.) is 0.67 oz. or 0.019 kg, the average number of vehicles on the road in Barbados is 110,000 cars; this is based on the 2015 Ambient Air Quality Report. Vehicle wheel balancing weight information was provided by Nassco Limited, Automotive Arts and Courtesy Garage Ltd.

The input factor for this category is based on an article by Rick Kelter, n.d., which states that vehicle wheel balancing weights have a composition of 0.995 or 99.5% lead. The assumption was also made that 100% of the lead release from the weights will be released to land upon disposal. Some of the contacted car repair companies do reuse balancing weights, however further information on the amount of weights that are reused annually would be necessary to determine the actual amount of weights being disposed.

Lead Crystal and Other Glass

The data for the inventory was provided by the Barbados Statistical Service for the following types of leaded glass: lead crystal drinking glasses, lead crystal table and kitchen glassware and other lead crystal glassware under the HS codes: 701321, 701331 and 701391.

The activity rate (3366 ± 1574 kg used/y) was calculated by taking the average of all of the leaded crystal imported annually for the five-year period 2013-2017. Based on literature, it was estimated that 24% of the lead crystal is lead oxide (736 kg of PbO) (Hynes & Jonson, 1997). The amount of lead (Pb) in the lead oxide was calculated as 0.5 of the PbO based on the molecular weight of lead. Therefore, the amount of lead found in lead crystal would represent the input factor for the crystal imported.

It was assumed that the total Lead emissions from the lead crystal would be emitted to land; therefore, the distribution emission factor is 1 towards land.

Road Marking Paints

The average amount of two types of road marking paints sold by Berger Paint Barbados Ltd was used for this inventory: reflective and non-reflective yellow. There are other manufacturers and suppliers of paint suppliers on the island as well; however, no data was received from these companies up to the date of publication. Therefore, the activity rate, metal content and emission releases calculated for this sub-category could be an underestimation.

The mass of each paint product was first calculated from the volumes and the density of the road marking paints from Berger Paint Barbados Ltd. (Berger Paints, 2018). The mass of each paint product was calculated by multiplying the density of the paint (1.4 kg/l) by the volume (Litres) of paint sold annually. The activity rates for reflective (3 ± 0.75 Mt of paint used/y) and non-reflective (2.54 ± 0.86 Mt of paint used/y) road paints were then determined by converting the mass of each paint product from kilograms to metric tonnes. This step was done because the associated Lead content in each product was provided by the company in mg per metric tonne (Thomas, 2018).

The total Lead content in the each product (reflective 60.98 mg/MT, non-reflective 90.02mg/MT) was used as the input factor under the assumption that this was the amount of Lead that could be released from the products on to the land when disposed or used. The assumption was also made that the total Lead content in the road marking paints sold/used will eventually be released to land.

Lead plates, sheets, strips and foil

The import figures for the inventory was provided by the Barbados Statistical Service for two categories under the HS codes: 780411, 780419.

The articles of lead in this category are either of a thickness of less than 0.2 mm of Lead or of a thickness other than that. The imports form the two categories from the period 2013-2017 were combined and averaged to calculate the activity rate. The activity rate (149 ± 79 units used/y) was converted from kilograms to units of lead articles by dividing the mass by the weight of a single lead sheet of thickness 3.39 mm (3.63 kg) (Rotometals, 2018). Lead roofing is not used in Barbados, instead galvanise roofing is the primary material used.

The input factor for this category was estimated as the amount of lead found in a single lead sheet. According to Lassen et al., 2003, the lead content in a single lead sheets equates to 99% of the total weight. It was assumed that the same lead content was found in lead sheets, plates, strips and foil. Using a lead sheet with a weight of 3.63 kg (Rotometals, 2018), 99% of the weight of a lead sheet was used as the input factor for each sheet (3.59 kg/unit). It was assumed that the total lead would be released to land on disposal.

Antiknock agents based on Lead compounds

The figures for this category were from the import records from the Barbados Statistical Service for the period 2013-2017 under HS code 381111.

The activity rate (5 ± 3 units used/y) for lead antiknock agents was determined by calculating the average annual mass of this product imported. That mass was then converted to the number of lead anti-knock products imported by dividing the mass by the assumed weight of a single container of lead anti-knock product, Motor Fuel Additive with Tetraethyl Lead (5.90 kg) (BatteryStuff, 2018).

The input factor for this category was estimated as the amount of lead found in a container of lead anti-knock agent. The lead content in a single container was estimated as 1.22% or 0.072 kg/unit of the total container weight (Kemco Oil, 2011). Using this estimate, the input factor for a container was calculated as 0.07 kg for a container weighing 5.90 kg. It was assumed that the total Lead emissions in the container would be emitted to air because antiknock agents are added to the fuel in vehicle engines and any emissions would be released in the vehicle's exhaust.

Lead compounds and chemicals

The import data for the inventory was provided by the Barbados Statistical Service for the following types of lead compounds/chemicals: lead and orange lead oxide, other lead oxides, lead monoxide under the HS codes: 282420, 282490 and 282410.

The activity rate for lead monoxide (1 kg) and other lead oxides (3113 ± 2,528 kg) represent the average amount of each type of lead compound/chemical imported annually for the period 2013-2017.

The input factor for this category was estimated as the amount of lead found in lead monoxide. According to Lassen et al., 2003, the lead content in lead monoxide equates to 93% of the total weight of the chemical. The lead content in other lead oxides differs with 91 % of the weight being lead (Lassen et al., 2003). Using the mass of imported lead monoxide and the other forms of lead oxides, 0.93 and 0.91 were used as the input factors respectively. The actual use of these lead oxides is not known, but use in paints and ceramic glazing are likely. These may ultimately be releases to waste/land and water, however for simplicity the lead in these oxides is considered released to land/waste through disposal in the landfill.

Lead alloys

Alloys such as brass and bronze have a lead content ranging from 3-60% (Lassen et al., 2003). The import data for these lead alloys was provided by the BSS under several HS code categories (Table 7). Others brass products such as pipe fixtures are imported which could be significant contributors to lead releases. However no product information was obtained from any other stakeholders that had been contacted.

For bronze imports, imports for a single HS code category. The average imports from each alloy type from the period 2013-2017 were combined to calculate the activity rate.

Table 7. Activity rates for lead alloys:

	Associated HS code	Estimated activity rate	Unit	Input Factor
Brass	*740321*	66	kg/y	0.04 or 4% of Pb in the total weight
Brass bars, rods and profiles	*740721*	2317	units/y; brass bars	0.023 kg of Pb or 2.5% per brass bar. The lead content in a typical brass bar was used as it was the largest of the items in the category and would therefore have the largest lead content.
Brass wire	*740821*	19421	units/y; wire	0.0000048 kg or 0.07 % of Pb per wire
Brass plate	*740921740929*	270	units/y; plate	0.013 kg or 65% of Pb per plate
Bronze	*740940*	431	kg/y	0.2 or 20% of Pb in the total weight

It was assumed that the total Lead emissions from the alloys would be emitted to land; therefore, the distribution emission factor is 1 towards land. There is no specific disposal treatment for alloys and any that are disposed would usually be deposited to the landfill.

Lip Makeup

The figures for this category were provided by the Barbados Statistical Service for the period 2013-2017 under the HS code 330410.

The activity rate (37,782 ± 21,315 kg of lip makeup used/y) is the average amount of lip makeup imported for the period. The assumption was made that all lip makeup referred specifically to lipstick. The input factor used was based on a study on the amount of Lead in lipsticks from 400 brands (U.S. Food and Drug Administration, 2011). The average amount of lead found in a kilogram of lipstick was 0.000111 mg of lead per kilogram of lip makeup.

Lipstick could be excreted in urine and/or faeces or disposed to landfill, meaning some may end up in water. Since the distribution of these releases is unknown it was assumed that all the lead in lipstick is disposed to land. Therefore the distribution emission factor is 1.

Printed Circuit Board (PCB) in computers

Data for PCBs were provided by Caribbean E-waste Management Inc. (CEWMI) for the period 2013, 2014, 2016-2017. CEWMI is only associated with the recycling of PCBs and not the sale of any circuit boards. Circuit boards are sold by other suppliers on the island however no information was obtained from any other stakeholders that had been contacted. Therefore the activity rate was not based on the sale or import of PCBs. The annual activity rate (32,324 ± 5,763 PCBs recycled /y) was calculated by averaging the mass amount of circuit boards collected by the recycling facility over the pre-mentioned period, then dividing that mass by the weight of an average laptop PCB (0.198 kg) to determine the average number of circuit boards collected per year (BPS, 2018).

Tin-solder is used in many PCBs and can contain different types of metals including lead. The input factor used to calculate the releases of the lead in the tin-solder found in these boards was determined as the amount of this lead found in a laptop PCB that would be released to land, 0.01 kg per PCB (FWI, 2001). This mass was used as the input factor as no literature could be found regarding the emission factors for PCBs. PCBs collected by CEWMI are exported for recycling. There is a waiting period between collection, processing and shipping of the articles overseas where a minor part of the metal could be released to land (FWI, 2001). As such emissions from this category are still included in the inventory.

Motherboards

Data for computer motherboards were provided by the Caribbean E-waste Management Inc. (CEWMI) for the period 2013-2017. CEWMI is only associated with the recycling of motherboards and not the sale of. It should be noted that motherboards and printed circuit boards were treated separately. Computers and motherboards are sold by other suppliers on the island however no information was obtained from any other stakeholders that had been contacted. Therefore the activity rate was not based on the sale or import of motherboards. The activity rate for the tin-solder used in the motherboards (2,353 ± 959 units used/y) was calculated by averaging the mass amount of motherboards collected by the recycling facility over the pre-mentioned period, then dividing that mass by the weight of an average computer motherboard (1.63 kg) (Amazon, 2019c) to determine the average number collected per year.

The input factor used to calculate the releases of the lead in the tin-solder found in these motherboards was determined as the amount of lead found in a laptop computer that would be released to land, 0.01 kg/unit. Tin-solder is used in motherboards as a connecting agent and can contain lead typically in the amount of 9.50 g per motherboard (FWI, 2001). This mass was used as the input factor as no such literature could be found for motherboards. The assumption was made that the motherboards that were imported would eventually be disposed in the landfill.

As information on computer sales was provided in a limited amount the emission releases were based on motherboards collected by CEWMI for recycling. There is a waiting period between collection, processing and shipping of the articles overseas where a minor part of the metal could be released to land (FWI, 2001). As such emissions from this category are still included in the inventory.

Cadmium

Computer batteries

Data for this category were provided by Massy Technology, Caribbean E-waste Management Inc. (CEWMI) and the UN Comtrade database. Computers are sold by suppliers other than Massy Technologies on the island however no information was obtained from any other stakeholders that had been contacted. Massy Technologies provided computer sale figures for the period 2013-2015 while CEWMI provided mass of laptop batteries collected for recycling for the years 2013, 2014 and 2017. CEWMI collects old/damaged computer batteries from the general population for recycling off island. It is expected that some if not all of the collected batteries have been shipped for recycling by CEWMI. However, during processing and the time period between shipping a minor part of the metal could be released to the land (FWI, 2001).

To avoid double counting, data from UN Comtrade and Massy Technologies were omitted in the activity rate calculation and only data from CEWMI was used to calculate the release from computer batteries. The activity rate (21349 ± 814 batteries sold/y) was calculated as the average annual number of computers recovered by CEWMI for the years 2013, 2014 and 2017.

Previously many laptop computers used nickel cadmium batteries as a power source, and they may thus contribute to cadmium releases from recycling and waste treatment today. However, all laptop batteries can be considered to be lithium-ion batteries. Therefore, for the purpose of this inventory, the assumption was made that all computers imported contained nickel cadmium batteries. The cadmium content was based on nickel cadmium batteries that are used for laptop power supply as laptops are the more popular type of computers using this types of power source. According to one study, the cadmium content found in a single battery is 0.16 or 16% of the weight of a battery (Thomas, 2003). This was used as the input factor as it would be the amount of Cadmium expected to be contained in the batteries.

The assumption was made that 24% of computer batteries imported will eventually be exported for recycling. This percentage was calculated as the percentage of computer batteries collected by CEWMI in 2013 and 2015 against the overall imports of batteries during those same years (5249 kg/21349 kg *100). The remaining 76% will end up in the landfill and the Cadmium and Lead will eventually be released to the land.

Portable radio communication (PMR) device batteries

Massy Technologies provided the data for this category for the period 2013-2017 which was used to calculate the activity rate (51± 72 PMR devices sold per year). Massy Technologies is the only known distributors of these devices; however, there may have been other suppliers that were not contacted for this inventory. The activity rate of the PMR batteries was calculated as the annual average of the PMR devices and batteries sold for the period.

The input factor used to calculate the releases of cadmium to land from PMR devices was determined as the amount of cadmium found in a single nickel cadmium (Ni-Cd) battery that powers the devices. PMR devices can be powered by nickel-cadmium batteries and as such the focus would be on the cadmium contain found in these batteries. The input factor for this category 0.01 kg represents 16% of the average weight of a PMR device battery, 0.00943 grams; this is based on a study on the cadmium content of batteries concluding that Ni-Cd batteries typically contain 16% cadmium (Thomas, 2003).

The assumption is that the PMR devices being purchased would have Li-ion batteries and would therefore replace the older devices that used nickel cadmium batteries and as such the amount of Cadmium estimated to be released would be the same. The assumption was also made that the batteries that were sold would eventually be disposed in the landfill where 100% of the metal could be released to land.

Replacement single cell batteries

The figures for this category are from the BSS import records for the period 2013-2017 under HS code 850730.

The activity rate used (714 kg used/y) is the average amount of replacement single cell batteries imported annually for the five-year period.

The input factor used to calculate the releases of cadmium to land from these batteries was determined as the amount of cadmium found in a single battery. Replacement single cell batteries are of the nickel-cadmium type and it was assumed that the imports were nickel cadmium replacement single cell batteries. A typical AA rechargeable replacement Ni-Cd battery can contain 0.16 or 16% of cadmium (Thomas, 2003). This mass was used as the input factor. No literature could be found regarding the emission factors for these nickel cadmium batteries. The assumption was made that the batteries that were imported would eventually be disposed in the landfill where 100% of the metal could be released to land.

It must be noted however that although import information was provided the BSS for this category, upon inspection of major hardware stores and supermarkets the only type of rechargeable batteries found where of the Nickel-Metal Hydride kind. Further research is therefore needed to find out where the imported batteries are sold and their specific application on island.

Mobile phone batteries

Mobile phone batteries are today considered to be 100% lithium-ion batteries. However older phones disposed of today may in some cases contain NiCd batteries, which was the prevailing battery type earlier. The fraction of NiCd batteries among mobile phones disposed of today is likely low, but unknown.

The activity rate for mobile phone batteries (45.36 kg recycled/y) was based on the assumption that each mobile phone collected by CEWMI contained one battery and that the average life span of a mobile phone battery is 2-3 years. The calculations used the total mobile phones collected by CEWMI in 2014. CEWMI only collects used or discarded mobile phones for recycling, no retail of mobile phones is done by the company. Mobile phones are sold by suppliers on the island however no information was obtained from any other stakeholders that were contacted. Therefore, the activity rate was not based on the sale or import of mobile phones.

The input factor used to calculate the releases of cadmium to land from these batteries was determined as the amount of cadmium found in a single battery. Mobile phone batteries are may be of the nickel-cadmium type and it was assumed that the phones contained nickel cadmium batteries. A typical Ni-Cd battery in a mobile phone can contain 16% of cadmium. Using this estimate, the input factor was calculated as 0.16 (Thomas, 2003). No literature could be found regarding the emission factors for nickel cadmium batteries in mobile phones; a distribution faction of 1 was applied to land as it was assumed that all of the cadmium was released to land.

It is expected that some of but not all of the batteries have been shipped for recycling by CEWMI. However during processing and the time period between shipping a minor part of the metal could be released to the land (FWI, 2001). As such, emissions from this category are still included in the inventory.

Articles of Cadmium

The data for this category include the BSS import records for other cadmium over the period 2013-2017. The HS codes used were 810720 and 810790 Cadmium powders are used in several products and applications including NI- Cd batteries, pigments and computer manufacturing.

The activity rate (123 kg used/y) for this category was calculated by combining the averages of the imports of unwrought cadmium powder and articles of cadmium for the time period.

According to ESPSI, 2015; the cadmium content equates to 100% of the total weight. It was assumed that the same content was found in the powder and articles. Therefore 1.0 or 100% was use as the input factor.

It was assumed that the total emissions from the powder would be emitted to land though it was imported in a powdered form. At the end of these products' life cycle they would be most likely deposited in the landfill where the metal could be released to land.

Cigarettes, cigars, cheroots and cigarillos containing tobacco

The data for this category were obtained from the Barbados Statistical Service for the period 2013-2017 under the HS codes: 240220 and 240210. The activity rate for this category (97,895,000 ± 24,156,000 cigarettes imported/year) was calculated by using the average mass of cigarettes and the average mass of cigars, cheroots and cigarillos imported annually from 2013-2017 and dividing this total imported mass by the average weight of a single cigarette. The weight of a cigarette was estimated as 0.001 kg (Martin, 2018). The imported mass of the cigars, cheroots and cigarillos was multiplied by ten to estimate the weight of these items; this was done due to the assumption that the weight of cigars, cheroots and cigarillos is 10 times the weight of a cigarette.

The input factor used for this category was based on literature for the amount of tobacco contained in a single cigarette, an estimated 2 micrograms of cadmium per cigarette (Martin, 2018).

Approximately 40-60% of cadmium is inhaled to the body and the rest emitted to air. Taking an average of this percentage, around 50% of the cadmium in smoke will be dispersed to air (Martin, 2018). The following assumptions were made regarding this category: 1) the 50% of cadmium that is absorbed into the body from smoking would eventually be emitted to land through excretion or once the person dies and has been buried, 2) 50% of the cadmium contained in all tobacco containing articles for smoking was emitted to air and 3) cigarettes, cigars, cheroots and cigarillos have the same cadmium content.

Products containing both Cadmium and Lead

Eye Makeup

The statistics for this category were provided by the Barbados Statistical Service for the period 2013-2017 under the HS code 330420. The activity rate (31,770 ± 10,185 kg used/y) is the average amount of eye makeup imported for the period. The assumption was made that all eye makeup referred specifically to eyeshadow in the absence of detailed information about the classification.

The input factor used was based on a study on the amount of Cadmium and Lead in various brands of eyeshadow (Ahmed et al., 2017). The estimated metal content in eye makeup is 0.067 mg of Lead per kg of eye makeup and 0.0000000014 Cadmium per kg of eye makeup.

Cathode Ray Tubes in CRT Screens

The data for the inventory was provided by Barbados Statistical Service (BSS) and the Caribbean E-waste Management Inc. (CEWMI). CEWMI collects CRTs and ships them off to be recycled; there is a possibility that Cadmium and Lead can be leached to land during the processing period before shipment (FWI, 2001), however, to avoid double counting of possible Cadmium and Lead releases, the data from CEWMI was excluded from the activity rate calculation.

The import figures provided by the BSS for this category under the HS codes: 854011 and 854020.

The activity rate (93 ± 96 CRTs/y) was calculated as the average number of CRT's imported annually for the period 2013-2017. The assumption was made that computer monitors contained at least one cathode ray tube containing lead and cadmium. The weight of a single monitor is 8 lb. (Amazon, 2018).

The input factors used for Cadmium and Lead in CRT televisions and screens was based on literature. The average amount of Lead and Cadmium found in a single tube is 0.91 kg and 0.01 kg respectively (FWI, 2001).

The assumption was made that all CRT televisions imported will eventually end up in the landfill and once the screens are broken, the cadmium and lead will be emitted to the land.

6. Lead and cadmium releases from waste handling and recycling

Incineration of municipal/general waste

Releases estimates for this category was based on data for municipal waste incineration at the Grantley Adams International Airport (GAIA) for the 2013-2017 period. The Barbados Port Inc. (BPI) also provided the amount of waste incinerated at that facility in 2018. GAIA uses a wet scrubber to control air emissions. Waste is delivered to GAIA in both loose and compacted forms, compacted waste accounting 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. The activity rate (2827 ± 413 Mg waste burnt/y) was the average waste incinerated at the GAIA from 2013-2017 and the incinerated waste at the BPI for the year 2018.

The emission factor for Lead (0.0015 kg/Mg) and Cadmium (0.000323 kg/Mg) is based on emissions from a facility with an electrostatic precipitator (ESP) (USEPA, n.d.). The assumption was made that a wet scrubber has the same effectiveness as an ESP since no literature could be found regarding Lead and Cadmium emission factors from an incineration facility that uses of a wet scrubber.

The output distribution factor for the estimated releases was 100% or one to air, all emissions were assumed to be released to the atmosphere through the burning of the waste.

Incineration of Hazardous Waste

The incineration for hazardous waste is not performed in Barbados. Mangrove Pond Landfill is the engineered landfill site currently in use and it is assumed that hazardous waste not exported is deposited there.

Incineration and open burning of medical waste

According to the Queen Elizabeth Hospital (QEH) incineration of medical waste does take place at this facility. However no data on the amount of wasted burnt at the Queen Elizabeth Hospital was available (QEH, 2018).

Sewage Sludge Incineration

There is no known sewage sludge incineration taking place in Barbados. Sludge from the Barbados Water Authority sewage treatment facility is occasionally deposited at a specific location in Spencers, St. Philip.

Open Fire Waste Burning (on landfills and informally)

The majority of municipal/general waste in Barbados is collected and taken to the Mangrove Landfill where there is no intentional open burning, but, there may be spontaneous ignitions.

However, there is the possibility that some of that waste is informally dumped or burned in the open.

Controlled Landfills/Deposits

The figures (103,789 ± 5501 Mt) used for the inventory was the average amount of municipal/general waste landfilled per year at the Mangrove Pond Landfill from 2013-2017.

The input factors for lead and cadmium releases to land were determined as 400 mg/kg of Lead per litre of waste and 20 mg/kg of Cadmium per litre respectively. These estimates are the highest quantities of these heavy metals estimated to be disposed per year in landfills in the United States of America (Aucott, 2006), and as such – and for cadmium due to changes in especially NiCd battery use - they may overestimate the metal amounts released.

An output distribution factor of one for land was applied since the vast majority is expected to be released to land.

Waste Water System/Treatment

Barbados has two sewage treatment plants: the South Coast Waste Treatment Plant and Bridgetown Waste Treatment Plant. The Bridgetown Plant carries out the secondary waste treatment while the South Coast Plant employs primary treatment only. Figures on water production for the year 2018 were provided by the Barbados Water Authority. The assumption was made that 80% of the water used would be converted to waste water within the same year as 80% of the water supply is expected to reach the sewers (Nptel, n.d.). Therefore, the activity rate (40,306,468,800 L) represents 80% of the annual water consumption (3,358,872,400 L used/y).

The input factors for lead and cadmium releases to wastewater were determined as the concentration of the metals in domestic wastewater (ICON, 2001). The majority of freshwater in Barbados is used by the domestic sector (MPDE, 2001) as such it was assumed that this sector would be the major contributor to waste water discharge. The assumption was made that the amount of domestic wastewater produced is greater than the amount of commercial wastewater produced as there is a much greater number of houses than businesses in Barbados. Hence, the input factors for Lead and Cadmium releases in this category represent the total concentration of Lead (0.10 mg/l) and Cadmium (0.015 mg/l) found in domestic wastewater (ICON, 2001) .

The output distribution factor for the estimated releases was 100% or one to water, meaning that all releases were expected to be to the sea.

References

Table 8: Local stakeholders who provided information towards the inventory

Date of Contact	Institution	Contact
10/10/2018	A-Class Battery Services Ltd.	Andrew Craigwell
10/3/2018	Arawak Cement Company Limited	Omobamidele Adesegha
6/11/2018	Barbados Community College	Annette Alleyne
10/10/2018	Barbados Defence Force	Colonel Glyne Grannum
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
10/10/2018	Barbados Yacht Club	Stephen Scott
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	CaribSupply (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
19/10/2018	Earthwork Pottery	David Spieler
10/4/2018	Future Energy Caribbean Inc.	Mr. Frank Butcher

22/10/2018	*Goodyear Tyre*	*Mark Wilson*
6/11/2018	*Grantley Adams International Airport (GAIA)*	*Roger Best*
		Morland Williams
12/10/2018	*Massy Technologies*	*Micah Gittens*
10/3/2018	*Massy Trading*	*Ron Hope*
	McBrides	*Prince Forde*
10/15/2018	*Megapower Limited*	*Joanna Edgehill*
10/12/2018	*Meridian Caribbean Inc. Windows*	*Zian Kazad*
10/18/2018	*Ministry of Health and Wellness*	*Mrs. Audrey Lovell-Wickham*
4/10/2018	*Ministry of Maritime Affairs & the Blue Economy*	*Ms. Jacqueline Blackman*
10/12/2018	*Oran Limited*	*Scott Oran*
24/10/2018	*Pharmacy Sales Caribbean Inc.*	*Donald Emptage*
8/10/2018	*Pinnacle Feeds Ltd*	*Tony Spencer*
5/10/2018	*Portvale Factory*	*Mr. Raphael Oneal*
10/10/2018	*Quality Tyre*	*Ms. Lashley*
22/10/2018		*Derek Daniel*
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	*Royal Barbados Police Force*	*Commissioner of Police*
9/10/2018	*RPI Recycling Preparation Inc*	*Peter Chesham, Managing Director*
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*
11/10/2018	*Scrapman Recycling*	*Hume Yearwood*
3/10/2018	*Sol (Barbados) LTD.*	*Diane Tull-Knight Operation Manager*
8/10/2018	*Statistical Services*	*Katrina Reid*
		Jamar Bellamy
10/10/2018	*Tropical Battery*	*Knight Desmond*
9/10/2018	*Trowel Plastics Barbados Ltd*	*Nicole Headley*

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12. Appendix A

Activity Rate Data for Mobilization sources Sub-Categories

Combustion of Heavy and Light Fuel Oils

Oil Products Combustion (Metric Tonnes)						
		2013	**2014**	**2015**	**2016**	**2017**
BL&P	**Heavy Fuel Oil No. 6**	203,763	190,171	208,382	179,559	174,105
BL&P	**Heavy Vacuum Gas Oil**	1,526	1,957	722	149	172
BL&P	**Jet A1 Fuel**	7,244	37,754	41,780	72,688	69,379
BNOC	**Extraction of Crude Petr.**	34,712.96	31,967.94	34,033.56	31,528.24	31,853.89
BNTCL	**Gasoline**	92,568	88,063	82,502	94,716	89,856
BNTCL	**Diesel**	104,395	96,619	68,989	58,335	58,592
BNTCL	**Fuel Oil**	172,907	175,185	149,837	23,649	142,865
	SUM	**617,116**	**621,717**	**586,246**	**460,624**	**566,823**

Average	**Convert Metric Tonnes to Gigaloules**	**Standard Deviation**	**Worst Case**	**Best Case**
570,506	2,386,998	273,809	2,934,616.00	1,839,380

Extraction of Crude Petroleum

Extraction of Crude Petroleum					
	2013	**2014**	**2015**	**2016**	**2017**
Annual Production (Barrels)	**254,446.00**	**234,325.00**	**249,466.00**	**231,102.00**	**233,489.00**
Annual Production (Barrels to Metric Tonnes)	**34,712.96**	**31,967.94**	**34,033.56**	**31,528.24**	**31,853.89**

Average	**Standard Deviation**	**Worst Case**	**Best Case**
32,820.00	1,448.00	35,716.00	29,924.00

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
Annual Production (terajoule to gigaloule)	799,285.94	782,510.38	743,194.75	642,457.02	555,838.36

Average	**Standard Deviation**	**Worst Case**	**Best Case**
704,658.00	103,098.00	910,854.00	498,462.00

Biomass Power and Heat Production

Biomass Power and Heat Production					
Biomass Type	**2013**	**2014**	**2015**	**2016**	**2017**
Sugar Cane Bagasse (kg/y)	27,456,140.00	68,742,530.00	48,026,650.00	37,605,690.00	56,019,730.00
Annual Use of Bagasse (kg/y) FAO Yearbook 2016 (Forestry)	3623190	3623190	3623190	3623190	-
Annual Use of Bagasse (kg/y)	31,079,330.00	72,365,720.00	51,649,840.00	41,228,880.00	56,019,730.00

Average	**Standard Deviation**	**Worst Case**	**Best Case**
50,468,700	15,596,558	81,661,816	19,275,584

Cement Production

Cement Production					
	2013	**2014**	**2015**	**2016**	**2017**
Cement production (kg/y)	360,000,000	360,000,000	360,000,000	-	-

Average	**Standard Deviation**	**Worst Case**	**Best Case**
360,000,000	0	0	0

Feedstuff Production

Feedstuff Production					
	2013	**2014**	**2015**	**2016**	**2017**
All Feedstuff (Swine, Cattle, Horse, Poultry, sheep, rabbit etc.)	54,891,000	57,238,000	58,826,000	56,226,000	56,215,000
Horse	477000	462000	431000	474000	506
Swine	6,760,000	7,492,000	7,028,000	6,554,000	6,868,000
Cattle	1,871,000	1,865,000	1,978,000	1,608,000	1,702,000

	Average (kg)	**Standard Deviation**	**Best Case**	**Worst Case**
All Feedstuff (Swine, Cattle,Horse, Poultry, sheep, rabbit etc.)	56,679,200	1306870	54065460.00	59292940.00
Horse	368,901	206743	0.00	782387.20
Swine	6,940,400	353210	6233980.00	7646820.00
Cattle	1,804,800	147736	1509328.00	2100272.00

Activity Rate Data for Waste Treatment Sub-Categories

Wastewater Treatment

Water Production figures	
	Total monthly yield (Cu.M)
Jan	4,007,864
Feb	3,563,986
Mar	4,704,598
Apr	4,678,687
May	4,967,385
Jun	3,943,586
Jul	3,792,821
Aug	3,930,945
Sep	4,037,812
Oct	4,437,928
Nov	4,448,730
Dec	3,868,744
TOTAL (Cu.M)	50,383,086
Total (Litres)	50,383,086,000

Controlled Landfill Deposits

Controlled Landfill Deposits					
	2013	**2014**	**2015**	**2016**	**2017**
Domestic Waste Mangrove Pond Landfill (Mt)	112,677.41	104,759.85	102,269.62	98,210.96	101,022.66

Total (Controlled Landfilling) (Mt)	**112,677.41**	**104,759.85**	**102,269.62**	**98,210.96**	**101,022.66**

	Annual Average	**Standard Deviation**	**Worst Case**	**Best Case**
Mangrove Pond Landfill (Mt)	103789.00	5501.00	114791.00	92787.00

Waste Incineration

Municipal Waste Incineration						
	GAIA 2013-2017					Barbados Port Inc 2018
	2013	**2014**	**2015**	**2016**	**2017**	**2018**
Waste burned (Mt)	1276.40	1316.80	1607.20	3093.20	2876.40	4050.21
Weights	0.0897596	0.092601	0.113022	0.217521	0.202276	0.284820487
Weighted Totals (Mt)	114.5691532	121.9365	181.6494	672.8374	581.8254	1153.581646

	Average	Standard Deviation	Worse Case	Best Case
Waste burned (Mt)	2371.00	1140	4651.00	91.00
Weighted Totals (Mt)	2827	413	3653	2001

Activity Rate Data for intentional use products containing lead or cadmium

Item	2013	2014	2015	2016	2017	Total (kg)	Avg/ Most Likely Activity Rate (kg)	All avg kg/y	Standard Deviation	Best Case Activity Rate (kg)	Worst Case Activity Rate (kg)	Units (Most Likely)	Units (Best Case Activity Rate)	Units (Worst Case Activity Rate)	Standard Deviation (Units)	MT (Most Likely Activity Rate)	MT (Best Case Activity Rate)	MT (Worst Case Activity Rate)	Standard deviation (MT)
LEAD-ACID BATTERIES FOR STARTING PISTONS ENGINES-EXCL.MOTOR CYCLE	182587	57362.96	71455.64	28084.87	108827.1	448317.53	90499		64412	0	219323								
LEAD GRIDS; PLATES COATED WITH PASTE FOR ELECTRIC ACCUMULATORS	0	0	835	0	0	835													
LEAD-ACID BATTERIES FOR STARTING PISTON ENGINES FOR MOTOR CYCLES	1675	2175	1462	1277	2453	9042	1809		493	823	2795	1392	634	2150	380				
OTHER LEAD-ACID ELECTRIC ACCUMULATORS	413637	431387	220081	243600	139738	1448443	289689		127374	34941	544437	998928	120487	1877369	439221				

Item	2013	2014	2015	2016	2017	Total (kg)	Avg/ Most Likely Activity Rate (kg)	All avg kg/y	Standard Deviation	Best Case Activity Rate (kg)	Worst Case Activity Rate (kg)	Units (Most Likely)	Units (Best Case Activity Rate)	Units (Worst Case Activity Rate)	Standard Deviation (Units)	MT (Most Likely Activity Rate)	MT (Best Case Activity Rate)	MT (Worst Case Activity Rate)	Standard deviation (MT)
CARTRIDGES FOR RIVETING ETC. FOR CAPTIVE-BOLT HUMANE KILLERS & PARTS	1691	305	300	0	15	2311	463		703	0	1869	178077	0	718847	270385				
SHOTGUN CARTRIDGES	220	12683	12041	6364	220	31528	6306		6076	0	18458	252240	0	738320	243040				
OTHER AMMUNITION CARTRIDGES	8220	506	1187	46753	476	57142	11429		20015	0	51459	3265429	0	14702572	5718572				
.22 inch	8436	8987	2898	845	0	21166	4234		4227	0	12688	1628462	0	4880000	1625770				
5.56 mm	107606	56895	55306	62461	86741	369009	73802		22731	28340	119264	21086286	8097143	34075429	6494572				
9 mm	67318	57694	23614	8259	37917	194802	38961		24158	0	87277	5194800	0	11636934	3221067				
.45 inch	9957	3986	1600	2037	4933	22513	4503		3344	0	11191	302215	0	751074	224430				
12 guage	0	0	0	0	545	545				0	0	19465	0	0					

Item	2013	2014	2015	2016	2017	Total (kg)	Avg/ Most Likely Activity Rate (kg)	All avg kg/y	Standard Deviation	Best Case Activity Rate (kg)	Worst Case Activity Rate (kg)	Units (Most Likely)	Units (Best Case Activity Rate)	Units (Worst Case Activity Rate)	Standard Deviation (Units)	MT (Most Likely Activity Rate)	MT (Best Case Activity Rate)	MT (Worst Case Activity Rate)	Standard deviation (MT)
7.62 mm	7676	5035	1408	5400	0	19519	3904		3132	0	10168	354910	0	924364	284728				
COLOUR CATHODE-RAY TV PICTURE TUBES, INCL VIDEO MONITOR CATHODE-RAY TUBES	0	0	207	86	171							93	0	285	96				
DRINKING GLASSES OF LEAD CRYSTAL	0	174	873	2636	1059	4742	949	3068	1636	0	6340								
TABLE AND KITCHEN GLASSWARE, NOT DRINKING GLASSES, OF LEAD CRYSTAL	0	276	249	536	157	1218	244												
OTHER GLASSWARE OF LEAD CRYSTAL	2595	1059	1715	1466	2537	9372	1875												
COPPER-ZINC BASE ALLOYS (BRASS),	3	322	0	4	1	330	66		144	0	354								
BARS, RODS, & PROFILES OF COPPER- ZINC BASE ALLOYS (BRASS)	2330	1709	2367	2232	1866	10504	2101		296	1509	2693	2317	1664	2970					

Item	2013	2014	2015	2016	2017	Total (kg)	Avg/ Most Likely Activity Rate (kg)	All avg kg/y	Standard Deviation	Best Case Activity Rate (kg)	Worst Case Activity Rate (kg)	Units (Most Likely)	Units (Best Case Activity Rate)	Units (Worst Case Activity Rate)	Standard Deviation (Units)	MT (Most Likely Activity Rate)	MT (Best Case Activity Rate)	MT (Worst Case Activity Rate)	Standard deviation (MT)
WIRE OF COPPER-ZINC BASE ALLOYS (BRASS)	271	381	8	0	10	670	134		180	0	494	19421	0	71595					
WIRE OF OTHER COPPER ALLOYS	9443	760	828	11428	3	22462	4493		5481	0	15455								
PLATES, ETC. OF COPPER-ZINC BASE AL- LOYS IN COILS, OF A THICK. > 0.15MM	657	0	216	0	0	873	175		286	0	747	270	0	1150					
OTHER PLATES ETC. OF COPPER-ZINC BASE ALLOYS, > 0.15MM THICK	173	106	244	587	477	1587	318		206	0	730								
COPPER-TIN BASE ALLOYS (BRONZE),	614	17	1511	0	10	2152	431		659	0	1749								
SHEETS, STRIP AND FOIL OF 2 THICKNESS < 0.2MM OF LEAD	281	0	0	0	55	336	68	538	285	0	1108	149	0	306	79				

Item	2013	2014	2015	2016	2017	Total (kg)	Avg/ Most Likely Activity Rate (kg)	All avg kg/y	Standard Deviation	Best Case Activity Rate (kg)	Worst Case Activity Rate (kg)	Units (Most Likely)	Units (Best Case Activity Rate)	Units (Worst Case Activity Rate)	Standard Deviation (Units)	MT (Most Likely Activity Rate)	MT (Best Case Activity Rate)	MT (Worst Case Activity Rate)	Standard deviation (MT)
OTHER LEAD PLATES SHEETS, STRIP AND FOIL	161	100	0	1996	92	2349	470												
ANTI-KNOCK PREPARATIONS BASED ON LEAD COMPOUNDS	19	24	55	21	23	142	29		15	0	59	5	0	10	3				
RED LEAD AND ORANGE LEAD	0	0	342	0	0	342													
OTHER LEAD OXIDES	0	4780	984	5943	3854	15561	3113		2528	0	8169								
LEAD MONOXIDE (LITHARGE, MASSICOT)	0	1	0	0	0	1				0	0								
LIP MAKE-UP PREPARATIONS	27364	21561	30544	34480	74960	188909	37782		21315	0	80412								
EYE MAKE-UP PREPARATIONS	26524	23771	26341	33374	48839	158849	31770		10185	11400	52140								

Item	**2013**	**2014**	**2015**	**2016**	**2017**	**Total (kg)**	**Avg/ Most Likely Activity Rate (kg)**	**All avg kg/y**	**Standard Deviation**	**Best Case Activity Rate (kg)**	**Worst Case Activity Rate (kg)**	**Units (Most Likely)**	**Units (Best Case Activity Rate)**	**Units (Worst Case Activity Rate)**	**Standard Deviation (Units)**	**MT (Most Likely Activity Rate)**	**MT (Best Case Activity Rate)**	**MT (Worst Case Activity Rate)**	**Standard deviation (MT)**
Printed Circuit Boards (CEWMI)	7000	8000	6000	5000	6000	32000	6400		1141	4118	8682	32324	20798	43849	5763				
Motherboards (CEWMI)	2000	3000	4000	2000	5000	16000	3200		1304	592	5808	2353	436	4271	959				
Mobile phones (CEWMI)	0	45.36	0	0	0	45.36						1134							
Cordless Phones & batteries (Carters General Store)												1527							
Emergency lights												73							
OTH.BEAUTY/MAKE-UP PREP.&PREP.FOR THE CARE OF THE SKIN(OTH.THAN MEDICA	472514	598970	529907	581744	534631	2717766	543554		49604	444346	642762								
CIGARETTES CONTAINING TOBACCCO	109372	75509	71553	67840	62160	386434	77287		18599	40089	114485								
CIGARS,CHEROOTS AND CIGARILLOS,	19920	14150	18010	29160	21800	103040	20608		5557	9494	31722								

Item	2013	2014	2015	2016	2017	Total (kg)	Avg/ Most Likely Activity Rate (kg)	All avg kg/y	Standard Deviation	Best Case Activity Rate (kg)	Worst Case Activity Rate (kg)	Units (Most Likely)	Units (Best Case Activity Rate)	Units (Worst Case Activity Rate)	Standard Deviation (Units)	MT (Most Likely Activity Rate)	MT (Best Case Activity Rate)	MT (Worst Case Activity Rate)	Standard deviation (MT)
CONTAINING TOBACCO																			
Cigarettes, Cigars,CHEROOTS AND CIGARILLOS, CONTAINING TOBACCO	129292	89659	89563	97000	83960	489474	97895		24156	49583	146207	97895000	49583000	146207000	24156000				
UNWROUGHT CADMIUM, POWDERS	0	8	0	0	0	8		123											
OTHER CADMIUM AND ARTICLES OF CADMIUM	115	0	0	0	0	115													
Computer batteries (CEWMI)	249	5000	0	0	228		1096	24.58663169	2187	0	5470								
Computer batteries (UN Comtrade)	22241	20648	21157				21349		814	19721	22977								
Portable Radio Communication Device	0	0	1	97	155	253						51	0	195	72				

Item	2013	2014	2015	2016	2017	Total (kg)	Avg/ Most Likely Activity Rate (kg)	All avg kg/y	Standard Deviation	Best Case Activity Rate (kg)	Worst Case Activity Rate (kg)	Units (Most Likely)	Units (Best Case Activity Rate)	Units (Worst Case Activity Rate)	Standard Deviation (Units)	MT (Most Likely Activity Rate)	MT (Best Case Activity Rate)	MT (Worst Case Activity Rate)	Standard deviation (MT)
NICKEL-CADMIUM ELECTRIC ACCUMULATORS	841	782	816	639	488	3566	714		149	416	1012								
FLUORESCENT, HOT CATHODE LAMPS	138438	108946	84881	68608	45518	446391	89279		35935	17409									
MERCURY OR SODIUM VAPOUR LAMPS; METAL HALIDE LAMPS	1212	2171	413	953	1144	5893	1179		638	0	2455								
ARC-LAMPS	268	70	55	111	39	543	109		94	0	297								
OTHER MINERAL OR CHEMICAL FERTILISER, PHOSPHATIC	6612	1319	23592	1214	105014	137751	27551		44262	0	116075								
AMMONIUM DIHYDROGENORTHO PHOSPHATE (MONOAMMONIUM PHOSPHATE) ETC.	0	4	46000	328914	70	374988	74998		143333	0	361664								

Item	2013	2014	2015	2016	2017	Total (kg)	Avg/ Most Likely Activity Rate (kg)	All avg kg/y	Standard Deviation	Best Case Activity Rate (kg)	Worst Case Activity Rate (kg)	Units (Most Likely)	Units (Best Case Activity Rate)	Units (Worst Case Activity Rate)	Standard Deviation (Units)	MT (Most Likely Activity Rate)	MT (Best Case Activity Rate)	MT (Worst Case Activity Rate)	Standard deviation (MT)
DIAMMONIUM HYDROGENORTHOPHOSPHATE (DIAMMONIUM PHOSPHATE)	0	5792	92000	0	4822	102614	20523		40047	0	100617								
SUPERPHOSPHATES	0	10	0	0	0	10	2		5	0	12								
MINERAL/CHEMICAL FERTIL.CONT.THE TWO FERLIS. ETC.PHOSPHOROUS & POTASSIUM	1661	37400	179554	47365	35014	300994	60199		68905	0	198009								
OTH.MINER./CHEM.FERTIL.CONT.2/3 OF ETC. NITROGEN,PHOSPHORUS,POTASSIUM	557394	1356537	790832	608849	765285	4078897	815780		318267	179246	1452314								
OTHER MINERAL/CHEMICAL FERTILISERS CONTAINING NITRATES AND PHOSPHATES	0	0	547	0	0	547	110	80076	245	0	600								

Item	2013	2014	2015	2016	2017	Total (kg)	Avg/ Most Likely Activity Rate (kg)	All avg kg/y	Standard Deviation	Best Case Activity Rate (kg)	Worst Case Activity Rate (kg)	Units (Most Likely)	Units (Best Case Activity Rate)	Units (Worst Case Activity Rate)	Standard Deviation (Units)	MT (Most Likely Activity Rate)	MT (Best Case Activity Rate)	MT (Worst Case Activity Rate)	Standard deviation (MT)
OTH.MINER./CHEM.FERTILISERS CONT.THE TWO FERTTILISING ELEMENTS ETC.	1165	941	311152	0	86568	399826	79966		134481	0	348928								
POLYURETHANES	80283	101818	64563	75961	122283	444908	88982		22996	42990	134974								
PRIMARY CELLS AND PRIMARY BATTERIES, OF MERCURIC OXIDE	1	7	0	14	141	163	33		61	0	155								
THERMOMETERS AND PYROMETERS, LIQUID FILLED, FOR DIRECT READING	2639	1382	1127	1294	2493	8935	1787		719	349	3225								
Mercury	0	1	0	0	0	1	1		1	0	3								
OTH INSTR. TO MEASURE/CHECK THE FLOW OF OTHER VARIABLES OF LIQUIDS/GASES (including manometers)	17829	13346	12135	10962	18139	72411	14483		3308	7867	21099								

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Acrylic Road Marking Paint Reflective Yellow	1605	2174	2843	1634	2462	10718	2144		535	1074	3214					3.0016	1.5036	4.4996	0.749
Acrylic Road Marking Paint Non-Reflective Yellow	1634	1321	1385	2836	1879	9055	1811		615	581	3041					2.53540	0.8134	4.2574	0.861
Zinc anodes	0	0	0	0	1500							1500							
fishing sinkers	0	0	0	0	38862							38862							
Balancing weights for vehicles	0	0	0	0	10260							10260							