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Item 5 (l) of the provisional agenda*

Matters for consideration or action by the Conference of the Parties: emissions of mercury resulting from the open burning of waste

Compilation of information submitted in relation to emissions of mercury resulting from the open burning of waste

Note by the secretariat

As referred to in the note by the secretariat on the matter (UNEP/MC/COP.2/16), a compilation of submissions from parties and other stakeholders on mercury emissions resulting from the open burning of waste is set out in the annex to the present note. The submissions are reproduced as received, without formal editing.

* UNEP/MC/COP.2/1.

Annex

Compilation of information submitted in relation to emissions of mercury resulting from the open burning of waste

1. Information submitted by the Republic of Moldova

Ministry of Agriculture, Regional Development and Environment of the Republic of Moldova

MERCURY RELEASES FROM OPEN BURNING IN THE REPUBLIC OF MOLDOVA

2018

LEVEL 2

This calculation of releases was performed in accordance with UNEP's "Toolkit for identification and quantification of mercury releases", Inventory Level 2 (version 1.03, April 2015).

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1 Summary

The inventory of sources of mercury releases in the Republic of Moldova conducted in 2014 reference year 2014 based on UNEP Toolkit Level 2 (version April 2015). The inventory has been elaborated by the Environmental Pollution Prevention Office within the Ministry of Environment of the Republic of Moldova (EPPO) in the frames of the project *UNEP/GEF Project "Enabling activity development of Minamata initial assessment in the Republic of Moldova"* revealed that the **main source categories present in country** are:

i) Extraction and use of fuels/energy sources
ii) Production of other minerals and materials with mercury impurities
iii) Consumer products with intentional use of mercury
iv) Other intentional products/process uses,
v) Production of recycled metals,
vi) Waste incineration and waste burning
vi) Waste deposition/landfilling and waste water treatment,
vii) Cremation and cemeteries.

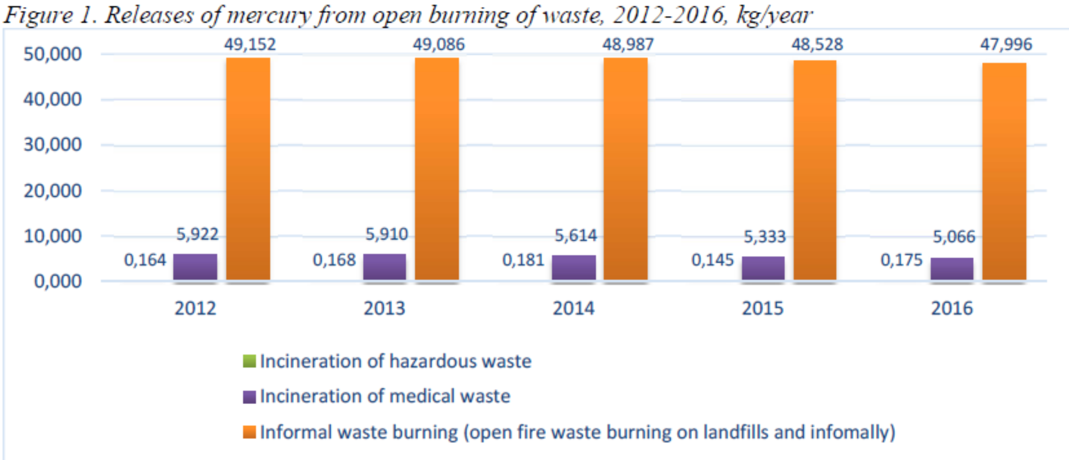
An aggregated presentation of the results for the category open burning of waste is presented in Table 1.1 below.

Table 1-1 Summary of mercury releases from open burning of waste for the period 2012-2016, kg/year

Source category: Waste incineration	**2012**	**2013**	**2014**	**2015**	**2016**
Incineration of municipal/general waste	0,000	0,000	0,000	0,000	0,000
Incineration of hazardous waste	0,164	0,168	0,181	0,145	0,175
Incineration of medical waste	5,922	5,910	5,614	5,333	5,066
Sewage sludge incineration	0,000	0,000	0,000	0,000	0,000
Informal waste burning (open fire waste burning on landfills and informally)	49,152	49,086	48,987	48,528	47,996
Total	**55,238**	**55,163**	**54,782**	**54,006**	**53,237**

In 2016, the waste open burning sub-category contributing with the highest **mercury releases to the atmosphere** is the informal waste burning with 47,99 Kg Hg/y, that represents 90% of mercury releases from the source category *5.8 Waste incineration and burning, followed by open burning of medical waste.*

Figure 1. Releases of mercury from open burning of waste, 2012-2016, kg/year



2. Data and inventory on waste incineration and burning

2.1 Incineration of municipal/general waste

In the Republic of Moldova, there are no authorized facilities for incineration of municipal/general waste. For this reason, emissions of mercury from this sub-category were not estimated.

2.2 Open burning of hazardous waste

Subcategory description

Hazardous waste refers to residues and wastes which contain hazardous materials in significant quantities. Generally spoken, all materials including consumer goods, which require special precautions and restrictions during handling and use, belong to this group. These include solvents and other volatile hydrocarbons, paints and dyes, chemicals including pesticides and herbicides, pharmaceutical products, batteries, fuels, oils and other lubricants, as well as goods containing heavy metals. Also, all materials contaminated with these materials such as soaked rags or paper, treated wood, production residues, etc., are considered hazardous waste (UNEP, 2003).

Methodology applied to estimate releases from open burning of hazardous waste

The formula used for calculation of mercury emissions to different media is:

Estimated mercury release to pathway Y	=	**activity rate × input factor × output distribution factor for pathway Y**

Source: UNEP, 2015

Activity rate data

The activity rate data needed to estimate releases from open burning of hazardous waste in the Republic of Moldova is the amount of hazardous waste burnt annually.

For this sub-category the releases has been assesses for one waste flow – used vehicle oil, which is informally burned in auto service centers for heat production purposes and thus, can be considered as open burning. An estimate of the potential quantity of waste oil generated by transport in Moldova in the period 2012-2016 in presented in the table 2-1. The source of data is the official reply provided by the Customs Service of the Republic of Moldova (letter no 28/07-3590 as of 14.03.2017).

It is assumed that 90 % of the generated waste oil is burnt by the service centers.

Table 2-1 Activity rate data used to estimate releases from incineration of hazardous waste – waste oil, tones

Customs code	2012	2013	2014	2015	2016
271019810	5911.281	6255.602	6601.358	6101.920	6557.095
271019990	474.812	529.551	756.963	486.789	421.500
271019870	631.809	687.564	691.038	778.616	831.513
271019830	481.254	546.979	594.339	760.027	712.342
271019930	137.356	81.758	98.228	60.562	61.456
270900900	75.178	677.074	298.218	52.019	
271019910			30.728		

271019850	25.328		20.073	29.816	
271011900	50.350	459.210	554.618		
271019310					
271019250				8.715	
271019650					
271019610	503.461	23.120			
271019290	0.386		0.147	2.033	
271019110					
271099000	0.009			0.087	
271019150	0.105				
271011250	1041.474		939.640		
271011210	163.820				
271019910	44.725	44.733		18.940	19.295
270750900	41.900				
270799990		0.106		1.568	1.697
270900100		504.880			
271012210				152.796	154.956
271020900				0.900	
271012900				0.509	6.080
271012110				0.046	
271012250					1469.343
270730100					0.510
271012150					0.024
Total placed on market	**9583,248**	**9810,577**	**10585,35**	**8455,343**	**10235,811**
Total waste oil generated	**9104,0856**	**9320,048**	**10056,082**	**8032,575**	**9724,0204**
Total burnt	**8193,67704**	**8388,043**	**9050,4742**	**7229,318**	**8751,6184**

Mercury input factor

In order to estimate emissions of mercury from the sub-category Incineration of hazardous waste, information on the concentration of mercury in the processed hazardous waste is needed. Since the type of hazardous waste identified to be burned in the country is vehicle used oil, which represents a mix of synthetic and mineral lubricants, it was considered appropriate to use as input factor for this sub-category the concentration of mercury offered in the Toolkit as default input factor for heavy oils, namely 0.02 g Hg per ton of oil incinerated. For a more accurate estimate, actual results of mercury content analysis of the used oil would be required. However, at this point of the inventory, such data has not been identified within the company or sought independently by the project team.

Output distribution factors

For the calculation of mercury emissions based on IL2 approach the default output distribution factors that have been already provided in the IL2 Excel calculation spreadsheet were used.

Summary of inputs and results

Table 2-2 Summary of inputs and results from sub-category 5.8.2 Incineration of hazardous waste in the Republic of Moldova in 2012-2014

Incineration of hazardous waste	Unit	Produc-tion	Use	Disposal (open burning)				
				2012	2013	2014	2015	2016
Activity rate	Used oil open burnt, t/y	-	-	8193,6	8388,0	9050,4	7229,3	8751,6
Input factor for phase	g Hg/t waste oil burnt	-	-	0.02	0.02	0.02	0.02	0.02
Calculated input to phase	kg Hg/y	-	-	0,1638	0,1677	0,1810	0,1445	0,1750
Output distribution factors for phase:	fraction		-					
- Air	-	-	-	1	1	1	1	1
- Water	-	-	-	-	-	-	-	-
- Land	-	-	-	-	-	-	-	-
- Products	-	-	-	-	-	-	-	-
- General waste treatment	-	-	-	-	-	-	-	-
- Sector specific waste treatment	-	-	-	-	-	-	-	-
Calculated outputs/releases to:			-	-	-	-	-	-
- Air	kg Hg/y	-	-	0,1638	0,1677	0,1810	0,1445	0,1750
- Water	kg Hg/y	-	-	-	-	-	-	-
- Land	kg Hg/y	-	-	-	-	-	-	-
- Products	kg Hg/y	-	-	-	-	-	-	-
- General waste treatment	kg Hg/y	-	-	-	-	-	-	-
- Sector specific waste treatment	kg Hg/y	-	-	-	-	-	-	-

Data gaps and priorities for potential follow up

Due to the lack of authorized hazardous waste treatment facility/ incinerator and lack of statistic data on open burning of waste oil, the quantity of waste oil was estimated on the basis of expert judgement.

Because an analysis of the used oils for mercury content has not been carried out by the company or other specialized institutions, it is highly uncertain that the default input factor used in the IL2 calculation spreadsheet is appropriate for use in the calculation of mercury emissions from this subcategory. It is probable that concentration of mercury in used vehicle oil is different than the one in the initial oil used as lubricant in vehicles.

It should be noted that, according to the Waste Act no. 209 of July 29, 2016, which entered into force on January 23, 2017, all economic operators carrying out dangerous waste management activities are to be authorized to carry out their activity on the basis of the new requirements stipulated in the said law. Until now, no economic agent has obtained authorization for the collection and management of used oil.

At the same time, Article 12 of the Waste Act contains provisions related to the extended responsibility of the producers of products. The article provides that natural and legal persons designing, producing, processing, treating, selling and / or importing products are subject to extended producer responsibility in order to enforce reuse and prevention, recycling and other forms of waste recovery. In order to promote the principle of extended producer responsibility, the following products will be subject to these regulations:

- batteries and accumulators;
- electrical and electronic equipment;
- vehicles;
- oils;
- packaging.

2.2 Incineration of medical waste

Subcategory description

Medical waste includes infectious and non-infectious wastes generated by a variety of facilities engaged in medical care, veterinary care, or research activities such as hospitals, clinics, doctors' and dentists' offices, nursing homes, veterinary clinics and hospitals, medical laboratories, and medical and veterinary schools and research units. The mercury content in the medical waste stream originates primarily from intentionally used mercury in discarded products and process waste. The mercury concentrations are directly dependent on the inputs of mercury to the waste (UNEP, 2015).

Medical waste is considered to be every waste generated from medical activities regardless if these activities take place in a hospital or are performed by a medical doctor, dentist or any other physician. The waste generated during these activities includes secretes, blood, pharmaceuticals and packaging materials and/or tools used for the medical treatment of people or animals. To reliably destroy viruses, bacteria, and pathogens this waste is often thermally treated by incineration (UNEP, 2003).

Methodology applied to estimate releases from incineration of medical waste

The formula used for calculation of mercury emissions to different media is:

Estimated mercury release to pathway Y = **activity rate × input factor × output distribution factor for pathway Y**

Source: UNEP, 2013

Activity rate data

The activity rate data needed to estimate releases from incineration of medical waste in the Republic of Moldova is the amount of medical waste incinerated/ burnt annually.

In the Republic of Moldova, there are no authorized medical waste incinerators.

However, it is common practice that medical waste is burnt at the medical institutions and hospitals in order to destroy infectious waste. The practice of medical waste burning is carried out mainly through three methods: 1) open burning, 2) closed burning in boilers for heating or metal barrels and 3) transportation for treatment through pyrolysis by a specialized authorized company[1].

The total amount of medical waste burnt in the public health institutions in the country has been summarized on the basis of data presented by the National Public Health Centre[2] and is presented in the Table 2-3 below.

Table 2-3 Estimated amounts of medical waste treated by thermal methods from public medical institutions in Republic of Moldova for the period 2012-2016

	2012	2013	2014	2015	2016
Amount of medical waste burnt, tones	740,3	738,7	701,7	666,62	633,289

Mercury input factor

Available information indicates that medical waste incineration systems can be significant sources of mercury emissions. Mercury emissions result from mercury-bearing materials contained in the waste. Known mercury sources include thermometers, blood pressure gauges, dental material with mercury amalgam, batteries, laboratory chemicals (in tissue samples etc.), fluorescent lamps, high-intensity discharge lamps (mercury vapour, metal halide, and high-pressure sodium); special paper and film coatings, and pigments; most of which should preferably be sorted out the waste stream before incineration, if possible (UNEP, 2015).

The type of medical waste burnt within medical institutions in the country constitutes largely infectious (pathological) waste, such as syringes and post-operational waste. Mercury-bearing materials mentioned above such as mercury thermometers, fluorescent lamps and high-intensity discharge lamps are usually collected and stored separately within the institutions. Dental material with mercury amalgam is not used in the country, therefore it is estimated as not being present in the produced medical waste.

The mercury content in the medical waste determines the mercury inputs to incineration of medical waste. However, as presented above, the medical waste burned by medical institutions in the Republic of Moldova is composed of infectious waste, which is free of mercury containing products. Information received from medical institutions in the country confirmed that the type of medical waste burned includes infectious waste.

Analysis of mercury in infectious waste burned in the country has not been carried out up to date, therefore in order to determine potential concentration of mercury in medical waste burned, results of studies of mercury emissions from incineration of medical waste carried out in other countries could be used. Results of an USA study that looked at mercury emissions from incineration of pathological waste and general medical waste can be considered relevant for establishing possible mercury concentration in medical waste burned in the Republic of Moldova. According to the data obtained in this study, an average atmospheric emission of 8.9 g Hg per metric ton of incinerated pathological and general medical waste was

[1] Trisumg Ltd treats certain plastic medical waste through pyrolysis

[2] Letter no. 06t-3-2524 of 30.10.2015 from the National Public Health Centre

produced in the USA in 1996 (US EPA, 1997b cited in UNEP, 2015). Also, it was established that pathological waste contain significantly less than mercury than general medical waste, which on average contain about 8.2 g mercury per metric ton (US EPA, 2004 cited in UNEP, 2015).

Based on above data, it can be deduced that infectious medical waste could contain up to 8 g of mercury per metric ton. Additionally, the UNEP Toolkit methodology indicates that the low end input factor (8 g Hg/metric ton waste) is expected to be relevant for a situation where substantial parts of the waste products with high mercury concentration (thermometers, batteries, dental amalgam wastes, fluorescent lamps etc.) have been sorted out of the waste for separate treatment, and will therefore be present in lower amounts in the waste (UNEP, 2015). Taking into consideration this information, in the case of the Republic of Moldova it was deemed appropriate to choose the low end default input factor of 8 g Hg/t of incinerated waste, which was used for the quantification of mercury releases from this sub-category.

The incineration technology and particularly the flue gas cleaning systems applied, determine the distribution of the output of mercury between air emissions and releases to water (UNEP, 2013). According to the data presented by the National Public Health Centres across the country, in the Republic of Moldova, medical waste is burnt either openly or in furnaces of the local medical institutions. Therefore, no emission reduction devices are applied; hence for the quantification of releases from this sub-category *Output Scenario 1) No emission reduction devices* has been chosen.

Output distribution factors

For the calculation of mercury emissions, the default output distribution factors already provided in the IL2 Excel calculation spreadsheet have been used.

Mercury inputs and results

Table 2-4 Summary of inputs and results from sub-category Incineration of medical waste in the Republic of Moldova in 2012-2016

Incineration of medical waste	Unit	Produc-tion	Use	Disposal (open burning)				
				2012	2013	2014	2015	2016
Activity rate	t medical waste/y	-	-	740,3	738,7	701,7	666,62	633,289
Input factor for phase	g Hg/t medical waste	-	-	8	8	8	8	8
Calculated input to phase	kg Hg/y	-	-	5,922	5,910	5,614	5,333	5,066
Output distribution factors for phase:	fraction		-					
- Air	-	-	-	1	1	1	1	1
- Water	-	-	-	-	-	-	-	-
- Land	-	-	-	-	-	-	-	-
- Products	-	-	-	-	-	-	-	-
- General waste treatment	-	-	-	-	-	-	-	-
- Sector specific waste treatment	-	-	-	-	-	-	-	-
Calculated outputs/releases to:			-	-	-	-	-	-
- Air	kg Hg/y	-	-	5,922	5,910	5,614	5,333	5,066
- Water	kg Hg/y	-	-	-	-	-	-	-
- Land	kg Hg/y	-	-	-	-	-	-	-
- Products	kg Hg/y	-	-	-	-	-	-	-
- General waste treatment	kg Hg/y	-	-	-	-	-	-	-
- Sector specific waste treatment	kg Hg/y	-	-	-	-	-	-	-

Data gaps and priorities for potential follow up

The full data on amounts of waste formed in private hospitals, clinics, doctors' and dentists' offices that activate in the country is missing. Additionally, an in-depth assessment of mercury contents in medical waste is needed.

2.3 Incineration of sewage sludge

In Republic of Moldova, the practice of sewage sludge incineration is not present. For this reason, emissions of mercury from this sub-category are not estimated and presented.

2.4 Open fire waste burning (on landfills and informally)

Subcategory description

Informal waste incineration is defined as waste incineration undertaken at informal conditions, in barrels, containers, or on bare land, with no flue gas controls and diffuse spreading of incineration residues on land. Open burning of waste at landfills – often applied to reduce waste amounts - also belong to this subcategory. The mercury present in the waste, part of it will be released to air, and part of it will remain in incineration residues (including unburned and semi-degraded waste) with a potential for additional subsequent mercury releases to air, ground water and surface waters. Given the volatility of mercury, it is expected that most of the mercury is released into the air as a result of informal waste incineration. This waste disposal method may pose an immediate risk for the local community in which it takes place, because air emissions (of several potent pollutants) are not controlled and residues may cause contamination of the local ground water (UNEP, 2015).

Methodology applied to estimate releases from open fire waste burning

If open fire waste burning is a widespread waste disposal method in the country examined, the potential mercury releases can be indicated through 1) quantification of mercury inputs with individual products and, or 2) by applying the mercury input default factors (mercury concentrations in municipal waste), in combination with rough estimates of amounts of waste incinerated informally per year. The resulting estimates are of course very uncertain, but may give a rough indication of the order of magnitude of mercury releases from informal waste incineration (UNEP, 2015).

The approach chosen to estimate potential mercury releases from open-burning of general waste is to apply the mercury input default factors for IL2, in combination with rough estimates of amounts of waste incinerated informally per year.

The formula used for calculation of mercury emissions to different media is:

Estimated mercury release to pathway Y	=	**activity rate × input factor × output distribution factor for pathway Y**

Source: UNEP, 2015

Activity rate data

The activity rate data needed to estimate releases from open fire waste burning in the Republic of Moldova is the amount of waste burned informally per year.

The amount of waste burned informally per year has been estimated by using the equation suggested for calculation of the amount of municipal solid waste open-burned in the IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 5section 5.3.2 (2006).

The equation used is the following:

$$\mathbf{MSW_B = P * P_{frac} * MSW_P * B_{frac} * 365 * 10^{-3}}$$

Where:
MSW_B = Total amount of municipal solid waste open-burned, t/yr
P = population (capita)
P_{frac} = fraction of population burning waste, (fraction)
MSW_P = per capita waste generation, kg waste/capita/day
B_{frac} = fraction of the waste amount that is burned relative to the total amount of waste treated, (fraction)
365 = number of days by year
10^{-3} = conversion factor from kilogram to ton.

The data necessary for calculating the amount of waste open burnt is presented in the table below.

Table 2-5. The estimated quantity of municipal waste open burned

	2012	2013	2014	2015	2016
Urban per capita waste generation, kg waste/capita/day	0,9	0,9	0,9	0,9	0,9
Rural per capita waste generation, kg waste/capita/day	0,5	0,5	0,5	0,5	0,5
Population urban	1721,4	1728,2	1732,5	1726,1	1711,4
Population rural	2204,6	2195,5	2185,8	2158,7	2132,2
Population total	3926	3923,7	3918,4	3884,8	3843,6
MSW incinerated urban, kt	16,964	17,032	17,074	17,011	16,866
MSW incinerated rural, kt	32,187	32,054	31,913	31,517	31,13
MSW incinerated total, kt	49,152	49,086	48,987	48,528	47,996

According to the 2006 IPCC Guidelines, open burning includes regularly burning and sporadically burning. Regularly burning means that this is the only practice used to eliminate waste. Sporadically burning means that this practice is used in addition to other practices and therefore open burning is not the only practice used to eliminate waste. For countries that have well-functioning waste collection systems in place, it is good practice to investigate whether any fossil carbon is open-burned. In a developed country, P_{frac} can be assumed to be the rural population for a rough estimate. In a region where urban population exceeds 80 per cent of total population, one can assume no open burning of waste occurs. In a developing country, mainly in urban areas, P_{frac} can be roughly estimated as being the sum of population whose waste is not collected by collection structures and population whose waste is collected and disposed in open dumps that are burned.

The incineration of waste practice is predominantly characteristic to rural areas, both in households and on landfills in order to reduce the volume of solid waste disposed, mainly by burning organic waste (paper, cardboard, plastics and vegetable waste).
It is worth mentioning that specialized waste collection and disposal services exist in the municipalities of the country as well as in the district centres, but this system covers only about 60-80 per cent of the total urban population generating solid municipal waste. Therefore, the share of the population that does not benefit from waste collection services is about 10-30 per cent, or on average about 20 per cent. In the absence of official data on per capita waste generation, it was used the value of 0.5 kg/capita/day for rural population, respectively 0.9 kg/capita/day for the urban population of the Republic of Moldova.

It was considered that circa 20 per cent of the urban population that does not benefit from waste disposal services uses to burn in open-air the organogenic solid waste, while the fraction for solid waste burned (B_{frac}) from the total amount of treated waste in urban areas represents 0.15 (15 per cent of the total). In rural areas, it was considered that 40 per cent of the population uses to burn in openair the organogenic solid waste, and the B_{frac} represents 0.2 (20 per cent of the total).

Mercury input factor

UNEP recommends a input factor of 1 g Hg / tonne of waste where the significant amounts of waste with increased concentration of mercury (thermometers, batteries, dental amalgam wastes, switches etc.) selected from the waste that is generated to be treated separately and, therefore, are present in the municipal waste in smaller quantities, and a factor of 10 g Hg / t of waste where such a selection is not taking place and the much of the waste products with increased concentrations of mercury are present in municipal waste.

Possible mercury concentration in municipal solid waste disposed of in the Republic of Moldova can be inferred on the basis of available statistical data on imports of mercury containing products , such as fluorescent lamps, thermometers and batteries with mercury and appropriate input factors for each product category (see section on consumer products with intentional use of mercury). Estimated amount of mercury to be released in Moldova with mercury-added products in 2014 is shown in the Table 2-6 below. Using statistics on the total amount of waste transported to controlled landfills and the assumption that most mercury containing products are shipped along general waste to these landfills, the calculation is done based on the average concentration of mercury possible per tonne of waste from controlled landfills.

Table 26. Estimated amount of mercury to be released in Moldova with mercury-added products in 2014

Consumer products with intentional use of mercury	Estimated quantity of mercury at disposal stage in 2014, kg/year
Thermometers with mercury	195 kg
Electrical switches and relays with mercury	81 kg
Light sources with mercury	33 kg
Batteries containing mercury	21 kg
Polyurethane with mercury catalysts	65,5 kg
	Total: 395.5 kg/year

The table 2-6 below provides an estimate of the concentration of mercury in a tonne of general waste, considering that all imported products are discarded annually. Given the total incomings of mercury calculated for these products (395.5 kg Hg / year) compared to the total amount of municipal solid waste transported to controlled landfills in Moldova, including ATULBD (1.32568 million tons), it was estimated that 1 tonne of waste collected and transported to dumps containing less than 1 g of mercury (0.3 g / Hg). As the result given

calculations are based on estimates, the default factor concentration used for calculations in this report is 1 g Hg / tonne waste, as recommended by UNEP Toolkit.

Table 2-7 Estimation of the concentration of mercury in a tonne of municipal waste, considering that all imported products are removed annually

The total amount of municipal solid waste transported to landfills controlled in Moldova, including AUTLBD, 2014	1 325 680 tonnes
Estimation of total amount of mercury removed with mercury containing products for 2014	395.5 kg Hg
The average concentration of mercury calculated per ton of waste	395 500 g Hg/ 1 325 680 tonnes waste = 0.3 g Hg/tonne of waste

Output distribution factors

For the calculation of mercury emissions the default output distribution factors that are provided in the IL2 Excel calculation spreadsheet have been used.

Data gaps and priorities for potential follow up

No major data gaps were revealed within this category. The assumptions made with regard to the practice of informal waste burning for the population living on the left side of Dniestr River have been made based solely on the data available for the population from the right bank of Dniestr River.

Summary of inputs and results

Table 2-8 Summary of inputs and results from sub-category Informal burning of waste in the Republic of Moldova in 2014

Open burning of municipal waste	Unit	Produc-tion	Use	Disposal (open burning)				
				2012	2013	2014	2015	2016
Activity rate	t municipal waste/y	-	-	49152	49086	48987	48528	47996
Input factor for phase	g Hg/t municipal waste	-	-	1	1	1	1	1
Calculated input to phase	kg Hg/y	-	-	49,15	49,09	48,98	48,52	47,99
Output distribution factors for phase:	fraction		-					
- Air	-	-	-	1	1	1	1	1
- Water	-	-	-	-	-	-	-	-
- Land	-	-	-	-	-	-	-	-
- Products	-	-	-	-	-	-	-	-
- General waste treatment	-	-	-	-	-	-	-	-
- Sector specific waste treatment	-	-	-	-	-	-	-	-
Calculated outputs/releases to:			-	-	-	-	-	-
- Air	kg Hg/y	-	-	49,15	49,09	48,98	48,52	47,99
- Water	kg Hg/y	-	-	-	-	-	-	-
- Land	kg Hg/y	-	-	-	-	-	-	-
- Products	kg Hg/y	-	-	-	-	-	-	-
- General waste treatment	kg Hg/y	-	-	-	-	-	-	-
- Sector specific waste treatment	kg Hg/y	-	-	-	-	-	-	-

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2. Information submitted by Nigeria

Mercury emissions resulting from the open burning of waste.

The inventory of mercury emissions and releases using the UNEP Toolkit Inventory Level 2 (2017) shows that mercury emissions from informal waste burning is 10,900Kg Hg.

3. Information submitted by the United Nations Institute for Training and Research (UNITAR)

unitar
United Nations Institute for Training and Research

Mercury emissions from open burning of waste   Geneva, 29 June 2018

Dear colleagues at the Minamata Convention Secretariat,
As part of the follow up from the first meeting of the Conference of the Parties to the Minamata Convention, UNITAR would hereby like to contribute with our observations regarding emissions from open burning of waste in our work with the Minamata Initial Assessments in many countries, as well as our work with waste in developing the UN Environment Mercury Inventory Toolkit.

As conveyed in the plenary at COP1, UNITAR has observed in its inventory assistance to many countries that open burning of waste is among the major mercury emissions sources, especially in countries with no non-ferrous mining activities or coal-fired power plants.

As the open burning issue will likely, among others, be investigated through the results from the national mercury inventories conducted with the methodology of the UN Environment Toolkit, we would like to bring the following to your attention:

The Toolkit works with two different approaches to quantifying mercury flows to waste treatment. One that is based on the estimated output of mercury from products and processes (is often under-estimated due to lack of data in developing countries), and the other one which works with input factors for mercury concentrations in relevant waste types, including municipal waste. In the general mode of using the Toolkit, it is the latter approach that is used for estimation of mercury emissions from open waste burning.

The input factor of the latter approach for municipal waste was at the time of the creation of the Toolkit based solely on data from developed countries, as no data from developing countries were available at that time (2004). The factor was set at 1-10 g/t waste, with a conservatively set intermediate value of 5g/t, considering that on-going substitution of mercury-added products in developed countries would be ahead of the substitution in developing countries, where the cheaper mercury-added products were still not regulated and the mercury-free alternatives were generally not in demand, and where segregation of mercury-containing waste was not practiced.

UNITAR is currently conducting an update for UN Environment of the Toolkit, expected to be finalised by the end of 2018. Preliminary collection of data in spring 2018 on mercury concentrations in municipal waste in developing countries for this work, supported by data from UN Environment's work on open waste burning (Honda et al., 2018), and from the Global Mercury Assessment work (Kindbom et al., 2018), indicate that the average mercury concentrations in the developing countries from which data on this subject have been published (mainly China, and a bit on Thailand and India) may be in the low end of the Toolkit default input factor range, that is, around or even below 1g/t waste.

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While this work is still in progress, and additional data is needed from other parts of the developing world, it should be safe to say with some certainty that the mercury emission estimates from open waste burning based on the Toolkit may in some cases be overestimated. In some recent cases, where UNITAR has assisted countries' inventory efforts on The Toolkit's Inventory Level 2 (where estimation factors can be adjusted to local conditions), the input factors have been adjusted accordingly to 1 g/t waste).

Another massive uncertainty in this calculation is the amount of municipal waste burned nationally and globally. Nationally, authoritative data on this issue are not available, as open waste burning is mostly informal, and never registered in detail. Estimates have in some case been developed for waste management planning, for uPOP inventories (under the Stockholm Convention work), or for climate emissions inventories under the Kyoto Protocol.

To illustrate the order of magnitude of mercury emissions from open waste burning however, it may be useful to look at a global study on emission of trace gasses (etc.) from open waste burning conducted by Wiedinmeyr et al. (2014). The study applies available national or regional experience estimates on amounts of municipal waste produced per capita in combination with municipal waste collection rates, and a set of assumptions developed by the IPCC (2006) for greenhouse gas emission inventories. Thereby they reach an estimate for global amounts of municipal waste burned informally plus waste burned in controlled landfills (where fires can happen spontaneously from ignition of landfill gas, or be initiated on purpose to reduce waste amounts). Wiedinmeyr et al. (2014) combines this waste amount with an emission factor of 0.208 (+/-0.13) g Hg/t waste from one study in (Chen et al, 2013), and reach a resulting estimate for mercury emissions from open waste burning of 204Kg Hg/y.

It is worth noting the major uncertainties in the study by Wiedinmeyr et al. (2014):

- The estimates used for municipal waste generation are uncertain, and in many cases aged, indicating that they could potentially underestimate the waste amounts generated.
- The study applies an assumption (from the IPCC manual) that 100% of the waste in rural areas is burned informally and that 100% of the un-collected waste in urban areas is burned informally, and in addition to this comes burning of collected waste in landfills/dumps. While the fraction of uncollected waste being burned is no doubt high in many developing countries, this may likely be an overestimation.
- The emission factor used (from China, Chen et al, 2013) is in fact an emission factor from a modern technical waste incineration facility with air pollution control filters, and the relevance of the factor for open waste burning can thus be questioned.

Our (very) preliminary estimate of average mercury concentration in municipal waste in developing countries, where open burning is most prevalent, is in the range of 0.6-1.9 g Hg/t waste, where the low end is closer to current developed countries levels (to be further worked on). Now, currently no studies have been identified on what fraction of mercury is emitted to the atmosphere per tonne of waste burned openly. Mercury's boiling temperature is 356.7 degrees Celsius, and emissions will even start happing below that temperature (as the vapour pressure increased with increased temperature even below the boiling point). If it is assumed, as seems reasonable, that 356.7 degrees Celsius can easily be reached in open waste burning, it seems likely that most of the mercury may be emitted when municipal waste is burned openly. This is also the assumption in the Toolkit, where – for simplicity, given the lack of precise data – 100% of the mercury present is considered as emitted from open waste burning.

As a very preliminary conclusion, based on the considerations above, in combination with knowledge of the estimated mercury demand over the years, the total emission could very well be larger than

estimated by Wiedinmeyr et al. (and the draft GMA 2018), possibly in the range of some 200-600 Hg/y, including mercury from trace concentrations in other materials than mercury-added products (the estimate can be refined further based on existing data). Even ion case the actual emissions from open waste burning are be in the low end of this interval, the numbers underline that this is indeed a significant mercury emission source in the global perspective that is worth investigating in more detail with a view to inform considerations on including reduction of open waste burning in the Minamata Convention.

We hope that you may find the provided information of relevance, and we remain available, should the Secretariat wish to involve UNITAR in the further investigations of this issue.

With the best wishes,

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4. Information submitted by the International POPs Elimination Network (IPEN)

28/06/2018

a toxics-free future

IPEN combined submission to the Minamata Convention secretariat on;

- **mercury emissions resulting from the open burning of waste.**
- **capacity-building and technical assistance and technology transfer,**

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Mercury emissions from the open burning of waste.

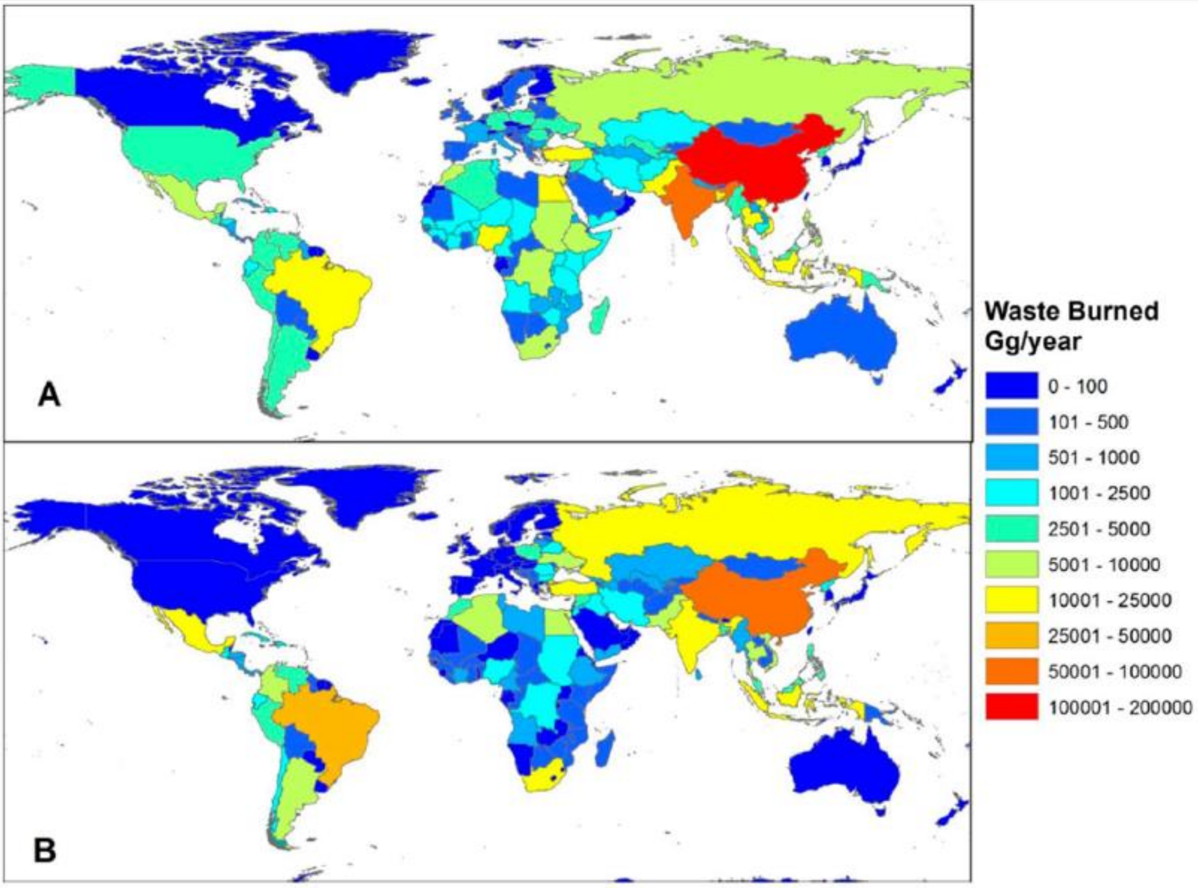
In many developing countries (and in some developed countries) the practice of open burning of waste is practiced for a range of reasons including;

- volume reduction in the absence of a waste management/collection system;
- sanitation in the absence of a waste management/collection system;
- recovery of valuable metals from some waste streams (such as e-waste);
- mixed waste is too contaminated to recycle
- spontaneous or deliberately lit landfill fires.

This submission comments on the potential for capacity building and technology transfer to dramatically reduce the prevalence of open burning and the mercury emissions that result from it. Technology and capacity building should be extended beyond a narrow mercury focus to establish programmes that establish basic waste collection and separation systems that have an emphasis on separating organic and hazardous waste (highlighting mercury waste streams) from the recyclable waste stream. Synergies with funding, capacity building and technology transfer mechanisms of other chemical conventions should be explored as open burning is also a significant contributor of UPOPs such as PCDD/DF (Wiedinmyer et al 2014) and could be addressed in joint waste management projects based around collection and source separation to allow for recycling and treatment of discreet waste streams. Without basic source separation and collection systems mercury waste will continue to be a major contributor to anthropogenic mercury emissions from open burning.

Mercury can be liberated as vapor phase and particulate bound emissions from open burning waste fires leading to air, soil and water contamination as well as human health impacts. Waste containing mercury such as e-waste, medical waste and consumer products (CFLs, cosmetics,

switches, thermometers) contribute to these emissions. It has been estimated that open burning of waste may contribute up to 10% of current anthropogenic emissions of mercury (Wiedinmyer et al 2014). A significant amount of open burning is situated in South Asia, south east Asia, Latin America and to a lesser extent, Africa (see fig 1). Open waste burning is also conducted in Pacific Islands.



l. Total estimated annual waste burned (Gg yr^{-1}) at the residential level (A) and at dumps (B).

Fig 1 Open burning estimates for residential and landfill mass. (source Wiedinmyer et al 2014)

A key response to open burning of waste which is leading to mercury emissions is the need to implement decentralised, economical waste management systems that maximise reuse and recycling of materials, separate hazardous materials for recycling or disposal and which directs organic wastes to value added processes while creating local employment opportunities.

Capacity building programmes for developing countries and countries with EIT to develop basic waste management systems based on collection and separation of material types is essential. Aid programmes often prioritise the construction of landfills and waste incinerators which sit at the bottom of the waste management hierarchy and are the least sustainable waste management and resource recovery options. They lead to ongoing groundwater contamination, UPOPs release and destruction of resources. Waste incineration is often proposed as a 'solution' to landfill and even as a better alternative to open burning as incineration allegedly takes place in 'controlled conditions'. However, the production of thousands of tonnes of toxic ash from

incinerators requires additional landfill so the landfill problem is not in any sense 'solved'. Mercury waste management experts also contend that waste incineration is not appropriate for mercury contaminated or containing wastes as the risk of release of mercury vapors is high (Merly and Hube, 2014).

Fortunately, mercury waste is amenable to recovery despite its hazardous nature. If capacity building programmes can be directed at development of locally relevant, basic waste collection and sorting systems then hazardous components of the waste stream such as mercury bearing waste can be separated for treatment and recovery of mercury using technology that is readily available in developed countries and which is a fraction of the expense of establishing landfills or incinerators.

These technologies include fluorescent lamp and other mercury bearing lighting recycling, continuous distillation processes for mercury contaminated soils, mining wastes and sludges from the petrochemical and gas industries. Distillation technologies are already employed in the oil and gas sector to remove mercury from produced gas to protect gas storage systems from corrosion.

Technology transfer and capacity building that addresses the whole of the waste system in developing countries is important. The waste sector should be seen through the lens of the emerging circular economy and sustainable development goals. Instead of perceiving waste as a problem to be buried or burned it should be an opportunity to build small sustainable businesses in impoverished communities, generate local scale clean energy and employment while protecting human health and the environment.

Attention should be given to non-combustion waste management alternatives in terms of technology transfer. Waste management policy in the EU is moving away from incineration of waste and subsidies are being withdrawn in recognition that incineration is not compatible with the circular economy. Developing countries should be given the opportunity to 'leap-frog' polluting incineration and burial technology in the waste management sector and adopt cutting edge techniques to manage their waste through the capacity building and technology transfer processes.

A key aspect of this sustainable waste management process is source separation of organics. Organic waste is the main contributor to anaerobic conditions in landfill, leaching metals under reductive conditions into the groundwater and releasing large volumes of methane- a potent GHG. Organic waste also poses problems for incineration due to its high moisture content requiring supplemental fuel application (usually gas or oil) to reduce moisture levels. This leads to further emissions. Far more productive is the separation of organic materials from the waste stream and their use in anaerobic digestion (AD) and/or composting. The development of biogas from AD can be utilised for energy generation without the release of UPOPs and ash, a major problem suffered by waste incineration. The AD systems can be scaled up from basic household models through to school, commercial and fully industrialised models. Biogas from AD can also

be used for cooking displacing more polluting cooking fuels. The final solid residue, digestate, is a valuable fertiliser for agricultural communities. There are clearly opportunities for technology transfer and capacity building programmes to address the waste systems of developing countries more holistically and the instruments of the Minamata Convention dedicated to these purposes (such as the Specific Trust Fund) could be applied. There is a clearly a need to use such mechanisms to address the uptake of AD in developing countries. Sub-Saharan Africa being a case in point where biogas could have enormous positive impacts but lacks seed funding and institutional understanding (Mwirigi et al 2014).

Once organics are removed from the waste stream other benefits are apparent. Organic wastes contaminate recycling in mixed waste systems. Their removal at the source separation stage increases the value of the recyclable component of the MSW stream which remains clean. Mixed waste and recyclables contaminated with organic materials has low value and is at higher risk of open burning. One sector of the recyclable components includes mercury impacts wastes.

A key source of mercury waste in municipal waste generation is compact fluorescent lighting (CFL) and associated fluorescent tubes. Once added to burning waste and broken the mercury phosphor powder escapes the glass lamp and can cause significant contamination and human exposure in vapor phase and as particulate.

Small-scale recycling facilities can be developed for CFL and tubes which contain the mercury-based powder, while separating glass, metal and plastic components for recycling. Many spent lamp recycling collection systems are being established at point of sale to allow customers to return burned out lamps intact. These collected lamps can then be consolidated and sent to regional recycling facilities.

Figure 2. Fluorescent lamp recycling unit

These semi-automated units can recycle between 1 and 10 million lamps per year, are fitted with carbon filters and claim to limit mercury emissions to 0.001-0.002 mg/m³. The outputs are separated mercury bearing phosphor power, glass cullet, and metal or plastic end caps.

Figure 3. CFL recycling unit fitted in Surabaya Indonesia 2013 and glass cullet from the process.

Locations that lack waste collection infrastructure may benefit from point of sale collection systems where clusters of recycling collection can take place for other hazardous and problematic wastes such as batteries and plastic. This helps to streamline the collection systems for the end recycling operation and is more convenient for the consumer resulting in higher collection rates.

Figure 4. Collection points for fluorescent lamps using mercury can also be combined with collection points for other problematic wastes such as batteries and plastics.

as they may require significant volumes to remain profitable. National governments can consider extended producer responsibility schemes to help fund the establishment of these recycling operations. Poor disposal of CFL and mercury tube lamps is widespread in developing countries (Ecowaste Coalition, 2018) as represents a sector where successful recycling could be implemented economically based on commercialised technology.

Medical, dental, commercial, mining, oil/gas and industrial mercury waste.

These sources of mercury waste may also be included in open burning practices where waste collection infrastructure is absent. Technologies to extract mercury from these wastes and preventing them from entering the environment are readily available. Capacity building and technology transfer could see the implementation of regional, national and state mercury recovery centres in developing countries to manage these sources of mercury pollution.

Dental amalgam separators fitted in dental clinics where mercury amalgam is used can play a role in reducing mercury in the waste stream. However, eliminating mercury from dental therapy is a far more efficient solution which is clinically and economically feasible on a global scale. Many countries no longer use dental amalgam and the alternatives are well established and cost effective. However, for those dental practices that persist in using mercury separators are a significant barrier to environmental releases assuming that the waste they collect is managed in an environmentally sound manner. Mercury waste from dental amalgam separators can be processed for mercury recovery in the same way as industrial mercury waste through distillation and recovery methods.

Figure 5. Dental amalgam waste separator

Continuous distillation processes from recovering mercury from commercial, mining, oil/gas and industrial mercury waste are well established. However, under the article 11 of the Minamata Convention recovered mercury can still be marketed as a commodity for uses allowed under the convention. For uses where the mass balance of mercury inputs and waste can be potentially be contained by recovery technologies (e.g. CFL recycling) this may not present a large problem. However, if mercury recovery technology becomes widespread in developing countries the supply of this form of mercury could dramatically increase global supply. This is especially true of the mining and gas sectors where large volumes of mercury can be recovered from production gas and tailings.

Continuous Flow Distiller

Figure 6. Continuous Flow Distillation plant for mercury extraction from waste

Careful thought need to be given to control mechanisms to restrict the supply of recovered mercury to the global market to prevent a proliferation of mercury supply. At the same time any restriction of sales of mercury by those operators of recovery systems may undermine the viability of their operation. It is clear that if mercury produced through recovery operations is to be 'retired' from the commodity market then consideration needs to be given to purchasing mercury for retirement from recovery operations. A key consideration will be who should pay for mercury to be retired? For the mining, petroleum and gas sector there are clearly opportunities to implement polluter pays systems. For products containing mercury, the costs of retirement could be directed to manufacturers who choose to use mercury in production and processes. In any event if the twin policy aspirations or mercury recovery and permanent mercury retirement are to be achieved, then this issue will need to be resolved.

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