SITUATION ANALYSIS OF MERCURY IN SOUTH AFRICA: DEVELOPMENT OF AN INVENTORY OF MERCURY USES AND SOURCES

PREPARED FOR THE

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by

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PART ONE

EXECUTIVE SUMMARY

Introduction

Mercury is a potent neurotoxin, bio-accumulative and persists in the environment. Therefore, it is extremely important to properly handle and dispose of mercury-containing products. Moreover, the responsible use and end-of-life management of mercury-containing products (i.e., recycling rather than landfilling) can actually help to reduce the overall amount of mercury entering the environment. The benefits of undertaking a situation analysis of mercury in South Africa, and the development of an inventory of mercury use, sources, availability of safer and effective and affordable alternatives where applicable in South Africa include:

- protecting the environment from releases of mercury and
- preparation for effective participation of the South African delegation in the Intergovernmental Negotiating Committee (INC IV) on mercury, and priority setting for the country.

OBJECTIVES

The objectives of this study were to:

- develop a situation analysis of mercury in South Africa;
- develop an inventory of mercury use and sources, mercury containing products, availability of safer, effective and affordable alternatives where applicable in South Africa;
- identify whether business and industry have undertaken voluntary programs to reduce mercury use and/or emissions in South Africa;
- identify and propose NGOs/research institutions in the country addressing/studying mercury related or chemical related environmental problems for continued monitoring of intentional mercury introduction into the environment;
- identify, if any, vulnerable populations that require awareness raising about the mercury issue to protect human health and the environment;
recommend a comprehensive information system for tracking/tracing/monitoring mercury;

➢ come up with recommendations on mitigation and decontamination and

In pursuance of these goals, the scientists available in AJUA Environmental Consultants CC, applied their expert knowledge on toxic metal analysis as well as the successful completion of Rotterdam Convention Prior Informed consent (PIC) final regulatory action on chemicals and pesticides currently banned and severely restricted in South Africa for DEA in 2008-2009, to achieve aforementioned goals. The study was approached using the following methods namely:

METHODS

INDICATIVE METHOD INCLUDE:

• desk research of existing information;
• focus group meetings;
• questionnaire surveys
• postal communication
• life cycle product identification (supply chain)
• Relevant stakeholder consultation
• telephone interviews
• email/Web based information sourcing
• face to face interviews
• statistical methods

➢ UNEP Toolkit level 1 (revised January 2011)

The mass balance principle, inputs and outputs

The mercury release calculations used in this Toolkit are based on the mass balance principle: All the mercury fed into the system (say, an industrial sector) with materials and fuels are expected to come out again, either as releases to the environment or in some kind of product stream. In other words: "Sum of inputs = sum of outputs".

Inputs: Therefore, the quantity of mercury inputs is obtained from the amount of mercury containing material fed into the system (called "activity rate") and general data on the mercury concentration in the feed material (called "input factor").

Outputs: The mercury releases from the system are calculated by distributing this mercury amount on the relevant release pathways based on available data on how the releases (or
"outputs") are generally distributed in this sector. For calculating this distribution, we use general "output distribution factors". On inventory Level 1, these calculations are automatic, and are based on default input factors and default output distribution factors, which are already entered in the electronic calculation spreadsheet [UNEP TOOLKIT, 2008].

The generalized formula used in the calculations is:

\[
\text{Estimate mercury released to pathway } X = \text{activity rate} \times \text{input factor} \times \text{output distribution factor for pathway } X
\]

RESULTS
A summary of the results obtained in the study is shown in the table below. As can be seen from the table, the following source categories contributed the major mercury inputs: energy consumption and fuel production, domestic production of metals and raw materials and waste handling and recycling. The individual mercury release sub-categories contributing with the highest mercury inputs were: coal combustion and other coal uses, primary metal production and other material production. Waste deposition also constitutes a significant flux of mercury, but the majority of the mercury in the waste stream originates from products and processes with intentional mercury use. The individual mercury release sub-categories with the highest mercury releases to the atmosphere were coal combustion and other coal uses, primary metal production (excluding gold production by amalgamation), other material production and waste deposition. Other contributors to the release of mercury into the environment include: disposal of dental amalgam and crematoria and cemeteries.
### SUMMARY OF MERCURY RELEASES FROM MAIN GROUP SOURCES

<table>
<thead>
<tr>
<th>Source category</th>
<th>Estimated Hg input, Kg Hg/y</th>
<th>Estimated Hg releases, standard estimates, kg Hg/y</th>
<th>By-products and impurities</th>
<th>General waste</th>
<th>Sector specific waste treatment/disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Air</td>
<td>Water</td>
<td>Land</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal combustion and other coal use</td>
<td>44,826.5</td>
<td>40,343.8</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Other fossil fuel and biomass combustion</td>
<td>343.1</td>
<td>343.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Oil and gas production</td>
<td>139.7</td>
<td>19.0</td>
<td>27.8</td>
<td>0.0</td>
<td>37.4</td>
</tr>
<tr>
<td>Primary metal production (excl. gold production by amalgamation)</td>
<td>2,197,727.9</td>
<td>91,955.4</td>
<td>43,664.3</td>
<td>1,964,804.2</td>
<td>92,148.6</td>
</tr>
<tr>
<td>Gold extraction with mercury amalgamation</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Other materials production</td>
<td>4,027.2</td>
<td>2,459.4</td>
<td>0.0</td>
<td>0.0</td>
<td>783.9</td>
</tr>
<tr>
<td>Chlor-alkali production with mercury-cells</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other production of chemicals and polymers</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Production of products with mercury content</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Use and disposal of dental amalgam fillings</td>
<td>7,588.0</td>
<td>151.8</td>
<td>2,519.2</td>
<td>0.0</td>
<td>273.2</td>
</tr>
<tr>
<td>Use and disposal of other products</td>
<td>14,388.8</td>
<td>1,117.6</td>
<td>2,045.2</td>
<td>708.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Production of recycled metals</td>
<td>41.8</td>
<td>13.8</td>
<td>0.0</td>
<td>14.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Waste incineration and open waste burning*1</td>
<td>0.7</td>
<td>0.6</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Waste deposition*1</td>
<td>100,000.0</td>
<td>1,000.0</td>
<td>10.0</td>
<td>0.0</td>
<td>-</td>
</tr>
<tr>
<td>Informal dumping of general waste <em>1</em>2</td>
<td>1,000.0</td>
<td>100.0</td>
<td>100.0</td>
<td>800.0</td>
<td>-</td>
</tr>
<tr>
<td>Waste water system/treatment *3</td>
<td>39.9</td>
<td>0.0</td>
<td>35.9</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Crematoria and cemeteries</td>
<td>1,561.5</td>
<td>93.7</td>
<td>0.0</td>
<td>1,467.8</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>2,371,685.1</strong></td>
<td><strong>137,598.2</strong></td>
<td><strong>48,402.4</strong></td>
<td><strong>1,967,794.2</strong></td>
<td><strong>93,243.1</strong></td>
</tr>
</tbody>
</table>

**CONCLUSION**

The aforementioned objectives have been achieved in this study by:

- Providing a situation analysis of mercury in South Africa;
- Developing an inventory of mercury use and sources, mercury containing products, in South Africa;
- Identifying NGOs/research institutions in the country addressing/studying mercury related or chemical related environmental problems for continued monitoring of
intentional mercury introduction into the environment. Those identified are contained in the reference section of this report;

• Identifying business and industry who have undertaken voluntary programs to reduce mercury use and/or emissions in South Africa. For example, during the cause of this study, it was found out that the dental practitioners have embarked on providing alternatives to the mercury amalgam for filling. Furthermore, there is a national campaign by the energy sectors on the use of low mercury containing compact fluorescent lamps (CFL) instead of the high mercury containing long fluorescent lamps.

• Women using skin lightening creams and soaps which may contain mercury have been identified as the vulnerable populations and they require awareness raising about the mercury issue to protect human health and the environment. Also people using mercury amalgam for dental fillings as well as those living within the vicinity of power generating plants and illegal gold miners have been identified as vulnerable.

• Recommend the need for tracking/tracing/monitoring mercury as well as some recommendations on mitigation and decontamination.

The present study has shown that energy consumption and waste disposal are the major contributors of mercury releases to the atmosphere and land so far in South Africa. However, information on other sources of mercury still need to be collected and added to the present results in order to give an overview of mercury releases within the South African environment. By examining the steps and strategies other countries are taking to reduce the releases of mercury into the environment, South Africa’s drive to undertake a situation analysis and develop inventories of monitoring mercury and coming up with recommendations and mitigation measures to control the releases of mercury into the South African environment will be achieved. However, the present study was not able to provide information on mercury releases from some source categories as contained in the UNEP toolkit level 1. This was attributed to either lack of available information or the non-cooperation of the identified users/consumers to give out information.
ACKNOWLEDGEMENTS

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Mr Rico Euripidou: Groundwork, Durban
Ms Joy Learner: Department of Environmental Affairs and Development Planning, Private Bag 9086, Cape Town 8000, South Africa;

Jakob Maag: COWI Consultancy, Denmark
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## ABBREVIATIONS

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<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMAP</td>
<td>The Arctic Monitoring and Assessment Programme;</td>
</tr>
<tr>
<td>EU</td>
<td>European Union;</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization;</td>
</tr>
<tr>
<td>FGD</td>
<td>Flue gas desulfurization; process of/equipment for primarily minimizing emissions of sulphur from combustion flue gases;</td>
</tr>
<tr>
<td>GEF</td>
<td>Global Environment Facility;</td>
</tr>
<tr>
<td>Hg</td>
<td>Mercury;</td>
</tr>
<tr>
<td>Hg₀</td>
<td>Elemental mercury;</td>
</tr>
<tr>
<td>Hg²⁺</td>
<td>Divalent mercury - the dominating mercury form in organic and inorganic mercury compounds. In the atmosphere, mercury species with divalent mercury are more easily washed out of the air with precipitation and deposited than elemental mercury;</td>
</tr>
<tr>
<td>Hgₚ</td>
<td>Particulate mercury - mercury bound in, or adsorbed on, particulate material. In the atmosphere, particulate mercury is deposited much faster than elemental mercury;</td>
</tr>
<tr>
<td>IARC</td>
<td>International Agency for Research on Cancer;</td>
</tr>
<tr>
<td>ILO</td>
<td>International Labor Organization;</td>
</tr>
<tr>
<td>IPCS</td>
<td>International Programme on Chemical Safety;</td>
</tr>
<tr>
<td>Kg</td>
<td>kilogram;</td>
</tr>
<tr>
<td>l or L</td>
<td>litre;</td>
</tr>
<tr>
<td>LC₅₀</td>
<td>Lethal concentration, 50%; concentration of toxic substance in a medium (for example water) at which 50% of the individuals in the toxicity test sample die; a unit used to describe the level of toxicity of a substance to a specific species, for example fish;</td>
</tr>
<tr>
<td>LD₅₀</td>
<td>Lethal dose, 50%; dose (intake) of a toxic substance at which 50% of the individuals in the toxicity test sample die; a unit used to describe the level of toxicity of a substance to a specific species, for example in laboratory tests on mice, birds or other animals;</td>
</tr>
<tr>
<td>Life-time</td>
<td>In atmospheric physio-chemistry: Time during which the first order processes (or totality of the first order processes) of scavenging results in mercury species mass reduction in e times in a geophysical reservoir; for a reservoir with homogeneous mercury species distribution the life-time is equal to the ratio of the mass contained in the reservoir to scavenging rate. Since the mass of mercury in the reservoir left to be reacted or removed decreases over time, the amount reacted or removed per unit of time decreases in a natural logarithmic fashion. For example, a lifetime of mercury of one year, does not mean that it would all be gone in one year if emissions were zero. It means that the rate of removal at the start of the time period in terms of mass per</td>
</tr>
</tbody>
</table>
unit time would remove it all in one year, but since the rate of removal decreases as the mass of mercury left decreased, the amount of mercury left after one year would be \((1/e)\) times the initial mass, where \(e\) is 2.71828183 defined to 8 decimals. In descriptions of life-cycles of products: The time span from when the product is put into use (usually time of purchase) until it is no longer used or discarded;

**Load**  
The intensity of input of pollutants to a given ecosystem from the environment; atmospheric load - the intensity of input from the atmosphere;

**LOEL:**  
Lowest observed effect level (also called **LOAEL** – lowest observed adverse effect level); for toxic or other effects imposed on organisms or experienced by humans;

**LRTAP Convention:** Convention on Long-Range Transboundary Air Pollution;

**M:**  
meter;

**MethylHg or MeHg:** methylmercury;

**metric ton:**  
1000 kg;

**mg:**  
Milligram \((10^{-3} \text{ gram})\);

**MSC-E:**  
Meteorological Synthesizing Centre – East (associated with the LRTAP Convention);

**MSW:**  
Municipal solid waste;

**MW:**  
Megawatt;

**MWC:**  
Municipal waste combustor;

**MWh:**  
Megawatt-hour;

**Natural emission:**  
Mercury input to the atmosphere, which is not connected with current or previous human activity;

**NEMA:**  
National Electrical Manufacturers Association (in the USA)

**Ng:**  
Nanogram \((10^{-9} \text{ gram})\);

**NGO:**  
Non-governmental organization;

**NRC:**  
National Research Council of the United States of America;

**OECD:**  
Organization for Economic Cooperation and Development;

**Pg:**  
Picogram \((10^{-12} \text{ gram})\);

**PM:**  
Particulate matter

**POPs:**  
Persistent Organic Pollutants;

**Ppb:**  
Parts per billion;

**Ppm:**  
parts per million;

**PS:**  
Particle scrubber; equipment designed to reduce emissions of particles from combustion flue gases

**Re-emission:**  
Secondary input of mercury to the atmosphere from geochemical reservoirs (soil, sea water, fresh water bodies) where mercury has
been accumulating as a result of previous and current human activity;

**RfD:** Reference dose; term used in evaluation of risk of toxic effects various chemicals (such as methylmercury) on humans; the RfD is defined by US EPA as an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

**SCR:** Selective catalytic reduction; equipment designed to reduce emissions of certain pollutants from combustion flue gases;

**SDA:** Spray dryer adsorber system; equipment designed to reduce emissions of certain pollutants from combustion flue gases;

**Slag:** Waste material produced when coal is dug from the earth, or a substance produced by mixing chemicals with metal that has been heated until it is liquid in order to remove unwanted substances from it.

**SNCR:** Selective non-catalytic reduction; equipment designed to reduce emissions of certain pollutants from combustion flue gases;

**TLV:** Threshold limit value;

**TWA:** Time weighted average;

**UN:** United Nations;

**UNCED:** United Nations Conference on Environment and Development;

**UNEP:** United Nations Environment Programme;

**US EPA:** Environmental Protection Agency of the United States of America;

**USA:** United States of America;

**Wet deposition** - Flux of substance from the atmosphere onto the underlying surface with atmospheric precipitation;

**WHO** World Health Organization;