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Draft annotated outline of the study report on mercury from non-ferrous metals mining and smelting for consideration by the Global Mercury Partnership Advisory Group at its eleventh meeting

Note by the secretariat

1. At its tenth meeting held in Geneva on 23 November 2019, the UNEP Global Mercury Partnership Advisory Group (PAG) decided to initiate work on the issue of mercury from non-ferrous metals mining and smelting, identified as a cross-cutting topic amongst different Partnership Areas[1]. The PAG requested the Secretariat of the Partnership to convene targeted discussions with interested Partnership Area leads, partners as well as other relevant stakeholders, to identify the needs and challenges, the information currently available as well as the possible aspects where the Partnership may have a useful contribution and move the issue forward.

2. In response to this request, expert consultations were launched through an online meeting held on 29 April 2020[2], with the overall objective to identify potential useful contributions from the Partnership, within the context of its mission and its existing areas of work. Participants were invited to attend in their expert capacity, to share views and ideas, and any useful background information.

3. Interested Partnership Area leads subsequently agreed to guide a process for developing a study report on the topic. As per their guidance, the report should be concise, i.e. not exceed 40 to 50 pages, benefit from global experience, and aim to better understand the mercury mass balance globally between supply, storage, and waste treatment related to non-ferrous metals mining and smelting operations. The guidance further provided that the report could include:

[1] The report of the tenth meeting of the Partnership Advisory Group (document UNEP/ Hg/PAG.10/5) is available at: https://web.unep.org/globalmercurypartnership/partnership-advisory-group-meeting-10

[2] Further information, including summary of main discussion points, may be found at: https://web.unep.org/globalmercurypartnership/expert-consultations-"mercury-non-ferrous-metals-mining-and-smelting"

- a review of existing knowledge and information gaps concerning mercury volumes from different stages of the processes,

- a showcase of the different methods currently in use for reducing mercury releases and disposing mercury at different key stages of the processes, highlighting best practices (including methods of detection and monitoring of mercury releases along the processes);

- potential ideas for further research and cooperation, including opportunities for capacity development.

4. A draft annotated outline of the study report on mercury from non-ferrous metals mining and smelting is annexed to the present note for consideration and further discussion by the PAG at its eleventh meeting. Together with the information collected, the finalized annotated outline will be used as a basis to develop the study report during the first half of 2021.

When considering the draft annotated outline, the PAG may wish to provide feedback on the proposed flow of the report, its chapters and sections; consider the suitability of the identified dimensions and topics as per the guidance received by the Partnership Area leads; highlight topics meriting further elaboration; and propose key references to be used and cited in drafting the document. The PAG may also wish to discuss next steps, including further consultations with relevant stakeholders and dissemination of the reports.

Annex

Draft annotated outline of the study report on mercury from non-ferrous metals mining and smelting for consideration by the Global Mercury Partnership Advisory Group at its eleventh meeting

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

2. INTRODUCTION

A. Mercury in the Environment – the need for action

Mercury is an environmentally extremely harmful pollutant, due to its toxicity, long range mobility, and persistence. Mercury emissions can not only cause localized harm, to which children and pregnant women are especially vulnerable, through air borne emissions or soil and water contamination, but also travel long distances that can reach around the globe.

Hence, mercury is a major global, regional and national challenge in terms of threats to human health and the environment.

Between 2010 and 2013, the international community developed the Minamata Convention on mercury, an internationally legally binding instrument aiming at reducing anthropogenic emissions of mercury to the environment. The Minamata Convention addresses issues of mercury supply, uses and emissions, providing the framework for countries to take coordinated actions to reduce the concentration of this toxic metal in the environment. The benefits of reducing exposure to mercury are large. A significant pathway for exposure is through the ingestion of seafood, and as seafood provides 2.5 billion people with at least 20% of their animal protein this can have major impacts on the global burden of disease. In small island states and coastal regions this amount can increase to 50% (UNEP 2013). A US study estimated cumulative lifetime benefits from measures to be implemented through the Minamata Convention for individuals affected by 2050 at $339 billion (Giang and Selin 2016).

In 2005, the UNEP Governing Council also initiated the formation of the Global Mercury Partnership (GMP). The GMP consists of stakeholders from governments, industry, intergovernmental, non-governmental organizations, and academia who are dedicated to reducing mercury pollution and protecting human health and the environment from the impacts of mercury. The Partnership plays an important role in catalyzing global action on mercury and offering information, capacity-building, and awareness-raising in support of implementation of the Minamata Convention.

The Partnership has eight identified priorities for action - or partnership areas - that are reflective of the major source of mercury releases categories. However although the non-ferrous sector is estimated to be a major contributor to mercury emissions and releases, there is no Partnership area devoted to this major source.

Recognizing the sector was estimated to be a major source of mercury emissions and releases, the UNEP Global Mercury Partnership Advisory Group (PAG) decided at its tenth meeting (Geneva, 23 November 2019) to initiate work in relation to mercury from non-ferrous metals

mining and smelting, which it had identified as a cross-cutting topic amongst different Partnership areas [3] and requested the Secretariat of the Partnership to convene targeted discussions with interested area leads, partners as well as other relevant stakeholders.

In response to this request, expert consultations were launched on 29 April 2020, with the overall objective to identify potential useful contributions from the Partnership, within the context of its mission and its existing areas of work.[4].

Interested Partnership Area leads subsequently agreed to guide a process for developing a concise report on "Mercury from non-ferrous metals mining and smelting", which would be discussed at PAG-11.

This annotated outline presents the proposed structure and content of such a study report on "Mercury from non-ferrous metals mining and smelting" which will be developed during the first half of 2021. This outline was developed with the intention to present the conceptual framework of the report, which will bring together information gathered from a body of literature review, including resources shared during the launch of the consultations. By presenting the currently available information, the report will seek to identify the different aspects, challenges and gaps of this area of interest to usefully contribute to moving the issue forward.

In some cases the outline includes substantial text but in others the headings only are given and these will be developed more extensively in the full report. Together with the information collected, the finalized annotated outline will be used as a basis to develop the first draft of the study report.

B. Mercury from the industrial sources and the Minamata Convention

Article 8 of the Convention addresses emissions of mercury and mercury compounds to the atmosphere through control measures from the point sources falling within the source categories listed in Annex D to the Convention. These sources are:

- Coal-fired power plants
- Coal-fired industrial boilers
- Smelting and roasting processes used in the production of non-ferrous metals (where non-ferrous metals refers to lead, zinc, copper and industrial gold)
- Waste incineration facilities
- Cement clinker production facilities.

[3] Report of the tenth meeting of the Global Mercury Partnership available at: https://wedocs.unep.org/bitstream/handle/20.500.11822/31824/GMP_PAG10-report.pdf?sequence=1&isAllowed=y

[4] Summary points of the expert consultations available at: https://web.unep.org/globalmercurypartnership/expert-consultations-"mercury-non-ferrous-metals-mining-and-smelting"

In these activities, mercury is emitted because it is a naturally occuring impurity in fuels and raw materials. Mercury emissions of this type are sometimes referred to as unintentional emissions or releases. Taken together these sources make a very substantial contribution to total emissions of mercury to the atmosphere; the most recent 2018 UNEP Global Mercury Assessment (GMA) (UNEP 2019) estimates that the total emissions from these industrial sources amount to 55% of all emissions. Hence reduction of emissions from these sources is essential to meet the overall objectives of the Convention.

Article 8 of the convention stipulates measures to be undertaken by parties to control and, where feasible, reduce emissions of mercury and mercury compounds. In addition, it suggests separate approaches for new and existing sources. For new sources these measures require the use of best available techniques and best environmental practices (BAT/BEP). For existing sources parties are required to develop a national plan and shall implement one or more of the following measures: a quantified goal; emission limit values; BAT/BEP; a multi-pollutant strategy capable of producing co-benefits for control of mercury emissions; and, alternative measures.

A BAT/BEP guidance was developed by a technical experts group and adopted by the first meeting of the Conference of the Parties to the Minamata Convention to support Parties in meeting the requirements of Article 8 . Details of the guidance for the non-ferrous sector can be found under section 6 of this document.

C. Mercury emissions and releases from the non-ferrous sector
   i. Smelting and roasting processes used in the production of non-ferrous metals (lead, zinc, copper and industrial gold)

In spite of the significance of the non-ferrous sector as a source of mercury emissions and releases it has received less attention, in the context of the Global Mercury Partnership, than other major sources, and this report aims to identify existing knowledge and knowledge gaps.

Mercury exists as a trace element in nearly all metallurgical raw materials and hence thermal processing and other smelting operations have the potential to release mercury to the atmosphere. The main aim of the smelting and roasting processes is to convert metals from their native state in ores to pure metals and hence smelting and roasting are forms of extractive metallurgy. Metals commonly exist in nature as oxides, sulfides, or carbonates and the smelting process requires a chemical reaction in the presence of a reducing agent to liberate the metal.

The 2013 UNEP Global Mercury Assessment (AMAP/UNEP 2013) presents an emissions inventory for 2010, based on a 2005 inventory which was presented in the 2008 GMA (AMAP/UNEP 2008). Data in both these inventories illustrate that metal production in general, and non-ferrous metal production in particular, is a large anthropogenic source of mercury emissions and estimated to account for around 10 per cent of global emission. It is recognized that this estimate is subject to considerable uncertainty, and that site-specific data is required to manage mercury at the local plant level.

More recently non-ferrous metals mining and smelting was estimated by the UNEP Global Mercury Assessment 2018 (AMAP/UNEP 2019) (https://web.unep.org/globalmercurypartnership/global-mercury-assessment-2018) to be the third largest source of mercury emissions to air, and the largest source of mercury releases to water after artisanal and small-scale gold mining. With respect to emissions of mercury, the assessment estimated that 326 tonnes of mercury originated from the production of non-ferrous metals (aluminum, copper, large scale gold, lead, and zinc), representing about 15% of total emissions. Total mercury emissions were estimated at 140 tonnes for zinc, 84.5 tonnes for large scale gold, 50 tonnes for copper and 30 tonnes for lead. The report noted that with an estimated 240 tonnes per year, the sector was responsible for roughly 40% of total releases to water. The report noted however that estimates from non-ferrous metals production had relatively large uncertainties.

ii. Future growth in the non-ferrous sector

The non-ferrous sector is likely to grow considerably over the next 30 years. In a study (Elshkaki *et al.* 2018) of resource demand scenarios for the major metals, several scenarios of future metal demand were calculated from 2010 to 2050 under alternative patterns of global development. The calculated demand for each metal doubles or triples relative to 2010 levels by mid-century. Hence, if these projections come to pass, without mitigation measures in place, this sector could make increasing contributions to global mercury emissions and releases.

There is also a recognition ((World Economic Forum ; World Economic Forum 2014; World Economic Forum 2015) that the production of metals requires a long term commitment to increased recycling and reuse while ensuring energy efficient and environmentally friendly production. In mining dependent countries there may also be a need to adjust economies to ensure adding a significant share of downstream value to their mining and metals sectors (World Economic Forum 2015). Such adjustments would represent significant change: for example, in Peru mineral production represents a value of 16% of GDP, and contributes 63% to exports; in Zambia the corresponding figures are 43% and 84%. Should no emissions' management measures be in place, these and other countries have the potential to make significant and growing contributions to mercury emissions from the non-ferrous sector.

Also see recent Chinese estimates for future emissions (presentation by Wang to Minamata online, November 2020: http://www.mercuryconvention.org/Portals/11/documents/Presentations/Nov5_Shuxiao_Wang.pdf)

iii. Mercury releases from by-product and waste mining materials

The UNEP Global Mercury Assessment 2018 reported no quantitative data was available for releases to land as well as for non-ferrous metals other than aluminum, copper, lead, industrial gold, mercury and zinc. This issue is currently under discussion in the Minamata Convention Experts Group on releases.

By-product mercury recovery from non-ferrous mining operations is also assumed to be an important source of global mercury supply, estimated at about 15% in the UNEP Global Mercury Supply, Trade and Demand report 2017[5].

A recent Minamata Online event focused on this issue with a presentation from the International Council on Mining and Metals outlining the sources of mercury wastes from the mining and metals sector along with the downwards trends in terms of mercury supply observed on the ground.

15Oct_Melissa_Barbanell.pdf (mercuryconvention.org)

3. EXISTING ACTIVITIES RELATED TO MERCURY IN THE NON-FERROUS SECTOR

A. National and regional regulations and guidelines
B. International Agreements, Partnerships and Guidance

i. Convention on Long-Range Transboundary Air Pollution

ii. UNEP Global Mercury Partnership

The Partnership has eight identified priorities for action - or partnership areas - that are reflective of the major source of mercury releases categories[6]. As noted above none is currently devoted to the non-ferrous sector. However, the work on waste management, mercury air transport and fate research and mercury supply and storage do provide guidance to address some of the elements related to mining and metal production that are common with other sectors of industry.

iii. Minamata Convention on Mercury

Adopted in 2013, the Minamata Convention on mercury is an internationally legally binding instrument aiming at protecting human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds. The Minamata Convention contains provisions that relate to the entire life cycle of mercury and addresses issues of mercury supply, trade, uses, emissions, releases, storage and disposal, providing the framework for countries to take coordinated actions to reduce the concentration of this toxic metal in the environment. Articles 3 (mercury supply sources and trade), 8 (emissions), 9 (releases), 11 (mercury wastes), and 12 (contaminated sites) are all of potential relevance to the non-ferrous sector.

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[5] https://www.unenvironment.org/resources/report/global-mercury-supply-trade-and-demand
[6] Areas are: artisanal and small scale gold mining (ASGM), mercury releases from coal combustion, mercury cell chlor-alkali production, mercury in products, mercury air transport and fate research, mercury waste management, mercury supply and storage, mercury releases from the cement industry

1. Minamata Article 8 Guidance

At its first meeting, the Conference of the Parties to the Convention adopted guidance called for under article 8 on emissions, including:

- guidance on best available techniques and best environmental practices,
- guidance on criteria that parties might develop pursuant to paragraph 2 (b) of article 8,
- guidance on preparing inventories of emissions, and
- guidance on support for parties in implementing the measures set out in paragraph 5 of article 8, in particular in determining goals and in setting emissions limit values.

The guidance will function as a crucial source of information, criteria and support as parties to the Convention develop responses to the requirements to reduce and where possible eliminate mercury emissions from the sources included in Annex D, and specific details of the guidance are listed below in Section 6.A. This guidance includes a section dedicated to addressing sound management measures for smelting and roasting processes for industrial gold, lead, zinc and copper. Amongst other things, it also provides recommendations in terms of the production of sulphuric acid that takes place as part of the exhaust gas cleaning process at most metals production sites.

C. Industry Sector activities

i. The International Council on Mining & Metals (ICCM)

Members of the International Council on Mining & Metals (ICCM), which brings together 27 mining and metals companies and over 30 regional and commodities associations, have taken a number of commitments related to mercury, including to:

- not open any mines designed to produce mercury as the primary product.
- Apply materials stewardship to promote the responsible management of the mercury produced from ICMM members' operations including that which naturally occurs in our products.
- Identify and quantify point source mercury air emissions from their operations and minimise them through the application of cost effective best available technology, using a risk based approach.
- Report significant point source mercury air emissions from our operations consistent with our commitment to report in accordance with the GRI framework.
- Participate in government-led partnerships to transfer low- to no-mercury technologies into the ASM sector in locations where ICMM member companies have operations in close proximity to ASM activity such that livelihoods are enhanced through increased productivity and reduced impacts to human health.
- Through ICMM, encourage the development of sound science on the fate and transport of mercury as well as natural sources of mercury in the environment.
- Work on an integrated multi-stakeholder strategy through ICMM to reduce and eventually cease supplying mercury into the global market once policy and economically viable long-term technological solutions for the retirement of mercury are developed.

As part of its efforts to support the development and implementation of the Convention, ICMM has been actively engaged in the INC and COP process, participated as an observer in the experts groups on air emissions, and is currently involved in the experts groups on waste and releases. In addition, ICMM has presented as part of the Minamata Online programme, provided comments to the contaminated sites guidelines, the interim storage guidelines developed in the context of the Minamata Convention and the Basel Convention technical guidelines on mercury waste management.

D. NGOs

4. LIFE CYCLE OF MERCURY IN NON-FERROUS METALS MINING AND SMELTING

Including information on mercury volumes in different stages of the processes.

5. MERCURY EMISSION AND RELEASES ESTIMATES FROM THE NON FERROUS SECTOR – EXISTING KNOWLEDGE AND KNOWLEDGE GAPS

A. Mercury Release Mechanisms and Speciation

Brief description of current understanding of mercury release from ores during smelting and mercury speciation. Speciation is important for determining mercury fate.

B. Global Mercury Assessments

C. UNEP Mercury Inventory Toolkit

D. EU BREF

E. Mercury concentrations in ores and concentrates – data sources and quality

Organisations may have data here that is not widely known: eg mining companies and industry bodies; US Geological Survey (https://www.researchgate.net/publication/225798176_Mercury_from_mineral_deposits_and_potential_environmental_impact).

Geographical variations will be addressed in this section.

F. Mercury concentrations in by product and waste materials – data sources and quality

G. Location of mercury emissions

Ores are commonly converted to concentrates before smelting or roasting. The smelting or roasting may take place on the same site or the concentrates may be transported to other

places (including in other countries). This is a potential knowledge gap in the location of mercury emissions.

6. CONTROL OF MERCURY EMISSIONS AND RELEASES

Extensive work has been undertaken as part of the intersessional process supporting the implementation of the Minamata Convention to identify the best practices available in the management of metal production. Many of the practices are common with other sectors of industry and the equipment used to control emissions should be readily available in many countries.

A. BAT/BEP guidance
   i. INTRODUCTION
   ii. PROCESS DESCRIPTIONS
      1. Lead
      2. Zinc
      3. Copper
      4. Industrial Gold
   iii. Emission Control Techniques
      1. Boliden Norzink Process
      2. Selenium Filter
      3. Activated Carbon
      4. DOWA filter process
      5. Jerritt process
      6. Co-benefits of air pollution abatement technologies
      7. Acid plants in mercury control
      8. Sulphuric acid
   iv. Process changes to eliminate smelting and emissions from that source
   v. BAT/BEP
   vi. Monitoring

B. Smelter/ roasting waste management

BAT/BEP guidance discusses this briefly but there are two recent studies from China which provide detailed information (Tsinghua University 2019; Zhang *et al.* 2019)

C. Case studies prepared for BAT/BEP guidance

See Attachment. The case studies illustrate various issues mostly concerning smelting/ roasting emissions, but also waste handling and acid plants. At this stage only the titles and locations of the case studies are included but the full report will include significant detail.

7. IDENTIFIED NEEDS FOR FURTHER RESEARCH AND COOPERATION

The comments raised during the launch of the expert consultations meeting held in April 2020 have been summarized below:

- A large number of countries are concerned about the fate of mercury and other impurities released during the mining and smelting of copper, lead and zinc, which belong to the top 5 largest internationally traded commodities;
- The need for further dissemination of information and awareness-raising on existing best practices and case studies on the issue of mercury in the sector, mercury removal systems, including from off-gas cleaning systems in smelters, risks mitigation measures as well as options for environmentally sound interim storage and disposal of mercury (Section 6.B addresses this to some extent – further information is also provided in the BAT/BEP guidance mentioned above);
- Further information gathering on certain topics, including:
    - the quantities of waste generated from non-ferrous metals mining and smelting; including the amount of mercury found in the sulphuric acid produced as part of the exhaust gas cleaning process;
    - standards for the levels of mercury in sulphuric acid established at national levels;
    - the magnitude and latest trends regarding the sector as a source of mercury supply
    - the importance of mercury from non-ferrous metals other than lead, zinc, copper;
    - the impact of deep-sea mining on mercury releases;
    - mercury mass balance for smelting plants (See case studies in Section 6.B for some information on this);
    - Enhanced information on the mercury content in ores feeding the smelting process, which would support the selection of appropriate mercury management options onsite as well as refining emission and release factors; (See Section 5 and Section 6.A.ii. Process descriptions for references to blending practices that provide information on means to ensure that the mercury content in ores can be managed through well established manufacturing practices)
    - A traceability mechanism on the transboundary movement of ores and concentrates that could assess the volumes of mercury present in these materials as well as an overview of the different limit values established by countries around the world (See Section 5)
    - Speciation of mercury (ie proportion of elemental, oxidized and particulate Hg) in non-ferrous emissions and releases. This is important information for fate and transport of these mercury sources
- Gaps identified in the 2018 GMA:

Gaps/needs to improve factors and profiles: (1) Information on the Hg and metal content of concentrates processed in different countries, including details of co-production of non-ferrous metals. (2) Information base for assumptions regarding technology profiles, especially detailed information on the amount of production in different countries that is associated with facilities with integrated acid plants as opposed to artisanal production or production at larger facilities with no integrated acid plant.

8. EXISTING RELEVANT WORK AND GUIDANCE ON BEST PRACTICES

Amongst others, participants have shared information with respect to the following:

A. Available guidance, tools and resource:

- The guidance document on Best Available Techniques and Best Environmental Practices adopted under the Minamata Convention[7], which addresses the control options for mercury from smelting and roasting processes used in the production of non-ferrous metals (lead, zinc, copper and industrial gold);
- The Basel Convention technical guidelines for the environmentally sound management of wastes consisting of elemental mercury and wastes containing or contaminated with mercury[8], which is currently being updated;
- The Minamata Convention guidelines on the environmentally sound interim storage of mercury other than waste mercury[9];
- The "Catalogue of Technologies and Services on Mercury Waste Management - 2020 version" compiled by the leads of the Partnership area on mercury waste management, which highlights services provided by some partners of relevance to the sector[10].

B. Ongoing relevant work

- Intersessional work called for by the Conference of the Parties to the Minamata Convention in relation to mercury releases and mercury waste, which includes consideration of certain aspects of mercury from non-ferrous metals mining and smelting
- The development of a study for the German Environment Agency with mass balances for the national copper, lead, zinc (primary and secondary) industries, among others, which is expected to be published during the summer 2020;
- A compilation of information on mercury removal systems from off gas cleaning systems in smelters: http://www.sulphuricacid.com/techmanual/GasCleaning/gcl_hg.htm

[7] http://mercuryconvention.org/Portals/11/documents/publications/BAT_BEP_E_interractif.pdf
[8] http://www.basel.int/Implementation/MercuryWastes/TechnicalGuidelines/tabid/5159/Default.aspx
[9] http://mercuryconvention.org/Portals/11/documents/formsguidance/English/2_5_e_Rev1_storage.pdf
[10] https://web.unep.org/globalmercurypartnership/catalogue-technologies-and-services-mercury-waste-management-2020-version

9. ATTACHMENT: CASE STUDIES

A. Case Study – Zinc/Lead Smelter and Refinery

B. Case Study on Mercury Controls for a Gold Ore Roasting Facility
Facility Name: Barrick Goldstrike Roaster
Facility Location: 26 miles Northeast of Carlin, NV

C. Case study: mercury scrubbing during zinc smelting in ISF furnace
Facility Name: Hachinohe Smelting, ISP plant
Facility Location: 80 km East of Hirosaki, Japan

D. Case study Zinc/lead/copper production at Boliden Rönnskär (Sweden)

E. Mercury Air Emission Sources and Controls - PT. Smelting - Gresik Smelter & Refinery

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