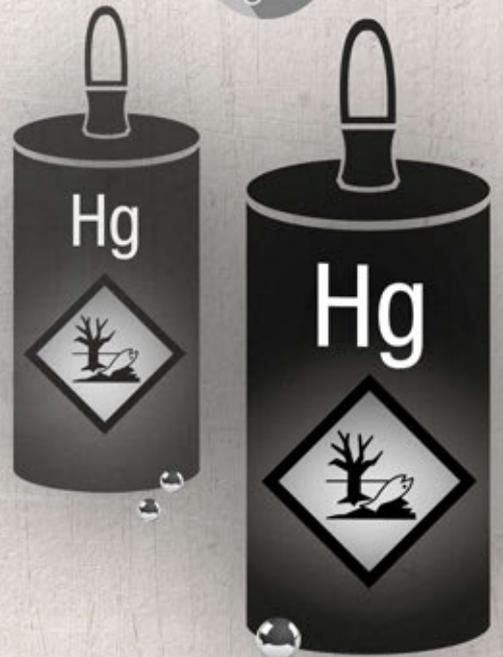




PRACTICAL SOURCEBOOK ON MERCURY WASTE STORAGE AND DISPOSAL



Editorial team and overall supervision:

David Piper, Jacob Duer, Eisaku Toda, Desiree Narvaez (Chemicals and Waste Branch, Division of Technology, Industry and Economics, United Nations Environment Programme); Jean-Paul Leglise, Jiao Tang, Jost Dittkrist (International Solid Waste Association); Otto Simonett (Zoï Environment Network); Stephen Hoffman

Cover artwork and layout:

Carolyne Daniel (Zoï Environment Network)

Valuable contributions to this paper were received from (in alphabetical order):

Paul Abernathy, John Adefemi Adegbite, Takafumi Anan, Rodges Ankrah, Natsumi Oka Antweiler, Marianne Baley, Sonja Bauer, Aris Begemann, Michael Bender, Ludovic Bernaudat, Paul de Bruycker, Jorge G. Conte Burrell, Alberto Santos Capra, Surya Chandak, Pam Clark, Victor Andres Escobar, Michael Franck, Uwe Gebert, Ana García González, Sven Hagemann, Karel Haubourdin, Grace Halla, Charles Harder, Dadan Wardhana Hasanuddin, Gregory Helms, Andrew Helps, William H. Hermes, Lars Olof Höglund, Shunichi Honda, Shariar Hossain, Nicolas Humez, Yutaka Ichihashi, Hiroki Iwase, Paul Kalb, Mahmood A Khwaja, Susanne Kummel, Stephanie Laruelle, Teddy Lee, David Lennett, Sheila Logan, Félix A. López, Shigeru Matsubara, Mushtaq Memon, Vilma Morales, Naoko Moritani, Ndèye Fatou Ndiaye, Emmanuel Odjam, Dieter Offenthaler, Kaoru Oka, Oladele Osibanjo, Manuel Ramos Pino, Jim Quinn, Long Rlthirak, Christoph Rittersberger, Mitsugu Saito, Geri-Geronimo R. Sanez, Eduardo Sebben, Ibrahim Shafii, Franz Xaver Spachtholz, Zdravko Špirić, Christian Stiels, Jerome Stucki, Yangzhao Sun, Masaru Tanaka, Yasuaki Tanaka, Usman Tariq, Samuel Tetsopgang, Lynn Vendinello, Dolf van Wijk, Eirik Wormstrand, Yasuyuki Yamawake, Mario Yarto, Xuemei Zhu

Special thanks are also due to:

International Environmental Technology Centre (IETC), UNEP, and its Director Surendra Shrestha; Ministry of the Environment of the Government of Japan, lead of the Global Mercury Waste Management Partnership Area; Ministry of Agriculture, Food and Environment of the Government of Spain, co-lead of the Global Mercury Supply and Storage Partnership Area

Copyright © United Nations Environment Programme, 2015

This publication may be reproduced in whole or in part and in any form for educational or non-profit purposes without special permission from the copyright holder, provided acknowledgement of the source is made. UNEP would appreciate receiving a copy of any publication that uses this publication as a source. No use of this publication may be made for resale or for any other commercial purpose whatsoever without prior permission in writing from the United Nations Environment Programme.

Disclaimer:

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the United Nations Environment Programme concerning the legal status of any country, territory, city or area or of its authorities, or concerning delimitation of its frontiers or boundaries. Moreover, the views expressed do not necessarily represent the decision or the stated policy of the United Nations Environment Programme, nor does citing of trade names or commercial processes constitute endorsement. Mention of a commercial company or product in this publication does not imply endorsement by the United Nations Environment Programme.

ISBN: 978-92-807-3482-9

Job number: DTI/1873/GE



UNEP promotes environmentally sound practices globally and in its own activities. This publication will be available as an electronic document and will only be printed on demand. Our distribution policy aims to reduce UNEP's carbon footprint.

TABLE OF CONTENTS

ABOUT THE SOURCEBOOK	1
TOWARDS THE ENVIRONMENTALLY SOUND STORAGE AND DISPOSAL OF MERCURY WASTES	3
INTRODUCTION: MERCURY AS A GLOBAL POLLUTANT	4
1. TYPES AND SOURCES OF MERCURY WASTES	6
1.1 Types of Mercury Wastes	6
1.2 Characterization of Mercury Wastes	8
1.3 Inventories of Mercury and Mercury Wastes	9
1.4 Mercury Supply Exceeding Demand	11
1.5 Sources of Wastes Consisting of Mercury or Mercury Compounds	12
1.6 Sources of Wastes Containing Mercury or Mercury Compounds	13
1.7 Sources of Wastes Contaminated with Mercury or Mercury Compounds	14
2. ENVIRONMENTALLY SOUND MANAGEMENT OF MERCURY WASTES	16
2.1 Important Concepts and Considerations in the ESM of Mercury Wastes	16
2.2 Health and Safety	18
2.3 Government, Laboratory and/or Private Stocks	19
2.4 Spent Mercury-added Products	20
2.5 Industrial Processes Using Raw Materials Containing Mercury	25
2.6 Industrial Processes Using Mercury	28
3. STORAGE OF MERCURY WASTES	32
3.1 Handling, Packaging, Labelling and Transport	32
3.2 Traceability	35
3.3 Storage Options	37
4. RECOVERY OPERATIONS FOR MERCURY WASTES	44
5. DISPOSAL OPERATIONS FOR MERCURY WASTES	50
5.1 Physico-chemical Treatment (Stabilization/Solidification)	50
5.2 Specially Engineered Landfill	54
5.3 Permanent Storage (Underground Facilities)	58
6. EXPORT OF MERCURY WASTES	64
7. MANAGEMENT OF SITES CONTAMINATED WITH MERCURY WASTES	68
KEY MESSAGES AND ACTION POINTS	73
LIST OF ACRONYMS AND ABBREVIATIONS	74

LIST OF FIGURES

Figure 1: Towards the Environmentally Sound Storage and Disposal of Mercury Wastes	3
Figure 2: Potential Sources of Mercury Supply	10
Figure 3: Excess Mercury: Origin and Development	11
Figure 4: Potential Sources of Wastes Consisting of Mercury or Mercury Compounds	12
Figure 5: Potential Sources of Wastes Containing Mercury or Mercury Compounds	13
Figure 6: Potential Sources of Wastes Contaminated with Mercury or Mercury Compounds	14
Figure 7: Options for the ESM of Wastes Consisting of Mercury or Mercury Compounds	20
Figure 8: ESM of Spent Mercury-added Products	23
Figure 9: ESM of Dental Amalgam Wastes	24
Figure 10: ESM of Industrial Processes Based on Raw Material Containing Mercury	26
Figure 11: Simplified Process Flow and Fate of Mercury in NFM Processing with Dedicated Mercury Control	27
Figure 12: ESM in Manufacturing Processes Using Mercury	29
Figure 13: Preparation for Permanent Storage of Metallic Mercury and Site Remediation	30
Figure 14: The Traceability Chain	36
Figure 15: End-cut/air-push Fluorescent Lamp Recycling	41
Figure 16: Vacuum Thermal Desorption	48
Figure 17 Suggestions on the Eligibility of Mercury Wastes for Disposal in a Specially Engineered Landfill	55
Figure 18: Example (A) of a Specially Engineered Landfill	56
Figure 19: Suggestions on the Eligibility of Mercury Wastes for Underground Disposal	58
Figure 20: Layout of the Planned Deep Rock Disposal Facility	60
Figure 21: Combination of Wet Screening and Vacuum Distillation Flow Chart	69
Figure 22: Key Steps in the Environmentally Sound Storage and Disposal of Mercury Wastes	73

LIST OF BOXES

Box 1: Wastes Consisting of Mercury or Mercury Compounds	7
Box 2: Wastes Containing Mercury or Mercury Compounds	7
Box 3: Wastes Contaminated with Mercury or Mercury Compounds	7
Box 4: Mercury Wastes under the Minamata Convention: Art. 11, Para. 2	7
Box 5: Examples of Methods to Determine the Mobility and Leachability of Mercury in Waste	8
Box 6: Identification of Stocks and Sources of Mercury under the Minamata Convention: Art. 3, Para. 5 (a)	9
Box 7: Excess Mercury from the Decommissioning of Chlor-alkali Facilities under the Minamata Convention: Art. 3, Para. 5 (b)	10
Box 8: Primary Mercury Mining under the Minamata Convention: Art. 3, Para. 4	10
Box 9: The Methodological Guide for the Development of Inventories under the Basel Convention	11
Box 10: The UNEP Toolkit for Identification and Quantification of Mercury Releases	11
Box 11: ESM of Mercury Wastes under the Minamata Convention: Art. 11, Para 3	17

Box 12: Special Considerations for Spillage of Mercury	18
Box 13: Worker Health and Safety Measures	19
Box 14: Extended Producer Responsibility	21
Box 15: Packaging of Wastes Consisting of Mercury	33
Box 16: Packaging of Wastes Containing Mercury	33
Box 17: Packaging of Wastes Contaminated with Mercury	33
Box 18: Labelling	34
Box 19: Acceptance and Consistency Control	35
Box 20: Basic Steps in the Recovery/recycling of Mercury Wastes	45
Box 21: Example of a Recovery/recycling Process for Linear Fluorescent Lamps: End-cut/air-push	46
Box 22: Example of Thermal Treatment in a Multiple Hearth Furnace	47
Box 23: Example of Recovery/recycling of Mercury-added Batteries via Pyrolysis	47
Box 24: Example of a Vacuum Distillation Process	47
Box 25: Example of an Indirect Heated Vacuum Dryer (Vacuum Mixer)	48
Box 26: Stabilization	51
Box 27: Solidification	51
Box 28: Sulphur Stabilization of Mercury (Germany)	51
Box 29: Sulphur Polymer Stabilization and Solidification (SPSS) of Wastes Consisting of Mercury and Mercury Wastes (Spain)	52
Box 30: S/S with Sulphur Microcements (Spain)	52
Box 31: Example (A) of a Specially Engineered Landfill	56
Box 32: Example (B) of a Specially Engineered Landfill	57
Box 33: Transport across International Boundaries under the Minamata Convention: Art. 11, Para. 3 (c)	66
Box 34: Transport across International Boundaries under the Basel Convention: Art. 9	66
Box 35: Contaminated Sites under the Minamata Convention: Art. 12, Para 1 and 2	68

LIST OF CASE STUDIES

Case Study 1: The Waste Electrical and Electronic Equipment Directive (EU) and its Implementation (Austria)	21
Case Study 2: The National Environmental Waste Act (South Africa)	22
Case Study 3: Collection Campaign for Fluorescent Lamps (Kingdom of Thailand)	22
Case Study 4: Recovery/recycling of Mercury-contaminated Sludge from NFM (Japan)	28
Case Study 5: Transport of Wastes Consisting of Mercury (US)	34
Case Study 6: Storage of Sludge Contaminated with Mercury at a NFM plant (Japan)	38
Case Study 7: Storage of Mercury-added Products in the San Lazaro Hospital (Philippines)	39
Case Study 8: Off-site Storage of Hazardous Waste in a Dedicated Facility (Germany)	40
Case Study 9: Storage of Mercury in Warehouses (US)	41
Case Study 10: Specially Designed Storage Container (Spain)	42
Case Study 11: Prototype Container Potentially Suited for Permanent Storage	59
Case Study 12: Permanent Storage of Mercury Wastes from Mining in Crystalline Rock (Sweden)	60
Case Study 13: Permanent Storage in Salt Mines (Germany)	61

Case Study 14: Export of Catalysts Contaminated with Mercury (Indonesia)	64
Case Study 15: Export of Mercury-added Fluorescent Lamps for Recovery/recycling (Philippines)	64
Case Study 16: Export of Mercury Waste from a Gold Mine for Stabilization and Permanent Storage (Peru)	65
Case Study 17: Treatment of Soil Contaminated with Mercury through a Combination of Wet Screening and Vacuum Distillation (France)	69

LIST OF TABLES

Table 1: Classification of Mercury Wastes under the US EPA Land Disposal Restrictions Program	9
Table 2: Recovery and Disposal Operations for Mercury Wastes as listed in the Basel Technical Guidelines	16
Table 3: Information to be Provided in the Tracking Records	37
Table 4: Challenges Related to Physico-chemical Treatment (S/S)	53
Table 5: Opportunities Related to Physico-chemical Treatment (S/S)	53
Table 6: Eligibility Criteria for Landfill Disposal in the EU, the US and Japan	54
Table 7: Challenges Related to Specially Engineered Landfills	57
Table 8: Opportunities Related to Specially Engineered Landfills	57
Table 9: Challenges Related to Permanent Storage	62
Table 10: Opportunities Related to Permanent Storage	62

LIST OF PHOTOS

Photo 1: Mercury	7
Photo 2: Example of Spent Mercury-added Products	7
Photo 3: Example of Waste Contaminated with Mercury	7
Photo 4: Protective Clothing	19
Photo 5: Multiple Hearth Furnace	28
Photo 6: Mercury Flasks	33
Photo 7: 125 Litre UN-approved Plastic Drum	33
Photo 8: UN-approved 110 Litre Stainless Steel Drum with Epoxy Lining	33
Photo 9: GHS06 – Acute Toxicity	34
Photo 10: GHS08 – Health Hazard	34
Photo 11: GHS09 – Environmental Hazard	34
Photo 12: Example of Product Labelling	34
Photo 13: Transport of Wastes Consisting of Mercury	34
Photo 14: Acceptance Control	35
Photo 15: Storage Site for Spent Mercury Contaminated Catalysts from Natural Gas Production	38
Photo 16: Packaging of Sludge	38

Photo 17: Transport of Drums	38
Photo 18: Storage in the San Lazaro Hospital Step 1: Original Box	39
Photo 19: Storage in the San Lazaro Hospital Step 2: Primary Container	39
Photo 20: Storage in the San Lazaro Hospital Step 3: Secondary Container	39
Photo 21: Storage in the San Lazaro Hospital Step 4: Dedicated Facility	39
Photo 22: Hazardous Waste Storage Facility	40
Photo 23: Mercury Drums Staged in Hawthorne	41
Photo 24: Overpacking	41
Photo 25: Warehouse for the Storage of Mercury	41
Photo 26: MERSADE Container	42
Photo 27: Example of Pre-Treatment	45
Photo 28: Example of Thermal Treatment	45
Photo 29: Example of Refining	45
Photo 30: Multiple Hearth Furnace	47
Photo 31: Pyrolysis	47
Photo 32: Retorts	47
Photo 33: Commercial Stabilization Plant	51
Photo 34: Monolithic Block after the Treatment of Waste Consisting of Mercury from the Chlor-alkali Sector	52
Photo 35: Monolithic Block after the Treatment of Zinc Production Waste	52
Photo 36: Monolithic Block after the Treatment of Fluorescent Lamp Dust	52
Photo 37: Example (B) of a Specially Engineered Landfill	57
Photo 38: Prototype Container	59
Photo 39: Placement of big bags in the salt mine	61
Photo 40: Storage arrangement of drums in the salt mine	61
Photo 41: Recycling of Catalysts	64
Photo 42: Storage of Fluorescent Lamps	64
Photo 43: Transport of Fluorescent Lamps	64
Photo 44: The Yanacocha Mine in Peru	65
Photo 45: Indirectly Heated Discontinuous Vacuum Mixer for Mercury Recovery, Including Solidification Mixer	69

ABOUT THE SOURCEBOOK

How was the Sourcebook prepared?

The United Nations Environment Programme (UNEP) Governing Council (GC), in decision 25/5, requested UNEP to enhance capacity for mercury storage and provide information on the sound management of mercury and mercury wastes. The project for the preparation of the 'Practical Sourcebook on Mercury Waste Storage and Disposal' (hereinafter referred to as the 'Sourcebook') is one of UNEP's responses to this request. The project is a joint initiative of UNEP Chemicals Branch, Division of Technology Industry and Economics (DTIE), UNEP's International Environmental Technology Centre (IETC), and the International Solid Waste Association (ISWA) under the UNEP Global Mercury Partnership. Drawing on existing work within the Global Mercury Partnership (notably the Partnership areas on waste management, supply and storage, products, and chlor-alkali), including studies, guidance and information material disseminated by the Partnership, as well as other relevant documents, reports and publications, the Sourcebook has been prepared in a consultative process, involving experts from governments, the private sector, civil society, academia and intergovernmental organizations (IGOs). Selected experts were partners of the Global Mercury Partnership, other experts UNEP Chemicals has worked with under the Partnership umbrella, and members of ISWA's Working Group on Hazardous Waste. Their role was to provide input for preparation of the Sourcebook and to give feedback on the various drafts, including at a face-to-face meeting held in Vienna in August 2014.

Who is the audience?

The main target audience of the Sourcebook are technical

What is the purpose?

The overall objective is to enhance the capacity of governments – but also industry and the general public – to store and dispose mercury wastes in an environmentally sound manner. The Sourcebook aims to do so by providing information on commercially available storage and disposal technologies. This document is envisaged to address practical questions such as: What are mercury wastes? Where are they generated? How can mercury wastes be recovered and recycled? Which options and experiences exist for the storage and disposal of mercury wastes? The Sourcebook synthesizes existing knowledge in the field of storage and disposal to provide answers to these questions. It will thus allow relevant stakeholders to make informed choices and ensure the environmentally sound management (ESM) of mercury wastes.

What is the format?

The Sourcebook is a practical introduction to mercury waste storage and disposal. The Sourcebook should not be used as guidance. Other sources, such as the 'Updated Technical Guidelines for the Environmentally Sound Management of Wastes Consisting of, Containing, or Contaminated with Mercury or Mercury Compounds'¹ (hereinafter referred to as Basel Technical Guidelines) provide greater detail regarding mercury waste storage and disposal and are cross-referenced in this document. The updated Basel Technical Guidelines were adopted by the Conference of the Parties (COP) to the Basel Convention at its twelfth meeting in May 2015.

What is the scope?

预览已结束，完整报告链接和二维码如下：

https://www.yunbaogao.cn/report/index/report?reportId=5_15634

