



MINAMATA
CONVENTION
ON MERCURY

Project funded
by the Specific
International Programme

**Strengthening National Capacity for Phasing Out Mercury-added
Products and Environmentally Sound Management of Waste
Consisting of, Contaminated with and Containing Mercury in
Sri Lanka**

Final Report

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Ministry of Environment

Sri Lanka

2024

**Strengthening National Capacity for phasing out mercury-added
products and environmentally sound management of waste consisting
of, contaminated with and containing mercury
in Sri Lanka**

Final Report

Ministry of Environment

Executive Summary

This final report summarizes the outcomes and accomplishments of the Ministry of Environment during the implementation of the project "Strengthening National Capacity for Phasing Out Mercury-Added Products and Environmentally Sound Management of Waste Containing Mercury in Sri Lanka". The project, spanned from 24th March 2021 to 23rd March 2024, aimed to assess project execution, evaluate its impact, and present recommendations for lasting effectiveness.

Throughout the project period, significant strides were made in achieving the project's objectives. Firstly, the identification and prioritization of mercury-added products occurred through collaborative efforts with industries and government bodies. This informed the successful implementation of regulatory frameworks and incentives, resulting in a tangible reduction in the use of targeted products. Secondly, a robust waste management strategy for mercury-containing products was developed and executed. Collaborative initiatives with stakeholders ensured the establishment of functional collection, recycling, and disposal systems, contributing to effective mercury waste management. Capacity-building efforts were paramount during the project, including tailored training programs for government officials, industry representatives, and waste management professionals. Concurrently, improvements to laboratory capacities for mercury analysis and monitoring significantly enhanced technical capabilities.

The project encountered challenges, notably regulatory compliance issues and initial resistance from certain industries. Valuable lessons were gleaned, emphasizing the importance of continuous stakeholder engagement, adaptability in approach, and the necessity for flexible management strategies.

To sustain the positive momentum achieved, future efforts should prioritize ongoing collaboration between government agencies, industries, and civil society. Strengthening monitoring and enforcement mechanisms will ensure sustained compliance with established regulatory frameworks. Continued investment in public awareness campaigns remains essential to maintain a high level of awareness and engagement.

The successful conclusion of this project marks a significant milestone in fortifying Sri Lanka's national capacity to phase out mercury-added products and implement environmentally sound waste management practices. The accomplishments and insights garnered during this period provide a solid foundation for future initiatives, with the outlined recommendations serving as a guide for sustained efforts in safeguarding public health and the environment from the adverse effects of mercury contamination.

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1. Introduction

Mercury, a potent neurotoxin, poses significant risks to human health and the environment. Recognizing these risks, the Ministry of Environment embarked on a critical initiative to phase out mercury-added products and implement sustainable waste management practices for mercury-contaminated materials. This report represents the culmination of an in-depth attempt to strengthen Sri Lanka's capacity in addressing the challenges associated with mercury usage and disposal.

The project was initiated in response to the pressing need to mitigate the adverse impacts of mercury on public health and the environment. The widespread use of mercury in various industries, such as healthcare, mining, and manufacturing, has contributed to a concerning accumulation of mercury-containing waste. Improper disposal and handling of such waste pose substantial threats, necessitating urgent action to mitigate these dangers.

The primary focus of this was twofold: first, to identify and eliminate mercury-added products across industry, health, education sectors and, second, to establish protocols for the environmentally sound management of waste contaminated with and containing mercury. Through a collaborative effort involving government agencies, industry stakeholders, environmental experts, and community engagement, this initiative aimed to pave the way for a safer and more sustainable future.

Over the course of this project, an array of comprehensive assessments, capacity-building exercises, regulatory analyses, and stakeholder engagements were undertaken. The insights gathered, coupled with the achievements made, underscore the critical strides taken towards achieving the goal of phasing out mercury and ensuring proper management of mercury-related waste in Sri Lanka.

This report encapsulates the findings, accomplishments, recommendations, and policy directives generated through this project. It serves not only as a testament to the dedication and efforts of all involved parties but also as a roadmap for sustained progress in the realm of mercury phase-out and waste management in Sri Lanka.

The subsequent sections detail the activities undertaken, achievements realized, recommendations proposed, and future policy directives intended to solidify and expand upon the groundwork laid during this project.

1.1 Background

The Minamata Convention was established in 2013 to reduce and manage the use of mercury with the primary objective of protecting human health and the environment from the adverse effects of mercury globally. Sri Lanka signed the Minamata Convention on 8th October 2014 and ratified it on 19th June 2017. The Convention is effective globally from 16th August 2017 and the Ministry of Environment acts as the National focal point for the Minamata Convention. According to the Minamata Convention, member countries are committed to minimize the use of mercury and take appropriate management measures. The Convention provides support to strengthen national capabilities for the successful implementation of the Convention and to conduct research required for the proper management of mercury. Hence, as a party, Sri Lanka needs to fulfil the mentioned obligation in the convention.

The Ministry of Environment implemented the Minamata Initial Assessment project (phase I) in 2016- 2018. Under the MIA - phase I the National Inventory of Mercury was developed and legislative and institutional gaps were identified. Minamata Initial Assessment (Phase II) mainly focused to mercury usage in Small Scale Jewellery (SSJ) sector.

“Strengthening National Capacity for phasing Out Mercury Added Products and environmentally Sound Management of Waste consisting of, contaminated with and containing Mercury in Sri Lanka” project funded by the Specific International Programme (SIP) supports implementation of the Minamata Convention in Sri Lanka, through developing national capacity to management of waste containing, consisting and contaminated with mercury in an environmentally friendly manner. Technical consultancy of the project was undertaken by the National Cleaner Production Centre, Sri Lanka.

1.2 Objectives

This project was designed based on the recommendations provided in the Minamata Initial Assessment in order to implement obligations of the Minamata Convention in Sri Lanka. The overall objective of this project is to build capacity for the phase-out of mercury -added products and the Environmentally Sound Management of eliminated mercury and wastes consisting of, containing or contaminated with mercury in Sri Lanka.

1.3 Scope

The scope of the project had five main outputs.

1.3.1 Output 1: Establish Institutional setup for project implementation

A Project Steering Committee and a Technical Committee were established to streamline the project activities.

The steering committee that functioned under the Minamata Initial Assessment (MIA) project was used as the steering committee for the project, considering the similarity in the composition of stakeholders. The Steering Committee was chaired by the Additional Secretary (Environment Policy & Planning) of the Ministry of Environment. The Project Steering Committee consisted with representatives from following institutions.

- Ministry of Health
- Ministry of Education
- Ministry of Industries
- Central Environmental Authority
- National Gem & Jewellery Authority
- Gem & Jewellery Research and Training Institute
- Industrial Technology Institute
- Consumer Affairs Authority
- Imports and Exports Control Department
- National Aquatic Resources Research and Development Agency
- Centre for Environmental Justice

Considering the efficiency and the convenience a single technical committee was established instead of establishing three technical committees for the sectors of industry, health and education. The technical committee reviewed and evaluated technical aspects of the deliverables submitted by the consultants and recommended for payments.

1.3.2 Output 2: Develop report on mercury free alternatives with their costs and benefits and recommendations for future policy directives

There are different kinds of alternatives for mercury added products in the world. As a developing country like Sri Lanka, those alternatives should be affordable and environmentally friendly alternatives. Therefore, following activities were carried out under the output 2.

- Carry out the survey on mercury contained products and processes available in market under the Industry, Education, Health sectors using the MIA as the base document but not limited to it. And find out available alternatives for each identified products and processes.
- Develop a list of mercury free alternative products or processes available locally or internationally in relation to Industry, Education, Health and Household sectors.
- Develop questionnaires for surveys to be conducted to generate the information needed for cost-benefit analysis for each of the identified alternative products/processes.
- Carry out the Cost-Benefit analysis related to all identified mercury free alternative products and processes in Industry, Health, Education and Household sectors.
- Make recommendation to fulfill the obligations of the Minamata Convention related to the products/ Processes in the Industry, Health, Education and Household sectors and propose policy directives necessary to fulfill the recommendations made.
- Identify mercury contaminated sites in Industry, Health, Education and Household (if applicable) sectors and propose the remedial measures and necessary future actions to discontinue the present activities if any.
- Consult key stakeholders/ relevant agencies or individuals through individual interviews and discussions as required.
- Showcasing alternatives for mercury containing equipment.

1.3.3 Output 3: National technical guideline on Environmentally Sound Management of mercury waste by adapting the content of “Basel Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with mercury or mercury compounds” to local conditions

The technical guideline provides guidance for the environmentally sound management (ESM) of wastes consisting of elemental mercury and wastes containing or contaminated with mercury. The guideline covers all aspects of lifecycle management of mercury containing products and mercury waste including Mercury Wastes prevention and Minimization, Handling, Separation, Collection, Packaging, Labelling, Transportation and Storage and Environmentally sound disposal. Therefore, following activities were carried out under the output 3.

- In- depth study of the Minamata Initial Assessment, Basel Guidelines and activities in output 2 of the Project.
- Develop the zero draft of technical guideline for the environmentally sound management of mercury waste in adherence to the Basel Guidelines for Mercury waste management (consisting or containing or contaminated with mercury) in Industrial, Health, Education and Household sectors.
- Consult key stakeholders/ relevant agencies or individuals through individual interviews and discussions as required.
- Conduct stakeholder workshops to develop and review draft guideline (Draft 1 & 2).
- Conduct validation workshop to finalize the Technical Guideline/s on Mercury Waste Management

1.3.4 Output 4 : Trained and raised awareness of employees from health, industrial and education sectors, mercury equipment suppliers and general public on health and environmental impacts of elemental mercury and wastes containing or contaminated with mercury and their management

Awareness on Mercury issues is low among risk groups, the population at large or even government agencies and institutions having responsibilities pertaining to Mercury and Mercury wastes. During the awareness raising activities, the main focus was given to adoption of alternatives to the use of Mercury and proper management, storage, transport and disposal/ treatment of Mercury and Mercury containing products and wastes. The three main provinces which have the highest population density and highest number of industries were selected for awareness raising. Therefore, following activities were carried out under the output 4.

- Develop a detail plan/ Schedule for training and awareness raising programmes on mercury management in the context of chemical management adhering to the time period of consultancy.
- Develop training modules for mercury waste management in industry, health, and education sectors.
- Conduct training programs on mercury waste management with a focus on Chemical Management in Industry, Health and Education sectors. (20 programmes)
- Training programmes consisted of following areas:
 - Introduction to chemical management
 - Information on technically and economically viable alternatives to mercury added/ mercury containing products
 - Aspects in the technical guideline on mercury/ mercury waste management
 - Scientific, technical, economic and legal information concerning mercury and mercury compounds including toxicological, eco toxicological and safety information
 - Information on the reduction or elimination of the production, use, emissions and releases of mercury and mercury compounds
 - Information on environmental, health and safety risks with exposure of mercury
 - Mercury Spill management
 - Mercury Storage management
 - Best practices of mercury disposal

- Design different modes of awareness materials to effectively communicate the information on mercury waste management in the context of chemical management.
Eg. Brochures, Posters, Videos, Articles in printed media and social media
- Conduct awareness workshops on mercury waste with a focus on Chemical Management in Industry, Health and Education sectors and general public (25 programmes)

1.3.5 Output 5 : Disseminate information on the success of the project at UNEP organized international Forum

The United Nations Environment Programme invited Sri Lanka to participate mid-term workshop of the project on “Promoting Minamata Convention on Mercury by making the most of Japan’s knowledge and experiences” held in Minamata City, Japan on 20 – 22 February 2023.

Ms. Jeeva Palugaswewa, Assistant Director (Environment Pollution Control and Chemical Management) representing the Ministry of Environment, Sri Lanka in this workshop. At the workshop she presented country’s status regarding implementation of the Minamata Convention and shared the experiences and outputs of the project.

2. Summary : Develop report on mercury free alternatives with their costs and benefits and recommendations for future policy directives

2.1 Objective

The objective of this task was to comprehensively evaluate and present mercury-free alternatives to existing products, processes, or technologies, while concurrently conducting a rigorous cost-benefit analysis.

2.2 Activities Implemented

2.2.1 Desk Review and Literature Survey

An extensive review of existing literature was conducted to identify studies, reports, and case studies related to mercury-free alternatives in various sectors. Scientific publications, industry publications, and international standards on mercury reduction were examined. The Minamata Initial Assessment conducted in Sri Lanka was specifically reviewed to gain insights into the local usage of mercury-containing items.

2.2.2 Survey Conduct

A survey was designed and executed to identify specific mercury-containing products and processes within the health, industry, and education sectors. A self-administered questionnaire, incorporating closed and open-ended questions, was developed and pretested to ensure clarity, completeness, and user-friendliness. Permission was obtained from relevant authorities, and the questionnaire was distributed to heads of institutions in the health, industry, and education sectors, who then nominated a focal person to complete the survey. Online training on completing the questionnaire was provided to the nominated officers, and responses were collected via email. Data extraction and analysis were performed using descriptive statistics to derive meaningful insights.

2.2.3 Qualitative Data Collection

Focus group discussions and interviews were conducted with professionals in specialized areas within the respective sectors. Pre-identified questions and a guide facilitated the discussions, ensuring a systematic approach to gather qualitative data. Responses were documented and analyzed to provide additional depth and context to the quantitative survey findings.

These activities collectively aimed to comprehensively identify mercury-containing items in health, industry and education sectors, assess their prevalence, and explore viable alternatives. The integration of quantitative and qualitative methods ensured a robust analysis, contributing to the development of informed recommendations for the reduction or proper management of mercury usage in the health, industry and education sectors.

2.3 Key Findings

2.3.1 Health Sector

2.3.1.1 Procurement Practices:

- The Bio Medical Engineering division is fully aware of the need to phase out Mercury-containing pressure meters, adhering to guidelines issued by the Ministry of Health in 2013.
- They currently procure aneroid pressure meters and digital thermometers, having procured around 3000 aneroid pressure meters and 2500 digital thermometers for government healthcare institutions over the past five years.
- The Medical Supplies Division and Provincial Health Ministries also follow a mercury-phasing-out approach in their procurement, opting for digital thermometers and non-Mercury containing pressure meters.

2.3.1.2 Preference for Aneroid Pressure Meters:

- Health staff generally prefers aneroid pressure meters over digital ones. However, during the COVID-19 pandemic, there was an increased demand for digital pressure meters, although concerns about their accuracy were noted.

2.3.1.3 Amalgam Use in Dental Procedures:

- Amalgam is still being used for dental procedures in government health institutions, and procurement continues. However, a Silver-Mercury capsule is now used to prevent mercury emissions during mixing and ensure occupational health and safety for staff.
- Composite is also used for dental procedures, with concerns raised about its cost and effectiveness.

2.3.1.4 Challenges in Private Health Institutions:

- Mercury-containing thermometers and pressure meters are still being procured in private health institutions, highlighting a potential gap in phasing out mercury in the private healthcare sector.

2.3.1.5 Waste Management Challenges:

- The disposal of waste mercury-containing thermometers and sphygmomanometers poses a challenge in Sri Lanka.
- Unusable mercury-containing CFL and fluorescent tubes are also a concern due to lack of disposal mechanism.
- Despite awareness initiatives for health staff on mercury spill management, gaps exist, and government health institutions lack mercury spill management kits.

2.3.2 Industry Sector

2.3.2.1 Mercury Use in Manufacturing:

- The industry sector in Sri Lanka utilizes mercury-added products or materials during manufacturing processes, rather than incorporating mercury in manufacturing itself.
- The Norochcholei Coal Power Plant, a significant contributor to mercury release through energy consumption, employs Electro Static Precipitators (ESP) and Flue Gas De-Sulphurisation (FGD), but these mechanisms are ineffective in removing mercury emissions. Recommends the optimization of existing ESP and FGD systems.
- Recommends to procure mercury free coal.

2.3.2.2 *Cosmetics Industry Oversight:*

- The National Medicine Regulatory Authority (NMRA) controls the quality of cosmetics in Sri Lanka.
- Standards set a maximum mercury level of 1 mg/kg or 1 ppm. Compliance testing is carried out by manufacturers or importers, lacking a mechanism for random quality checks. Recommends the development of a random sample testing mechanism to ensure compliance.
- Challenge of controlling the import of mercury-containing cosmetics and related products through international online marketing.

2.3.2.3 *Wastewater Discharge Regulations:*

- Industry sectors are obligated to adhere to National Environmental (Protection & Quality) Regulations during wastewater discharge.
- The Central Environmental Authority monitors wastewater quality during the issuance of Environmental Protection Licenses (EPL).
- Identifying mercury-contaminated sludge and wastewater-generating industries is recommended, along with proposing a suitable mechanism for mercury-contaminated sludge waste management in Sri Lanka.

2.3.2.4 *Gold Waste Recovery Practices:*

- Small-scale jewelry manufacturers use mercury for gold waste recovery, posing health and environmental risks.
- Alternatives such as a mixture of "Pushkara" (Borax powder), "Nawasaram" (Amonium chloride), potassium nitrate, and Aqua regia solution are available for gold waste recovery.
- Recommends the development of guidelines, process optimization, and safety measures for the gold waste recovery sector. Urges the need for regulations and policies to control mercury use in this sector.

2.3.2.5 *Mercury Contaminated Sites:*

- Small-scale jewelry manufacturing sites using mercury for gold extraction may lead to soil contamination.
- The possibility of purchasing contaminated soil due to the presence of gold in these areas poses environmental and health risks.

- Recommends interventions to address mercury contamination at these sites and mitigate the potential health hazards associated with mercury exposure.

2.3.3 Education Sector

2.3.3.1 Mercury Use in Research:

- Mercury-containing chemicals are frequently used in university laboratories for research purposes, especially in older equipment acquired a decade ago.
- New apparatus in universities is generally mercury-free, reflecting a positive shift toward safer alternatives.

2.3.3.2 Phasing Out in Schools:

- In the school sector, steps have been taken to phase out mercury-containing experiments from the curriculum, as indicated by Circular No. 21/2021 from the Ministry of Education.
- Schools primarily use a limited number of general-purpose products containing mercury in their activities.

2.3.3.3 Alternatives in Research Studies:

- Mercury-containing compounds in the education sector are mainly utilized for research studies. Depending on the scope of the study, numerous alternatives can be selected to replace mercury-containing substances.

2.3.3.4 Mercury Import Data:

- Mercury Country Situation Report (2018) revealed that 1817.85 kg of metallic mercury was imported to Sri Lanka in 2016 with distribution among the education sector (laboratories), health sector (preparation of Ayurvedic drugs), and the industrial sector (Artisanal Gold Waste Recovery).
- Unfortunately, specific data on the amount delivered to the education sector was not reported.

2.3.3.5 Toxic Waste Management Challenges:

- Toxic waste management, particularly related to mercury-containing waste, has been given the least priority in the national waste management planning context.
- Solid wastes, irrespective of content, are commonly discharged with municipal solid

waste management and deposited at open dump sites operated by local government authorities.

- Instances of responsible authorities collecting and storing mercury-containing waste in designated areas within premises, such as broken mercury thermometers stored in fume hoods.

2.3.3.6 Disposal Practices:

- Broken CFL bulbs are stored in some universities and taken away by the maintenance division.
- Liquid wastes, including those containing mercury, are either discharged into common wastewater drains or stored within the premises.

2.3.4 Cost Benefit Analysis

2.3.4.1 Scope and Product Identification:

- The cost-benefit analysis focuses on comparing monetary costs and benefits associated with introducing mercury-free alternatives in industry, health and education sectors in Sri Lanka, including household sector.

2.3.4.2 Key Steps in Analysis:

- Identified a comprehensive list of mercury-containing/added products used in industry, health, education and household sectors.
- Assessed initial costs (prices), maintenance costs, and damage costs of mercury, with a primary focus on health-related costs.

2.3.4.3 Total Cost Estimation:

- Estimated the total cost of using mercury-added products, including damage costs. The estimation assumes an equal probability of each item being damaged during its lifetime.

2.3.4.4 Net Present Value Calculation:

- Calculated the net present value of the cost to understand the long-term economic impact of using mercury-added products.

2.3.4.5 External Cost Considerations:

- Due to the absence of country-specific data on the external cost of mercury

emission, the average damage cost in 2013 was derived from literature.

- Adjusted the cost for inflation using the 10-year average global inflation rate

2.3.4.6 Data Sources:

- Utilized survey data as the primary information source for the study.
- Incorporated inflation rates and discount rates from the central bank's annual report for 2021.

2.3.4.7 Price Considerations:

- Addressed the wide price range by using an average price for each item in the study.
- Considered variations in mercury levels in different products during the comparison.

2.3.4.8 Estimated Damage Costs:

- Reported the estimated damage cost for each item as a crucial component of the cost- benefit analysis.

2.3.4.9 Net Benefits Estimation:

- Estimated the net benefits of replacing mercury-added products under various scenarios, considering lower limits, upper limits, and constant mercury content in each item.

2.4 Showcasing alternatives for mercury containing equipment

Since children are one of the most vulnerable groups for Mercury, ‘Lady Ridgeway Hospital for Children’, the largest and most specialized pediatric government hospital in South Asia, was selected for implementing this activity.

At the start of the activity, the hospital used mercury free equipment as well as mercury containing equipment such as sphygmomanometers, mercury thermometers for healthcare operations and CFL bulbs for lighting purpose. The project facilitated to purchase 120 number of aneroid BP apparatus, 200 number of digital thermometers and 1400 number of LED bulbs for the hospital to replace mercury containing equipment. Furthermore, the project facilitated to recycle 295.6 kg of discarded CFL bulbs in the hospital.



Figure 1: Lady Ridgeway Hospital for Children



Figure 2: Aneroid BP apparatus and digital thermometers purchased under the project



Figure 3: LED bulbs purchased under the project

Annexure 1 – Report of Mercury-Free Alternatives with their Cost-Benefit Analysis

3. Summary: National technical guideline on Environmentally Sound Management of mercury waste

3.1 Objective

The primary objective of the National Technical Guideline was to support Sri Lanka's commitment to the Minamata Convention by providing comprehensive guidance on the responsible management of mercury throughout its life cycle. This included procurement, handling, storage, waste separation, and transportation. The guideline aimed to educate individuals, especially in the Industry, Health, and Education sectors, on the hazards of mercury and promote practices that contribute to the gradual phase-out of mercury use within the country.

3.2 Activities Implemented

3.2.1 National Situation Analysis:

An overview of mercury, its unique properties, and historical applications was provided. The current status of mercury use in Sri Lanka across various sectors was examined. Mercury waste generation and its implications for the environment were assessed.

3.2.2 Common Guidelines for All Sectors:

A set of guidelines were developed as applicable to all sectors, covering storage, handling, spill management, and mercury waste management.

3.2.3 Sector Specific Guidelines:

Sector-specific guidelines tailored for the Health, Industry and Education sector emphasizing on best practices and alternatives to mercury-containing products and equipment. The challenges and practices related to mercury usage were addressed.

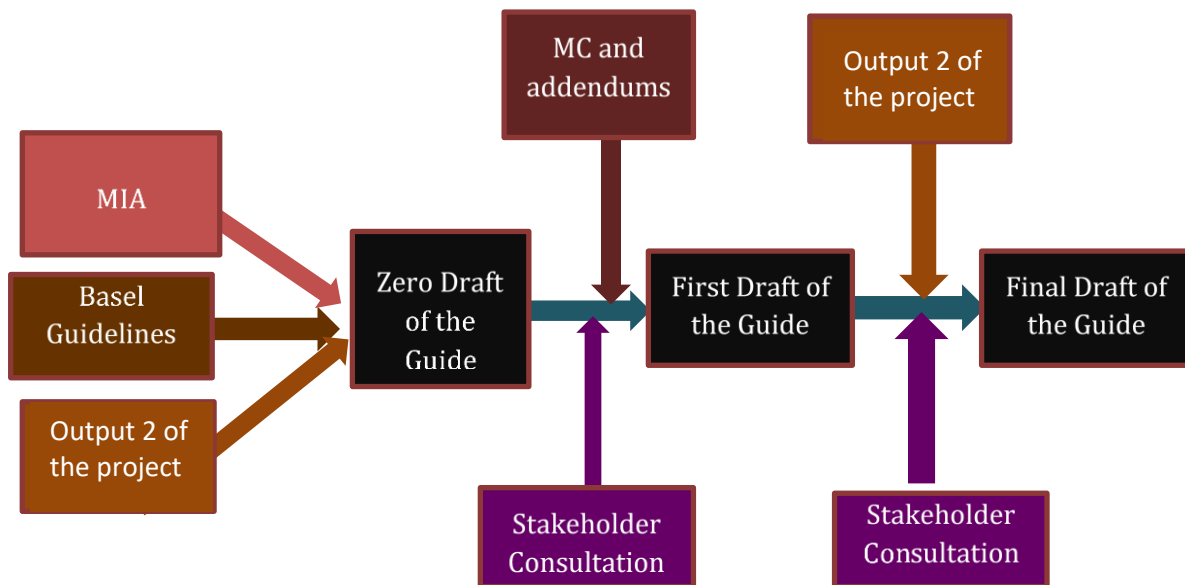


Figure 4: Process of development of the guideline

Two Stakeholder consultation meetings were organized in the process of developing national technical guidelines (Figure 4). The main objective of the 1st stakeholder consultation meeting was to present the zero draft of the technical guideline to the stakeholders and obtain feedback from them to further develop the zero draft of the technical guideline in order to prepare the 1st draft of the technical guideline. The main objective of the 2nd stakeholder consultation meeting was to present the first draft of the technical guideline to the stakeholders and obtain feedback from them to further develop the first draft of the technical guideline in order to prepare the final draft of the technical guideline. The final guide was translated into Sinhala and Tamil to facilitate easy reference for users.

3.3 Key Findings

3.3.1 Life Cycle Approach:

Life cycle approach is emphasized in the guideline, covering procurement, handling, interim storage, waste separation, and packaging. This ensures a comprehensive strategy for management of mercury, mercury containing products, equipment and waste.

3.3.2 Sector-specific Challenges:

- Identified the challenges specific to the Health sector, including the use of mercury in medical equipment, and the guideline is formulated to address these challenges.
- Challenges in the Education sector related to the use of mercury in laboratories and educational materials are explored, and the guideline addresses the best and sustainable practices.
- Challenges specific to the Industry sector was investigated, particularly in manufacturing processes, and the guideline was developed to encourage the adoption of mercury-free alternatives.

3.3.3 Role of the Guideline in Phasing Out Mercury:

- The contribution of the guideline to the overarching goal of phasing out mercury use in Sri Lanka is clearly articulated through the promotion of informed decision-making and promoting the adoption of responsible practices.

Annexure 2 – National Technical Guideline on Environmentally Sound Management of Mercury Waste

4. Summary: Trained and raised awareness of employees from health, industrial and education sectors, mercury equipment suppliers and enlightened of general public on health and environmental impacts of elemental mercury and wastes containing or contaminated with mercury and their management

4.1 Objective

The objective of this task was to conduct training and awareness programmes focused on promoting the adoption of mercury alternatives and proper management of mercury and mercury-containing products, equipment and waste. Aligned with the goals of the Minamata Convention, the effectiveness of these training and awareness programmes were evaluated in enhancing knowledge and best practices related to mercury management.

4.2 Activities Implemented

4.2.1 Methodology Development:

- Meticulous planning, module development, and program execution were crafted under output 4 of the project.
- The training curriculum was developed consisting of 6 modules covering the following areas.
 1. Introduction to Chemical Management
 2. Sources, types, properties, and adverse health effects of Mercury
 3. The use of technical guideline
 4. Mercury-free alternatives to Mercury-containing products
 5. Mercury Spill management
 6. Mercury waste packaging, storage, transport and disposal methods.
- The training programmes were conducted based on the curriculum developed.
- A systematic approach was implemented to measure metrics such as relevance, instructional effectiveness, impact on participants' knowledge, and overall satisfaction.

4.2.2 Conducting Training and Awareness Programs:

- Twenty training programmes (Table 1, 2) and twenty-five awareness programmes were conducted, targeting stakeholders from Health, Education, Industry sectors and the general public.
- Inclusive participation contained, involving 116 participants in Training of Trainers (ToT) programmes (Table 3), 141 in Health sector training, 210 in Industry sector training, 169 in Education sector training, and 659 participants in awareness sessions.

Table 1: Training of Trainers programme

Training Programme	Sectors	Location
ToT Training Programme 1	Industry, Health, Education	Western Province
ToT Training Programme 2	Industry, Health, Education	Southern Province
ToT Training Programme 3	Industry, Health, Education	Central Province

Table 2: Sector-wise training programme

Sectors	Number of training programmes
Industry	6
Heath	5
Education	6

4.3 Key Metrics and Results:

4.3.1 Total Participants: 1,295

- Training of Trainers (ToT): 116 participants (Table 4)
- Health Sector Training: 141 participants (Table 5)
- Industry Sector Training: 210 participants (Table 6)
- Education Sector Training: 169 participants (Table 7)
- Awareness Sessions: 659 participants (Table 8)

Table 3: Details of the Training of Trainers Programmes

Training Programme	Date conducted	Number of participants	Location
Training of Trainers programme – Colombo	28.02.2023	49	Ministry of Environment
Training of Trainers programme – Kandy	02.03.2023	37	Postgraduate Institute of Science, University of Peradeniya
Training of Trainers programme – Galle	20.03.2023	30	Hall de Galle, Galle
Total number of participants		116	

Table 4: Details of the Health Sector Training Programmes

Training Programme	Date conducted	Number of participants	Location
Training programme for Health Sector in Colombo	08.05.2023	60 (Considered as two programmes)	Ministry of Environment
Training programme for Health Sector in Kalutara	24.05.2023	25	Auditorium of the Teaching Hospital in Kalutara
Training programme for Health Sector in Kandy	01.06.2023	21	Auditorium of the Teaching Hospital in Peradeniya
Training programme for Health Sector in Galle	23.06.2023	35	Auditorium of the Teaching Hospital in Karapitiya
Total number of participants		141	

Table 5: Details of the Industry Sector Training Programmes

Training Programme	Date conducted	Number of participants	Location
Training programme for IDB Officers	27.06.2023	19	Auditorium of Industrial Development Board, Moratuwa
Training programme for BOI Officers	05.07.2023	21	Auditorium of the BOI Head office, Colombo 01.
Training programme for IDB industrial zone – Horana	13.07.2023	33	Conference hall of Camy Smart (Pvt) Ltd
Training programme for IDB industrial zone – Pallekele	21.07.2023	22	Industrial Zone, Pallekele
Training programme for IDB industrial zone – Ekala	25.07.2023	47	NERDC Auditorium
Training programme for BOI Export Processing Zone – Katunayake	31.08.2023	68	Auditorium, Board of Investment Zonal Office, Katunayake
Total number of participants		210	

Table 6: Details of the Education Sector Training Programmes

Training Programme	Date conducted	Number of participants	Location
Training programme for Technical Officers of University of Peradeniya	28.06.2023	30	Auditorium of Department of Chemistry, University of Peradeniya
Training programme for Technical Officers of University of Kelaniya	18.07.2023	33	Auditorium, Staff Development Centre, University of Kelaniya
Training programme for Technical Officers of University of Sri Jayawardenapura	15.08.2023	30	Department of Chemistry, University of Sri Jayawardenapura
Training programme for Technical Officers of The Open University of Sri Lanka	21.08.2023	17	Staff Development Centre, The Open University of Sri Lanka
Training programme for Technical Officers, Lecturers and undergraduates of Sri Lanka Institute of Information Technology (SLIIT)	25.08.2023	30	SLIIT, Malabe Campus
Training programme for Technical Officers, Lecturers and undergraduates of University of Colombo	06.09.2023	29	Faculty of Technology, University of Colombo, Pitipana
Total number of participants		169	

Table 7: Details of the Awareness Programmes

District	Date conducted	Details	Number of participants
Galle	27.04.2023	Awareness programme for the Development Officers of the Southern Province Management Development and Training institute	55 (considered as 4 programmes)
Hambantota	30.05.2023	Awareness programme for Walasmulla Base Hospital	43
Kandy	28.06.2023	Development Officers of the Ministry of Environment, National Institute of Co-operative Development, Polgolla	100 (considered as 4 programmes)
Kalutara	06.07.2023	Awareness programme for Panadura Base Hospital	37
Colombo	20.07.2023	Awareness programme for the lecturers and undergraduates of SLTC Research University	33
Kurunegala	28.07.2023	Awareness session for the Technical Officers of the Wayamba University of Sri Lanka, Makandura Premises	25
Kurunegala	28.07.2023	Awareness session for the Technical Officers of the Wayamba University of Sri Lanka, Kuliypitiya Premises	22
Colombo	16.08.2023	Environmental and Occupational Health Directorate, Ministry of Health	46 (considered as 2 programmes)
Ampara, Trincomalee, Batticaloa, Jaffna, Vavuniya, Mannar, Kilinochchi and Anuradhapura	18.08.2023	Development Officers of Northern and Eastern Provinces	63 (considered as 4 programmes)
Batticaloa	18.08.2023	Awareness programme for the Technical Officers of Eastern University, Sri Lanka	19
Colombo	23.08.2023	Organization and Development Unit, Ministry of Health	80 (considered as 2 programmes)
Colombo	24.10.2023	Ministry of Environment	133 (considered as 4 programmes)
Total number of participants for Awareness sessions			656

4.3.2 Impact Assessment Metrics:

Effectiveness of training programs was assessed through the analysis of feedback forms collected from participants. The feedback forms were designed to capture participant

experiences, perceptions, and suggestions for improvement. Feedback forms were distributed to participants at the end of each training session. The forms included quantitative and qualitative questions to gather comprehensive insights. The key parameters assessed included:

- Relevance and clarity of content
- Effectiveness of instructional methods
- Impact on participants' knowledge and skills
- Overall satisfaction with the training

The positive response from the majority (Figure 3(a) – (d)) exhibits the success of the training programs in meeting or exceeding participant expectations, contributing to a highly satisfactory experience.

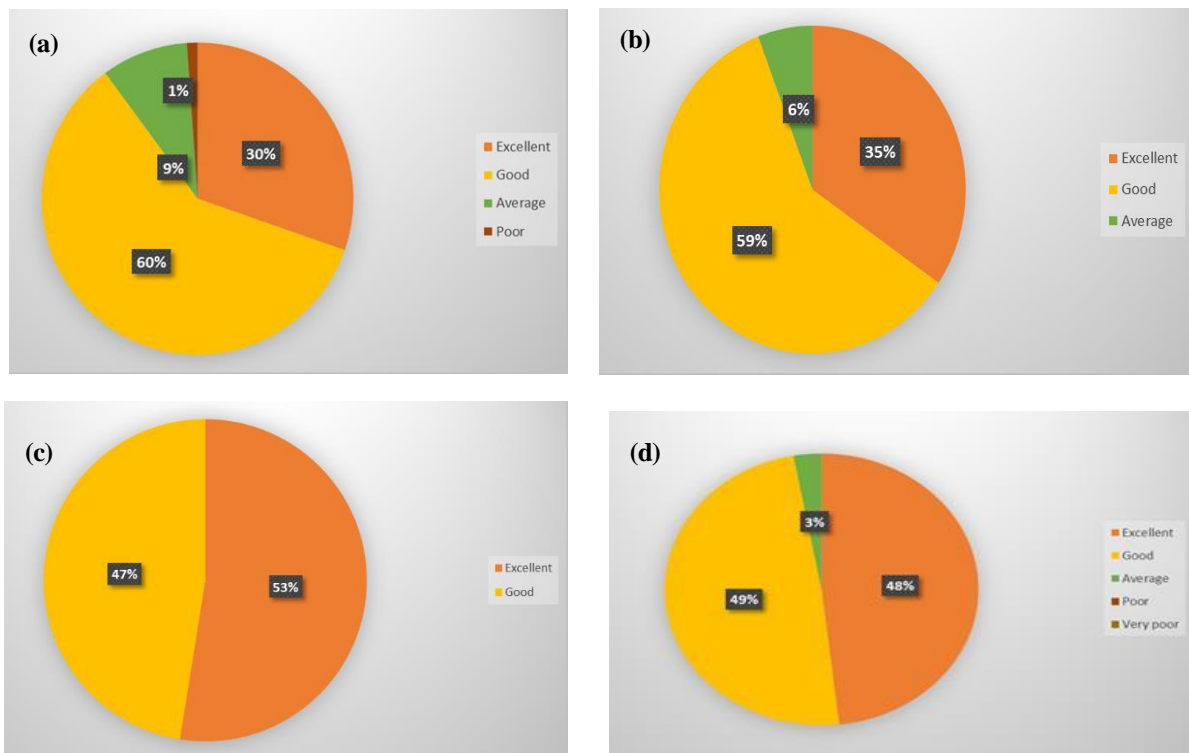


Figure 5: Analysis of “Overall satisfaction with the training” for (a) ToT programmes (b) Health sector trainings (c) Industry sector trainings (d) Education sector trainings

4.3.3 Challenges Identified:

Conducting training and awareness programmes has been quite challenging, especially considering the recent economic crisis that has taken place in the country. Following are some of the challenges faced when organizing and conducting the training and awareness programmes.

- Challenges in Securing Appropriate Training Venues
- Stakeholder Engagement and Interest in Training Programmes
- Escalating Costs in Training Programmes Implementation
- Navigating Attention Retention Challenges
- Administrative Challenges in Involving Schools for Education Sector Trainings
- Challenges in Engaging Small-Scale Jewellery Manufacturing Sector for Training Programs
- Challenges in Addressing Concerns Regarding the Managing Accumulated Mercury Waste

Annexure 3 – Final Report on Analysis of the Effectiveness of Training and Awareness Raising Programmes Conducted on Sound Management of Mercury and Mercury Containing Waste

5. Recommendations and future policy directives

The findings and insights obtained from the execution of three pivotal tasks, Output 2: Detailed analysis of mercury-free alternatives with their costs and benefits and recommendations for future policy directives; Output 3: Development of a National technical guideline on Environmentally Sound Management of mercury waste; and Output 4: Training and awareness initiatives for stakeholders across health, industrial, and education sectors propose a set of strategic recommendations and future policy directives.

5.1 Output 2: Develop a report on mercury-free alternatives with their costs and benefits and recommendations for future policy directives

5.1.1 Sector-Specific Adoption Strategies:

Different sectors in Sri Lanka may have varied economic capacities. Policies should consider this diversity, offering targeted strategies for each sector's transition to mercury-free alternatives.

5.1.2 Financial Incentives:

Given economic considerations, incentives such as tax breaks or subsidies can encourage businesses in Sri Lanka to invest in and transition to alternatives without causing financial strain.

5.2 Output 3: Develop National technical guideline on Environmentally Sound Management of mercury waste

5.1.1 Periodic Guideline Review:

Establish a mechanism for periodic reviews of the National Technical Guideline to ensure its relevance and effectiveness over time. Sri Lanka's waste management practices and technologies may evolve. Periodic reviews ensure that the guideline remains aligned with the latest advancements.

5.1.2 Integration with Local Waste Management Plans:

Integrate the National Technical Guideline into local waste management plans across regions in Sri Lanka. Aligning the guideline with local plans ensures that it becomes an integral part of regional waste management strategies.

5.1.3 Technology Transfer Support:

Facilitate technology transfer programs to disseminate best practices outlined in the guideline. Supporting the transfer of effective waste management technologies ensures that regions across Sri Lanka can benefit from successful practices.

5.1.4 Incentives for Guideline Adherence:

Develop incentives for businesses and organizations that actively adhere to the guidelines. Recognizing and rewarding entities in Sri Lanka that adhere to the guidelines encourages widespread compliance and responsible waste management.

5.3 Output 4: Trained and raised awareness of employees from health, industrial and education sectors, mercury equipment suppliers and enlightened of general public on health and environmental impacts of elemental mercury and wastes containing or contaminated with mercury and their management

5.3.1 Regional Training Hubs:

Create regional training hubs across Sri Lanka to decentralize awareness initiatives. Regional hubs facilitate easier access to training for participants in different parts of the country, considering Sri Lanka's geographical diversity.

5.3.2 Monitoring and Evaluation Framework:

Develop a comprehensive monitoring and evaluation framework to assess the effectiveness of training programs. Regular evaluations in Sri Lanka ensure that training initiatives align with objectives and provide valuable insights for continuous improvement.

5.3.3 Integration with Educational Curriculum:

Integrate elements of mercury awareness into the formal educational curriculum. Including mercury-related content in educational programs ensures that future generations in Sri Lanka grow up with a strong understanding of mercury issues.

5.3.4 Industry Collaboration in Training:

Encourage collaboration between training initiatives and industries for specialized programs. Collaboration in Sri Lanka between training programs and industries ensures that sector-specific challenges are effectively addressed.

5.4 General Future Policy Directives

5.4.1 Policy Flexibility:

Develop policies that are flexible and adaptable to changes in socio-economic conditions in Sri Lanka. Policies should have mechanisms for periodic reviews and adjustments to remain effective and relevant in the dynamic Sri Lankan context.

5.4.2 Collaborative Governance:

Encourage collaboration between government bodies, private sectors, and non-governmental organizations for effective governance. Mercury management involves multiple stakeholders. Collaborative governance ensures a coordinated effort and shared responsibility. Develop a mechanism to identify the demand for mercury and mercury-containing products, and establish a central monitoring system for the lifecycle management of mercury, covering its import, use, and export for environmentally sound disposal.

5.4.3 Technological Innovation Support:

Invest in research and development to support technological innovations for mercury-free alternatives. Sri Lanka should encourage and fund local research initiatives to discover innovative solutions that align with the country's technological landscape.

5.4.4 Capacity Building for Enforcement:

Strengthen enforcement capabilities to ensure compliance with mercury management regulations. Policies should prioritize training and capacity building for enforcement agencies in Sri Lanka to effectively implement and monitor compliance.

These recommendations and future policy directives are designed to address the challenges and opportunities presented by the Sri Lankan context in the transition to mercury-free alternatives and effective management of mercury, mercury containing products, equipment and waste. They emphasize sector-specific strategies, community engagement, policy flexibility, and collaboration to ensure a sustainable and tailored approach. By embracing these directives, Sri Lanka can fulfil its commitment to minimizing mercury's adverse effects on health and the environment, promoting a sustainable and responsible approach across sectors.

Annexures

Annexure 1 – Report of Mercury-Free Alternatives with their Cost-Benefit Analysis

Annexure 2 – National Technical Guideline on Environmentally Sound Management of Mercury Waste

Annexure 3 – Final Report on Analysis of the Effectiveness of Training and Awareness Raising Programmes Conducted on Sound Management of Mercury and Mercury Containing Waste

REPORT OF MERCURY FREE ALTERNATIVES WITH THEIR COST –BENEFIT ANALYSIS



REPORT OF MERCURY-FREE ALTERNATIVES WITH THEIR COST- BENEFIT ANALYSIS

**STRENGTHENING NATIONAL CAPACITY FOR PHASING OUT
MERCURY-ADDED PRODUCTS AND ENVIRONMENTALLY SOUND
MANAGEMENT OF WASTE CONSISTING OF, CONTAMINATED
WITH AND CONTAINING MERCURY IN SRI LANKA**

Ministry of Environment

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1. INTRODUCTION

Mercury has been widely used in products such as medical devices (thermometers, blood pressure gauges), switches and relays, barometers, fluorescent light bulbs, batteries and dental fillings, and in industrial production such as chlor-alkali plants, vinyl chloride monomer (VCM) production, acetaldehyde production and mercury-added product manufacturing. Mercury may also be a by-product of raw materials refining or production processes such as non-ferrous mining and oil and gas operations. However, mercury has been recognized as a global hazardous pollutant. Mercury emissions and releases can be human caused (anthropogenic) and may also come from natural sources. Once mercury is released into the environment, it persists in the atmosphere (mercury vapour), soil (ionic mercury) and aquatic phase (methylmercury (MeHg, or CH₃Hg⁺)). Some mercury in the environment ends up in the food chain because of bioaccumulation and biomagnification and is eventually ingested by humans.

As a response to the increasing threats from mercury, the world leaders took actions to phase out the use of mercury. The culmination of these actions was the Minamata which was opened for signature on the 10th of October 2013 and was entered into force on 16th August 2017. The objective of the Minamata Convention is to protect the human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds. It contains provisions that relate to the entire life cycle of mercury, including controls and reductions across a range of products, processes and industries where mercury is used, released or emitted.

Sri Lanka has signed the Minamata Convention on 8th October 2014. Furthermore, Sri Lanka became a Party to the Convention by ratification on June 19, 2017. As a part of commitments made under Minamata Convention, Sri Lanka conducted the Minamata Initial Assessment in 2017.

According to the Minamata Initial Assessment (MIA), Sri Lanka has never been involved in the manufacture of mercury-containing or mercury-added products, hence all needs are met by imports. As stated in the Mercury country situation report, 2018; the pesticides, paints, batteries, ayurvedic medicine, measuring equipment, switches/relays, cosmetics, CFL/LFL, dental amalgam and laboratory chemicals are identified as major mercury contained products. The MIA, Sri Lanka has mainly covered the Industrial, Health and Education sectors of Sri Lanka. The major contributors to Sri Lankan mercury inventory, according to the MIA, is given in Figure 1.

With signing of Minamata Convention, Sri Lanka has to fulfil the commitments for phasing out the use of mercury containing product and managing mercury containing waste in an environmentally sound manner. However, this requires capacity building and technical support to ensure that each sector gradually phase out mercury and mercury containing products and the waste properly managed.

Under the project on “Strengthening National Capacity for phasing out mercury added products and environmentally sound management of waste consisting of, contaminated with and containing mercury in Sri Lanka” a series of surveys carried out on mercury contained products and processes available in market under the Industry, Education, Health sectors using the MIA as the base document but not limited to it. Available alternatives for each identified products and processes were identified. Lists of mercury free alternative products or processes available locally or internationally in relation to Industry, Education, Health and Household sectors were prepared and a cost benefit analysis was carried out to identify feasible alternatives.

Further, this report make recommendation to fulfil the obligations of the Minamata Convention related to the products/ Processes in the Industry, Health, Education and Household sectors and propose policy directives necessary to fulfil the recommendations made. Mercury contaminated sites in Industry, Health, Education and Household (if applicable) sectors were identified.

This report has been arranged to present the findings in sector-wise. Accordingly, health, education and industrial sector related findings are presented in that order. Then the cost benefit analysis of identified mercury free alternative products and processes are presented. Annexes related to each chapter are presented at the end of the report.

2. HEALTH SECTOR

2.1 Introduction

Mercury is a naturally occurring heavy metal with a unique feature of being a liquid at room temperature. Its symbol is 'Hg' and the atomic number is 80. Mercury has a relatively high vapour pressure and it strongly depends upon environment temperature, and it vaporizes readily under ambient conditions.

Exposure to mercury poses a serious risk to the environment and human health worldwide. Exposure to mercury threatens our health, with many often-irreversible toxic effects. Mercury pollution also harms wildlife and ecosystems. Mercury can enter the body through inhalation, skin wounds, abrasions and ingestion. Adverse health outcomes of mercury exposure include impairment of cognition, permanent damage to the central nervous system, kidney and heart disease, infertility, respiratory, digestive and immune problems. Of even more concern in terms of public health is the toxicity produced when mercury emitted into the environment accumulates in lake, river, stream and ocean sediments. It is then digested and converted there by anaerobic organisms into methyl mercury, a more deadly form of mercury that builds up and gets concentrated in plankton, fish, birds, and mammals, including people. Methyl mercury is especially dangerous for fetuses, newborns, and children because it interferes with neurological development at incredibly low concentrations.

Exposure to elemental mercury in health care settings from spills or broken equipment, such as mercury-containing thermometers and sphygmomanometers (blood pressure devices), is a serious health problem for health employees, patients, visitors as well as those tasked with repairing and cleaning up such broken equipment. It is also a problem that is entirely preventable through the careful choice and use of mercury-free alternatives.

The Ministry of Health, Sri Lanka has taken initiatives to phase out Mercury containing thermometers and sphygmomanometers in the government health institutions. A letter has been issued by the Secretary, Health in 2013, requesting hospitals under the Line Ministry and Provincial administration to phase out the usage of Mercury containing thermometers and Sphygmomanometers. As such procurement of Mercury containing thermometers and Sphygmomanometers does not happen for government healthcare institutions at present by

Ministry of Health or Provincial Health Ministries. However, infrequently hospitals get Mercury thermometers and Sphygmomanometers as donations. This was mostly seen during the COVID-19 pandemic. Procurement of Mercury containing thermometers and Sphygmomanometers have not been banned in the private sector hospitals and clinics as yet. It can be seen, that still some medical practitioners prefer to use mercury sphygmomanometers. Department of Meteorology uses thermometers and barometers for environmental monitoring. They have the intention of replacing them with non-mercury alternatives but the equipment at present will continue to be used until they are non-serviceable. Due to the national obligations on the data accuracy, even the modern equipment is to be calibrated against classical equipment that contains mercury. Hence, they expect to retain a few mercury contained to take as reference values, even after gradual replacement of them.

- Previous studies carried out in the sector and studies reviewed
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- Global health effects of future atmospheric mercury emissions Yanxu Zhang, Zhengcheng Song , Shaojian Huang , Peng Zhang , Yiming Peng , Peipei Wu , Jing Gu , Stephanie Dutkiewicz, Huanxin Zhang, Shiliang Wu, Feiyue Wang, Long Chen, Shuxiao Wang & Ping Li
- Costs and benefits of Australia phasing down mercury Report prepared for the Department of the Environment and Energy, 2018

2.2 Methodology (Survey, Interviews, Secondary data gathering)

Identification of mercury containing products and processes available in government healthcare settings and finding out available alternatives for each identified product

was done using several methodologies.

Desk review

A literature survey was carried out on this aspect. The Minamata Initial Assessment conducted in Sri Lanka too was reviewed. It was revealed that in the health sector globally as well as locally, the following mercury containing items are being used commonly.

1. Mercury thermometers
2. Mercury sphygmomanometers
3. Amalgam
4. Fluorescent tubes and CFL bulbs
5. Certain laboratory chemicals containing Mercury

Conducting a survey

A survey was conducted to identify mercury containing products and processes available in government healthcare settings and to find out available alternatives for each identified product. A self-administered questionnaire with closed and open ended questions was developed and was pretested in some private hospitals. During the pre-testing, clarity, presence of any misleading questions, completeness, user-friendliness of the questionnaire and the overall time taken to complete the questionnaire were determined. The questionnaire was modified according to the findings during pretesting. Permission was obtained from the relevant authorities to conduct the survey. Questionnaire was emailed to heads of institutions in Base and above hospitals in the government sector. Heads of institutions were informed to nominate an officer to fill the questionnaire. They were requested to nominate the focal person from the following categories: Medical Officer (Public Health)/Infection Control Nursing Officer/Medical Officer of Health/ MOIC or a suitable officer. Nominated officers were given an online training on completing the survey questionnaire. Responses were received via e mail and data extraction was carried out. Every effort was done to increase the response rate. A random check was done to identify any errors in data entry and to assess the quality of data. Data was analyzed using descriptive statistics.

1. Collecting qualitative data

Two focus group discussions and three key informant interviews were conducted. Two focus group discussions were conducted in Kalutara and Kandy in person with a team of eight

healthcare staff comprising of Medical Officers, Sisters and Nursing Officers. Four key informant interviews were conducted via telephone with the following personnel.

- a. Bio Medical Engineer responsible for sphygmomanometers at the Bio Medical Engineering Division of the Ministry of Health
- b. Regional Director of Health Services, Kandy
- c. Director, Private Health Directorate, Ministry of Health
- d. Assistant Director from Medical Supplies Division, Ministry of Health

Questions were pre identified and a small guide was prepared. The findings were written down and the responses were identified and recorded.

2.3 Analysis

There are different levels of government healthcare settings and the numbers are as follows (as at 30th September 2022). These healthcare settings are distributed in all districts in Sri Lanka as mentioned in the below table.

Type of Hospital	Administration		Total
	Line Ministry	Provincial	
National Hospital	2	0	2
Teaching Hospital	18	0	18
Provincial General	1	0	1
District General	13	7	20
Specialized Hospitals	9	4	13
Base Hospital	7	73	80
Total	50	84	134

Table 2. 1 Number of Government Healthcare Institutions in Sri Lanka

Mercury containing products and processes in the government health care institutions (Base and above)

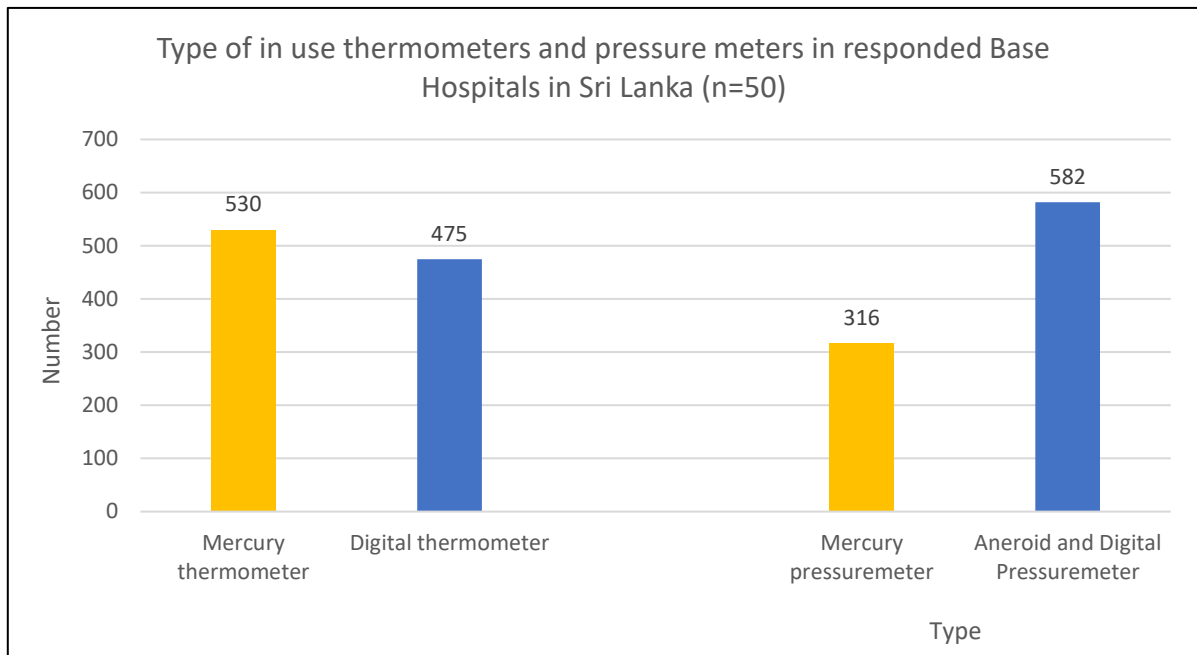


Figure 2. 1 Type of in use Thermometers and Pressure meters in responded Base Hospitals in Sri Lanka

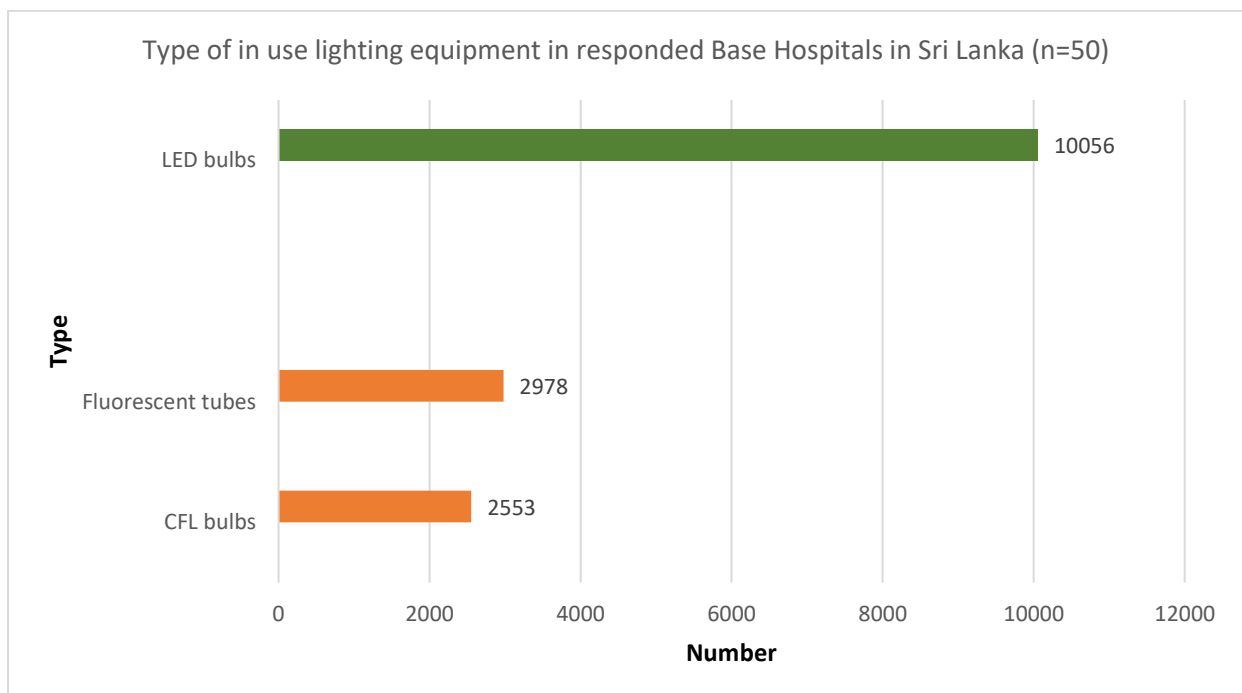


Figure 2. 2 Type of in use lighting equipment in responded Base Hospitals in Sri Lanka

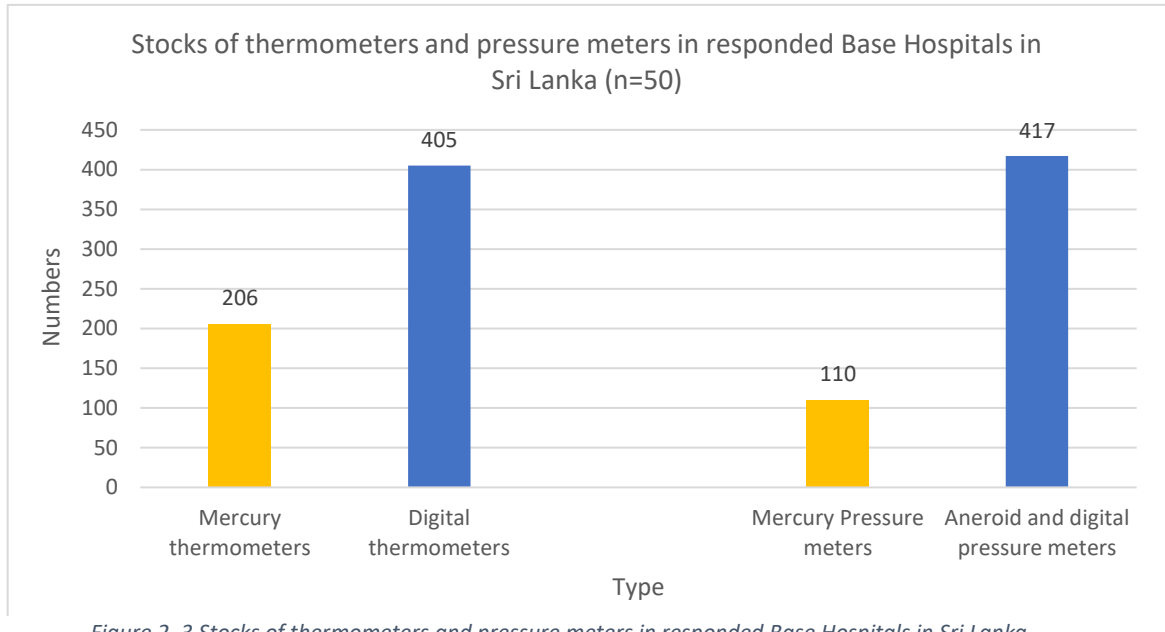


Figure 2. 3 Stocks of thermometers and pressure meters in responded Base Hospitals in Sri Lanka

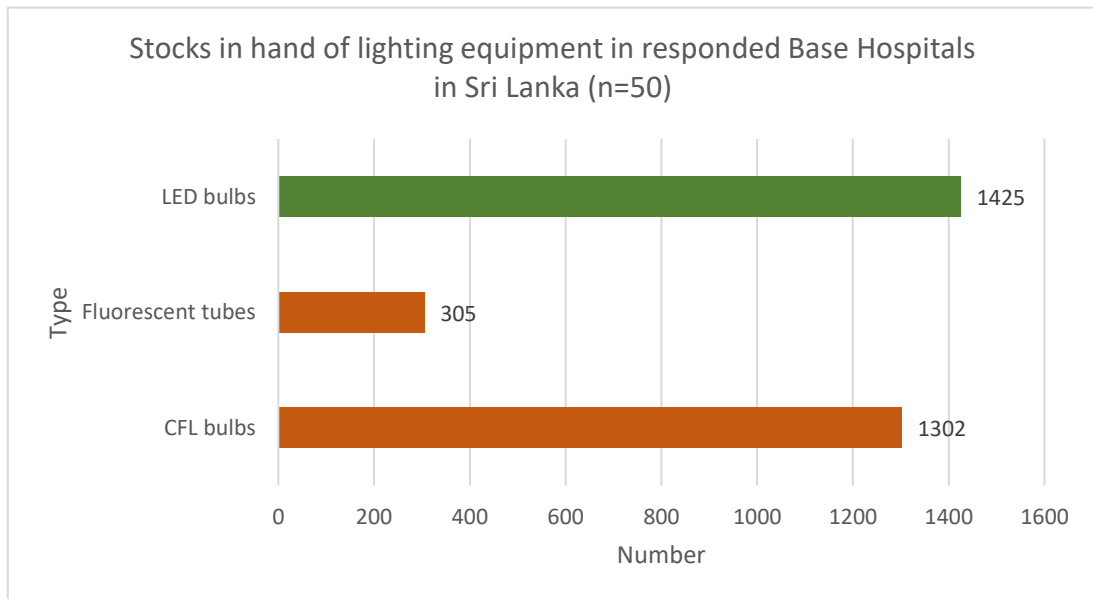


Figure 2. 4 Stocks in hand of lighting equipment in responded Base Hospitals in Sri Lanka

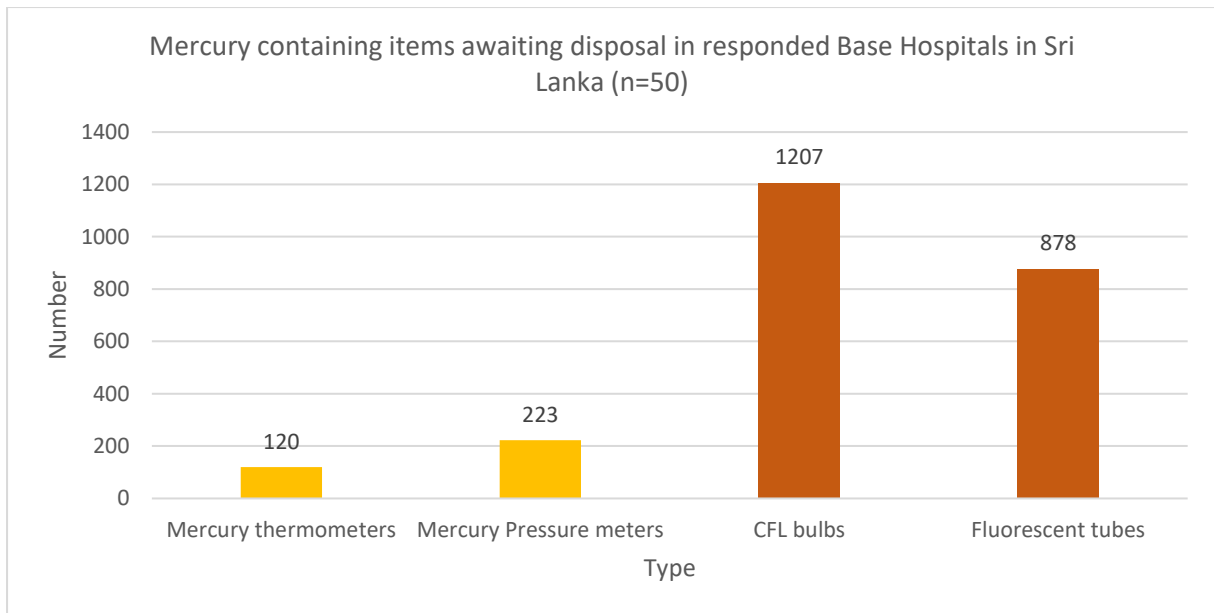


Figure 2. 5 Mercury containing items awaiting disposal in responded Base Hospitals in Sri Lanka

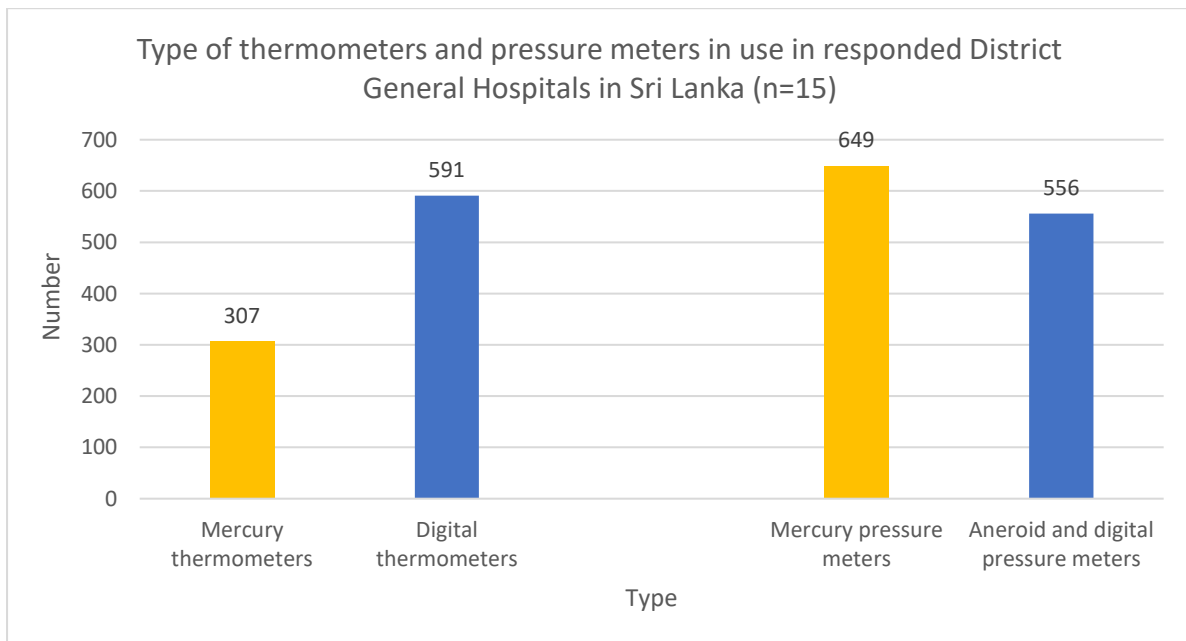


Figure 2. 6 Type of in use thermometers and pressure meters in responded District General Hospitals in Sri Lanka

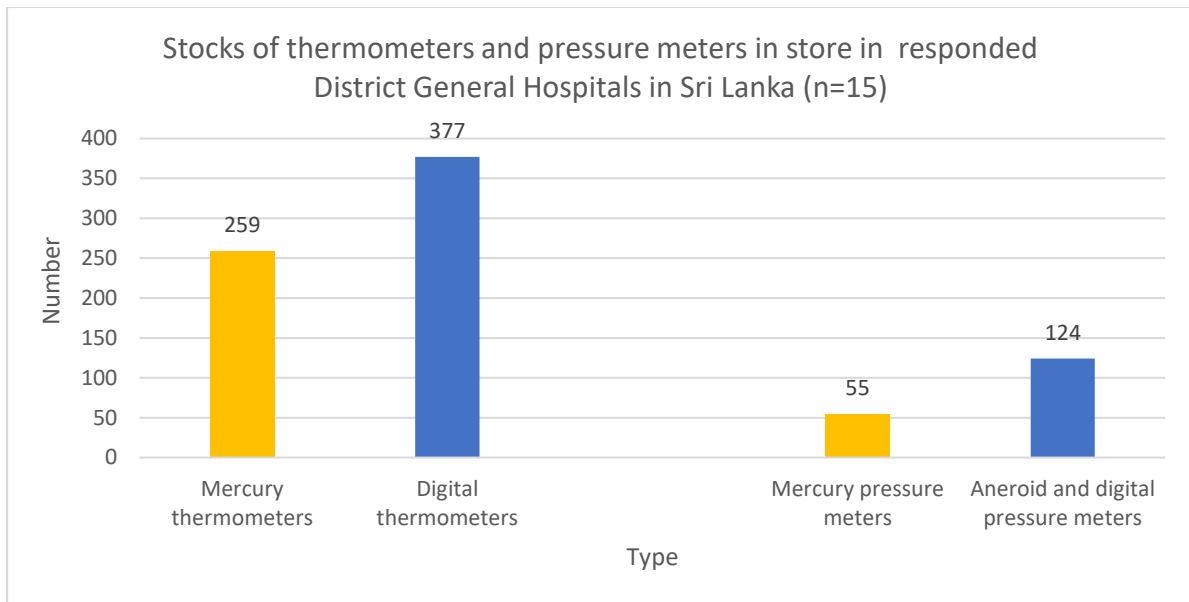


Figure 2. 7 Stocks of thermometers and pressure meters in store in responded District General Hospitals in Sri Lanka

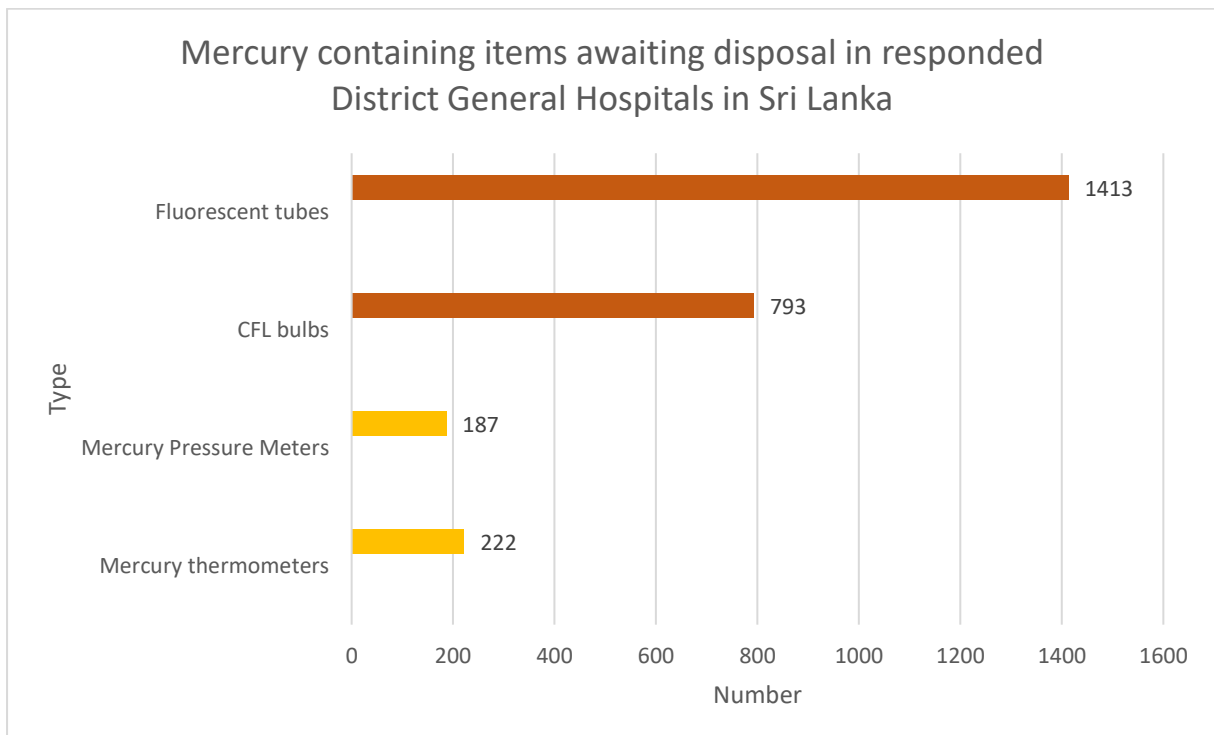


Figure 2. 8 Mercury containing items awaiting disposal in responded District General Hospitals in Sri Lanka

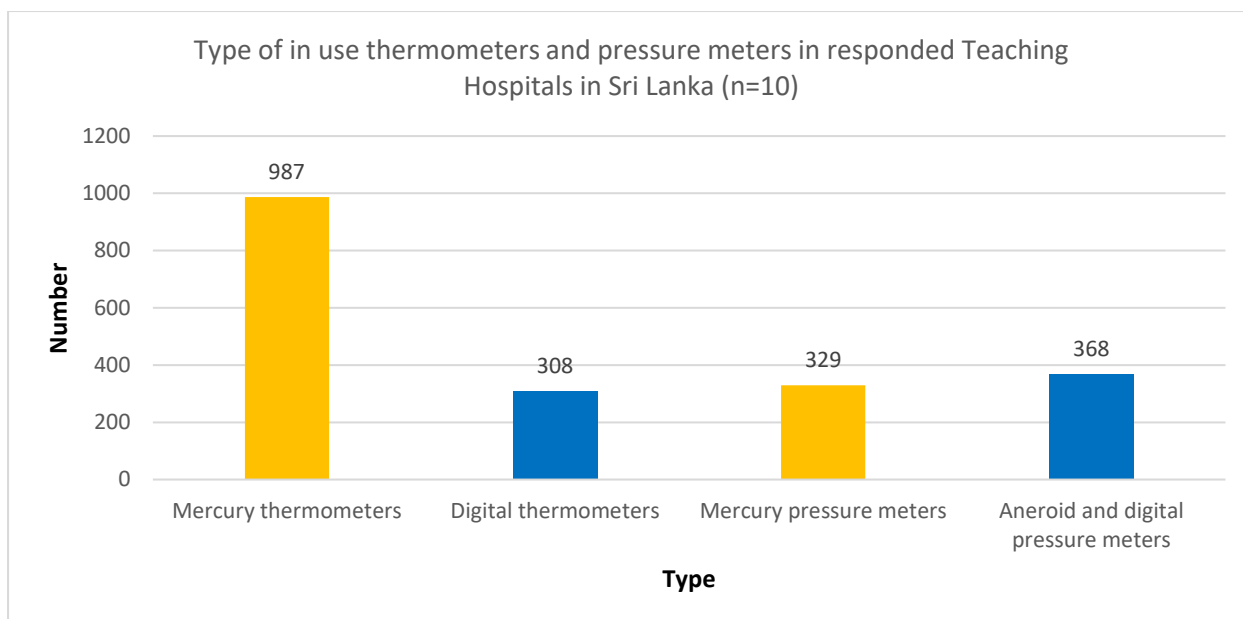


Figure 2. 9 Type of in use thermometers and pressure meters in responded Teaching Hospitals in Sri Lanka

2.4 Findings of the focus group discussions and the key informant interviews

1. The Bio Medical Engineering division is responsible for procuring pressure meters. They are well aware about the phasing out of the Mercury containing pressure meters. They do not procure Mercury containing pressure meters as per the letter issued by the Secretary, Ministry of Health in 2013.
2. They currently procure aneroid pressure meters and digital thermometers according to a specification developed. Over the past five years, they have procured around 3000 aneroid pressure meters and 2500 digital thermometers to be used in government healthcare institutions.
3. There is a preference for aneroid pressure meters over digital pressure meters by the health staff. However, during COVID-19 pandemic there was an increased demand for digital pressure meters in health institutions. Certain concerns regarding the accuracy of digital pressure meters by the health staff too were revealed.
4. The Medical Supplies Division is responsible for procuring thermometers. They too are well aware about the phasing out of Mercury containing items and they only procure digital thermometers for government healthcare institutions in Sri Lanka.
5. The procurement entities in the Provincial Health Ministries are aware about the Mercury phasing out decision of the Health Ministry and they procure only non-

Mercury containing thermometers and pressure meters for healthcare institutions under the Provincial system.

6. However, donations have been received with Mercury thermometers to some government health institutions during the COVID-19 pandemic.
 7. Amalgam is being used for dental procedures in the government health institutions. Still procurement of amalgam is taking place. However, they use Silver-Mercury capsule currently to prevent the release of mercury emissions when mixing and to ensure occupational health and safety to staff. Composite too is used for dental procedures in Sri Lanka. The cost and the effectiveness are some of the concerns.
 8. However, procurement of Mercury containing thermometers and pressure meters still continue in the private health institutions.
- Practices related to management of wastes containing or contaminated with mercury

Waste Mercury containing thermometers and sphygmomanometers (pressure meters)

As this equipment contain liquid Mercury, environmental sound management of such wastes cannot be done in Sri Lanka. Therefore, the Ministry of Health has advised health settings to store such wastes safely until a methodology is found. However, Ministry of Health has requested support from the Ministry of Environment in this regard. A joint project proposal has been submitted for GEF cycle 7 funding to find a solution for this issue.

The proposal is to collect all Mercury containing thermometers and sphygmomanometers from health institutions and to at least store in a safe central storage facility operated by a licensed operator and to send it to a country where such waste management facilities are available. Japan is found to have management capacity of liquid Mercury waste.

Unusable Mercury containing CFL and fluorescent tubes too are an issue since disposal modalities are limited. There are only two registered recyclers for managing Mercury waste (powdered form). However, the cost is significantly higher and they have limited capacity currently. Instructions have been given by the Environmental and Occupational Health Directorate of the Ministry of Health to safely store unusable CFL and fluorescent tubes until a solution is found with the proposed GEF project with the Ministry of Environment.

Awareness for health staff on Mercury spill management have been done. However, there are many gaps. Health institutions in the government sector do not have Mercury spill management kits. However, they have been instructed to collect the Mercury and put in a bottle/container and tighten the lid, label and keep it safely stored.

2.5 Discussion

Recommendation to fulfill the obligations of the Minamata Convention related to the products/ Processes in the relevant sectors and propose policy directives necessary to fulfill the recommendations made.

1. Instructions need to be given to private sector healthcare institutions to adhere to the phasing out of Mercury containing thermometers, sphygmomanometers, fluorescent tubes and CFL bulbs. This is possible through the Director, Private Health Regulatory Council. However, not all private health institutions are registered there. Therefore, it's important to seek the possibility of banning the importation of Mercury containing thermometers and sphygmomanometers since Sri Lanka has ratified the Minamata convention.
2. Government health sector hospitals need to be instructed not to accept Mercury containing thermometers and sphygmomanometers as donations
3. A proper and a feasible method of environmentally sound management of Mercury containing waste in the health sector needs to be developed. At least a temporary storage facility has to be established to collect Mercury waste in health institutions till a final disposal modality is identified. A national level program for collection, transport, intermediate storage and final treatment is essential to reduce the burden on healthcare facilities due to onsite storage of mercury wastes.
4. Guidelines need to be developed for Mercury spill management for health sector, Mercury waste management in the health sector and specifications for accurate aneroid and digital sphygmomanometers and thermometers.
5. Seek the possibility of using composite instead of amalgam at least for children and pregnant mothers.
6. Develop a communication strategy to improve oral health among Sri Lankans and especially children and pregnant mothers.

7. Review laboratory chemicals containing Mercury periodically to identify non-mercury alternatives and replace if feasible.
8. Develop an Management Information System so that Healthcare facilities can report information and data to support decision making, including the implementation of obligations under the Minamata Convention

2.6 Success stories in the health sector

Ministry of Health started the phasing out of Mercury containing thermometers and sphygmomanometers in 2013 even before the ratification of the Minamata Convention by Sri Lanka. Due to that decision, the Ministry of Health has been able to successfully implement the phasing out of these items. CFL bulbs and fluorescent tubes too are being phased out. Initially, it was challenging since the Medical Professionals were opposing the decision due to accuracy issues of the readings. However, awareness, improving the specifications and strictly adhering to the decision paved the way for the successful phasing out measures. Additionally Environmental and Occupational Health Directorate of the Ministry of Health, Sri Lanka supported the development of “Strategic planning for implementation of the health-related articles of the Minamata Convention on Mercury”. The WHO selected three countries in the world to obtain inputs for this and Sri Lanka was chosen as one country considering the initiatives taken for Mercury management in the health sector.

2.7 Conclusions

- Mercury containing products used in the health sector and the identified alternatives

The following mercury containing items were selected for cost benefit analysis to assess the feasibility of mercury alternatives. The cost benefit analysis is presented in Chapter 5 of this report.

	Activity/process	Equipment/item	Alternative(non-Mercury)
1	Measuring temperature in persons	Mercury thermometer	Digital thermometer
2	Measuring pressure in persons	Mercury pressure meter (sphygmomanometer)	1. Aneroid sphygmomanometer 2. Digital Sphygmomanometer
3	Lighting	CFL bulbs Fluorescent tubes	LED bulbs
4	Dental filling	Amalgam	Composite filling
5	Lab investigations	Hg containing stains for cervical cancer screening Other Hg containing stains	Harris Hematoxillin Mercury free stain for cervical cancer screening None

Table 2. 2 Items selected for cost benefit analysis

3. EDUCATION SECTOR

3.1 Introduction

Education sector in Sri Lanka consists of government schools, private and special schools, Pirivenas, public universities, private degree awarding institutions of higher education including medical schools, engineering schools, schools of law, technical and vocational training schools and National Colleges of Education.

This section describes the study carried out to identify the uses of mercury containing substances and equipment in the educational sector in Sri Lanka. The study collected data on mercury containing products and processes, quantifying need and inventories, mercury free alternatives products and processes and mercury contaminated sites to perform the cost benefit analysis and to propose suitable policy directives to phase out mercury from the educational sector.

3.2 Methodology

The data gathering methodology included literature reviews, questionnaire surveys, meetings and interviews. The collected data were verified, and cost-benefit analysis was carried out for selected significant mercury phasing out alternatives.

Methods of data collection

- Literature survey

The information on mercury containing products and processes in the education sector in Sri Lanka was obtained from several sources;

School sector; the modules given by the National Institute of Education and GCE A/L physics syllabus, reputed websites and other relevant documents.

Universities; published data, module materials etc., reputed websites and other relevant documents

The alternative products and processes for the identified mercury containing products were obtained from numerous publications.

The safe disposal methods and the mercury waste collection methods were obtained by studying related resources.

- Questionnaire survey

A questionnaire was developed by the information gathered from the literature survey. Primarily, Minamata Initial Assessment report was used to acquire the necessary background information for the questionnaire survey.

The questionnaire was designed to;

- identify and quantify mercury-containing products and processes
- identify mercury-contaminated sites
- identify available alternatives
- identify the methods of mercury waste management
- generate the information required for the Cost – Benefit analysis

The questionnaire is available in Annexure 1

- Selected higher educational institutions

For the convenience of data gathering, higher educational institutions were categorized as

- University category-1 Universities established under the authority of the University Grants Commission (UGC)
- University category-2 Universities established by Acts of Parliament of Sri Lanka
- University category-3 Institutes recognized to award degrees Under the Universities Act No. 16 of 1978

The full list of above three categories are given in Annexure 2.

Questionnaire surveys were conducted by emailing the questionnaire to the respective Dean of the Faculty offering programs in science, technology and engineering (Science Faculties,

Medical Faculties, Agriculture faculties, Dental Faculties and Engineering Faculties). In many instances, a faculty member was contacted over the phone and requested to complete the questionnaire by citing the importance of this project.

Selected schools

Schools representing all nine provinces that offer GCE Advanced Level Science stream courses were selected for the study. The full list of schools selected is given in Annexure 3.

The survey was conducted in schools by sending the questionnaire to the principal of the selected schools. In many instances, a school teacher in an Advanced Level Class was contacted over the phone and requested to complete the questionnaire by citing the importance of this project.

Interviews

Interviews and meetings were conducted for several universities and schools by visiting selected universities as well as via phone calls. Annexure 4 provides the list of educational institutions from which the data were gathered by interviews.

- Data verification

The module guides and the syllabuses provided from the National Institute of Education were used to confirm the data obtained from the questionnaire surveys sent to the schools. Moreover, meetings were held with the head of the science division, Ministry of Education to verify the data. Discussions were held with the experts in the sector and Manufacturers and Suppliers to confirm the data obtained from the universities and other educational institutes.

- Mercury contaminated sites

Mercury contaminated sites of the schools were identified during the interviews of the data collection step.

3.3 Results

Mercury contained products and processes identified from the collected data

- In universities

The summary of responses received from universities and higher educational schools are given below:

Type of Educational Institute	No. of Universities / Schools contacted	No of Faculties contacted	No. of responses received
University: Category 1	14	46	15
University: Category 2	2	4	0
University: Category 3	5	10	2
Total	21	60	17

Table 3. 1 Summary of responses received from Educational Institutes

The sources of mercury in universities are not always obvious. In many instances mercury containing chemicals are used for research purposes. Most of the mercury-containing equipment was acquired a decade ago and most of the new apparatus are free from mercury.

The identified mercury-containing products and processes found in universities are tabulated below.

Mercury containing products available in the universities

Mercury containing products	No of institutions reported having the compound	Quantity available	Applications
Mercury-containing thermometers	12	1095	To measure temperature
Hygrometers	2	2	An instrument used to measure humidity in air. This equipment comprises with 2 identical thermometers
Barometers	-	-	An instrument used to measure atmospheric pressure
Mercury U-Tubes (manometers)	-	-	A U-tube manometer with a small quantity of mercury is used to measure the static pressure difference between two locations A and B in a conical section through which an incompressible fluid flows.
Manometer in Boyle's apparatus	-	-	An apparatus used to demonstrate Boyle's law (elasticity of gases). The pressure gauge contains mercury in this apparatus (manometer fluid).
Manometer in Universal tensiometers	-	-	Provide the user with accurate information on soil moisture status. The pressure gauge contains mercury in this apparatus (manometer fluid).
Manometer in Blaine apparatus	-	-	Blaine apparatus is used for air permeability tests. The pressure gauge contains mercury in this apparatus (manometer fluid).

Calomel electrode (Hg: Hg ₂ Cl ₂ 0.75:0.25)	4	74	A reference electrode based on reactions between mercury (I) chloride and elemental mercury. These electrodes are commonly used in voltmeters and pH meters.
Dropping mercury electrode	3	5	Used to determine concentrations of electroactive species in liquids by measuring their mass-transport limiting currents
Mercury hollow cathode lamp for AAS	4	18	A hollow cathode lamp is used as a spectral line source for Atomic Absorption (AA) instruments for the detection of elemental Mercury (Hg).
Mercury spectral lamp	1	1	Low-pressure mercury lamps are used as relatively efficient sources of ultraviolet light for UV spectroscopy
Mercury plated flasks	-	-	Shiny mirror-like surfaces made out of mercury were used on flasks as transfer barriers.
CFL light bulbs	3	120	To illuminate
Linear fluorescent bulbs	1	600	To illuminate
Mercuric Oxide Batteries	-	-	In the past, mercuric oxide button-cell batteries were used in calculators, electronic cameras, and some electronic items requiring a small battery
Mercury containing Computer Equipment	1	163	Mercury is used in LCD screens and monitors

Table 3. 2 Mercury containing products available in the universities

Mercury containing processes (chemicals used for practical) available in the universities

Mercury containing compounds	No of institutions reported having the compound	Quantity available	Applications
Metallic mercury	2	250 g	This is an old stock kept at the stores. Sometimes metallic mercury is used as a display item.
Mercuric oxide: HgO		1.1 kg	An analytical reagent. Not used for routine practicals.
Mercury(II) oxide: Hg ₂ O	1	250 g	Use as a photo-catalyst in the visible light degradation of rhodamine B dye. Purchased for a non-routine student project.
Mercury (II) thiocyanate: Hg(SCN) ₂	1	100 g	Use for the determination of chloride ions in water by UV-visible spectroscopy. Used for non-routine student projects.
Mercury (II) Nitrate Dihydrate: HgNO ₃ .2H ₂ O	1	1 kg	Occasionally used as a reagent.
Mercury(II) chloride: HgCl ₂	2	200 g	Use as a topical antiseptic and disinfectant. HgCl ₂ was historically favored for its ability to enhance the staining properties of tissues, particularly with the trichrome stains. HgCl ₂ is also used as a reagent to form an amalgam with metals, such as aluminum and once amalgamated, aluminum can undergo a variety of reactions.. It is also used as a catalyst for the conversion of acetylene to vinyl chloride
Mercury (II) iodide: HgI ₂	1	600 g	Use for the preparation of Nessler's reagent. The Nessler's reagent is used for the detection of presence of ammonia.

Mercuric (II) acetate: $\text{Hg}(\text{CH}_3\text{CO}_2)_2$	1	200 g	Use for the oxymercuration reaction which transforms an alkene into a neutral alcohol. Purchased for a non-routine student project.
Mercury (II) sulphide: HgS	4	695 g	Use mainly as a pigment in paints, rubber, and plastics.
Mercuric sulphate: HgSO_4	1	600 g	Use as a catalyst for the production of acetaldehyde from acetylene and water. Can also be used to prepare Denigés' reagent to identify tertiary alcohols. HgSO_4 is also use for COD analysis
Dental amalgam containing mercury	-	-	Dental filling material used to fill cavities caused by tooth decay
Nessler's reagent: K_2HgI_4 containing solution	3	1.7 L	Use for qualitative analysis ammonium ion (NH_4^+ ion)
Millon's reagent: $\text{Hg}(\text{NO}_3)_2$ in HNO_3	2	900 mL	An analytical reagent used to detect the presence of soluble proteins.
Mercury containing COD vials	1	400 g	Use to remove the interference of Chloride in the sample when measuring COD

Table 3. 3 Mercury containing processes (chemicals used for practicals) available in the universities

- In schools

The summary of responses received from schools are given below:

Province	No. of Schools contacted	No. of responses received
Central Province	3	1
Eastern Province	2	0
Northern Province	5	1
Southern Province	2	0
Western Province	11	7
North Western Province	7	1
North Central Province	2	1
Uva Province	6	3
Sabaragamuwa Province	2	2
Total	40	16

Table 3. 4 Summary of responses received from Schools

It was revealed at a meeting held with the highest level administrators of school education that the school sector has already taken steps to phase out mercury containing experiments from the school curriculum (see Annexure 5-Circular No. 21/2021, Ministry of education). As a result, it was observed that the schools use only a few general purpose products containing mercury in their activities. The identified products and processes available in schools based on the literature and questionnaire surveys, are listed below:

Mercury containing products possibly available in the schools

Mercury containing products	No of institutions reported having the compound	Quantity available	Applications
Mercury-containing thermometers	2	80	To measure temperature
Barometers	1	3	To measure pressure

Table 3. 5 Mercury containing products possibly available in the schools

Mercury containing processes (chemicals used for practicals) possibly available in the schools

Mercury containing compounds	No of institutions reported having the compound	Quantity available	Applications
Metallic mercury	1	450 g	This is an old stock kept at the stores. Sometimes used as a display item.
Nessler's reagent: K_2HgI_4 containing solution	2	100 mL	Use for qualitative analysis ammonium ion (NH_4^+ ion)

Table 3. 6 Mercury containing processes

- Identified alternatives for the existing products and processes

A thorough literature review was carried out to identify alternatives for identified mercury containing products and processes. Table below shows a summary of the literature review:

Item	Application	Alternative
Mercury Lab Thermometer	To measure temperature of fluids	Alcohol and mineral spirits glass bulb thermometer, digital thermometers
Mercury Barometer	To measure atmospheric pressure	Aneroid, digital, and liquid-gas silicon pressure gauges
Hygrometer containing mercury thermometers	To measure humidity in air	Spirit-filled glass bulb, digital hygrometers
Mercury Hydrometer	To measure density	Lead ballast hydrometers, Hydrometer Mercury Free
Mercury Vacuum Gauge	To measure vacuum pressure	Digital, electronic or mechanical gauges that use a needle or Bourdon tube may substitute for certain gasses only
Mercury containing Manometer	To measure differential pressure	U-shaped tubes using any colored liquid, digital manometers
Mercury Molecular Motion Device	To demonstrate the kinetic theory of matter	Apparatus for use with overhead projector uses balls on a glass plate
Charles' Law apparatus	To verify the physics law that rules the volume variations of a gas (at constant pressure) as its temperature varies	Charles' Law apparatus with mercury free manometer
Mercury Boyle's Law Apparatuses	To demonstrate the relationship between the pressure of a gas and its volume while it is held at a constant temperature is 'PV = k' pressure by volume is a constant	A traditional Boyle's Law Apparatus showing the elasticity of gasses can be replaced with lower cost non-mercury apparatuses.
Mercury Thermostats	to sense and control room temperature	Non-mercury sealed switches, programmable and non-programmable electronic thermostats

Mercury Float Control Switches (e.g., used on sump pumps)	To control flow of fluid pumping	Non-mercury switches float control switches
Mercury switches		Hard-contact switches, solid-state switches, electro-optical switches, inductive sensors, capacitive sensors, photoelectric sensors, and ultrasonic sensors

Table 3. 7 Alternatives for mercury based products & processes, identified through literature

3.4 Identified alternatives for Mercury containing compounds

Mercury containing compounds are mainly used for research studies, therefore depending on the scope of the study numerous alternatives can be selected. Given below is a list of alternatives for some common uses.

Hg Compounds	Alternatives
Mercury chloride	Magnesium chloride or zinc
Mercury iodine	Formalin
Mercury nitrate	Freeze drying
Mercury oxide	Phenate method
Mercury sulfate	Ammonia, copper sulfate, Neosporin, mycin copper catalyst, silver nitrate, potassium, or chromium sulfate
Mercury (II) Oxide	Copper catalyst
Mercury (II) Chloride	Magnesium Chloride/Sulfuric Acid or Zinc Formalin, Freeze drying
Mercury (II) Sulfate	Silver Nitrate/Potassium/Chromium-(III) Sulfate
Mercury Nitrate (for corrosion of copper alloys) for antifungal use (mercurochrome)	Ammonia/Copper Sulfate Neosporin, Mycin
Mercury Iodide	Phenate method
Zenker's Solution	Zinc Formalin

Table 3. 8 List of alternatives for some common uses

- Metallic mercury and other mercury compounds imported to Sri Lanka for laboratory use

A study published in 2018 the Centre for Environmental Justice, revealed the quantity of mercury compounds imported to Sri Lanka. According to the import data, 1817.85 kg of metallic mercury was imported to the country in 2016. This amount has been distributed among the educational sector (laboratories), health sector (preparation of Ayurvedic drugs) and industrial sector (Artisanal Gold Waste Recovery). The amount delivered to the education sector was not reported.

The table below, shows the imports of mercury containing compounds and metallic mercury:

HS Code	Description	Net weight imported in 2016, kg
HS 28.05	Alkali or alkaline-earth metals; rare-earth metals, scandium and yttrium, whether or not intermixed or inter-alloyed; mercury.	
HS 2805.40	- Mercury	1817.85
HS 28.52	Inorganic or organic compounds of mercury, whether or not chemically defined, excluding amalgams.	

HS 2852.10	- Chemically defined All organic or inorganic compounds of mercury meeting the requirements a) to e). a) Separate chemical elements and separate chemically defined compounds, whether or not containing impurities. b) Mixtures of two or more isomers of the same organic compound (whether or not containing impurities), except mixtures of acyclic hydrocarbon isomers (other than stereoisomers), whether or not saturated. c) These products either dissolve in water or other solvents provided that the solution constitutes a normal and necessary method of temporarily for safety or for transport purposes. The used solvent does not render the product suitable for specific use other than for general use. d) Mentioned product with an added stabilizer (including anti-caking agent) necessary for their preservation or transport. e) Mentioned product upon the addition of an anti-dusting agent or a colouring substance added to facilitate identification or for safety reasons. These additives do not render the p	27.35
HS 2852.90	- Other Compounds of mercury that does not meet the requirements of HS Code: 2852.10.00 a) to e)	186.30
HS 2931.90.20	- Organo-mercury compound	No imports since 01.01.2013 to date

Table 3.9 Import details of mercury containing compounds and metallic mercury

(Source: Centre for Environmental Justice, 2018)

- Practices related to management of wastes containing or contaminated with mercury

Unfortunately, toxic waste management has been given the least priority in the context of national waste management planning. Irrespective of the content, all solid wastes are discharged together with the municipal solid waste management and are finally deposited at open dump sites operated by the local government authorities. At instances where the responsible authority has a concern over the consequences of mercury containing waste, the waste is collected and stored in designated areas within the premises. For example, broken mercury thermometers are stored in the fume hood after adding sulfur. In some universities, broken CFL bulbs are stored and taken away by the maintenance division.

Liquid wastes are usually discharged into common wastewater drains or stored within the premises.

- Cost benefit analysis

The following data were used for the cost benefit analysis to identify feasible mercury free alternatives for the education sector. The result of the analysis is presented in Chapter 5 of this report)

List of Mercury Added Product (currently used)						List of available Mercury free substitute Product 1				
No.	Item Name	Cost or Price per unit by 30 October, 2022 (LKR)	Hg amount (g)	No. of items available or used	Durability or warranty period	Item Name	Hg Amount	Cost or Price per unit by 30 October, 2022 (LKR)	No. of items needed (to replace)	Durability or warranty period
1	Mercury Lab Thermometer (Range 0 C-100C)	3,600	3	856 Faculties-12	5 years	Digital thermometers (Range 0 C-100C)	0	6,300	1	2years
2	Mercury U-Tubes manometers	64,940	60-600	Not asked in the questionnaire	20 years	Pressure gauges with diaphragm elements	0	4,460 - 17,800	1	5 years
3	Mercury Barometer	18,000	500	3 responses	50-60 years	Aneroid Barometer	0	14,528	1	30 years.
4	Mercury thermostats	12,111	3-5	Not asked in the questionnaire	10 years	Digital Programmable Thermostat	0	11,181	1	1 year
5	Mercury Hygrometer	10,279	3-7	2 responses	5 years	Digital Hygrometer	0	8,000	1	5 years
6	COD Vials with Mercury (25 vials per Pack)	30,260	0.025	Widely used	one time use	Mercury free COD Vials (25 Vials per Pack)	0	48,600	1	one time use

Table 3. 10 Data used for Cost Benefit Analysis

- Mercury contaminated site identification

Mercury contaminated sites of the schools were identified during the interviews of the data collection step. According to some respondents, the expired and used mercury containing chemicals are buried at the school sites. Apart from that, expired mercury containing chemicals are stored in the school and university premises. However, this data needed to be verified through a site visit.

3.5 Discussion

Mercury as a chemical compound is no longer used in the school curriculum in Sri Lanka. The Secretary of the Ministry of Education by the Circular No 21/2021 published on 09/11/2021 instructed to remove four (04) practicals from the GCE (A/L) syllabus in order to phase out mercury use. However, mercury thermometers, fluorescent light bulbs, CRT monitors, etc. are still in use. Even though mercury is toxic, the importance of keeping a small sample of metallic mercury was highlighted by the educational administrators as an exhibit for teaching purposes.

Most of the stakeholders of schools are not aware of the real danger of mercury and are not trained for the safe disposal in an event of accidental spillage. chemical incidents, such as the breakage of a mercury thermometer are not even reported to the responsible parties. The Ministry of Education has expressed its willingness to jointly conduct training programs, if technical experts can identify the needs and propose suitable training programs for teachers, students and laboratory staff.

At the end of lifetime, the inventoried items are disposed as per the regulations of the ministry.

Numerous types of mercury containing chemicals and products are used in higher educational institutions in Sri Lanka. Almost all mercury compounds found in the questionnaire survey were claimed to be used for research purposes, but not for routine laboratory experiments. Since no proper disposal system is established in the country yet, most universities, too, are keeping the toxic liquid wastes in safe containers until a solution is found. In an unofficial communication, it was revealed that the liquid waste containing toxic chemicals in some laboratories are disposed of with stormwater assuming that the chemicals will be diluted so that the impacts could be negligible.

Number of mercury-containing instruments are used in the higher educational sector. Mercury thermometers, pressure gauges, float switches, etc., are still in use and are purchased, since they are comparatively cheap, and no guidelines are in place for phasing out of mercury. However, most of such instruments can easily be replaced, since mercury free instruments are available in the market. Chemical Oxygen Demand (COD) is a parameter widely determined in water related research. Generally a mercury containing reagent is used in the COD test in order to suppress interferences of chloride ions in water (irrespective of whether an interference is present or not), but this can easily be avoided if the analysts can make sure that the water sample is free of chloride ions. Mercury hollow cathode lamp is used in Atomic Absorption Spectrophotometer (AAS) to detect mercury in liquid samples. Although mercury free lamps for this purpose are available in the market, expert analysts are skeptical of using them. Nessler's reagent was widely used in the past for the detection of NH_4^+ ions in liquid samples, but the modern high precision analytical equipment have replaced the traditional analytical technique.

The higher educational institutions, too, face similar problems as the schools, due to non-availability of safe disposal systems. Burnt out mercury containing light bulbs are either stored on-site or disposed of with municipal garbage. Out of order inventoried items such as computer monitors and laboratory equipment are sold out.

Substantial efforts are place elsewhere targeting educators for making awareness of mercury abatement. University of Wisconsin has made a publication on "Mercury in Schools and the Community: A National Issue," 2002. The Environmental Protection Agency of the United States of America has extracted information from the national issue and prepared the "Mercury: An Educator's Toolkit". The tool kit contains a variety of activities, educational videos, and other information designed to enhance students' understanding and appreciation of mercury and its potential health hazards. Depending on the needs of their curriculum, educators can select material from the most appropriate sections of the toolkit. The document, "Background Information for Educators" will assist teachers in considering the types of mercury information that best meet the needs of their students. The Department of Chemistry of Goucher College in the USA, took the step of eliminating mercury containing thermometers completely from laboratory use.

The New York State Department of Environmental Conservation (DEC), in conjunction with staff from the Northeast Waste Management Officials Association conducted half-day workshops in 2006-2008 to promote the elimination of mercury in schools. The workshops targeted school administrators, science teachers, health and safety coordinators, building and grounds personnel and school nurses. Feedback

from the post-workshop mercury surveys indicated that a total of 6.8 kg of various types of mercury compounds were removed from 7 schools in this region where workshops were conducted.

Mercury vacuum cleaner which is specifically designed to collect mercury (the metallic element) has been used in many instances to clean up spills of mercury in laboratories.

Although the concerned agencies such as the Ministry of Environment and Ministry of Health have programs to eliminate mercury, those initiatives are yet in their preliminary stage in Sri Lanka. In order to abate mercury use in educational sector and to minimize health and environmental impacts, following actions can be proposed:

1. Strong “Policy Directives” from the Government of Sri Lanka for mercury abatement
2. Declare “National Science Education Standards”
3. Educational and awareness documents, videos and brochures for schools;
 - a. Students of different age groups: Several volumes for making students aware of and appreciation of mercury and its potential health hazards
 - b. Teacher’s Guide: guides for teachers for helping students to grab the contents in Educational Videos
 - c. Mercury I.Q. Test: age-appropriate individual and group activities to assess what students know about mercury.
 - d. Guides for technical staff and teachers on “How to Take Action in Mercury Spillage” advising on how to react to accidental or deliberate releases of mercury and where to find assistance when removing mercury and mercury-containing devices from school property.
 - e. Guides for administrators to replace mercury and mercury-containing devices with nonhazardous, mercury-free alternatives
4. Guidelines for “Procurement, Use and Disposal of Mercury and its Compounds”
5. Establish a system for collection, transportation, treatment, recovery and disposal of toxic waste. This should include an engineered landfill for unrecoverable toxic waste including mercury.

3.6 Conclusion

Literature reviews, questionnaire surveys, meetings and interviews were held for identifying and quantifying the mercury containing processes and products in the educational sector. Relevant top officials in the Ministry of education were interviewed. Sectional Heads and Teachers in the GCE (A/L) science sections were contacted through school principals. In higher educational institutes, the relevant Heads of Departments were contacted through Deans of Faculties for gathering information.

Irrespective of repeated reminders, the rate of responses received for the questionnaire survey was at a very low level due to many reasons. Fear of disciplinary actions by the top management for releasing information that might damage the good name of the institution, lack of awareness of adverse impacts of mercury compounds, extremely busy work schedules after resuming educational activities due to covid restrictions and general attitudes about questionnaire surveys were among the reasons for low response rate.

Use of mercury as a chemical compound is being gradually removed from the school curriculum in Sri Lanka. In higher education too, mercury compounds are not used for routine laboratory experiments. Some mercury compounds are purchased from local suppliers mainly for research studies.

Thermometers, barometers, mercury containing u-tubes, Mercury hollow cathode lamps (for AAS), CFL light bulbs, fluorescent bulbs, mercuric oxide batteries, mercury contaminated computer parts are still in use in the educational sector. Most of these products can easily be replaced by non-toxic mercury free alternatives that are already available in the market.

No proper systems are established in the country for disposing of toxic chemicals, hence either they are stored securely until a solution is found or disposed of through unacceptable methods such as draining into the wastewater discharge system or handing to the municipal waste collectors.

It is utmost important for the Government of Sri Lanka to develop Policies for mercury abatement and declare national science education standards (which should include mercury abatement). Guidelines for procurement, use and disposal of mercury and its compounds are also essential to publish. Awareness tools should be developed targeting schools children, teachers, laboratory staff and administrators for self-learning and aggressive training programs should be conducted for a selected period to make all stakeholders aware about mercury and its adverse health and environmental impacts. Hazardous solid waste management is another important area that requires urgent attention.

- Annexure 1. Questionnaire survey on mercury-containing products and processes in the educational sector
- Annexure 2. Categories of higher educational institutions
- Annexure 3. Full list of schools selected for the survey
- Annexure 4. List of educational institutions from which the data were gathered by interviews
- Annexure 5. Ministry of Education Circular on mercury

4. INDUSTRY SECTOR

4.1 Introduction

Mercury is used in a wide variety of industrial activities such as power generation, oil refining, measuring and control devices, metal and electrical and electronic waste recycling, gold waste recovery, waste incineration, wastewater treatment and batteries (MIA Sri Lanka, 2019) in Sri Lanka. According to the Minamata Initial Assessment (MIA), the estimated Mercury input for the industry sector was 21,432 Hg/year while the estimated Mercury releases to the environment was 21,374 Hg/Year in 2019.

The industry sector Mercury content analysis was carried out in order to identify new activities/products that use or release Hg in the Sri Lankan context. Accordingly, the project team started the scenario analysis of the industry sector by analyzing the previous studies and reports in order to gain a more comprehensive understanding on the nation's condition regarding mercury management in the industry sector. In addition, this study describes the methods for gathering data and potential sources for doing so in order to pinpoint the processes and products used in the industry that contain mercury.

To determine the level of Mercury consumption in Sri Lanka's industrial sector, numerous researches had been conducted. The three main studies that are pertinent to the industry sector are the Mercury Country Situation Report (2018), the Minamata Initial Assessment (MIA) (2019), and Assessing the Mercury Usage in Small Scale Jewellery Manufacturing: A Detailed Study from Sri Lanka (2019).

4.2 Methodology

- Methods used for data collection

To determine the present state of previously implemented MIA, a thorough examination was conducted, and gaps were found. A thorough literature review has been carried out to find possible industrial sectors that use mercury-containing products and processes, in addition to the sectors that have been recognized through the MIA and relevant Sri Lankan publications. In order to identify the possible sectors, other factors such as stakeholder consultations, expert interviews relevant to the industry, information from manufacturers and suppliers, and other related effects have been taken into account. A thorough list of industries has been created for the survey after selecting the potential industrial list. Industry evaluation visits and an online survey with a structured questionnaire (Annex 2) have been used to collect data. A visit to collect data on-site has been planned for the industries that are unable to do so online. Key industries associated with Mercury exposure have been prioritized based on all of these facts.

- Data verification

Data verification aims to reduce human and instrument errors and guarantee that the data collected are as accurate as feasible. Several techniques have been employed to verify the data collected. As stated in the methodology, questionnaires, interviews, and literature were used to collect data. Data from the questionnaires and interviews were checked against the literature that was accessible. Verification of the information gathered from the literature was done through interviews and two stakeholder meetings. Additionally, professional opinions were sought for the aim of data verification.

4.3 Results

- Mercury contained products and processes available in the sector

The study found that Sri Lanka only has a small number of processes that use mercury. Different industrial sectors that potentially contain mercury are included in the MIA assessment report. The list of activities can be found below.

- Power Generation
- Oil Refining
- Small-scale Gold Mining
- Cement Production
- Metal Production
- Cosmetic Production
- Production of Chemicals
- Production of Product with Mercury Content
- Metal Recycling
- E-waste Recycling
- Gold waste Recovery
- Waste Incineration
- Wastewater Treatment

Thermal power, hydropower, and other unconventional renewable energy sources including solar power and wind power are the three main ways that electricity is produced in Sri Lanka. The country's sole coal-fired power station is the Lakvijaya Power Station, which is situated in Norochcholai, North Western Province. Results from the questionnaire and the interview show that despite using 250,344 T of coal every month, the power plant has not detected any mercury. However, according to the literature they have studied, coal could contain 0.1 mg/Kg of mercury. Currently, coal is conveyed in a covered belt convey system to pulverize after being deposited in a well-secured coal yard with geo membrane protection. Power plants produce bottom ash (2745 T/month) and fly ash (27400 T/month) as waste. Bottom ash is used to make bricks, and fly ash is transported entirely to the making of cement. There is a clean ash yard with a geomembrane underneath where fly ash and bottom ash can be dumped if necessary. The production of Autoclaved Aerated Concrete (AAC) blocks will thereafter use the ashes that were deposited. Currently, the plant controls emissions using Electro Static Precipitators (ESP) followed by a once through wet Flue Gas De-Sulphurisation (FGD) for acid gas scrubbing.

Mercury may be present during the refining of crude oil, according to MIA. In Sri Lanka, there is only one refinery for crude oil, and it is situated in Sapugaskanda. The crude Distiller unit can currently process crude oils that are similar to Iranian light and fulfill the necessary criteria. It was de-bottlenecked to boost the refining capacity to 50,000 barrels per steam day (6,900 tonnes per day). However, based on information gleaned from an interview at the oil refinery, there is no necessity for them to check for mercury contamination in the crude oil. The assay of crude oils also omits any information on mercury.

The MIA claims that there is no artisanal or small-scale gold mining (ASGM) in Sri Lanka. However, there have been a few rare cases of gold being extracted from river sand in recent years, although it is unclear whether mercury was used in these instances. Neither the questionnaire nor the interview provides information about this process.

In Kerawalapitiya's waste-to-energy facility, waste is currently being burned. The dumping of MSW is only done under restricted circumstances, based on the information we obtained from Western Power Company (Pvt) Ltd. The delivery of hazardous waste, e-waste, construction debris, and demolition waste to the plant is not permitted under the agreement with CMC / waste providers. However, both parties constantly monitor and manage these deliveries in order to run the plant. As a result, their process doesn't include any information about mercury contamination.

In Sri Lanka, the goldsmithing business is well-established, and traditional goldsmiths are renowned for their designer and traditional jewelry. The information acquired from the questionnaires and interviews indicates that mercury is employed in the process of recovering gold waste. A small-scale jewelry producer uses no more than 1g of mercury each month. Mercury is sold in the market for roughly Rs. 60,000 for 1 kilogram, and it is kept in plastic bottles. The materials are delivered in a self-sealing polythene packet and are purchased by jewelry manufacturers in quantities of 5g to 10g. According to the gold dust collection, they use a gold recovery method, which only occurs twice a year in some locations. These manufacturers are considering different strategies for recovering gold. But if there is more sand, they employ mercury to retrieve the gold. They use alternate procedures if the sand content is lower. There is no personal protective equipment accessible, and there is no procedure to follow while handling mercury in the locations visited during the study.

The manufacture and import of cosmetics in Sri Lanka is controlled by the National Medicines Regulatory Authority Act, No. 5 of 2015. Accordingly, all cosmetic manufacturers and importers should be registered at National Medicine Regulatory Authority (NMRA) and the products should follow relevant SLS product standards. The SLS 1342:2018 for Hair shampoo for babies (first revision)

prescribes the requirements and methods of sampling and test for baby shampoo based on surfactants and herbal shampoo with AMD No.1 (AMD 539:2021) while the SLS 1346:2018 for hair shampoo (first revision) prescribes the requirements and methods of sampling and test for hair shampoo based on surfactants with AMD No.1 (AMD 540:2021). Further, there are two standards for skin creams and lotions: SLS 742:2014 (Skin creams and lotions for babies) and SLS 743:2014 (Skin creams and lotions (First revision)) which prescribe the requirements and methods of sampling and test for skin creams and lotions with or without herbs/ herbal extracts and medicated skin creams and lotions. It does not prescribe requirements related to therapeutic/ medicinal claims and efficacy of skin creams and lotions. In all of these standards, it was mentioned that the maximum permissible level of mercury is 1 mg/kg and the products with mercury level below the maximum limit will be allowed for manufacture and import in the country.

The sole integrated cement factory in Sri Lanka is the Puttalam Cement Kiln, which is situated in the North Western Province's Puttalam District. The average annual clinker production rate is 640,000 t. Coal from Indonesia is used as the main kiln fuel. As a raw material for creating cement that is chemically resistant, coal fly ash plays a significant role in the production of cement. Currently, fly ash is imported from India in large quantities and obtained from the Norochholei Coal Power Plant. The specifics state that mercury is present in the manufacturing of cement in coal and sludge.

The central/common wastewater treatment plant facility is provided in ten of Sri Lanka's twelve BOI-managed industrial zones, which currently have twelve operational industrial zones with piped sewerage and sanitation services. In their treatment plants, the BOI reports that they have not detected any mercury. However, there is a possibility to contain mercury in chemical treatment plants which are controlled by industries.

Since Sri Lanka doesn't generate mercury, imports are required to meet all domestic needs. Additionally, Sri Lanka does not produce primary metals by extractive metallurgy or metal oxides, notably alumina (aluminum oxide), by refining bauxite using the Bayer process. At Paranthan in the Northern Province, Sri Lanka had a chlor-alkali production plant that stopped operating in 1985. As a result, Sri Lanka now lacks infrastructure for producing basic chemicals. The current chemical businesses use imported chemicals and active components to create chemical products.

Since Sri Lanka has never produced anything with mercury in them or added to them, all of the country's needs are satisfied by imports. Since there is no such technology in Sri Lanka, recycling of mercury is

not done there. When fluorescent lights are recycled, just the mercury and phosphor powder are retained until they are exported to Germany for refinement.

Further Sisili Hanaro Encare and Nithya papers were selected for the study. Despite being a facility for the burning of medical waste, Sisili Hanaro Encare has not found any mercury in its materials or in the Ash. Also, as a paper manufacturing company, Nithya papers has not detected any mercury in their process.

- Identified alternative for the existing products and processes

The analysis identified waste gold recovery as the primary process in Sri Lanka that uses mercury. As a result, alternatives to the gold recovery procedure have been found using the questionnaire and the interviews. Despite the low recovery rate, these techniques are used by jewelry producers to reclaim the gold.

Item Name	Cost or Price per unit by 30 October, 2022	No. of items needed (to replace)	Gold Recovery	
mixture of "Pushkara", "Nawasaram" (Borax Powder) and Potassium Nitrate	Pushkara - Rs. 2300 per Kg, Nawasaram - Rs.1500 per Kg, Potssium Nitrite - Rs.5200 per Kg	1.5g of gold is recovered from 2g of the mixure	80-90%	Potassium Nitrate (2) + Pushkara (1)
Sodium Bicarbonate	Rs. 1400 per Kg	1.5g of gold is recovered from 2g of sodium bicarbonate	80-90%	
Aqua Regia Process			80-90%	HNO ₃ +3HCL

Table 4. 1 Alternatives used for Gold recovery

Further, below details have been identified for alternative methods of gold separation (De Silva, A.D.C et al., 2019);

1. Use a mixture of "Pushkara" (Na₂O 98.2%, MgO 0.99%), "Nawasaram" (Borax Powder), and potassium nitrate for chemical separation. According to those who participated in the interviews, this method's main disadvantage is that its yield is not as high as it would be if gold were recovered using hexavalent chromium instead of mercury. This technique can be suggested as an environmentally friendly way to recover gold from waste when compared to the separation of gold using mercury. The employed chemicals are substantially safer for both humans and the environment.
2. Aqua regia solution-based chemical separation. The acid solution known as aqua regia is created by combining three parts of HCl with one part of concentrated HNO₃ (HNO₃+3HCl). Nitrogen Oxide (NO_x), a very toxic and corrosive gas, is produced in large quantities during the decomposition of this extremely concentrated acid. As a result, under normal circumstances, this method cannot be recommended as a good alternative method to be used in gold recovery. However, by developing a technique to capture and purify the gases released during the process, this method may be promoted as a good mercury-free alternative for gold separation.
3. Biological separation employing fruit extract from *Tamarindus indica*. The forebears of today's practitioners used this technique and had previously recovered gold using tamarind extract. The method of gold separation was not well understood by anyone, and it was advised against because of its poor yield and efficiency. On the other hand, a literature review revealed some recent journals on the use of tamarind extract to separate gold nanoparticles.

In addition to these alternatives, further alternatives have been identified covering other processes using the literature. These methods are available in the Annex 1.

- Practices related to management of wastes containing or contaminated with mercury

According to the jewelry manufacturers, they do not follow any procedure to handle mercury or mercury-containing waste. In addition to that, PPE is not used when using mercury. However, Lakvijaya Power Plant maintains a well maintain ash yard with an under layed geo membrane.

4.4 House hold Sector

No survey was conducted covering the domestic sector due to practical difficulties. However, during the stakeholder consultation under Task 2 of the project, certain suggestions were made by the participants. Due to the widespread nature of the sector, it is very important to reduce the mercury emission from households.

Implementation of the following recommendations will help to reduce the mercury release to the environment from the disposal of mercury containing items by households

1. Carrying out a national level campaign to raise the awareness of citizens on the mercury containing household items, risk of mercury and proper disposal methods of mercury containing items.
2. Resing the awareness and technical capabilities of local authorities for proper management of hazardous wastes, including mercury.
3. Develop infrastructure and procedure for local authorities to safe collection and intermediate storage of hazardous materials.
4. Developing a national level programme for environmentally sound management of hazardous waste including mercury.
5. Strict imposing of the ban on open burning of wastes.
6. Phasing out of mercury containing batteries, switches, and other household items.

4.5 Discussion

The industry sector of Sri Lanka doesn't incorporate manufacturing processes in which mercury or mercury compounds are used, but the sector use mercury added products or materials during the manufacturing processes. Coal is a major contributor for the Mercury release in the country during energy consumption activities in the Norochholei Coal Power Plant and therefore, it is recommended to develop a guideline to optimize the process, air pollution control and emission monitoring in the power plant. However, there are two emission control mechanisms in the plant, namely Electro Static Precipitators (ESP) and Flue Gas De-Sulphurisation (FGD) which are ineffective in removing Mercury emissions from the production process.

The quality of cosmetics is controlled by the National Medicine Regulatory Authority (NMRA) followed by the Sri Lanka Standards for relevant products as mentioned in the results section. The standards have mentioned that the maximum level of Mercury in cosmetics should be 1 mg/kg or 1 ppm and according to the Minamata convention, the cosmetics with mercury content above 1ppm or 1mg/kg should be phased out. However, the testing of cosmetic samples is carried out by the manufacturer or the importer while there is no proper mechanism for random quality checking in the products. Therefore, it is recommended to develop a random sample testing mechanism for the products in order to verify the compliance with the SLS standards over the NMRA licensing period.

Industry sector should follow National Environmental (Protection & Quality) Regulations (Gazette No. 1534/18) during the discharge of their wastewater into the environment. Central Environmental Authority closely monitor the wastewater qualities when they issue the Environmental Protection License (EPL), however, both sludge and wastewater might consist of trace quantities of Mercury. Generally, the sludge generated from Chemical wastewater treatment plants in Sri Lanka are handed over to INSEE Ecocycle for co-processing bearing a cost for transportation by the company. In this context, it is recommended to identify Mercury contaminated sludge and wastewater generating industry and levels of Mercury available, and to propose a suitable mechanism for Mercury contaminated sludge waste management in Sri Lanka.

In Sri Lanka, Gold waste recovery in the small-scale jewellery sector is carried with Mercury due to its high efficiency to extract gold dust waste. However, the health and environmental impacts of this process is high as people directly expose to Mercury during the process. However, there are alternatives for Mercury that could be used in the process of Gold waste recovery. The use of a mixture of "Pushkara" (Na₂O 98.2%, MgO 0.99%), "Nawasaram" (Borax Powder), and potassium nitrate and Aqua regia solution are the major alternatives available for the Gold waste recovery sector. Therefore, it is recommended to develop guidelines for alternative mechanisms, process optimization and safety for Gold waste recovery sector. Further, regulations and policies are required to control Mercury use in this sector.

- **Mercury contaminated sites**

As small-scale jewelry manufacturers use mercury to extract gold dust, there is a chance that the land around them could become contaminated. Some people purchase the soil of these sites because it may contain gold since these operations happen for a long period of time. When extracting gold, they also use mercury. As a result, the environment around them might also be contaminated.

- **Case studies/ success stories**

Through the investigation, we were able to pinpoint additional strategies for gold recovery in the industry of small-scale jewelry production. There is a case study on gold extraction utilizing borax smelting in a global context.

Location	Amalgamation	Borax smelting
Suerte 1, Bolivia	0.1 gram	0.5 gram
Suerte 2, Bolivia	0.4 gram	0.5 gram
Gaang 1, Philippines	1.2 gram	3.2 gram
Gaang 2, Philippines	2.3 gram	4.8 gram
Gaang 3, Philippines	1.8 gram	4.2 gram
Gaang 4, Philippines	7.2 gram	22.5 gram
Kias, Philippines 1	0.4 gram	1.1 gram
Kias, Philippines 2	0.8 gram	1.3 gram

(Source: Appel and Na-Oy, 2014)

The aforementioned findings demonstrate that borax smelting, a mercury-free gravity gold extraction method, recovers noticeably more gold than amalgamation. The trials mentioned above demonstrate that the mercury-free procedure is a little quicker than amalgamation of the entire ore.

Outcomes from projects in the Philippines, Dialogos, Denmark, Indonesia, GAHP, Bolivia, European Union, Plagbol, and Blacksmith, New York were used to cite the results. Actlabs in Canada performed gold and mercury analysis.

According to the study, “Assessing the Mercury Usage in Small Scale Jewelry Manufacturing: A Detailed Study from Sri Lanka”, there are three distinct waste gold separation procedures, each with advantages and disadvantages.

Existing Possible Non-Mercury Alternatives for Waste Gold Separation	Advantages	Disadvantages
Mixture of Pushkara, Nawasaram & Pottasium Nitrate	<ul style="list-style-type: none"> • Low cost • Environmentally friendly • Raw materials are easy to find 	<ul style="list-style-type: none"> • More time consuming • Low yield

Aqua regia solution	<ul style="list-style-type: none"> • High yield • More purity 	<ul style="list-style-type: none"> • Chemicals used are hazardous • Release toxic and corrosive gases during the process
Tamarindus indica fruit extract	<ul style="list-style-type: none"> • Environmentally friendly 	<ul style="list-style-type: none"> • Low yield • Less efficient

(Source: De Silva et al, 2019)

We also discovered success stories from significant jewelry manufacturers in Sri Lanka while conducting interviews. Devi Jewelers and Ravi Jewelers claim to have taken mercury out of the gold dust recovery method. Therefore, gold dust recovery involves the use of an aqua regia solution and a borax powder mixer.

4.6 Conclusion

A literature review, a structured questionnaire, and expert interviews were used in the study. Through the investigation, potential mercury-containing areas were discovered. Power generation, cosmetics manufacturing and import, wastewater treatment and gold waste recovery are the major sectors that release Mercury into the environment in Sri Lanka. Therefore, the development of guidelines should be carried out for all the above sectors; In power generation, process optimization, air pollution control and emission monitoring should be covered while the cosmetics sector requires a random sampling mechanism to be established. Identification of Mercury contaminated sludge and wastewater generating industry and levels of Mercury available, and proposing a suitable mechanism for Mercury contaminated sludge waste management are the major areas of consideration the Wastewater treatment.

Small-scale jewelry production is the primary industry sector to take into account for mercury because they use it for gold dust recovery. Additionally, there are Mercury alternatives that can be utilized in the recovery of gold waste. Borax powder mixer and aqua regia solution were noted as the main alternatives. The promotion of alternatives in this sector should be carried out through regulations and policy directives. Cost-benefit analysis of the industry sector can be found in chapter 5.

4.7 Reference

Appel, P.W.U. and Na-Oy, L.D. (2014). Mercury-Free Gold Extraction Using Borax for Small-Scale Gold Miners. *Journal of Environmental Protection*, 05(06), pp.493–499. doi:10.4236/jep.2014.56052.

De Silva, A.D.C., Rubasinghe, T.M., Manthirathne, M.A.N.C., Wewegedara, W.G.C.N., Diyabalanage, R.S., Jaysinghe, R.M.N.P.K. and Dharmaratne, T.S., (2019). Assessing the Mercury Usage in Small Scale Jewellery Manufacturing: A detailed study from Sri Lanka.

5. COST BENEFIT ANALYSIS

Mercury pollution has societal costs, such as damage costs from negative effects on human health and the environment, lost income from reduced commercial fisheries, and administrative costs for scientific research and development, control, and risk communication (Spadaro and Rabl, 2008). The most serious human health impact of global mercury pollution, according to available literature, is neurological damage leading to impaired brain development when exposure occurs during the prenatal phase (if pregnant women ingest food contaminated with methyl mercury). The impaired brain development results in a loss of IQ (Intelligence Quotient) points. Increased risks of cardiovascular disease are among the other toxicological effects. The societal costs associated with IQ loss include lost earnings and education costs.

A cost-benefit analysis of mercury-free alternative products in the industry, health, and education sectors is conducted in this study, with input from relevant sector experts. The relevant CBA parameters used in the estimation are summarized in Table 1 and 2. The basic parameters for this study were derived from previous literature and a survey conducted by the research team. Damage costs contributions for Hg are based on a study conducted by Nedellec and Rab (2016). It primarily consists of the cost of mortality and IQ losses.

Summary of the parameters

Variable	Parameters	Note
Damage cost (Rs per kg of mercury released).	73,310	Global Average*
Global inflation rate (%)	2.61	10-year average
Inflation rate in Sri Lanka (%)	5.33	10-year average
Discount rate (%)	7.2	Five-year average

Table 5. 1 Summary of the parameters

* Taken from the study conducted by Nedellec, V. and A. Rab .(2016). Costs of Health Damage from Atmospheric Emissions of Toxic Metals: Part 2—Analysis for Mercury and Lead, Risk Analysis, Vol. 36, No. 11, 2016

A large body of research has linked mercury exposure to negative health effects in humans. The majority of these studies have addressed the presence of Mercury in the environment in various forms, the most toxic being methyl mercury (Trasande et al. 2005). This form also bioaccumulates in aquatic food chains. Fish consumption is thus one of the most important human exposure pathways (Nedellec and Rab, 2016). Evidence shows that a significant proportion of humans and wildlife worldwide are exposed to methyl mercury.

The findings of most studies in this area show that the cost of damage varies significantly. According to Trasande et al. (2006), the true cost of methyl mercury exposure from American emissions ranges from \$0.4 to \$15.8 billion per year. According to Shih and Tseng (2014), health costs in Taiwan, including excess mortality and IQ loss, were US\$1.87 million per kg of mercury emitted, while health costs were only US\$0.32 million when mortality costs were excluded. Giang and Selin (2016) present results in terms of benefits per unit of avoided Mercury emissions in the United States. This research was conducted in the context of the UN Minamata Convention on Mercury and the United States Mercury and Air Toxics Standards (MATS) policy, with a focus on the benefits experienced in the United States between 2016 and 2050. costs, which provide global averages for cost estimates.

Summary of the Mercury Added Products and alternatives

Mercury Added Products				Mercury Free Products		
Name of the item	Unit Price (Rs.)	Mercury content (g)	Durability (year)	Name of the item	Unit Price (Rs.)	Durability (year)
Health Sector						
Hg thermometers	450	0.5-1.5	10	Digital thermometers	10,400	7
Hg pressure meters	20,000	3.0-4.0	12	Aneroid pressure meters	30,000	5
Mercury Lab Thermometer (Range 0 C-100C)	3,600	3.0	6	Digital thermometers (Range 0 C-100C)	6,300	2
Mercury U-Tubes manometers	64,940	60.0 – 600.0	20	Pressure gauges with diaphragm elements	17,800	5
Fluorescent tubes	2,500	10.0 – 15.0	8000-10000 hours	LED bulbs	3,500	30000-40000 hours
CFL bulbs	800	4.0-5.0	8000-10000 hours	LED bulbs	1500	30000-40000 hours
Education Sector						
Mercury Barometer	18000	500	55	Aneroid Barometer	14528	30
Mercury thermostats	12111	3.0-5.0	10	Non-mercury thermostats	11181	1
COD Vials with Mercury (25 vials per Pack)	30260	0.001		Mercury free COD Vials (25 Vials per Pack)	48,600	
Industrial Sector						
Mercury use for Gold recovery	60 per gram		26878	1. Mixture of "Pushkara", "Nawasaram" (Borax Powder) and Potassium Nitrate 2. Sodium Bicarbonate		1.46 1.05

Table 5. 2 Summary of the Mercury Added Products and alternatives

Note: A significant price variation was observed in each item. Average price was used for both categories in this study.

The present value of the MATS scenario's benefits to the United States over the period to 2050 is estimated to be USD 147 billion. These are benefits to the United States that are entirely due to reductions in domestic mercury emissions (Dubourg, 2018). The present value of the Minamata scenario's benefits to the United States over the same time period is estimated to be USD 339 billion (Dubourg, 2018). These are benefits to the United States that are entirely due to reductions in mercury emissions in the rest of the world. It is clear that the estimates provided by these studies are specific to those countries, and without a proper benefit transfer approach, these estimates cannot be applied to countries such as Sri Lanka. As a result, this study employs Nedellec and Rab (2016)'s average damage.

Cost-benefit analysis undertaken in this study attempts to compare the costs and benefits of introducing mercury free alternative products, where both are expressed in monetary units. This involves several steps as explained below.

1. Identify the list of Mercury Containing/added Products which are used in health, education, industrial and household sectors in Sri Lanka.
2. Identify the initial costs (prices), maintenance costs, and damage costs of mercury which includes mainly health cost.
3. Estimate the total cost of using Mercury Added Products including damage cost assuming the equal probability of being damage of each item during its life time.
4. Estimate the net present value of the cost using the following equation

$$NPV = \frac{R_t}{(1 + r)^t}$$

NPV = Net present value

R_t = Net cash flow at time t (total cost of the mercury added product in each time period)

R = Discount rate

t = time of the cash flow

5. Identify the list of alternative mercury free product for replacing the mercury added product
6. Estimate the cost of replacement after adjusting to the durability
7. Compare the NPV of the cost of mercury added product and mercury free product

Due to the lack of country-specific data on the external cost of mercury emission, the average damage cost in 2013 was derived from the literature. To determine the present value of the cost, it was adjusted for inflation using the 10-year average global inflation rate. The survey data provided the majority of the other information for this study. The central bank's annual report for 2021 provides inflation and the

discount rate. Due to the wide price range, an average price for each item is used in this study. However, the comparison was made to different mercury levels in each product. The estimated damage cost for each item is reported in the Table 3. Table 4 reports the estimated costs of mercury and products and cost of mercury free products

Estimated damage cost for each item

Name of the item	Estimated Damage Cost (Rs.) - 1	Estimated Damage Cost (Rs.) - 2
Hg thermometers	18,000 (Hg 0.5 g)	54,000 (Hg 1.5g)
Hg pressure meters	114,319 (Hg 3.0g)	152,425 (Hg 4.0g)
Mercury Lab Thermometer (Range 0 C-100C)	96,653 ((Hg 3g)	
Mercury U-Tubes manometers	2,895,333 (Hg 60g)	2,895,334(Hg 600g)
Fluorescent tubes	314(Hg 0.01g)	470 (Hg 0.015g)
CFL bulbs	125(Hg 0.004g)	157(Hg 0.005g)
Mercury Barometer	78,801,373(Hg 500g)	
Mercury thermostats	108,002 (Hg 3g)	173,627(Hg 5g)
COD Vials with Mercury (25 vials per Pack)	669 (Hg 25mg)	
Mercury use for Gold recovery	26,758(Hg 1g)	

Table 5. 3 Estimated damage cost for each item

Costs comparison (Rs. per item)

	Name of the item	Mercury Added Products			Mercury Free Products
1	Hg thermometers	13,485 (Hg 0.5g)	39,557 (Hg 1.5g)	Digital thermometers	14,857
2	Hg pressure meters	96,894 (Hg 3g)	122,525 (Hg 4g)	Aneroid pressure meters	30,000
3	Mercury Lab Thermometer(Range 0 C-100C)	84549 (Hg 3g)		Digital thermometers (Range 0 C-100C)	18900
4	Pressure gauges with diaphragm elements	1503,026 (Hg 60g)	14,445,804 (Hg 600g)	Pressure gauges with diaphragm elements	71,200
5	Fluorescent tubes	10,272 (Hg 0.010g)	10408 (Hg 0.015g)	LED bulbs	3,500
6	CFL bulbs	3,309 (Hg 0.004g)	3,336 (Hg 0.005g)	LED bulbs	1,500
7	Mercury Barometer	9,126,333 (Hg 500g)		Aneroid Barometer	24,213
8	Mercury thermostats	90,326 (Hg 3g)	137851 (Hg 5g)	Non-mercury thermostats	111,810
9	COD Vials with Mercury (25 vials per Pack)	30330 (Hg 25mg)		Mercury free COD Vials (25 Vials per Pack)	48,600
10	Mercury use for Gold recovery*	26,878		1. Mixture of "Pushkara", "Nawasaram" ** 2. Sodium Bicarbonate**	1.46 1.05

Table 5. 4 Costs comparison

*1.5g of gold is recovered from 3g of mercury

**1.5g of gold is recovered from 2g of the mixture

We also estimated the net benefits of replacing mercury added product under lower limit, upper limit and constant of the mercury content in each items. The results are reported in Table 5.

Net Benefits of replacing each item (Rs. per item)

	Name of the item	Lower limit	Upper limit	Constant
1	Hg thermometers	(1,371)	24,700	
2	Hg pressure meters	66,894	92,526	
3	Mercury Lab Thermometer(Range 0 C-100C)			65,650
4	Pressure gauges with diaphragm elements	1,431,826	14,374,604	
5	Fluorescent tubes	6,772	6,908	
6	CFL bulbs	1,809	1,836	
7	Mercury Barometer			9,102,119
8	Mercury thermostats	(21,484)	26,041	
9	COD Vials with Mercury (25 vials per Pack)			(18,270)
10	Mercury use for Gold recovery	26,877	26,877	

Table 5. 5 Net Benefits of replacing each item (Rs. per item)

5.1 Reference

Dubourg, R. (2018). Economic assessments of the benefits of regulating mercury: A review, OECD Environment Working Papers No. 132.

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6. Annexure

6.1. Annexure – Education sector

- Annexure 1. Questionnaire survey on mercury-containing products and processes in the educational sector
- Annexure 2. Categories of higher educational institutions
- Annexure 3. Full list of schools selected for the survey
- Annexure 4. List of educational institutions from which the data were gathered by interviews
- Annexure 5. Ministry of Education Circular on mercury

Annexure 1

Questionnaire survey on mercury-containing products and processes in the educational sector

Background

The Minamata Convention on Mercury is the first global agreement specifically designed to address contamination from a heavy metal which was entered into force on August 16, 2017. This survey is conducted on behalf of the Ministry of Environment (MoE) in order to strengthen the national capacity for phasing out mercury-added products and environmentally sound management of waste consisting of, contaminated with, and containing mercury in Sri Lanka. The objectives of the survey are to

- (i) identify and quantify mercury-contained products and processes
- (ii) identify mercury-contaminated sites
- (iii) identify available alternatives

Disclaimer and contact

The provided information will be used **only** for the purpose of planning and implementing future activities related to phasing out the use of mercury and mercury-containing products in the education sector. The information gathered will not be disclosed to any third party without individual agreement. Should you have any inquiries about this questionnaire survey, please feel free to contact Prof. C.S. Kalpage or Ms. Iresha Gurusinghe (email: csk@eng.pdn.ac.lk, iresha.ch@gmail.com, eeconga@yahoo.com)

Questionnaire on the mercury-containing products and processes

A. Identification and quantification of mercury-containing products and processes

General information

Name of the School	
Type of School	<input type="checkbox"/> Government <input type="checkbox"/> Private <input type="checkbox"/> Other (Specify)

Additional information (optional)

Name of the person who provides this information	
Department/Division	
E-mail address	
Contact number	

Information regarding mercury-containing products and processes

(a) Mercury-containing products/ equipment

Name of the product/equipment	Frequency of purchasing (last year/last 5 years)	The quantity used	Specification of the product (Product name, Manufacturer, Model number)	The total cost of the product	Average shelf life of the product/equipment	Quantity in-stock
1. Mercury-containing thermometers						
2. Barometers						
3. Mercury hollow cathode lamp for AAS						
4. Mercury plated flasks						
5. CFL light bulbs						
6. Linear fluorescence bulbs						
7. Mercuric Oxide Batteries						
8. Computer Equipment (Please specify)						
Others (Please specify)						

(b) Processes containing mercury

Name of the chemical	Purpose of use (Practical / Lab test / medical treatment / other use - specify)	Frequency of Purchasing (last year/ last 5 years)	The quantity used per annum (mass /volume, concentration)	The total cost of the product	Quantit y in- stock	Average shelf life of the product/equip ment
1. Metallic mercury						
2. Nessler's reagent: K_2HgI_4 (0.09 mol/L) in KOH (2.5 mol/L)						
3. Millon's reagent: $Hg(NO_3)_2$ (5 % w/v) in HNO_3						
4. Others (please specify)						

c) Contact details of the suppliers

Mercury-containing product/chemical	Brand name	Name of the supplier	Contact details (Tel. no., email or address)

(d) Wastes management practices

Mercury-containing product/chemical	Average quantity wasted per annum (no of items/volume or mass and concentration)	Method of waste handling (destroy by burning/ drain into the wastewater line/buried in the garden/ sent to the municipal dump site/ sent to a specialist hazardous waste handler/Stored until dispatching/ other methods - specify)	Disposed cost per one unit

Please mark the correct response

No	Information	Yes	No	Don't Know
1	Availability of mercury spill kits			
2	Availability trained individuals to handle spillages			

(e) Alternative products and processes

(If you are aware of alternatives for mercury containing products or processes, please provide information)

Mercury-containing product /process	Alternatives to replace the products and processes containing mercury	Cost per unit (LKR)	Average shelf life

.....

(Name)

.....

(Date)

Questionnaire survey on mercury-containing products and processes in the educational sector

Background

The Minamata Convention on Mercury is the first global agreement specifically designed to address contamination from a heavy metal which was entered into force on August 16, 2017. This survey is conducted on behalf of the Ministry of Environment (MoE) in order to strengthen the national capacity for phasing out mercury-added products and environmentally sound management of waste consisting of, contaminated with, and containing mercury in Sri Lanka. The objectives of the survey are to

- (iv) identify and quantify mercury-contained products and processes
- (v) identify mercury-contaminated sites

- (vi) identify available alternatives

Disclaimer and contact

The provided information will be used **only** for the purpose of planning and implementing future activities related to phasing out the use of mercury and mercury-containing products in the education sector. The information gathered will not be disclosed to any third party without individual agreement. Should you have any inquiries about this questionnaire survey, please feel free to contact Prof. C.S. Kalpage or Ms. Iresha Gurusinghe (email: csk@eng.pdn.ac.lk, iresha.ch@gmail.com, eeconga@yahoo.com)

Questionnaire on the mercury-containing products and processes

B. Identification and quantification of mercury-containing products and processes

General information

Name of the School	
Type of School	<input type="checkbox"/> Government <input type="checkbox"/> Private <input type="checkbox"/> Other (Specify)

Additional information (optional)

Name of the person who provides this information	
Department/Division	
E-mail address	
Contact number	

Information regarding mercury-containing products and processes

(c) Mercury-containing products/ equipment

(Please add or remove accordingly.)

Name of the product/equipment	Frequency of purchasing (last year/last 5 years)	The quantity used	Specification of the product (Product name, Manufacturer, Model number)	The total cost of the product	Average shelf life of the product/equipment	Quantity in-stock
9. Mercury-containing thermometers						
10. Barometers						
11. Mercury hollow cathode lamp for AAS						
12. Mercury plated flasks						
13. CFL light bulbs						
14. Linear fluorescence bulbs						
15. Mercuric Oxide Batteries						
16. Computer Equipment (Please specify)						
Others (Please specify)						

(d) Processes containing mercury

Name of the chemical	Purpose of use (Practical / Lab test / medical treatment / other use - specify)	Frequency of Purchasing (last year/ last 5 years)	The quantity used per annum (mass /volume, concentration)	The total cost of the product	Quantit y in- stock	Average shelf life of the product/equip ment
5. Metallic mercury						
6. Nessler's reagent: K_2HgI_4 (0.09 mol/L) in KOH (2.5 mol/L)						
7. Millon's reagent: $Hg(NO_3)_2$ (5 % w/v) in HNO_3						
8. Others (please specify)						

c) Contact details of the suppliers

Mercury-containing product/chemical	Brand name	Name of the supplier	Contact details (Tel. no., email or address)

(f) Wastes management practices

Mercury-containing product/chemical	Average quantity wasted per annum (no of items/volume or mass and concentration)	Method of waste handling (destroy by burning/ drain into the wastewater line/buried in the garden/ sent to the municipal dump site/ sent to a specialist hazardous waste handler/Stored until dispatching/ other methods - specify)	Disposed cost per one unit

Please mark the correct response

No	Information	Yes	No	Don't Know
1	Availability of mercury spill kits			
2	Availability trained individuals to handle spillages			

(g) Alternative products and processes

(If you are aware of alternatives for mercury containing products or processes, please provide information)

Mercury containing product /process	Alternatives to replace the products and processes containing mercury	Cost per unit (LKR)	Average shelf life

.....

(Name)

.....

(Date)

Annex 2

Categories of higher educational institutions

University Category	University	Faculty	Department	Remarks
University Category-1	University of Vavniya	Applied Sciences		
		Technological Studies		
	University of Colombo	Faculty of Medicine		
		Faculty of Nursing		
		Faculty of Technology		
		Faculty of Science		
	Eastern University	Faculty of Agriculture		
		Faculty of Healthcare science		
		Faculty of Applied Science		

	University of Jaffna	Faculty of Agriculture		
		Faculty of science	Dep. of Chemistry	
		Faculty of Medicine		
		Faculty of Allied Health Science		
		Faculty of Technology		
	University of Kelaniya	Faculty of Medicine	Dep of Chemistry	
		Faculty of science-Chemistry		
	University of Moratuwa	Medicine		
		Engineering	Dep. of Chemical and Process	3 labs were covered
		Engineering		

	Open University of Sri Lanka	Health Sciences			
		Natural sciences	Dep of Chemistry		
	University of Peradeniya	Agriculture			
		Dental science			
		Medicine			
		Allied Health Science			
		Engineering	Dep of Chemical and Process		
			Dep of Civil Engineering		
		Science			
	PGIS				
University of Rajarata	Agriculture				

		Applied sciences			
		Technology			
		Medicine and allied sciences			
	University of Sri Jayawardenapura	Applied science	Dep of Chemistry Dep of Botany		
		Medicine			
		Technology	Dep of Civil and Environmental Technology		
		Engineering			
		Allied health sciences			
		Dental sciences			

	Sabaragamuwa University	Applied sciences		
		Medicine		
		Technology		
	South Eastern University	Applied Science		
		Engineering		
	Uva Wellassa University	Technological studies		
		Applied science		
	Wayamba University	Applied science		
		Medicine		
		Livestock fisheries & nutritions		
University Category-2	General Sir John Kotelawala Defence University	Medicine		
		Allied health science		
		Technology		

		Engineering		
	University of Vocational Technology	Engineering technology		
		Industrial technology		
	National School of Business Management	Science		
		Engineering		
		Nursing		
	Institute of Chemistry Ceylon			
	National School of Business Management			
	Sri Lanka Institute of Information Technology	Engineering		
	International college of Business and Technology	Engineering and construction		
		Science		

Annexure 3

Full list of schools selected

No	Province	School Name
1	Central Province	St. Sylvester College
		Trinity College
		Dharmaraja College
2	Eastern Province	Agrabodhi National School
		Chenkalady Central College National School
3	Northern Province	Victoria College
		Illavai convent
		Vaddu Hindu college
		Vembadi Girls high school
		St. Patricks college
4	Southern Province	Richmond College

		Matara St. Thomas College
5	Western Province	Asoka Vidyalaya
		Ananda College
		Holy family convent
		Sirimavo Bandaranaike Vidyalaya
		Tissa College Kaluthara
		St. Sebastian College
		C.W.W. Kannangara College, Matugama
		Ananda Shashthralaya, Mathugama
		Mihindu Madya maha Vidyalaya
		St. Marrys College, Matugama
Kamburawala M.M.V.		
6	North Western Province	Vishvoda College
		Sir John Kothalawala college

		Wayamba Royal college
		Maliyadeva Girls college
		Maliyadeva Boys college
		Polgahawela Central college
		Maliyadeva Adarsha college
7	North Central Province	Anuradhapura Central College
		Royal Central College, Polonnaruwa
8	Uva Province	Badulla Central College
		Welimada Janadipathi Vidyalaya
		Bandarawela Central College
		Vishaka Girls college, Bandarawela
		Mahanama College
		Welimada Central college

9	Sabaragamuwa Province	Wijeriya Sumana Maha Vidyalaya
		Tholangamuwa Central College

Annexure 4

List of educational institutions from which the data were gathered by interviews

1. National Institute of Education
2. Ministry of Education
3. Zonal Educational Office, Matugama
4. Zonal Educational Office, Welimada

6.2. Annexure – Industry sector

Annex 1

	Industrial sector application		Current method	Suggested Alternative	DOI/ Source
01.	Power Generation	Power Plant	Coal	Natural gas, nuclear power, wind or solar, hydro power. Power plants can slash their mercury emissions by as much as 95 percent by improving coal and plant performance, and optimising control systems for other pollutants.	https://www.epa.gov/mercury/mercury-your-environment-steps-you-can-take
			Biomass fired power and heat production	Natural gas, nuclear power, wind or solar	
		Coal fired industrial boilers		Activated Carbon Injection, sodium tetrasulfide (Na ₂ S ₄) to control of mercury emissions from coal combustion	Brintnell, Randy Ray, "Activated Carbon Injection for Mercury Control in Coal-Fired Boilers" (2000). Theses and Dissertations. 946. https://commons.und.edu/theses/946 , COAL-

					FIRED POWER PLANTS MERCURY CONTROL WITH POLYSULFIDES By Anthony Licata Director, Client Relations Babcock Power Environmental Inc
		Charcoal combustion	household coal burning is also a significant source of mercury emissions	Burn wood instead of coal	
02.	Oil Refining		Bio refining	In biorefinery, almost all the types of biomass feedstocks can be converted to different classes of biofuels and biochemicals through jointly applied conversion technologies	https://doi.org/10.1016/j.enconman.2010.01.015
03.	Small-scale Gold Mining	2	Mercury is mixed with gold-containing materials, forming a mercury-gold amalgam which	Using Concentration Methods Concentration means increasing the amount of gold in ore or sediment, by selectively removing lighter particles. If employed effectively, concentration methods can eliminate or greatly reduce the need for mercury. Most concentration methods rely on the	https://www.epa.gov/international-cooperation/artisanal-and-small-scale-gold-mining-without-mercury

			<p>is then heated, vaporizing the mercury to obtain the gold.</p>	<p>high density of gold relative to other minerals in ore and alluvium mixture.</p> <p>Gravity Concentration Methods</p> <p>Panning</p> <p>Sluicing</p> <p>Shaking Table/ Gemini Table (elevated tables tilted to one side with raised ridges running horizontally down the length)</p> <p>Spiral Concentrators</p> <p>Vortex Concentrators</p> <p>Centrifuges</p> <p>Other Concentration Methods</p> <p>Magnets</p> <p>Flotation</p> <p>Processing with chlorine</p> <p>Gold extraction with borax</p>	<p>https://doi.org/10.1016/j.jclepro.2004.09.007</p> <p>https://www.researchgate.net/publication/285974945_Borax_-_an_alternative_to_mercury_for_gold_extraction_by_small-scale_miners_Introducing_the_method_in_Tanzania</p>
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04.	Cement Production			<p>Applying additional mercury emission reduction methods;</p> <p>Adsorption on activated charcoal and SCR or SNCR will enable a reduction of emissions</p> <p>Dust Shuttling for high concentrations</p> <p>Activated carbon/sorbent injection</p> <p>Oxidizing agents (Oxidized mercury is adsorbed more effectively than elemental mercury. Bromine, sulphur or other compounds with similar properties may enhance adsorption rate by oxidizing elemental mercury)</p> <p>Thermal treatment of shuttled dust (In research/pilot phase)</p> <p>Selective catalytic reduction (SCR) (Oxidization of mercury with acidic compound on catalyst surface)</p> <p>Wet scrubbers (Side effect: soluble mercury compounds are washed out. Elemental mercury remains in the gas stream)</p> <p>Breaking the mercury cycle (well-known practice in the cement industry)</p> <p>Flue gas mercury capture</p>	<p>DOI:10.1016/j.jclepro.2021.126053</p> <p>European Cement Research Academy ECRA_WBCSD-CSI Mercury_20130618</p> <p>GROSSMAN, D., 'Alternatives to ACL,' <i>International Cement Review</i> (May 2011)</p> <p>'USEPA Report: Control of Mercury Emissions from Coal-Fired Electric Utility Boilers,' www.epa.gov/ttnatw01/utility/hgwhitepaperfinal.pdf</p>

05.	Metal Production	Sri Lanka does not produce mercury; hence its domestic requirements are completely met through imports. Primary metal production by extractive metallurgy or production of metal oxides, specifically alumina (aluminum oxide) by refining bauxite via Bayer process is also not done in Sri Lanka. However, metal production from imported billets and metal scrap recycling is widely practiced in the country.			
06.	Production of Chemicals	Basic chemical manufacturing facilities are currently not available in Sri Lanka.			

		The existing chemical industries involve in the formulation of chemical products by use of imported chemicals and active ingredients.			
07.	Production of Products with Mercury Content	Sri Lanka has never been involved in the production of mercury containing or mercury added products, thus the total requirement is met through imports	<p>Cosmetics</p> <p>Skin lightening creams and soaps with mercury chemicals</p>	<p>Glutathione</p> <p>Kojic acid</p> <p>Arbutin</p> <p>Topical corticosteroids (but severe side effects)</p> <p>Carrot oil + Kojic acid + Hydroquinone (2%)</p> <p>Placenta based products</p>	<p>Masub, N., & Khachemoune, A. (2022). Cosmetic skin lightening use and side effects. <i>Journal of Dermatological Treatment</i>, 33(3), 1287-1292.</p> <p>Cohen, M. (2019). The Law of Placenta. <i>Yale JL & Feminism</i>, 31, 337.</p>
			<p>mercury added light sources and parts are imported.</p> <p>Metal</p>		

			Laboratory chemicals	Proper disposal and recycling of mercury containing chemicals used in laboratories	https://dec.vermont.gov/waste-management/solid/product-stewardship/mercury/proper-disposal https://www.epa.gov/mercury/storing-transporting-and-disposing-mercury
08.	Metal Recycling	Mercury recycling is not done in Sri Lanka due to the absence of such technology in the country. Only mercury and phosphor powder recovered during fluorescent lights recycling are stored until exporting to Germany for refining.	Production of recycled ferrous metals (iron and steel)		

09.	Electrical and Electronic Waste (e-waste) Recycling	Light sources with mercury Include fluorescent lamps (including tubes and compact fluorescent lamps, or CFLs), high-intensity discharge (HID) lamps (including high-pressure sodium (HPS), mercury vapor and metal halide lamps) and UV lamps		LED Light Bulbs (Use significantly less energy than even CFLs, and do not contain mercury) Electron-stimulated luminescence bulb (uses accelerated electrons to stimulate phosphor to create light) Ordinary glow lights, low sodium vapor tubes or high energy long-lasting lights (mercury-containing lamps are two to three times more energy efficient than incandescent lamps) Utilisation of E-Waste as a Concrete Mixture for Infrastructural Buildings Actions that could be taken: regulations to prohibit the knowing disposal of mercury-containing lamps into landfills. Prohibits the disposal of fluorescent lamps as municipal waste. Require labelling of mercury-containing lamps	https://doi.org/10.4028/p-z09ao7 https://www.clasp.ngo/research/all/mercury-free-alternatives-to-certain-fluorescent-lamps-a-report-to-the-european-commissions-committee-on-the-regulation-of-hazardous-substances/ https://www.unep.org/news-and-stories/story/many-products-still-contain-mercury-these-alternatives-could-replace-them#:~:text=Fluorescent%20lamps&text=Light%20emitting%20diode%20(LED),and%20LEDs%20contain%20no%20mercury.

				<p>Require manufacturers of mercury-added lamps to implement a plan to educate users about proper recycling options for end-of-life lamps and to meet specific recycling targets that increase over time.</p> <p>Exempting high intensity discharge (HID) lamps, including metal halide, high-pressure sodium, and mercury vapor lamps from phase-out requirements.</p> <p>Mercury-containing lamp recycling as an environmental management system (EMS) activity.</p>	
		Batteries with mercury		<p>Recycling</p> <p>Zinc-Air batteries</p> <p>Silver oxide</p> <p>Alkaline batteries/ Alkaline Manganese Dioxide Miniature Batteries</p> <p>Stacked Batteries (A possible alternative for mercury containing stacked miniature batteries is to stack mercury free versions of the alkaline and silver oxide miniature batteries.)</p> <p>Lithium Miniature Batteries</p> <p>Cylindrical Alkaline Batteries</p> <p>Secondary (Rechargeable) Batteries</p>	<p>DOI: http://ijmer.in.doi./2022/11.04.49</p> <p>https://doi.org/10.1016/j.otc.2018.08.009</p> <p>http://www.sustainableproduction.org/downloads/MaineDEPButtonBatteryReportFinal12-17-04.pdf</p>

				(There are several miniature battery technologies available for secondary batteries. These include the following technologies: • Nickel Metal Hydride • Lithium Ion • Titanium Carbon Lithium Ion • Lithium Manganese Dioxid)	
10.	Gold Waste Recovery	<p>Recovery of gold from the gold dust is practiced in the industry using mercury</p> <p>(Gold dust is mixed with mercury and the resulting amalgam is heated to evaporate off mercury)</p>		<p>Direct Smelting</p> <p>Gravity only (most used method)</p> <p>Chemical Leaching</p> <p>Pre-concentration and in mill leaching</p> <p>Mercury-Free Gold Extraction Using Borax</p> <p>Panning with water</p> <p>Fume hoods designed with mercury capture systems can reduce mercury emissions and exposure to mercury fumes</p> <p>The quartering method (involves melting 2.5 parts silver together with 1 part gold dore)</p> <p>Avoiding mercury use before cyanidation</p>	<p>https://wedocs.unep.org/bitstream/handle/20.500.11822/11524/UNEP_Tech_Doc_APRIL_2012_120619_with_links_web.pdf?sequence=1&isAllowed=y (UNEP_Tech_Doc_APRIL_2012_120619_with_links_web.pdf)</p> <p>DOI:10.4236/jep.2014.56052</p>

11.	Waste Incineration			<p>Thermal Desorption</p> <p>uses a hybrid of incineration and recycling to replace incineration and landfilling of the mix of coke, coal tar, coal oil, and traces of aromatics found at former manufactured-gas plants.</p> <p>Microwaving</p> <p>The process combines shredding, steam injection, and conventional microwaves to disinfect biomedical waste. Microwave technology is environmentally clean, efficacious in its ability to disinfect medical waste, produces no harmful air or water emissions, and uses very few utilities.</p> <p>Vitrification</p> <p>A vitreous state is a nanocrystalline solid or rigid liquid formed by supercooling a melt. It's also called a glassy state. For hazardous or radioactive wastes, vitrification is the process of cooling a liquid fast enough to prevent crystallization. This process turns waste material, even high- and low-level radioactive wastes, into glass. The advantage of vitrification is that it converts a waste product into recyclable, reusable glass that has value.</p>	<p>https://ehp.niehs.nih.gov/doi/pdf/10.1289/ehp.94102840</p> <p>Alternatives to Incineration: There's More Than One Way to Remediate.</p>

12.	Wastewater Treatment		<p>The most common processes used for treatment of mercury-contaminated water are precipitation, adsorption and membrane filtration</p>	<p>Bioremediation of wastewater containing mercury using three newly isolated bacterial strains.</p> <p>After 48 h of treatment, the concentration of Hg²⁺ in the wastewater could reach the national standard (Hg²⁺ ≤0.05 mg/L). The bacterial strains also exhibited tolerance and transformational abilities for Pb²⁺, Cr⁶⁺, As⁵⁺, and Cd²⁺, indicating that these bacteria could be utilized in more complex heavy metal-polluted environments</p>	<p>https://doi.org/10.1016/j.jclepro.2021.126869</p>
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Annex 2

Assessment on the usage and disposal of Mercury in Industry sector in Sri Lanka

1) General Information about the enterprise

Name of the enterprise:			
Address:			
Contact details of the enterprise	Name:	Position:	
	Mobile No:	Email:	
Industry sector: (Electronic and electric, jewellery, Healthcare etc)			
Manufacturing processes:			
No. of employees:			
Production capacity:		per month	
Types of products:			
Market type:	Local		Export

2) Use of Mercury for the manufacturing process

Use of Mercury contained equipment/raw materials: Yes No

Form:			
Quantity:		per month	
Cost of the equipment/material:		per unit/per Kg	
Average quantity of mercury in equipment/material:		g	per unit/per Kg
Process or service:			
Source of mercury:			

Are there alternatives to complete the process without Mercury contained equipment/raw materials?

Alternatives	Cost	Limitations
1)		
2)		
3)		

Purchasing frequency of Mercury containing raw materials/equipment:		per month
---	--	-----------

Direct use as a raw material:

Yes

No

Form:		
Quantity:		per month
Cost of the material:		per Kg
Process:		
Source of mercury:		

Are there alternatives to complete the process without mercury?

Alternatives	Cost	Limitations
1)		
2)		
3)		

Purchasing frequency of Mercury:		per month
----------------------------------	--	-----------

3) Unintentional use of mercury

Have you ever noticed the presence of mercury in the materials used in the processes?

Yes

No

If yes,

Name of the material:		
Cost of the material:		
Average quantity of mercury in the material:		g
Name of the supplier:		
Address:		
Contact details:	Name of the person:	
	Mobile no:	Email:

4) Mercury handling, and disposal

4.1) Mercury Handling

Is there a procedure to handle mercury or mercury-containing raw materials on the premises?

Yes

No

If yes, attach the procedure:

If there is no written procedure, what is the current practice:

Do you have Personal Protective Equipment (PPEs) in place?

Yes

No

How do you store mercury or mercury-containing raw materials?

How do you transfer mercury or mercury-containing raw materials from storage to the production process?

What are the preparations of the organization to deal with accidents involving Mercury?

4.2) Waste Disposal

Quantity of waste generated:		Quantity (kg per month)	Cost of the waste disposal (per kg)
Waste disposal mechanism:	Incineration <input style="float: right;" type="checkbox"/>	Quantity of waste disposed: kg per month	
	Open dumping <input style="float: right;" type="checkbox"/>	Quantity of waste disposed: kg per month	
	Hand over to a waste collector <input style="float: right;" type="checkbox"/>	Quantity of waste disposed: kg per month	
	Other (please specify)	Quantity of waste disposed: kg per month	

Is there a procedure to dispose mercury or mercury-containing waste on the premises?

Yes

No

If yes, attach the procedure:

If there is no written procedure, what is the current practice:

5) Awareness among employees:

1	No's of staff expose/ engage in mercury-related activities				
2	The staff mentioned in Q1 trained for mercury safety	Yes		No	
3	No's of staff trained for mercury handling/ safety training				
4	If Q2 yes, what is the content covered during the training				
Content		Training/ Awareness coverage			
		Basic Awareness	Technical training	ToT	
I.	Chemicals management				

II.	Alternatives to mercury-added/ mercury-containing products			
III.	Information on environmental, health and safety risks with exposure to mercury			
IV.	& Mercury Storage management Mercury Spill management			
V.	Best practices of mercury disposal			



National Technical Guideline on Environmentally Sound Management of Mercury Waste

MERCURY
DANGER



**National Technical Guideline on Environmentally Sound
Management of Mercury Waste
by adapting the content of “Basel Technical Guidelines on
the Environmentally Sound Management of Wastes
Consisting of, Containing or Contaminated with Mercury
or Mercury Compounds” to Local Conditions**

**Strengthening National Capacity for phasing out mercury-added
products and environmentally sound management of waste
consisting of, contaminated with and containing mercury in
Sri Lanka**

Ministry of Environment

Executive Summary

Mercury has been in use for a significant period due to some of its unique properties. It is the only metal that is in a liquid state at room temperature and atmospheric pressure. It also has the highest density for a liquid. These properties have enabled mercury to be used in various applications in our day-to-day lives. However, with the occurrence of the Minamata Mercury poisoning incident in the 1950s, the hazardous nature of mercury was brought to the spotlight.

Heightened global awareness on the health and environmental impact of mercury led to the establishment of the Minamata Convention. The Minamata Convention on Mercury is an international treaty that was adopted on October 10, 2013, in Minamata, Japan, and entered into force on August 16, 2017. The convention aims to protect human health and the environment from the adverse effects of mercury exposure. It specifically addresses and regulates activities that contribute to mercury pollution.

Having signed the Minamata Convention, Sri Lanka is committed to implementing its provisions and gradually eliminating the use of Mercury within the country. In support of this initiative led by the Ministry of Environment, a National Guideline has been developed to educate and offer guidance to all Sri Lankans, particularly those in the Industry, Health, and Education sectors, on the proper management of mercury, products containing mercury, and mercury-containing wastes.

This guideline adopts a life cycle approach, beginning with the procurement phase and progressing through handling, interim storage, waste separation, and storage, culminating in packaging and labelling for safe transportation of mercury-related materials. The aim is to ensure responsible practices and effective management throughout the entire lifecycle of mercury-containing substances in Sri Lanka.

Chapter 1: Provides an introduction to Mercury and its usage in our activities. It also gives an outline of the activities already carried out to fulfil the obligations of the Minamata Convention.

Chapter 2: This chapter discusses the current country situation with respect to Mercury and Mercury-containing product use, as well as providing insight into Mercury Waste generation.

Chapter 3: Provides common guidelines developed for any sector involving Mercury. This includes guidelines on storage, handling, spill handling, as well as Mercury waste management.

Chapter 4: Explores areas specific to the Health Sector and provides any guidelines developed specifically for the Health Sector.

Chapter 5: Discusses areas specific to the Education Sector and provides any guidelines developed specifically for the Education Sector.

Chapter 6: Looks into areas specific to the Industry Sector and provides any guidelines developed specifically for the Industry Sector.

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Abbreviations and Acronyms

APCD	Air Pollution Control Devices
BEP	Best Environmental Practices
CCFL	Cold Cathode Fluorescent Lamps
CCRs	Coal Combustion Residues
CFL	Compact Fluorescent Lamps
EEFL	External Electrode Fluorescent Lamps
EIA	Environmental Impact Assessment
ESM	Environmentally Sound Management
ESP	Electrostatic Precipitator
FF	Fabric Filter
FGD	Flue Gas Desulfurization
HCl	Hydrochloric acid
HDPE	High Density Polyethylene
Hg	Mercury
HNO ₃	Nitric acid
HPMV	High Pressure Mercury Vapour Lamps
IQ	Intelligence Quotient
LED	Light-emitting Diode
LFL	Linear Fluorescent Lamps
MATS	Mercury and Air Toxics Standards
MeHg	Methylmercury
MIA	Minamata Initial Assessment
MSDS	Material Safety Data Sheet
NMRA	National Medicines Regulatory Authority
NO _x	Nitrogen Oxides
NPV	Net Present Value
PM	Particulate Matter
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride

SCR	Selective Catalytic Reduction
SDS	Safety Data Sheet
SO ₂	Sulphur dioxide
SOP	Standard Operating Procedure
S/S	Stabilization/Solidification
VCM	Vinyl Chloride Monomer

1. INTRODUCTION

Mercury has been widely used in products such as medical devices (thermometers, blood pressure gauges), switches and relays, barometers, fluorescent light bulbs, batteries, and dental fillings. It is also utilized in industrial production, such as chlor-alkali plants, vinyl chloride monomer (VCM) production, acetaldehyde production, and mercury-added product manufacturing. Mercury may also be a by-product of raw materials refining or production processes, such as non-ferrous mining and oil and gas operations. However, mercury has been recognized as a global hazardous pollutant. Mercury emissions and releases can be human-caused (anthropogenic) and may also come from natural sources. Once mercury is released into the environment, it persists in the atmosphere (mercury vapor), soil (ionic mercury), and aquatic phase (methylmercury (MeHg, or CH_3Hg^+)). Some mercury in the environment ends up in the food chain because of bioaccumulation and biomagnification and is eventually humans.

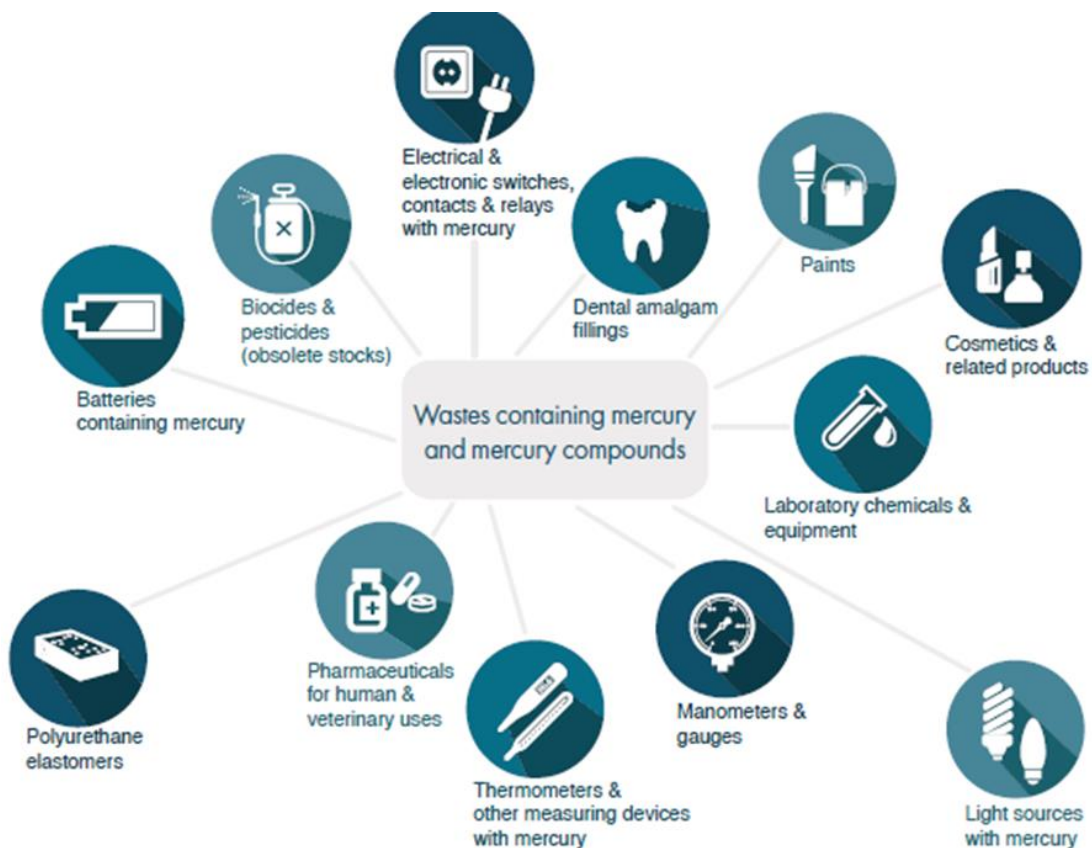


Figure 1-1: Potential sources of Mercury (Source: UNEP 2015)

As a response to the increasing threats from mercury, global community decided to take actions to phase out the use of mercury. The culmination of these actions was the Minamata Convention, which was opened for signature on the October 10, 2013 and entered into force on August 16, 2017. The objective of the Minamata Convention is to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds. It contains provisions that relate to the entire life cycle of mercury, including controls and reductions across a range of products, processes, and industries where mercury is used, released, or emitted.

Sri Lanka signed the Minamata Convention on October 8, 2014. Furthermore, Sri Lanka became a Party to the Convention by ratification on June 19, 2017. As part of the commitments made under the Minamata Convention, Sri Lanka conducted the Minamata Initial Assessment in 2017.

Under the Minamata Initial Assessment, the following activities were carried out:

- Review of the institutional and capacity required for the implementation of the convention.
- Assessment of national regulations, policies, and legislation to assist with preparations for compliance with the obligations of the convention.
- Identification of the primary sources of mercury emissions and releases as part of a detailed National Mercury Profile.

According to the Minamata Initial Assessment (MIA), Sri Lanka has not been involved in the manufacture of mercury-containing or mercury-added products; hence, all needs are met by imports. As stated in the Mercury Country Situation Report, 2018, the pesticides, paints, batteries, Ayurvedic medicine, measuring equipment, switches/relays, cosmetics, CFL/LFL, dental amalgam, and laboratory chemicals are identified as major mercury-containing products. The MIA for Sri Lanka has mainly covered the Industrial, Health, and Education sectors. The major contributors to the Sri Lankan mercury inventory, according to the MIA, are given in Figure 1.1.

With the signing of the Minamata Convention, Sri Lanka must fulfil the commitments for phasing out the use of mercury-containing products and managing mercury-containing waste

in an environmentally sound manner. However, this requires capacity building and technical support to ensure that each sector gradually phases out mercury and mercury-containing products, and that the waste is properly managed.

Under the project on **“Strengthening National Capacity for phasing out mercury-added products and environmentally sound management of waste consisting of, contaminated with, and containing mercury in Sri Lanka”**, this National Technical Guideline is developed for education, industry, and health sectors to provide technical guidance for the environmentally sound management (ESM) of wastes consisting of elemental mercury and wastes containing or contaminated with mercury. The guidelines cover all aspects of the lifecycle management of mercury-containing products and mercury waste applicable for Sri Lanka, including,

- Mercury waste Prevention and Minimization
- Handling
- Separation
- Collection
- Packaging
- Labelling
- Transportation
- Storage
- Environmentally sound disposal

The areas and activities that should be covered by the guideline were identified based on the information available from the Minamata Initial Assessment (MIA) and the outcomes of Task 1 activities of the project *“Strengthening National Capacity for phasing out mercury-added products and environmentally sound management of waste consisting of, contaminated with, and containing mercury in Sri Lanka”*. The MIA has identified the industry, health, and education sectors as the major contributors to mercury release, and the guidelines presented herein cover the major activities in these sectors that must be controlled to manage wastes containing or contaminated with mercury.

This technical guideline is prepared based on the “Basel Convention technical guideline for the environmentally sound management of wastes consisting of elemental mercury and wastes containing or contaminated with mercury” (UNEP, 2011). The guidelines given therein were

adopted to suit country requirements. Throughout the process of the development of this document stakeholder inputs (Figure 1.2) were taken in, so that the guidelines are applicable to the Sri Lankan context.

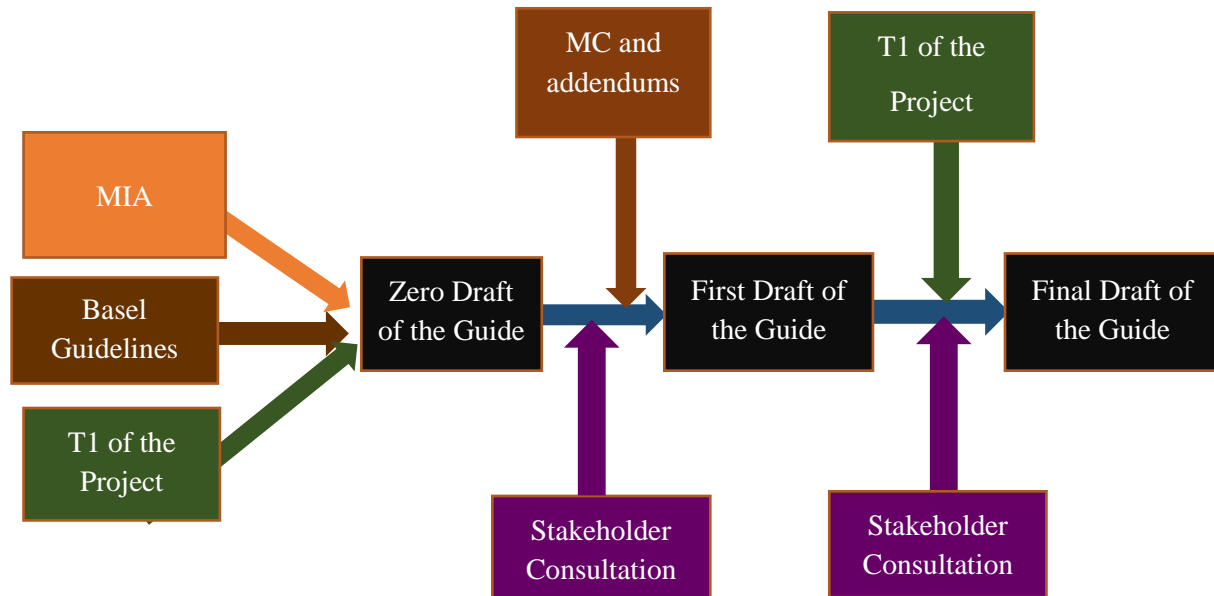


Figure 1-2: Process of development of the guideline

2. COUNTRY STATUS

There have been several studies conducted to assess the country's situation regarding Mercury, Mercury-containing products, processes, and waste in Sri Lanka. Under this chapter, the current situation is analysed relating to mercury in the Education, Industry, and Health Sectors to identify key areas to be considered in the guideline.

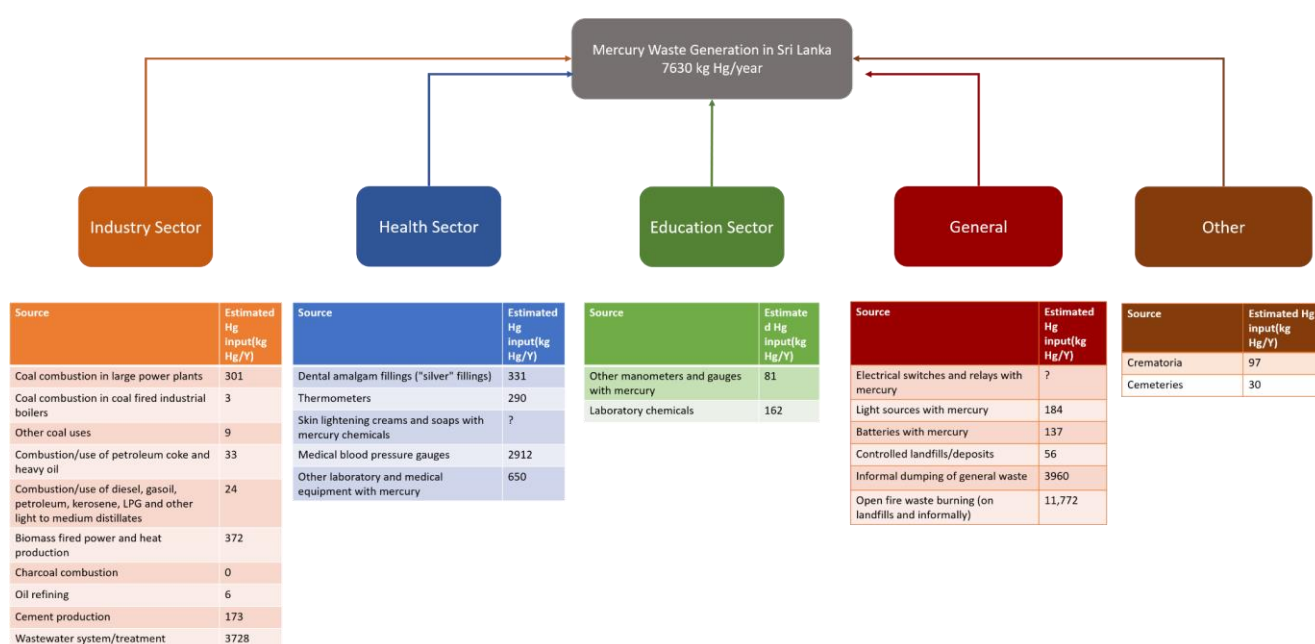


Figure 2-1: Summary of Mercury inventory in Sri Lanka (Based on the estimates given in MIA)

2.1 Mercury-containing products and processes in Education Sector

As one of the key sectors considered for the guideline development, the following areas (Table 2.1 and Figure 2.2) were identified as major contributors of mercury containing products, processes, and wastes in education sector.

Table 2.1: Estimated Hg Input – Education Sector (kg Hg/Y)

Source	Estimated Hg input (kg Hg/Y)
Other manometers and gauges with mercury	81
Laboratory chemicals	162

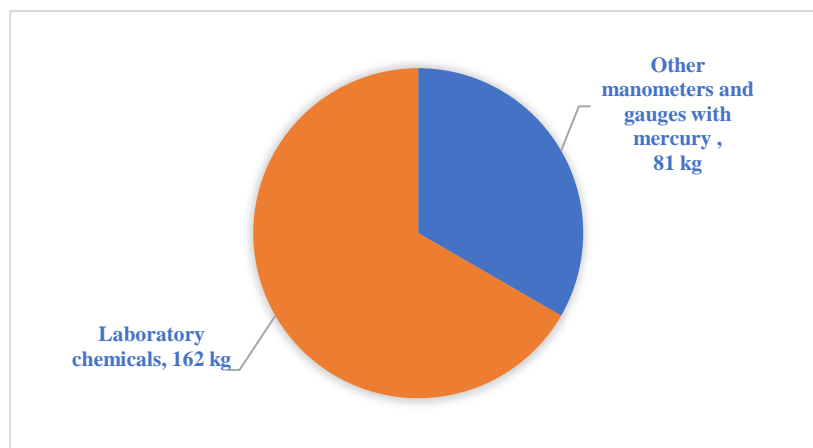


Figure 2-2: Estimated Hg Input – Education Sector (kg Hg/Y)

According to Circular No. 21/2021 issued on 09/11/2021 by the Ministry of Education, practical sessions involving mercury have been removed from the curriculum. This circular will be effective from the 2023 A/L batch onwards. However, even without being included in the curriculum, mercury will be kept in laboratories to demonstrate as a liquid metal at room temperature. Furthermore, waste generated from laboratories is stored within the laboratories due to the unavailability of a proper method for disposal.

2.2 Mercury-containing products and processes in Industry Sector

According to the Minamata Initial Assessment Report of Sri Lanka, the following products and processes (Table 2.2 and Figure 2.3) were identified as containing mercury in the industry sector.

Table 2.2: Estimated Hg Input - Industry Sector (kg Hg/Y)

Source	Estimated Hg input (kg/year)
Coal combustion in large power plants	301
Coal combustion in coal fired industrial boilers	3
Other coal uses	9
Combustion/use of petroleum coke and heavy oil	33
Combustion/use of diesel, gasoil, petroleum, kerosene, LPG and other light to medium distillates	24
Biomass fired power and heat production	372
Charcoal combustion	0
Oil refining	6
Cement production	173
Wastewater system/treatment	3728

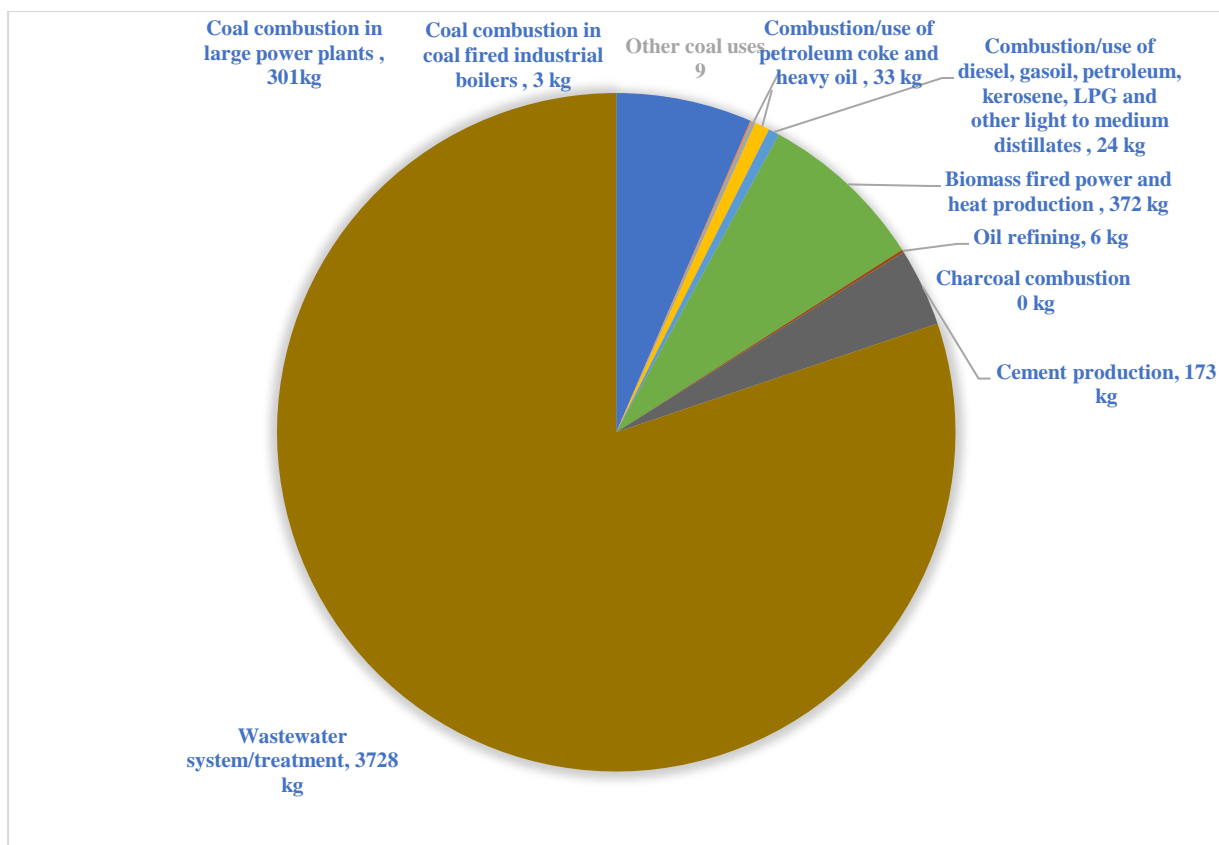


Figure 2-3: Estimated Hg Input - Industry Sector (kg Hg/Y)

The guideline for the industry sector is developed considering the type of industry as well as the life cycle stages of the industries that are applicable to Sri Lanka. Identified industrial sectors that are covered under guidelines include cement production, wastewater treatment and sludge disposal, waste incineration, and coal combustion.

2.3 Mercury-containing products and processes in Health Sector

The Minamata Initial Assessment of Sri Lanka identified the following areas as the major sources of mercury products and process in health sector (Table 2.3 and Figure 2.4) which ultimately emits to the environment as mercury waste.

Table 2.3: Estimated Hg Input – Health Sector (kg Hg/Y)

Source	Estimated Hg input (kg Hg/Y)
Dental amalgam fillings ("silver" fillings)	331
Thermometers	290
Medical blood pressure gauges	2912
Other laboratory and medical equipment with mercury	650

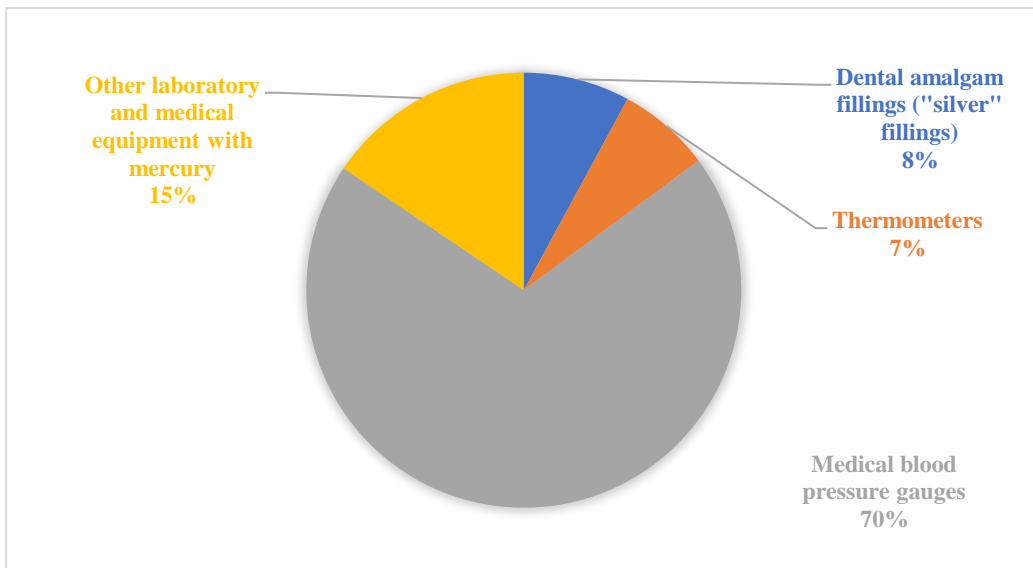


Figure 2-4: Estimated Hg Input – Health Sector (kg Hg/Y)

3. GENERAL GUIDELINES

In the life-cycle management of mercury, it is important to prioritize the reduction of mercury used in products and processes to reduce the mercury content in the wastes to be disposed of and in wastes generated during industrial processes. When using mercury-added products, special care should be taken to prevent the release of mercury into the environment. Wastes consisting of elemental mercury or wastes containing or contaminated with mercury should be treated to recover the mercury or to immobilize it in an environmentally sound manner. The recovered mercury should be disposed of after stabilization/solidification (S/S) at a permanent storage site or a specially engineered landfill site; alternatively, it may be used as an input for products for which mercury-free alternatives do not exist or are unavailable, or where it would take a long time to replace mercury-added products; this could help reduce the amount of mercury released into the environment. Wastes consisting of elemental mercury or wastes containing or contaminated with mercury may be stored, for example, for further treatment until facilities become available or for export to other countries for disposal.

Waste management covers source separation, collection, transportation, storage, and disposal (e.g., recovery, solidification, stabilization, and permanent storage). When government plans to collect wastes consisting of elemental mercury or wastes containing or contaminated with mercury, it also needs to plan the subsequent waste management steps, such as storage and disposal.

The following set of guidelines were identified as applicable for all three sectors: Industry, Education and Health.

3.1 Green Procurement

Procurement programmes for mercury-free products should be encouraged in order to pursue waste prevention and promote uses of mercury-free products and products containing less mercury. Purchasing practices should aim “to purchase mercury-free products,” except in the few cases where alternatives to mercury-added products are practically or technologically unavailable, or “to purchase products whose mercury content is minimized”.

Larger users of mercury-added products, such as healthcare facilities and educational institutions, can play an important role in stimulating the demand for mercury-free products by implementing green procurement programmes. In some cases, financial incentives could be used to encourage green procurement programmes. Some states in the United States, for instance, have subsidized the purchase of mercury-free thermometers.

Green procurement is the incorporation of environmental considerations when procuring products or services. This section of the guideline explains factors that should be considered when purchasing mercury containing/added products or materials.

- Verify whether the intended product or material is not restricted item under the Minamata Convention or by the Government of Sri Lanka.
- Identify mercury free alternatives, if any, that can provide the same intended functionality. The table below (Table 3.1) provides a list of mercury free alternatives for some selected products. If an alternative has been recommended in the guideline, only the mercury free alternative should be procured.
- If any alternative product is available in the market, ensure that the quotations are obtained for both mercury containing and mercury free products.
- Add the damage cost of mercury (Rs. 73,310/kg of mercury as of January 2023) into the price of the mercury containing product when comparing the prices for purchasing.
- Whenever replacing Mercury containing products, priority should be given for Mercury-free alternatives. If such alternatives are not available, then reduced-mercury alternatives should be considered.

Table 3.1: Mercury free alternatives for selected products

Product Category	Specific Use/Application	Mercury-Free Alternatives
Batteries	Button cell, silver oxide	Mercury-free units
	Button cell, zinc air	
	Alkaline manganese (manganese dioxide)	
	Mercuric oxide	
	Button cell, mercuric oxide	
	Button cell, zinc carbon	

Electrical/ electronic devices	Tilt/vibration switch	Capacitive, electrolytic, mechanical, metallic ball, potentiometer, solid-state
	Float switch	Alloy, capacitance, conductivity, magnetic dry reed, mechanical, metallic ball, optical, pressure transmitter, sonic/ultrasonic, thermal
	Pressure switch	Mechanical, solid-state
	Temperature switch	Mechanical, solid-state
	Displacement relay	Dry magnetic reed, electromechanical, hybrid (electromechanical & solid-state), silicon controlled rectifier, solid-state
	Wetted reed relay	
	Contact relay	
	Flame sensor	Electronic ignition system
	Thermostat	Digital, snap-switch
Measuring devices	Sphygmomanometer	Aneroid, oscillometrics
	Fever Thermometer	Digital, Liquid-in-glass
	Non-fever Thermometer	Bi-metal, digital, infrared, liquid-in-glass
	Hygrometer/Psychrometer	Digital, spirit-filled
	Barometer	Aneroid, digital
	Manometer	Aneroid, digital, needle/bourdon
	Flow Meter	Ball-actuated, digital
	Pyrometer	Digital, optical
Lamps/lighting	Hydrometer	Spirit-filled
	Linear fluorescent	Linear LED
	Compact fluorescent	LED, LED downlight
	High intensity discharge	Halogen, LED, mercury-free units
Cosmetics	Backlight units for LCD displays	LED
	Skin care products	Non-mercury preservative/microbial

MERCURY-CONTAINING OBJECTS



Mercury oxide or
Mercury zinc batteries



MERCURY-FREE ALTERNATIVES



Alkaline, Lithium and
NiCad batteries



Figure 3-1: Mercury containing products and alternatives.

3.2 Handling

3.2.1 Safety Precautions for Mercury Use

3.2.1.1 Training

Students and employees who handle mercury must have read the Safety Data Sheet (SDS) or formerly known as Material Safety Data Sheet (MSDS) and receive training on the hazards of mercury from their respective work places. They must know what to do in the event of a spill or an exposure incident. The SDS must always be kept in the immediate vicinity of the working area along with the Standard Operating Procedure (SOP) for the task.

3.2.1.2 Ventilation

All operations involving open sources of liquid mercury or any mercury-containing organic/inorganic compounds must be carried out in a certified chemical fume hood.

3.2.1.3 Eye Protection

Chemical goggles or a face shield **MUST** be worn when handling liquid mercury. Safety glasses are sufficient when handling solid mercury-containing organic/inorganic compounds or materials.



Figure 3-2: Protective Clothing for Mercury handling

3.2.1.4 Gloves

Always consult the manufacturer's glove selection guide when selecting gloves for working with mercury. Organo-mercury compounds can easily pass-through latex gloves. (In June of 1997, a researcher died from acute mercury poisoning. Her exposure was the result of approximately 0.5 ml of dimethyl mercury falling on her latex glove-covered hand during an experiment. The reason for her exposure was that dimethyl mercury easily permeates latex gloves).

Elemental mercury requires nitrile, PVC, or latex gloves. Organo-alkyl mercury compounds require the use of silver shield, 4H, or other brand laminate-style gloves and outer gloves (heavy-duty nitrile or neoprene, with long cuffs).

It is recommended to wear highly resistant, flexible, plastic-laminate gloves when handling dimethyl mercury and other similarly dangerous substances. For increased protection, such thin gloves can be worn under long-cuffed, heavy-duty outer gloves made of neoprene.

3.2.1.5 Protection Clothing

A lab coat (with full sleeves), along with full-length pants and close-toed shoes, **MUST** be worn when handling mercury and other mercury-containing compounds.

3.2.1.6 Respiratory Protection

Elemental mercury vapor: concentrations up to 0.5 mg/m³, a half-face air purifying respirator with a cartridge that provides protection for mercury vapor can be used. For concentrations between 0.5 and 2.5 mg/m³ a full-face cartridge respirator may be used. Above that, a self-contained breathing apparatus is required. Organo-alkyl mercury vapor: due to the high toxicity of organo-alkyl mercury compounds, a self-contained breathing apparatus is required if concentrations are in excess of the Permissible Exposure Limit (0.05 mg/m³)

Lab personnel intending to use/wear a respirator mask must be trained and fit-tested. Only mercury (Hg) vapor cartridges must be used with half-face and full-face respirators.

3.2.1.7 Safe Work Practice

- Always work in a well-ventilated area when handling mercury or mercury-containing materials.
- Absolutely no eating, drinking, or chewing gum where mercury is used.
- The area must be equipped with an emergency shower, an eyewash station and a first aid kit.
- A mercury spill kit should be available in areas where mercury is being used.
- Whenever possible, less hazardous materials should be substituted for mercury.
- Never add water to mercury.

Table 3.2: Extracts from the Basel Guideline

Areas to be considered	Guideline (Extracted from Basel Guideline)
Handling elemental mercury	<ul style="list-style-type: none">• Those who handle wastes consisting of elemental mercury should pay particular attention to the prevention of evaporation and spillage of elemental mercury into the environment.• Such waste should be placed in a gas- and liquid-tight container that bears a distinctive mark indicating that it contains “toxic” elemental mercury.
Handling mercury containing products	<ul style="list-style-type: none">• End users should handle safely and prevent any breakage or damage to waste mercury-added products such as fluorescent lamps, thermometers, sphygmomanometers, electrical and electronic devices, etc.• Waste mercury-added products such as paints and pesticides should be handled safely and should not be discharged into sinks, toilets, storm

	sewers or other rainfall runoff collection systems. These wastes should not be mixed with any other wastes. If such wastes are accidentally broken or spilled, the clean - up procedure should be followed (see section 3.4).
Transport of elemental mercury	<ul style="list-style-type: none"> • Wastes consisting of elemental mercury and wastes containing or contaminated with mercury should be transported in an environmentally sound manner in order to avoid accidental spills and to track their transportation and ultimate destination appropriately. • Prior to transportation, contingency plans should be prepared in order to minimize environmental impacts associated with spills, fires and other emergencies that might occur. • During transportation, such wastes should be identified, packaged and transported in accordance with the “United Nations Recommendations on the Transport of Dangerous Goods: Model Regulations (Orange Book)”. • Persons transporting such wastes should be qualified and certified as carriers of hazardous materials and wastes.

3.2.2 Steps to take in case of an elemental Mercury Spill

This detailed mercury spill clean-up procedure is intended as a guide to help develop facility-specific procedures. Each facility should develop its own procedures according to what is practical and available, while maximizing protection for their everyone involved.



Figure 3-3: Mercury Spill Kit

- Mercury spill kits must be readily available in places that store and/or handle mercury. Spill clean-up must be performed only if personnel are trained and feel comfortable cleaning up mercury (Hg) spills. Mercury spill kits are commercially available (Figure 3.3). They usually include gloves, sponges impregnated with a material to absorb

mercury, absorbent powder that reacts with mercury to form a harmless amalgam, and plastic bags for disposal. Some kits may include a small handheld pump.

- Another alternative is to make your own spill kit. You will need:
 - Disposable gloves.
 - Disposable shoe covers (double plastic bags will work);
 - Index card or rubber squeegee
 - Disposable syringe or a vacuum trap flask fitted with tubing and a Pasteur pipet;
 - Inactivating solutions and/or powders.

Step 1 – Quickly determine the extent of the spill: Determine which surfaces the mercury spilled on and how far the mercury beads travelled. (See the Note at the end of this procedure)

Step 2 – Immediately block off foot traffic: Do not allow anyone to walk across the contaminated site or to go near areas where the mercury travelled. If the extent of a small spill is not immediately obvious, block off traffic for a radius of about 2 meters around the centre of the spill.

Step 3 – Contain the spill: If necessary, prevent the mercury beads from traveling further by blocking their path with rags or impervious material. Take steps to keep mercury from falling into drains or cracks. Check to see if anyone's skin, shoes or clothing was splashed with mercury. If shoes or parts of clothing were contaminated, they should be removed and left around the spill area before allowing the person to leave. Skin that was in contact with mercury should be washed with alkaline soap.

Step 4 – Evacuate the area: Ask everyone to leave the room or the general area, giving priority to pregnant women and children. Seek assistance to provide first-aid to anyone requiring immediate medical attention.

Step 5 – Minimize the spread of vapours to interior areas: Close all interior doors that lead to other indoor areas. Turn off central ventilation or air conditioning systems, if available, that circulate air from the spill site to other inside areas of the building.

Step 6 – Reduce vapor concentrations in the spill area if possible: After making sure that windows and exterior doors open to outside areas that are free of people, open the windows and exterior doors to dilute the vapor concentrations in the room. Prevent access to the area by putting up signs and, if necessary, seeking help from other staff persons, and then leave the area to prepare for clean-up.

Step 7 – Prepare for clean-up: Remove jewellery, watch, mobile phones, and other metal containing items. Get the mercury spill kit.

Step 8 – Put on personal protective equipment (PPE): Change to old clothes if possible. Put on the apron or coveralls, disposable shoe covers, rubber or nitrile gloves, goggles, and face mask before re-entering the spill site. Make sure metal items such as eyeglass frames are covered by PPE.

Step 9 – Remove visible mercury beads and broken glass: Place the jar and container on the plastic tray. Starting from the outside of the spill site and moving towards the centre, carefully remove visible mercury beads and broken glass. Use tweezers to remove broken glass pieces and place them in the jar or wide-mouthed container over the tray. Using a playing card or piece of plastic, slide the mercury beads onto the plastic dustpan or scoop, and away from any carpet or porous surface. Use a slow, short, sweeping motion to prevent spreading mercury droplets. Carefully place the mercury beads into the plastic container partially filled with water or vapor suppression agent. Do this over the tray to catch any spillage. You can also use an eyedropper or syringe for small beads. Hold the eyedropper or syringe almost parallel to the floor to draw in the beads and keep the eyedropper or syringe horizontal when transferring the beads to the plastic container to prevent the mercury from falling out.

Step 10 – Search for and remove tiny mercury droplets and glass: Look for any remaining droplets and glass pieces by shining the flashlight at different low angles to the floor and looking for reflections from the shiny droplets and glass. For very tiny droplets, it may be easier to pick them up using sticky tape, but be careful since they may not always stick. Place the sticky tape in the sealable plastic bag.

Step 11 – Clean up cracks and hard surfaces: Sprinkle sulphur powder on cracks and crevices, and on hard surfaces (tile, linoleum, wood, etc.) that had come in contact with mercury; a colour change in the powder from yellow to reddish-brown indicates that mercury is still present, and more clean-up is needed. If so, sprinkle zinc flakes or copper flakes to amalgamate any residual mercury. Use the brush or small broom to remove the powder and/or the metal flakes and place them in the sealable plastic bag. An alternative way to clean hard surfaces after adding sulphur powder is to wipe them with vinegar-soaked cotton swabs, followed by peroxide-soaked swabs. Place the swabs in a sealable plastic bag.

Step 12 – Remove contaminated soft materials: Carpets, carpet padding, upholstery, curtains, rugs, bedding, and other soft materials cannot be easily cleaned. Use the utility knife to cut out pieces of carpet, padding, and other soft materials that are contaminated with mercury. Place the contaminated materials in a sealable plastic bag.

Step 13 – Clean out contaminated drains: If mercury was spilled over a drain, sink or washbasin, remove and replace the “J”, “U” or “S” trap. Put a sheet of plastic or plastic tray under the work area to catch any mercury that might spill out. Hold the old trap over a tray while transferring the mercury to the air-tight container. Dispose of the old trap as hazardous waste.

Step 14 – Dispose of or decontaminate clean-up material: Place all contaminated materials used during the clean-up (including cards, plastic pieces, cardboard, paper, rags, cotton swabs, paper towels, sticky tape, piece of soap, brush, or broom) into a leak-proof, sealable plastic bag. Other items (tweezers, plastic scoop, tray, eyedropper, utility knife, etc.) should either be disposed of with the contaminated items in the sealable plastic bag or cleaned thoroughly with the decontaminant solution.

Step 15 – Label and seal all contaminated material: Ensure that the air-tight jar and container are filled with enough water to cover the elemental mercury and broken glassware, close the jar and container tightly, label, and place each in a re-sealable plastic bag. The jar and container should be stored safely for future use. Place all sealed plastic bags with mercury-contaminated waste inside a second plastic bag, seal the outer

bag using duct tape, and affix a label (“Mercury: Hazardous waste”) and include a brief description of the contents. The mercury waste can be stored temporarily on-site.

Step 16 – Remove and dispose or decontaminate Personal Protective Equipment (PPE): Begin by removing PPE starting with the shoe covers, which should be placed in another sealable bag. Then, remove the gloves by grasping one glove with the other, peeling off the first glove, sliding the fingers under the remaining glove at the wrist, peeling off the second glove, and discarding both gloves in the sealable plastic bag. Next, remove the goggles by the headband or earpieces. Remove the apron or coverall without touching the front and turn it inside out. Finally, remove the face mask or respirator without touching the front. Dispose of the gloves, shoe covers, apron (and regular face mask if used in lieu of a specialty mask) in the sealable plastic bag, which should be stored along with the mercury waste. Decontaminate goggles and respirators or specialty face mask using the decontaminant solution.

Step 17 – Wash hands and all exposed skin: Use soap and water to scrub all exposed skin and rinse thoroughly.

Step 18 – Ventilate the spill area: Place a fan next to the spill area to volatilize mercury and a second fan in a window or doorway to move air to the outside air for 48 hours or more. If this is not possible due to central heating or air conditioning, increase the air exchange rate for the building for several days to reduce any mercury vapor concentrations.

NOTE: If more than the amount in one thermometer was spilled on a wood floor or other porous material, use heaters to heat the room to about 30 °C while blowing the air to the outside using a fan or blower for at least 48 hours. Treating the porous flooring with a sealant is an added safety option.

Step 19 – Medical monitoring: If the spill resulted in acute exposure to a worker, conduct blood and urine tests, provide support for respiratory and cardiovascular function,

and if necessary, initiate chelation therapy if the person is symptomatic of acute mercury poisoning.

Step 20 – Write a report on the spill incident: Document the incident in keeping with the procedures of the health facility. The report can be used to improve safety in the facility.

The following should **NOT** be done in the event of a spill:

- Do not use a regular vacuum cleaner to pick up the mercury and mercury-contaminated items. The mercury will become airborne through the vacuum's exhaust and spread the contamination. Moreover, the vacuum cleaner will become contaminated and would have to be disposed as hazardous waste.
- Do not wash mercury-contaminated clothing, rugs or other fabrics in a washing machine. The washing machine and wastewater may become contaminated.
- Do not use a broom to sweep up the mercury. It can break the mercury into smaller beads, spreading them.
- Do not pour mercury down the drain.
- Do not spread mercury that has gotten onto your shoes. If possible, clean the shoes with the decontaminant solution. If the shoes cannot be decontaminated, wrap them in a plastic bag and dispose of them properly.

Note:

It is critical to determine what type of response is appropriate for any mercury spill by evaluating its size and dispersal, and whether the necessary clean-up resources and expertise are available. Professional help should be sought in the following cases:

- (a) The amount of mercury could be more than 2 tablespoons (30 millilitres). Larger spills should be handled by specially trained individuals;
- (b) The spill area is undetermined: If the spill was not witnessed or the extent of the spill is hard to determine, there could be small amounts of mercury that are hard to detect and that necessitate clean-up efforts;
- (c) The spill area contains surfaces that are porous or semi-porous: Surfaces such as carpet and acoustic tiles can absorb the spilled mercury and make clean-up practically impossible; and

- (d) The spill occurs near a drain, fan, ventilation system or other conduit: mercury and mercury vapours can quickly move away from the spill site and contaminate other areas without being easily detected. Scattering of spilled mercury (e.g., by using water jets) should be avoided as much as possible because it significantly increases the evaporation rate. (World Chlorine Council 2004)

3.3 Storage



Figure 3-4: A Mercury Storage Facility

3.3.1 Storing of Elemental Mercury

- The storage location should restrict its access to authorized personnel only.
- The storage location of mercury or mercury compounds should not share a common ventilation system. A separate ventilation system should be in place for them, and it should directly vent to the outdoors. Ideally, the ventilation system should include air pollution control devices, such as activated carbon filters, to capture any mercury vapour or dust released.
- Ideally, the storage temperature should be less than 25 °C.
- Storage containers used should meet the following criteria.
 - Should not be damaged by any materials previously stored in them.
 - Should not have stored material that can react with mercury.
 - Should have its structural integrity intact.
 - Should not be corroded.
 - Should have a protective coating (paint) on the outside to prevent corrosion.
 - Should be liquid tight and gas tight.

- The storage container can be made out of carbon and stainless steel which do not react with mercury at ambient temperature.
- There should be some headspace left when storing liquid mercury in a container in order to allow for thermal expansion. (As per EU guidelines, the headspace should not be less than 20% from the volume of the container)
- When storing liquid mercury, it is recommended to have 99.9% purity by weight in order to avoid chemical reactions with the storage container. If storing liquid mercury below this purity level, it is recommended to monitor the condition of the container in order to detect any degradation.
- The storage containers of liquid mercury should be stored in an appropriate containment trays or secondary containers (ideally with curved edges to limit mercury accumulation) where spills can be contained. The liquid containment volume should have enough margin from the maximum liquid volume, taking into account the space taken up by items stored in the containment area. If two or more containers are stored at a containment area, the volume of the largest container should be used as the maximum liquid volume.
- The containers should be appropriately labelled. The label should include the details of the supplier, the level of purity of mercury stored. It is recommended to use the globally harmonized system of classification and labelling when labelling the mercury containers.
- An inventory for mercury should be created and updated. The inventory should be accessible in an emergency.

3.3.2 Storing of Mercury containing products

- Since unbroken mercury devices (e.g., thermometers, barometers and sphygmomanometers) are fragile, they should be stored in a safe manner that reduces the chance of breakage.
- Since mercury devices may break during storage or transport, the primary container must be puncture-resistant and air-tight unless they are placed in their original portable cases or individual boxes used during shipment.
- The primary container should be marked with the type of mercury device, the quantities inside the container, the initial date of storage, and any additional description if necessary.

- As a redundant safety measure, the primary container should be placed in a secondary container that prevents the release of mercury vapour in case the mercury devices break. If the secondary container is not transparent or the label on the primary container cannot be seen, a label should also be placed outside the secondary container.
- Make available a mercury spill kit or prepare a spill kit to handle a mercury spill if it occurs.
- Preferably maintain a temperature in the storage area below 25 °C.
- An inventory of mercury containing devices (including the amount of mercury in each device) should be created and updated. The inventory should be accessible in an emergency.

3.4 Management of wastes containing/contaminated with mercury

The Basel Technical Guidelines, as well as the Minamata Convention on Mercury, identify three categories of mercury wastes: wastes consisting of mercury or mercury compounds, wastes containing mercury or mercury compounds, and wastes contaminated with mercury or mercury compounds.

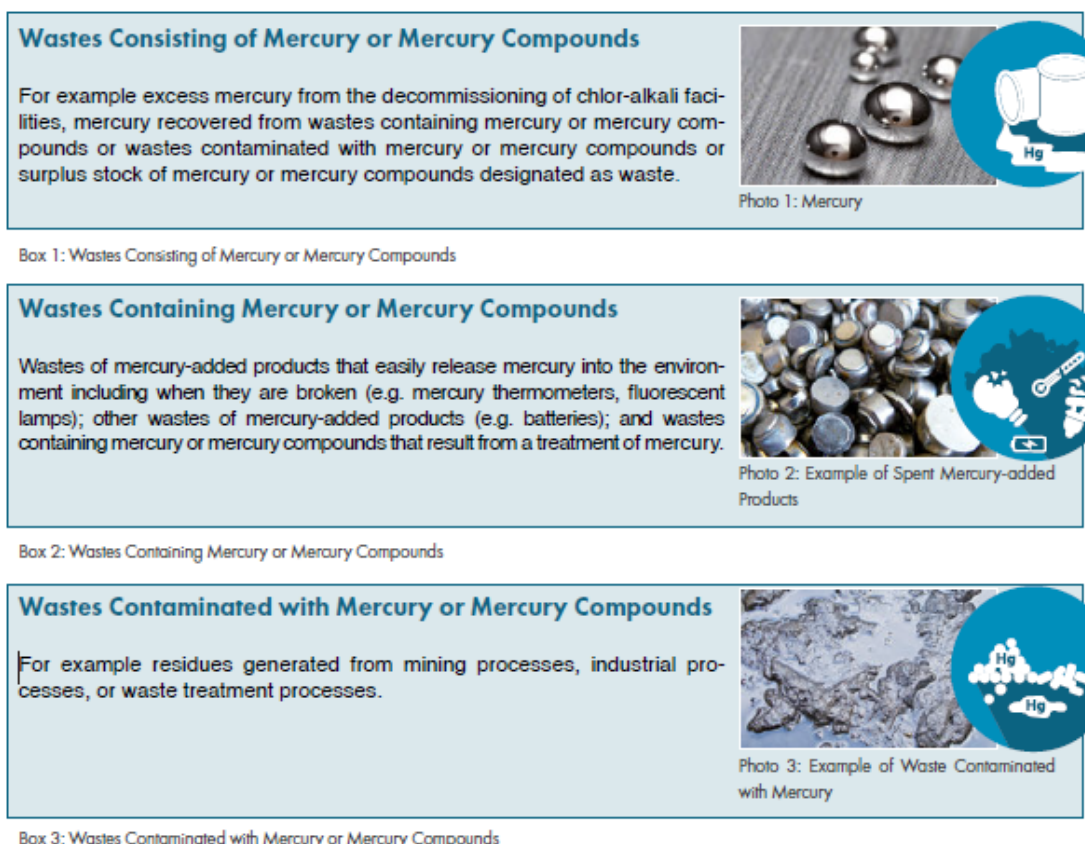


Figure 3-5: Categories of mercury wastes (Source: UNEP 2015, Practical Sourcebook on Mercury Waste Storage and Disposal)

Figure 3.6 indicates the overall process of managing mercury-containing, mercury-consisting of and waste contaminated with mercury (hereafter referred to as mercury wastes). Accordingly, the mercury waste generated needs to be segregated and stored properly until the authorised mercury waste recyclers/processors can collect the waste.

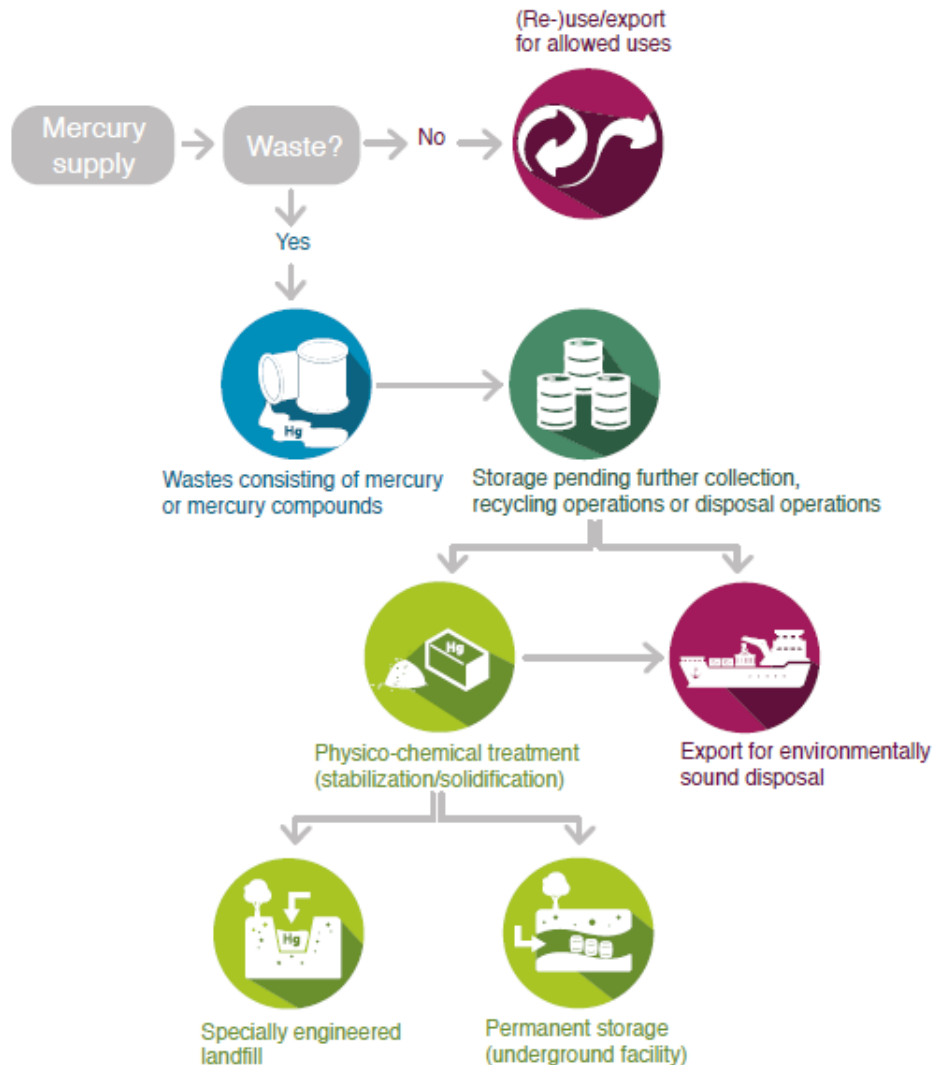


Figure 3-6: Overall process of mercury waste management (UNEP 2015)

The authorised mercury waste processors can either export the waste for environmentally sound disposal or can treat the waste locally if facilities are available. The treatment options include stabilisation or solidification so that the wastes can be disposed of in specially engineered landfills or permanently stored in underground facilities.

3.4.1 Facility level waste management

Facility level mercury wastes should follow waste management hierarchy, with priority given to prevent, reduce, reuse, recycle and proper storage of disposal in that order. Following actions should be taken to prevent or reduce the mercury waste generated from your facility.

3.4.1.1 Prevention and reduction of mercury waste generation

- (a) Use mercury free alternatives as much as practically possible.
- (b) Go for minimum possible mercury levels in mercury added products
- (c) Use mercury containing products such as thermometers with utmost care to prevent breakage.
- (d) Follow proper waste segregation procedures to prevent mixing of mercury waste with other wastes. Adopting a labelling system for mercury added product such as CFL bulbs will facilitate the segregation.

3.4.1.2 Collection of Packaging of waste

When handling wastes consisting of mercury, it is important to pay particular attention to the prevention of evaporation and spillage of mercury into the environment. Breakage or damage to mercury-added products is to be prevented whenever possible. It is essential that appropriate PPEs are used during the handling of waste.

Packaging of waste will depend on the type of waste. It is therefore necessary to carefully package mercury wastes in appropriate containers that have been manufactured to conform to standards for the packaging of mercury wastes or hazardous wastes.

Following figures (Figure 3.7) illustrate appropriate packaging for wastes consisting of, containing, or contaminated with mercury.

Packaging of Wastes Consisting of Mercury

Wastes consisting of mercury are stored in exclusively designed stainless steel containers. These are stored in a dry location, upright on pallets off ground with overpacking and have the following characteristics:

- Gas-and liquid-tight
- Coated from the outside
- No damage to the structural integrity of the container
- No materials adversely reacting with mercury (e.g. ammonia or halogens) previously stored in the container.¹



Photo 6: Mercury Flasks (Courtesy: Umwelt Technik Metallrecycling GmbH) (2.5 litre) are commonly used and are also the standard unit for trading. 1 ton stainless steel pressure receptacles may also be used.

Packaging of Wastes Containing Mercury

Wastes containing mercury are transported in appropriate packages (such as original boxes or closed containers) that prevents them from breaking and releasing mercury.¹



Photo 7: 125 Litre UN-approved Plastic Drum (courtesy: Umwelt Technik Metallrecycling GmbH)

Packaging of Wastes Contaminated with Mercury

Liquid wastes contaminated with mercury are packed in appropriate containers which are placed in containment trays or a curved and leak-proof area. **Solid wastes contaminated with mercury** are stored in sealed containers, steel waste containers or specially constructed containers.¹



Photo 8: UN-approved 110 Litre Stainless Steel Drum with Epoxy Lining

Figure 3-7: Packaging of mercury wastes (Source UNEP 2015)

3.4.1.3 Temporary On-site Storage

This section has been adopted from the UNDP GEF (2015) publication “*Global Healthcare Waste Project: Guidance on Mercury Clean-up, Storage, and Transport*” and can be accessed through <https://www.undp.org/publications/cleanup-storage-and-transport-mercury-waste-healthcare-facilities>

(a) General guidelines for temporary on-site storage

The following general points should guide the design of on-site storage of mercury devices, mercury-contaminated waste, and elemental mercury

(b) Siting and preparation

- The storage space should be located in a secure, restricted-access area. If the storage space is in a multi-purpose building, it should be a locked room or locked partitioned space.
- The storage space should be readily accessible to personnel who are authorized to collect, store, and transport the waste.
- The exhaust vent from the storage space should not direct air towards crowded areas and should be far from any air intake vents.
- An estimate should be made of the anticipated volume of mercury and mercury waste to be stored and this value should be used to determine the minimum size of the storage space, and the types and sizes of containers.
- Mercury waste should be kept segregated from regular waste, infectious waste, and other types of waste.

(c) Storage space design requirements

- The storage space should have:
 - A roof and walls that protect from the weather, insects, and other animals; a sloping roof to drain water away from the site is preferred
 - Floor made of a material that is smooth and impervious to mercury
 - If there is a drain in the storage space, it should have an easily accessible and replaceable drain trap to capture mercury in the event of a spill.
- The storage space should be locked to prevent theft.
- The storage space should have ventilation that can eject air from the space directly to the outside and ventilation controls that can stop air circulation from the storage space to the inside of the facility.
- The storage space should have bunding or barriers on the floor or a spill containment tray directly below the waste containers to prevent spills from spreading. The containment volume inside the bund wall or the containment volume of the tray should be at least 125% of the total volume of liquid mercury stored.
- Personnel protection equipment, a spill kit, and wash areas should be located near (but not in) the storage space for easy access by authorized personnel.

- The storage space should be kept cool and dry (ideally below 25°C to minimize volatilization and below 40% relative humidity to minimize corrosion if steel containers and shelves are used).

(d) Labelling and signage:

- The entrance and exit doors of the storage space should be marked with warning signs, such as “Danger: Hazardous Mercury Waste” and the skull-and cross bones symbol for toxic or poisonous waste.
- The waste containers should be labelled “Hazardous Mercury Waste” along with a description of the contents and the initial date of storage.

(e) Storage of elemental mercury:

- When elemental mercury is stored for the purpose of accumulation, the primary container should have the following characteristics:
 - Easy to open and re-seal
 - Leak-proof, air-tight
 - Made of a material that does not react or amalgamate with mercury
 - Made of a material that is not brittle
 - Made of a material that resists corrosion
 - Small enough such that the weight of mercury is not too heavy to lift (a typical ergonomic weight limit is 23.5 kg)
 - Small enough such that the weight of mercury does not exceed the strength of the container
- When elemental mercury is stored for the purpose of accumulation, a vapor suppression agent or water should be added to the primary container to protect workers when adding more mercury. Workers should use PPE including respiratory protection.
- The primary container should be marked with the type of mercury waste and the date mercury was first placed in the container.
- When elemental mercury is stored, storage should include a secondary container that further prevents the release of mercury vapor as a redundant safety measure. If the secondary container is not transparent or the label on the primary container cannot be seen, a label should also be placed outside the secondary container.

- The mercury waste containers that are used for accumulation should be on top of a plastic pan or spill-control tray to catch any spills during filling. The containment volume of the pan or tray should exceed the total volume of liquid mercury stored in the container.

(f) Storage of mercury device:

- Since unbroken mercury devices (e.g., thermometers and sphygmomanometers) are fragile, they should be stored in a manner that reduces the chance of breakage.
- Since mercury devices may break during storage or transport, the primary container must be puncture-resistant and air-tight unless they are placed in their original portable cases or individual boxes used during shipment.
- The primary container should be marked with the type of mercury device, the quantities inside the container, the initial date of storage, and any additional description if necessary.
- As a redundant safety measure, the primary container should be placed in a secondary container that prevents release of mercury vapor in case the mercury devices break. If the secondary container is not transparent or the label on the primary container cannot be seen, a label should also be placed outside the secondary container.

(g) Storage of mercury-contaminated waste:

- Mercury-contaminated wastes that include broken glass or other items with sharp edges or points (e.g., broken thermometers) should be placed in a primary container that is puncture-resistant and air-tight. As a redundant safety measure, the primary container should be placed in a secondary container that further prevents the release of mercury vapor.
- Mercury-contaminated wastes that do not contain sharp edges or points or that do not result in sharp edges or points when dropped or smashed (e.g., contaminated rags, paper towels, or pieces of carpet) should be placed in an airtight primary container. As a redundant safety measure, the primary container should be placed in a secondary container that further prevents the release of mercury vapor.
- The primary container should be marked with the type of mercury waste, the estimated amount, the date the material was placed in the container, and additional description if

necessary. If the secondary container is not transparent or the label on the primary container cannot be seen, a label should also be placed outside the secondary container.

- Place a spill containment tray directly under the containers in storage.
- Inspect waste storage area at least once a month to ensure no spillage has happened.
- Store the wastes safely till a proper collection method of mercury waste is developed by the government of Sri Lanka.
- Do not dispose mercury wastes with general wastes.



Figure 3-8:
Containment
Tray



Figure 3-8:
Primary Container



Figure 3-10:
Secondary
Container

(h) Storage of fluorescent lamps:

- When unbroken fluorescent lamps are stored, storage should include:
 - A primary container that prevents breakage, preferably the original box in which the lamps were shipped. (If available, a box with a well-sealed vapor-resistant liner, such as a plastic-foil liner, is recommended. Otherwise, a long box or other box that fits the shape of the lamp can be used.)
 - A secondary container, such as a taped plastic sheet, that prevents the release of mercury vapor as a redundant safety measure. If the secondary container is not transparent or the label on the primary container cannot be seen, a label should also be placed outside the secondary container.
 - If the fluorescent lamps are stored in their original shipping cases, in a UN-approved fluorescent lamp drum or container, or in a box with a vapor-resistant liner, a secondary container is not required.
- Broken fluorescent lamps should be stored as mercury-containing waste.

(i) General procedures:

- All personnel involved in collection, storage, transport, and supervision of mercury waste should receive special training on mercury waste management including spill clean-up.
- Safety Data Sheets and International Chemical Safety Cards on mercury should be available to the employees and discussed during training sessions.
- The storage space should be inspected every month to check for leaks, corroded or broken containers, improper methods of storage, ventilation, the condition of the PPE and wash area, spill kit contents, and updated records. Special attention should be given to waste that has the potential to generate the highest vapor concentrations (e.g., elemental mercury, sphygmomanometers, etc.).
- There should be no smoking or eating in and around the storage space.
- Inventory records should be kept of the types of mercury waste, descriptions, quantities in storage, and initial dates of storage.

3.4.2 Packaging, Labelling, And Off-Site Transport



Figure 3-9: Hazard Indicating Pictograms/ Symbols

3.4.2.1 General Guidelines for Packaging and Labelling

(a) Packaging:

- In preparation for transport, mercury waste should be placed in a transport container that is closed, structurally sound, compatible with the contents, and designed to prevent release of mercury. If the original transport case or box in which devices were shipped is still in good condition, it can be used for shipment of unbroken devices.
- The mercury waste should be packed carefully with packing material such as plastic bubble wrap or plastic packing foam to prevent breakage inside the container. Other packing options include bentonite clay, kaolinite (sold for medicinal use, paper

production, and farming), and vermiculite. These clay minerals can absorb mercury and act as a barrier to prevent spreading. Commercial mercury absorbent products can also be used.

- The transport container should be tightly sealed to prevent escape of mercury if breakage occurs.

NOTE on fluorescent lamps: The way fluorescent lamps are transported can be a health hazard. A study by the University of Minnesota School of Public Health that found that the way in which fluorescent lamps are packaged and sealed during transport makes a difference in terms of occupational and environmental health. If only 5% of 30,000 lamps in a transport truck break, the transport workers will be exposed to 160 times the European Commission's recommended exposure limits. The researchers recommend placing the fluorescent lamps in a well-sealed vapor-resistant liner (such as a plastic-foil liner) inside an inner box which in turn is placed in an outer box that is structurally sound and adequate to prevent breakage.

(b) Labelling:

- The outside of the container used for transport should have a clear label "Hazardous Mercury Waste."
- The label should also include content (chemical composition or description of the waste), warnings, special handling procedures, if necessary, emergency contact numbers, and the name and contact information of the generator.

3.4.2.2 General guidelines for off-site transportation

(a) Preparation:

- For transport of large amounts of mercury waste, the regulatory authority may issue special permits or licenses to the transporter and a special registration for the vehicle. The licensed transporter may be given a unique identification number or code. To obtain a license to transport mercury waste, the transporter may be required to undergo training specific to mercury waste, submit proof of liability insurance or guarantee bond, and provide copies of an emergency preparedness and emergency response plan. The training could include legal obligations, planning, routing, handling, visual inspection, packaging, labelling, loading/unloading, securing, placarding, manifest or consignment forms, occupational safety, hazard recognition, hazard mitigation

(including ways to minimize the possibility and the consequences of accidents), use of PPE, spill response planning, use of spill kits, emergency procedures, and accident reporting. The vehicle may be inspected and certified prior to obtaining a special vehicle registration.

- The regulatory authority may specify the maximum amounts above which a registered transporter is required. For example, the regulatory authority may allow a generator (hospital, clinic or other health facility) transporting less than 100 kilograms of mercury-containing waste, less than 300 fluorescent lamps, and less than 0.45 kilogram of elemental mercury to transport the mercury waste by ground transportation to the storage facility in the generator's own vehicle; waste quantities above this limit would require a licensed transporter and a registered vehicle.
- A specially registered vehicle used to transport mercury care waste should fulfil some basic design criteria. Examples of the design criteria are as follows:
 - The registered vehicle should be a closed vehicle.
 - The body of the vehicle should be of a suitable size commensurate with the design of the vehicle and the load to be transported.
 - There should be a bulkhead between the driver's cabin and the vehicle body, which is designed to retain the load if the vehicle is involved in a collision.
 - There should be a suitable system for securing the load during transport.
 - Empty air-tight containers, plastic bags, PPE, spill kits, cleaning equipment, and decontaminating agents should be carried in a separate compartment in the vehicle.
 - The registered vehicle should be marked with the name and address of the waste carrier.
- The licensed transporter should have appropriate warning signs and placards displayed on the registered vehicle in accordance to national or international regulations. Mercury compounds are generally categorized under Class 6.1 (toxic substances) and elemental mercury (UN number 2809) under Class 8 (corrosive substances). In countries that require Emergency Action Codes, elemental mercury is a 2X (fine water spray, liquid tight chemical protective clothing). Examples of placards are shown below:



Figure 3-10: Example of placards

- The transporter should have a routing plan, emergency response or contingency plan, and emergency phone numbers before transporting mercury waste. The transporter should also have a spill kit, PPE, first-aid kit, fire extinguisher, labels, and extra containers in the passenger compartment for use in case of a spill.

(b) Off-Site Transport of Mercury Waste:

- Before transporting the waste, the transporter should inspect all the waste containers to ensure that they are packed and labelled properly.
- Whether transporting the mercury waste in a registered vehicle or in the generator's own vehicle, the waste containers should be placed in the back of the vehicle (cargo compartment of a truck or lorry, back trunk or boot of a car) and not in the passenger section.
- All waste containers should be firmly secured such that the containers do not tip over, slide, or shift during accelerations, stops, turns, and driving over bumps and holes on the road.
- Containers should not be stacked more than 1.5 meters high to avoid crushing items.
- The transport vehicle should be kept locked whenever there is waste in the vehicle except during inspection, loading, and unloading.
- The transporter should transport the waste as soon as possible using the safest or most direct route to the storage facility. If the transporter collects mercury waste from multiple facilities, the routing plan should reflect the shortest and safest route to minimize time and distances travelled. The transporter should transfer the waste only to the storage facility or to another licensed transporter.
- The transport vehicle should be kept clean and maintained in good running condition.

- Ideally, the registered vehicle should be used to transport mercury and other hazardous wastes only. However, if the vehicle is used to transport other types of wastes, the vehicle should have a sealed, bulk container that is used only for mercury and other hazardous wastes and that can be removed from or lifted on to the vehicle chassis.
- A manifest form or consignment note must accompany the movement of mercury waste.
- The manifest or consignment note should identify the source of the waste, the transporter, the storage facility, and the relevant government authority.
- The generator, transporter, and storage facility should each have copies of the manifest or consignment note. Each copy should contain the signatures of the persons handling the waste from the generator to the storage facility, as well as the names of the responsible persons representing the generator, transporter, and storage facility. Copies of the manifest or consignment note should be kept by the generator, transporter, and storage facility.
- The generator should keep a copy of the manifest or consignment note for at least five years from the date of shipment. The licensed transporter should keep a copy of the manifest and other records of each shipment for at least five years from the date of shipment, and these records should be made available to the regulatory authority as may be required by law.

3.4.3 Intermediate Storage at a Central Facility

3.4.3.1 General design guidelines for intermediate storage

These general guidelines relate to a centralized facility that will be used for intermediate storage, i.e., until such time as long-term storage (terminal storage) or mercury treatment and disposal facilities become available in the country.

These guidelines do not apply to facilities used for mercury processing or other operations that require opening of mercury containers, such as mercury scrap grading, mercury recovery from mercury-rich wastes, transferring elemental mercury to other containers (except for emergencies), etc. These processing facilities require other occupational and environmental safety features beyond the scope of these guidelines.

The following general points should guide the design of an intermediate, centralized storage facility for mercury waste:

- **Siting and preparation:**

- The intermediate storage facility should be at least 150 meters away from schools, healthcare facilities, residences, densely populated areas, food processing facilities, animal feed storage or processing facilities, agricultural operations, bodies of water (lakes, river, ocean, etc.), and environmentally sensitive areas.
- The storage facility should be located in a secure area to prevent theft.
- The storage facility should be accessible to trucks and other vehicles that transport mercury waste.
- The storage facility should be located in an area that is not prone to natural disasters, such as flooding, typhoons, hurricanes, brush fires, and earthquakes. If this is not possible, measures should be taken to withstand or ameliorate the effects of natural disasters, such as building an earthquake-resistant structure or conducting seismic retrofitting, building on higher elevations in flood plains, maintaining fire lines and using fire-resistant materials to prevent brush fires, etc.
- Where possible, the location should have a cool climate to minimize mercury volatilization and a dry atmosphere to reduce corrosion.

- **Overall Design Requirements:**

- The size of the storage area should be sufficient to hold safely the anticipated volume of mercury waste from the region being served. The estimated maximum volume should account for the different types of waste (elemental mercury, contaminated broken glassware, undamaged mercury thermometers and sphygmomanometers, other mercury-containing medical devices, fluorescent lamps, dental amalgam), their respective packaging, and the necessary space needed for shelving or storage racks, aisles, transport carts, etc. NOTE: When using an existing facility, the size of the existing storage space should determine the maximum volume of mercury waste that can be stored safely in the facility taking into consideration the types of mercury waste, their packaging, and other necessary space. Storage facilities should not exceed the maximum limit.
- The storage facility should be very secure with closely controlled access and an intrusion detection and alarm system.

- The facility should have static or natural ventilation. This should be supplemented by air conditioning to control temperature and humidity.
- Fires pose a high catastrophic potential. The storage facility should have a heat, smoke and fire detection and alarm system, and a fire suppression system. It should comply with national building code requirements for fire prevention. Fire extinguishers should be installed, inspected regularly, and recharged when needed. The kinds of fire extinguishers available should be consistent with the classes of fires that may be possible in the facility (e.g., paper, cardboard, or plastic fires; combustible liquid fires; electrical fires; etc.). Furthermore, selection of fire extinguishers should take into consideration the need for personnel safety, limiting the spread of mercury droplets and vapor, mercury clean-up and recovery after the fire, and avoiding stress corrosion of containers and shelves.
- The storage facility should have at least four distinct and separate functional areas:
 - i. Receiving area for receiving and pre-sorting waste, re-labelling if necessary, and signing documents
 - ii. Inspection area for checking for leaks, repackaging, secondary containment, and re-labelling if necessary
 - iii. Storage area specific for mercury waste
 - iv. Administrative and record-keeping area.
- PPE, spill clean-up kits, first-aid medical supplies, and wash areas should be located in the receiving area, inspection area, and near but not in the storage area. The PPE, spill kits, first-aid supplies, and wash areas should be easily accessible to personnel. Spill kits should include absorbent pads, plastic liners, vapor suppression and decontamination agents. The PPE should include:
 - o Rubber or nitrile gloves
 - o Safety goggles
 - o Respiratory protection: self-contained breathing apparatus (SCBA) for large spills, fit-tested full- or half-facepiece air-purifying respirator with mercury vapor cartridges, face mask with sulphur or iodide impregnated activated carbon, face mask made of sandwiched activated charcoal-impregnated cloth, or other mask designed specifically for mercury
 - o Polymer or rubber-based, protective full-body suits for large spills and protective coveralls
 - o Disposable shoe covers

- o Helmets.
- The drains in the receiving, inspection, and storage areas should be connected to a separate wastewater collection system and not to the regular sewer system nor to surface water. Drains in the storage facility should have an easily accessible and replaceable drain trap to capture mercury in the event of a spill.

i. Receiving Area:

- The receiving area should have a sign to guide and instruct waste generators and transporters.
- The receiving area should have: a pre-sort table for incoming waste; a cart made of impervious material such as steel, rubber or hard plastic (do not use aluminium carts); spill kits and emergency supplementary containers for leaking containers or broken packaging; PPE for the staff; and a separate table or counter for signing documents.
- A cart should be used to transfer the waste to the inspection area and to move the waste around the facility.

ii. Inspection area:

- The inspection area should be located near the receiving and storage areas. Because of the possibility that leaking containers may be brought in, the inspection area should have engineered spill-control features including containment dikes or bunding on the floor.
- The inspection area should have a mercury vapor detection probe, detector tubes, or other methods to detect leaking mercury containers.
- The inspection area should have local exhaust ventilation, such as a fume hood or enclosed hood, built in accordance to national guidelines. Ideally, the hood should be connected to an activated carbon filter or other device specifically designed to remove mercury before the air is discharged. The minimum average face velocity of the hood, when in use, should be about 0.5 meters per second. The exhaust stack should be at least 15 meters away from any fresh air intakes to the building and should extend at least 3 meters above the roof line. When the hood is in use, the exhaust air velocity should be at least 15 meters per second to overcome downdraft effects.
- The inspection area should have a spill control tray or containment device over which the waste should be inspected. The containment volume of the tray should be large enough to hold the maximum amount of liquid mercury expected by the facility to be received for inspection.

- The inspection area should have emergency supplementary containers to be used for leaking containers, packaging to replace broken or inadequate packaging, labels for re-labelling containers, spill kits, and PPE for the staff.

iii.Storage area:

- The storage area specific for mercury waste should be clearly marked with warning signs on all doors leading to the storage area. Copies of the spill response and emergency procedures should be on display in the storage area and kept with the spill clean-up kits and PPE.
- The storage area for mercury waste should have continuous or periodic monitoring of mercury levels in ambient air using mercury vapor monitors. Periodic monitors should sample mercury levels at least daily. The monitoring equipment should be able to detect mercury in air in parts per billion.
- The storage area specific for mercury waste should have engineered spill-control features to prevent mercury spills from exiting the area; these should include:
 - o Flooring that does not have cracks, seams, or other openings where mercury could get lodged in
 - o A floor sealant system that is impervious to mercury and makes it easy to collect spilled mercury such as a durable (6 mm thick) plastic flooring or seamless epoxy-coated concrete
 - o Suitable containment dikes incorporated into the floor sealant on all doors of the storage area.
- Mercury waste from health facilities may be segregated according to the following risk categories based on the amounts of available mercury:
 - o Risk Level 1 (highest risk): elemental mercury, unbroken sphygmomanometers, and medical devices containing large amounts of mercury (gastro-intestinal tubes, esophageal dilators, large mercury float switches and relays from electrical equipment)
 - o Risk Level 2: unbroken mercury thermometers, small mercury switches and small relays from electrical equipment
 - o Risk Level 3: broken glassware contaminated with mercury, mercury clean-up waste
 - o Risk Level 4: fluorescent lamps, compact fluorescent bulbs, dental amalgam.
- Shelving and storage racks for Risk Levels 1 and 2 should be fitted with plastic containment trays or shelves made of a material impervious to mercury such as steel. The containment volume of each tray should be at least 125% of the total volume of liquid

mercury stored on the tray. An option is the use of slightly sloped storage rack for containers of elemental mercury to facilitate discovery of leaks. This is not necessary if continuous monitoring of mercury levels is conducted.

- Shelving and storage racks should be able to support the weight of mercury waste and have back-and-side cross bracing or back-and-side panels to prevent sway. The shelves and racks should not be above shoulder height.
- In facilities that store other types of hazardous waste, mercury waste should not be stored near incompatible chemicals such as acetylene, alkali metals (lithium, sodium), aluminium, amines, ammonia, calcium, fulminic acid, halogens, hydrogen, nitric acid with ethanol, oxalic acid, and oxidizers.
- Lighting, aisle space, stacking, arrangements of containers, and placement of labels and markings should be designed to facilitate inspection of the storage area.
- The storage area should be designed to facilitate the transfer of mercury waste to a long-term (terminal) storage facility or a treatment and disposal facility in the future.

iv. Administrative and Record-Keeping Area:

- The administrative and record-keeping area should be separated from the receiving, inspection, and storage areas. Records should be maintained in good order and kept in a secure location.
- The administrative and record-keeping area should maintain copies of MSDSs and international chemical safety cards which should be readily available to the staff.
- The storage facility should be a non-smoking facility. There should be no eating in the storage area.

3.4.3.2 General procedures for intermediate storage

(a). Manifest System:

- A manifest form or consignment note must accompany the movement of mercury waste.
- The manifest or consignment note should identify the source of the waste, the transporter, the storage facility, and the relevant government authority.
- Copies of the manifest or consignment note should be kept by the generator, transporter, and storage facility.

- Copies of the manifest or consignment note should be kept by the storage facility until the waste is removed from the facility. The copies should be made available to the relevant government authority according to national regulations.

(b). Storage Facility Procedures:

- Storage facilities should comply with licensing and registration requirements and other provisions under the country's laws and regulations. In order to receive a license, the storage facility may be required to submit an ambient air monitoring plan, proof of liability insurance or guarantee bond, emergency preparedness and emergency response plan, description of waste management practices and other procedural guidelines, personnel training, and overall facility design. The storage facility may be inspected to ensure compliance with building, fire, electrical, and other health and safety codes prior to licensing. The regulatory authority may assign a unique identifier number or code to each storage facility.
- Storage facilities should submit periodic reports regarding safety issues (including accidents and spills), storage conditions, capacity, and monitoring data to the designated government authority, as may be required by the country's laws and regulations.
- Storage facilities should have a hazardous waste management plan which establishes procedures for receiving waste, internal transport, waste inspection, re-labelling, repackaging, supplementary containment, storage, facility inspection, general cleaning (housekeeping), spill control, spill clean-up, emergency procedures, worker safety (including hazard identification, hazard mitigation, proper use of PPE, ergonomic techniques for handling waste, and medical surveillance), reporting, and record-keeping.
- All storage facility staff should be familiar with all aspects of the hazardous waste management plan, receive initial and periodic refresher training, and be equipped to handle spills and other emergencies.
- When receiving the waste, the containers should go through an initial visual inspection to determine the condition of the packaging and containers without opening the primary and secondary containers. If a leak or breakage is suspected, the waste should be brought immediately to the inspection area.
- After the initial inspection, the waste should be brought to the inspection area for a more detailed inspection of the physical integrity and seal of the primary and secondary containers, to check for possible breakage of contents and proper labelling, and to

validate the amount of mercury waste (e.g., weight of containers, number of bags, number of fluorescent lamps, etc.). If outer containers have to be opened to test for suspected leaks, this should be done under the fume hood (local exhaust ventilation). Mercury probes or detector tubes could also be used to verify suspected leaks.

- The storage facility should have clear guidelines on repackaging and supplementary containment if outside packaging is inadequate or if primary or secondary containers are broken. If there are indications of a leak in the primary and/or secondary container, the waste should be placed in an air-tight supplementary container of the appropriate size and strength.
- The storage facility should have clear labelling guidelines that describe when a label should be replaced. The labels should say “Hazardous Mercury Waste” and include the content (chemical form, composition, or description of the waste), warnings, special handling procedures, if necessary, emergency numbers, and the name and contact information of the generator. The storage facility should add the following information to the existing label or in an additional label: UN number or hazardous substance identification number used by the country for mercury, hazardous waste description (toxic, corrosive for elemental mercury), date that the waste was received, and an identification code that links to a specific record with additional details about the waste, measured quantity, the transporter, and the generator.
- The storage area for mercury waste should be routinely monitored, including daily readings of mercury levels in ambient air; weekly inspections for leaks and corroded or broken containers, and improper methods of storage, as well as routine tests of the burglar alarms, fire alarms, fire suppression systems, and exhaust ventilation; and monthly inspections of the condition of the PPE and wash units, spill kit contents, flooring (to check for cracks), and files. Inspection logs including the inspection dates, observations, name, and signature of the inspector should be kept and made available to regulatory authority as may be required by law.
- During facility inspection, if a container is found to show signs of losing its physical integrity, the container should be removed from the shelf, carefully inspected under the fume hood, placed inside a supplementary container, and then re-labelled before being returned to the shelf.
- Records should be kept until such time that the mercury waste is transferred to a long-term (terminal) storage facility or to a treatment and disposal facility. The records should be linked to an identifier number or code on the mercury waste labels.

- The records should include the name and contact information of the source of mercury waste (including generator identification number if available), the quantities (number of containers, weights, approximate volumes) and descriptions of the waste (including composition and information on how the mercury waste was generated), special handling procedures or warnings if appropriate, the date when the waste was received, name and contact information of the transporter (including transporter identification number if available), the name of the person receiving and inspecting the waste, any notes or observations on the condition of the waste when received, any corrective actions taken (e.g., repackaging or re-labelling), the manifest or consignment note, and appropriate signatures.
- Records of accidents, spills, worker injuries, and chemical exposure should also be kept by the storage facility and made available to relevant government authorities, as may be required under the country's laws and regulations.
- Due to the significant risk of adverse health effects as a result of exposure to mercury at the facility, a health surveillance or medical monitoring program should be established.

4.1 Introduction

The Ministry of Health, Sri Lanka has taken initiatives to phase out Mercury containing thermometers and sphygmomanometers in the government health institutions. A letter has been issued by the Secretary, Ministry of Health in 2013, requesting hospitals under the Line Ministry and Provincial administration to phase out the usage of mercury containing thermometers and sphygmomanometers. As such procurement of mercury containing thermometers and sphygmomanometers does not come to pass for government healthcare institutions at present by Ministry of Health or Provincial Health Ministries. Hospitals still use Hg containing sphygmomanometers and thermometers purchased before the Ministry of Health decision not to procure those. Further, infrequently hospitals get mercury thermometers and sphygmomanometers as donations. This was mostly seen during the COVID-19 pandemic. Procurement of mercury containing thermometers and sphygmomanometers have not been banned in the private sector hospitals and clinics yet. It can be seen that still some medical practitioners prefer to use mercury sphygmomanometers.

Though there are certain guidelines related to mercury containing equipment have been developed by the Ministry of Health, there are certain important areas that are not addressed by these guidelines. This chapter provides guidelines specific for the health sector that would help to reduce the health and environmental impacts of mercury releases from the health sector. The guidelines cover lifecycle management of mercury containing products and waste consisting of or contaminated with mercury.

4.2 Green Procurement

Green procurement is the incorporation of environmental considerations when procuring products or services. This section of the guideline explains factors that should be considered when purchasing mercury, mercury containing/added products or materials.

- Verify whether the intended product or material is not restricted item under the Minamata Convention or by the Government of Sri Lanka.

- Identify mercury free alternatives, if any, which can provide the same intended functionality. This guideline provides a list of mercury free alternatives for some selected products in Table 4.1. If an alternative has been recommended in the guideline, only the mercury free alternative should be procured.
- If the guideline does not recommend any alternative, the purchaser is required to verify if any mercury free alternative is available in the market at the time of placing order.
- If any alternative product is available in the market, ensure that the quotations are obtained for both mercury containing and mercury free products.
- If mercury containing products are to be ordered, request the suppliers to provide the amount of mercury contained in products.
- Add the damage cost of mercury (Rs 73,300/kg of mercury as of January 2023) into the price of the mercury containing product when comparing the prices for purchasing.
- Whenever replacing mercury containing products, priority should be given for mercury-free alternatives. If such alternatives are not available, reduced-mercury alternatives should be considered.
- For Ayurvedic Rasa Medicine manufacturing process, it is recommended to follow the government procurement process. Specifications of required mercury to be specified prior to procurement.

4.3 Mercury Free Alternatives

Table 4.1: Mercury free alternatives for health sector

	Activity/process	Equipment/item	Alternative(non-Mercury)
1	Measuring temperature in persons	Mercury thermometer	Digital thermometer
2	Measuring pressure in persons	Mercury pressure meter (sphygmomanometer)	1. Aneroid sphygmomanometer 2. Digital Sphygmomanometer
3	Lighting	CFL bulbs Fluorescent tubes	LED bulbs
4	Dental filling	Amalgam	Composite filling

5	Lab investigations	Hg containing stains for cervical cancer screening	Harris Hematoxillin Mercury free stain for cervical cancer screening
		Other Hg containing stains	None

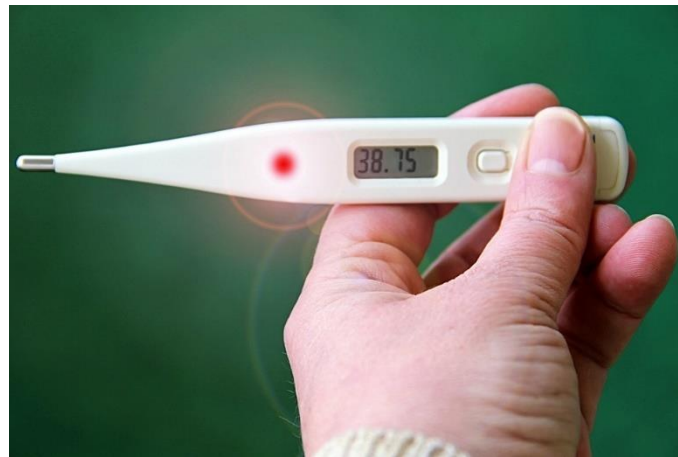


Figure 4-1: A Digital Thermometer

4.3.1 Technical Considerations when Selecting Alternatives

4.3.1.1 Fever Thermometers

- Only National Medicines Regulatory Authority (NMRA) approved digital thermometers should be purchased.
- Battery should preferably be mercury-free, with useful life guarantee of 200 hours continuous functioning.
- Maximum error permissible: +/- 0.1 °C between 32 °C and 42 °C. Guarantee must be provided that thermometers are acquired from manufacturers who abide by internationally recognized independently certified testing techniques and protocols in order to provide a product that offers the required accuracy.
- Digital clinical thermometers should conform with European Standard EN12470-3:2000+A1:2009 and/or international standard ASTM E1112-00.
- Protective sheath or hard case.
- Automatic shut-off.
- Resistant to use of disinfectants available in healthcare establishments

4.3.1.2 Sphygmomanometer

(a). Digital Sphygmomanometer

- The system shall have three BP recorders.
- Weight of the recorder shall be less than 275g.
- Measuring principle shall be Oscillo metric technique with linear deflation.

- Measurement Ranges:
Systolic: 60 to 280 mmHg
Diastolic: 30 to 160 mmHg
Pulse Rate: 30 to 180 bpm

- Measurement Accuracy
Blood Pressure: ± 3 mmHg mean.
difference ± 8 mmHg standard deviation
Pulse Rate: ± 3 bpm
(According to ANSI/AAMI SP-10:2002 &
BHS (Grade A/A) and ISO 81060-1:2007

- Measurement Intervals
Four adjustable intervals during 24-hour periods, each configurable to 0, 5, 10, 15, 20, 25, 30, 45, 60, 75, 90, 105, or 120-minute measurements.
Optional randomization factor up to 75% within intervals. Supports measurement over extended periods of time, typically 24 hours, and up to 7 days.

- Recorder shall be able to identify sleep/awake cycles.
- PC interface shall be USB.
- Shall supply extra cuffs with recorders.

4.4 Storage

4.4.1 Storing of Elemental Mercury

Please refer section [3.3.1](#) for guidelines on storing elemental mercury.

4.4.2 Storage of Mercury Device

Please refer section [3.3.2](#) for guidelines on storing mercury containing products.

4.5 Handling

Please refer section [3.2.1](#) for safety precautions when handling mercury.

Safe Work Practice

- Always work in a well-ventilated area when handling mercury or mercury-containing equipment/material.
- Never use a leaking mercury containing sphygmomanometer for recording blood pressure.
- Always use mercury containing equipment with extreme care.
- Absolutely no eating, drinking, or chewing gum where mercury is used.
- A mercury spill kit should be available in areas where mercury equipment is being used.

4.5.1 Use of Mercury in Ayurvedic Manufacturing Process

- The process equipment used for manufacturing process that comes in to contact with mercury should not react with mercury or mercury compounds. It is recommended to use Stainless Steel to fabricate such parts.
- If mercury is used in the manufacturing process, make sure optimum number of relevant reactants are used so that 100% conversion of elemental mercury is achieved.
- The manufacturing process equipment should be maintained according to a proper preventive maintenance schedule to ensure no leaks occur from the manufacturing process equipment.
- If any mercury is spilt or emitted from the manufacturing process due to a malfunction of the system, ensure to collect all the mercury spilt/leaked and prevent it from emitting to the environment. Adhere to guidelines provided for Spill Handling in case of a spill.
- The wastewater collected from cleaning of process equipment should be stored safely to ensure it does not emit in to the environment.

4.6 Spill Handling

The following guidelines developed by the Ministry of Health should be used to deal with a mercury spill in healthcare facilities.



Figure 4-2: A mercury spill

Mercury Spill Guideline

1. Evacuate area
 - Remove everyone from the area that has been contaminated and shut the door.
 - Turn off fans or the air conditioner to avoid dispersing mercury vapour throughout the facility.
2. Put on face mask
 - In order to prevent breathing of mercury vapour, wear a protective face mask (preferably N 95).
3. Put on old clothes
 - Change into old clothes and shoes that can be discarded if they become contaminated.
4. Remove jewellery
 - Remove all jewellery from hands and wrists so that the mercury cannot combine (amalgamate) with the precious metals.
5. Wear gloves Put on rubber or latex gloves.
 - If there are any broken pieces of glass or sharp objects, pick them up with care. Place all broken objects on a paper towel. Fold the paper towel and place in a zip lock bag. Secure the bag and label it as containing items contaminated with mercury.
6. Locate mercury beads
 - Locate all mercury beads, then carefully use the cardboard/X-ray sheets to gather them together. Use slow sweeping motions to prevent accidentally spreading the mercury. Small and hard-to-see beads can be located with the

flashlight: hold it at a low angle close to the floor in a darkened room and look for additional glistening beads of mercury that may be sticking to the surface or have gathered in small cracks in the surface. Mercury can move a surprisingly long distance on hard and flat surfaces: be sure to carefully inspect the entire room.

7. Use a syringe and sticky tape

- Use a syringe (without a needle) to draw up the mercury beads. Slowly and carefully transfer the mercury into an unbreakable plastic container with an airtight lid (such as a plastic film canister). Place the container in a zip-lock bag. Label the bag as containing items contaminated with mercury. After you remove larger beads, use sticky tape to collect smaller hard-to-see beads. Place the sticky tape in a zip lock bag and secure.

8. Leak-Proof Bag

- Place all materials used during the clean-up, including gloves, into a leak-proof plastic bag or container. Seal and label it.

9. Final disposal

- Keep the items safely stored till the Ministry of Health recommends the final disposal of this waste.

10. Outside ventilation

- Keep the affected area ventilated to the outside (with windows open and ventilation running) for at least 24 hours after the clean-up. If sickness occurs, seek medical attention immediately.

Six things you should NEVER do in case of a spill:

1. Never use a vacuum cleaner to clean up mercury: the vacuum cleaner will vaporise the mercury and drastically increase exposure in the area.
2. Never use a broom to clean up mercury: it breaks up the mercury droplets and moves them around, making it harder to decontaminate the area.
3. Never pour mercury down the drain: it can lodge in the plumbing and contaminate the septic tank and sludge in sewage treatment plants.
4. Never wash mercury-contaminated items in a washing machine: mercury can contaminate the sewage system and the washing machine.

5. Never continue wearing shoes and clothing that might have been contaminated in the mercury spill: this increases the wearer's exposure and helps spread contamination.
6. Never burn shoes, clothing, fabric, or anything that has been contaminated with mercury: this puts mercury into the atmosphere.

4.7 Dental Amalgam

Use of mercury containing amalgam is a major source of mercury release from the health sector. Following guidelines may be followed to reduce the release of mercury from dental care facilities.



Figure 4-3: Mercury containing amalgam filling in a tooth

4.7.1 Safety precautions when handling dental amalgam

Oral health staff should be trained in the correct and safe handling of mercury and dental amalgam, and the following guidelines could be followed:

- Use only single-use encapsulated amalgam complying with ISO 20749:2017 Dentistry — Pre-capsulated dental amalgam.
- Use PPE's when handling dental amalgam.
 - Skin protection: Nitrile Gloves, lab coats, aprons
 - Eye protection: Goggles
 - Respiratory protection: Masks (N95 preferred)
- It is recommended to have an emergency eye washer and an emergency shower in close proximity (within 30m).
- Avoid direct skin contact with mercury and freshly mixed dental amalgam.
- Recap single-use capsules after using them.
- Store used capsules and amalgam scrap in a closed container and according to the guidelines for mercury waste storage.
- Clean amalgam contaminants from instruments prior to heat sterilization or heat disinfection.
- Do not use bleach or other chlorine-containing cleaners to flush wastewater lines.

- Use ISO 11143 accredited amalgam separators to capture mercury. Separators can be re-used after appropriate processing. Introducing a collection and audit system will help to remind dentists that the units need to be replaced periodically and encourage better recycling practice.
- Train dental professionals in the ESM of dental amalgam.



Figure 4-4: Amalgam Capsules

4.7.2 Storage of Dental Amalgam

- When dental amalgam is stored for the purpose of accumulation, storage should include:
 - o A primary container that is easy to open, re-sealable, leak-proof, and air-tight
 - o A vapor suppression agent or water in the primary container
 - o A label with the type of mercury waste and the date mercury was first placed in the container.
 - o A secondary container that further prevents the release of mercury vapor as a redundant safety measure. If the secondary container is not transparent or the label on the primary container cannot be seen, a label should also be placed outside the secondary container.

4.7.3 Amalgam Waste Best Management Practices

Dental best management practices for amalgam waste handling and disposal include use of chair-side traps, use of amalgam separators, regular inspection and cleaning of traps, and use of appropriate waste service to recycle and/or dispose of collected amalgam. The following table (Table 4.2) gives Do's and Don'ts related to amalgam waste.

Table 4.2: Do's & Don'ts of Amalgam

DO	DON'T
Do use pre-capsulated alloys and stock a variety of capsule sizes	Don't use bulk mercury
Do recycle used disposable empty amalgam capsules.	Don't put used disposable amalgam capsules into sharps containers, infectious waste containers or into general waste.
Do salvage, store, and recycle non-contact amalgam (scrap amalgam).	Don't put non-contact amalgam waste into sharps containers, infectious waste containers or into general waste.
Do salvage (contact) amalgam pieces from restorations after removal and recycle the amalgam waste.	Don't put contact amalgam waste into sharps containers, infectious waste containers or into general waste.
Do use chairside filters to retain amalgam and recycle the content.	Don't rinse chairside filters containing amalgam over drains or sinks
Do store properly the contents retained by the vacuum pump filter or other amalgam collection devices, if they contain amalgam.	Don't rinse vacuum pump filters containing amalgam or other amalgam collection devices over drains. Don't dispose solids trapped in the chairside trap or amalgam separators with the clinical wastes.
Do recycle teeth that contain amalgam restorations.	Don't dispose of extracted teeth that contain amalgam restorations into sharps containers, infectious waste containers, or into general waste.
Do manage amalgam waste through recycling as much as possible.	Don't flush amalgam waste down the drain or toilet.
Do use line cleaners that minimize dissolution of amalgam.	Don't use bleach or chlorine-containing cleaners to flush wastewater lines.

Source(<https://www.ada.org/resources/research/science-and-research-institute/oral-health-topics/amalgam-separators>)

Table 4.3: Best practices in dental care sector (Source ADA 2022)

NON-CONTACT (SCRAP) AMALGAM
<ul style="list-style-type: none"> • Place non-contact, scrap amalgam in wide-mouthed, airtight container that is marked “Non-contact Amalgam Waste for Recycling.” • Make sure the container lid is well sealed

AMALGAM CAPSULES

- Stock amalgam capsules in a variety of sizes.
- After mixing amalgam, place the empty capsules in a wide-mouthed, airtight container that is marked “Amalgam Capsule Waste for Recycling.”
- Capsules that cannot be emptied should likewise be placed in a wide-mouthed, airtight container that is marked “Amalgam Capsule Waste for Recycling.”
- Make sure the container lid is well sealed.
- When the container is full, send it to a recycler.

AMALGAM SEPARATORS

- Check supplier instructions for replacement of the waste.
- Check with supplier re model information against specific conditions in the practice, e.g., space, plumbing, access, workload and regulatory requirements
- Consider capacity (in chairs), maximum flow rate and life cycle.

DISPOSABLE CHAIR SIDE TRAPS

- Open the chairside unit to expose the filter.
- Remove the filter and place it directly into a wide-mouthed, airtight container that is marked “Contact Amalgam Waste for Recycling.
- Make sure the container lid is well sealed.
- When the container is full, send it to a recycler.
- Filters from dental units dedicated strictly to hygiene and non-amalgam related activities may be placed into the general waste.

REUSABLE CHAIR SIDE TRAPS

- Open the chairside unit to expose the filter.
- Remove the filter and empty the contents into a wide-mouthed, airtight container that is marked “Contact Amalgam Waste for Recycling.”
- Make sure the container lid is well sealed.
- When the container is full, send it to a recycler.
- Replace the filter into the chairside unit. (Do not rinse the filter under running water as this could introduce dental amalgam into the waste stream.)

LINE CLEANERS

- Use line cleaners recommended by the unit manufacturer

VACUUM PUMP FILTERS

- Change the filter according to the manufacturer’s recommended schedule. Note: The following instructions assume that your recycler will accept whole filters; some recyclers require different handling of this material, so check with your recycler first.

- Remove the filter. While holding the filter over a tray or other container that can catch any spills, decant as much of the liquid as possible without losing any visible amalgam. The decanted, amalgam-free liquid can be rinsed down the drain.
- Put the lid on the filter and place the sealed container in the box in which it was originally shipped. When the box is full, the filters should be recycled.

INSTRUMENTS

- Clean scrap amalgam from instruments and matrix bands
- Place scrap into a wide-mouthed, airtight container that is marked “Contact Amalgam Waste for Recycling.”

ULTRASONIC CLEANING SOLUTION

- Dispose of ultrasonic cleaning solution via the amalgam separator

(Link: <https://www.ada.org/resources/research/science-and-research-institute/oral-health-topics/amalgam-separators>)

4.8 Management of wastes containing mercury or mercury compounds

Proper management of waste containing mercury or contaminated with mercury in healthcare facilities is essential to reduce the health and environmental impacts of mercury released from the health sector. Mercury containing waste includes broken or discarded mercury containing equipment, dental amalgam waste, waste from mercury spills, plus mercury containing bulbs, batteries, and switches. These wastes should be properly collected and stored safely until a proper disposal mechanism is developed.

4.8.1 General procedures

Please refer section [3.4.1](#) for guidelines on Mercury and Mercury contaminated waste management

4.9 Mercury containing bulbs



Figure 4-5: A CFL Bulb

Healthcare facilities use a considerable number of mercury containing bulbs such as fluorescent tubes and compact fluorescent lamps (CFLs). The replacement of these bulbs with LED bulbs are both economical and environmentally beneficial. Therefore, whenever the replacing burnt mercury containing lamps, priority should be given to replace it with a suitable LED bulb. Health care settings under the Ministry of Health and Provincial Ministries of Health have initiated the procurement of LED bulbs instead of CFL bulbs at present. However, healthcare settings possess significant amounts of waste CFL and fluorescent tubes containing Hg needing disposal.

The following guidelines will help the HCFs to properly handle their existing mercury containing bulbs and the safe storage of used bulbs.

4.9.1 Safe handling of compact fluorescent lights and fluorescent tubes

Since CFLs contain mercury, care must be exercised when handling, disposing, and dealing with broken bulbs. The following steps may be followed to reduce the risk.

- Remove and install the CFL by handling only the base of the lamp to prevent any unnecessary pressure on the glass that may cause it to break.
- Consider using a drop cloth when replacing a CFL to minimize the chance of breakage should the lamp fall or to protect the flooring and assist in clean-up should the bulb drop and break.
- Store fluorescent lamps in containers that prevent them from breaking, such as in their original packaging.
- Consider avoiding the use of CFLs in areas where the lamps may be easily broken.

4.9.2 Clean-up of a broken CFL

If you break a CFL, follow these directions for clean up:



Figure 4-6: A broken CFL

Leave the room.

- Remove people from the room and keep them out of the room during the clean-up process.
- Avoid stepping on any broken glass.

Ventilation

- Ventilate the room for at least 15 minutes prior to starting clean-up by opening windows and doors to the outdoors. This will ensure that mercury vapour levels are reduced before you start cleaning.

Clean-up directions for hard and carpeted surfaces

- Do not use a vacuum to clean up the initial breakage, as it will spread the mercury vapour and dust throughout the area and may contaminate the vacuum.
- Wear disposable gloves and masks (N95 preferred) if available, to avoid direct contact with mercury and to prevent cuts.
- Scoop or sweep up the broken pieces and debris with two pieces of stiff paper or cardboard. Do not use a broom.
- Use sticky tape, such as duct tape or masking tape, to pick up any remaining fine glass or powder.
- Wipe the area with a damp paper towel, cloth, or disposable wet wipe to remove any residual particles.
- Place the broken glass and clean-up materials in a container with a tight-fitting lid to further minimize the release of mercury vapour.

Carpeting - steps to take after the initial clean-up.

- If the rug is removable, take it outside, shake and air it out for as long as is practical.
- The first time you vacuum on installed carpet after the clean-up, shut the door to the room or isolate the area from other parts as much as possible and ventilate the room in which the lamp was broken by opening the windows and doors to the outside. When the vacuuming is done, remove the bag, wipe the vacuum with a damp paper towel, cloth or disposable wet wipe, and then place the vacuum bag and paper towel in a sealed plastic bag outside. In the case of a canister vacuum, wipe the canister out with a wet paper towel and dispose of the towel as outlined above. Continue to ventilate the room for 15 minutes once the vacuuming is completed.

Disposal

- Store the broken CFLs clean-up wastes safely in air-tight container till transferred for treatment.
- Do not dispose with general wastes.

4.10 Packaging, Labelling, And Off-Site Transport

Please refer section [3.4.2](#) for guidelines on Packaging Labelling and Off-site Transport

5. EDUCATION SECTOR

5.1 Introduction

According to the Minamata Initial Assessment, education sector contributed to 3% of the mercury emission in Sri Lanka which amounted to 243 kg. About 67% of this emission was related to use of mercury and mercury containing chemicals. The rest of the releases were related to mercury containing equipment and electronic components. However, Minamata Convention has exempted the use of mercury containing equipment for research purpose. Sri Lanka schools and universities use elemental mercury and mercury containing compounds for educational and research purposes. The Ministry of Education has recently issued a circular ceasing the procurement and use of mercury in school for educational purposes. Accordingly, only small quantity of mercury is allowed to be kept for demonstration.

The survey conducted parallel to the development of this guideline revealed that in many cases proper procedures are not followed when storing, handling, and dealing with mercury or mercury containing chemicals. The objective of the development this set of guidelines is to fill this information gap and to reduce the environmental and health impact of mercury usage in the education sector by improving the management practices.

5.2 Green Procurement

Green procurement is the incorporation of environmental considerations when procuring products or services. This section of the guideline explains factors that should be considered when purchasing mercury containing/added products or materials.

- Verify whether the intended product or material is not restricted item under the Minamata Convention or by the Government of Sri Lanka. Annex 1 provides a list of restricted items under the Minamata Convention.
- Identify mercury free alternatives, if any, which can provide the same intended functionality. This guideline provides a list of mercury free alternatives for some selected products in Tables 5.1 and 5.2. If an alternative has been recommended in the guideline, only the mercury free alternative should be procured.
- When calling for tenders during the procurement process to supply equipment, a clause should be added to ensure only mercury free products can be supplied.

- If the guideline does not recommend any alternative, the purchaser is required to verify if any mercury free alternative is available in the market at the time of placing order.
- If any alternative product is available in the market, ensure that the quotations are obtained for both mercury containing and mercury free products.
- If mercury containing products are to be ordered, request the suppliers to provide the amount of mercury contained in products. If mercury free alternatives are not available, a limit should be enforced during the procurement process to ensure the equipment with least amount of mercury is procured.
- Add the damage cost of mercury (Rs 73,300/kg of mercury as of January 2023) in to the price of the mercury containing product when comparing the prices for purchasing. (As indicated in the Annex 5.3, this value is a global average, and for more accurate estimation a country specific study should be conducted.)
- Whenever replacing mercury containing products, priority should be given for mercury-free alternatives. If such alternatives are not available, reduced-mercury alternatives should be considered.

Table 5.1: Replacements for mercury products commonly found in schools

ITEM	NON-MERCURY SUBSTITUTE
Mercury Lab Thermometer	Alcohol and mineral spirits glass bulbs, digital thermometers
Mercury Barometer	Aneroid, digital, and liquid-gas silicon
Mercury Hygrometer	Spirit-filled glass bulb, digital, aneroid
Mercury Hydrometer	Lead ballast hydrometers
Mercury Vacuum Gauge	Digital, electronic or mechanical gauges that use a needle or Bourdon tube may substitute for certain gases only
Mercury Spectral Tube	16 alternative gases are available
Mercury Manometer	U-shaped tubes using any coloured liquid, digital manometers
Mercury Molecular Motion Device	Apparatus for use with overhead projector uses balls on a glass plate
Mercury Sling Psychrometer	Mineral spirits glass bulb thermometers, some can fit in old frames; digital

Mercury Compounds: mercury oxide, chloride, sulphate, nitrate, iodide, Zencker's solution,	Other compounds, depending on experiment
Mercury Gas Law Apparatus	Charles' Law apparatus
Sphygmomanometer for Biology classrooms	Aneroid and digital

(Source: <https://www.newmoa.org/prevention/mercury/schools/mercuryalternativesreport.pdf>)

Table 5.2: List of alternatives chemicals and methods for some common uses

Hg Compounds	Alternative Chemicals and Methods
Mercury chloride	Magnesium chloride or zinc
Mercury iodine	Formalin
Mercury nitrate	Freeze drying
Mercury oxide	Phenate method
Mercury sulphate	Ammonia, copper sulphate, Neosporin, mycin copper catalyst, silver nitrate, potassium, or chromium sulphate
Mercury (II) Oxide	Copper catalyst
Mercury (II) Chloride	Magnesium Chloride/Sulfuric Acid or Zinc Formalin, Freeze drying
Mercury (II) Sulphate	Silver Nitrate/Potassium/Chromium-(III) Sulphate
Mercury Nitrate (for corrosion of copper alloys) for antifungal use (mercurochrome)	Ammonia/Copper Sulphate Neosporin, Mycin
Mercury Iodide	Phenate method
Zenker's Solution	Zinc Formalin

5.3 Laboratory safety and good practices

All the laboratories that handle mercury compounds or mercury containing equipment are strongly advised to develop laboratory guidelines for handling, storing, and managing mercury waste. Annex 5.2 gives a sample mercury safety data sheet for elemental mercury.

Mercury can be handled safely by a professional chemist, although you should minimize or eliminate its use whenever possible. Commonly used good practices when using mercury are listed below.

- Look for an alternative to using mercury in the first place:
- Use alcohol or digital thermometers instead of mercury ones.
- Use oil bubblers instead of mercury bubblers when possible.
- Consider using reducing agents other than mercury amalgams in your laboratory procedures.
- **Absolutely no eating, drinking, or chewing gum where mercury is used.**
- **NEVER use a mercury thermometer in a laboratory oven.** If it breaks in a hot oven, the heat will lead to dangerous concentrations of mercury in the air. This could cause the permanent or temporary shutdown, probably for several days, for cleaning and testing. The oven will have to be disposed of as hazardous waste. A break in a cold oven is an equally serious situation. The cost of cleaning up a thermometer break in a laboratory oven far exceeds that of a new laboratory oven with a built-in digital temperature display and fail-safe mechanism.
- Do not leave open containers of mercury in the laboratory. If used in a bubbler, the exhaust should go up a vertical tube to eliminate splashing and should be vented to a fume hood.
- Do not keep excess mercury around if you do not need it.
- Clean up spills promptly. When handling mercury use a glass, plastic or steel tray to contain any spills that might occur.

Caution: *mercury amalgamates with many common metals such as aluminium, so choose your container carefully.*

- Glass or plastic vessels should have a secondary steel or plastic container around them in case the vessel fails.
- Do not use mercury where it could contact a hot surface and vaporize.
- Avoid inhaling mercury vapor and use suitable gloves when working with it.

- Put mercury waste in a special waste container. Do not combine it with "regular" organic or inorganic wastes. **NEVER dispose of it down the sink!**
- Do not wear gold or silver jewellery when working with mercury; it will amalgamate and irreversibly damage your jewellery!
- Take appropriate measures in the event of a spill (see section 5.5 below).
- Read the Safety Data Sheet (SDS) for mercury before using it. As indicated on the SDS, mercury is dangerously incompatible with;
 - Aluminium
 - Ammonia
 - Chlorates
 - Copper
 - Copper alloys
 - Ethylene oxide
 - Halogens
 - Iron
 - Nitrates
 - Sulfur
 - Sulfuric acid
 - Oxygen
 - Acetylene
 - Lithium
 - Rubidium
 - Sodium carbide
 - Lead
 - Nitromethane
 - Peroxyformic acid
 - Calcium
 - Chlorine dioxide
 - Metal oxides
 - Azides
 - 3-bromopropyne
 - Alkynes + silver perchlorate
 - Methylsilane + oxygen
 - Tetracarbonylnickel + oxygen
 - boron diiodophosphide
- As with most other chemicals in your laboratory, access to mercury should be restricted to a locked cabinet or room. Do not leave mercury where a passer-by or unauthorized person can swipe it.

5.4 Storage

5.4.1 Storing of elemental mercury

Please refer section [3.3.1](#) for guidelines on storing elemental mercury.

5.4.2 Storage of Mercury Device

Please refer section [3.3.2](#) for guidelines on storing mercury containing products.

5.5 Handling

Please refer section [3.2.1](#) for safety precautions when handling mercury.

5.6 Spill Handling

Please refer section [3.2.2](#) for guidelines on mercury spill handling.

5.7 Management of wastes containing mercury or mercury compounds

Proper management of waste containing mercury or contaminated with mercury in educational facilities is essential to reduce the health and environmental impacts of mercury released from the laboratories. Mercury containing waste includes broken or discarded mercury containing equipment, waste from mercury spills, plus mercury containing bulbs, batteries, and switches. These wastes should be properly collected and stored safely until a proper disposal mechanism is developed.

5.7.1 General procedures

Please refer section [3.4.1.3](#) for guidelines on temporary storage of mercury contaminated waste.

5.7.2 Storage of mercury-contaminated waste

Please refer section [3.4.1.3](#) for guidelines on temporary storage of mercury contaminated waste.

5.7.3 Storage of fluorescent lamps

Please refer section [3.4.1.3](#) for guidelines on temporary storage of mercury contaminated waste.

5.8 Mercury containing bulbs

Educational facilities use a considerable number of mercury containing bulbs such as fluorescent tubes and compact fluorescent lamps (CFLs). The replacement of these bulbs with LED bulbs are both economical and environmentally beneficial. Therefore, whenever the replacing burnt mercury containing lamps, priority should be given to replace it with a suitable LED bulb.

The following guidelines will help educational institutions to properly handle their existing mercury containing bulbs and the safe storage of used bulbs.

5.8.1 Safe handling of compact fluorescent lights and fluorescent tubes

CFLs are commonly used in many facilities. Since CFLs contain mercury, care must be exercised when handling, disposing, and dealing with broken bulbs. The following steps may be followed to reduce the risk.

- Remove and install the CFL by handling only the base of the lamp to prevent any unnecessary pressure on the glass that may cause it to break.
- Consider using a drop cloth when replacing a CFL to minimize the chance of breakage should the lamp fall or to protect the flooring and assist in clean-up should the bulb drop and break.
- Store fluorescent lamps in containers that prevent them from breaking, such as in their original packaging.
- Consider avoiding the use of CFLs in areas where the lamps may be easily broken.

5.8.2 Clean-up of a broken CFL

If you break a CFL, follow these directions for clean up:

Leave the room.

- Remove people from the room and keep them out of the room during the clean-up process.
- Avoid stepping on any broken glass.

Ventilation

- Ventilate the room for at least 15 minutes prior to starting clean-up by opening windows and doors to the outdoors. This will ensure that mercury vapour levels are reduced before you start cleaning.

Clean-up directions for hard and carpeted surfaces

- Do not use a vacuum to clean up the initial breakage, as it will spread the mercury vapour and dust throughout the area and may contaminate the vacuum.
- Wear disposable gloves and masks (N95 preferred) if available, to avoid direct contact with mercury and to prevent cuts.
- Scoop or sweep up the broken pieces and debris with two pieces of stiff paper or cardboard. Do not use a broom.

- Use sticky tape, such as duct tape or masking tape, to pick up any remaining fine glass or powder.
- Wipe the area with a damp paper towel, cloth, or disposable wet wipe to remove any residual particles.
- Place the broken glass and clean-up materials in a container with a tight-fitting lid to further minimize the release of mercury vapour.

Disposal

- Store the broken CFLs and waste from the clean-up safely in air-tight container until handed over to a Central Environmental Authority (CEA) authorized mercury containing waste collector.
- Do not dispose with general wastes.

Note:

If a school consists of a Dental Unit, kindly refer the Health Sector Guidelines for management of mercury and mercury containing waste generated from Dental Amalgam.

5.9 Packaging, Labelling, And Off-Site Transport

Please refer section [3.4.2](#) for guidelines on Packaging Labelling and Off-site Transport

6. INDUSTRY SECTOR

6.1 Introduction

There is potential for mercury emissions in a variety of industrial applications. Some examples are, power generation using coal or petroleum products, petroleum refining, measuring and control devices, metal smelting, electrical and electronic waste recycling, gold waste recovery, waste incineration and wastewater treatment. As per the Minamata Initial Assessment (MIA), the industry sector is a significant contributor for mercury emissions in Sri Lanka.

To determine the level of Mercury consumption in Sri Lanka's industrial sector, numerous research had been conducted. The three main studies that are pertinent to the industry sector are the Mercury Country Situation Report (2018), the Minamata Initial Assessment (MIA) (2019) and Assessing the Mercury Usage in Small Scale Jewellery Manufacturing: A Detailed Study from Sri Lanka (2019).

During the project activities, it was revealed that the intentional addition of mercury into a product or process in the industry sector was minimal. Mainly mercury was extensively used in the small-scale jewellery sector and it was present in various forms of waste generated such as e-waste and wastewater residue. However, common equipment such as bulbs and pressure meters can be present in industries and related laboratories.

This Section of the Guideline covers the industry related activities that need to be controlled to reduce to control the mercury emission from the sector. The guidelines cover the life cycle management of mercury containing products as well as wastes containing or contaminated with mercury.

6.2 Green Procurement

Green procurement is the incorporation of environmental considerations when procuring products or services. This section of the guideline explains factors that should be considered when purchasing mercury containing/added products or materials.

- Verify whether the intended product or material is not restricted item under the Minamata Convention or by the Government of Sri Lanka.
- Identify mercury free alternatives, if any, which can provide the same intended functionality. This guideline provides a list of mercury free alternatives for some

selected products in Table 6.1. If an alternative has been recommended in the guideline, only the mercury free alternative should be procured.

- If the guideline does not recommend any alternative, the purchaser is required to verify if any mercury free alternative is available in the market at the time of placing order.
- If any alternative product is available in the market, ensure that the quotations are obtained for both mercury containing and mercury free products.
- If mercury containing products are to be ordered, request the suppliers to provide the amount of mercury contained in products.
- Add the damage cost of mercury (Rs 73,300/kg of mercury as of January 2023) in to the price of the mercury containing product when comparing the prices for purchasing. (As indicated in the Annex 6.2, this value is a global average, and for more accurate estimation a country specific study should be conducted.)
- Whenever replacing mercury containing products, priority should be given for mercury-free alternatives. If such alternatives are not available, reduced-mercury alternatives should be considered.

6.3 Mercury Free Alternatives

Table 6.1: Mercury free alternatives for Industry sector

Activity/process	Equipment/item	Alternative(non-Mercury)
1 Measuring temperature	Mercury in glass thermometers	Digital thermometers
2 Measuring pressure	Mercury containing barometers	Pressure gauges
3 Lighting	CFL bulbs Fluorescent tubes	LED bulbs
4 Gold dust recovery	Elemental mercury	1. Aqua-regia solution 2. Hypochlorite leaches solutions 3. Borax Powder, Ammonium Chloride and Potassium Nitrate

6.3.1 Applicability of alternatives used in Small Scale Jewellery Sector

The following alternatives have been identified in the report “Introducing Non-Mercury Alternative for Gold Separation in Small Scale Jewellery Sector” compiled and submitted to Ministry of Environment by the Gem and Jewellery Research and Training Institute.



Figure 6-1: Goldsmith engaged in jewellery making.

6.3.1.1 Gold Separation through Aqua-regia solution

- Aqua-regia solution is created by mixing 1 part of concentrated Nitric acid (HNO_3) with three parts of concentrated Hydrochloric acid (HCl).
- The collected gold dust is then dissolved in the solution.
- Afterwards, a reducing agent - Sodium meta- bisulphate is added to the solution.
- The solution is then kept for forming of gold precipitation.
- The precipitated gold particles are then added to a graphite crucible and is heated using a wind blowing furnace to recover the gold.
- The gold recovery percentage through Aqua-regia solution is approximately 82%.

6.3.1.2 Gold separation through hydrochloric acid and sodium chloride solution

- Collected gold dust particles are ground to form a fine powder.
- Clorox is added to the beaker with HCl , and gold powder and the gold powder is dissolved in hypochlorite solution
- The reducing agent sodium meta-bisulphate is added to the solution and left for gold precipitate to form.
- The precipitated gold particles are then added to a graphite crucible and is heated using a wind blowing furnace to recover the gold.

- The gold recovery percentage through hydrochloric acid and sodium chloride solution is approximately 78%.

6.3.1.3 Gold separation through Borax Powder (Pushkara), Ammonium Chloride (Ammonium Chloride) and Potassium Nitrate

- Collected gold dust particles are mixed with Borax, Ammonium Chloride and Potassium Nitrate.
- The mixture is then heated.
- Gold sinks to the bottom of this melt mixture and can be separated.
- However, the recovery efficiency of gold through this method is only 42%

6.4 Power Generation

Power generation using coal is a major source of mercury emission in Sri Lanka. The level of emission will depend on factors such as the initial mercury content of coal, combustion process related parameters, air pollution control system and the disposal method of ash.

During combustion, the mercury (Hg) in coal is volatilized and converted to elemental mercury (Hg^0) vapor in the high temperature regions of coal-fired boilers. As the flue gas is cooled, a series of complex reactions begin to convert Hg^0 to ionic mercury (Hg^{2+}) compounds and/or Hg compounds (Hg^p) that are in a solid-phase at flue gas cleaning temperatures or Hg that is adsorbed onto the surface of other particles. The presence of chlorine gas-phase equilibrium favours the formation of mercuric chloride (HgCl_2) at flue gas cleaning temperatures. However, Hg^0 oxidation reactions are kinetically limited, and, as a result, Hg enters the flue gas cleaning device(s) as a mixture of Hg^0 , Hg^{2+} , and Hg^p . This partitioning of Hg into Hg^0 , Hg^{2+} , and Hg^p is known as mercury speciation, which can have considerable influence on selection of mercury control approaches. In general, the majority of gaseous mercury in bituminous coal-fired boilers is Hg^{2+} . On the other hand, most of the gaseous mercury in subbituminous- and lignite-fired boilers is Hg^0 . Control of mercury emissions from coal-fired boilers is currently achieved via existing controls used to remove particulate matter (PM), sulphur dioxide (SO_2), and nitrogen oxides (NO_x). This includes capture of Hg^p in PM control equipment and soluble Hg^{2+} compounds in wet flue gas desulfurization (FGD) systems. Available data also reflect that use of selective catalytic reduction (SCR) NO_x control enhances oxidation of Hg^0 in flue gas and results in increased mercury removal in wet FGD. Injection of activated carbon powder, in addition to existing air pollution control equipment increase the efficiency of mercury capture.

6.4.1 Selection low mercury coal

Though the mercury content of the coal is not a criterion for purchasing of coal, it is worthwhile to see the possibility of inclusion of this as a specification in purchasing coal. The following Table shows the mercury content of coal from different regions of the world.

Table 6.2: Mercury content of coal from different countries

Country	Coal type	Average of all samples (mg/kg)	Range (mg/kg)	Reference
Russia	Bituminous/ Subbituminous	0.12	<0.02-0.25 (23)	UNEP. 2013b Romanov <i>et at.</i> 2012
Slovak Rep.	Bituminous Lignite	0.08 0.057	0.03-0.13 (7) 0.032-0.14 (8)	Finkelman, 2004 Tewalt et aL. 2010
South Africa		0.157	0.023-01 (40)	Leaner et al. 2009: Tewalt et al. 2010
Tanzania	Bituminous	0.12	0.03-0.22 (75)	Finkelman, 2004
Thailand	Lignite	0.137	0.02-0.6 (23)	Tewalt et al., 2010
Turkey	Lignite	0.12	0.03-0.66 (149)	Tewalt et at, 2010
United Kingdom	Bituminous	0.216	0.012-0.6 (84)	Tewalt et al., 2010
USA	Subbituminous Lignite Bituminous Anthracite	0.1 0.15 0.21 0.23	0.01-8.0 (640) 0.03-1.0 (183) <0.01-3.3 (3527) 0.16-0.30 (52)	US EPA. 1997 US EPA. 1997 US EPA. 1997 US EPA. 1997
Vietnam	Anthracite	0.348	<0.02-0-34 (6)	Tewalt <i>et al.</i> 2010
Zambia	Bituminous	0.6	<0.03-3.6 (14)	Tewalt et <i>al.</i> 2010
Zimbabwe	Bituminous	0.08	<0.03-0.15(6)	Tewalt <i>et at.</i> 2010
Australia	Bituminous	0.075	0.01-0.4	Nelson. 2007: Tewatl et al. 2010
Argentina	Bituminous	0.19	0.02-0.96 (8)	Finkelman. 2004: Tewatt et al. 2010
Botswana	Bituminous	0.10	0.04-0.15 (28)	Finkelman. 2004: Tewatt et al. 2010
Brazil	Bituminous Subbituminous	0.20 0.3	0.04-0.81 (23) 0.06-0.94 (45)	Finkelman. 2004: Tewalt et al., 2010

Canada		0.058	0.033-0.12 (12)	Tewalt et al. 2010
Chile	Bituminous Subbituminous	0.21 0.033	0.03-2.2 (19) 0.022-0.057 (4)	Tewatt et al, 2010
China	Bituminous/ Subbituminous	0.17	0.01-2.248 (482)	Zhang et al., 2012: UNEP, 2011
Colombia	Subbituminous	0.069	>0.02-0.17 (16)	Finkelman, 2004
Czech Rep.	Lignite Bituminous	0.338 0.126	<0.03-0.79(16) 0.03-0.38 (21)	Finkelman, 2003 Tewalt et al. 2010
Egypt	Bituminous	0.12	0.02-0.37 (24)	Tewalt et al. 2010
France	Bituminous	0.044	0.03-0.071(3)	Tewatt et al., 2010
Germany	Bituminous Lignite	0.05	0.7-1.4 Max: 0.09	Pirrone et al. 2001 MUNLV 2005
Hungary	Bituminous Subbituminous Lignite	0.354 0.138 0.242	0.091-1.2 (5) 0.04-0.31 (19) 0.075-0.44 (12)	Tewatt et al, 2010
India	Bituminous Lignite	0.106 0.071	0.02-0.86 (99) 0.053-0.093 (8)	Tewatt et al. 2010: UNEP. 2014
Indonesia	Lignite Subbituminous	0.11 0.03	0.02-0.19 (8) 0.01-0.05 (78)	Finkelman. 2003: Tewalt et al. 2010 US EPA. 2002
Iran	Bituminous	0.168	0.02-0.73 (57)	Tewalt et al. 2010
Japan	Bituminous	0.0454	0.01-0.21(86)	Ito et al., 2004
Kazakhstan	Bituminous	0.08	<0.03-0.14 (15)	Tewalt et al., 2010
New Zealand	Bituminous	0.073 0.082	0.03-0.1(5) 0.062-0.13 (9)	Tewalt et al, 2010
Mongolia	Bituminous	0.097	0.02-0.22 (36)	Tewalt et al. 2010
Peru	Anthracite +	0.27	0.04-0.63 (15)	Finkelman. 2004
Philippines	Subbituminous	0.04	<0.04-0.1	Finkelman, 2004
Poland	Bituminous	0.085	0.013-0.163	BoJkowska et al., 2001
Romania	Lignite+ Subbituminous	0.21	0.07-0.46 (11)	Finkelman, 2004

Source: https://mercuryconvention.org/sites/default/files/2021-06/BAT_BEP_E_interractif.pdf

NOTE: Caution should be used when interpreting the above mercury concentration information, as populations of coal samples for different countries vary widely. In addition, information is not universally available to indicate whether the reported concentrations of mercury are based on dry coal or as-received coal figures. These data may not be representative of coal from the as-burned standpoint. The number in parentheses in the 'range' column reflects the number of samples.

6.4.2 Proper Storage of Coal

The following areas should be considered when storing of Coal.

- Avoid ground contamination.
 - Use appropriate preventive mechanisms in order to avoid leakages to soil and ground water. Therefore, the coal yard should be properly prepared according to the following manner. (the following is extracted from best practices available in the industry).
 - On compacted earth, HDPE layer is to be laid of at least 1 mm thickness
 - On top of it, 20 mm thick sand layer is to be added
 - On top of it ABC (crushed stone) of at least 300 mm thickness should be added
 - Deft coal (poor coal) layer of at least 500 mm should be added on top of the ABC layer
 - Thermal coal can be stored on top of this
 - An underground drainage system should be in place under the coal yard in order to capture the wastewater and direct it to the wastewater treatment plant. The wastewater should be treated according to the national standard
- Storing of coal to avoid dust formation
 - The coal storing yard should ideally be fully covered to avoid dust formation due to wind. In case if it is not possible to fully cover the area, adequate wind barriers should be in place to prevent dust formation of coal and coal from being blown away
 - A water sprinkling system should be in place to keep the yard in wet condition to prevent dust formation
- During transportation or transferring of coal, it should be done so via fully covered vehicles, covered conveyor system or covered bucket elevators.

6.4.3 Use of Air Pollution Control Devices

The following table shows the removal efficiency of mercury in flue gas by different air pollution control devices (APCD) employed in power plants.

Table 6.3: Mercury removal efficiency percentage (%) by typical APCD combinations

APCD combination	Mean	Min	Max	Standard Deviation	Number of tests
Wet PM Scrubber	23	7	59	18	8
ESPc	29	1	83	19	64
FF	67	9	92	30	10
ESPc+wFGD	62	13	88	22	19
FF+wFGD	86	77	97	10	3
SCR+ESP+wFGD	69	36	95	24	4
SCR+FF+wFGD	93	86	99	9	2
ESPc+CFB-FGD+FF	68	68	68		1

ESP = electrostatic precipitator; ESPc = cold side ESP; FF = fabric filter; SCR = selective catalytic reduction; Wet FGD = wet flue gas desulfurization scrubber; CFB = Circulating Fluidised Bed

6.4.4 Environmentally Sound Management of Coal Combustion Residues

Environmentally sound management of coal combustion residues (CCRs) is important to minimize the potential for increasing the risk of mercury re-emission and other potential problems. Throughout the process of mercury emission control from coal-fired sources, mercury is removed from flue gas and transferred to CCRs, including boiler bottom ash, fly ash, and sludge from wet FGD. Sludge from wet FGD and other CCRs are either stored at the site or reused, including through further processing into gypsum wallboard. In the latter case, after FGD gypsum has been filtered out of the sludge, mercury may need to be extracted from the FGD wastewater effluent depending on the levels present. This may be accomplished via chemical treatment, ion exchange, or with membrane filtration. In the processes of gypsum wallboard production, other use of CCRs, including during storage of CCRs at the site, mercury contained within them may have the potential of being re-released.

In the process of gypsum wallboard production, a fraction of mercury may be re-released because the production processes often include high-temperature units. In one study, total mercury loss across the wallboard plant represented about 5 per cent of the incoming FGD gypsum mercury content. However, another study indicated that 12–55 per cent of total mercury in the FGD gypsum would be emitted during wallboard production and a third study found releases ranging from 2 to 66 per cent of the mercury in the incoming FGD gypsum. Given the potential variability in release rates, wallboard production using FGD gypsum is not regarded as BEP unless the mercury re-emissions are shown to be minimal or are captured during the wallboard production.

In the case of on-site storage of CCRs, there may be a potential for cross-media impacts (e.g., for leaching of mercury into groundwater). A multi-year study of leaching characteristics of CCRs concluded that any potential release of metals from CCRs to the environment is affected by leaching conditions. Leaching conditions are affected by the pH and by the amount of water contact (ratio of liquid to-solids). When evaluated over the pH range from 5.4 to 12.4 (plausible range for management of CCRs), the mercury leach results did not exceed existing standards for the concentration of mercury in well-water in the United States. In these same studies, some leach results for some other heavy metals, such as arsenic, were found to exceed existing standards for concentration in well-water in the United States. It should be noted that the data presented do not include any attempt to estimate the amount of constituent that may reach an aquifer or drinking water well. Groundwater transport and fate modelling, including the consideration of many additional factors – including how the fly ash is managed – would be needed to assess the potential risk. The storage of CCRs with impervious surfaces at the site can be considered as one aspect of environmentally sound management.

6.5 Storage

6.5.1 Storage of Elemental Mercury

Please refer section [3.3.1](#) for guidelines on mercury storage.

6.5.2 Storage of Mercury Device

Please refer section [3.3.2](#) for guidelines on mercury containing product storage.

6.6 Handling

Please refer section [3.2.1](#) for guidelines on safety precautions when using mercury.

6.7 Spill Handling

Please refer section [3.2.2](#) for guidelines on mercury spill handling.

6.8 Management of wastes containing mercury or mercury compounds

Proper management of waste containing mercury or contaminated with mercury in healthcare facilities is essential to reduce the health and environmental impacts of mercury released from the health sector. Mercury containing waste includes broken or discarded mercury containing equipment, dental amalgam waste, waste from mercury spills, plus mercury containing bulbs,

batteries, and switches. These wastes should be properly collected and stored safely until a proper disposal mechanism is developed.

6.8.1 General procedures

Please refer section 3.4.1.3 for guidelines on temporary storage of mercury contaminated waste.

6.8.2 Storage of mercury-contaminated waste

Please refer section 3.4.1.3 for guidelines on temporary storage of mercury contaminated waste.

6.8.3 Storage of fluorescent lamps

Please refer section 3.4.1.3 for guidelines on temporary storage of mercury contaminated waste.

6.9 Mercury containing bulbs

Industrial facilities use a considerable number of mercury containing bulbs such as fluorescent tubes and compact fluorescent lamps (CFLs). The replacement of these bulbs with LED bulbs are both economical and environmentally beneficial. Therefore, whenever the replacing burnt mercury containing lamps, priority should be given to replace it with a suitable LED bulb.

The following guidelines will help the HCFs to properly handle their existing mercury containing bulbs and the safe storage of used bulbs.

6.9.1 Safe handling of compact fluorescent lights and fluorescent tubes

CFLs are commonly used in healthcare facilities. Since CFLs contain mercury, care must be exercised when handling, disposing, and dealing with broken bulbs. The following steps may be followed to reduce the risk.

- Remove and install the CFL by handling only the base of the lamp to prevent any unnecessary pressure on the glass that may cause it to break.
- Consider using a drop cloth when replacing a CFL to minimize the chance of breakage should the lamp fall or to protect the flooring and assist in clean-up should the bulb drop and break.
- Store fluorescent lamps in containers that prevent them from breaking, such as in their original packaging.
- Consider avoiding the use of CFLs in areas where the lamps may be easily broken.

6.9.2 Clean-up of a broken CFL

If you break a CFL, follow these directions for clean up:

Leave the room

- Remove people from the room and keep them out of the room during the clean-up process.
- Avoid stepping on any broken glass.

Ventilation

- Ventilate the room for at least 15 minutes prior to starting clean-up by opening windows and doors to the outdoors. This will ensure that mercury vapour levels are reduced before you start cleaning.

Clean-up directions for hard and carpeted surfaces

- Do not use a vacuum to clean up the initial breakage, as it will spread the mercury vapour and dust throughout the area and may contaminate the vacuum.
- Wear disposable gloves and masks (N95 preferred) if available, to avoid direct contact with mercury and to prevent cuts.
- Scoop or sweep up the broken pieces and debris with two pieces of stiff paper or cardboard. Do not use a broom.
- Use sticky tape, such as duct tape or masking tape, to pick up any remaining fine glass or powder.
- Wipe the area with a damp paper towel, cloth or disposable wet wipe to remove any residual particles.
- Place the broken glass and clean-up materials in a container with a tight-fitting lid to further minimize the release of mercury vapour.

Carpeting - steps to take after the initial clean-up.

- If the rug is removable, take it outside, shake and air it out for as long as is practical.
- The first time you vacuum on installed carpet after the clean-up, shut the door to the room or isolate the area from other parts as much as possible and ventilate the room in which the lamp was broken by opening the windows and doors to the outside. When the vacuuming is done, remove the bag, wipe the vacuum with a damp paper towel, cloth or disposable wet wipe, and then place the vacuum bag and paper towel in a sealed

plastic bag outside. In the case of a canister vacuum, wipe the canister out with a wet paper towel and dispose of the towel as outlined above. Continue to ventilate the room for 15 minutes once the vacuuming is completed.

Disposal

- Store the broken CFLs clean-up wastes safely in air-tight container till transferred for treatment.
- Do not dispose with general wastes.

6.10 Packaging, Labelling, And Off-Site Transport

Please refer section [3.4.2](#) for guidelines on Packaging Labelling and Off-site Transport

6.11 Recommendations

- In future, new industries may come up in which mercury is being used. Hence, it is important to identify industries in which there is potential to use mercury or mercury containing products. This can be incorporated into the aspects that are considered in the Environmental Impact Assessment (EIA) which is carried out prior to establishing the industry in Sri Lanka.
- Fly ash waste generated through the coal powerplant have accumulated. The government should enforce regulations to encourage the utilization of this waste in products. For example, the fly ash waste can be incorporated into bricks. This can be used to construct new buildings in close proximity to the power plant.
- It is recommended to develop a national level health and environmental cost for mercury emissions in Sri Lanka which is accepted by the government of Sri Lanka. This would give credibility to the stakeholders of the health and environmental cost incurred when mercury is emitted in to the environment.
- It is recommended to develop policies and regulations to ban mercury containing products if safer alternatives are present.
- It is recommended to develop policies and regulations to prevent incineration of mercury and mercury containing waste using industrial scale incinerators. The input of the incinerators needs to be monitored to ensure no mercury is present.
- Regulations should be developed to limit the ability to freely purchase mercury and mercury containing products.

Annex 1 – Restricted products which includes Mercury

Annex 2 – A Sample Laboratory Safety Guideline

Annex 3 – Cost Benefit Analysis

Annex 4 – List of Stakeholder Consultation Workshop Participants

7. Annex 1: Restricted products which includes Mercury

Table 7.1: Restricted Products

Category No	Products
1	Batteries, except for button zinc silver oxide batteries with a mercury content < 2% and button Zinc air batteries with a mercury content < 2%
2	Switches and relays, except very high accuracy capacitance and loss measurement bridges and high frequency radio frequency switches and relays in monitoring and control instruments with a maximum mercury content of 20 mg per bridge, switch, or relay
3	Compact fluorescent lamps (CFLs) for general lighting purposes that are ≤ 30 watts with a mercury content exceeding 5 mg per lamp burner
4	Linear fluorescent lamps (LFLs) for general lighting purposes: <ul style="list-style-type: none"> • Triband phosphor < 60 watts with a mercury content exceeding 5 mg per lamp. • Halophosphate phosphor ≤ 40 watts with a mercury content exceeding 10 mg per lamp
5	High pressure mercury vapour lamps (HPMV) for general lighting purposes
6	Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for electronic displays: <ul style="list-style-type: none"> • short length (≤ 500 mm) with mercury content exceeding 3.5 mg per lamp. • medium length (> 500 mm and ≤ 1 500 mm) with mercury content exceeding 5 mg per lamp • long length (> 1 500 mm) with mercury content exceeding 13 mg per lamp
7	Cosmetics (with mercury content above 1ppm), including skin lightening soaps and creams, and not including eye area cosmetics where mercury is used as a preservative and no effective and safe substitute preservatives are available ^{1/}
8	Pesticides, biocides and topical antiseptics
9	The following non-electronic measuring devices except non-electronic measuring devices installed in large-scale equipment or those used for high precision measurement, where no suitable mercury-free alternative is available: <ul style="list-style-type: none"> • barometers. • hygrometers. • manometers. • thermometers. • sphygmomanometers.

8. Annex 2: A Sample Laboratory Safety Guideline

(Extracted from Harvard Campus Services)



https://www.ehs.harvard.edu/sites/default/files/lab_safety_guideline_mercury.pdf

LABORATORY SAFETY GUIDELINE

Mercury [CAS No. 7439-97-6]

All mercury users at Harvard must review this document and should contact their EHS Laboratory Safety Advisor and department safety officer prior to using this substance. Elemental mercury is a heavy, shiny, silver-white, odourless liquid. It is non-flammable, but releases toxic, odourless vapor, especially when heated.

HAZARDS

	Short-term exposure to high mercury concentrations in air can initially cause cough, sore throat, shortness of breath, nausea, vomiting, diarrhoea, abdominal pain, headache, weakness, and visual disturbances. Several days after the initial exposure to high concentrations in air, heavy salivation, more severe gastrointestinal symptoms, and kidney damage can develop. Exposure to high concentrations of mercury vapor in air can ultimately be fatal.
	Long-term exposure to lower levels of mercury in air can damage multiple organs (the central nervous system and the kidneys are at the greatest risk of damage). If a pregnant woman is exposed to mercury vapor in air, her baby may have a greater risk of being born with birth defects.

Note: This guide is for elemental mercury. Organomercury compounds (e.g., dimethylmercury) are typically much more toxic and hazardous than elemental mercury. Please see our other Laboratory Safety Guidelines for information on the safe handling of organomercury compounds.

PRECAUTIONS

Before starting work:

- Determine if you can use a less hazardous substance in place of elemental mercury.
- Review the manufacturer's Safety Data Sheet and additional chemical information at

<http://www.ehs.harvard.edu/safety-data-sheets-sds>

- Ensure that a written experimental protocol including safety information is available;
- Ensure that you are working on a non-porous surface since mercury easily collects in tiny cracks and scratches;
- Be familiar with general University emergency procedures in the EHS Emergency Response Guide;
- Order only the quantity that you need.
- Identify the location of the nearest eyewash and shower and verify that they are accessible;
- Locate and verify that appropriate mercury spill clean-up materials are available, including the following:
 - o An appropriately sized spill kit specially designed for mercury (e.g., New Pig's Mercury Spill Kit) – this type of kit includes an absorbent material that will transform the mercury into a stable, safer amalgam.
 - o NEVER use a vacuum to clean up a mercury spill.
- Post a sign in the work area: “Danger: Mercury Used in this Area”; and
- Do not work alone! Ensure another person who is familiar with your work and mercury hazards is in the area.

During work:

- AVOID INHALATION! Perform any heating operations in a certified chemical fume hood or other approved ventilated enclosure.
- AVOID CONTACT! Use appropriate personal protective equipment (PPE):
 - o Wear a lab coat, long pants, shirt, and closed-toed shoes.
 - o Standard 4-mil thick nitrile gloves are adequate to protect the skin on your hands while working with mercury;
 - o Gloves must be thoroughly inspected prior to each use. Do not use damaged gloves.
 - o Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with mercury;
 - o Change gloves at least once an hour and immediately whenever you suspect mercury has contacted your gloves;
 - o Wear chemically-protective goggles (in lieu of goggles, work behind a mostly closed fume hood sash while wearing safety glasses); and
 - o Wash hands and forearms thoroughly with soap and water each time gloves are removed.
- Use materials and containers appropriate for mercury use and remain aware of potential incompatibilities. Mercury vapor can penetrate some plastics. Therefore, glass containers/materials work well. Keep in mind, however, that glass is fragile – overpack glass containers in plastic containers. Additionally, consider placing mercury absorbent material in

the overpack container so that any potential spilled mercury is amalgamized immediately. Mercury absorbent powders are commercially available and commonly contain zinc.

- Keep all containers tightly closed when not in use and during transport.

After completing the work

- Dispose of waste mercury following Harvard University Hazardous Waste Procedures. Collect mercury waste in a tightly sealed glass container. Overpack the glass waste container in a plastic container with a tight-fitting lid.
 - o Hazardous Waste Classification: Toxic
- Return container to storage area following Harvard University Laboratory Chemical Storage Guide
 - o Storage Group AT [High Acute Toxicity]
 - o Store in designated plastic (polyethylene) secondary container.
 - o Store in original containers or other appropriate containers (see section above)
 - o Store mercury in a cool, dry, well-ventilated space. Also, mercury can be mildly corrosive – avoid storage in a metal cabinet.
- Because mercury residue easily remains on surfaces, it is a best practice to decontaminate any surfaces on which you worked with mercury. Mercury decontamination wipes are commercially available.
- Wash hands and forearms thoroughly with soap and water before leaving the lab.

EMERGENCY PROCEDURES

First Aid

SKIN CONTACT

- Flush skin with water for 5 minutes using the closest available sink, portable drench hose or safety shower. Remove any exposed clothing as well as any jewellery that may be trapping mercury;
- Call 911 on a landline phone for medical assistance (or provide location if calling on a mobile phone).

EYE CONTACT

- Using eyewash, flush eyes while holding eyelids open;
- Call 119 for medical assistance.
- Continue flushing eyes with water until emergency medical personnel arrive.

INHALATION

- If mercury mist or vapours are inhaled, immediately move to get fresh air;
- Call 119 for medical assistance.

INGESTION

- Do not induce vomiting.
- Call 119 for medical assistance.
- Rinse mouth with water if conscious.
- Never give anything by mouth to an unconscious person.

Spill Response

OUTSIDE FUME HOOD OR VENTILATED ENCLOSURE

- If the spill occurs on heated surfaces, alert others and evacuate to a safe distance and prevent entry.
- Contact the University Operations Centre at (617) 495-5560 [HMS/HSDM (617) 432-1901]
- Remain in a safe location until EHS or other response personnel arrive.
- If the spill does not occur on heated surfaces, follow the procedures below.

INSIDE FUME HOOD OR VENTILATED ENCLOSURE (< 500 ml)

- If trained and confident, use your mercury spill kit to clean up the spill. During clean-up, ensure you are wearing PPE described above including goggles.
- Otherwise close the fume hood sash and await support.
- Contact the University Operations Centre at (617) 495-5560 [HMS/HSDM (617) 432-1901] for any

9. Annex 3: Cost Benefit Analysis

Mercury pollution has societal costs, such as damage costs from negative effects on human health and the environment, lost income from reduced commercial fisheries, and administrative costs for scientific research and development, control, and risk communication (Spadaro and Rabl, 2008). The most serious human health impact of global mercury pollution, according to available literature, is neurological damage leading to impaired brain development when exposure occurs during the prenatal phase (if pregnant women ingest food contaminated with methyl mercury). The impaired brain development results in a loss of IQ (Intelligence Quotient) points. Increased risks of cardiovascular disease are among the other toxicological effects. The societal costs associated with IQ loss include lost earnings and education costs.

A cost-benefit analysis of mercury-free alternative products in the industry, health, and education sectors is conducted in this study, with input from relevant sector experts. The relevant CBA parameters used in the estimation are summarized in Table 9.1 and 9.2. The basic parameters for this study were derived from previous literature and a survey conducted by the research team. Damage costs contributions for Hg are based on a study conducted by Nedellec and Rab (2016). It primarily consists of the cost of mortality and IQ losses.

Summary of the parameters

Table 9.1: Summary of the parameters

Variable	Parameters	Note
Damage cost (Rs per kg of mercury released).	73,310	Global Average*
Global inflation rate (%)	2.61	10-year average
Inflation rate in Sri Lanka (%)	5.33	10-year average
Discount rate (%)	7.2	Five-year average

* Taken from the study conducted by Nedellec, V. and A. Rab .(2016). Costs of Health Damage from Atmospheric Emissions of Toxic Metals: Part 2—Analysis for Mercury and Lead, Risk Analysis, Vol. 36, No. 11, 2016

A large body of research has linked mercury exposure to negative health effects in humans. The majority of these studies have addressed the presence of Mercury in the environment in various forms, the most toxic being methyl mercury (Trasande et al. 2005). This form also bioaccumulates in aquatic food chains. Fish consumption is thus one of the most important

human exposure pathways (Nedellec and Rab, 2016). Evidence shows that a significant proportion of humans and wildlife worldwide are exposed to methyl mercury.

The findings of most studies in this area show that the cost of damage varies significantly. According to Trasande et al. (2006), the true cost of methyl mercury exposure from American emissions ranges from \$0.4 to \$15.8 billion per year. According to Shih and Tseng (2014), health costs in Taiwan, including excess mortality and IQ loss, were US\$1.87 million per kg of mercury emitted, while health costs were only US\$0.32 million when mortality costs were excluded. Giang and Selin (2016) present results in terms of benefits per unit of avoided Mercury emissions in the United States. This research was conducted in the context of the UN Minamata Convention on Mercury and the United States Mercury and Air Toxics Standards (MATS) policy, with a focus on the benefits experienced in the United States between 2016 and 2050. costs, which provide global averages for cost estimates.

Summary of the Mercury Added Products and alternatives

Table 9.2: Summary of the Mercury Added Products and alternatives

Mercury Added Products				Mercury Free Products		
Name of the item	Unit Price (Rs.)	Mercury content (g)	Durability (year)	Name of the item	Unit Price (Rs.)	Durability (year/ hours)
Health Sector						
Hg thermometers	450	0.5-1.5	10	Digital thermometers	10,400	7 y
Hg pressure meters	20,000	3.0-4.0	12	Aneroid pressure meters	30,000	5 y
Mercury Lab Thermometer (Range 0 °C - 100 °C)	3,600	3.0	6	Digital thermometers (Range 0 °C - 100 °C)	6,300	2 y
Mercury U-Tubes manometers	64,940	60.0 – 600.0	20	Pressure gauges with diaphragm elements	17,800	5 y
Fluorescent tubes	2,500	10.0 – 15.0	8000-10000 hours	LED bulbs	3,500	30000-40000 h
CFL bulbs	800	4.0-5.0	8000-10000 hours	LED bulbs	1500	30000-40000 h
Education Sector						
Mercury Barometer	18000	500	55	Aneroid Barometer	14528	30 y
Mercury thermostats	12111	3.0-5.0	10	Non-mercury thermostats	11181	1y

COD Vials with Mercury (25 vials per Pack)	30260	0.001		Mercury free COD Vials (25 Vials per Pack)	48,600	
Industrial Sector						
Mercury use for Gold recovery	60 per gram		26878	1. Mixture of "Pushkara", "Nawasaram" (Borax Powder) and Potassium Nitrate 2. Sodium Bicarbonate		1.46 y 1.05 y

Note: A significant price variation was observed in each item. Average price was used for both categories in this study.

The present value of the MATS scenario's benefits to the United States over the period to 2050 is estimated to be USD 147 billion. These are benefits to the United States that are entirely due to reductions in domestic mercury emissions (Dubourg, 2018). The present value of the Minamata scenario's benefits to the United States over the same time is estimated to be USD 339 billion (Dubourg, 2018). These are benefits to the United States that are entirely due to reductions in mercury emissions in the rest of the world. The estimates provided by these studies are specific to those countries, and without a proper benefit transfer approach, these estimates cannot be applied to countries such as Sri Lanka. As a result, this study employs Nedellec and Rab (2016)'s average damage.

Cost-benefit analysis undertaken in this study attempts to compare the costs and benefits of introducing mercury free alternative products, where both are expressed in monetary units. This involves several steps as explained below.

1. Identify the list of Mercury Containing/added Products which are used in health, education, industrial and household sectors in Sri Lanka.
2. Identify the initial costs (prices), maintenance costs, and damage costs of mercury which includes mainly health cost.
3. Estimate the total cost of using Mercury Added Products including damage cost assuming the equal probability of being damage of each item during its lifetime.
4. Estimate the net present value of the cost using the following equation.

$$NPV = \frac{R_t}{(1 + r)^t}$$

NPV = Net present value

R_t = Net cash flow at time t (total cost of the mercury added product in each time period)

r = Discount rate

t = time of the cash flow

5. Identify the list of alternative mercury free product for replacing the mercury added product
6. Estimate the cost of replacement after adjusting to the durability
7. Compare the NPV of the cost of mercury added product and mercury free product

Due to the lack of country-specific data on the external cost of mercury emission, the average damage cost in 2013 was derived from the literature. To determine the present value of the cost, it was adjusted for inflation using the 10-year average global inflation rate. The survey data provided the majority of the other information for this study. The central bank's annual report for 2021 provides inflation and the discount rate. Due to the wide price range, an average price for each item is used in this study. However, the comparison was made to different mercury levels in each product. The estimated damage cost for each item is reported in the Table 9.3. Table 9.4 reports the estimated costs of mercury and products and cost of mercury free products

Estimated damage cost for each item

Table 9.3: Estimated damage cost for each item

Name of the item	Estimated Cost (Rs.) - 1	Damage Estimated Damage Cost (Rs.) - 2
Hg thermometers	18,000 (Hg 0.5 g)	54,000 (Hg 1.5g)
Hg pressure meters	114,319 (Hg 3.0g)	152,425 (Hg 4.0g)
Mercury Lab Thermometer (Range 0 C-100C)	96,653 ((Hg 3g)	
Mercury U-Tubes manometers	2,895,333 (Hg 60g)	2,8953,334(Hg 600g)
Fluorescent tubes	314(Hg 0.01g)	470 (Hg 0.015g)
CFL bulbs	125(Hg 0.004g)	157(Hg 0.005g)
Mercury Barometer	78,801,373(Hg 500g)	
Mercury thermostats	108,002 (Hg 3g)	173,627(Hg 5g)
COD Vials with Mercury (25 vials per Pack)	669 (Hg 25mg)	
Mercury use for Gold recovery	26,758(Hg 1g)	

Costs comparison (Rs. per item)

Table 9.4: Costs comparison

Name of the item		Mercury Added Products		Mercury Free Products	
1	Hg thermometers	13,485 (Hg 0.5g)	39,557 (Hg 1.5g)	Digital thermometers	14,857
2	Hg pressure meters	96,894 (Hg 3g)	122,525 (Hg 4g)	Aneroid pressure meters	30,000
3	Mercury Lab Thermometer (Range 0 °C – 100 °C)	84549 (Hg 3g)		Digital thermometers (Range 0 °C – 100 °C)	18900
4	Pressure gauges with diaphragm elements	1503,026 (Hg 60g)	14,445,804 (Hg 600g)	Pressure gauges with diaphragm elements	71,200
5	Fluorescent tubes	10,272 (Hg 0.010g)	10408 (Hg 0.015g)	LED bulbs	3,500
6	CFL bulbs	3,309 (Hg 0.004g)	3,336 (Hg 0.005g)	LED bulbs	1,500
7	Mercury Barometer	9,126,333 (Hg 500g)		Aneroid Barometer	24,213
8	Mercury thermostats	90,326 (Hg 3g)	137851 (Hg 5g)	Non-mercury thermostats	111,810
9	COD Vials with Mercury (25 vials per Pack)	30330 (Hg 25mg)		Mercury free COD Vials (25 Vials per Pack)	48, 600
10	Mercury use for Gold recovery*	26,878		1. Mixture of "Pushkara", "Nawasaram" **	1.46
				2. Sodium Bicarbonate**	1.05

*1.5g of gold is recovered from 3g of mercury

**1.5g of gold is recovered from 2g of the mixture

We also estimated the net benefits of replacing mercury added product under lower limit, upper limit and constant of the mercury content in each item. The results are reported in Table 9.5.

Net Benefits of replacing each item (Rs. per item)

Table 9.5: Net Benefits of replacing each item (Rs. per item)

	Name of the item	Lower limit	Upper limit	Constant
1	Hg thermometers	(1,371)	24,700	
2	Hg pressure meters	66,894	92,526	
3	Mercury Lab Thermometer (Range 0 °C – 100 °C)			65,650
4	Pressure gauges with diaphragm elements	1,431,826	14,374,604	
5	Fluorescent tubes	6,772	6,908	
6	CFL bulbs	1,809	1,836	
7	Mercury Barometer			9,102,119
8	Mercury thermostats	(21,484)	26,041	
9	COD Vials with Mercury (25 vials per Pack)			(18,270)
10	Mercury use for Gold recovery	26,877	26,877	

10. Annex 4: List of Stakeholder Consultation Workshop Participants

List of Participants Attended the Stakeholder Consultative Meetings on the “Development of National Technical Guideline on Environmentally Sound Management of Mercury Waste” on 30th September 2022 and 14th December 2022 at the Conference Room of the Ministry of Environment.

Table 10.1: List of Stakeholder Consultation Workshop Participants

No	Name	Designation	Organisation
1	Ms. Samudrika Divithuragama	District Manager	Waste Management Authority WP
2	Dr. Udaya K. Jayasundara	Senior Lecturer	Institute of Chemistry, Ceylon
3	Ms. Nipuni Illangakoon	Chemist	Sri Lanka Cosmetic Association
4	Mr. Tissa Gamage	Deputy Director	Hazard Waste and Chemical Management Division, Central Environmental Authority
5	Ms. Sharmila Fernando	Asst. Director	Environment Management Division, Board of Investments
6	Dr. SKMK Herapathdeniya	Senior Lecturer	Faculty of Indigenous Medicine, University of Colombo
7	Dr. N.S. Narasinghe	Lecturer	University of Peradeniya
8	Ms. Hasanthi Dissanayake	Senior Research Engineer	Industrial Technology Institute
9	Ms. Medhavi Medaduwage	Deputy Controller	Dept. of Import and Exports Control
10	Dr. N.S. Narasinghe	Lecturer	Faculty of Dentals Science, University of Peradeniya
11	Dr. Russel De Silva	Senior Lecturer	Department of Chemistry, University of Kelaniya
12	Dr. Asitha Cooray	Senior Lecturer	Department of Chemistry, University of Sri Jayawardenapura
13	Mr. U.G.C Sampath	Training Officer	Sri Lanka Vocational Training Authority of Sri Lanka
14	Mr. Ashraf Samusudeen	Superintendent of Customs	Sri Lanka Customs
15	Mr. L.K. Waduge	Senior Lecturer	National Institute of Education
16	Prof. Jagath Premacandra	Senior Lecturer	University of Moratuwa
17	Mr. D.M.C.J. Dissanayake	Environment Engineer	Lakvijaya Coal Power Plant (CEB)
18	Ms. P. Naamagal	Director (PD)	Ministry of Industries
19	Mr. A.D Liyanagamage	Radiographer	Dental Institute
20	Mr. Sudesh Nandasiri	Chairman/MD	Ceylon Waste Management (pvt) Ltd
21	Mr. Sangeeth Wickremesinghe	Manager, Sustainable Development	Cleantec (Pvt) Ltd

22	Mr. Naleen Jayasinghe	Head (Research)	Gem and Jewellery Research and Training Institute
23	Dr. Thushara Subasinghe	Senior Lecturer	University of Moratuwa
24	Dr. P. Iyngaran	Senior Lecturer	Department of Chemistry, University of Jaffna
25	Ms. Jeewa Palugaswewa	Asst. Director	Ministry of Environment
26	Ms. Nadeera Ramanayake	Act. Asst. Director	IDB
27	Ms. Arosha Hemali		INSEE
28	Mr. Lalantha Ruwan		INSEE
29	Mr. Kasun Thennekoon	Manager (Circular Economy)	Cleantec (Pvt) Ltd
30	Ms. S. R. Wijesinghe	Zonal Manager	Waste Management Authority (WP)
31	Ms. S.M.D. Madhumali	Asst. Director	Export Development Board
32	Ms. Uthpala Abeypala		NGIA
33	M.A.N.C. Manthirathna	Research Officer	Gem and Jewellery Research Institute
34	Mr. Arjuna Chandrasekara	Asst. General Manager	Sri Lanka Ayurvedic Drug Cooperation
35	Ms. Gayani Manchanayake	Deputy Director	Sri Lanka Standards Institute
36	Ms. S.M.D. Madhumali	Asst. Director	Export Development Board
37	Ms. Padmini Dahanayake	Deputy Director (Science)	Ministry of Education
38	Dr. A.A.D. Amarathunga		NARA

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**FINAL REPORT ON TRAINING AND AWARENESS
PROGRAMMES ON SOUND MANAGEMENT OF MERCURY AND
MERCURY CONTAINING WASTE**

**Strengthening National Capacity for phasing out mercury-added
products and environmentally sound management of waste
consisting of, contaminated with and containing mercury
in Sri Lanka**

Ministry of Environment

Executive Summary

This report offers a comprehensive analysis of the training and awareness initiatives focused on the adoption of mercury alternatives and the proper management of mercury-containing waste, aligning with the goals of the Minamata Convention. Twenty training programs and twenty-five awareness sessions were successfully conducted encompassing stakeholders from Health, Education, and Industry sectors, as well as the general public. The total number of participants included 116 in the Training of Trainers (ToT) programmes, 141 in the Health sector training programmes, 210 in the Industry sector training programmes, 169 in the Education sector training programmes, and 659 participants in awareness sessions.

The methodology of this project crafted under output 4 had meticulous planning, module development, and program execution. Key findings, assessed through metrics such as relevance, instructional effectiveness, impact on participants' knowledge, and overall satisfaction, exhibited the positive impact of the initiatives. However, challenges including venue selection, communication with the stakeholders, and attention retention were identified and subsequent recommendations are identified.

In response to these challenges, the report outlines strategic recommendations that not only refine future programs but also address specific concerns related to the management of mercury, mercury containing products, equipment and waste. Participants stressed the need for comprehensive information on mercury waste disposal practices, urging an exploration beyond surface-level knowledge to include emerging technologies and advancements. Practical applications, field activities, and real-world case studies are suggested to enhance learning, especially within the industrial sector.

In conclusion, the proposed recommendations aim to increase the impact of this project ensuring the effective management of mercury, mercury containing products, equipment and waste in Sri Lanka. The significant engagement of 1,295 participants from three major sectors highlights the importance of the training and awareness raising programmes.

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Raising awareness and conducting training and awareness sessions on mercury waste management in Sri Lanka is an important step in fulfilling the country's obligations under the Minamata Convention on Mercury and in mitigating the health and environmental risks associated with mercury exposure. Thus, conducting training and awareness sessions on mercury waste management in Sri Lanka is essential for protecting the environment, public health, and national well-being. It not only helps the country meet its international obligations but also fosters sustainable development, empowers communities, and enhances Sri Lanka's reputation on the global stage.

The knowledge and awareness on mercury and mercury containing products is quite limited in Sri Lanka. Lack of knowledge and awareness among the stakeholders on the availability of suitable alternatives is another major challenge faced when eliminating the use of mercury and mercury containing products from use. For these reasons, the output 4 of the project *“Strengthening National Capacity for phasing out mercury-added products and environmentally sound management of waste consisting of, contaminated with and containing mercury in Sri Lanka”* was designed to build capacities and increase the knowledge of the stakeholders in the health, education and industry sectors as well as the general public. This effort aims to effectively manage mercury, mercury-containing products, and waste while minimizing their use. Ultimately, this initiative is crucial for Sri Lanka to fulfill its obligations under the Minamata Convention.

1.1 Objectives for Conducting Training and Awareness Programmes on Mercury Waste Management

Organizing training and awareness sessions on management of mercury, mercury containing products, equipment and waste in Sri Lanka addresses a spectrum of critical issues, ranging from environmental conservation and public health protection to compliance with international agreements and the promotion of sustainable development goals. These sessions lay a crucial foundation for promoting informed decision-making and responsible conduct in the field of mercury waste management. Some of the major reasons for conducting these training and awareness programmes include;

1. ***Environmental Protection:***

Mercury is a highly toxic heavy metal that can have severe environmental impacts. Training and awareness programmes can help individuals and organizations understand how to properly manage mercury, mercury containing products, equipment and waste to prevent its release into the environment, safeguarding ecosystems and aquatic life.

2. ***Public Health:***

Mercury exposure can lead to serious health issues, including neurological and developmental problems. By educating the public, healthcare professionals, and industry workers, training programmes can reduce the risk of mercury-related health problems.

3. ***Compliance with International Agreements:***

Sri Lanka is a signatory to the Minamata Convention on Mercury, which obligates the country to take measures to reduce mercury use and emissions. Conducting training and awareness programmes help fulfil these international obligations.

4. ***Preventing Contamination:***

Mercury can contaminate water bodies, soil, and air. By training industries, healthcare facilities, and waste handlers on proper disposal and containment methods, the risk of contamination is reduced.

5. ***Promoting Best Waste Management Practices:***

Inadequate management of mercury-containing compounds, equipment and waste can lead to accidents and spills, endangering human health and the environment. Training and awareness programmes promote safe handling, storage, and disposal practices, reducing the risk of accidents.

6. ***Sustainable Development:***

Raising awareness about the management of mercury, mercury containing products, equipment and waste aligns with the United Nations Sustainable Development Goals (SDGs), particularly Goal 3 (Good Health and Well-Being), Goal 6 (Clean Water and Sanitation), and Goal 12 (Responsible Consumption and Production). It contributes to a safer and more sustainable future.

7. *Capacity Building:*

Training and awareness programmes enhance the capacity of relevant authorities, agencies, and organizations to effectively regulate and manage mercury, mercury containing products, equipment and waste. This capacity can lead to more efficient and coordinated efforts in mercury management.

8. *Economic Benefits:*

By promoting responsible and efficient management of mercury, mercury containing products, equipment and waste, Sri Lanka can reduce the financial burden associated with cleaning up contaminated sites and addressing mercury-related health issues. It can also attract responsible businesses and investments that prioritize environmental and public health concerns.

9. *International Reputation:*

Complying with international agreements and demonstrating a commitment to responsible environmental practices enhances Sri Lanka's reputation in the global community. This can positively impact trade, foreign relations, and international cooperation.

The primary objective of this task (output 4) was to provide training and awareness on the adaption of alternatives to the use of mercury and proper management of mercury, mercury containing products, equipment and waste.

By conducting training and awareness programmes on the management of mercury, mercury containing products, equipment and waste, Sri Lanka can make progress in reducing the risks associated with mercury exposure and demonstrate its commitment to fulfilling its obligations under the Minamata Convention on Mercury.

2.1 Activities covered under output 4 of the Project

The project team developed a comprehensive methodology for output 4 depending on the progress of output 2. Following activities were covered by the project team under output 4

1. Develop a detailed plan/schedule for training and awareness raising programs on management of mercury, mercury containing compounds and mercury containing equipment and waste including a brief introduction to chemical management adhering to the time period of the consultancy
2. Develop training subject modules and detailed syllabus for mercury, mercury containing products, equipment and waste related to industry, health and education sectors
3. Conduct training and awareness programmes on the management of mercury, mercury containing products, equipment and waste with brief introduction to Chemical Management in Industry, Health, and Education Sector

2.2 Steps taken to organise training and awareness programmes

Below mentioned are some steps that were taken to organize the training and awareness sessions:

1. *Identify Target Audiences:*

The key stakeholders and target audiences for the training and awareness sessions were identified. This includes government officials, industry representatives, healthcare professionals, educators, and the general public.

2. *Develop Educational Materials:*

Educational materials such as subject modules and detailed syllabus, brochures, fliers, videos, and presentations that explain the hazards of mercury waste and how to manage it safely were developed.

3. *Monitoring and Feedback:*

After conducting training sessions, feedback forms were collected from participants to evaluate the effectiveness of the training sessions.

2.3 Organizing Training and Awareness Programs

The consultant identified the main products and processes which contain mercury in the selected 3 sectors (Industry, Health, and Education) under output 2. Based on that, the consultant the major target groups that can get exposed to mercury in each sector was identified. Inputs from output 2 experts were incorporated to finalize the target groups. Then the target groups were categorized under the below mentioned levels to develop training modules;

- Level 1: Professional staff
- Level 2: Supportive staff

According to the target group, a detailed training schedule/training plan was developed. The training schedule includes

- Target audience /Target group
- Agenda of the training Programme
- Information of the resource panel
- Content covered
- Location
- Number of participants

In addition, the consultant organised Training the Trainers (ToT) Programmes as part of our output 4 activities. These ToT programmes were specifically designed to train individuals who, in turn, would become trainers themselves. These programmes were structured to equip participants with the necessary skills, knowledge, and resources to effectively convey information and expertise to others within their respective domains on the management of mercury, mercury containing products, equipment and waste.

2.4 Developing Training Materials

Consultant developed a comprehensive training subject modules and detailed syllabus on the management of mercury, mercury containing products, equipment and waste for the industry, health, and education sectors. The developed subject modules and detailed syllabus was presented to an expert committee for their feedback and comments

The structure of the expert committee:

1. Representatives from Ministry of Environment and other relevant Ministries involved in the chemical management were the key members of the expert committee.
2. Representatives from following organizations were also participated
 - University Academics
 - Industries
 - Waste Management organizations
 - Suppliers
 - Laboratory staff. etc

The representatives with the following qualifications were appointed as a member of the expert committee

- Experience in chemical management related subjects
- Experience in guideline development activities
- Practical experience of working with industries
- Knowledge in mercury management

Two expert committee meetings were organized to finalize the subject modules and detailed syllabus. In addition, the project experts (team leader, industry, health, education) also provided inputs for the development of the training module.

2.4.1 Developing a training curriculum

Under the output 4 of the project, initially a training curriculum was developed consisting of 6 modules covering the following areas mentioned in the project ToR. The training programmes were conducted based on the curriculum developed.

- i. Introduction to Chemical Management
- ii. Sources, types, properties, and adverse health effects of Mercury
- iii. The use of technical guideline
- iv. Mercury-free alternatives to Mercury-containing products
- v. Mercury Spill management
- vi. Mercury waste packaging, storage, transport and disposal methods

2.5 Training and Awareness raising Programmes

In total twenty training programmes were conducted to cover the maximum stakeholders identified in the target groups that cover three major districts; Colombo, Galle and Kandy according to the following arrangement mentioned as follows. The twenty training programmes were organised according to the following categories;

2.5.1 Training of Trainers (ToT) programme

Three training of trainers (ToT) programs were organized for the identified stakeholders. Participants were invited from all three sectors. The training programs were conducted (Table 1) in Sinhala and/or English Language.

Table 1: Training of Trainers programme

Training Programme	Sectors	Location
ToT Training Programme 1	Industry, Health, Education	Western Province
ToT Training Programme 2	Industry, Health, Education	Southern Province
ToT Training Programme 3	Industry, Health, Education	Central Province

The objective of organizing the ToT programme was to disseminate the training for a wider stakeholder network. The selected key organizational members trained as Trainers and were motivated to train their other staff members in each respective organization. Therefore, a comprehensive training module was developed for the ToT programmes.

2.5.2 Sector-wise Training programmes

The sector-wise training programmes were organized as specific training programmes and they were extended-half day programmes conducted. As mentioned above, the training programmes were organized according to the two levels of participants (level 1: Professional staff, level 2: supportive staff). These training programmes were organized as mentioned in the below table (Table 2).

Table 2: Sector-wise training programme

Sectors	Number of training programmes
Industry	6
Health	5
Education	6

2.5.3 Awareness programmes

In total twenty-five awareness raising programmes were conducted covering all major districts in Sri Lanka. The awareness raising programmes were of 2 to 3 hours in length. It targeted stakeholders of the Health, Education and Industry sectors as well as the members of the general public. Under the output 4 of the project, awareness material was developed and used in creating awareness among the stakeholders.

2.6 Evaluation of the effectiveness of Training Programmes

The evaluation of the effectiveness of these programs involved various methods, including surveys, interviews, and data analysis. The key indicators used to measure the success of the programmes include:

- i. Reduction in mercury exposure
- ii. Increase in knowledge about mercury and its health effects
- iii. Adoption of best practices
- iv. Community engagement and empowerment
- v. Long-term sustainability of the initiatives

2.7 Awareness Materials

Following awareness materials conducted (Table 3) were developed under the project. Awareness materials were designed with the support of qualified external professionals (videography, photography, IT Experts) and the content was developed by the expert who was assigned for output 4

Table 3: Awareness Materials

Awareness Materials	Content	Dissemination channels
Brochures and Flyers	Poster for general public on alternatives to mercury containing products	targeted audience and social media
	Poster for general public on impacts of mercury on human health	
	Brochure for laboratories on handling mercury spill	
	Poster for laboratories on sound management of chemicals: Globally Harmonized System (GHS) of classification and labelling of chemicals	
	Poster for laboratories on safe handling and sound management of chemicals: Personal Protective Equipment (PPE)	
Videos	Impact of mercury on human health and the environment	social media
	Effective Chemical Management: Ensuring Safety and Sustainability	

Say NO to MERCURY Containing Products

Mercury Thermometer ❌
Digital Thermometer ✅

CFL Bulbs ❌
LED Bulbs ✅

Light Switches ❌
Mechanical Switches ✅

Mercury Batteries ❌
Alkaline Batteries ✅

Lithium Ion Batteries ❌

Use Alternatives to avoid

Possible Health Effects

- Lack of co-ordination of movements
- Impairment of Speech, hearing, walking
- Muscle weakness
- Tremors
- Emotional changes such as mood swing, irritability
- Memory loss.
- Trouble falling asleep, Staying a sleep, getting good quality sleep
- Skin rashes and dermatitis
- Learning disabilities
- Headache

Organs Affected

- Nervous system
- Skin

Mercury is a powerfull neurotoxin

Mercury and Your Health

Most Vulnerable Groups

Unborn Children
Pregnant Mothers
Nursing Mothers
Young Children

Children exposed to mercury while in the womb can have problems in memory, attention, language and fine motor skills.

Commonly used products that may contain Mercury

Mercury Thermometers
Cosmetics
Electrical & Electronic Switches
CFL
Dental Amalgam
Mercury Blood Pressure Meters
Batteries

Personal Protective Equipment (PPE)

Safety Helmet

- Prevention of head injury
- Prevention from falling or flying objects
- For getting angle in machinery, electrical circuit, optical, thermal or toxicities

Safety Glasses

- Flame
- Projectile
- Low and high impact
- Electricity
- Chemical or metal splash

Respirator

- Dust
- Gas and vapour
- Organic and inorganic substances

High Visibility Clothing or Vest

- Flame
- Chemical or metal splash
- Contaminated dust
- Impact or penetration
- Spill from pressure vessels or other parts
- Electric shock or electrification of work facilities

Foot Protection

- Wet, natural soil conditions
- Electricity in the air
- Slipping
- Chemical protection
- Falling objects, heavy loads, metal and electrical shock
- Volcanic

Hearing Protection

- Noise
- A combination of sound level and duration of exposure
- Very high-level sounds may be harmful even with short duration

Face Shield

- Flame
- Projectile
- Gas and vapour
- Radiation
- Chemical or metal splash

Dust Mask

- Dust
- Gas and vapour

Hand Protection

- Acid
- Temperature extremes
- Chemical substances
- Sharp and pointed objects
- Other tools
- Electric shock
- Electricity
- High level sparks
- High level heat or radiation

Protective Clothing

- Flame
- Chemical or metal splash
- Outfall toxic dust
- Impact or penetration
- Electricity from pressure vessels or other parts
- Electricity shock or electrification of work facilities

Globally Harmonized System (GHS) of Classification & Labelling of Chemicals

Physical Hazards

- Flame Over Circle
 - Oxidizing Gases
 - Oxidizing Liquids
 - Oxidizing Solids
- Explosion Bomb
 - Explosives
 - Self-Reactives
 - Organic Peroxides
- Gas Cylinder
 - Gases under Pressure
- Flame
 - Flammables
 - Pyrophorics
 - Self Heating
 - Limits Flammable Gas
 - Self-Reactives
 - Organic Peroxides

Health Hazard

- Corrosion
 - Skin Corrosion / Burns
 - Eye Damage
 - Corrosive to Metals
- Skull & Crossbones
 - Acute Toxicity (fatal or toxic)
- Health Hazard
 - Carcinogen
 - Mutagenicity
 - Reproductive Toxicity
 - Respiratory Sensitizer
 - Target Organ Toxicity
 - Aspiration Toxicity
- Exclamation Mark
 - Irritant (skin & eye)
 - Skin Sensitizer
 - Acute Toxicity
 - Narcotic Effects
 - Respiratory Tract Irritant
 - Hazardous to Ozone Layer

Environmental Hazards

- Environment
 - Aquatic Toxicity



How to handle a mercury spill ?

Step 13 -

- Pick up with care any broken pieces of glass or sharp objects.
- Place all broken objects on a paper towel.
- Fold the paper towel and place in a zip lock bag. Seal the bag.

Step 14 -

- Use an eyedropper to pick up the beads you can't get with the stiff paper or cardboard.
- Hold the eyedropper almost parallel with the floor for the effective removal
- Clear the eyedropper by gently squeezing the contents into the container.
- In order to remove tiny beads of mercury press the sticky side of the tape to the beads and dispose the tape into the container.

Step 15 -

- If you think you've picked up all the mercury beads, shine a flashlight (at many different, low angles) on the area, to find any remaining mercury beads or broken glass.
- Light will reflect off the mercury beads and glass helping you to locate them. (Note: Mercury can move far on hard flat surfaces, so inspect the entire room.)

For Porous surfaces (Carpets, Rugs or upholstery)

Step 16 -
If it is difficult to remove, gently push mercury beads through the pile of the carpet or rug, use an eye dropper to pick up the mercury.

Step 17 -
Rugs can be discarded or hung on an outside clothesline for several days to air out. If the mercury cannot be removed from the contaminated material:

- Cut around the spill and place the contaminated item and all items used for cleanup in a plastic bag
- Place the bag into a second plastic bag and seal the outer bag with tape

Things not to do upon a mercury spill!

- Do NOT use a regular vacuum cleaner
- Do NOT wash contaminated clothing or fabrics in a washing machine
- Do NOT use a large broom to sweep mercury
- Do NOT pour mercury down the drain
- Do NOT spread mercury with shoes. Never allow people who are wearing mercury-contaminated shoes or clothing to walk around the house.





MINAMATA CONVENTION ON MERCURY | Project funded by the Specific International Programme

Protective Equipment (PPE's) to be used

1. Protective eye wear – Chemical Safety goggles, Face Shields
2. Respiratory Protection
3. Skin protectors – Gloves, aprons, boots, full-body encapsulating and self-contained breathing apparatus (SCBA).
4. Disposable shoe covers

Other Mercury Clean-up Products and Equipment

1. Vapor suppression agents – Sulfur powder, Zinc or Copper flakes, Mercury amalgam powder
2. Mercury Indicator Powder
3. Mercury Sponge/ Absorbent pads
4. Materials for decontamination – Vinegar, Hydrogen peroxide, Cotton swabs
5. Mercury neutralizing agents – 20% Calcium sulfide solution, 20% Sodium thiosulfate solution
6. Mercury spill cleaning vacuum cleaner

Step 05 -
Avoid cross contamination and take necessary actions for people who have been exposed to mercury

Step 6 - Ventilate the room immediately by opening doors and windows to the outside

Step 7 -
Prepare for clean-up

- Remove jewellery form hands and wrists

Step 8 - Put on PPE

Step 9 - Contain the spill

- Surround or block off the mercury to keep it from spreading onto sloped or porous surfaces.
- Sweep the mercury toward the center of the spilled area away from any carpet, fabric, or porous surfaces.
- Divert all mercury away from floor drains, cracks, or crevices that may impact groundwater, surface water, and soils.



Mercury Spill Kit Components

1. Eye dropper or syringe (without the needle) – to pick up the mercury
2. Tweezers - to remove small broken glass pieces
3. Small plastic scoop or plastic dust-pan
4. Wide mouth plastic container with air tight lid – to hold the spilt mercury
5. Tape (wide, sticky, duct, or masking) – to help pick up tiny mercury droplets
6. Plastic bags with zipper seal – to store mercury-contaminated debris and equipment
7. Rubber gloves – to protect hands from mercury contact
8. Garbage bags – for containing mercury waste
9. Stiff paper or cardboard – for collecting mercury beads
10. Flashlight – to reflect mercury beads
11. Powdered sulphur
12. Brush to remove powder or flakes
13. Utility knife blade

Clean-up procedure

Step 1 -
Quickly determine the extent of the spill.

Step 2 -
Turn off the heating or air conditioning to prevent air in the contaminated room from moving into other parts of the house

Step 3 -
Immediately block off foot traffic

Step 4 -
Send all the people and pets out from the contaminated area

For Non-porous surfaces...

Step 10 -
Use the 2 pieces of stiff paper or cardboard (such as playing cards or index cards) to slowly push the mercury beads together and then scoop them up.

Step 11 -
Place the beads in the plastic container.

Step 12 -
Tighten the lid securely so that the liquid and vapor will be contained.

3.1 Details of the Training and Awareness Programmes

3.1.1 Training of Trainers (ToT) Programmes

Three Training of Trainers programmes were held in Colombo, Kandy and Galle districts. These three Training of Trainers programmes were conducted with the purpose of training and building capacities of the stakeholders in the three sectors; Industry, Health and Education. Hence the participants consisted of stakeholders representing all three sectors. Summary of the details of the three training of trainers (ToT) programmes is given below in Table 4. Agenda and pictures taken during the ToT programmes are annexed (Annexure 1 and 2).

Table 4: Details of the Training of Trainers Programmes

Training Programme	Date conducted	Resource Panel	Number of participants	Location
Training of Trainers programme – Colombo	28.02.2023	<ol style="list-style-type: none"> 1. Prof. Ajith de Alwis, Dean, Faculty of Graduate Studies, University of Moratuwa. 2. Prof. Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa. 3. Prof. Parakrama Karunarathna, Department of Chemical & Process Engineering, University of Peradeniya 4. Dr. Inoka Suraweera, Consultant Community Physician, Environmental and Occupational Health Directorate, Ministry of Health 5. Dr. Udaya Jayasundara, Senior Lecturer, Institute of Chemistry 	49	Ministry of Environment

Training of Trainers programme – Kandy	02.03.2023	<ol style="list-style-type: none"> 1. Prof. Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa. 2. Prof. Parakrama Karunarathna, Department of Chemical & Process Engineering, University of Peradeniya 3. Dr. Udaya Jayasundara, Senior Lecturer, Institute of Chemistry 	37	Postgraduate Institute of Science, University of Peradeniya
Training of Trainers programme – Galle	20.03.2023	<ol style="list-style-type: none"> 1. Prof. Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa. 2. Prof. Parakrama Karunarathna, Department of Chemical & Process Engineering, University of Peradeniya 3. Dr. Inoka Suraweera, Consultant Community Physician, Environmental and Occupational Health Directorate, Ministry of Health 4. Dr. Udaya Jayasundara, Senior Lecturer, Institute of Chemistry 	30	Hall de Galle, Galle
Total number of participants for Training of Trainers (ToT) programmes			116	

3.1.2 Health Sector Trainings

Five training programmes were conducted for the health sector. Participants of the training programmes consisted of Doctors, Nurses, PHIs, Administration officers, pharmacists, school dental therapists and minor workers. Summary of the details of the five health sector training programmes is given below in Table 5. Agenda and pictures taken during the health sector training programmes are annexed (Annexure 3).

Table 5: Details of the Health Sector Training Programmes

Training Programme	Date conducted	Resource Panel	Number of participants	Location
Training programme for Health Sector in Colombo	08.05.2023	<ol style="list-style-type: none"> 1. Prof. Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa. 2. Prof. Parakrama Karunarathna, Department of Chemical & Process Engineering, University of Peradeniya 3. Dr. Inoka Suraweera, Consultant Community Physician, Environmental and Occupational Health Directorate, Ministry of Health 4. Dr. Udaya Jayasundara, Senior Lecturer, Institute of Chemistry 	60 (Considered as two programmes)	Ministry of Environment
Training programme for Health Sector in Kalutara	24.05.2023	<ol style="list-style-type: none"> 1. Prof. Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa. 2. Dr. Inoka Suraweera, Consultant Community Physician, Environmental and Occupational Health Directorate, Ministry of Health 3. Eng. Lakmini Edirisinghe, Senior RECP Expert, 	25	Auditorium of the Teaching Hospital in Kalutara

		National Cleaner Production Centre 4. Eng. Dumindu Fernando, RECP Engineer, National Cleaner Production Centre		
Training programme for Health Sector in Kandy	01.06.2023	1. Prof. Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa. 2. Dr. Inoka Suraweera, Consultant Community Physician, Environmental and Occupational Health Directorate, Ministry of Health 3. Eng. Dumindu Fernando, RECP Engineer, National Cleaner Production Centre	21	Auditorium of the Teaching Hospital in Peradeniya
Training programme for Health Sector in Galle	23.06.2023	1. Prof. Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa. 2. Dr. Inoka Suraweera, Consultant Community Physician, Environmental and Occupational Health Directorate, Ministry of Health 3. Eng. Dumindu Fernando, RECP Engineer, National Cleaner Production Centre	35	Auditorium of the Teaching Hospital in Karapitiya

Total number of participants for Health Sector training programmes	141
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3.1.3 Industry Sector Trainings

Six training programmes were conducted for the industry sector. Industrial Development Board (IDB) and the Board of Investment (BOI) Sri Lanka were identified as two key stakeholders of the Sri Lankan industry sector. As they have several industrial zones operating under their purview, the officers of these institutes have the opportunity to cascade knowledge to the industries in the industrial zones through their interactions over a long period of time. Hence the officers of these two organizations were provided training with the idea of disseminating knowledge among the industries. Following table (Table 6) provides a summary of the training programmes conducted for the industry sector. Agenda and pictures taken during the industry sector training programmes are annexed (Annexure 4).

Table 6: Details of the Industry Sector Training Programmes

Training Programme	Date conducted	Resource Panel	Number of participants	Location
Training programme for IDB Officers	27.06.2023	1. Eng. Lakmini Edirisinghe, Senior RECP Expert, National Cleaner Production Centre 2. Eng. Dumindu Fernando, RECP Engineer, National Cleaner Production Centre	19	Auditorium of Industrial Development Board, Moratuwa
Training programme for BOI Officers	05.07.2023	1. Dr. Udaya Jayasundara, Senior Lecturer, Institute of Chemistry 2. Eng. Dumindu Fernando, RECP Engineer, National Cleaner Production Centre	21	Auditorium of the BOI Head office, Colombo 01.
Training programme for IDB	13.07.2023	1. Dr. Udaya Jayasundara, Senior Lecturer, Institute of Chemistry	33	Conference hall of Camy Smart (Pvt) Ltd

industrial zone – Horana		2. Eng. Dumindu Fernando, RECP Engineer, National Cleaner Production Centre		
Training programme for IDB industrial zone – Pallekele	21.07.2023	1. Prof. Parakrama Karunarathna, Department of Chemical & Process Engineering, University of Peradeniya 2. Eng. Dumindu Fernando, RECP Engineer, National Cleaner Production Centre	22	Industrial Zone, Pallekele
Training programme for IDB industrial zone – Ekala	25.07.2023	1. Prof. Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa 2. Ms. Nadeera Ramanayake Enterprise Promotion Manager. Industrial Development Board	47	NERDC Auditorium
Training programme for BOI Export Processing Zone – Katunayake	31.08.2023	1. Prof. Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa 2. Ms. Terancy Samarawickrama Assistant Director, Environment Management Department, Board of Investment of Sri Lanka	68	Auditorium, Board of Investment Zonal Office, Katunayake
Total number of participants for Industry Sector training programmes			210	

3.1.4 Education Sector Trainings

Education sector in Sri Lanka can be divided in to two segments; Schools and Higher Educational Institutions. School system in Sri Lanka consists of mainly government schools. However, there are some private schools as well. The higher education sector consists of government, semi government and private educational institutions. All these institutes may contain mercury or mercury containing equipment.

The school system needs to be approached through the Ministry of Education. However, the project team was able to collaborate with the higher education institutes on a standalone basis. Six training programmes were conducted specifically for the education sector. Since Technical Officers of the Laboratories and Lab Attendants are in the front lines of dealing with Mercury and Mercury containing equipment, they were the primary stakeholders which were invited for the training. The details of the training programme conducted is presented in Table 7. Agenda and pictures taken during the industrysector training programmes are annexed (Annexure 5).

Table 7: Details of the Education Sector Training Programmes

Training Programme	Date conducted	Resource Panel	Number of participants	Location
Training programme for Technical Officers of University of Peradeniya	28.06.2023	<ol style="list-style-type: none"> 1. Dr. Udaya Jayasundara, Senior Lecturer, Institute of Chemistry 2. Eng. Lakmini Edirisinghe, Senior RECP Expert, National Cleaner Production Centre 3. Eng. Dumindu Fernando, RECP Engineer, National Cleaner Production Centre 	30	Auditorium of Department of Chemistry, University of Peradeniya
Training programme for Technical Officers of University of Kelaniya	18.07.2023	<ol style="list-style-type: none"> 1. Prof. Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa 2. Eng. Dumindu Fernando, RECP Engineer, 	33	Auditorium, Staff Development Centre, University of Kelaniya

		National Cleaner Production Centre		
Training programme for Technical Officers of University of Sri Jayawardenapura	15.08.2023	1. Prof. Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa 2. Ms. Terancy Samarawickrama Assistant Director, Environment Management Department, Board of Investment of Sri Lanka	30	Department of Chemistry, University of Sri Jayawardenapura
Training programme for Technical Officers of The Open University of Sri Lanka	21.08.2023	1. Prof. Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa 2. Ms. Terancy Samarawickrama Assistant Director, Environment Management Department, Board of Investment of Sri Lanka	17	Staff Development Centre, The Open University of Sri Lanka
Training programme for Technical Officers, Lecturers and undergraduates of Sri Lanka Institute of Information Technology (SLIIT)	25.08.2023	1. Prof. Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa 2. Ms. Terancy Samarawickrama Assistant Director, Environment Management Department, Board of Investment of Sri Lanka	30	SLIIT, Malabe Campus

Training programme for Technical Officers, Lecturers and undergraduates of University of Colombo	06.09.2023	1. Prof. Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa 2. Ms. Terancy Samarawickrama Assistant Director, Environment Management Department, Board of Investment of Sri Lanka	29	Faculty of Technology, University of Colombo, Pitipana
Total number of participants for Education Sector training programmes			169	

3.1.5 Awareness Programmes

In total 25 awareness raising sessions were conducted covering all major districts in Sri Lanka. The awareness raising sessions were of 2-3 hours in length. Stakeholders of the Health, Education and Industry sectors as well as the members of the general public were the target audience for these awareness sessions. Under the output 4 of the project, awareness material was developed and used in creating awareness among the stakeholders. The details of the awareness programmes conducted are presented in Table 8. Agenda and pictures taken during the industrysector training programmes are annexed (Annexure 6).

Table 8: Details of the Awareness Programmes

District	Date conducted	Details	Number of participants
Galle	27.04.2023	Awareness programme for the Development Officers of the Southern Province Management Development and Training institute	55 (considered as 4 programmes)
Hambantota	30.05.2023	Awareness programme for Walasmulla Base Hospital	43
Kandy	28.06.2023	Development Officers of the Ministry of Environment, National	100 (considered as 4 programmes)

		Institute of Co-operative Development, Polgolla	
Kalutara	06.07.2023	Awareness programme for Panadura Base Hospital	37
Colombo	20.07.2023	Awareness programme for the lecturers and undergraduates of SLTC Research University	33
Kurunegala	28.07.2023	Awareness session for the Technical Officers of the Wayamba University of Sri Lanka, Makandura Premises	25
Kurunegala	28.07.2023	Awareness session for the Technical Officers of the Wayamba University of Sri Lanka, Kuliypitiya Premises	22
Colombo	16.08.2023	Environmental and Occupational Health Directorate, Ministry of Health	46 (considered as 2 programmes)
Ampara, Trincomalee, Batticaloa, Jaffna, Vavuniya, Mannar, Kilinochchi and Anuradhapura	18.08.2023	Development Officers of Northern and Eastern Provinces	63 (considered as 4 programmes)
Batticaloa	18.08.2023	Awareness programme for the Technical Officers of Eastern University, Sri Lanka	19
Colombo	23.08.2023	Organization and Development Unit, Ministry of Health	80 (considered as 2 programmes)
Colombo	24.10.2023	Ministry of Environment	133 (considered as 4 programmes)
Total number of participants for Awareness sessions			656

3.2 Evaluation of Training Programmes: Efficacy Through Analysis of Feedback Forms

This section assesses the effectiveness of training programs through the analysis of feedback forms collected from participants. The feedback forms were designed to capture participant experiences, perceptions, and suggestions for improvement. Feedback forms were distributed to participants at the end of each training session. The forms included quantitative and qualitative questions to gather comprehensive insights. The key parameters assessed included:

1. Relevance and clarity of content
2. Effectiveness of instructional methods
3. Impact on participants' knowledge and skills
4. Overall satisfaction with the training

3.2.1 Relevance and clarity of content

This section analyses the extent to which the material presented in a training program is both applicable to the participants' needs and goals, as well as easily understandable. Assessing the relevance and clarity of content is crucial for determining the success of a training program, as it directly influences participants' ability to grasp and apply the information presented. The following questions were used for the analysis

- a. Overall expectations in attending this training programme were met
- b. The content of the programme was well-organized and easy to follow
- c. The learning objectives for each topic were identified and followed

3.2.1.1 Training of Trainers (ToT) Programmes

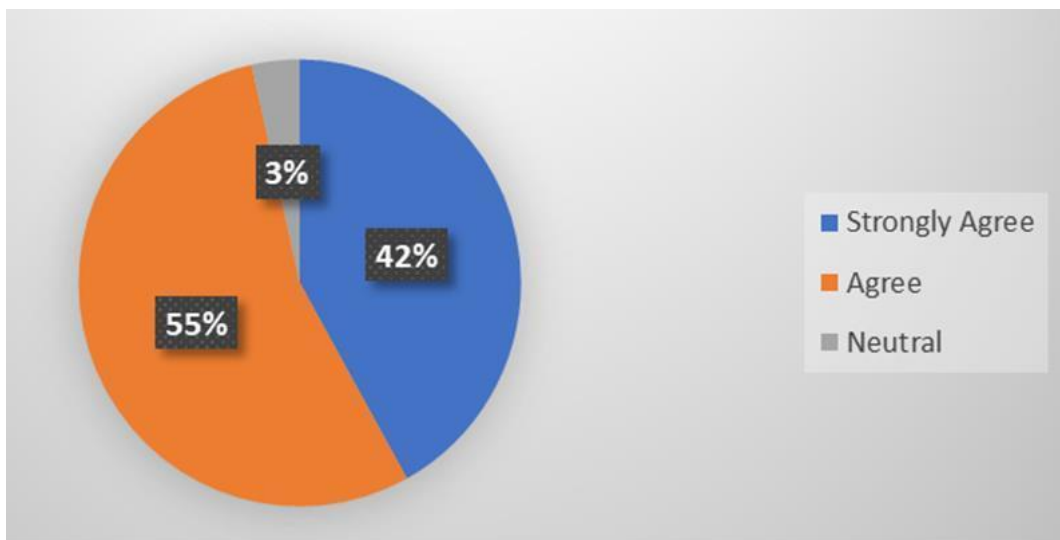


Figure 1: Analysis of "Overall expectations in attending this training programme were met" for ToT programmes

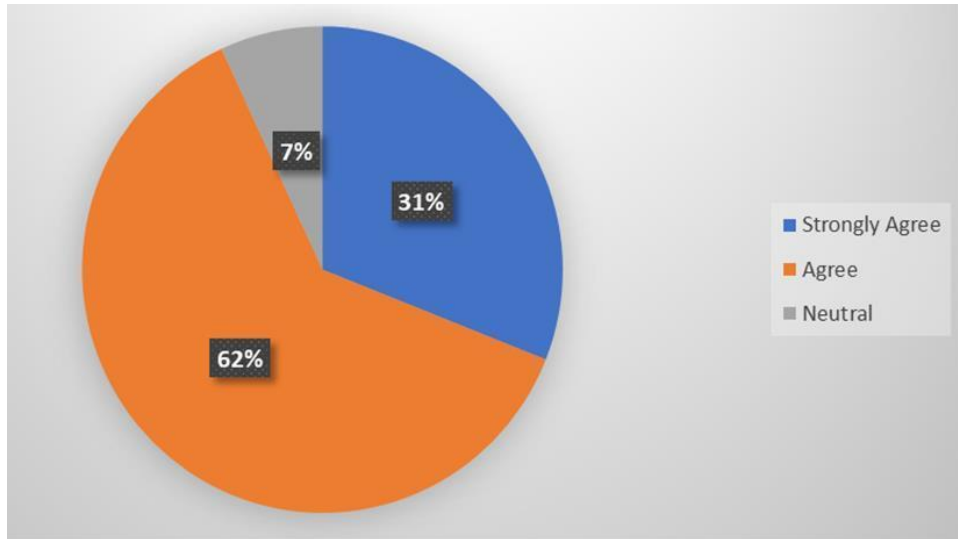


Figure 2: Analysis of “The content of the programme was well-organized and easy to follow” for ToT programmes

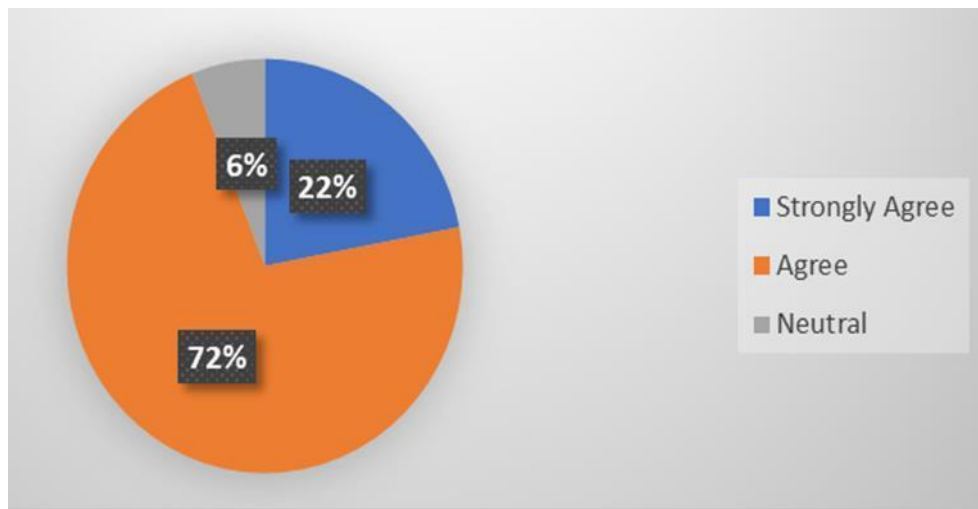


Figure 3: Analysis of “The learning objectives for each topic were identified and followed” for ToT programmes

In conclusion, the positive feedback from participants (Figure 1-3), with more than 93% expressing satisfaction, exhibits the relevance and clarity of the content. The attainment of overall expectations, the well-organized structure of the program, and the successful identification and adherence to learning objectives for each topic collectively validate the relevance and clarity of content of the Training of Training (ToT) programmes.

3.2.1.2 Health Sector Trainings

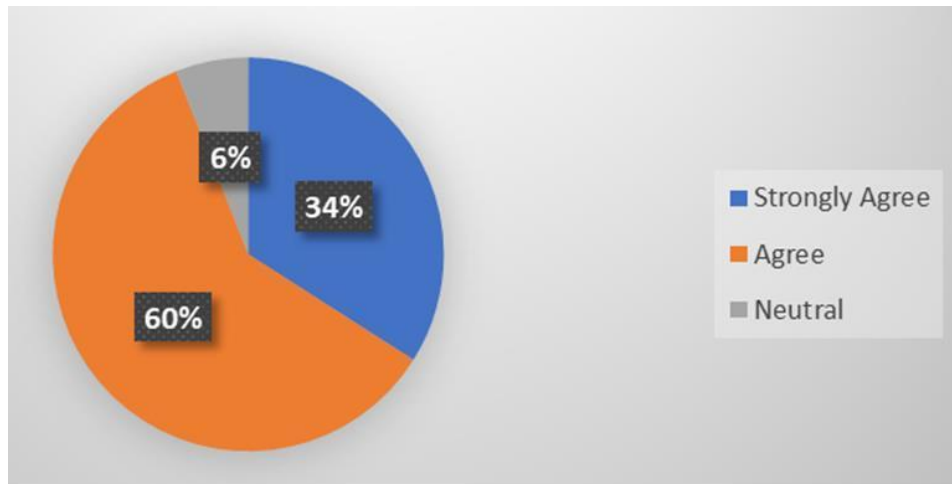


Figure 4: Analysis of "Overall expectations in attending this training programme were met" for Health sector trainings

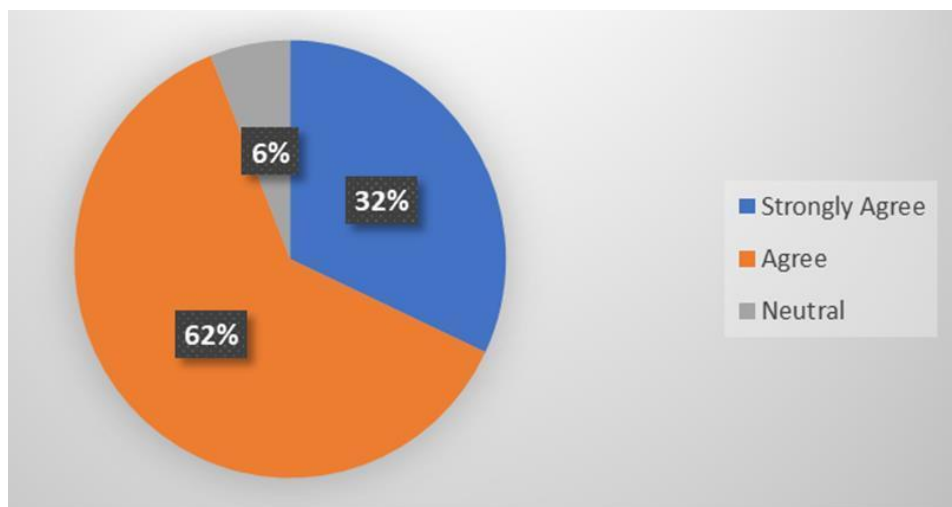


Figure 5: Analysis of "The content of the programme was well-organized and easy to follow" for Health sector trainings

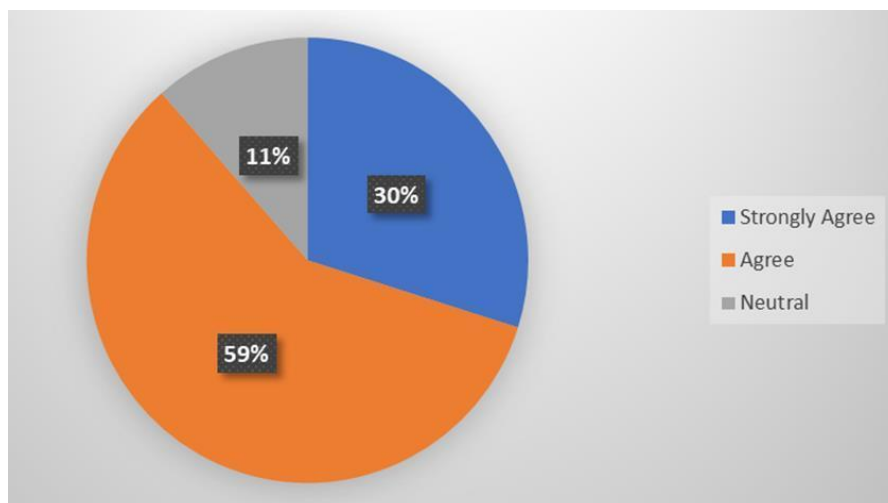


Figure 6: Analysis of "The learning objectives for each topic were identified and followed" for Health sector trainings

In summary, the health sector training programmes have demonstrated a satisfactory level in terms of relevance and clarity of content, as evidenced by the positive responses (Figure 4-6) from participants, with over 94% expressing satisfaction. The programmes not only met the overall expectations of attendees but also showcased a well-organized structure that was easy to follow. The adherence to learning objectives for each topic further highlight the effectiveness in delivering comprehensive and focused training programmes.

3.2.1.3 Industry Sector Trainings

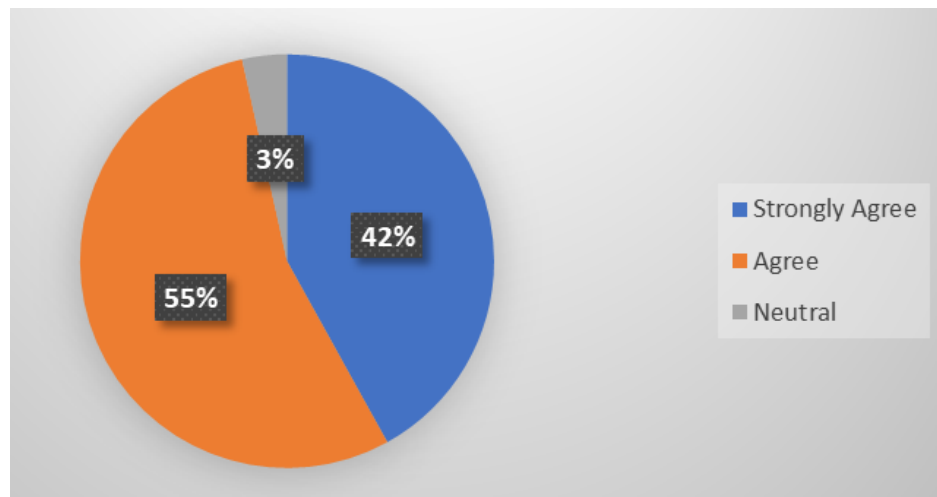


Figure 7: Analysis of “Overall expectations in attending this training programme were met” for Industry sector trainings

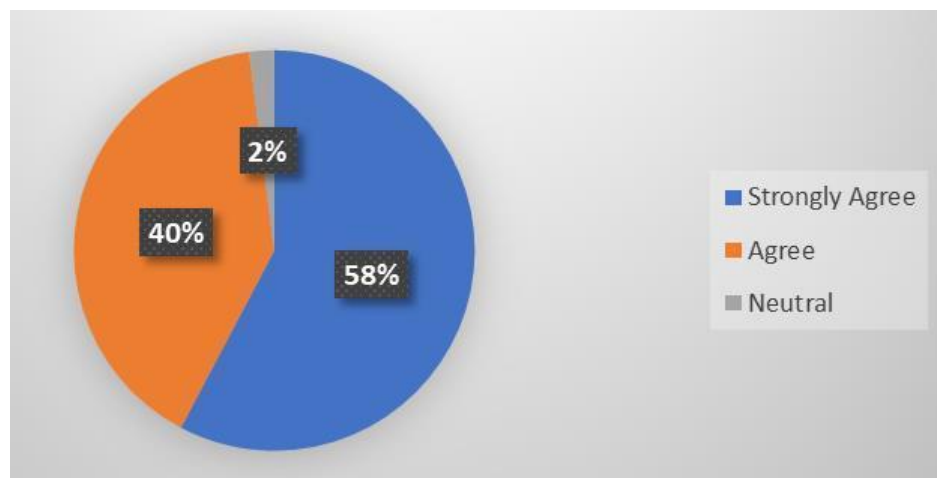


Figure 8: Analysis of “The content of the programme was well-organized and easy to follow” for Industry sector trainings

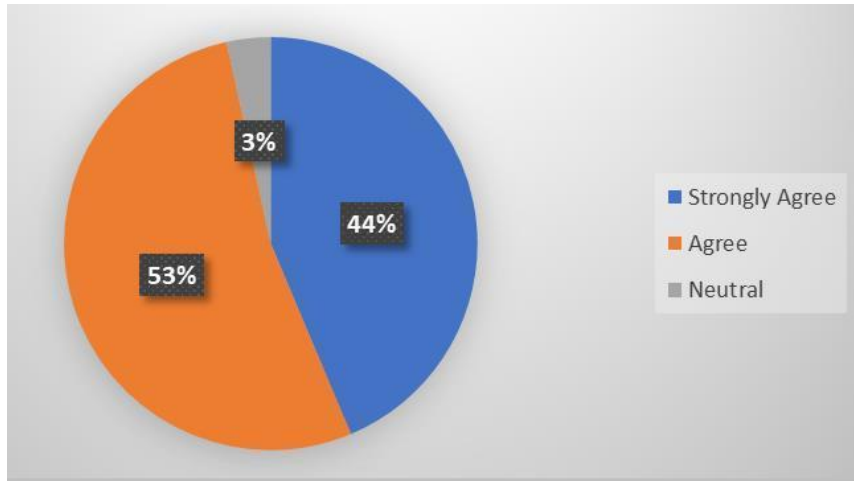


Figure 9: Analysis of “The learning objectives for each topic were identified and followed” for Industry sector trainings

In conclusion, the industry sector training programs have proven to be highly effective in terms of both relevance and clarity of content, with a notable agreement among participants (Figure 7-9). Over 97% of the respondents express satisfaction, attesting to the success of the training programmes in meeting their overall expectations. The well-organized structure of the content has contributed to a positive learning experience, while the meticulous identification and adherence to learning objectives for each topic highlights the effectiveness in delivering focused and impactful training.

3.2.1.4 Education Sector Trainings

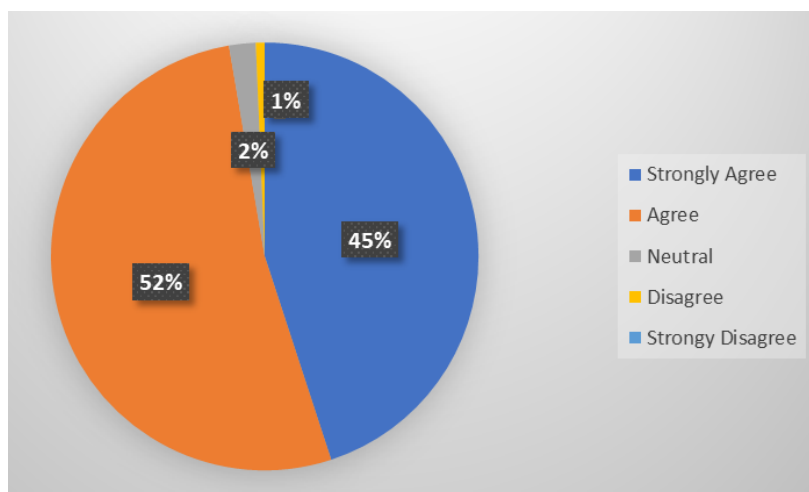


Figure 10: Analysis of “Overall expectations in attending this training programme were met” for Education sector trainings

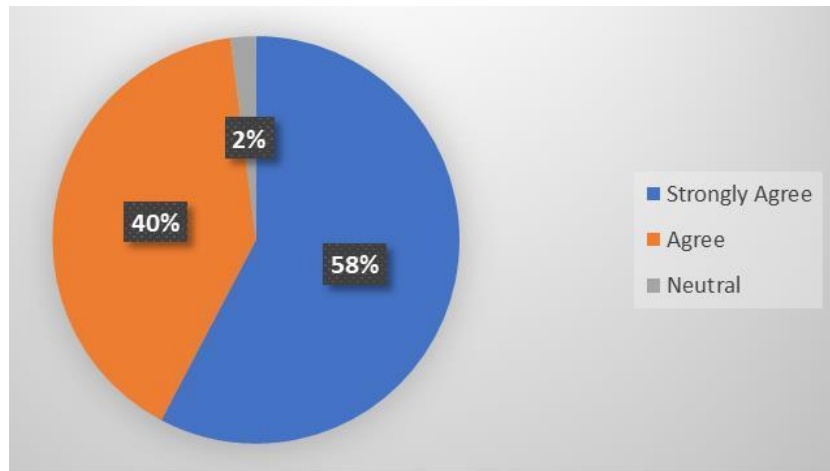


Figure 11: Analysis of “The content of the programme was well-organized and easy to follow” for Education sector trainings

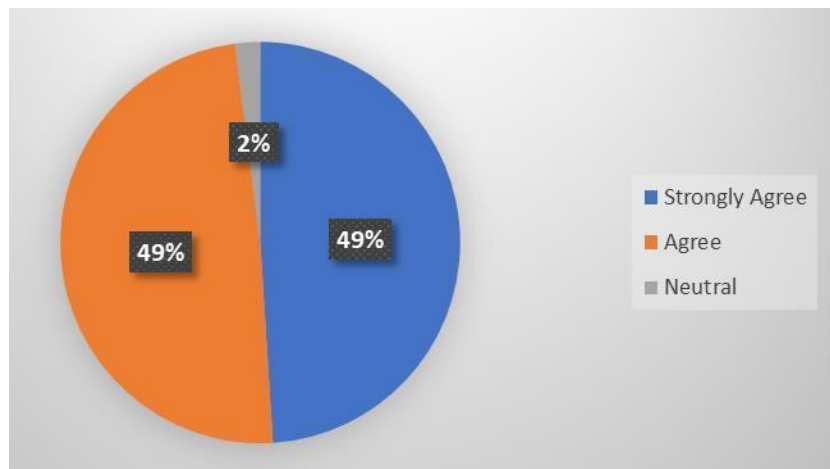


Figure 12: Analysis of “The learning objectives for each topic were identified and followed” for Education sector trainings

In summary, the education sector training programmes have excelled in delivering content that is both relevant and clear, as evidenced by the positive response from participants (Figure 10-12). Impressively, more than 98% of the participants agree that the programmes met their overall expectations, featured well-organized and easily comprehensible content, and successfully identified and adhered to learning objectives for each topic. This high level of agreement highlights the effectiveness of the training programmes within the education sector, with only a marginal 1% expressing disagreement. Hence, the positive feedback exhibits the success of these training programmes in providing a valuable, well-structured, and learning experience for participants in the education sector.

3.2.2 Effectiveness of instructional methods

This section evaluates the efficiency and impact of the teaching approaches employed during the training programmes. It assesses the extent to which the instructional methods contribute to the achievement of objectives and the overall success of the trainings. Analysing the effectiveness of instructional methods helps us to refine the approaches, ensuring that the chosen methods contribute optimally to the learning experience and the attainment of goals. The following questions were used for the analysis

- a. The reading materials distributed were relevant and useful
- b. The trainers were competent to deliver the respective subject
- c. The quality of presentations was good

3.2.2.1 Training of Trainers (ToT) Programmes

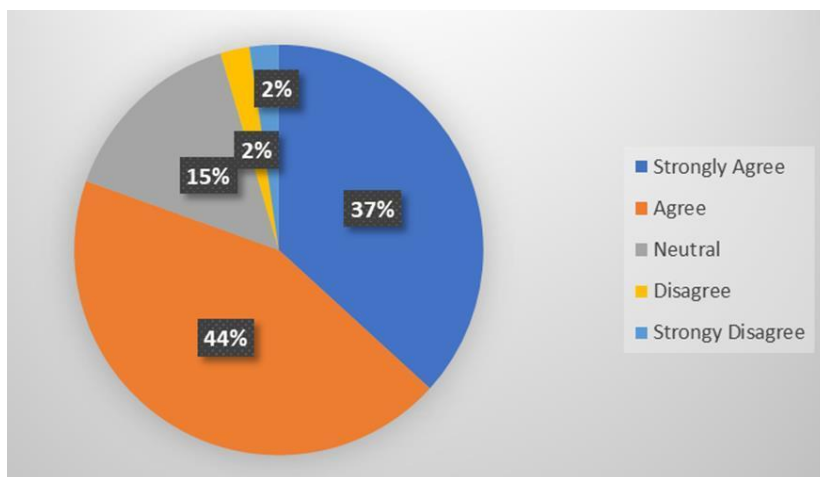


Figure 13: Analysis of “The reading materials distributed were relevant and useful” for ToT programmes

The majority of participants, 81%, found the distributed reading materials to be both relevant and useful (Figure 13). This suggests that the materials provided were well-received and contributed to the overall effectiveness of the training.

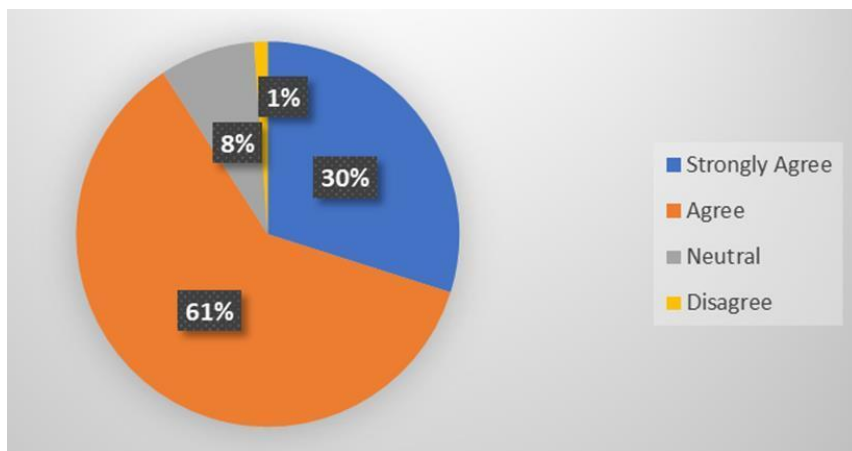


Figure 14: Analysis of “The trainers were competent to deliver the respective subject” for ToT programmes

A significant 91% of participants agreed (Figure 14) that the trainers were competent in delivering their respective subjects. This high level of agreement emphasizes the success of the programs in ensuring the expertise and effectiveness of the trainers in knowledge transfer.

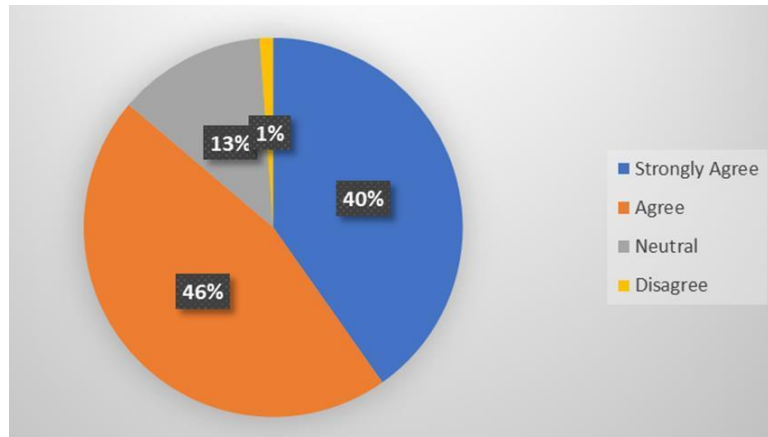


Figure 15: Analysis of “The quality of presentations was good” for ToT programmes

The quality of presentations received positive responses, with 86% of participants agreeing (Figure 15) that they were good. This indicates the success of the instructional methods employed in ensuring engaging and impactful presentations.

In conclusion, the Training the Trainers Programs have demonstrated a high level of effectiveness in their instructional methods, as evidenced by the positive feedback from participants. The minimal disagreement observed across all criteria (ranging from 1% to 4%) further supports the conclusion that the instructional methods utilized in these programs were effective and well-received by the participants. Overall, the positive feedback highlights the success of the Training the Trainers Programs in delivering a valuable and impactful learning experience.

3.2.2.2 Health Sector Trainings

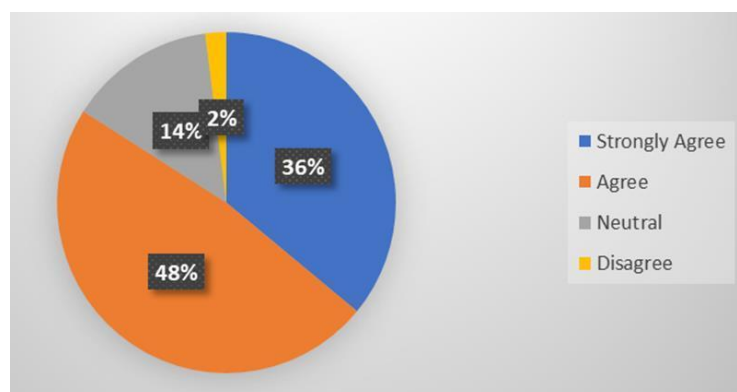


Figure 16 : Analysis of “The reading materials distributed were relevant and useful” for Health sector trainings

The distribution of reading materials received positive reviews (Figure 16), with 84% of participants expressing agreement on their relevance and usefulness. This reflects the success of the programs in providing valuable resources for participants.

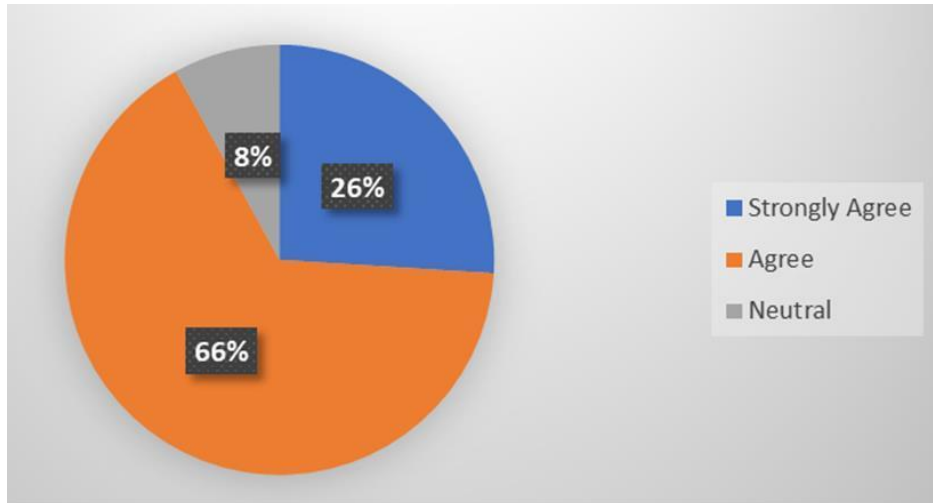


Figure 17: Analysis of “The trainers were competent to deliver the respective subject” for Health sector trainings

A substantial 92% of participants agreed (Figure 17) that the trainers displayed competence in delivering their respective subjects. This high level of agreement highlights the effectiveness of the instructional methods in ensuring the proficiency and expertise of the trainers were well-received.

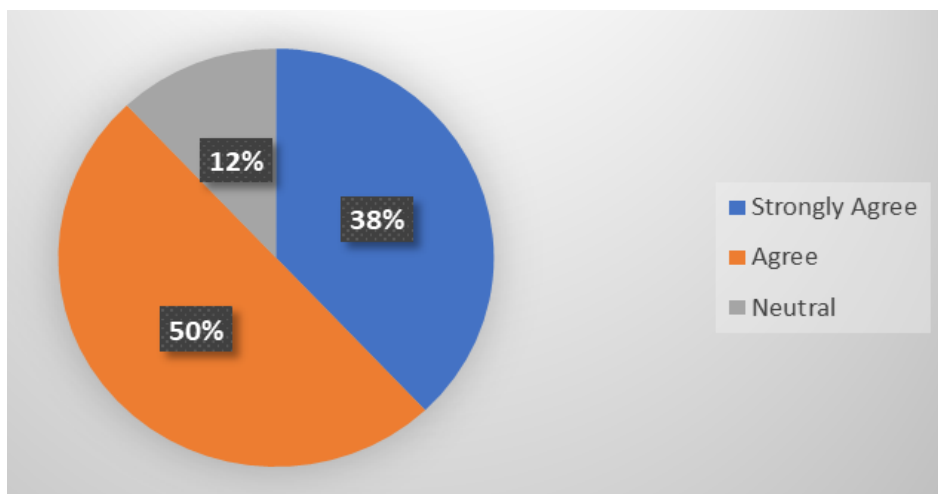


Figure 18: Analysis of “The quality of presentations was good” for Health sector trainings

The quality of presentations was well-regarded, with 88% of participants agreeing (Figure 18) that they were good. This positive response highlights the success of the instructional methods in facilitating engaging and high-quality presentations.

In summary, the health sector training programmes have demonstrated the effectiveness in their instructional methods, as evidenced by participant feedback. The relatively low percentages of neutral responses across all criteria further indicate a consistent and positive trend in participant perceptions. Overall, the feedback supports the conclusion that the instructional methods employed in these health sector training programmes have been effective in delivering a valuable and impactful learning experience for participants.

3.2.2.3 Industry Sector Trainings

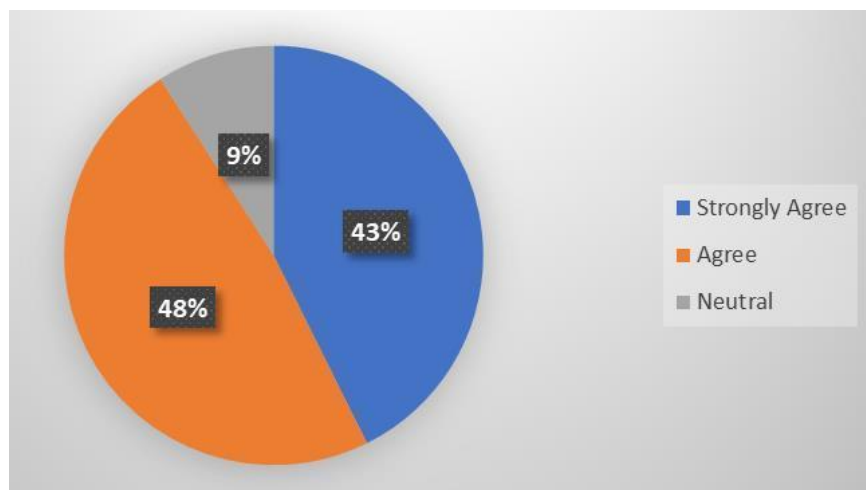


Figure 19: Analysis of “The reading materials distributed were relevant and useful” for Industry sector trainings

A substantial 91% of participants agreed (Figure 19) that the reading materials distributed were both relevant and useful. This indicates the success of the programmes in providing valuable resources that enhance the learning experience.

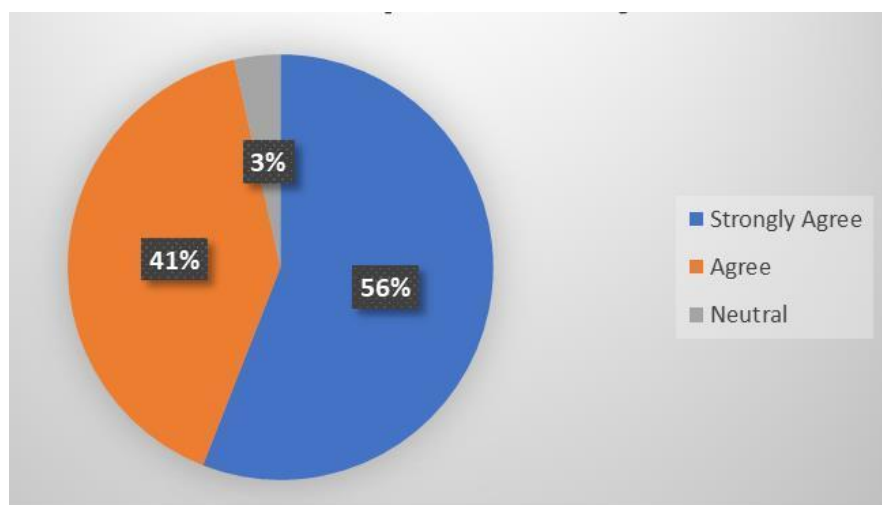


Figure 20: Analysis of “The trainers were competent to deliver the respective subject” for Industry sector trainings

97% of participants confirmed (Figure 20) that the trainers displayed competence in delivering their respective content. This high level of agreement highlights the success of the programmes in ensuring the proficiency and expertise of the trainers, contributing to an effective learning environment.

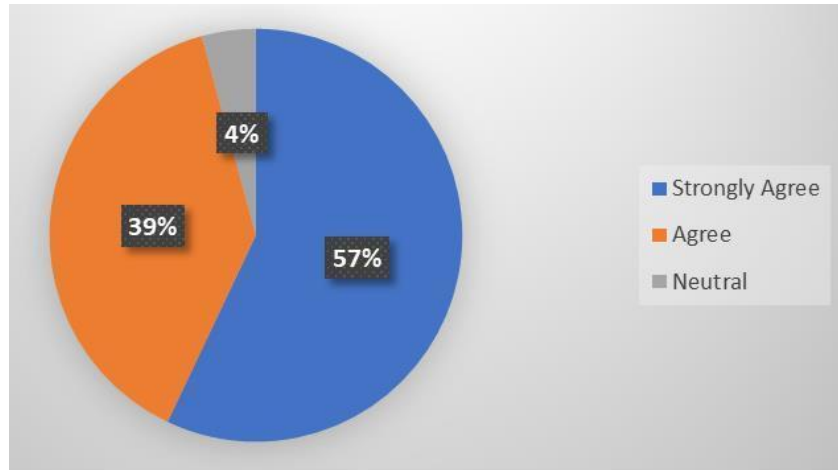


Figure 21: Analysis of “The quality of presentations was good” for Industry sector trainings

The quality of presentations received a positive feedback (Figure 21), with 96% of participants agreeing that they were good. This suggests that the instructional methods employed were successful in facilitating engaging and high-quality presentations, enhancing the overall learning experience.

In summary, the industry sector training programs have demonstrated a high level of effectiveness in their instructional methods, with a positive feedback from participants. The minimal neutral responses (ranging from 3% to 9%) further support the conclusion that the instructional methods utilized in these programs were effective and well-received by the participants.

3.2.2.4 Education Sector Trainings

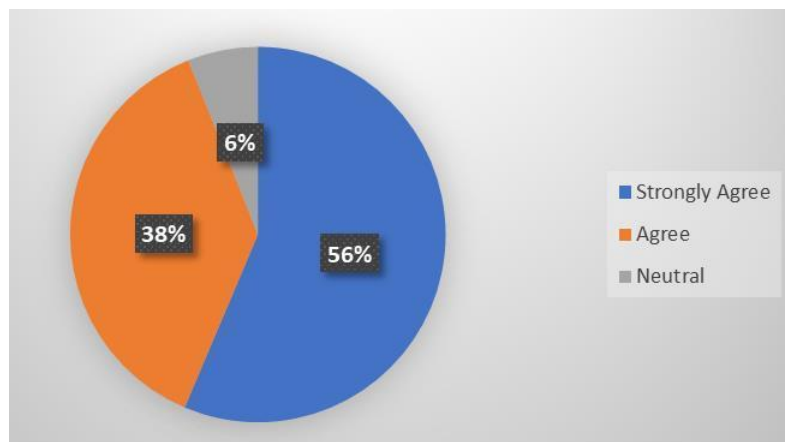


Figure 22: Analysis of “The reading materials distributed were relevant and useful” for Education sector trainings

A significant 94% of participants agreed (Figure 22) that the reading materials distributed were both relevant and useful. This agreement suggests that the programmes succeeded in providing valuable resources, enhancing the learning experience.

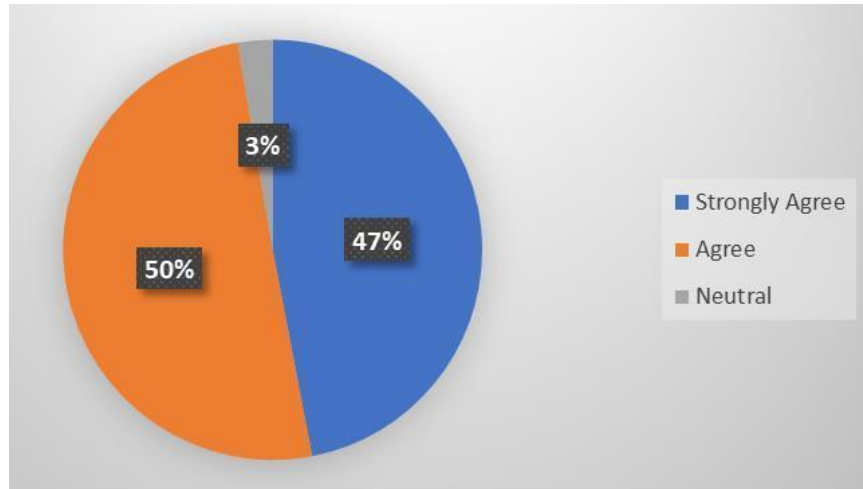


Figure 23: Analysis of “The trainers were competent to deliver the respective subject” for Education sector trainings

97% of participants agreed (Figure 23) that the trainers demonstrated competence in delivering their respective contents. This high level of agreement underscores the success of the programmes ensuring the proficiency and expertise of the trainers, contributing to an effective learning environment.

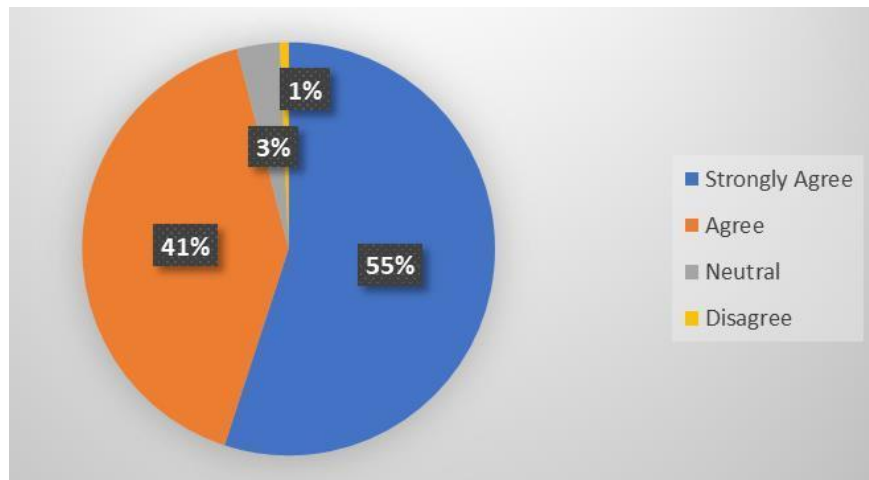


Figure 24: Analysis of “The quality of presentations was good” for Education sector trainings

The quality of presentations received a positive feedback (Figure 24), with 96% of participants agreeing that they were good. This indicates that the instructional methods used were successful in facilitating engaging and high-quality presentations, contributing to the overall effectiveness of the learning experience.

In conclusion, the education sector training programmes have demonstrated the effectiveness in their instructional methods, as indicated by the positive feedback from participants. The minimal neutral responses (ranging from 3% to 6%) and the slight disagreement (1%) regarding the quality of presentations further support the conclusion that the instructional methods utilised in these programmes were effective and well-received by the majority of participants. Overall, the feedback affirms the success of the education sector training programs in providing a valuable and impactful learning experience.

3.2.3 Impact on participants' knowledge and skills

Assessing the impact on the knowledge and skills of participants is essential for determining the overall success and effectiveness of a training program. This section gives an assessment of how the training programmes influenced and enhanced the knowledge and skills of the participants. The following question was used for the analysis

- a. The knowledge gained during the in-class trainings will be useful to carry out the duties of my occupation

3.2.3.1 Training of Trainers (ToT) Programmes

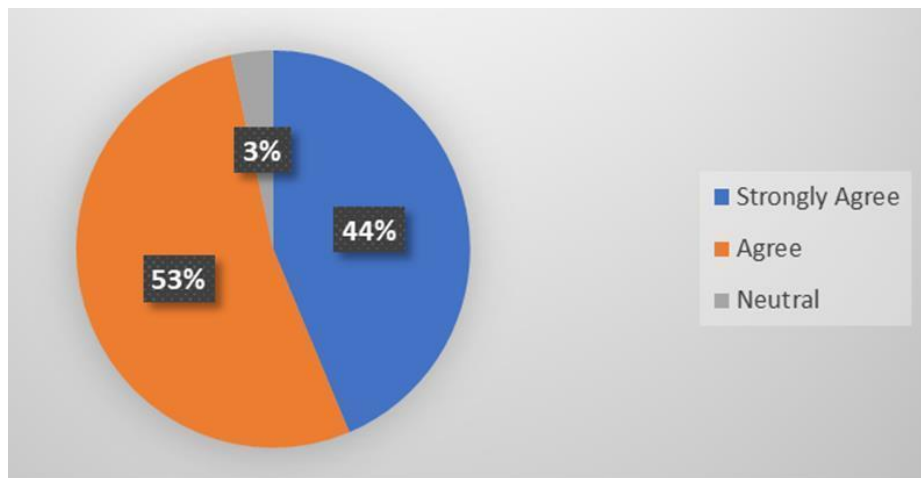


Figure 25: Analysis of “The knowledge gained during the in-class trainings will be useful to carry out the duties of my occupation” for ToT programmes

97% of participants agree (Figure 25) that the knowledge acquired during the training the trainers programmes will be beneficial in effectively implying the knowledge gained at their workplaces. This highlights the significance of the training programs in equipping participants with relevant and applicable skills for their professional roles.

In conclusion, the Training the Trainers Programs have exhibited a significant impact on knowledge and skills of the participants, as reflected in the positive feedback regarding the knowledge from the training programme. The minimal neutral response (3%) suggests the degree of alignment among participants regarding the practical value of the knowledge gained. Overall, the positive feedback affirms the success of the Training the Trainers Programs in promoting tangible and applicable knowledge, enhancing participants' abilities to excel in their occupational responsibilities.

3.2.3.2 Health Sector Training

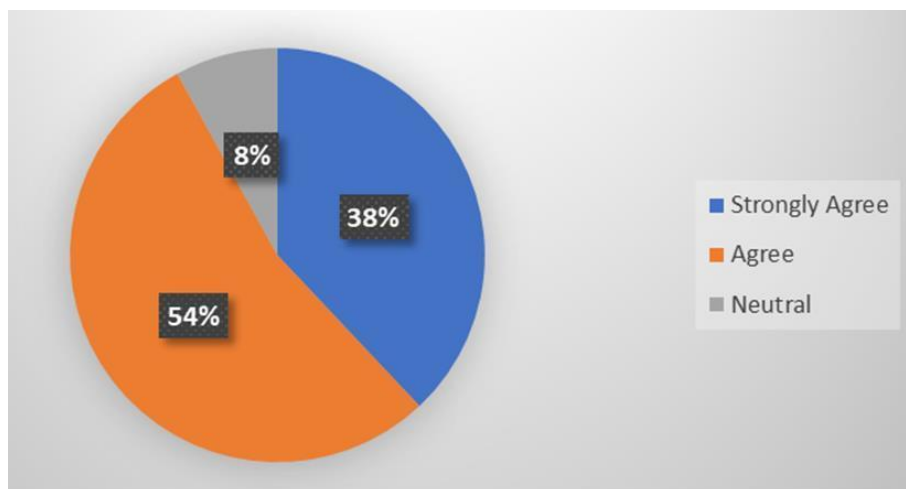


Figure 26: Analysis of “The knowledge gained during the in-class trainings will be useful to carry out the duties of my occupation” for Health sector trainings

92% of participants agree (Figure 26) that the knowledge gained during the health sector training programmes will be valuable for effectively carrying out the duties of their occupation. This agreement indicates that the training programs have successfully equipped participants with relevant and applicable skills for their roles in the health sector.

In conclusion, the health sector training programmes have made a notable impact on participants' knowledge and skills, as evidenced by participant feedback. The 8% neutral response suggests that while a majority find the knowledge useful, a portion of participants may have reservations or remain undecided. Overall, the positive feedback confirms the effectiveness of the health sector training programmes in enhancing participants' knowledge and skills for application in their professional responsibilities.

3.2.3.3 Industry Sector Trainings

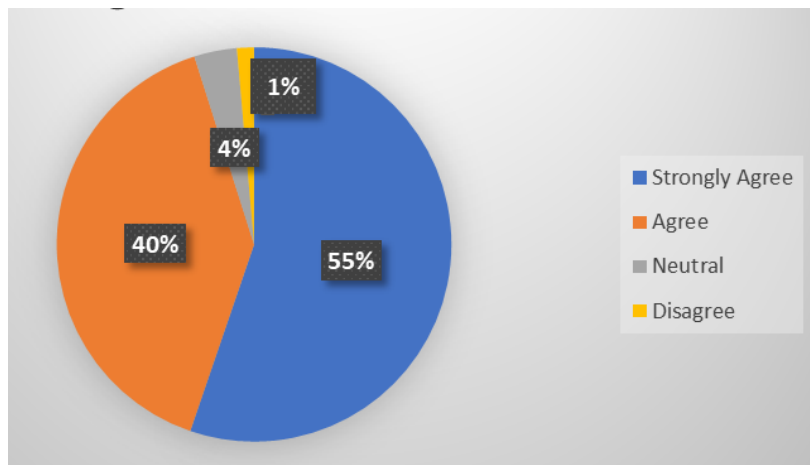


Figure 27: Analysis of “The knowledge gained during the in-class trainings will be useful to carry out the duties of my occupation” for Industry sector trainings

A substantial 95% of participants agree (Figure 27) that the knowledge acquired during the training programmes will be beneficial for effectively applying at their workplaces. This high level of agreement exhibits the success of the training programmes in providing participants with valuable and applicable skills relevant to their roles in the industry sector.

In conclusion, the industry sector training programmes have demonstrated a significant positive impact on participants' knowledge and skills, as indicated by the feedback. The minimal neutral response (4%) and disagreement (1%) suggest a strong consensus among participants regarding the practical value of the knowledge gained. Overall, the positive feedback affirms the effectiveness of the industry sector training programmes in enhancing participants' knowledge and skills for successful application in their professional duties.

3.2.3.4 Education Sector Trainings

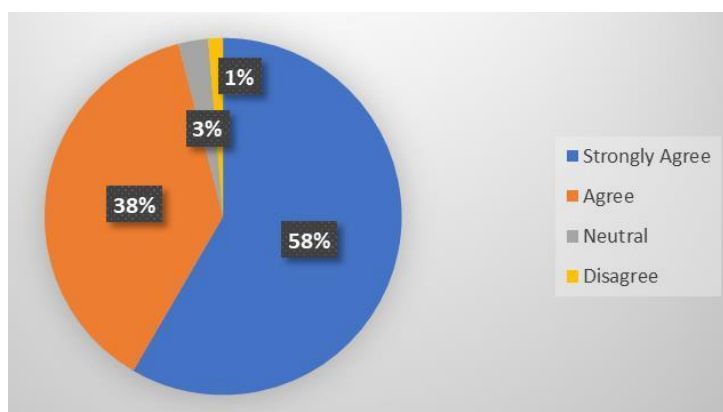


Figure 28: Analysis of “The knowledge gained during the in-class trainings will be useful to carry out the duties of my occupation” for Education sector trainings

A substantial 96% of participants agree (Figure 28) that the knowledge acquired during the training programmes will be valuable for effectively carrying out the duties at their institutions. This high level of agreement emphasizes the success of the training programmes in equipping participants with relevant and applicable skills applicable to their roles in the education sector.

In conclusion, the education sector training programs have demonstrated a significant and positive impact on participants' knowledge and skills, as evidenced by the feedback regarding the practical utility of the gained knowledge. The minimal neutral response (3%) and disagreement (1%) suggest a strong consensus among participants regarding the practical value of the knowledge gained. Overall, the positive feedback affirms the effectiveness of the education sector training programs in enhancing participants' knowledge and skills for successful application in their professional duties.

3.2.4 Overall satisfaction with the training

Evaluating overall satisfaction provides valuable insights into the participants' overall experience and whether the training programmes successfully met or exceeded their expectations.

3.2.4.1 Training of Trainers (ToT) Programmes

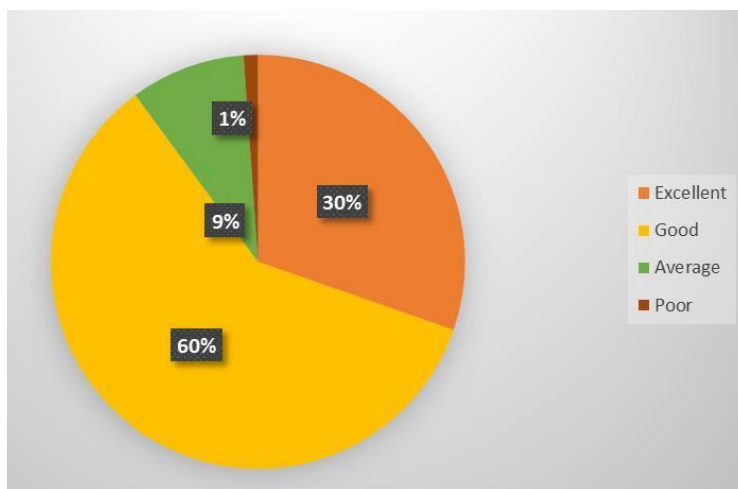


Figure 29: Analysis of “Overall satisfaction with the training” for ToT programmes

The overall satisfaction with the Training the Trainers Programs is notably high (Figure 29), with 90% of participants expressing a positive rating of "excellent and good". This majority indicates a strong endorsement of the program's quality, effectiveness, and overall value. While 9% rated the training as "average," suggesting a moderate satisfaction level, only a minimal 1% found it "poor". The positive response from the majority exhibits the success of the training programs in meeting or exceeding participant expectations, contributing to a highly satisfactory experience.

3.2.4.2 Health Sector Trainings

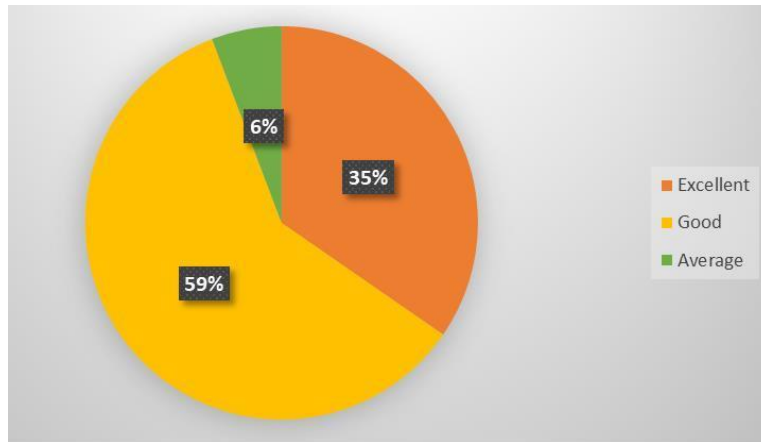


Figure 30: Analysis of “Overall satisfaction with the training” for Health sector trainings

The overall satisfaction with the Health Sector Training Programs is notably high (Figure 30), with an impressive 94% of participants expressing a positive rating of "excellent and good". This substantial majority confirms a strong approval of the program's quality and effectiveness in meeting participants' expectations. Additionally, while 6% rated the training as "average", indicating a moderate level of satisfaction, the positive response from the majority emphasizes the success of the training programs in delivering a highly satisfactory and impactful learning experience within the health sector.

3.2.4.3 Industry Sector Trainings

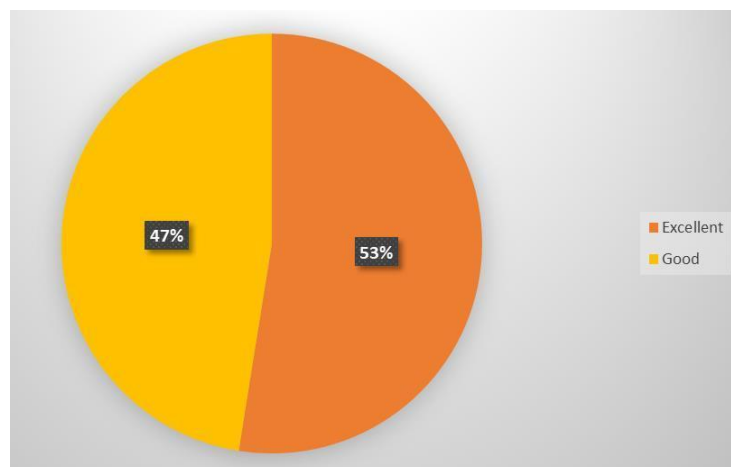


Figure 31: Analysis of “Overall satisfaction with the training” for Industry sector trainings

The satisfaction level with the Industry Sector Training Programmes is positive, with a balanced distribution among participants (Figure 31). Approximately 53% of participants rated the training as "excellent", indicating a substantial portion expressing the highest level of satisfaction. Additionally, 47% rated the training as "good", further emphasizing a positive overall assessment. This balanced distribution suggests a notable degree of approval and

effectiveness, with a majority either highly satisfied or expressing a positive sentiment. The varied responses contribute to an overall positive conclusion regarding the industry sector training programmes, indicating a considerable level of participant satisfaction.

3.2.4.4 Education Sector Trainings

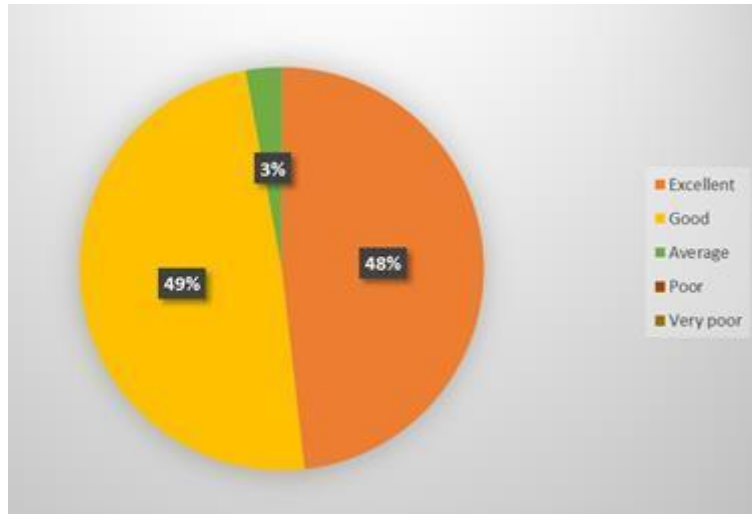


Figure 32: Analysis of “Overall satisfaction with the training” for Education sector trainings

The satisfaction level with the Education Sector Training Programmes is high (Figure 32), with an overwhelming 97% of participants expressing a positive rating of "excellent and good". This majority indicates a strong endorsement of the program's quality and effectiveness, highlighting a highly satisfactory learning experience within the education sector. Additionally, with only 3% rating the training as "average", the positive response exhibits the success of the training programs in meeting or exceeding participant expectations. The outstanding feedback reflects the impactful and valuable nature of the education sector training programs, reinforcing their success in delivering a highly satisfying educational experience.

CHALLENGES AND RECOMMENDATIONS

4.1 Challenges faced in conducting the training and awareness raising sessions

Conducting training and awareness programmes has been quite challenging, especially considering the recent economic crisis that has taken place in the country. Following are some of the challenges faced when organizing and conducting the training and awareness programmes.

4.1.1 Challenges in Securing Appropriate Training Venues

Locating suitable venues for conducting the training and awareness programmes were a challenge, particularly as the chosen locations needed to be convenient for participants in terms of travel, equipped with the necessary facilities for effective training, and financially viable.

4.1.2 Challenges in Stakeholder Communication and Participant Engagement

Communicating information regarding the programmes to relevant stakeholders was challenging. In many instances, a nomination and approval process, which proved time-consuming, was in place. Even with this process, ensuring the participation of all nominated individuals was challenging due to last-minute cancellations.

4.1.3 Stakeholder Engagement and Interest in Training Programmes

In some instances, a lack of interest from certain stakeholders was also a challenge faced. Even though the training was relevant to them, they were not keen to participate in the training and awareness programmes.

4.1.4 Escalating Costs in Training Programmes Implementation

Due to the country's situation, the cost of goods and services provided has increased drastically since March 2022. As a result, the cost of conducting training programs and providing refreshments has increased significantly. This has limited the options available for holding the training programmes.

4.1.5 Scheduling Challenges in Sector-Specific Programmes

Sector-wise programmes were organized with the support of institutes and organizations in the relevant sectors. Hence, at times, it was challenging to secure a date for conducting the training.

Even after confirming a date, sometimes the training got postponed due to internal issues within the relevant organization.

Organizing training and awareness programmes involves a lead time for discussions, particularly as these programmes are predominantly arranged in collaboration with various institutes. Regrettably, there has been a lack of response from certain organizations regarding the scheduling of training programs, despite their relevance to the respective entities.

4.1.6 Navigating Attention Retention Challenges

It was observed that retaining the attention of participants regarding the content delivered on Mercury, especially within the industry sector, was challenging. Factors such as the technical nature of the information and the busy schedules of industry professionals contributed to this difficulty.

4.1.7 Administrative Challenges in Involving Schools for Education Sector Trainings

It was challenging to involve schools from the education sector for the training programmes because permission from the Ministry of Education was required for teachers and laboratory staff to attend the sessions.

4.1.8 Challenges in Engaging Small-Scale Jewellery Manufacturing Sector for Training Programs

Due to the prevailing economic situation in the country, some sectors, such as small-scale jewellery manufacturing, have been severely affected. The lack of demand for jewellery has resulted in a scarcity of available work for workers in this sector. Hence, it was difficult to generate interest in training programmes among this group.

4.1.9 Challenges in Addressing Concerns Regarding the Managing Accumulated Mercury Waste

A constant inquiry raised by participants during the training sessions was, 'What should be done with the collected mercury waste that has been accumulating for some time now?' Due to the absence of a proper process for managing mercury waste, providing a definitive answer to such inquiries was challenging.

4.2 Strategic Recommendations for Overcoming Challenges in conducting Awareness and Training Programmes on Mercury Management

Addressing the multifaceted challenges encountered in the implementation of mercury awareness and training programmes is essential for ensuring the success and impact of these initiatives. These suggestions, articulated by participants, address various facets of the program, recognizing the intricate challenges and opportunities associated with mercury management. From practical applications in the industrial sector to in-depth discussions on waste disposal and chemical storage, these recommendations encompass a spectrum of crucial considerations.

4.2.1 Comprehensive Information on Mercury Waste

Participants emphasize that a thorough exploration of mercury waste disposal practices should go beyond surface-level knowledge. The recommendation entails providing in-depth insights into the various aspects of handling, transporting, and treating mercury waste. Further, the recommendation stresses the importance of addressing emerging technologies and advancements in mercury waste treatment. As the field continues to evolve, participants express the need for up-to-date information on innovative and environmentally friendly disposal methods that align with global best practices.

4.2.2 Practical Applications and Field Activities

The participants emphasize the need for a hands-on approach, the integration of field activities and practical applications to enhance the learning experience, particularly within the industrial sector. To ensure the practical applicability of the information, participants suggest real-world case studies and examples illustrating successful mercury waste management practices. These practical insights will not only enhance the participants' understanding but also equip them with actionable knowledge to implement effective waste management strategies in their respective contexts.

4.2.3 Inclusion of Other Industrial Hazardous Chemicals and chemical waste management

Participants suggest incorporating dedicated sessions within the training program that covers the characteristics, risks, and safe handling practices of commonly used industrial chemicals apart from mercury. This could encompass chemicals prevalent in diverse industrial sectors, ensuring relevance to a wide range of participants. Additionally, participants recommend

incorporating case studies and practical examples showcasing incidents related to other hazardous chemicals, emphasizing the importance of proper handling and preventive measures. Real-world scenarios will enhance the participants' ability to apply theoretical knowledge to practical situations, fostering a deeper understanding of chemical safety.

4.2.4 Mercury Waste Disposal Methods

Participants stress the importance of incorporating practical examples and case studies related to the disposal of mercury waste. Real-world scenarios will enhance participants' understanding of the complexities involved and provide practical insights into effective waste management practices for materials containing mercury. To enhance clarity and engagement, participants suggest the incorporation of visual aids such as diagrams or instructional videos demonstrating the steps involved in the disposal process for mercury waste. These visual elements can serve as valuable tools for reinforcing theoretical knowledge and ensuring participants grasp the intricacies of the disposal procedures. Furthermore, participants emphasize the necessity of ongoing updates on emerging technologies and advancements in the field of mercury waste disposal. This recommendation encourages the inclusion of information on innovative, environmentally friendly, and sustainable methods, ensuring participants remain well-informed about the latest developments.

4.2.5 Extension to School Outreach

Participants propose the expansion of these training and awareness raising programmes through a targeted School Outreach initiative, emphasizing the importance of educating the younger generation about mercury-related issues.

The recommendations extend beyond immediate training concerns to include broader environmental considerations, such as including practical applications, field activities and comprehensive waste management procedures. Additionally, there is a focus on educational outreach, proposing the extension of the program to school children, nurturing awareness from an early age.

Finally, recognizing the significance of visual learning, participants advocate for the integration of more videos to enhance engagement and comprehension. Collectively, these recommendations form a roadmap for an enriched, inclusive, and sustainable outcome from these training and awareness raising programmes, poised to make a lasting impact on mercury awareness and management.

The effectiveness of the training and awareness raising programmes conducted on mercury waste management is evident through several key observations and outcomes. The collective impact of these initiatives has contributed to advancing environmental sustainability, public health, and the fulfilment of international obligations under the Minamata Convention. The following conclusions highlight the effectiveness of the programs:

5.1 Increased Knowledge and Awareness

The programs have succeeded in enhancing the knowledge and awareness levels among stakeholders, ranging from industry professionals to the general public. Participants now possess a deeper understanding of the risks associated with mercury exposure and the importance of responsible waste management.

5.2 Positive Behavioural Changes

Observable behavioral changes, both in personal and professional contexts, indicate the effectiveness of the programs. Individuals and organizations are making informed decisions regarding the use and disposal of mercury-containing products, contributing to a reduction in environmental impact.

5.3 Enhanced Institutional Capacities

Training initiatives targeting professionals and key stakeholders have led to an improvement in institutional capacities. Organizations now possess the knowledge and skills necessary for effective mercury waste management, reducing the likelihood of improper disposal practices.

5.4 Cross-Sectoral Collaboration

The programs have fostered cross-sectoral collaboration, bringing together government bodies, educational institutions, industries, and communities. This collaborative approach enhances the collective capacity to address mercury waste management comprehensively.

5.5 Global Reputation and Compliance

The commitment to fulfilling obligations under the Minamata Convention has strengthened the global reputation of the country. Demonstrating compliance with international standards positions Sri Lanka as a responsible country in global environmental protection.

In conclusion, the effectiveness of the training and awareness-raising programs on mercury waste management is evident in the tangible positive changes observed across various sectors. These outcomes not only fulfill immediate objectives but also lay the groundwork for a more sustainable, responsible, and environmentally conscious society. Continued evaluation and adaptation of these programs will be crucial for maintaining and expanding their positive impact in the future.

Annex 1 – Agendas of the Training of Trainers (ToT) programmes

Annex 1.1 – Agenda for the Training of Trainers Programme in Colombo

Annex 1.2 – Agenda for the Training of Trainers Programme in Kandy

Annex 1.3 – Agenda for the Training of Trainers Programme in Galle

Annex 2 – Photos captured during the Training of Trainers (ToT) programmes

Annex 2.1 – Photos captured during the Training of Trainers Programme in Colombo

Annex 2.2 – Photos captured during the Training of Trainers Programme in Kandy

Annex 2.3 – Photos captured during the Training of Trainers Programme in Galle

Annex 3 – Agenda and Photos captured during Health Sector Training programmes

Annex 3.1 – Agenda and Photos from the Health Sector training programme – Colombo

Annex 3.2 – Agenda and Photos from the Health Sector training programme – Kalutara

Annex 3.3 – Agenda and Photos from the Health Sector training programme – Kandy

Annex 3.4 – Agenda and Photos from the Health Sector training programme – Galle

Annex 4 – Agenda and Photos captured during Industry Sector Training programmes

Annex 4.1 - Agenda and Photos from the Industry Sector training programme – IDB Officers, Katubedda

Annex 4.2 – Agenda and Photos for the Industry Sector training programme – BOI Officers, Colombo

Annex 4.3 – Agenda and Photos for the Industry Sector training programme – IDB Industrial Zone, Horana

Annex 4.4 – Agenda of the Industry Sector training programme – IDB Industrial Zone, Pallekele

Annex 4.5 – Agenda and Photos for the Industry Sector training programme – IDB Industrial Zone, Ekala

Annex 4.6 – Agenda and Photos for the Industry Sector training programme – BOI EPZ, Katunayake

Annex 5 – Agenda and Photos captured during Education Sector Training programmes

Annex 5.1 - Agenda and Photos from the Industry Sector training programme – IDB Officers, Katubedda

Annex 5.2 – Agenda and Photos for the Industry Sector training programme – BOI Officers, Colombo

Annex 5.3 – Agenda and Photos for the Industry Sector training programme – IDB Industrial Zone, Horana

Annex 5.4 – Agenda of the Industry Sector training programme – IDB Industrial Zone, Pallekele

Annex 5.5 – Agenda and Photos for the Industry Sector training programme – IDB Industrial Zone, Ekala

Annex 5.6 – Agenda and Photos for the Industry Sector training programme – BOI EPZ, Katunayake

Annex 6 – Agenda and Photos captured during Awareness programmes

Annex 1.1 – Agenda of the Training of Trainers Programme in Colombo

Date	28th February 2023
Venue	8th Floor Auditorium, Ministry of Environment
Time	Agenda item
8.30 am- 9.00 am	Registration
9.00 am- 9.15 am	Welcome and introduction to the programme
9.15 am- 10.00 am	Module 1: Introduction to chemical management <i>By Prof. Ajith de Alwis, Dean Faculty of Graduate Studies University of Moratuwa</i>
10.00 am – 10.30 am	Module 2: Sources, types, properties of Mercury <i>By Prof. Parakrama Karunarathne, Department of Chemicals & Process Engineering, University of Peradeniya</i>
10.30 am – 11.00 am	Module 2: Adverse health effects of mercury <i>By Dr. Inoka Suraweera Consultant Community Physician Environmental and Occupational Health Directorate Ministry of Health</i>
11.00 am – 11.15 am	Tea Break
11.15 am- 12.15 pm	Module 3: Guidelines for mercury waste management <i>By Prof Parakrama Karunarathna</i>
12.15 am- 1.15 pm	Module 4: Mercury-free alternatives to mercury-containing products <i>By Prof Jagath Premachandra, Department of Chemicals & Process Engineering, University of Moratuwa</i>
1.15 pm – 2.00 pm	Lunch Break
2.00 pm- 2.30 pm	Module 5: Mercury spill management <i>Prof Jagath Premachandra</i>
2.30 pm – 4.00 pm	Module 6: Mercury waste packaging, storage, transport and disposal methods <i>By Dr Udaya Jayasundara Senior Lecturer, Institute of Chemistry</i>
4.00pm	Tea Break

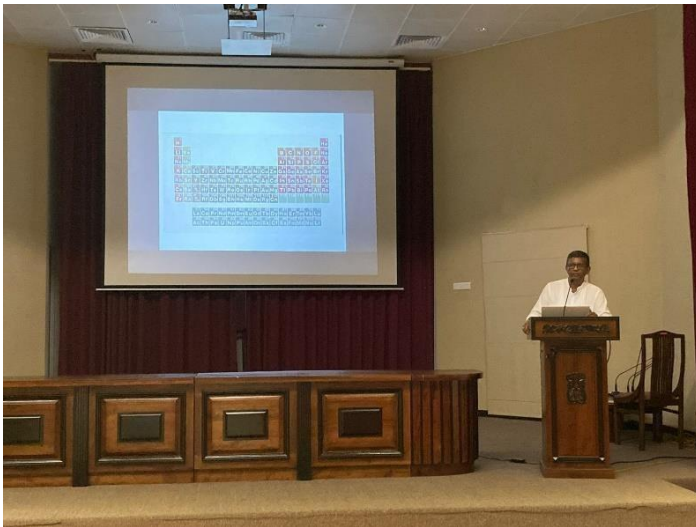
Annex 1.2 – Agenda for Training of Trainers Programme in Kandy

Date	2nd March 2023
Venue	Auditorium of Postgraduate Institute of Science, University of Peradeniya
Time	Agenda item
8.30 am- 9.00am	Registration
9.00 am- 9.15 am	Welcome and introduction to the programme
9.15 am- 10.15 am	Importance of Chemicals Management Module 1: Introduction to chemical management By Dr Udaya Jayasundara Senior Lecturer, Institute of Chemistry Ceylon
10.15 am – 11.15 am	Module 2: Sources, types, properties of and adverse health effects of mercury By Prof. Parakrama Karunarathna Department of Chemical & Process Engineering, University of Peradeniya
11.15 am – 11.30 am	Tea Break
11.30 am- 12.00 pm	Module 3: Guidelines for mercury waste management Prof Parakrama Karunarathne
12.00 pm – 12.45 pm	Module 4: Mercury-free alternatives to mercury-containing products By Prof. Jagath Premachandra Department of Chemical & Process Engineering, University of Moratuwa
12.45 pm – 1.30 pm	Lunch Break
1.30 pm- 2.30 pm	Module 5: Mercury spill management By Prof. Jagath Premachandra
2.30 pm – 4.00 pm	Module 6: Mercury storage management By Dr Udaya Jayasundara
4.00pm	Tea Break

Annex 1.3 – Agenda for the Training of Trainers Programme in Galle

Date	20 th March 2023
Venue	Hall De Galle
Time	Agenda item
9.00 am- 9.15 am	Welcome and introduction to the programme
9.15 am- 10.00 am	Module 1: Introduction to chemical management <i>By Dr Udaya Jayasundara</i> <i>Senior Lecturer, Institute of Chemistry</i>
10.00 am – 10.30 am	Module 2: Sources, types, properties of Mercury <i>By Dr Udaya Jayasundara</i>
10.30 am – 11.00 am	Module 2: Adverse health effects of mercury <i>By Dr. Inoka Suraweera (Online)</i> <i>Consultant Community Physician</i> <i>Environmental and Occupational Health Directorate</i> <i>Ministry of Health</i>
11.00 am – 11.15 am	Tea Break
11.15 am- 12.15 pm	Module 3: Guidelines for mercury waste management <i>By Prof Parakrama Karunaratna</i> <i>Department of Chemicals & Process Engineering,</i> <i>University of Peradeniya</i>
12.15 am- 12.45 pm	Module 4: Mercury-free alternatives to mercury-containing products <i>By Prof Jagath Premachandra,</i> <i>Department of Chemicals & Process Engineering,</i> <i>University of Moratuwa</i>
12.45 pm – 1.30 pm	Lunch Break
1.30 pm- 2.30 pm	Module 5: Mercury spill management <i>Prof Jagath Premachandra</i>
2.30 pm – 4.00 pm	Module 6: Mercury waste packaging, storage, transport and disposal methods <i>By Dr Udaya Jayasundara</i>
4.00pm	Tea Break

Annex 2.1 – Photos captured during the Training of Trainers Programme in Colombo



Annex 2.2 – Photos captured during the Training of Trainers Programme in Kandy



Annex 2.3 – Photos captured during the Training of Trainers Programme in Galle



Annexure 3.1: Agenda and Photos from the Health Sector training programme – Colombo

“Sound Management of Mercury and Mercury Containing Waste”

Agenda for the Health Sector Training Programme

On 08/05/2023 at 8th Floor Auditorium, Ministry of Environment

Time	Agenda item
8.30 am- 9.00 am	Registration
9.00 am- 9.10 am	Welcome and introduction to the programme
9.10 am- 10.00 am	Module 1: Introduction to chemical management <i>By Dr Udaya Jayasundara</i> <i>Senior Lecturer, Institute of Chemistry</i>
10.00 am – 10.30 am	Module 2: Sources, types, properties of Mercury <i>By Dr Udaya Jayasundara</i>
10.30 am – 11.00 am	Module 2: Adverse health effects of mercury <i>By Dr. Inoka Suraweera</i> <i>Consultant Community Physician</i> <i>Environmental and Occupational Health Directorate</i> <i>Ministry of Health</i>
11.00 am – 11.15 am	Tea Break
11.15 am- 12.00 pm	Module 3: Guidelines for mercury management (Online) <i>By Prof Parakrama Karunarathna</i> Senior Lecturer, Department of Chemical & Process Engineering, University of Peradeniya
12.00 pm- 12.45 pm	Module 4: Mercury-free alternatives to mercury-containing products <i>By Prof Jagath Premachandra,</i> <i>Department of Chemicals & Process Engineering,</i> <i>University of Moratuwa</i>
12.45 pm – 1.30 pm	Lunch Break
1.30 pm- 2.30 pm	Module 5: Mercury spill management <i>Prof Jagath Premachandra</i>
2.30 pm – 4.00 pm	Module 6: Mercury waste packaging, storage, transport and disposal methods <i>By Dr Udaya Jayasundara</i> <i>Senior Lecturer, Institute of Chemistry</i>
4.00pm	Tea Break



Annexure 3.2: Agenda and Photos from the Health Sector training programme – Kalutara

Sound Management of Mercury & Mercury Containing Waste

Venue: Auditorium of District General Hospital, Kalutara

Date: 24/05/2023

Time	Agenda item
8.30 am- 9.00 am	Registration
9.00 am- 9.05 am	Welcome and introduction to the programme
9.05 am- 9.45 am	Module 1: Introduction to chemical management <i>By Eng. Lakmini Edirisinghe</i> <i>National Cleaner Production Centre</i>
9.45 am – 10.15 am	Module 2: Sources, types, properties of Mercury <i>By Eng. Lakmini Edirisinghe</i>
10.15 am – 10.30 am	<i>Tea break</i>
10.30 am – 11.00 am	Module 2: Adverse health effects of mercury <i>By Dr. Inoka Suraweera</i> <i>Consultant Community Physician</i> <i>Environmental and Occupational Health Directorate</i> <i>Ministry of Health</i>
11.00 am – 11.45 am	Module 4: Mercury-free alternatives to mercury-containing products <i>By Prof Jagath Premachandra,</i> <i>Department of Chemicals & Process Engineering,</i> <i>University of Moratuwa</i>
11.45 am – 12.45 pm	Module 5: Mercury spill management <i>Prof Jagath Premachandra</i>
12.45 pm - 1.15 pm	Module 3: Guidelines for mercury waste management <i>By Eng. Lakmini Edirisinghe & Eng. Dumindu Fernando</i> <i>National Cleaner Production Centre</i>
1.15 pm	End of the Programme with Lunch



Annexure 3.3: Agenda and Photos from the Health Sector training programme – Kandy

Sound Management of Mercury & Mercury Containing Waste

Venue: Auditorium, Teaching Hospital, Kandy

Date: 01/06/2023

Time	Agenda item
8.30 am- 9.00 am	Registration
9.00 am- 9.05 am	Welcome and introduction to the programme
9.05 am- 9.45 am	Module 1: Introduction to chemical management <i>By Eng. Dumindu Fernando</i> <i>RECP Engineer</i> <i>National Cleaner Production Centre</i>
9.45 am – 10.15 am	Module 2: Sources, types, properties of Mercury <i>By Eng. Dumindu Fernando</i>
10.15 am – 10.45 am	Module 3: Guidelines for mercury waste management <i>By Eng. Dumindu Fernando</i>
10.45 am – 11.00 am	Tea
11.00 am – 11.30 am	Module 2: Adverse health effects of mercury <i>By Dr. Inoka Suraweera</i> <i>Consultant Community Physician</i> <i>Environmental and Occupational Health Directorate</i> <i>Ministry of Health</i>
11.30 am- 12.15 pm	Module 4: Mercury-free alternatives to mercury-containing products <i>By Prof Jagath Premachandra,</i> <i>Department of Chemicals & Process Engineering,</i> <i>University of Moratuwa</i>
12.15 pm - 1.15 pm	Module 5: Mercury spill management <i>Prof Jagath Premachandra</i>
1.15pm	End of Programme



Annexure 3.4: Agenda and Photos from the Health Sector training programme – Galle

Sound Management of Mercury & Mercury Containing Waste

Venue: Auditorium, Teaching Hospital, Karapitiya

Date: 23/06/2023

Time	Agenda item
8.30 am- 9.00 am	Registration
9.00 am- 9.05 am	Welcome and introduction to the programme
9.05 am- 9.45 am	Module 1: Introduction to chemical management <i>By Eng. Dumindu Fernando</i> <i>RECP Engineer</i> <i>National Cleaner Production Centre</i>
9.45 am – 10.15 am	Module 2: Sources, types, properties of Mercury <i>By Eng. Dumindu Fernando</i>
10.15 am – 10.45 am	Module 3: Guidelines for mercury waste management <i>By Eng. Dumindu Fernando</i>
10.45 am – 11.00 am	Tea
11.00 am- 11.45 pm	Module 4: Mercury-free alternatives to mercury-containing products <i>By Prof Jagath Premachandra,</i> <i>Department of Chemicals & Process Engineering,</i> <i>University of Moratuwa</i>
11.45 pm - 12.45 pm	Module 5: Mercury spill management <i>Prof Jagath Premachandra</i>
12.45 pm – 1.15 pm	Module 2: Adverse health effects of mercury <i>By Dr. Inoka Suraweera</i> <i>Consultant Community Physician</i> <i>Environmental and Occupational Health Directorate</i> <i>Ministry of Health</i>
1.15pm	End of Programme



Annexure 4.1: Agenda and Photos from the Industry Sector training programme – IDB Officers, Katubedda

Sound Management of Mercury & Mercury Containing Waste

Venue: – Industrial Development Board, Katubedde

Date: 27/06/2023

Time	Agenda item
8.30 am- 9.00 am	Registration
9.00 am- 9.05 am	Welcome and introduction to the programme
9.05 am- 9.45 am	Module 1: Introduction to chemical management <i>By Eng. Lakmini Edirisinghe Senior Consultant for National Cleaner Production Centre</i>
9.45 am – 10.15 am	Module 2: Sources, types, properties of Mercury <i>By Eng. Lakmini Edirisinghe</i>
10.15 am – 10.30 am	<i>Tea break</i>
10.30 am – 11.00 am	Module 2: Adverse health effects of mercury <i>By Eng. Dumindu Fernando RECP Engineer, National Cleaner Production Centre</i>
11.00 am- 11.45 am	Module 4: Mercury-free alternatives to mercury-containing products <i>By Eng. Dumindu Fernando</i>
11.45 am - 12.45 pm	Module 5: Mercury spill management <i>By Eng. Dumindu Fernando</i>
12.45 pm – 1.15 pm	Module 3: Guidelines for mercury waste management <i>By Eng. Lakmini Edirisinghe & Eng. Dumindu Fernando National Cleaner Production Centre</i>
1.15pm	End of Programme



Annexure 4.2: Agenda for the Industry Sector training programme – BOI Officers, Colombo

Sound Management of Mercury & Mercury Containing Waste

Venue: Auditorium, Board of Investment Head Office, Colombo

Date: 05/07/2023

Time	Agenda item
8.30 am- 9.00 am	Registration
9.00 am- 9.05 am	Welcome and introduction to the programme
9.05 am- 9.45 am	Module 1: Introduction to chemical management <i>By Dr Udaya Jayasundara</i> <i>Senior Lecturer, Institute of Chemistry Ceylon</i>
9.45 am – 10.15 am	Module 2: Sources, types, properties of Mercury <i>By Dr Udaya Jayasundara</i>
10.15 am – 10.45 am	Module 3: Guidelines for mercury waste management <i>By Eng. Dumindu Fernando</i> <i>RECP Engineer, National Cleaner Production Centre</i>
10.45 am – 11.00 am	Tea
11.00 am- 11.45 pm	Module 4: Mercury-free alternatives to mercury-containing products <i>By Dr Udaya Jayasundara</i>
11.45 pm - 12.45 pm	Module 5: Mercury spill management <i>By Dr Udaya Jayasundara</i>
12.45 pm – 1.15 pm	Module 2: Adverse health effects of mercury <i>By Eng. Dumindu Fernando</i>
1.15pm	End of Programme



Annexure 4.3: Agenda for the Industry Sector training programme – IDB Industrial Zone, Horana

Sound Management of Mercury & Mercury Containing Waste

Venue: – Horana

Date: 13/07/2023

Time	Agenda item
8.30 am- 9.00 am	Registration
9.00 am- 9.05 am	Welcome and introduction to the programme
9.05 am- 9.45 am	Module 1: Introduction to chemical management <i>By Eng. Dumindu Fernando</i> <i>RECP Engineer, National Cleaner Production Centre</i>
9.45 am – 10.15 am	Module 3: Guidelines for mercury waste management <i>Eng. Dumindu Fernando</i>
10.15 am – 10.30 am	<i>Tea break</i>
10.30 am – 11.00 am	Module 2: Adverse health effects of mercury <i>By Eng. Dumindu Fernando</i>
11.00 am – 11.30 am	Module 2: Sources, types, properties of Mercury <i>By Dr Udaya Jayasundara</i> <i>Senior Lecturer, Institute of Chemistry Ceylon</i>
11.30 am- 12.15 am	Module 4: Mercury-free alternatives to mercury-containing products <i>By Dr Udaya Jayasundara</i>
12.15 pm - 1.15 pm	Module 5: Mercury spill management <i>By Dr Udaya Jayasundara</i>
1.15pm	End of Programme



Annexure 4.4: Agenda for the Industry Sector training programme – IDB Industrial Zone, Pallekele

Sound Management of Chemicals & Chemical Waste including Mercury

Agenda for the Industry Sector Training

Venue: Industrial Zone, Pallekele

Date: 21st July 2023

Time	Agenda item
8.30 am- 9.00 am	Registration
9.00 am- 9.05 am	Welcome and introduction to the programme <i>Eng. Dumindu Fernando, RECP Engineer, National Cleaner Production Centre</i>
9.05 am- 9.30 am	Module 1: Introduction to chemical management <i>Eng. Dumindu Fernando</i>
9.30 am – 10.00 am	Module 1: Risk communication mechanisms <i>Eng. Dumindu Fernando</i>
10.00 am – 10.30 am	Module 1: How to utilize a Safety Data Sheet <i>Eng. Dumindu Fernando</i>
10.30 am – 10.45 am	Tea
10.45 am – 11.15 am	Module 2: Sources, types, properties of Mercury & Adverse health effects of mercury
11.15 am – 11.45 am	Module 3: Guidelines for mercury waste management <i>Prof Parakrama Karunaratne Head of the Department, Department of Chemical & Process Engineering, University of Peradeniya</i>
11.45 am- 12.15 pm	Module 4: Mercury-free alternatives to mercury-containing products <i>Prof Parakrama Karunaratne</i>
12.15 pm - 1.15 pm	Module 5: Mercury spill management <i>Prof Parakrama Karunaratne</i>
1.15pm	End of Programme

Annexure 4.5: Agenda for the Industry Sector training programme – IDB Industrial Zone, Ekala

Sound Management of Chemicals & Chemical Waste including Mercury

Agenda for the Industry Sector Training

Venue: IDB Industrial Estate - Ekala

Date: 25 July 2023

Time	Agenda item
8.30 am- 9.00 am	Registration
9.00 am- 9.05 am	Welcome and introduction to the programme
9.05 am- 9.30 am	Module 1: Introduction to chemical management Ms. Nadeera Ramanayake , <i>Enterprise Promotion Manager,</i> <i>Industrial Development Board</i>
9.30 am – 10.00 am	Module 1: Risk communication mechanisms Ms. Nadeera Ramanayake
10.00 am – 10.30 am	Module 1: How to utilize a Safety Data Sheet Ms. Nadeera Ramanayake
10.30 am – 10.45 am	Tea
10.45 am – 11.15 am	Module 2: Sources, types, properties of Mercury & Adverse health effects of mercury Prof. Jegath Premachandra , <i>Department of Chemical & Process Engineering,</i> <i>University of Moratuwa</i>
11.15 am – 11.45 am	Module 3: Guidelines for mercury waste management Prof. Jegath Premachandra
11.45 am- 12.15 pm	Module 4: Mercury-free alternatives to mercury-containing products Prof. Jegath Premachandra
12.15 pm - 1.15 pm	Module 5: Mercury spill management Prof. Jegath Premachandra
1.15pm	End of Programme



Annexure 4.6: Agenda for the Industry Sector training programme – BOI, Katunayake EPZ

Sound Management of Chemicals & Chemical Waste including Mercury

Agenda for the Industry Sector Training

Venue: Board of Investment Zonal Office, Katunayake

Date: 31st August 2023

Time	Agenda item
8.30 am – 9.00 am	Registration
9.00 am – 9.05 am	Welcome and Introduction to the programme
9.05 am – 9.30 am	Module 1: Introduction to chemical management By Ms. Terancy Samarawickrama Assistant Director, Environment Management Department, Board of Investment of Sri Lanka
9.30 am – 10.00 am	Module 1: Risk communication mechanisms By Ms. Terancy Samarawickrama
10.00 am – 10.30 am	Module 1: How to utilize a Safety Data Sheet By Ms. Terancy Samarawickrama
10.30 am – 11.00 am	Module 2: Sources, types, properties of Mercury & Adverse health effects of mercury By Ms. Terancy Samarawickrama
11.00 am – 11.15 am	Tea break
11.15 am – 12.15 am	Module 3: Mercury-free alternatives to mercury-containing products By Prof Jagath Premachandra Department of Chemical & Process Engineering, University of Moratuwa
12.15 pm – 1.15 pm	Module 4: Mercury spill management By Prof Jagath Premachandra
1.15pm	End of Programme with Lunch



Annexure 5.1: Agenda and Photos from the Education Sector training programme – Department of Chemistry, University of Peradeniya

Sound Management of Mercury & Mercury Containing Waste

Date: 28th June 2023

Venue: Auditorium, Department of Chemistry, University of Peradeniya

Time	Agenda item
12.45 pm- 1.00 pm	Registration
1.00 pm- 1.05 pm	Welcome and introduction to the programme
1.05 pm- 1.45 pm	Module 1: Introduction to chemical management Eng. Lakmini Edirisinghe Senior Consultant for National Cleaner Production Centre
1.45 pm – 2.45 am	Module 2: Sources, types, properties of Mercury & Adverse Health Effects of Mercury Eng. Lakmini Edirisinghe
2.45 pm – 3.00 pm	<i>Tea break</i>
3.00 pm- 3.30 pm	Module 4: Mercury-free alternatives to mercury-containing products Dr Udaya Jayasundara Senior Lecturer, Institute of Chemistry Ceylon
3.30 pm – 4.15 pm	Module 5: Mercury spill management Dr Udaya Jayasundara
4.15 pm – 4.45 pm	Module 3: Guidelines for mercury waste management Eng. Dumindu Fernando RECP Engineer National Cleaner Production Centre
4.45 pm	End of Programme



Anexure 5.2: Agenda and Photos from the Education Sector training programme – Staff Development Centre, University of Kelaniya

Training Workshop on “Sound Management of Chemicals” Including Mercury & Mercury Containing Products

Conducted by National Cleaner Production Centre Sri Lanka, Ministry of Environment
Organized by UHSS and SDC-University of Kelaniya

Venue: Auditorium, Staff Development Center, University of Kelaniya

Date: 18th July 2023

Time	Agenda item
8.30 am- 9.00 am	Registration
9.00 am – 9.05 am	Welcome
9.05 am – 9.10 am	Address by Chairman, University Health & Safety Services (UHSS) Steering Committee, University of Kelaniya Prof. Jeewantha Premaratne, Address by Director, Staff Development Centre (SDC), University of Kelaniya Dr. Pavithra Godamunne
9.10 am- 9.15 am	Introduction to the project Eng. Dumindu Fernando RECP Engineer, National Cleaner Production Centre
9.15 am- 10.15 am	Module 1: Introduction to chemical management and hazardous waste management Eng. Dumindu Fernando
10.15 am – 10.30 am	Tea
10.30 am – 11.15 am	Module 2: Sources, types, properties of Mercury & Adverse health effects of mercury Eng. Dumindu Fernando
11.15 am- 12.00 pm	Module 4: Mercury-free alternatives to mercury-containing products Prof. Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa
12.00 noon – 1.00 pm	Module 5: Mercury spill management Prof. Jagath Premachandra,
1.00 pm – 1.30 pm	Module 3: National Guidelines for mercury management Eng. Dumindu Fernando
1.30pm	End of Programme with Lunch



Anexure 5.3: Agenda and Photos from the Education Sector training programme – Department of Chemistry, University of Sri Jayawardenapura

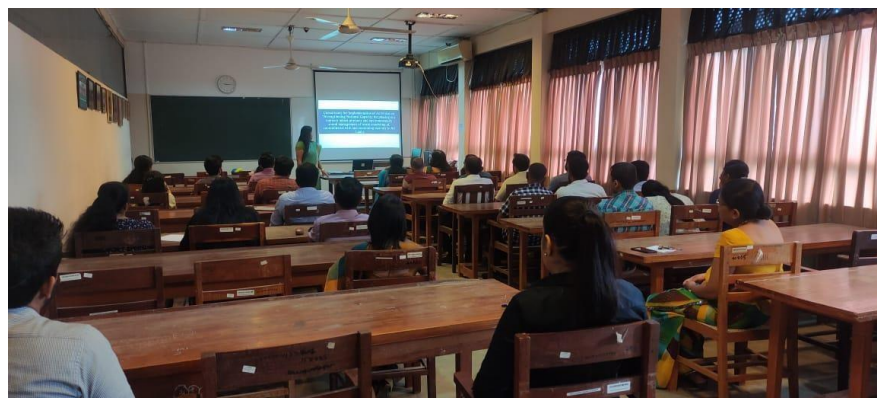
Sound Management of Mercury and Mercury Containing Waste

Agenda for the Education Sector Training

Venue: – University of Sri Jayawardenepura

Date: 15th August 2023

Time	Agenda item
08.30 am – 09.00 am	Registration
09.00 am – 09.05 am	Welcome and Introduction to the programme <i>By Prof. Chmapa D. Jayaweera Head, Department of Chemistry, University of Sri Jayawardenepura</i>
09.05 am – 10.15 am	Module 1: Introduction to chemical management <i>By Ms. Terancy Samarawickrama Assistant Director, Environment Management Department, Board of Investment of Sri Lanka</i>
10.15 am – 11.00 am	Module 2: Sources, types, properties of Mercury and Adverse health effects of mercury <i>By Ms. Terancy Samarawickrama</i>
11.00 am – 11.15 am	Tea break
11.15 am – 12.15 am	Module 3: Mercury-free alternatives to mercury-containing products <i>By Prof Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa</i>
12.15 pm – 1.15 pm	Module 4: Mercury spill management <i>By Prof Jagath Premachandra,</i>
1.15pm	End of Programme



Anexure 5.4: Agenda and Photos from the Education Sector training programme – Staff Development Centre, The Open University of Sri Lanka, Nawala

Sound Management of Mercury and Mercury Containing Waste

Agenda for the Education Sector Training

Venue: – Staff Development Centre, The Open University of Sri Lanka, Nawala

Date: 21st August 2023

Time	Agenda item
09.00 am – 09.10 am	Registration
09.10 am – 09.15 am	Welcome and Introduction to the programme <i>By Mrs. Abirami Senthuran RECP Technologist, Chemicals Management & Industrial Safety Division, National Cleaner Production Centre, Sri Lanka</i>
09.15 am – 10.15 am	Module 1: Introduction to chemical management <i>By Ms. Terancy Samarawickrama Assistant Director, Environment Management Department, Board of Investment of Sri Lanka</i>
10.15 am – 11.15 am	Module 2: Sources, types, properties of Mercury and Adverse health effects of mercury <i>By Ms. Terancy Samarawickrama</i>
11.15 am – 11.30 am	Tea break
11.30 am – 12.30 am	Module 3: Mercury-free alternatives to mercury-containing products <i>By Prof Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa</i>
12.30 pm – 1.30 pm	Module 4: Mercury spill management <i>By Prof Jagath Premachandra</i>
1.30 pm	End of Programme with Lunch



Annexure 5.5: Agenda and Photos from the Education Sector training programme – Sri Lanka Institute of Information Technology (SLIIT), Malabe Campus

Sound Management of Mercury and Mercury Containing Waste

Agenda for the Education Sector Training

Venue: – SLIIT, Malabe Campus

Date: Friday, 25th August 2023

Time	Agenda item
09.15 am – 09.30 am	Registration
09.30 am – 09.35 am	Welcome and Introduction to the programme <i>By Mrs. Abirami Senthuran RECP Technologist, Chemicals Management & Industrial Safety Division, National Cleaner Production Centre, Sri Lanka</i>
09.35 am – 10.30 am	Module 1: Introduction to chemical management <i>By Ms. Terancy Samarawickrama Assistant Director, Environment Management Department, Board of Investment of Sri Lanka</i>
10.30 am – 11.15 am	Module 2: Sources, types, properties of Mercury and Adverse health effects of mercury <i>By Ms. Terancy Samarawickrama</i>
11.15 am – 11.30 am	<i>Tea break</i>
11.30 am – 12.30 am	Module 3: Mercury-free alternatives to mercury-containing products <i>By Prof Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa</i>
12.30 pm – 1.30 pm	Module 4: Mercury spill management <i>By Prof Jagath Premachandra</i>
1.30 pm	End of Programme



**Annexure 5.6: Agenda and Photos from the Education Sector training programme –
Faculty of Technology, University of Colombo, Pitipana**

Sound Management of Mercury and Mercury Containing Waste

Agenda for the Education Sector Training

Venue: – Faculty of Technology, University of Colombo, Pitipana

Date: 6th September 2023

Time	Agenda item
09.00 am – 09.10 am	Registration
09.10 am – 09.15 am	Welcome and Introduction to the programme <i>By Mrs. Abirami Senthuran RECP Technologist, Chemicals Management & Industrial Safety Division, National Cleaner Production Centre, Sri Lanka</i>
09.15 am – 10.15 am	Module 1: Introduction to chemical management <i>By Ms. Terancy Samarawickrama Assistant Director, Environment Management Department, Board of Investment of Sri Lanka</i>
10.15 am – 11.15 am	Module 2: Sources, types, properties of Mercury and Adverse health effects of mercury <i>By Ms. Terancy Samarawickrama</i>
11.15 am – 11.30 am	<i>Tea break</i>
11.30 am – 12.30 am	Module 3: Mercury-free alternatives to mercury-containing products <i>By Prof Jagath Premachandra, Department of Chemical & Process Engineering, University of Moratuwa</i>
12.30 pm – 1.30 pm	Module 4: Mercury spill management <i>By Prof Jagath Premachandra</i>
1.30 pm	End of Programme <i>with Lunch</i>



Annex 6 – Agenda and Photos captured during Awareness programmes

Agenda for the Awareness Session on
Sound Management of Mercury & Mercury Containing Waste
 Conducted by the **National Cleaner Production Centre, Sri Lanka**

Time	Agenda Item
09.15 am – 09.30 am	Registration
09.30 am – 09.35 am	Welcome and Introduction to the programme
09.35 am – 09.50 am	Sources, types, properties of Mercury and the Hazards associated with Mercury
09.50 am – 10.20 am	Proper Storage of Mercury and Mercury Containing products
10.20 am – 10.50 am	Mercury Free alternatives available for common mercury containing products
10.50 am – 11.30 am	Mercury spill management
11.30 am – 11.45 am	Q&A session
11.45 am	End of Programme <i>with Refreshment</i>



