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## LIFE MERCURY-FREE

Complex Awareness Raising and Behaviour Change for the Mercury-Free City  
Environment

The Guide on the Best Practices. 5 Good Practice Manuals (one about each partner state) with the information adopted to a layman level



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Project: 101074412 — LIFE21-GIE-PL-LIFE MERCURY-FREE — LIFE-2021-SAP-ENV

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Life Mercury Free Team



### Executive Summary

The LIFE MERCURY-FREE project (Project 101074412 — LIFE21-GIE-PL-LIFE MERCURY-FREE), funded by the European Union's LIFE Programme and coordinated by Lodz University of Technology (Poland) in collaboration with partners including AGH University of Science and Technology (Poland), Lviv Polytechnic National University (Ukraine), University of Évora (Portugal), Innovation Hive (Greece), University of Camerino (Italy), and Ivano-Frankivsk Academy Ivana Zolotoustoho

(Ukraine), addresses the critical issue of mercury pollution in urban environments. Spanning from Month 30 to 36 (June to September 2025), this deliverable (D6.5) presents "The Guide on the Best Practices" as a comprehensive resource for reducing mercury risks across partner states (Poland, Ukraine, Portugal, Greece, Italy), complemented by five tailored "Good Practice Manuals" adapted to local contexts at a layman level for accessibility.

Mercury, a persistent toxin found in everyday items like thermometers, fluorescent bulbs, batteries, and industrial processes such as mining and chlor-alkali production, poses severe threats to human health (e.g., neurological damage, developmental issues in children, kidney problems) and the environment (e.g., air and water pollution, soil degradation, biodiversity loss through bioaccumulation in fish and wildlife). The project highlights how mercury cycles globally, with atmospheric emissions enabling long-range transport and methylation in aquatic systems, amplifying risks.

Drawing on global frameworks like the Minamata and Basel Conventions, EU directives (e.g., Waste Framework Directive, RoHS, REACH, Mercury Regulation), and national laws (e.g., Ukraine's Waste Management Act and Chemical Safety Law, Poland's Environmental Protection Law), the Guide provides a unified approach to policy alignment and practical action. It outlines step-by-step recommendations for safe mercury waste collection, local campaigns in schools and communities, municipal guidance, and activist/educator strategies.

Country-specific sections reveal unique challenges and successes: Ukraine focuses on eco-buses, NGO initiatives like SortSmart, and emergency response; Portugal addresses legacy chlor-alkali contamination in hotspots like Ria de Aveiro through microbial remediation and monitoring; Greece emphasizes geochemical modeling and urban soil mapping; Italy promotes extended producer responsibility, ecological

islands, and school-based education for mercury-free communities; Poland leverages advanced industrial waste management and public awareness campaigns led by institutions like AGH University of Science and Technology to tackle mercury in urban and industrial settings.

Good practices emphasize prevention, awareness, and collaboration via the LIFE e-HUB platform, fostering behavioral change among municipalities, NGOs, educators, and citizens. The project demonstrates scalable solutions, such as phytoremediation pilots, sorbent technologies, and public campaigns, to minimize exposure and promote sustainability. Targeted at educational institutions, local authorities, NGOs, activists, and the public in control cities (e.g., Lviv, Ivano-Frankivsk, Lodz, Krakow, Évora, Larissa, Camerino), this deliverable ensures exploitation of results for EU cities and neighbors like Ukrainian- and Belarusian-speaking regions, aligning with EU zero-pollution goals and the Minamata Convention.

## **A. THE GUIDE ON THE BEST PRACTICES**

### **1. INTRODUCTION TO THE GUIDE ON THE BEST PRACTICES**

This Guide on the Best Practices is developed within the framework of the LIFE MERCURY-FREE project. It collects, structures, and presents practical knowledge, methodologies, and solutions to accelerate the transition of cities and communities towards mercury-free environments. The document is designed as a common reference point for all partner states, serving both as an informative and as a practical manual to support awareness raising, policy alignment, and behavioural change at multiple levels.

#### **1.1. Background: LIFE MERCURY-FREE Concept**

The LIFE MERCURY-FREE project addresses the urgent need to eliminate mercury pollution and to reduce human and environmental exposure to mercury-containing products. Mercury, being a highly toxic element, poses significant risks to human health and ecosystems, especially in urban settings where mercury-containing products are still in circulation.

The project aims to raise awareness, foster behavioural change, and develop systemic solutions for a mercury-free city environment. By combining awareness campaigns, knowledge transfer, and the creation of practical tools such as this Guide, the project builds a strong foundation for long-term environmental protection and sustainable urban development.

#### **1.2. Purpose of the Guide**

The Guide serves as a comprehensive tool to:

- Summarise the key challenges related to mercury use and contamination in partner countries;

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- Present effective practices, methods, and case studies for reducing mercury risks;
- Provide a harmonised framework that can be adapted and replicated in different European contexts;
- Support policymakers, municipalities, educators, NGOs, and other stakeholders in designing and implementing mercury-free strategies.

### **1.3. Overview**

Work Package 6 (WP6) of the LIFE MERCURY-FREE project focuses on the dissemination and exploitation of results, with a key deliverable being the creation of "The Guide on the Best Practices" and five "Good Practice Manuals" tailored to each partner state. This work is led by Lviv Polytechnic National University (LPNU) as the lead beneficiary, in collaboration with Politechnika Lodzka (TUL) as the coordinator, Akademia Gorniczo-Hutnicza (AGH), Ivano-Frankivsk Academy (IFA), Universidade de Evora (UEVORA), Universita degli Studi di Camerino (UNICAM), and Innovation Hive (InnoHive). The timeframe for this deliverable spans from Month 30 to Month 36 (June 2025 to September 2025), during which the consortium will finalize the documents, host an international press conference in Lodz, and distribute materials via library systems and the LIFE e-HUB platform.

### **1.4. Objectives of the Guide**

- To explain the significance of mercury as an environmental and public health threat;
- To present the global, EU, national, and local regulatory frameworks;
- To provide recommendations for municipalities, activists, educators, and citizens;

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- To establish a common basis for further adaptation in the five participating countries.

### **1.5. Target audience and how to use the Guide**

The GUIDE is intended for a wide range of stakeholders, including:

- Municipal and regional authorities responsible for environmental protection and public health;
- Policymakers and regulators working on environmental and chemical safety legislation;
- Educational institutions and teachers integrating mercury-free concepts into curricula;
- NGOs and civil society organisations promoting sustainable and safe urban environments;
- General public, particularly households, schools, and healthcare institutions where mercury exposure risks are most evident.

The Guide is structured in a way that allows readers to directly navigate to the sections most relevant to their role, whether policy, education, or community action.

## **2. WHY MERCURY MATTERS: RISKS AND CHALLENGES**

Mercury might seem like a distant concern, but it's actually all around us, hiding in everyday items and industrial processes, and it can cause serious problems for both people and the planet. In our homes, you might find it in old thermometers, fluorescent light bulbs, or even some batteries – things that can spill mercury if they break, turning a simple accident into a hidden danger. Industries also play a big role, using mercury in manufacturing, mining, and power generation, releasing it into the air and water where it spreads far beyond factory walls. This exposure can harm our health in ways we can feel, like causing shaky hands or memory troubles due to neurological effects, especially if we breathe it in or eat contaminated food. For children and pregnant women, it poses developmental risks, potentially leading to learning difficulties or growth issues later in life. Over time, mercury can build up, damaging kidneys and causing other long-term health problems that sneak up on us. Beyond our bodies, mercury travels through the environment, polluting the air we breathe with factory emissions or broken bulbs, contaminating water where fish absorb it – meaning it can end up on our plates if we're not careful. It damages soil, stunting plant growth and affecting our food supply, while also threatening biodiversity by sickening or killing birds, fish, and other wildlife, throwing nature's balance off course. Understanding these risks and challenges is the first step to protecting ourselves and our world, which is why action is so important.

### **2.1. Mercury in everyday life and industry**

Mercury appears in some legacy and current consumer products and several industrial processes; it bioaccumulates (as methylmercury) and poses neurotoxic and ecological risks. Global phase-outs, the Minamata

Convention, and technology shifts (process replacement, non-mercury devices, remediation R&D) are reducing releases while challenges remain in artisanal mining and legacy waste.

### *Consumer products*

Mercury still exists in a defined set of everyday items and many legacy products, so household exposure and disposal of these items remain important control points. National guidance lists specific product types and recommends non-mercury replacements and proper collection for recycling to limit environmental releases and inhalation exposures.

- **Thermometers** contain elemental mercury in older models and should be replaced with digital, non-mercury alternatives [1], [2].
- **Thermostats** and some older appliances may have mercury tilt switches and should be managed at end-of-life through recycling programs [1], [2].
- **Fluorescent lamps** (including CFLs) and HID bulbs contain small amounts of mercury and require appropriate disposal to avoid releases [1], [3], [4].
- **Medical gauges** contain minor quantities of mercury and require controlled disposal procedures to prevent environmental or occupational releases [1], [3], [4].
- **Dental amalgam** (silver fillings) contains elemental mercury and remains a noted source of mercury in waste streams and wastewater if not captured [1], [5], [6].
- **Small consumer items** such as some batteries (older types), antiques with liquid mercury, certain electronics, and imported skin-lightening creams have been documented as mercury sources [1], [7], [8].

Proper handling, household hazardous waste collection, and manufacturer take-back programs are widely recommended to prevent releases [1].

### **Major industrial applications**

Industrial uses historically contributed large quantities of commercially used mercury; some sectors have reduced use but others (especially artisanal activities) still drive releases. Historical inventories identify chlor-alkali production, certain product manufacturing and mining as major commercial sources of mercury in the environment.

- **Chlor-alkali industry** historically used mercury-cell electrolysis; large commercial releases and legacy stocks arose from that sector and contributed substantially to environmental loads over the industrial era [9].
- **Product manufacture and consumer-product supply** (batteries, switches, paints and measuring devices) were major commercial uses through the 20th century, with consumption peaking around the 1970s and declining thereafter as regulations and substitutes were adopted [9].
- **Mining and artisanal and small-scale gold mining (ASGM)** remain significant current sources of mercury releases because mercury is used to extract gold in many regions [10].
- **Combustion sources and industrial emissions** (e.g., coal combustion as a byproduct source) mobilize geologic mercury into the atmosphere and then into aquatic systems where methylation occurs [9], [11].

Industrial process change and management of legacy stocks are central to reducing future releases [9].

## **2.2. Impacts on human health**

Mercury exists as elemental, inorganic and organic species with distinct sources and toxicokinetics. Methylmercury is the main neurodevelopmental hazard while all forms can harm kidneys, the cardiovascular system, immune function and reproduction. Prevention

focuses on emission control, fish-consumption guidance, occupational controls and targeted medical treatment including chelation and supportive care.

### **Types and sources**

Mercury occurs in three major chemical forms that determine exposure routes, bioaccumulation, and target organs; these differences drive risk communication and control measures in communities and workplaces.

Form	Main exposure routes	Typical sources and notes
Elemental (metallic) Hg <sup>0</sup>	Inhalation of vapour (high lung absorption)	Thermometers, dental amalgam, artisanal small-scale gold mining (ASGM), industrial emissions; vapour crosses blood-brain barrier and olfactory route [12]
Inorganic mercury (Hg <sup>2+</sup> salts)	Ingestion, dermal contact (some)	Old medicines, skin-lightening creams, industrial wastes; soluble and accumulate in kidney causing renal injury [12]
Organic mercury (methylmercury, ethylmercury)	Dietary ingestion (fish) and less commonly medical preservatives	Methylmercury bioaccumulates/biomagnifies in aquatic food webs and is the principal developmental neurotoxicant; ethylmercury (e.g., thimerosal) has less epidemiologic evidence but limited mechanistic data [12,13]

- **Key exposure settings:** contaminated fish in riverine/indigenous communities and regions affected by ASGM, coal/biomass combustion and some industrial processes [12], [13].
- **Bioavailability note:** methylmercury is highly absorbed from the gut and crosses placenta, raising prenatal exposure concerns [13].

### **Neurological development mechanisms**

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The central nervous system is a primary target for organic mercury, and early-life (prenatal and infant) exposure produces the most serious, long-lasting effects; several molecular pathways explain these effects.

Methylmercury impairs neurodevelopment through covalent binding to thiol groups, oxidative stress, mitochondrial dysfunction, excitotoxicity, calcium dysregulation, and epigenetic alterations that disrupt neuronal growth and synaptogenesis [13].

- **Mechanisms:** thiol binding to proteins and enzymes alters protein function; oxidative stress (GSH depletion, ROS) damages lipids, proteins and DNA; mitochondrial impairment reduces ATP and triggers apoptosis; glutamate excitotoxicity and calcium imbalance disrupts neuronal signaling and dendritic spine density.
- **Clinical and subclinical outcomes:** prenatal methylmercury exposure is linked to deficits in attention, memory, language and fine motor skills and can produce sensorimotor and cognitive impairment in exposed populations.
- **Evidence differences:** epidemiologic cohorts and mechanistic studies converge for methylmercury's developmental toxicity, whereas evidence for ethylmercury (thimerosal) is sparse and calls for more follow-up studies.
- **Examples:** chronic community exposures (riverine/Amazon populations) demonstrate somatosensory loss, peripheral neuropathy and cognitive impairment consistent with methylmercury neurotoxicity.

### **Cardiovascular and systemic effects**

Mercury exposure has been associated with cardiovascular disease and multiple systemic toxicities through oxidative stress, endothelial dysfunction and organ accumulation. Epidemiologic syntheses report associations between mercury biomarkers and increased risk of

hypertension, myocardial infarction and cardiovascular mortality, with some studies suggesting nonlinear dose–response patterns depending on exposure source and co-exposures [14].

- **Cardiovascular mechanisms:** mercury reduces nitric oxide bioavailability, promotes oxidative stress, alters vascular smooth muscle tone, and can dysregulate lipid metabolism, all of which promote hypertension and atherogenesis [12], [14]
- **Renal effects:** inorganic mercury accumulates in kidneys and is a principal cause of mercury-related nephrotoxicity; renal functional impairment and proteinuria are described in acute and chronic exposures [12], [15].
- **Immune and systemic:** mercury can trigger immune dysregulation and autoimmunity, perturb hematologic parameters, and is implicated in pulmonary and hepatic effects in severe exposures [12], [15].

**Population findings:** in exposed Amazonian communities, hair or blood mercury correlates with altered cardiometabolic markers and clinical signals consistent with cardiovascular risk [14].

### 2.3. Environmental consequences (air, water, soil, biodiversity)

Mercury is a global pollutant that easily crosses environmental boundaries, cycles between different compartments (air, water, soil), and persists for long periods of time. Its transformations in the environment – particularly into methylmercury – make it especially dangerous, since this organic form accumulates in living organisms and biomagnifies through the food chain.

Atmospheric emissions are the dominant pathway through which mercury is released and distributed globally. According to the UNEP Global Mercury Assessment (2019), about 2,200 tonnes of mercury are emitted to the atmosphere each year from anthropogenic sources, with the

main contributors being coal combustion, artisanal and small-scale gold mining, cement production, and non-ferrous metal smelting.

Once released, elemental mercury ( $\text{Hg}^0$ ) can remain in the atmosphere for up to 6–12 months, enabling long-range transport across continents and oceans. This persistence explains why mercury is found even in remote regions, such as the Arctic, far from direct sources (AMAP/UNEP, 2019).

In the atmosphere, mercury undergoes chemical transformations:

- $\text{Hg}^0$  (elemental mercury) is relatively stable and mobile.
- $\text{Hg}^{2+}$  (oxidised mercury) is more reactive, soluble, and readily deposited via precipitation (wet deposition) or as particles (dry deposition).

Deposition of oxidised mercury to terrestrial and aquatic ecosystems creates a continuous cycle of re-emission and re-deposition, making atmospheric mercury both a primary emission source and a secondary reservoir.

Health and environmental consequences of atmospheric mercury include:

- Direct human inhalation exposure in polluted areas (e.g., near industrial sites).
- Widespread contamination of water bodies through deposition, leading to methylmercury formation and bioaccumulation.
- Contribution to global background mercury levels, which remain elevated compared to pre-industrial times (estimated 450% higher, UNEP, 2019).

Mercury contamination of aquatic systems is one of the most critical pathways of exposure for both humans and ecosystems. Atmospheric deposition is the primary source of mercury in surface waters, though direct discharges from industry, wastewater, and mining also contribute significantly (UNEP, 2019).

Once deposited in aquatic environments, mercury undergoes complex biogeochemical transformations. The most critical is the microbial methylation of inorganic mercury ( $\text{Hg}^{2+}$ ) into methylmercury ( $\text{MeHg}$ ), a

highly toxic and bioavailable form. This process occurs mainly in sediments, wetlands, and low-oxygen water layers.

Key features of mercury in aquatic systems:

- Persistence: Mercury does not degrade; it cycles between water, sediments, and biota.
- Bioaccumulation: Methylmercury efficiently enters aquatic food webs, accumulating in fish and shellfish.
- Biomagnification: Concentrations increase at higher trophic levels, leading to high exposure in predatory fish (tuna, swordfish, pike) and in humans consuming them.

Environmental and health impacts:

- Consumption of contaminated fish is the main exposure route for humans worldwide [16].
- Methylmercury affects the neurological development of fetuses and young children, while long-term exposure in adults can cause cardiovascular and immune system disorders.
- Aquatic ecosystems are at risk: fish-eating birds and mammals (e.g., otters, seals, eagles) are particularly vulnerable to reproductive and behavioral effects [17].

Globally, it is estimated that over 200,000 tonnes of mercury are stored in the world's oceans, with concentrations in surface waters continuing to rise due to historic and ongoing emissions [17].

### 3. POLICY AND REGULATORY FRAMEWORKS

The fight against mercury pollution is supported by a strong network of policies and regulations that guide our efforts worldwide, across the European Union, and in specific regions like Ukraine. These frameworks set clear rules to limit mercury use, ensure safe disposal, and protect our health and environment, providing a foundation for the best practices outlined in this guide.

#### 3.1. Global Frameworks

**The Minamata Convention on Mercury** is a global treaty adopted in 2013 to protect human health and the environment from the harmful effects of mercury and mercury compounds. It was named after Minamata, Japan, where thousands of people suffered from mercury poisoning due to industrial wastewater contamination – a tragedy that became a symbol of the need for international action.

The treaty addresses mercury throughout its entire lifecycle, including:

**Mining and trade:** Restricts primary mercury mining and regulates international trade.

**Products:** Phases out mercury-added products like thermometers, batteries, and fluorescent lamps.

**Processes:** Controls industrial uses such as in chlor-alkali production and dental amalgam.

**Emissions:** Sets guidelines for reducing mercury emissions from coal combustion, cement production, and metal smelting.

**Waste:** Establishes protocols for safe storage and disposal of mercury waste.

**Health:** Promotes awareness, medical training, and protection of vulnerable populations

As of October 2024, there are 128 signatories to the treaty and 151 parties.



Figure 3.1. The countries signed the Minamata convention colored by green

Another international treaty is **the Basel Convention** on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. It plays a crucial role in managing mercury waste, especially in coordination with the Minamata Convention.

The Basel Convention addresses mercury through:

- Technical Guidelines: These outline best practices for the environmentally sound management of mercury waste, including:
- Waste from industrial pollution control devices
- Mercury-containing products (e.g., thermometers, batteries, fluorescent lamps)
- Contaminated soil and residues

The convention was opened for signature on 21 March 1989, and entered into force on 5 May 1992. As of June 2024, there are 191 parties to the convention. In addition, Haiti and the United States have signed the convention but did not ratify it.



Figure 3.2. The countries signed the Basel convention colored by green

**The World Health Organization (WHO)** provides comprehensive guidance on mercury due to its serious health risks. Here's a breakdown of their key recommendations and insights:

- Mercury is one of WHO's top ten chemicals of major public health concern.
- It can damage the nervous, digestive, and immune systems, and affect the lungs, kidneys, skin, and eyes.
- Methylmercury, found in contaminated fish and shellfish, poses a particular threat to fetal development and young children.

Thus, WHO sets a guideline value of 0.006 mg/L for mercury in drinking water. Countries apply WHO mercury guidelines in practice through a mix of legislation, public health programs, and environmental monitoring – often in coordination with the Minamata Convention.

European countries integrate WHO values into their water quality standards and pollution control laws.

### 3.2. EU Directives and Regulations

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The European Union (EU) is built on a unique legal system that combines directives, regulations, and other instruments to harmonize policies across its Member States. These legal acts are essential to achieving the Union's objectives, particularly in areas such as environmental protection, consumer safety, and sustainable development. In the context of projects like LIFE MERCURY-FREE, which addresses environmental contamination and public awareness of mercury use, understanding the framework of EU directives and regulations becomes crucial. These instruments not only shape project design but also ensure consistency in environmental standards across the EU.

### **EU Directives**

A directive is a legislative act that sets out a goal that all EU countries must achieve, but it is up to the individual countries to devise their own laws on how to reach these goals. This flexibility allows adaptation to national circumstances while maintaining a level of harmonization across the Union.

For example:

- The **Waste Framework Directive (2008/98/EC)** establishes the basic concepts and definitions related to waste management, including recycling and recovery.
- The **Directive on the restriction of the use of certain hazardous substances (RoHS, 2011/65/EU)** limits the use of mercury and other toxic materials in electrical and electronic equipment.
- Environmental directives often require Member States to transpose provisions into national law, followed by monitoring and enforcement mechanisms.

In the LIFE MERCURY-FREE project, the relevance of directives is clear. While mercury is addressed by global frameworks like the Minamata

Convention, EU directives guide Member States on how to phase out mercury use, ensure safe disposal, and inform citizens about risks.

### ***EU Regulations***

A regulation, unlike a directive, is a binding legislative act that must be applied in its entirety across the EU without the need for national transposition.

This ensures uniformity of law in all Member States.

Key examples include:

- The **REACH Regulation (EC No 1907/2006)**, which governs the registration, evaluation, authorization, and restriction of chemicals, including mercury compounds.
- The **Mercury Regulation (EU 2017/852)**, which directly implements the EU's obligations under the Minamata Convention and restricts mercury use, trade, and storage.

Because regulations are directly applicable, they provide stronger and more immediate enforcement. For instance, under Regulation 2017/852, Member States must prohibit new mercury-added products and establish proper waste management procedures. LIFE MERCURY-FREE aligns with these requirements by promoting citizen awareness, stakeholder collaboration, and alternatives to mercury-containing products.

### ***Differences and Complementarity***

The main difference between directives and regulations lies in their application:

- **Directives:** Set binding objectives but allow flexibility in implementation.
- **Regulations:** Apply directly and uniformly across the EU.

However, both are complementary. Directives often create the framework (e.g., environmental targets, waste hierarchies), while regulations provide detailed and immediate measures (e.g., bans, trade restrictions). In

practice, they work together to ensure that EU environmental goals are met consistently.

For projects funded under EU programmes, like LIFE, these legal instruments define both the scope of activities and the expected outcomes. LIFE MERCURY-FREE, for instance, supports EU legislation by raising awareness, encouraging behavioral change, and offering tools like the LIFE e-Hub for education and stakeholder dialogue.

### ***Case of Mercury: An EU Example***

Mercury illustrates the interplay between directives and regulations:

- Regulations ban or restrict mercury products, ensuring consistency across all Member States.
- Directives require Member States to establish systems for waste collection, safe disposal, and public information campaigns.
- Complementary actions, such as those taken under LIFE projects, address gaps in awareness and stakeholder engagement.

Thus, while the EU Mercury Regulation imposes clear legal obligations, initiatives like LIFE MERCURY-FREE make those obligations practical by involving municipalities, NGOs, schools, and citizens in solutions.

EU directives and regulations are the backbone of European governance. Directives set objectives that allow flexibility for national governments, while regulations ensure uniform rules across the Union. Together, they create a coherent system that supports environmental protection, public health, and sustainable growth. In the case of mercury, directives and regulations align with global commitments and are reinforced by projects like LIFE MERCURY-FREE, which translate legal obligations into real-world actions and societal change. Understanding this interplay is essential for appreciating how the EU shapes policy implementation, ensures compliance, and promotes long-term sustainability.

### 3.3. Ukrainian Legislation and EU Approximation

(Law of Ukraine on Ratification of the Minamata Convention, Law No 3116-IX of 29.05.2023: On Accession to the Minamata Convention, Law on Chemical Safety and Management of Chemical Products, Law of Ukraine "On Waste Management", Environmental Protection Act, State Sanitary Rules and Norms)

The Ministry of Environmental Protection and Natural Resources of Ukraine is the national coordination center for the exchange of information in accordance with the provisions of the Minamata Convention on mercury. In Ukraine, a law on the handling of chemical substances was adopted. With the exception of certain provisions, the new law entered into force on November 2, 2024. The Verkhovna Rada of Ukraine issued the Resolution dated October 18, 2022 "On adoption as a basis of the Law of Ukraine "On Chemical Safety and Management of Chemical Substances". Products" (reg. No. 8037). This law contains several important provisions. It: creates a regulatory framework for the management of chemical substances; gives authority to state bodies; determines the responsibility of business entities; introduces the international classification of hazardous chemicals into national legislation; mandatory registration of chemicals; meets the requirements of the following international treaties: Basel Convention (control of transboundary transportation of hazardous waste and its disposal), Rotterdam Convention (Prior Informed Consent (PIC) for Certain Hazardous Chemicals and Pesticides), Stockholm Convention (persistent organic pollutants (POPs)) and Minamata Convention (mercury). The Ministry of Environmental Protection and Natural Resources plays a key role in the formation and implementation of waste management policy. Local self-governments bodies in the field of

waste management ensure: fulfilling the requirements of the legislation on waste; implementation of control over rational use and safe handling of waste on its territory; liquidation of unauthorized and uncontrolled waste dumps; granting consent to place on the territory of a village, town, city places or objects for the storage and disposal of waste, monitoring compliance by legal entities and individuals with requirements in the field of industrial and household waste management in accordance with the law.

On September 1, 2017, the Association Agreement [6] between Ukraine and the European Union entered into force. The agreement is the basis for cooperation between the EU and Ukraine and EU support for reforms in the country, including the ecological issues and hazardous waste management.

On June 23, 2022, the member states of the European Union voted to grant Ukraine the status of a candidate country for joining the European Union. Regulatory and legal acts of the EU, the implementation of which is mandatory for Ukraine according to the Association Agreement.

#### **Ukrainian legislation regulating hazardous waste management**

- Law of Ukraine "On Environmental Protection" [45]. Date of entry into force: July 1, 1991. The law establishes environmental rights and responsibilities of citizens of Ukraine.
- Law of Ukraine "On Waste" [47]. Date of entry into force: April 14, 1998. The law defines the legal, organizational and economic principles of activities related to the prevention or reduction of the volume of waste generation, its collection, transportation, storage, processing, utilization and removal, disposal and burial.
- Law of Ukraine "On Chemical Sources of Current" [44]. Date of entry into force: July 1, 2006. The law defines the legal, organizational and economic principles in the field of handling chemical current sources.
- Law of Ukraine "On waste management" [48]. Date of entry into force: July 9, 2023. The law implements the fundamental principles of

European waste management legislation in Ukraine.

- Law of Ukraine “On Chemical Safety and Management of Chemical Products” [43]. Date of entry into force: November 2, 2024. The law defines the legal, organizational and economic principles for ensuring chemical safety, aimed at preventing the negative impact of chemical products on the environment and public health
- Law of Ukraine “On Ukraine’s accession to the Minamata Convention on Mercury” [46]. Date of entry into force: July 1, 2023.
- Resolution of the Cabinet of Ministers of Ukraine dated July 13, 2000 No. 1120 "On approval of the Regulation on control over cross-border transportation of hazardous waste and its utilization/removal and Yellow and Green lists of waste" [53]
- Resolution of the Cabinet of Ministers of Ukraine dated July 13, 2016 No. 446 "On approval of licensing conditions for conducting business activities related to the management of hazardous waste" [54]
- Decree of the Cabinet of Ministers of Ukraine dated February 20, 2019 No. 117-r "On the approval of the National Strategy for Waste Management in Ukraine until 2030" [10].

#### **4.1. Local and Regional Regulations**

Hazardous waste is generated in various industries, and waste classifications occur within specific groups as indicated in the waste catalog. Within each group, there are codes for different types of hazardous waste [18]. The exact breakdown can be found in the Regulation of the Minister of Climate dated January 2, 2020, on the waste catalog [19].

Examples of hazardous waste generated by companies include:

- Waste engine, gear, and lubricating oils, along with oil packaging;
- Sorbents, filter materials, wiping cloths, and protective clothing;
- Waste or unusable vehicles (including off-highway machinery), waste from dismantling, inspection, and maintenance of vehicles;

- Batteries and accumulators;
- Waste electronic equipment;
- Air conditioners;
- Sprays;
- Chemical packaging;
- Batches of non-conforming products and expired or unusable products, in which hazardous waste is highlighted;

Examples of municipal hazardous waste encompass:

- Cans and containers of paints and varnishes;
- Cytotoxic and cytostatic drugs;
- Wooden pallets and wooden boxes soaked in protective preparations;
- Batteries and rechargeable batteries;
- Waste electronic equipment;
- Plant protection products and their packaging.

Certain types of waste are subject to specific disposal and treatment, including disposal. These obligations primarily apply to waste generated by residents, who are not free to dispose of it, regardless of whether it is hazardous waste according to the waste catalog. This waste cannot be disposed of with other municipal waste [18].

### **Polish national legal documents defining waste management**

- Journal of Laws of 2013, item 21, Act of December 14, 2012 on waste [18];
- OJ 1996 no. 132 item 622 Act of September 13, 1996 on maintaining cleanliness and order in municipalities [20];
- OJ 2021 item 906 Regulation of the Minister of Climate and Environment of May 10, 2021 on the method of selective collection of selected waste fractions [21];
- OJ 2001 No. 62 item 627 Act of April 27, 2001, Environmental Protection Law [22];

- OJ 2020 item 10 Regulation of the Minister of Climate of January 2, 2020 on the waste catalogue [19];
- OJ 2015 item 1688 Act of September 11, 2015 on waste electrical and electronic equipment [23];
- OJ 2009 No. 79 item 666 Act of April 24, 2009 on batteries and accumulators [18];
- OJ 2013 item 888 Act of 13 June 2013 on packaging and packaging waste management [24];
- OJ 1996 no. 132 item 622 Act of September 13, 1996 on maintaining cleanliness and order in municipalities [20].

#### ***Lodz local legal documents defining waste management***

- Journal Laws of 2013, item 21, Act of December 14, 2012 on waste [18];
- OJ 1996 no. 132 item 622 Act of September 13, 1996 on maintaining cleanliness and order in municipalities [20]

The wastes covered by special obligations are:

- Used lead-acid car batteries (not hazardous waste) - They should be handed over to a dealer when buying a new battery or handed over to a municipal waste collection point [19];
- Used portable batteries and rechargeable batteries, e.g., "sticks," button batteries (they are not hazardous waste) - Dispose of them in the container for used batteries available at the store, school, office, etc., or hand them over to a selective collection point for municipal waste [23];
- Waste electrical and electronic equipment (may be hazardous waste, e.g., refrigerator, air conditioner, or non-hazardous waste, e.g., toy, TV remote control) - Dispose of it in a container available at the store, or donate used equipment when buying new equipment, or take it to a separate collection point for municipal waste (including mobile) [22];
- Unused or expired medicines (only cytotoxic and cytostatic drugs are hazardous waste) - Dispose of them in a container at a pharmacy or take

them to a separate collection point for municipal waste [18];

- Plant protection products and their packaging - Return them to the store [21];
- Packages of hazardous agents, such as paints - Should be handed over to the point of selective collection of municipal waste - if the rules of the point allow it [20].

With reference to EU directives and the national legal system, the following applies in the city of Lodz, among others: the following local legal acts:

- Resolution No xl/502/17 of the Łódź Voivodeship Assembly of June 20, 2017, on the adoption of the waste management plan for the Łódź Voivodeship for the years 2016-2020, taking into account the years 2023-2028;
- Waste management plan for the Łódź Voivodeship for 2019-2025, including 2026-2031;
- Resolution No xl/503/17 of the Łódź Voivodeship Assembly of June 20, 2017 on the implementation of the waste management plan for the Łódź Voivodeship for 2016-2020, including the years 2023-2028 (Journal of Laws of the Łódź Voivodeship, item 3160), as amended by resolutions of the Łódź Voivodeship Assembly : No. liv/676/18 of July 10, 2018 (Official Journal of the Łódź Voivodeship, item 3942), No. lviii/709/18 of October 30, 2018 (Official Journal of the Łódź Voivodeship, item 3393) ) and no. iv/68/19 of February 26, 2019 (Journal of Laws of the Łódź Voivodeship, item 1505);
- Resolution No. xlv/844/12 of the city council in Łódź of July 4, 2012 on the division of the city of Łódź into municipal waste collection sectors (Journal of Laws of the Łódź Voivodeship, item 2333);
- Resolution No. xv/647/19 of the city council in Łódź of October 16, 2019 on the decision on the collection of municipal waste by the city of Łódź

from owners of properties where no residents live and municipal waste is generated (Journal of Laws of the Province Łódź, item 5891);

- Resolution No. xxxii/1058/20 of the city council in Łódź of November 19, 2020 on the detailed method and scope of providing services in the field of collecting municipal waste from property owners and managing this waste (Journal of Laws of the Łódź Voivodeship, item 6298 ), amended by resolution No. lvii/1710/22 of March 16, 2022 (Journal of Laws of the Łódź Voivodeship, item 1844);
- Resolution No. xlix/1498/21 of the city council in Łódź of October 20, 2021 on the selection of the method for determining the fee for municipal waste management and determining the rate of such a fee in the city of Łódź (Journal of Laws of the Łódź Voivodeship, item 5070);
- Resolution No. xxxii/1054/20 of the city council in Łódź of November 19, 2020 on determining the fee rate for municipal waste management on the property on which a summer house is located or other property used for recreational and leisure purposes (art. Office of the Łódź Voivodeship, item 6295), as amended by resolution no. 6295;

Resolution No. xxxii/1057/20 of the city council in Łódź of November 19, 2020 on the introduction of regulations for maintaining cleanliness and order in the city of Łódź (Journal of Laws of the Łódź Voivodeship, item 6349), as amended by resolution No. lvii/1711 /22 of March 16, 2022 (Journal of Laws of the Łódź Voivodeship, item 1845).

### **Italy – Local and Regional Regulations in Italy**

Italy has developed one of the most comprehensive systems in Europe for regulating hazardous waste, including mercury-containing products. This system is largely shaped by European Union legislation, which Italy has transposed into national law.

The cornerstone is Legislative Decree No. 152/2006, which implements the European Waste Framework Directive (2008/98/EC). This decree sets the foundation for all waste management in Italy, establishing principles of

prevention, recycling, and safe disposal. It is complemented by Legislative Decree No. 189/2011, which transposed specific EU directives and laid out obligations and prohibitions for the life cycle of mercury-containing products. Together, these decrees regulate:

- Strict limits on mercury content in products.
- Labeling and information requirements for safe disposal.
- Collection and recycling standards for mercury waste.
- Prohibitions on landfill or incineration of mercury-containing products.

Other relevant laws include Legislative Decree No. 209/1999, concerning hazardous waste management in line with Directive 2012/19/EU, and EU's RoHS Directive (2002/95/EC), which restricts mercury in electrical and electronic equipment.

Italy also enforces bans on several mercury-containing products, such as thermometers, sphygmomanometers, and certain batteries, reducing the risk of uncontrolled releases.

### ***Italy - Extended Producer Responsibility (EPR)***

A major feature of Italy's regulatory model is the Extended Producer Responsibility (EPR) system. Under EPR, manufacturers, importers, and distributors are legally obliged to finance the collection, treatment, and recycling of their products at the end of their life cycle.

This means companies must:

- Establish take-back systems and collection points.
- Support recycling and safe treatment infrastructure.
- Provide technical documentation proving compliance with mercury concentration limits ( $\leq 100$  mg/kg for certain substances).

By shifting responsibility to producers, Italy incentivizes industries to innovate and adopt mercury-free alternatives, while ensuring sustainable financing for waste management.

### ***Italy - Regional and Local Regulations***

While the national framework provides uniform standards, regional governments and municipalities play an important role in adapting and enforcing regulations. Italy's governance model is decentralized, meaning regions have the power to issue regulations and plans tailored to local needs.

#### *Case Study: Marche Region and Camerino*

In the Marche region, where Camerino is located, the Regional Waste Management Plan (PRGR) was approved under D.A.C.R. 14/04/2015 n. 128, implementing Article 199 of Legislative Decree 152/2006. The PRGR sets ambitious targets:

- Reduce per capita urban waste by 10% compared to 2010–2012 levels.
- Achieve over 70% separate collection across all local areas.
- Minimize landfill reliance by enhancing pre-treatment and recovery processes, including energy valorization.

In Macerata province (including Camerino), several ecological collection points (isole ecologiche) are available for households to dispose of mercury waste safely. These sites are linked to treatment facilities that ensure hazardous substances are extracted and neutralized, complying with EU and Italian standards.

### ***Italy - Role of Regional Environmental Agencies***

Regional agencies such as ARPAM (Agenzia Regionale per la Protezione Ambientale delle Marche) monitor mercury pollution and run public awareness campaigns. They provide reports on environmental indicators,

air quality, and mercury-related risks. This localized governance ensures that communities are informed and engaged in safe waste practices.

### ***Portugal national and local legal documents defining mercury management***

Portugal is governed by EU mercury law (full life-cycle restrictions, export and many product bans) and by EU waste rules that set storage, landfill acceptance and shipment controls. Local implementation in Évora is seen mainly via the LIFE MERCURY-FREE awareness and pilot actions; municipal order texts and Évora's regional waste-plan details are not in the supplied corpus.

Portugal is subject to EU mercury legislation that covers the full life cycle of mercury, complemented by EU waste and landfill rules that set hazardous-waste handling and acceptance criteria. These EU instruments set the statutory prohibitions, product bans, storage rules and reporting obligations that Member States must apply in their territory [25].

- Mercury Regulation: full life-cycle controls including bans on exports and on many mercury-added products, restrictions on industrial uses, and measures to ensure mercury waste is managed without endangering health or the environment [16].
- Waste framework and landfill rules: require waste management plans and waste-prevention programmes, define hazardous-waste management hierarchy, set landfill classes and operational/monitoring requirements, and establish waste-acceptance and leaching criteria used to determine whether mercury-containing wastes may be accepted at a given landfill type [25].
- Export, storage and shipment rules: bans/restrictions on metallic mercury exports and rules for temporary/permanent storage, shipment

controls (prior notification/consent) and criteria for acceptable long-term storage locations.

Table 3.1

## Key EU instruments and primary focus

Instrument	Primary regulatory focus	Typical obligations
Revised Mercury Regulation (full life-cycle)	Manufacture, use, export/import, waste management	Product bans, use prohibitions, dental amalgam phase-out, reporting and implementing acts
Waste Framework Directive (2008)	National/regional waste plans and hierarchy	Waste management plans, prevention programmes, permits/registrations
Regulation/Directives on mercury storage & shipment (e.g., 1102/2008, 2011/97, 1013/2006)	Metallic mercury export, temporary storage, shipments	Export bans, temporary/permanent storage criteria, monitoring, notification/consent for shipments

**Implementation measures and compliance requirements**

Implementation measures combine product/use bans, storage and disposal controls, landfill acceptance tests, reporting, and enforcement mechanisms; compliance is achieved through licensing, reporting obligations and inspections. The EU law provides implementing/delegated acts plus Member-State reporting templates

and inventories that drive national/regional enforcement and monitoring [25].

- **Prohibitions** – bans on exporting metallic mercury and on manufacture/import/export of many mercury-added products, plus restrictions on industrial uses and a phase-out timeline for dental amalgam (with limited, time-bound derogations) [25].
- **Storage and disposal controls** – temporary and permanent storage criteria for metallic mercury (technical containment, certificates, monitoring and emergency requirements) and obligations to treat or stabilise mercury waste if leaching limits are exceeded before landfill acceptance [25].
- **Waste acceptance and testing** – specific leaching limit values and test methods determine whether mercury-containing wastes are acceptable at inert, non-hazardous or hazardous landfill classes; wastes exceeding limits must be treated or stabilised [25].
- **Reporting and inventories** – Member States must prepare inventories of mercury-added products, submit periodic reports using Commission questionnaires and follow implementing acts for import/export reporting [25].

**Compliance tools** – licensing/registration for certain activities, record-keeping obligations, spot inspections/authority to take samples, and penalties for non-compliance as implemented under the relevant national transposition measures [25].

### ***Greek national and local legal documents defining mercury management***

In Greece, the regulatory framework for waste management—including hazardous fractions such as mercury-bearing waste—operates through a three-tiered planning system that mirrors European Union directives. At the national level, the National Waste Management Plan (2020–2030) and the Circular Economy Law 4819/2021 provide the strategic vision

and binding targets for prevention, recycling, and hazardous waste handling. These frameworks transpose EU directives, ensure alignment with the Waste Framework Directive, and incorporate the obligations stemming from the EU Mercury Regulation (2017/852) and the Minamata Convention on Mercury, both of which Greece has ratified.

At the regional level, every administrative region must elaborate a Regional Waste Management Plan (Περιφερειακός Σχεδιασμός Διαχείρισης Αποβλήτων, ΠΕΣΔΑ). These plans detail infrastructure, siting of facilities, and separate-collection schemes, while also addressing special waste streams such as electronic waste, healthcare residues, and hazardous components containing mercury. For example, the updated ΠΕΣΔΑ of Central Greece sets regional infrastructure priorities and coordination mechanisms between municipalities, whereas the Peloponnese regional plan outlines functions and responsibilities for hazardous waste management. In addition, the Thessaly plan specifies technical instruments—such as transfer stations, mechanical-biological treatment plants, and green points—that are necessary to comply with the targets of the national strategy. By integrating local conditions and waste flows, ΠΕΣΔΑ serve as the essential intermediary between national goals and municipal responsibilities.

At the local level, municipalities are required by Law 4819/2021 to develop Local Waste Management Plans (Τοπικό Σχέδιο Διαχείρισης Αποβλήτων, ΤΣΔΑ). These documents translate regional frameworks into concrete local actions, including separate collection logistics, public awareness campaigns, and contracts with regional solid-waste authorities (ΦοΔΣΑ). For instance, the revised ΤΣΔΑ of Komotini (2021) and Chania (2022) demonstrate how municipalities set annual targets, budget collection schemes, and organise treatment routes. In practice, ΤΣΔΑ ensure that hazardous and mercury-containing wastes—such as fluorescent lamps,

small batteries, and certain healthcare residues—are collected separately and channelled to authorised facilities.

Mercury is specifically addressed through sectoral orders and circulars. In early 2024, the Greek Ministry of Health issued a reminder to all hospitals and dental clinics regarding the obligations of Regulation (EU) 2017/852, which bans bulk mercury, restricts dental amalgam use to pre-dosed capsules, and requires amalgam separators in dental facilities. These national reminders, enforced through local health and environmental services, are a good practice in ensuring compliance at the municipal level. They are complemented by regional ΠΕΣΔΑ provisions for hazardous waste flows, which include mercury-bearing streams within their infrastructure planning.

Finally, Greece supports implementation of these frameworks through regional and municipal programmes co-funded by European instruments. The LIFE-IP CEI-Greece project (Integrated Project for Circular Economy) directly assists municipalities and regions in updating their ΤΣΔΑ and ΠΕΣΔΑ, testing pilot schemes, and building local capacity. Regional solid-waste authorities (ΦοΔΣΑ) also play a central role by designing and operating treatment facilities that municipalities depend on. In this way, the multilevel governance structure ensures that mercury-containing waste, along with other hazardous and municipal fractions, is systematically managed from national strategy down to local collection.

### ***Ivano-Frankivsk local legal documents defining mercury management***

Removal of household waste in Ukraine is regulated by special laws of Ukraine "On Waste", "On Housing and Communal Services", Resolution of the Cabinet of Ministers of Ukraine "On Approval of the Rules for the Provision of Services for the Removal of Household Waste" dated 10.12.2008 No. 1070. Among the local ones - the Rules for the

Improvement of the City of Ivano-Frankivsk, as well as regulatory acts of the City Council and its Executive Committee, which determine the providers of services for the removal of household waste, establish tariffs for these services, etc.

### **Lviv local legal documents defining mercury management**

According to the Ukrainian legislation, the authorized executive authorities in the field of mercury contained waste management in the Lviv region are defined as:

- The Main Department of the State Service of Ukraine for emergency situations in the Lviv region
- Department of Ecology and Natural Resources of the Lviv Regional State Administration
- State Ecological Inspection in Lviv region
- Department of Emergency Situations, Civil Protection and Territorial Defense of the Lviv City Council
- Department of Waste Management of Lviv City Council
- Subsidiary enterprise "Bodnarivka" of Lviv municipal enterprise Green Lviv
- Department of Ecology and Natural Resources of the Lviv City Council
- State Institution "Lviv Regional Center for Disease Control and Prevention of the Ministry of Health of Ukraine"
- The Main Directorate of the National Police of Ukraine in the Lviv region

Normative legal acts, on the basis of which the Department for Emergency Situations, Civil Protection and Territorial Defense of the Lviv City Council organizes the collection and preparation for the disposal of metallic mercury and hazardous materials from the population, enterprises, institutions, and organizations regardless of the forms of ownership in the territory of the city. Lviv: Civil Protection Code of Ukraine, Laws of Ukraine "On Waste", "On Ensuring Sanitary and Epidemiological Welfare of the Population", Resolution of the Cabinet

of Ministers of Ukraine dated January 9, 2014. No. 11 "On approval of the Regulation on the unified state system of civil protection", order of the Ministry of Emergency Situations of Ukraine dated July 8, 2009. No. 463 "On the approval of methodological recommendations on the organization and implementation of demercurization", the decision of the executive committee of the Lviv City Council dated 10.17.2003. "On the approval of the Rules for the collection, storage, transportation, utilization, and disposal of waste in the city of Lviv".

#### 4. RECOMMENDATIONS

Based on the analysis of international practices, regulatory frameworks, and case studies from both the European Union and Ukraine, it is evident that the safe management of mercury waste remains a pressing challenge that requires systemic, coordinated action. Despite global commitments under the Minamata Convention, significant gaps persist in infrastructure development, public awareness, and enforcement mechanisms, particularly in transition economies.

This chapter outlines recommendations aimed at strengthening mercury waste collection, treatment, and disposal systems. The proposals are structured to address three levels of intervention: policy and regulation, infrastructure and technology, and awareness and capacity-building. They are grounded in lessons learned from EU member states, where advanced regulatory mechanisms and extended producer responsibility schemes have led to high collection rates, as well as from local initiatives in Ukraine, such as the Lviv mercury waste management model.

The recommendations are intended to support decision-makers, municipal authorities, and civil society in developing effective, sustainable, and safe mercury waste management systems that reduce risks to public health and the environment while ensuring compliance with international standards.

##### 4.2. Safe collection and disposal of mercury waste

The safe collection and disposal of mercury-containing waste is a cornerstone of environmental protection and public health policy, particularly in the framework of the **Minamata Convention on Mercury (2013)**, which aims to phase out mercury use and prevent releases. Despite progressive bans and substitution, mercury is still present in everyday products such as thermometers, sphygmomanometers, fluorescent

lamps, batteries, and dental amalgam. Improper handling of these items at the end of their life cycle can result in toxic vapor emissions, soil contamination, and leaching into water bodies, creating long-term health and ecological risks.

The first step in a safe collection system is the **identification of mercury-containing products** and the establishment of dedicated collection points. Good practices include the involvement of pharmacies, hospitals, schools, and municipal waste centers as decentralized collection hubs. Safe handling requires the use of sealed, shock-resistant, and corrosion-proof containers with appropriate hazard labeling. Personnel managing the collection must be properly trained, and the general population must be informed about the dangers of improper disposal.

During **transportation**, mercury waste must be transferred only by licensed operators with permits for hazardous waste. Shipments should be accompanied by official documentation to ensure traceability and compliance. This aligns with European requirements, in particular the **European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR, 2023)**.

Final **treatment and disposal** involve stabilization and secure storage. The most widely accepted technique is chemical stabilization (e.g., conversion of elemental mercury into mercury sulfide) followed by long-term disposal in specially engineered landfills or deep geological formations. Alternative methods that may lead to uncontrolled releases into the environment are not acceptable under current international frameworks.

An equally important element is **awareness-raising and education**. Public campaigns, school programs, and professional training for healthcare and municipal staff reduce the likelihood of unsafe handling. Moreover, regular audits of collection schemes and disposal contractors ensure

compliance with the **EU Waste Framework Directive (Directive 2008/98/EC, amended by Directive (EU) 2018/851)** and with the **Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (1989)**.

***Developing and implementing effective policy and governance measures to prevent the disposal of mercury-containing products at landfills***

Developing and implementing effective policy and governance measures to prevent the disposal of mercury-containing products at landfills requires a comprehensive and coordinated approach.

Here are some best practices:

**Regulatory Framework.** Establish and enforce strict regulations regarding the disposal of mercury-containing products. Ensure that these regulations are in line with international agreements and guidelines.

**Product Labelling and Identification.** Mandate clear labelling of products containing mercury to inform consumers and waste management facilities about the presence of this hazardous material. Implement systems for easy identification and separation of mercury-containing products at waste collection points.

**Product Bans and Alternatives.** Consider phasing out or banning the use of mercury in certain products where feasible alternatives exist. Promote the development and use of mercury-free alternatives and technologies.

**Extended Producer Responsibility (EPR).** Implement EPR programs to make producers responsible for the entire life cycle of their products, including proper disposal and recycling. Encourage manufacturers to take back and safely manage end-of-life products containing mercury.

**Waste Management Infrastructure.** Invest in and enhance the infrastructure for proper hazardous waste management, including

facilities for the safe disposal and recycling of mercury-containing products.

**Public Awareness and Education.** Conduct awareness campaigns to educate the public about the dangers of mercury and the importance of proper disposal. Provide information on safe handling, recycling options, and the environmental impact of mercury-containing products.

**Training for Stakeholders.** Train waste management personnel, including landfill workers, on the proper handling and disposal of mercury-containing products to minimize the risk of exposure.

**Monitoring and Enforcement.** Establish a robust monitoring and enforcement system to ensure compliance with regulations. Implement penalties for non-compliance to deter improper disposal practices.

**International Cooperation.** Collaborate with international organizations and neighbouring countries to share best practices, information, and technologies for the safe management of mercury-containing products.

**Research and Innovation.** Encourage research and innovation to develop new technologies for the safe disposal and recycling of mercury-containing products.

Stay informed about advancements in mercury-free alternatives and promote their adoption.

**Data Collection and Reporting.** Establish a system for collecting data on the production, use, and disposal of mercury-containing products to inform policy decisions and track progress over time. Regularly report on the implementation and impact of policies to ensure transparency and accountability.

In the framework of the **LIFE MERCURY-FREE** project activities were carried out, which are best practices for the development and implementation

of policy and governance measures for the prevention of disposal of mercury containing products at landfills:

- **The Methodical Recommendation “Advancement of the mercury containing waste management with quadruple helix territorial advisory structures”** provide practical recommendations for the involvement of various groups of stakeholders in solving the problems of mercury-containing waste at the level of local communities based on the Quadruple Helix Model. Objectives: Identification of key stakeholders for solving the problem of mercury-containing waste; Create a methodology for involving different groups of the public in the discussion and solution of the problem of mercury-containing waste; Develop methods for explaining the problem of mercury-containing waste to various groups of the public; Enhance cooperation between public authorities, business, science and society on mercury-containing waste management.
- **The international e-Conference “Mercury-Free City: Danger in our Homes”**. The conference was conducted online, with a live transmission in Facebook and YouTube and recording uploaded at LIFE e-HUB. The conference was devoted to the criss-cross exchange of opinions on the citizens’ point of view and problems with mercury containing waste disposal and their needs; the public authority position and the goods’ traders and waste collecting organizations position concerning the same problems. Positions of the named groups of stakeholders from different cities participating in the project were represented and compared. Representatives of the related projects (LIFE) were invited to present their projects and to express their opinion and advice.
- **Roadmap: Advancing Citizens’ Awareness and Behavior to Diminish Mercury Pollution in Cities**. The Roadmap presents the current legal status of hazardous waste disposal in the countries and regions participating in the life-mercury-free project, as well as currently

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implemented practices. Various solutions for the proper disposal of hazardous waste, such as those containing mercury, are discussed. By advocating for collaboration between retailers, manufacturers, and consumers, as well as the establishment of accessible collection points and innovative mobile collection methods, this paper provides a comprehensive framework to address the challenges associated with hazardous waste disposal. The proposed options not only contribute to environmental preservation but also emphasize the importance of public awareness and education in fostering a culture of responsible waste management. Implementing these strategies holds the potential to make significant strides towards a mercury-free and environmentally sustainable future.

- **Multi-Stakeholder Dialogue.** Establishing a structured and ongoing multi-stakeholder dialogue fosters collaboration and information exchange among local authorities, politicians, businesses, NGOs, and the public. Using the dialogue to identify challenges, share best practices, and collectively develop solutions for mercury-containing waste management.
- **Roundtable Discussions.** Organizing regular roundtable discussions with local authorities and politicians to maintain a strong commitment to mercury reduction policies. Ensuring that outcomes from these discussions are not only documented but also actively implemented, contributing to tangible policy changes.
- **Conducting a check of the citizens' attitude, behavioural biases, and their reasons.** Ex-ante survey of the awareness of citizens about the list of mercury-containing household goods, obtaining of these goods, reasons of not changing them for the modern devices and goods without mercury; their understanding of labelling at goods' packaging; their ways of disposal of these goods; their actions in a case, if a mercury

containing good is damaged; their sources of information about treating mercury containing goods.

### ***Practical Checklist for Safe Collection and Disposal of Mercury Waste***

At the point of generation:

- Identify mercury-containing products and waste (thermometers, sphygmomanometers, fluorescent lamps, dental amalgam, batteries).
- Provide clearly labeled, sealed, and impact-resistant collection containers.
- Train staff on handling mercury spills and safe packaging.

Collection and storage:

- Establish dedicated collection points (e.g., pharmacies, hospitals, schools, municipal centers).
- Ensure containers are stored in a dry, ventilated, and secure area, away from heat sources.
- Label all containers with hazard symbols and details of the waste type.
- Keep a log of quantities collected and dates of transfer.

Transportation:

- Use licensed waste transport companies with hazardous waste permits.
- Ensure transport containers are sealed, shock-resistant, and compliant with ADR (European Agreement concerning the International Carriage of Dangerous Goods by Road).
- Provide documentation (waste transfer notes) for traceability.

Treatment and disposal:

- Stabilize and solidify mercury waste where possible (e.g., sulfur stabilization).

- Transfer waste only to licensed hazardous waste facilities.
- Ensure final disposal is in line with Basel Convention and Minamata Convention requirements (engineered landfills, permanent geological storage).

Awareness and monitoring:

- Run public awareness campaigns about safe mercury waste disposal.
- Educate households and schools on where to bring mercury-containing products.
- Periodically audit collection points and disposal contractors for compliance.

#### **Case Example: European Union**

The EU has more advanced infrastructure for mercury waste management due to the EU Mercury Regulation (Regulation (EU) 2017/852), which sets rules for the storage, trade, and disposal of mercury and mercury waste.

A notable case is Sweden, which introduced a full ban on mercury and most mercury-containing products in 2009, including thermometers and other measuring devices. This legislative step was accompanied by the development of collection and treatment systems to ensure that mercury-containing waste is properly handled and not released into the environment.

Another example comes from Germany, where extended producer responsibility (EPR) schemes require manufacturers and importers of products such as fluorescent lamps to finance collection and recycling programs. Consumers can return lamps free of charge at designated collection points (including retailers), ensuring that mercury-containing products are not disposed of with municipal waste. This system contributes to higher collection rates and reduces the risk of mercury emissions.

### **Case of Ukraine: Lviv Mercury Waste Management System**

Ukraine has made notable progress in mercury waste collection and disposal, particularly at the municipal level. A flagship example is the city of Lviv, which, in cooperation with the EU-funded *Poland-Belarus-Ukraine Cross-Border Cooperation Program*, implemented a comprehensive system for handling household electronic and electrical waste.

Key achievements include:

- **Municipal program development:** Lviv adopted a city-wide program for handling electronic and electrical equipment waste, aligning local practices with European standards.
- **Specialized infrastructure:**
  - 80 specialized containers for used batteries were installed across the city.
  - Mobile collection points (“Eco-Buses”) were introduced to collect fluorescent lamps, batteries, and mercury thermometers from residents. Eco-Buses operate weekly, stopping near shopping centers, supermarkets, and administrative buildings, with schedules updated monthly.
- **Mercury treatment facility:** The municipal enterprise “*Bodnarivka*”, part of the Lviv City Council’s Department of Ecology, installed a mercury waste processing line supplied by the Swedish company *MRT System AB*. This equipment allows for the decontamination of mercury-containing lamps and thermometers under a “zero-waste” closed-cycle technology. The facility processes up to 200 kg of lamps per hour (approx. 500 tubular or 800 compact lamps). Outputs such as glass, caps, phosphor, and mercury are recovered for industrial reuse. This makes “*Bodnarivka*” the first and only mercury waste treatment plant of its kind in Ukraine.
- **Public engagement:** Information campaigns and educational programs raised awareness about safe disposal practices. The *Department of Emergency Situations and Civil Protection* also organizes “Mercury

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Acceptance Days,” where citizens can hand in mercury waste free of charge.

- **Emergency response system:** The *State Emergency Service of Ukraine (SES)* in Lviv region is responsible for responding to accidental mercury releases, supported by civil protection units trained in chemical, biological, and radiological safety.

This integrated model demonstrates how a Ukrainian municipality, with EU support, can establish an effective mercury waste management system that not only prevents environmental contamination but also aligns with EU best practices.

In summary, the safe collection and disposal of mercury waste is a multi-level system involving identification of waste streams, organization of local collection points, safe transport, environmentally sound treatment, and final disposal. Combining technical measures with effective public outreach provides a solid basis for minimizing risks and protecting both human health and the environment.

#### **4.3. Organizing local campaigns (school, community, NGO)**

The AGH conducted several campaigns beyond project

#### **4.4. Guidance for municipalities**

##### ***Guidance for Polish municipalities on mercury-containing goods waste management***

Mercury doesn't forgive mistakes. One broken lamp can contaminate a bay, a truck, or an RDF stream. Below is a practical framework tailored to Polish gminas, integrating EU rules, Polish practice (PSZOK), and producer responsibility.

Legal framework in Poland and the EU

- Core laws: Waste Act (Ustawa o odpadach, 2012); Act on maintaining cleanliness and order in gminas (1996); WEEE (Dyrektywa 2012/19/UE, transposed in Poland); Batteries (Regulation (EU) 2023/1542); EU Mercury Regulation (Regulation (EU) 2017/852); and the Minamata Convention. These establish selective collection, extended producer responsibility (EPR), and environmentally sound management (ESM).
- Municipal obligations: Selective collection of hazardous household fractions via PSZOK; integration with EPR systems for lamps, WEEE, and batteries; accurate coding and reporting in BDO; and contracting licensed carriers and treaters.
- Waste codes (EWC/LoW) commonly used:
  - 20 01 21\*: Fluorescent tubes and other mercury-containing waste
  - 16 06 03\*: Mercury-containing batteries
  - 16 02 13\*: Discarded equipment containing hazardous components (when unsure; confirm and reclassify if components are removed)
  - 16 02 15\*: Hazardous components removed from discarded equipment (e.g., switches, relays)
  - 18 01 10\*: Amalgam waste from dental care

Tip: Align local procedures with the Basel/Minamata technical guidance on mercury wastes for acceptance, storage, transport, and treatment standards.

What counts as mercury-containing goods

- Households/SMEs: Lamps: Fluorescent/CFL/mercury-vapor; devices: thermometers, manometers, sphygmomanometers; switches/relays in older equipment; button cells; legacy cosmetics/chemicals with Hg.
- Healthcare/dental: Amalgam capsules, separators, traps; legacy measuring devices with mercury.
- Spills and residues: Elemental mercury, contaminated absorbents/debris, broken lamp fragments.

- Default rule: If in doubt, treat as mercury waste and segregate. Never compact or crush suspect items.

Collection system design for gminas

PSZOK and complementary services

- PSZOK setup: Dedicated bays, clear signage with photos of common items, trained staff, posted acceptance hours, visible spill kit, and 1-page SOPs at intake.
- Mobile options: Quarterly “hazardous waste days”, especially in districts without easy PSZOK access; on-demand pickup for fragile long lamps to reduce breakage.
- EPR channels: Batteries: retail collection and producer systems; lamps & WEEE: producer schemes and retail take-back; dental amalgam: sectoral arrangements with separators and authorized carriers.

Acceptance rules and triage

- Do accept: Intact lamps (prefer in boxes/sleeves), sealed thermometers/manometers, button cells and mixed household batteries (into battery containers), devices suspected to contain mercury.
- Do not accept in general bays: Broken lamps or spill debris without containment; bulk elemental mercury or business volumes beyond household scope – direct to licensed hazardous carriers.
- Intake triage: Visual check for integrity; route by stream (lamps, batteries, devices, spills); log items (count/weight, source); apply proper EWC code and label immediately.

Tip: Post a laminated “mercury items quick guide” with photos (lamps, thermometers, button cells, switches) at the PSZOK counter.

Safe handling, storage, and spill response

Handling and storage

- Segregation: Keep mercury items separate from heat sources, acids/oxidizers, and general recyclables. Never compact or crush lamps.

- Containers: Closed, puncture-resistant, lined containers; for lamps, manufacturer lamp coffins/fiber drums, kept upright and not overfilled; include absorbent/vapor adsorbent.
- Area design: Cool, covered, well-ventilated zone with impervious flooring, secondary containment for liquids, and restricted access.
- Labeling: “Odpady niebezpieczne – zawierają rtęć”, EWC code, date of accumulation, PSZOK ID, and emergency contact.
- PPE and training: Nitrile gloves, eye protection; for breakage/spills, Hg-rated respirators. Annual training on hazard recognition, SOPs, and emergency response; drills twice per year.

#### Small spill/broken lamp protocol

- Immediate actions: Evacuate area and increase ventilation (windows/doors); shut HVAC near spill; wait 15 minutes before re-entry.
- Collection: Don PPE; use stiff paper/card to scoop fragments; adhesive tape for powders/shards; place all materials into a sealed jar/drum with sulfur-impregnated absorbent.
- Cleanup: Damp disposable wipes for surfaces; avoid vacuuming; double-bag wipes and PPE into the same sealed container; label and log incident; ventilate for 24 hours if indoors.

#### Transport, treatment, coding, and documentation

- Licensed carriers only: UN-rated packaging, proper ADR documentation, and chain-of-custody from PSZOK to the treatment facility; weighbridge or count at dispatch and receipt.
- Treatment routes:
  - Lamps: negative-pressure separation systems capturing phosphor powder and mercury; verified recovery efficiencies.
  - Batteries (esp. button cells): EPR recyclers; segregate to avoid shorts and leaks; keep dry and cool.
  - Devices/switches: de-mercurization with downstream mercury stabilization (e.g., sulfurization) prior to disposal.

- Amalgam: keep wet in sealed containers; send via dental EPR or licensed carriers.
- Elemental mercury/spill debris: stabilize/solidify before final disposal; avoid landfilling untreated mercury wastes.
- BDO and records: Accurate EWC coding, KPO/KPOK documents, storage time limits compliance, training logs, incident reports, and contractor audit files (permits, performance data, downstream due diligence).
- KPIs for oversight: Breakage rate, capture per capita (kg/inhabitant), access metrics (distance/time to PSZOK), diversion from mixed waste, and cost per kg managed.

#### Public communication and implementation checklist

##### Communication that changes behavior

- Key message: “Nigdy nie wrzucaj lamp, termometrów i baterii do pojemnika na odpady zmieszane.” Show photos and where to take them (PSZOK, retail take-back).
- Make it easy: Extended hours, mobile events, free household drop-off, on-demand pickup for long tubes.
- Swap programs: Glass-to-digital thermometer exchange; school button-cell drives; dentist partnerships for amalgam capture.
- Transparency: Monthly dashboard: lamps/batteries collected, breakage incidents, and improvements—builds trust and participation.

##### Implementation checklist

- Policy: Accepted items, fees (if any), EPR integration, EWC codes, incident reporting, spill SOP adoption.
- Infrastructure: Spill kits, lamp coffins, labeled containers, ventilated storage, secondary containment, signage with photos.
- Contracts: Authorized carriers, ESM-compliant recyclers/treaters, service-level KPIs, downstream due diligence clauses.

- Training: Annual staff training, semiannual drills, visible 1-page SOPs at intake and storage areas.
- Monitoring: Capture rates, breakage, complaints, costs; review quarterly and adjust routes/hours.
- Continuous improvement: Site audits, mystery-shop intake, update SOPs after incidents; pilot on-demand pickups in high-breakage zones.
- PSZOK Locations in Łódź (Table 4.1).

Table 4.1

## PSZOK Locations in Łódź

Location	Address	Hours
PSZOK Graniczna	ul. Graniczna 2, 93-428 Łódź	Mon, Wed, Thu, Fri: 08:00–17:00 Tue: 08:00–20:00 Sat: 08:00–12:00
PSZOK Kasprowicza	ul. Kasprowicza 10, 92-781 Łódź	Mon, Wed, Thu, Fri: 08:00–17:00 Tue: 08:00–20:00 Sat: 08:00–12:00
PSZOK Zamiejska	ul. Zamiejska 1, 91-867 Łódź	Mon, Wed, Thu, Fri: 07:00–18:00 Tue: 07:00–20:00 Sat: 07:00–14:00

These sites are free to use for Łódź residents, but you may be asked to verify your residency. Waste must be sorted by type and delivered using your own transport. Mixed municipal waste is not accepted.

To verify your residency at a PSZOK in Łódź, you typically need to present proof that you live in the city and pay for municipal waste services. Here's what usually works:

Accepted forms of residency verification:

- Personal ID (dowód osobisty) showing a Łódź address

- Recent utility bill (e.g., electricity, gas, water) with your name and Łódź address
- Waste fee payment confirmation (potwierdzenie opłaty za gospodarowanie odpadami komunalnymi)
- Resident card or city card (Karta Łodzianina, if applicable)

At the site:

- Staff may ask for your address verbally and check it against their system
- For some items (like construction waste), they may ask for additional documentation or limit quantities

If you're unsure, it's best to call ahead to the PSZOK you plan to visit.

#### **4.5. Guidance for activists and educators**

Mercury is a toxic heavy metal with serious implications for both human health and ecosystems. In Greece, it typically enters the environment through industrial emissions, wastewater discharges, healthcare facilities that use or dispose of dental amalgam, and consumer products such as fluorescent lamps, thermometers, and batteries. Although national monitoring indicates that concentrations of mercury in air and water are generally below European Union thresholds, local hotspots exist in industrialised bays such as Elefsina or in port sediments, and seafood consumption remains a significant pathway for human exposure. For activists and educators, mercury can serve as a powerful example of how chemical pollution connects everyday consumption patterns with public health and environmental sustainability. Framing mercury pollution in relation to the Minamata Convention and the EU Mercury Regulation (2017/852) helps situate local challenges within wider global and European commitments.

The governance of mercury in Greece is structured across three levels of authority. At the national level, the National Waste Management Plan (2020–2030) and Law 4819/2021 on the Circular Economy set the

framework for hazardous waste prevention, recycling, and disposal. These laws incorporate EU obligations and provide the foundation for local and regional planning. At the regional level, ΠΕΣΔΑ (Regional Waste Management Plans) define the necessary infrastructure, identify treatment routes, and include hazardous streams such as mercury-containing products and healthcare residues. At the local level, municipalities are obliged to prepare ΤΣΔΑ (Local Waste Management Plans), which outline separate collection schemes, public information activities, and contracts with regional solid waste authorities. Educators can use this multi-level structure to teach learners how environmental governance is translated from EU directives to concrete actions in Greek cities and villages.

For activists, there are several practical entry points to make a difference.

Community-based awareness campaigns are particularly effective, encouraging households to dispose of batteries, lamps, and thermometers at designated collection points rather than in mixed waste. Citizen science projects that measure mercury levels in water, seafood, or soils can help generate local evidence to pressure municipalities into strengthening their local waste plans and providing adequate infrastructure. Advocacy efforts during municipal consultations can focus on demanding compliance with European regulations, such as the mandatory installation of amalgam separators in dental clinics and the clear labelling of hazardous waste bins in public spaces. Linking mercury activism to broader policy objectives—such as the circular economy and the European Green Deal's zero-pollution ambition—can further enhance legitimacy and visibility at both local and European levels.

Educators can also incorporate mercury as a teaching theme across disciplines.

In science classes, mercury pollution can be used to explain chemical transformations, such as the conversion of elemental mercury to

methylmercury, and how these forms bioaccumulate in fish and shellfish. In civic education, mercury offers a practical case study of how EU directives are implemented nationally, regionally, and locally. Project-based learning activities can invite students to map hazardous waste collection points in their community, assess whether these points are accessible and sufficient, or design communication materials that raise public awareness about safe disposal practices. In this way, mercury becomes a tangible subject through which young people can learn about chemistry, governance, and active citizenship simultaneously.

Building partnerships is another crucial dimension. Activists and educators alike benefit from working with NGOs and networks focused on waste management, marine protection, and public health, such as WWF Greece or MEDSOS. Collaboration with municipal authorities and regional solid waste bodies (ΦοΔΣΑ) ensures that campaigns are grounded in existing infrastructure and legal obligations. Moreover, engagement with EU-funded initiatives such as the LIFE-IP CEI Greece project, which supports circular economy and waste management practices, provides opportunities to scale up local initiatives, secure funding, and exchange knowledge with other regions. By combining local mobilisation, educational initiatives, and policy advocacy, activists and educators can play a decisive role in reducing mercury pollution and protecting communities in Greece.

## **B. 5 GOOD PRACTICE MANUALS**

### **5. INTRODUCTION TO THE GOOD PRACTICE MANUAL**

The Good Practice Manuals present country-specific cases, solutions, and recommendations for addressing the mercury problem and for promoting safer alternatives in everyday life and local governance. Each Manual focuses on one partner country, combining an overview of the national mercury-related situation with examples of effective practices implemented at local or national levels.

#### **5.1. Purpose of the Manual**

The purpose of each Manual is to translate the general principles of mercury reduction into practical, context-based actions. By documenting real-life examples, the Manuals help municipalities, NGOs, and communities adopt effective measures adapted to their own social, cultural, and legislative context.

#### **5.2. Objectives of the Manual**

- To describe the mercury-related challenges in each country;
- To highlight successful practices and solutions already implemented;
- To provide replicable models for other municipalities or institutions;
- To raise awareness and promote behavioral change at the community level.

#### **5.3. Target audience**

The Manuals are designed for a broad audience including local and regional authorities, environmental managers, schools and universities, NGOs, healthcare providers, waste management operators, and citizen groups. They can be used both as a training resource and as a reference tool for implementing safe mercury-free practices.

## 6. MERCURY PROBLEM IN POLAND

Poland has historically been one of Europe's top emitters of mercury, largely due to its coal-based energy sector. In 2016, Poland was responsible for 18% of total atmospheric mercury emissions in the EU. While emissions have declined since the late 20th century, the country still faces elevated mercury levels in air, soil, and water.

Environmental Impact includes

- **Air pollution:** Mercury concentrations in Poland's atmosphere are still high, especially in industrial regions like Silesia. Studies show seasonal spikes due to coal combustion for heating.
- **Soil and ecosystems:** Mercury tends to bind with organic-rich soils, which helps limit its uptake by plants and animals – but it also means it lingers for decades.
- **Water bodies:** Mercury deposited from the air can contaminate rivers and lakes, where it transforms into methylmercury, a highly toxic form that bioaccumulates in fish.

There exist human health Risks:

- **Inhalation exposure:** Research in southern Poland found that while mercury levels in air are concerning, the health risk from inhalation is currently considered low.
- **Food chain exposure:** Mercury enters the food chain through fish and game. Fortunately, mercury levels in Polish wildlife and livestock are generally low, making them safe for consumption.
- **Vulnerable groups:** Pregnant women and children are most at risk from mercury exposure, especially through contaminated fish.

Poland's mercury problem isn't isolated. According to the European Environment Agency, nearly half of mercury deposited in Europe comes from outside the continent, and global mercury levels in the atmosphere are up to 500% above natural levels.

- Poland is a signatory to the Minamata Convention, a global treaty to reduce mercury emissions.
- The country has made progress, but climate change and industrial inertia threaten to slow or reverse gains.

Experts call for better bioindicator monitoring and stricter controls on coal combustion and industrial processes.

## 7. GOOD PRACTICE IN POLAND

Poland has made notable strides in tackling mercury pollution, especially through monitoring, emissions control, and policy innovation. Here are some standout practices that reflect Poland's commitment to cleaner air and environmental health:

### ***Advanced Monitoring Systems***

Poland's **State Environmental Monitoring** program tracks mercury levels at regional background stations, especially in non-urban areas. These long-term studies help identify trends and compare Poland's performance with other European countries.

### ***Emission Reduction Scenarios***

Researchers from NILU Polska and Polish universities developed detailed mercury emission scenarios to guide policy:

- Status Quo: Maintains current practices but predicts rising emissions due to economic growth.
- EXEC (Extended Emission Control): Projects a drop in mercury emissions to 6.3 Mg/year by implementing stricter controls.
- MFTR (Maximum Feasible Technical Reduction): Aims for 2.8 Mg/year, using the best available technology across sectors.

### ***Policy & Public Engagement***

Following recent political shifts, NGOs and climate advocates proposed five key strategies to clean Poland's air:

- Accelerate thermo-modernization of buildings
- Promote renewable energy
- Enforce EU-aligned air quality standards
- Reduce transport emissions

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- Foster stakeholder dialogue for sustainable solutions

These efforts show that while Poland still faces challenges, it's actively investing in smarter, cleaner, and more collaborative approaches. If you'd like, I can break down how these practices compare with other EU countries or explore how local communities are getting involved.

Here are some compelling user cases that illustrate how mercury pollution has been studied and addressed in Poland – across science, policy, and environmental monitoring:

### ***Industrial Emissions & Scenario Modeling***

A landmark study by NILU Polska and Polish universities modeled mercury emissions from coal combustion, industrial processes, and even dental practices. They developed three scenarios:

- Status Quo: Continued current practices, leading to increased emissions.
- EXEC (Extended Emission Control): Emissions drop from 17.7 Mg to 6.3 Mg by 2020.
- MFTR (Maximum Feasible Technical Reduction): Emissions fall to just 2.8 Mg annually.

This modeling helped guide national policy and prioritize technological upgrades in energy and waste sectors.

### ***Baltic Sea & River Sediment Studies***

Researchers found elevated mercury and methylmercury levels in Baltic Sea sediments and Polish rivers like the Warta and Odra. While most soils in Poland were below legal limits, Upper Silesia showed concentrations up to 4.01 mg/kg, well above the threshold. These findings prompted tighter controls on industrial discharge and sediment monitoring.

***Bioindicator Monitoring in Ecosystems***

A 2021 review highlighted that although Poland's atmospheric mercury emissions have declined, mercury still accumulates in organic-rich soils. Wildlife and livestock generally show low contamination, making them safe for consumption. However, the study emphasized the need for bioindicator-based monitoring – using species like mosses or small mammals to track mercury trends.

These cases show how Poland is blending science, policy, and environmental stewardship to confront mercury pollution. If you'd like, I can walk you through how these efforts compare with other EU countries or explore community-led initiatives.

## 8. MERCURY PROBLEM IN UKRAINE

The main sources of mercury pollution in Ukraine include industrial activities (chlorine production, coal mining), coal combustion at thermal power plants, as well as household and industrial waste. In Ukraine, the problem of mercury pollution has been exacerbated by the Soviet legacy (outdated enterprises), the war with Russia since 2014 and the full-scale invasion on February 24, 2022, and insufficient infrastructure for waste disposal. The war has exacerbated the situation: the destruction of industrial facilities, the flooding of mines in Donbas (for example, the Oleksandr-Zakhid mine with chlorobenzene and the Yuny Kommunar mine with radioactive elements), constant bombings and explosions release mercury into the atmosphere along with other heavy metals.

About 26 million fluorescent lamps containing about 130 kg of mercury are thrown away annually in Ukraine [26]. Another 40 kg of mercury enters the environment through the waste of electronic and electrical equipment, this is discussed in the analytical report "On the assessment of the volume of mercury-containing waste and recommendations for the implementation of the Minamata Convention in Ukraine" [27], [28].

The Main Department of Statistics in Lviv Region is a territorial body of the State Statistics Service of Ukraine, which implements state policy in the field of statistics within the limits of its powers. The Department carries out statistical observations on the amount of waste generation (Fig. 8.1, 8.2).

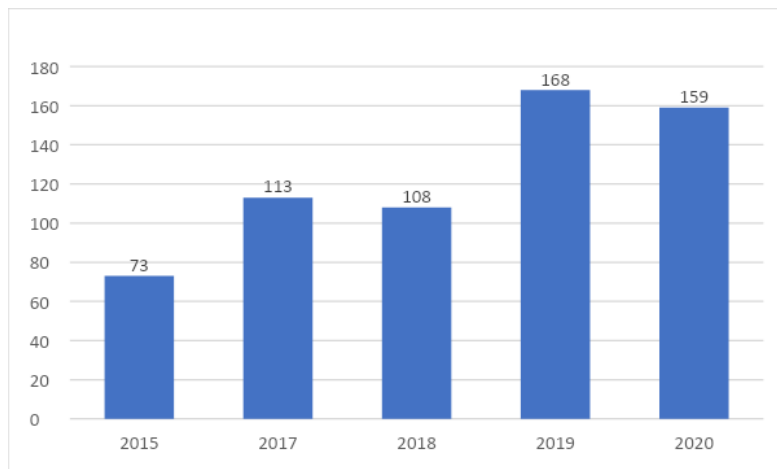


Figure 8.1. Waste generation by categories of materials: Accumulators and battery waste (in tons)

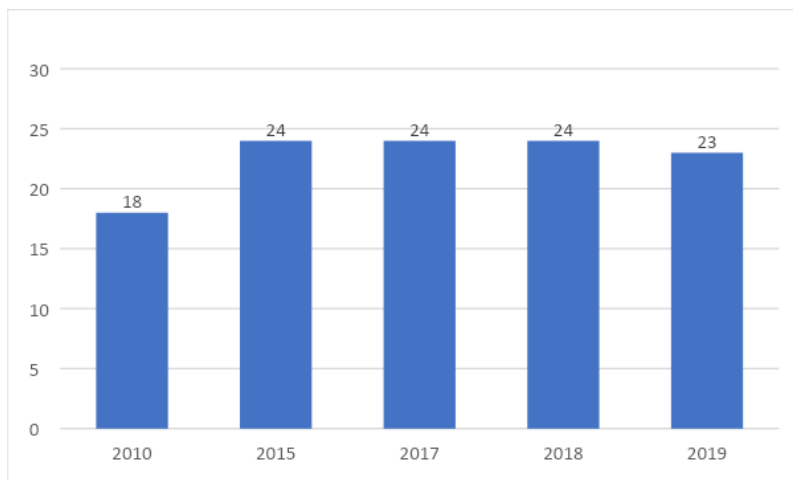


Figure 8.2. Waste generation by main waste groups: Waste containing mercury and its compounds (including fluorescent lamps) (in tons)

On the territory of the closed plant "Radykal" in Kyiv, mercury evaporation rates

exceed the norm by 4-16 times, and in summer by 40 times. The environmental problem has been going on since 1951, and the plant has been bankrupt since 1996. The plant was a monopolist in the production of some types of synthetic materials, in particular polyurethane foam, Bertolet salt, hermobutyl, chemical plant protection agents. Telescopes for submarines were produced there. In July 1996, the enterprise was stopped, but with a violation of decommissioning of capacities. Chemical residues were not removed from the enterprise. Now on the cleared territory there are dozens of offices, small businesses, shops, warehouses and other objects of the service sector, two residential buildings have been built nearby, another building is being rebuilt for housing.

State Institution "Lviv Regional Center for Disease Control and Prevention of the Ministry of Health of Ukraine" conduct laboratory studies of the determination of mercury content for the purposes of social and hygienic monitoring and response to emergencies in the field of public health. According to the results of 2019-2023, there is an excess of the maximum permissible concentration of mercury in some objects of study (Table 8.1).

Table 8.1

*The results of laboratory studies of the determination of mercury content for the purposes of social and hygienic monitoring and response to emergencies in the field of public health, Lviv region, 2019-2023*

Object of study	Number of studies	Exceeding the MPC	
		n	%
Living and public premises	66	9	13.6
Water	316	0	

Soil	91	1	1.1
Food	341	0	
Washes for mercury residues	54	-	
In total	868	10	1.2

The number of used mercury-containing lamps and thermometers collected by “Bodnarivka” subsidiary of the Lviv municipal company “Green Lviv” from the population of Lviv and licensed enterprises in Ukraine in recent years is demonstrated on the Fig. 8.3 - 8.6.

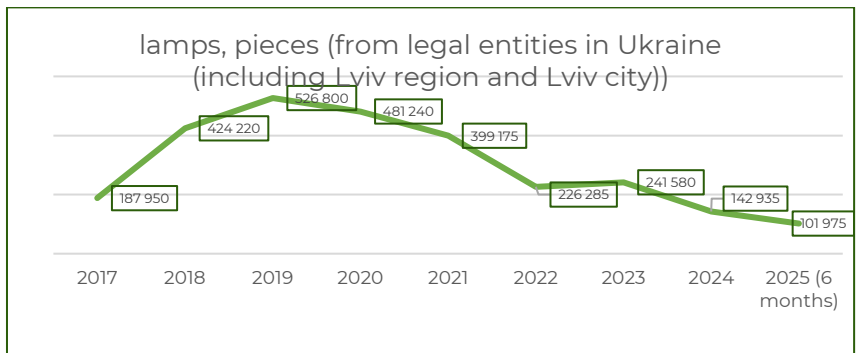


Figure 8.3. The number of used lamps (from legal entities in Ukraine (including Lviv region and Lviv city)) collected by “Bodnarivka” subsidiary of the Lviv municipal company “Green Lviv” by years

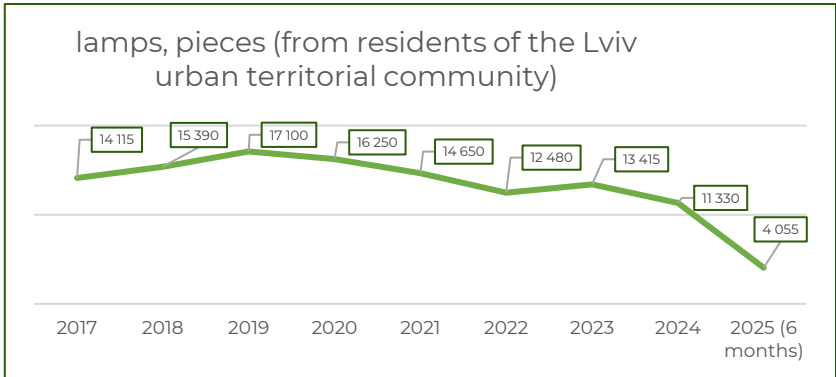


Figure 8.4. The number of used lamps (from residents of the Lviv urban territorial community) collected by “Bodnarivka” subsidiary of the Lviv municipal company “Green Lviv” by years

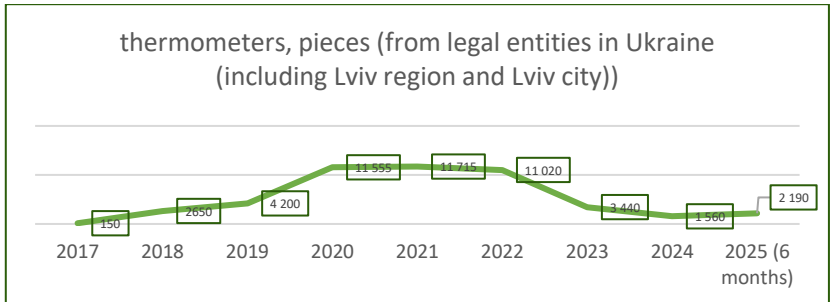
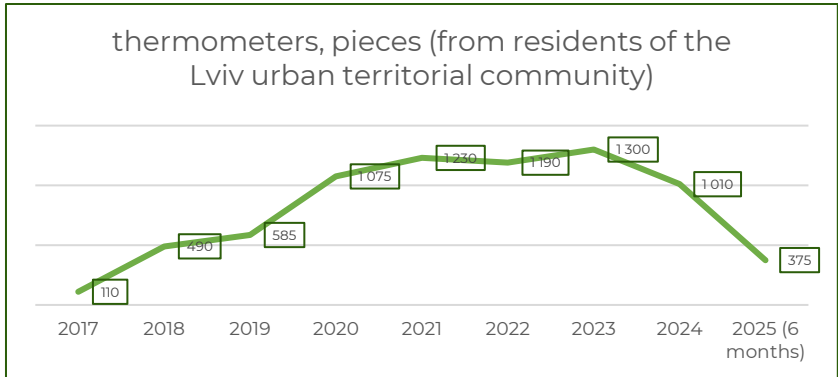


Figure 8.5. The number of used thermometers (from legal entities in Ukraine (including Lviv region and Lviv city)) collected by “Bodnarivka” subsidiary of the Lviv municipal company “Green Lviv” by years



*Figure 8.6. The number of used thermometers (from residents of the Lviv urban territorial community) collected by “Bodnarivka” subsidiary of the Lviv municipal company “Green Lviv” by years*

During 2016-2025, the State Emergency Service of Ukraine in the Lviv region was involved 210 times in responding to mercury detection events in the territory of the Lviv region (Fig. 8.7, 8.8). In addition, the State Emergency Services of Ukraine in the Lviv region were involved in responding to a chlorine leak (2017), a sulfuric acid spill (2018), a nitric acid leak (2019), and the burning of paints and solvents (2019), burning of household chemicals (2023), evaporation of ammonia, chlorine and phosphine (2023), hydrochloric acid leak (2024).

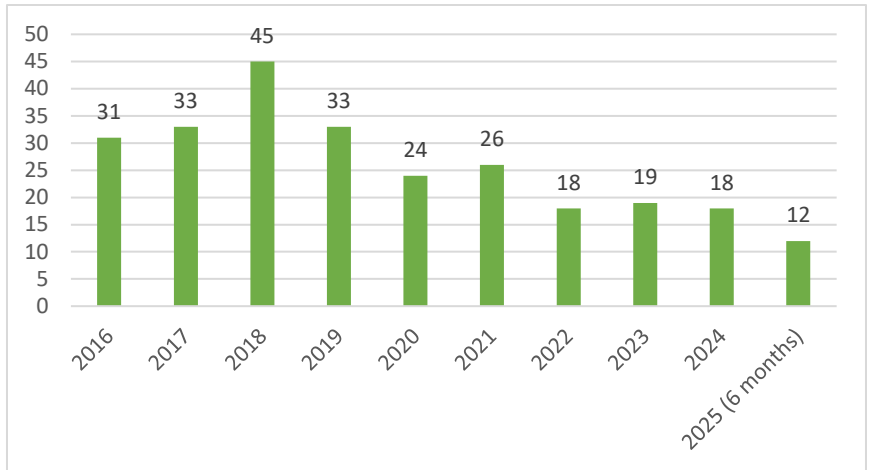


Figure 8.7. The number of detection of mercury in the territory of Lviv region



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Figure 8.8. Cases of mercury detection and demercurization in Lviv region

Currently, Lviv has the following mercury-containing waste management scheme (fig. 8.9). Part of the mercury-containing waste that ends up in regular waste cans is transported to unequipped waste landfills. The rest of the mercury-containing waste is collected by eco buses of "Bodnarivka" a subsidiary of the Lviv municipal company "Green Lviv", processed and then stored in temporary storage places. Also, one of the problems of the city of Lviv in the field of mercury-containing waste management is insufficient information and educational activities and cooperation in this matter of local and state municipalities, stakeholders, the public, educational and scientific institutions, businesses, and activists to raise public awareness [29], [30].

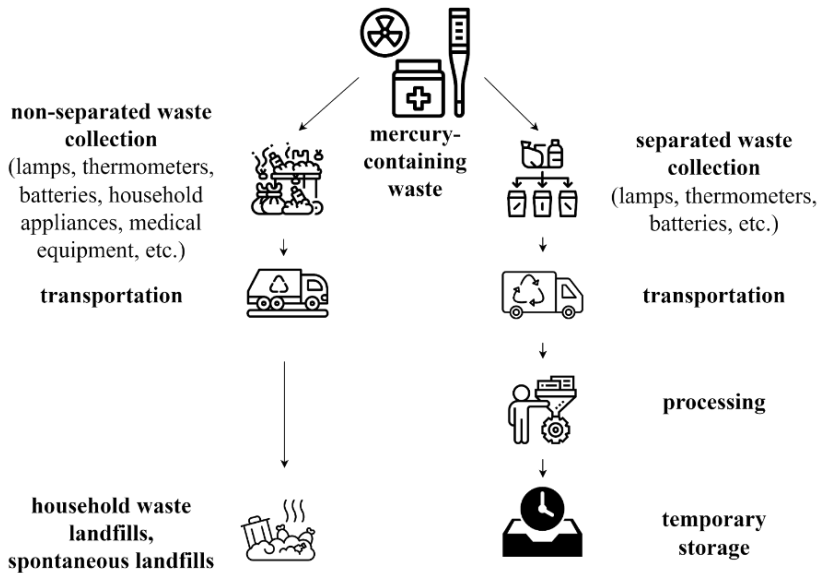


Figure 8.9. Mercury-containing waste management scheme in Lviv

One of the most pressing and unresolved issues in Ukraine is the accumulation of significant stocks of metallic mercury (elemental mercury). Unlike mercury-containing waste (such as fluorescent lamps, thermometers, or batteries), for which there are certain collection and treatment initiatives in Lviv and other regions, there is no national system for the management of elemental mercury.

Large quantities of metallic mercury remain stored at former industrial sites, research laboratories, and medical institutions. These stocks have accumulated over decades, particularly in connection with the chemical and mining industries. The problem is exacerbated by:

- Lack of licensed facilities for stabilization or long-term storage of metallic mercury in Ukraine.

- Absence of a clear legal framework that would regulate the transfer, stabilization, or disposal of elemental mercury.
- Risks of leakage and emissions during long-term uncontrolled storage.
- High costs of export for treatment abroad, which is regulated under the Basel Convention and requires state-level coordination.

While international practice (EU, USA, Japan) demonstrates that the most reliable solution is the stabilization of mercury into mercury sulfide (HgS) followed by geological disposal in deep formations (e.g., salt mines), Ukraine currently lacks such technological capacity.

Temporary storage in sealed containers and guarded warehouses is used as an interim solution, but it does not address the long-term risk of environmental contamination.

This situation creates a regulatory and technological gap: although Ukraine is a Party to the Minamata Convention on Mercury, the country does not yet have a national system for managing accumulated metallic mercury in line with its obligations.

## 9. GOOD PRACTICE IN UKRAINE

Although Ukraine still faces significant challenges in managing mercury and mercury-containing waste, several promising initiatives have emerged in recent years. These examples do not yet form a fully developed national system but can be regarded as elements of a growing practice of mercury management in the country. Taken together, they represent a **single good practice case** that demonstrates Ukraine's capacity to adapt international approaches, pilot safe technologies, and involve different stakeholders. This evolving system, while fragmented, provides valuable experience and a foundation for further national-scale implementation.

In practice, Ukraine's good experience in mercury management can be seen as a **multi-level system of responses**, combining grassroots initiatives, municipal projects, and institutional frameworks. Although still fragmented, these measures demonstrate how Ukraine is building a foundation for sustainable mercury waste management. The following examples illustrate key components of this system:

- **Grassroots initiatives:** the “Batteries, Surrender!” campaign, launched by IT specialists in Dnipro, which established a nationwide collection network for used batteries, ensuring that 100% of the collected waste is exported for recycling abroad.
- **Municipal solutions:** the project in Lviv, supported by the Poland–Belarus–Ukraine Programme, which created a municipal system for handling electronic and electrical waste, introduced eco-buses, and installed the first mercury lamp decontamination line in Ukraine.
- **Emergency and institutional response:** coordinated actions of the State Emergency Service in Lviv region and Mercury Acceptance Days organized by the City Council.
- **Civil society and advocacy:** initiatives of NGOs such as *SortSmart* and the *Zero Waste Alliance Ukraine*, which promote sustainable waste

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management and mercury-free lifestyles.

Also, the disposal of mercury-containing products is a significant environmental concern due to the potential risks associated with mercury pollution. Several measures and regulations were in place to address this issue, including:

- **International Agreements.** Ukraine is a party to international agreements and conventions aimed at controlling and reducing mercury emissions and waste. One such agreement is the Minamata Convention on Mercury [1], which Ukraine signed and ratified. The Minamata Convention aims to minimize mercury emissions and control the use and disposal of mercury-containing products.
- **National Legislation.** Ukraine has implemented specific laws and regulations to regulate the handling and disposal of hazardous waste, including mercury-containing products. The Law of Ukraine "On Waste" and other related regulations set guidelines for waste management and disposal practices.
- **Hazardous Waste Management.** Mercury-containing products, such as fluorescent lamps, batteries, and electronic devices, are typically classified as hazardous waste in Ukraine. These products are subject to special handling and disposal requirements to prevent mercury release into the environment.
- **Recycling and Collection Programs.** Some regions in Ukraine have established collection programs for mercury-containing products. These programs encourage the proper collection and recycling of such items, reducing the likelihood of their disposal in landfills.
- **Public Awareness.** Public awareness campaigns and educational initiatives have been conducted to inform the public about the dangers of mercury and the importance of proper disposal and recycling. These efforts aim to encourage individuals and businesses to participate in

safe disposal practices.

- **Reporting and Monitoring.** Environmental agencies and local authorities monitor waste disposal practices to ensure compliance with regulations. Penalties may be imposed for illegal disposal of hazardous waste, including mercury-containing products.

Addressing the problem of mercury-containing waste involves the cooperation and engagement of various stakeholders to develop effective solutions and mitigate environmental and health risks. The list of stakeholders involves four main groups of the public in the implementation of innovative changes: public authorities, industry, academia and citizens:

- **Government** may include national and local governments, government reform support offices, public agencies and their contractors, policy makers, state emergency services etc.
- **Industry** involves businesses that are represented in the targeted territory, for example producers of industrial and food products, waste companies, medicine, insurance services.
- **Academia** includes universities, scientific consortia, scientific laboratories and other research institutions.
- **Civil society** is a broad concept, therefore, it is necessary to divide it according to the criterion of relation to the problem of mercury-containing waste: the end-users, families, eco-activists, advocates of a healthy lifestyle, change makers etc. These can be individuals, NGOs, voluntary organisations or informal groups.

### ***All-Ukrainian initiative "Batteries, Surrender!"***

The movement began on the initiative of three dedicated IT professionals in the city of Dnipro, who decided to fight against environmental pollution in Ukraine. One battery, carelessly thrown into the ground, can pollute 16 m<sup>2</sup> of soil with dangerous substances, and the answer to "where to put used batteries" has not been found. But they decided to create it!

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They started to open their own battery collection points and attract people to do the same – in entrances, offices, schools, and shops. In short, everywhere, so that 100% of all batteries in Ukraine begin to be recycled, and not landfilled. The map has 1294 active battery collection points (fig. 9.1) [31].



Figure 9.1. The map of active battery collection points in Ukraine

All-Ukrainian initiative "Batteries, Surrender!" is the only campaign in Ukraine that actually sends 100% of batteries and provides reports about it. All batteries collected as part of the initiative go to the GreenWEEE plant in Romania.

***Project "Creation of a municipal system for handling waste of household electronic and electrical equipment in Lviv using the experience of Lublin"***

As part of the implementation of the project "*Creation of a municipal system for handling waste of household electronic and electrical equipment in Lviv using the experience of Lublin*" [32], the following was implemented:

- a comprehensive municipal program for handling household electronic

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and electrical equipment waste in the city of Lviv was developed and approved;

- purchased and placed 80 specialized containers for separate collection of spent power elements (batteries) in Lviv;
- purchased equipment based on minibuses of mobile points for collecting waste of household electronic and electrical equipment in Lviv;
- purchased and installed equipment for decontamination of mercury lamps and other equipment elements that contain mercury vapours in Lviv;
- an information and educational campaign was conducted for the population covering the issues of household electronic waste management.

"Bodnarivka" a subsidiary of the Lviv municipal company (LMC) "Green Lviv" that is part of the Department of Ecology and Natural Resources of the Lviv City Council accepts used fluorescent lamps, thermometers, and batteries from the public. Reception is carried out by special eco buses that run along the route according to the specified schedule on the website [33].

"Bodnarivka" purchased and installed a mercury-containing waste processing line. The supplier of the equipment for this line is the Swedish company "MRTSystemAB", which is the world leader in the production of equipment for the processing of hazardous waste. The line was purchased with the funds of the European Union as part of the Poland-Belarus-Ukraine Program (fig. 9.2). The system is equipped according to the European model and is the first and only one in the territory of Ukraine.



Figure 9.2. Fluorescent lamp processing plant

The company accepts for processing from legal entities compact energy-saving and tubular used fluorescent lamps, and mercury medical thermometers that have failed and are unusable. The company works on the “zero waste” technology with a closed cycle (absolutely waste-free), which makes it the first and only plant of its kind operating in Ukraine. The line's capacity is 200 kg/h, about 500 tubular or 800 compact fluorescent lamps per hour. After processing, glass, cap, phosphor, and mercury are obtained, which can be used as raw materials for industrial needs. This makes it possible to almost completely provide appropriate services to all of the west of Ukraine. Today, the company has stationary and mobile collection points for used lamps and thermometers containing mercury, batteries (Fig. 9.3-9.4).

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Figure 9.3. The equipment for mercury-containing waste processing line in "Bodnarivka" is the Swedish company "MRTSystemAB"



Figure 9.4. The decontamination equipment for mercury lamps and other items containing mercury vapor

Eco-buses usually run on Thursdays, Fridays, and Saturdays (Fig. 9.5). The stops are located near shopping centers, supermarkets, railway stations, and administration buildings and there are about 30 stops every month. They stand for 3 hours at each stop. The updated Eco-Bus schedule for each month with additional stops is distributed through social media and on official partner sites.



Figure 9.5. Eco-bus in Lviv

Today, the company has stationary and mobile collection points for used lamps and thermometers containing mercury, batteries. This service is free and unlimited.

Since 2018, Khmelnytskyi has had a hazardous waste collection program as part of household waste – Eco-bus (Fig. 9.6). Eco-bus accepts the following waste on a schedule in different neighborhoods of the city:

- Batteries and accumulators
- Fluorescent and energy-saving lamps
- Mercury thermometers
- Detergents, household chemicals
- Paints, adhesives, solvents
- Used lubricants
- Medicines
- Electrical and electronic equipment

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Figure 9.6. Eco-bus in Khmelnytskyi

In 2023, there were 21 locations in Khmelnytskyi, where Ecobus is located.

Ecobus activities are financed by the city budget and the Special Economic Zone “Spetskomuntrans”, which includes the transfer of hazardous waste to licensed companies: “Bodnarivka”, LMC “Green Lviv” and LLC “Ecological Investments” [34].

On October 1, 2019, an “ecobus” began operating in Poltava, a mobile point for receiving hazardous waste from the population (Fig. 9.7). Used batteries, lamps, and thermometers are accepted by an employee of KATP-1628, who has undergone training in hazardous waste management and received the appropriate license [35].

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Figure 9.7. Eco-bus in Poltava

Batteries are placed in cylindrical plastic boxes (Fig. 9.8). There are six such boxes in the car interior. They were made as part of the implementation of the “Participatory Budget” project by eco-activist Serhiy Antonenko. Mercury lamps are placed in a galvanized plastic box, made in the Czech Republic.

KATP-1628 is licensed only for the transportation of hazardous waste. Thermometers and lamps will be taken to the territory of the site of Polekozakhist LLC, which is located at the Suprunivka industrial complex. Then the lamps will go to Kyiv, and then to the Lviv region to a fluorescent lamp recycling plant. Used batteries will be transferred to the company Ecological Investments, which will transport the waste to the GreenWEEE plant in Romania.

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Figure 9.8. Containers for used mercury thermometers, fluorescent lamps and batteries

### ***The State Service of Ukraine for emergency situations***

Responses to events related to the detection of mercury and mercury-containing waste are carried out by formations that are created in accordance with current legislation and have appropriate training and equipment. These formations can be created at the state, regional, and local levels, and they can also be state, communal, or private.

Case of the Lviv region:

On the territory of the Lviv region, to date, the units of the Main Department of the State Service of Ukraine for emergency situations in the Lviv region [59] are involved in the response to the mentioned events, directly in the city of Lviv – the group of radiation chemical and biological protection of the Emergency and Rescue Unit of the Special Purpose Emergency and Rescue Squad of the Main Department of the State Service of Ukraine for Emergency Situations in the Lviv region [36]. When

receiving information about the occurrence of a Hazardous Event related to the detection of mercury or mercury-containing waste, the management bodies and civil defense forces specified in the response plans for such events are mutually informed and go to the place of occurrence of the event. When the information is received by the Main Department of the State Emergency Service of Ukraine in the Lviv Region (MD SES of Ukraine in the Lviv Region). The dispatcher of the operational coordination center of the State Emergency Service of Ukraine in the Lviv region or the dispatcher of the communication point of the state fire and rescue unit in accordance with the action algorithm informs State Institution "Lviv Regional Center for Disease Control and Prevention of the Ministry of Health of Ukraine", the Main Directorate of the National Police of Ukraine in the Lviv region, local self-government bodies in the territory which the event occurred and send to the scene of the incident the mobile operational group of the Main Directorate (operational group of the district (city) administration) and the group of radiation, chemical and biological protection of the emergency and rescue squad of the special purpose of the Main Directorate of the State Emergency Service of Ukraine in the Lviv region or another guard. This mutual information procedure is carried out regardless of who received the information about the event.

### ***Mercury Acceptance Days***

The Department of Emergency Situations and Civil Protection of the Population of the Lviv City Council is holding *Mercury Acceptance Days* for the citizens of Lviv. This service is free and unlimited [37].

### ***NGO "SortSmart"***

Since October 2018, the NGO "SortSmart" [38] has been sorting and submitting recyclable materials for processing in the city of Ivano-Frankivsk. Four

enthusiastic entrepreneurs came together to bring the city closer to European standards for household waste management. They collect sorted garbage from residents and companies of Ivano-Frankivsk. Currently, 20 local companies are partners of SortSmart. Paper, glass, plastic, metal and tetra pak are taken from their offices.

### **Zero Waste Alliance Ukraine**

Zero Waste Alliance Ukraine [39] is a union of Ukrainian organizations and activists working to solve the waste problem in Ukraine. The main goal of the union is to influence the reform of the waste and resource management system in Ukraine.

Their activities are aimed at changing the focus from the discourse of "how to recycle waste" to the discourse of "how to prevent the generation of waste". This means, first of all, looking for ways to reuse and popularize composting. Only then - recycle all resource-valuable materials. Zero Waste Alliance Ukraine includes six organizations: from Lviv, Kharkiv, Kyiv, Mariupol, Lutsk and Kherson.

Together, these practices illustrate that even in the absence of a nationwide system, Ukraine has developed innovative and effective solutions at different levels. The experience of grassroots campaigns, municipal programs, emergency services, and civil society organizations demonstrates the potential for scaling up mercury waste management practices across the country, in line with EU environmental standards and the objectives of the Minamata Convention.

## 10. MERCURY PROBLEM IN PORTUGAL

Historic chlor-alkali discharges (Estarreja/Laranjo) and legacy industrial inputs are the principal mercury sources in Portugal, with hotspots in Ria de Aveiro and parts of the Tagus estuary. Sediment-bound mercury still remobilizes seasonally, posing ecological risks; seafood and maternal biomonitoring show low-to-moderate human exposure but continued surveillance is advised.

### **Sources and industries**

The main Portuguese mercury inputs are tied to historical point sources (chlor-alkali plants) and past mineral/industrial processing, supplemented by diffuse atmospheric deposition and global emissions that also affect Portugal. The Ria de Aveiro contamination originates primarily from a chlor-alkali plant that discharged mercury from the 1950s to 1994 and is the dominant local source, while the Tagus estuary shows legacy inputs from chlor-alkali and pyrite processing activities, and coastal systems receive background atmospheric/diffuse inputs associated with global sectors such as coal combustion and non-ferrous metal production [40], [41].

### **Key contributors and evidence**

- Chlor-alkali production: Primary historical source at Estarreja/Laranjo bay with large sediment loading in Ria de Aveiro [40], [41].
- Pyrite and mineral processing: Identified as important past sources in the Tagus estuary south margin [41].
- Legacy industrial emissions: Local soil and urban contamination localized near plant sites from decades of discharges [42].
- Global sources and transport: Atmospheric emissions (e.g., coal combustion, non-ferrous metal production, cement, waste) contribute a background burden and can re-deposit mercury regionally [43].

**Environmental impacts**

Mercury in Portugal is largely stored in sediments and soils near point sources, but it is mobilized to water and biota under certain conditions, producing measurable concentrations in surface waters, sediments, and multiple fish tissues. Studies show elevated dissolved mercury in Ria de Aveiro and in parts of the Tagus estuary, localized soil contamination around chlor-alkali facilities, and bioaccumulation/bio-magnification through estuarine food webs, with tissue hierarchies (kidney, liver, muscle, brain) indicating risk to fish health and potential human exposure via seafood [40], [41], [42].

**Major environmental pathways and effects**

- Surface waters: Ria de Aveiro recorded the highest mean dissolved Hg among surveyed estuaries, with episodic peaks (~100–130 ng L<sup>-1</sup> at some stations) and seasonal increases (autumn) that sometimes exceed EU environmental quality thresholds [40], [41].
- Sediments: Historical deposition concentrates Hg in inner basins (e.g., Laranjo), acting as a long-term source that can be remobilized by dredging, storms, or resuspension [40], [41].
- Soils and urban/agricultural land: Elevated total Hg is found in soils adjacent to former chlor-alkali operations; urban soils farther afield did not show clear direct effects from the plant in some surveys, indicating strong spatial confinement [40], [41].
- Biota and food web: Mercury biomagnifies in estuarine food webs (BMFs >1 in many predator–prey links), and fish tissues show differential accumulation (kidney > liver > muscle > brain), with high proportions of organic Hg in edible tissues in many cases, posing ecological and food-chain concerns [41], [44].

- Microbial cycling: Mercury-resistant and cycling microbes have been isolated from Tagus sediments, indicating active biogeochemical transformation (including methylation potential) in contaminated estuarine sediments [45].

### **Hotspot regions and spatial patterns**

Ria de Aveiro (especially the Laranjo/Estarreja area) and discrete zones of the Tagus estuary (notably Seixal, Trancão, Alhandra and parts of the north channel) are the principal hotspots; Ria Formosa is comparatively low-contamination. Spatial monitoring shows contamination is often strongly localized to inner basins and near historic facilities, though remobilization can spread dissolved Hg episodically. Cardoso and the team reported Ria de Aveiro with the highest dissolved Hg averages and autumn peaks at specific stations, Tagus stations with elevated spring values at Seixal/Alhandra, and Ria Formosa as the least contaminated of the three studied estuaries [41].

Table 10.1

Comparative snapshot (multi-site)

Region	Main Issue	Typical environmental signal
Ria de Aveiro (Laranjo/Estarreja)	Historic chlor-alkali discharges; sediment reservoir	Highest dissolved Hg averages; episodic peaks (~100–130 ng L <sup>-1</sup> ) and potential moderate ecological risk seasonally [40], [41]
Tagus estuary (Seixal, Trancão, Alhandra)	Past pyrite processing and chlor-alkali inputs	Elevated water and sediment Hg at discrete stations; higher macrobenthic Hg than other coasts [41], [45]
Ria Formosa	Low industrial pressure	Lowest dissolved Hg among the three estuaries studied;

		values generally lower and stable [41]
--	--	--

Portugal's mercury problems are addressed within EU regulatory frameworks and global agreements; recent EU updates tightened controls in 2024, while national-level remediation and monitoring actions are described in scientific studies but specific national legal measures are not detailed in the supplied literature. The EU revised Mercury Regulation (entered into force 30 July 2024) tightens lifecycle controls (products, uses, waste) and implements Minamata Convention obligations, and EU food law sets mercury limits in seafood ( $0.5 \mu\text{g g}^{-1}$ ) and water quality standards have been used as benchmarks (EQS  $\sim 70 \text{ ng L}^{-1}$ ) in Portuguese monitoring studies [16,18].

## 11. GOOD PRACTICE IN PORTUGAL

Portugal implements EU mercury lifecycle rules, targeted local monitoring of air, water, sediments and biota, and a mix of containment, natural-attenuation and experimental remediation (microbial, algal, sorbent and phytoremediation) informed by site risk assessment and soil zoning.

### **Implemented measures**

Portugal combines supranational regulation with local monitoring, site zoning and remediation pilots to reduce mercury contamination. The mix below summarizes policies, monitoring programs, remediation techniques and management strategies reported in Portuguese studies and EU documents.

Table 11.1

Implemented measures

Category	Examples in Portugal	Evidence
Policies and standards	EU lifecycle regulation on mercury, Water Framework Directive environmental quality standards (EQS) applied to coastal waters	EU Mercury regulation and guidance on mercury lifecycle management and Member State reporting
Monitoring programs	Atmospheric TGM monitoring in Porto (continuous since 2008); seasonal estuarine monitoring of water, sediments and biota (Ria de Aveiro, Tagus, Ria Formosa)	Long-term atmospheric monitoring in Porto and multi-site seasonal coastal monitoring and risk assessment
Remediation techniques	Bioremediation using Hg-resistant bacteria (reduction/volatilization);	Experimental and field studies demonstrating

	macroalgae uptake (Ulva lactuca); sorbents and experimental sorbent deployment; phytoremediation/biotechnological pilots in Ria Formosa	microbial Hg reduction, macroalgal bioaccumulation, sorbent removal and remediation pilots
Site Management strategies	Contaminated-soil zoning and proposed soil limits around Estarreja; reliance on natural attenuation in some lagoon areas; targeted avoidance/minimization of dredging to limit resuspension	Geostatistical delimitation and proposed soil threshold; reports of natural recovery and management to avoid sediment disturbance

### **Policy and regulation**

Portugal applies EU mercury lifecycle rules and water quality standards and has reduced point-source inputs from industrial processes. EU legislation governing mercury across its lifecycle (products, emissions, waste and reporting) is directly applicable to Member States and further restricted uses under recent revisions of the Mercury Regulation [25], [46]. Portuguese coastal studies explicitly compare measured concentrations with EU environmental quality standards (EQS) under the Water Framework Directive and note that management actions (for example modernization of chlor-alkali electrolysis) have reduced ongoing direct emissions from historical industrial sources [18]. Historic point sources such as the Estarreja chlor-alkali complex remain important for remediation planning because they produced large local soil and sediment reservoirs of Hg [47].

**Monitoring and assessment**

Portuguese practice emphasizes long-term, multi-matrix monitoring and risk-based assessment to guide action. Continuous or long-term atmospheric monitoring of total gaseous mercury (TGM) has been conducted in Porto since 2008, providing trends for air emissions and urban background concentrations [48]. Coastal programs use repeated seasonal sampling of surface water, sediments and biota across Ria de Aveiro, the Tagus estuary and Ria Formosa to quantify dissolved Hg, methylmercury, and bioaccumulation in flora/fauna and to calculate hazard quotients (HQ) and ecological risk quotients (RQ) against PNEC/EQS values [41], [49]. Sediment monitoring and sediment–water flux studies identify contaminated sediment areas that act as ongoing sources and thus prioritize management and remediation [49].

Key monitoring elements used in Portugal include:

- Multi-matrix sampling (water, pore water, sediments, biota) for total Hg and MeHg to assess availability and trophic transfer
- Seasonal campaigns to capture variability and resuspension risks (e.g., autumn peaks in some lagoons)
- Biomonitoring (bivalves and other benthic species) to track bioaccumulation and human seafood-consumption risk.
- Remediation techniques and site management

Portugal combines natural attenuation, containment/zoning and several experimental or pilot remediation techniques informed by site studies. For historic chlor-alkali impacted areas managers use geostatistical soil mapping and propose soil-quality thresholds to delimit heavy contamination and prioritise interventions [47]. In sediments and waterbodies, studies recommend treating contaminated sediments as primary sources and avoiding activities (e.g., unnecessary dredging) that resuspend sediments and increase Hg mobilization [41], [49].

Applied or piloted remediation approaches include:

- Microbial detoxification — isolation and use of Hg-resistant microbial communities capable of  $\text{Hg}^{2+}$  reduction and partial volatilization have been demonstrated in Tagus estuary samples and optimized in laboratory designs to increase reduction under specific chemical conditions [45].
- Biological uptake — living macroalgae (*Ulva lactuca*) show high Cd/Pb/Hg uptake and have been trialed as a water remediation biotechnology for simultaneous metal removal [50].
- Sorbents and engineered removal — sorbent materials have been tested for Hg removal from river, estuarine and seawater matrices to lower concentrations toward EQS targets [51].
- Phytoremediation and biotechnology pilots — localized studies in Ria Formosa report trials with salt-tolerant plants and biotechnological agents (e.g., *Saccharomyces*) for sediment metal remediation, supporting nature-based remediation options [41].

Management strategies combine these technical actions with risk assessment: hazard quotients for seafood consumption and environmental risk quotients guide whether remediation or continued monitoring/natural attenuation is most appropriate for a site [18]. Prioritization is driven by mapped contamination hotspots (e.g., Estarreja) and by measured exceedances of EQS or ecotoxicological thresholds in specific locations or seasons [41], [47].

## 12. MERCURY PROBLEM IN GREECE

Mercury (Hg) in Greece derives from a combination of atmospheric deposition (historically influenced by coal/lignite combustion and other combustion sources), industrial and metallurgical activities near coastal zones, urban wastewater discharges, river-borne inputs, and legacy contamination in semi enclosed embayments. Greece monitors priority pollutants under the EU Water Framework Directive (WFD), where mercury is a “priority hazardous substance” with Environmental Quality Standards (EQS) set at EU level (Directive 2008/105/EC as amended by 2013/39/EU).

Greece also reports national emissions of heavy metals (including Hg) under the UNECE/LRTAP framework; the 2024 Informative Inventory Report (IIR) details methods and sectoral sources and notes that Hg from road transport is now only reported as total emissions in the COPERT model, reflecting continuing refinement of heavy-metal accounting; broader emission trends have been driven by declines in high-sulphur fuels and the lignite phase-down [52]. Recent nationwide coastal monitoring (2012–2022) synthesised by Greek marine researchers shows that total mercury (THg) concentrations in seawater around Greece are consistently below the EU EQS for the water column ( $70 \text{ ng L}^{-1}$ ), with a national median of  $1.65 \text{ ng L}^{-1}$ . However, spatial heterogeneity is pronounced: Elefsina (Eleusis) Bay west of Athens stands out as a clear hotspot (mean  $6.86 \text{ ng L}^{-1}$ ; 71% of samples  $>3.3 \text{ ng L}^{-1}$ ), likely reflecting industrial emissions, port activity, hypoxia-related sediment release, and urban atmospheric inputs from the greater Athens area. Elevated values also occur near river estuaries (e.g., Thermaikos Gulf influenced by Axios/Aliakmonas/Strymonas/Evros), near metallurgical/mining zones (e.g., Larymna/Asopos; a peak of  $28.1 \text{ ng L}^{-1}$ ), in ports (Igoumenitsa up to  $15.2 \text{ ng L}^{-1}$ ), and in volcanic island settings (Santorini/Milos  $5.5\text{--}6.6 \text{ ng L}^{-1}$ ). A notable extreme ( $90.2 \text{ ng L}^{-1}$ ) was recorded in Ierissos–Stratoni

(Halkidiki) in 2018. Although such peaks are episodic, they underline localised pressures superimposed on generally low open-coast background levels. These Greek patterns align with Mediterranean-wide assessments that highlight coastal/industrial hotspots and the importance of riverine and atmospheric inputs to the regional mercury budget [53]. On policy and governance, Greece signed the Minamata Convention in 2013 and ratified it in June 2020 (in force nationally since September 2020), committing to controls on Hg supply, products, processes, emissions, and waste, in concert with the directly applicable EU Mercury Regulation (EU) 2017/852 that governs trade, dental amalgam, industrial uses, and waste management across Member States. Recent EU amendments continue to tighten controls, and civil-society tracking tools monitor Member-State implementation progress [54].

### 13. GOOD PRACTICE IN GREECE

#### ***Implementation of the EU Mercury Regulation / Minamata Convention***

Greece is required under both EU law (Regulation (EU) 2017/852, and its 2024 revision) and the Minamata Convention to phase out or limit uses of mercury in products (e.g. dental amalgam), reduce emissions, and ensure environmentally sound management of mercury waste. These regulatory frameworks force operators (industrial, health-care, product manufacturers) to adopt alternatives, install abatement technologies, separate mercury-containing wastes, and report their mercury emissions/releases. Greece's ratification of Minamata in 2020 also commits it to national action plans [55].

#### ***Geochemical modelling and detailed speciation work***

In the context of Skiathos again, researchers have extensively studied Hg speciation in groundwater, examined how changes in salinity, chloride ions, /pH affect mobilization/solubilization. Such modelling provides direction for interventions (e.g. reducing over-pumping, controlling salinization) to prevent Hg mobilization.

#### ***Urban soil monitoring for hazard mapping***

The study "Mercury in the Urban Topsoil of Athens" provided spatial mapping of Hg in topsoil across many sites, differentiating between background and point sources (e.g. industrial, workshops, dental, silver/goldsmiths). This supports targeted remediation, land-use planning, public health assessments [56].

#### 14. MERCURY PROBLEM IN ITALY

Mercury is a heavy metal that is highly toxic for humans and the environment. Even small quantities can cause serious harm: it can damage the brain, nervous system, and kidneys, and it can persist in the environment for decades. Once released, mercury enters rivers, lakes, and seas, where it builds up in fish and shellfish, eventually reaching people through food. This makes mercury contamination not only an environmental challenge but also a direct public health issue. In Italy, the problem of mercury pollution has a long history. Industrial activities, household products, and improper waste management have been the main sources of mercury release. Although Italy has made great progress in reducing emissions, risks remain, especially in households and local communities where everyday products containing mercury are still found.

##### ***Historical Sources of Mercury in Italy***

For decades, Italian industry relied on processes that used mercury. In particular, chlor-alkali plants, which produce chlorine and caustic soda, were major sources of mercury emissions. Until the early 2000s, six plants in Italy still used the outdated mercury cell technology, despite warnings from scientists and environmental groups such as Legambiente. These plants slowly transitioned to cleaner “membrane technology,” but their legacy pollution remains a concern.

Mercury pollution is also linked to Italy’s goldsmithing and chemical sectors, as well as to coal-burning power plants. While regulations have reduced emissions from these sources, they left behind contaminated sites, soils, and sediments, some of which still require careful monitoring and remediation.

**Everyday Sources of Mercury**

While the image of mercury often brings to mind industrial plants, most Italians encounter mercury through much more ordinary items in their homes. Common products containing mercury include:

- Old thermometers (once found in every household)
- Fluorescent lamps and certain light bulbs
- Batteries
- Electrical devices and switches
- Dental amalgam fillings

When these products break or are thrown away with regular waste, mercury can escape into the air or seep into soil and water. Unfortunately, many people are unaware of the risks, or of the correct ways to dispose of such products.

To make disposal easier, Italy has set up a network of collection points (“isole ecologiche”) across the country, including in Camerino and the wider Macerata province. These facilities are specifically designed to handle dangerous waste safely, preventing contamination and protecting both people and ecosystems.

**Public Awareness and Education**

A crucial part of Italy’s strategy is education. Authorities, environmental groups, and universities provide campaigns and materials that explain the dangers of mercury and how to manage it properly.

- The Ministry of Health offers online information about mercury risks.
- In the Marche region, ARPAM (the regional environmental protection agency) organizes public awareness initiatives and publishes reports on environmental indicators.

Local communities, schools, and NGOs have also been engaged through EU projects like LIFE MERCURY-FREE, which encourage citizens to change habits and handle waste more responsibly.

### **Current Situation and Challenges**

Thanks to laws, technology upgrades, and awareness campaigns, Italy has greatly reduced mercury emissions. However, challenges remain:

- Legacy pollution from past industrial activity still affects soils and rivers.
- Household waste containing mercury often ends up in the wrong place because citizens are not always informed about proper disposal.
- Illegal dumping and poor waste management in some areas continue to pose risks.

At the same time, Italy has taken a leadership role internationally by aligning its actions with the Minamata Convention on Mercury, a global treaty designed to protect human health and the environment.

### **Why It Matters for Citizens?**

For ordinary Italians, the mercury problem may seem distant, but it touches daily life. Choosing the right light bulb, safely discarding an old thermometer, or taking batteries to a collection point all make a difference. Every small action prevents mercury from reaching landfills, rivers, and eventually our food.

By combining strict laws, effective recycling systems, and strong public awareness, Italy is moving towards a mercury-free future. But the success of this effort depends not only on governments and industries, it also relies on the informed and responsible choices of everyday citizens.

## 15. GOOD PRACTICE IN ITALY

The Italian Good Practice Manual is part of the broader LIFE MERCURY-FREE project, which brings together partners from across Europe to raise awareness, change behaviors, and build safer, mercury-free cities. Italy's contribution focuses on translating legal frameworks, technical solutions, and scientific knowledge into **practical steps for citizens, municipalities, schools, and organizations**.

The manual is not just a policy document, it is meant to be a **hands-on guide**, showing how communities can take responsibility for reducing mercury risks in everyday life. By adapting complex regulations and scientific findings into simple actions, the manual ensures that knowledge reaches those who need it most: families, students, local officials, and small businesses.

### **Key Principles**

The Italian manual is built around several core principles:

1. **Prevention First** – Avoid mercury use whenever safer alternatives exist.
2. **Correct Disposal** – Ensure that products containing mercury do not end up in household bins but go to safe collection points.
3. **Shared Responsibility** – Producers, municipalities, schools, and citizens all have roles to play.
4. **Education and Awareness** – Knowledge empowers people to make the right choices.
5. **Community Engagement** – Creating “Mercury-Free Communities” where local actors work together.

### **What It Means for Citizens**

For the average Italian household, the manual provides **practical advice**:

- **Thermometers and medical devices**: Old mercury thermometers should be returned to pharmacies or ecological islands (isole

ecologiche). Modern digital or alcohol-based thermometers are safe alternatives.

- **Lighting:** Compact fluorescent lamps (CFLs) contain mercury. The manual encourages switching to LED bulbs, which are safer, cheaper in the long run, and more energy efficient.
- **Batteries and electronics:** All small batteries and electronic devices must be disposed of through collection bins found in supermarkets, electronics shops, and municipal centers.
- **Dental care:** Although dental amalgam use is declining, the manual encourages patients and dentists to discuss mercury-free alternatives and safe waste handling.

These guidelines are designed to make disposal routines **part of everyday life**, rather than a burdensome extra step.

### ***Role of Municipalities and Local Authorities***

Municipalities are at the heart of Italy's mercury-free approach. The manual highlights several good practices already in place:

- **Collection Infrastructure** – Italian towns like Camerino maintain ecological islands where citizens can easily dispose of hazardous waste.
- **Awareness Campaigns** – Posters, leaflets, and school programs explain the dangers of mercury and where to bring products.
- **Monitoring and Reporting** – Regional environmental agencies (like ARPAM in Marche) regularly track mercury levels in soil and water and share results with the public.
- **Partnerships with Schools and NGOs** – Municipalities cooperate with educators and civic groups to reach broader audiences.

The manual stresses that cities should not work in isolation but **learn from each other** and share solutions, so that smaller towns can adopt proven methods developed in larger cities.

### **Schools and Education**

A standout feature of the Italian manual is its **focus on education**. Children and young people are seen as ambassadors for change. By integrating mercury awareness into school programs, Italy ensures that future generations grow up informed and responsible.

Best practices include:

- Interactive lessons on mercury pollution and health risks.
- Practical demonstrations (e.g., showing safe vs. unsafe thermometers).
- Student-led projects, such as surveys on household waste habits.
- Use of the LIFE e-Hub platform to access games, videos, and educational resources.

This approach creates a “multiplier effect”—students bring their knowledge home, influencing family behavior.

### **Producers and Retailers**

Under Italian law and EU rules, manufacturers and retailers must play their part through **Extended Producer Responsibility (EPR)**. The manual emphasizes how this principle works in practice:

- Retailers provide **collection bins** for batteries and electronics.
- Producers fund the recycling and safe treatment of collected products.
- Clear labeling helps consumers identify mercury-free alternatives.

This system means that the cost of safe disposal is not left to municipalities alone but is shared fairly along the product chain.

### **Community Engagement: The Mercury-Free City Model**

The manual also draws on the LIFE MERCURY-FREE project’s concept of **Mercury-Free City Communities**. In Camerino and other towns, local authorities, universities, NGOs, and citizens collaborate to:

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- Develop a **local roadmap** for phasing out mercury.
- Hold **public events and marathons** to raise awareness.
- Train municipal staff and teachers.
- Celebrate progress with recognition programs (e.g., schools or communities awarded as “Mercury-Free Champions”).

This model ensures that the fight against mercury is not top-down but involves everyone, from mayors to children.

### **Long-Term Sustainability**

The manual recognizes that awareness campaigns alone are not enough. Good practices must be **sustained over time**. Therefore, it recommends:

- **Monitoring Plans** – Regular evaluation of mercury waste flows and pollution levels.
- **Five-Year Strategies** – Municipalities should review and update their mercury-free roadmaps every five years.
- **Replication** – Successful models from Camerino and the Marche region should be shared with other Italian towns, and even abroad, to inspire wider adoption.

### **Why It Matters**

The Italian Good Practice Manual is more than just a set of instructions, it is a **tool for empowerment**. By putting clear, simple, and practical steps into the hands of citizens, schools, and municipalities, it ensures that Italy’s progress towards a mercury-free future is both achievable and sustainable.

For ordinary Italians, the manual shows that every action, whether changing a light bulb, taking a battery to the right bin, or teaching children about mercury, contributes to a healthier environment and safer communities.

Ultimately, Italy's manual demonstrates how local responsibility, combined with European cooperation, can turn a global problem into an opportunity for **collective action and long-term change**.

## C. FINAL PART

### 16. CONCLUSIONS

The LIFE MERCURY-FREE project has successfully compiled a robust set of best practices and country-specific manuals to combat mercury pollution, demonstrating that collaborative, multi-level actions can drive meaningful environmental and behavioral change. By addressing mercury's pervasive risks—from household hazards to industrial legacies—the Guide and Manuals provide accessible, actionable tools for stakeholders across Poland, Ukraine, Portugal, Greece, and Italy, fostering safer, mercury-free urban environments.

Key achievements include synthesizing global and EU policies with local innovations, such as Ukraine's eco-bus systems and NGO-led sorting initiatives, Portugal's remediation technologies, Greece's monitoring models, Italy's community engagement strategies, and Poland's advanced waste management and awareness campaigns led by institutions like Lodz University of Technology and AGH University of Science and Technology. These practices highlight the power of prevention, education, and partnerships, reducing exposure through safe disposal, awareness campaigns, and alternatives to mercury-containing products.

The project's legacy lies in its sustainability mechanisms: the LIFE e-HUB serves as an enduring digital platform for knowledge sharing, while recommendations emphasize ongoing monitoring, policy integration, and replication in EU and neighboring states. Challenges like legacy contamination and uneven awareness underscore the need for continued vigilance, but the demonstrated successes—backed by frameworks like the Minamata Convention—offer a blueprint for broader adoption.

Ultimately, this deliverable empowers municipalities, educators, NGOs, activists, and citizens to act collectively, ensuring long-term impact on public health and ecosystems. As mercury threats persist, sustained implementation of these practices will advance EU environmental goals, inspiring global efforts toward a truly mercury-free future.

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## 18. NNEXES

### 18.1. Glossary (layman level)

**Air Quality:** How clean or dirty the air is, affected by mercury emissions.

**Artisanal Mining:** Small-scale gold mining using mercury, often in underserved areas.

**Atmospheric Deposition:** When mercury falls from the air to the ground or water, often through rain or dust, spreading pollution far away.

**Awareness Campaign:** Events or materials, like posters or school talks, to educate people about mercury dangers and prevention.

**Baseline Monitoring:** The initial check of mercury levels to assess the situation.

**Behavioral Change:** When people adopt new habits, like using safe products or disposing of waste properly, to reduce mercury risks.

**Bioaccumulation:** When mercury builds up in the bodies of fish, animals, or people over time, especially from eating contaminated food like fish.

**Biodiversity Loss:** When animals or plants die out due to mercury, disrupting nature's balance.

**Biomagnification:** When mercury levels increase as you move up the food chain, from tiny fish to larger ones we eat.

**Cardiovascular Effects:** Heart and blood problems from mercury, like high blood pressure.

**Chemical Safety:** Rules to handle mercury and other chemicals safely.

**Chlor-alkali:** A factory process that used mercury to produce chemicals like chlorine, leaving mercury in the environment.

**Citizen Science:** When regular people help track mercury, such as in school projects.

**Coal Combustion:** Burning coal to generate energy, which releases mercury into the air.

- Community Engagement:** Bringing people together, like in schools or towns, to address mercury issues.
- Containment:** Keeping mercury trapped, such as in polluted soil, to prevent spreading.
- Contaminated Fish:** Fish that have mercury inside them from polluted water, which can make us sick if eaten.
- Decontamination:** Removing mercury from objects or places to make them safe.
- Dental Amalgam:** Silver fillings in teeth that contain mercury, which can release small amounts if not handled properly.
- Disposal Point:** A specific location, like a store or eco-bus, where mercury waste can be dropped off safely.
- Dissolved Mercury:** Mercury mixed into water, making it unsafe.
- Dredging:** Digging up river or lake bottoms, which can disturb mercury.
- Eco-bus:** A specialized vehicle that collects hazardous waste, such as mercury thermometers or batteries, from households for safe disposal.
- Ecological Island:** A designated place, like a drop-off point, where people can safely leave mercury waste instead of regular trash.
- Ecological Risk:** The chance that mercury will harm nature, like fish or birds.
- Ecosystem Health:** How well nature, like forests or rivers, remains healthy despite mercury.
- Emergency Response:** Quick action by teams to clean up mercury spills.
- Emission Control:** Measures or equipment that reduce mercury released from factories or vehicles.
- Endocrine Disruption:** When mercury interferes with hormones in our bodies.
- Environmental Impact:** How mercury harms nature, such as killing fish or plants.
- Environmental Quality Standards (EQS):** Guidelines that establish safe mercury levels in water, air, or soil to protect health and nature.

- Exposure Route:** The way mercury enters our bodies, such as eating fish or breathing air.
- Extended Producer Responsibility (EPR):** A rule where companies that make mercury products must help recycle or safely dispose of them.
- Fluorescent Lamp:** A light bulb containing a small amount of mercury, requiring special disposal.
- Food Chain:** The cycle of who eats whom, where mercury travels.
- Geochemical Modeling:** Using science to predict where mercury moves in nature.
- Global Treaty:** An agreement between countries, like Minamata, to fight mercury.
- Gold Mining:** A process where mercury is used to extract gold, often releasing it into the environment.
- Hazard Quotient:** A number indicating how risky mercury is to health or nature.
- Hazardous Material:** Substances like mercury that can harm if not handled correctly.
- Hazardous Waste:** Trash that can be dangerous, like mercury-containing bulbs or batteries, and needs special care to throw away safely.
- Health Risk:** A danger to our bodies from mercury, such as brain or kidney damage.
- Immune System Damage:** When mercury weakens our body's defenses against illness.
- Incineration:** Burning waste, which can release mercury into the air if not managed properly.
- Industrial Emission:** Mercury released into the air or water from factories.
- Kidney Damage:** Harm to the organs that clean our blood, caused by long-term mercury exposure.
- Landfill:** A place where trash is buried, but mercury waste should be avoided there.

- Legacy Pollution:** Mercury left behind from old factories or past activities that still harms the environment today.
- LIFE e-HUB:** An online platform providing information, tools, and resources about stopping mercury pollution.
- Long-Range Transport:** When mercury travels far through the air or water from its source.
- Mercury Cell:** An outdated factory method using mercury to make chemicals, now being replaced.
- Mercury Cycle:** The way mercury moves through air, water, and land over time.
- Mercury Vapor:** The gas form of mercury that can be inhaled from broken items.
- Mercury-Free Alternatives:** Safe products, like LED bulbs or digital thermometers, that do not contain mercury.
- Methylmercury:** A highly harmful type of mercury that forms in water and builds up in fish, affecting health if consumed.
- Microbial Transformation:** When tiny living things in water or soil change mercury into a more dangerous form.
- Minamata Convention:** A global agreement to stop mercury pollution and protect health and nature, named after a place where mercury poisoning occurred.
- Monitoring Program:** Regular checks on mercury levels in air, water, or soil to ensure safety.
- Natural Attenuation:** Allowing nature to slowly clean up mercury over time.
- Neurological Effects:** Health problems affecting the brain and nerves, like shaky hands or memory loss, caused by mercury exposure.
- NGO (Non-Governmental Organization):** A group like SortSmart that helps protect the environment outside of government.
- Occupational Exposure:** When workers, like in factories, are at risk from mercury.

- Oxidized Mercury:** A form of mercury that sticks to water or soil more easily after changing in the air.
- Phase-Out:** Gradually stopping the use of mercury products over time.
- Phytoremediation:** Using plants to clean up mercury from soil or water.
- Point Source:** A specific location, like a factory, where mercury is released.
- Pollution Control:** Steps to stop mercury from spreading, such as using filters in factories.
- Prenatal Exposure:** When a baby in the womb is affected by mercury from the mother.
- Public Awareness:** Educating everyone about mercury dangers.
- Public Health:** Keeping people healthy by reducing mercury risks.
- Recycling Program:** A system to reuse mercury waste, like bulbs or batteries, instead of discarding them.
- Regulatory Framework:** A set of laws and rules to control mercury use and disposal.
- Remediation:** Fixing or cleaning up mercury-contaminated places, like soil or rivers, to make them safe again.
- Resuspension:** When mercury in sediment is stirred up into water.
- Risk Assessment:** Evaluating how much danger mercury poses.
- Safe Disposal:** Throwing away mercury waste in a way that won't harm anyone.
- Seafood Safety:** Ensuring fish we eat isn't too contaminated with mercury.
- Sediment:** Mud or sand at the bottom of rivers or lakes where mercury can accumulate.
- Soil Contamination:** When mercury gets into the ground and harms plants or food.
- Soil Remediation:** Cleaning mercury from the ground to grow safe plants.
- Sorbent:** A material that absorbs mercury from water or air.
- Stakeholder Dialogue:** Discussions between groups like cities and NGOs to solve mercury problems.

- Stakeholders:** All the people involved, like city leaders, teachers, NGOs, and citizens, who work together to fight mercury pollution.
- Surface Water:** Rivers, lakes, or oceans where mercury can accumulate.
- Sustainable Development:** Making changes, like reducing mercury, that benefit the present and future.
- Sustainable Practice:** A way to handle mercury that benefits the present and future.
- Thermostat:** A device that controls temperature in homes or buildings and might contain mercury in older models, needing careful disposal.
- Toxic Substance:** Something harmful, like mercury, that can poison people or nature.
- Trophic Level:** A step in the food chain, like plants or fish, where mercury builds up.
- Urban Pollution:** Mercury problems in cities from homes or industries.
- Volatilization:** When mercury turns into a gas and escapes into the air.
- Waste Collection:** Picking up mercury waste from homes or streets for safe disposal.
- Waste Management:** The process of collecting, sorting, and safely disposing of mercury waste to protect the environment.
- Water Contamination:** When mercury gets into rivers or lakes, harming fish and people.
- Water Framework Directive:** An EU rule to keep water clean and safe from mercury.
- Wet Deposition:** When mercury falls with rain or snow to the ground.
- Wetland:** A swampy area where mercury can turn into methylmercury.
- Wildlife Protection:** Keeping animals safe from mercury damage.
- Zero Waste:** A goal to avoid creating waste, including mercury, by reusing or preventing it.
- Zero-Pollution Goal:** A plan to remove all harmful mercury from our environment.

Note



