Universiteit Utrecht

Sharing science, *shaping tomorrow*

Masters Thesis- Masters Sustainable Development

Estimating problem shifting from the Minamata Convention on Mercury

An assessment of the policy response and unintended impacts induced by the implementation of the Minamata Convention

Author: Sem Jans

Student number: 6543936

Email: s.jans@students.uu.nl

Supervisor: Dr. Rakhyun E. Kim

Second reader: Dr. Frank Biermann

Study programme: MSc Sustainable Development – Earth System Governance

Date: June 30, 2023

Summary

The challenge of global environmental governance lies largely in implementing effective solutions to environmental problems as articulated in multilateral environmental agreements (MEAs). Whilst these agreements aim to resolve their own problems, their implementation can generate new problems which may impact other people, places, and time, a phenomenon referred to as problem shifting. The assessment of problem shifting originating from multilateral environmental agreements has not been examined in a systematic manner. In this study, a first step is taken by assessing the Minamata Convention, an MEA tasked with the management of anthropogenic mercury emissions. To allow for a comprehensive assessment of the occurrence of problem shifting from the measures taken by countries to implement the Convention, national reports were used to extract over 1100 implementation measures, which were categorized into over 100 distinct types, based on the source of mercury, and type of measure implemented. These measures are then thoroughly examined against environmental literature to determine the nature of new problems that they have created. For instance, the identified measure regarding the prohibition of dental amalgam displaces the problem due to the increased occurrence and cost of restorative actions needed, resulting in financial and health complications for consumers. This analysis has identified eight measures that cause problem-shifting, generating problems in issue streams related to temporal and locational shifts in mercury and product management. Ultimately, the implementation of the Convention is hindered through costly systemic transformations and an overly simplified view of mercury management, resulting in the continuous degradation of environmental and human health, particularly for those of lower income. This assessment of problem shifts largely outlines the various types of shifts, the mechanisms through which they occur, and the impacts of the shifts. These results undermine the need for preventative and responsive measures to be established within MEAs, to avoid and mitigate the occurrence of such shifts. The methodology provided in this research may also be applied to the assessment of other agreements.

Acknowledgements

This work, and my mental status could not have prevailed without the continuous support of my advisor Dr. Rakyhun E. Kim, alongside my dearest friends and family. Mom and Dad, thank you for your everlasting and unconditional support and confidence in me, I am forever grateful. I want to acknowledge all the great moments, festivals, chats, and time spent with others during this master's degree. Everyone around me has made this time of my life some of the best.

Contents

Introduction

In the movement towards sustainable development, countries choose to work together in order to develop policies and strategies which can be used to tackle various sources of pollution, or environmental degradation. One tool used to formalize this international collaboration are multilateral environmental agreements (MEAs). Many MEAs are currently in force, addressing issues related to climate, energy, pollution, species protection and much more (Mitchell et al., 2020). However, despite the large quantity of MEAs in operation, we are faced with the continuous degradation of the environment, potentially related to the effectiveness of their implementation. Limitations to the effectiveness of these agreements can include a lack in scope or enforcement power, or issues within the treaty design (Escobar-Pemberthy & Ivanova, 2020). Recently, within the academic debate, another form of hindrance is becoming more apparent. The concept of problem shifting regards the unintentional consequences of solutions to environmental issues. When a solution for one problem is devised, and that solution generates new problems for different sectors, locations, peoples or for future generations, it can be considered problem shifting (Kim and van Asselt, 2016). The decisions made regarding the management of certain natural resources can have varying unintentional and detrimental impacts towards the management of other resources. MEAs and problem shifting have an inherently intertwined relationship, as MEAs aim to generate management systems which should resolve certain environmental problems and problem shifts are the resultant complications associated with those solutions. By assessing the occurrence of, and developing a greater understanding of the latter, progress can be made towards the enhancement of the effectiveness of MEAs.

The importance of problem shifting can be highlighted by delving into the implications that problem shifting holds in terms of hindering the effectiveness of different policies or measures targeted at resolving environmental issues. Whilst various problem shifts hold different levels of technical and environmental implications within their respective fields of analysis, it stands as a problem at all levels of environmental management. Across the hundreds of MEAs, and thousands of national policies that are resultant of those agreements, the potential amount of problem shifts is concerning. Thus, the improvement in the understanding of the nature of problem shifts, the magnitude of the impacts that they hold, for whom and where, and the relationship that they hold with MEAs is an important subject of analysis.

A similar concept in which this dilemma is discussed is that of risks emerging from response mechanisms. Response risks refer to instances in which systems designed to manage climate change either fail in their objective, or when these response mechanisms generate additional adverse outcomes due to their implementation (Andrews et al., 2023). In this framing, the additional adverse outcomes from response risks parallel the unintended consequences of problem shifts. The field of response risks is becoming increasingly aware of the interconnectedness of our global systems, the inter-regional/spatial/temporal impacts that our actions have, and the role that governance plays within the unintentional generation, and resolution of these impacts (Simpson et al., 2021). The increase in calls to action for governments to make changes in response to climate change, makes this field of study of much higher importance and interest. Identifying and analyzing failed response mechanisms allows for pivotal failures within governance systems to be addressed and adjusted to hopefully alleviate the unintended impacts that have been generated therefrom.

Within current academia, problem shifting is a rather under addressed subject field, with most articles covering niche subject fields on a smaller scale. This literature is focused on the quantitative assessment of problem shifts related to different technical measures within scattered subject fields. Whilst these studies are useful in terms of the context that they provide towards the effectiveness of sustainability management options within their respective fields, on a larger conceptual and analytical scale for problem shifting, the implications that these assessments provide are more limited. Because problem shifting provides an all-encompassing label for the unintentional consequences related to solutions for environmental problems, it can be expanded to a much larger scale of analysis. Utilizing problem shifting in a similar light as that of risks emerging from response mechanisms, will substantiate its importance in terms of global environmental management and risk assessment.

One MEA which can be assessed to better understand the linkage between problem shifting and MEAs, and the impacts that problem shifts can hold is the Minamata Convention. The Minamata Convention is an international treaty which has the objectives to protect people and the environment from the harms induced by mercury pollution. Entered into force in August 2017, this MEA stipulates legal obligation for countries to reduce or control the usage and emissions of mercury (Evers et al., 2016). Mercury is a naturally occurring element used for everyday products, such as in thermostats or as a chemical catalyst. Whilst it is naturally occurring, much of it is produced anthropogenically via industrial processes, such as the clinker process for cement production or the burning of fossil fuels (Evers et al., 2016). Mercury emissions are a great cause of concern for a multitude of reasons, primarily due to the detrimental impacts it has on human and ecosystem health. Mercury poisoning can result in neurological issues, alongside many developmental problems that impact humans, alongside many forms of marine life (Ha et al., 2017; Kessler, 2013; Esdaile and Chalker, 2018). Furthermore, mercury has the capacity to exist in the environment for long periods of time, and travel vast distances through bioaccumulation in fish, resulting in a greater area and population potentially exposed to mercury (Wang et al., 2019; Eriksen and Perrez, 2014). Because of these detrimental effects related to mercury exposure, the Minamata Convention was created to decrease the usage and emissions of mercury, hopefully alleviating these impacts (Bank, 2020). To support the effective transition away from mercury usage, the Convention outlines a multitude of provisions and actions that countries can follow in order to effectively control mercury releases. As a result of the Convention, each party to the Convention was required to submit a national report outlining the actions that have been taken to reduce mercury in their case. The case of the Minamata Convention was chosen for this analysis of problem shifting, due to the availability of information regarding the measures implemented by each country, and the potentially high probability of problem shifting resultant of the many measures established.

Research Aim and Objectives

Due to the contemporary nature of problem shifting as a concept, its little-understood connection with MEAs, and the importance of the Minamata Convention in the realm of environmental and human protection, this research aims to determine which problem shifts are resultant of the Convention, and the impacts that those problem shifts hold. To do so, this research will utilize the national reports created by each country to determine the actions taken and will assess those actions for their potential to induce a problem shift. With these objectives in mind, this research has the central research question of: *What is the impact of problem shifts resulting from the Minamata Convention?*

To structure the analysis, three sub-questions will be utilized. Firstly, to structure the assessment of the national reports, the first sub-question: *Which measures have been implemented by countries in response to the Minamata Convention?* will be used. Following the first phase of analysis, the second phase will be structured with the following two sub-questions: *Which measures of the Convention induce problem shifting? What are the impacts of the problem shifts resulting from the Convention?* These questions are employed to first delineate which measures result in problem shifting, followed by the assessment of the impacts of those problem shifts.

This analysis of the Minamata Convention will provide two key results. Firstly, an overarching review of the measures that have been implemented in response to the Minamata Convention will be provided. This review will highlight which sources of mercury are most targeted by countries, what types of measures have been utilized to manage those sources of mercury, and lastly, which regions have shown the highest rates of implementation. These results present the policy response to the Convention, highlighting largely prohibitive measures which countries have deemed to be the most suitable response mechanism towards managing mercury. Secondly, an overview of the problem shifting resultant of the Convention will be provided. This analysis will highlight which measures induce problem shifts, identify who, what, where, when those impacts will be felt, and who is responsible for the occurrence of those problem shifts. This research presents how the problem shifts have been found to have widespread spatial and social impacts, and how the Minamata Convention has played a central and causal role in the occurrence of such. Overall, this research aims to highlight problem shifting as a significant issue within the current field of global governance, to highlight its interconnectedness with MEAs and national policy implementation, and to provide recommendations on how such problem shifts can potentially be alleviated.

The research will be structured as follows, firstly a typology of problem shifts will be provided in the following section to highlight the various forms in which problem shifting can occur, and the types of impacts that each of those forms of problem shifts can induce Following this typology, a rigorous methodology outlines the research strategy and methods used in this research. Due to the novelty of national reports being used as a data type in this research, careful consideration is taken into how their contents will be systematically extracted and assessed. Further methods are generated to structure the analysis on which measures have induced problem shifting, and the impacts that those problem shifts hold. The research methodology is central to this research as the methods applied in this research can potentially be expanded to the assessment of other MEAs, in order to determine their potential for problem shifting. Once the methods have been clearly outlined, the results will be presented in two parts. Firstly, the results regarding the analysis of the national reports will be presented, highlighting insights regarding implementation rates, strategies most employed and the most targeted forms of mercury. Following this, the overview of the problem shifts resulting from key measures will be provided, highlighting the correlation between the Minamata Convention, the resultant global implementation of the measures, and the impacts felt by those problem shifts. Next, the discussion will highlight the connections and outcomes of the research, theoretical implications and contributions made, alongside the policy recommendations supported by the insights found within the analysis. Finally, the conclusion will answer the central research question, and provide the main insights of the research.

Theoretical Framework

Problem shifting is the central concept within this research and is the primary focus of analysis. Problem shifting has a multitude of definitions all centered around the concept of when a solution for one issue area comes with unintentional consequences or "backfires", resulting in the degradation of a different issue area (Kim and van Asselt, 2016; Galaz et al., 2012). Some of the more explored and concrete examples of problem shifting include the Montreal Protocol, where ozone depleting substances were prohibited, but resulted in an increased usage of harmful hydrofluorocarbons (Woodcock, 2023), or the current transition away from fossil fuels towards biofuels, which results in an increase in land transformation due to the increased necessity for the production of biofuel crops (Phungrassami and Usubhartana, 2021; Galaz et al., 2012). Whilst these are two of the more prevalent examples of problem shifting, there are many more examples, known and unknown, which hinder the total effectiveness of sustainability measures. The concept of problem shifting has already existed since the 1990's, van der Voet and van Oers (1998) have discussed the issue of problem shifting and the different forms of shifts, including shifts within the material chain, shifts to other material chains, shifts to other locations, shifts to future generations, and shifts to other functions (van der Voet and van Oers, 1998). Despite the acknowledgement of this issue, recent studies are now reintroducing the concept and are utilizing it to better address this type of hindrance in sustainability management.

The conceptual underpinning of problem shifting is complemented by the concept of risks emerging from response mechanisms. In the assessment by Andrews et. al. (2023), a typology of risks emergent from response mechanisms is outlined, highlighting the varying social, environmental, temporal impacts that may occur due to the implementation of a certain policy. Furthermore, Andrews highlights a "risk-response-feedback" which models the feedback between risks and their associated responses, encompassing a full-cycle assessment of the system at hand.

Below, this research has provided a typology of problem shifts, to expand on the concept of problem shifting, to highlight its many forms, and the impacts of each. This typology supports the past works of Van der Voets, by expanding on the forms of problem shifting identified, alongside highlighting a problem shifting mechanism, which compliments the "risk-response-feedback" of Andrews. This typology defines seven types of shifts, providing unique examples for each, and presents the mechanism through which each problem shift occurs. This typology serves as a framework in which the problem shifts that will be identified in this research can be labeled under.

Table 1. Typology of Problem Shifts

Type of Problem Shift	Definition	Key Examples	Problem Shifting Mechanism
Environmental	When the solution results in the generation of a new or similar problem related to the negative degradation of the environment.	Biofuels as a solution to fossil fuels (Yang et al., 2012)	Increased biofuel crop consumption → Increased land transformation → Increased eutrophication and water scarcity
Locational	When the solution utilized results in the degradation of other areas.	Renewable energy technologies	Increased demand for rare earth minerals → Increased mining in developing countries
Temporal	When the solution either doesn't fully resolve the problem (leading to future consequences, or results in another complication that would have to be dealt with in the future.	Nuclear Energy	Increase in nuclear waste → Unknown yet lasting impacts far into the future
Management	When the solution displaces the responsibility of management to another body, resulting in the negative impacts therefrom	Corporate environmental Responsibility (Peng et al., 2021)	Increase in corporate responsibility/power → Cost effective solutions are chosen → Decrease in environmental performance
Financial	When the solution generated requires a high financial input for implementation, resulting in either a lack of or insufficient implementation of the solution.	Renewable technologies (Min and Galle, 2001)	Renewable tech → financial barrier to implementation → Renewable tech is not chosen
Physiological	When the solution utilized results in some	Expansion of mining	Expansion of Mining → Increased informality →

Type of Problem Shift	Definition	Key Examples	Problem Shifting Mechanism
	populations being put at an increased risk of physiological damage.		Increased rate of individuals being placed in high-risk situations
Social	When the solution utilized results in some communities being put at risk of social disruption	Food safety regulations in the U.S.	Increased regulations → Increased pressure on smaller farming groups → Increase in anxiety in this group due to state-imposed pressure

The first three definitions have adapted the five types of problem shifts highlighted in Van der Voets (1998) research. The first shift, an environmental shift, was inspired by the "within the substance/materials chain" and "to other substance/materials chains" problem shifts. These shifts largely discuss the consequences related to solutions focusing on certain types of materials, resulting in other materials being used, generating new environmental problems. The second shift, a locational shift is based on the "shifting to other locations", which entails the transfer of the problem to a new location. Finally, the third shift, a temporal shift, is related to the "shifting to future generations", which entails the transfer of the problem to future time periods. Van der Voets work allowed for a useful assessment of problem shifts within the material chain of events, however, in sustainable development research, there is an inherent human aspect which should be taken into consideration. To expand upon the forms of problem shifts, human, social, financial and managerial aspects will be integrated into the problem shifting typology.

The fourth shift is a management shift, in which the responsibility for managing a certain system/product/waste is shifted from one person/business/institution to another, and that transfer resulting in the mismanagement of the system/product/waste (Belal et al., 2015). The fifth problem shift is a financial shift, in which financial burdens or costs act as a significant blockade to implementing environmental solutions. This was chosen to be classified as a problem shift due to the increasing frequency of such events, alongside environmental solutions often being coupled with expensive technologies which cannot be universally applied due to their cost. The sixth problem shift is the physiological shift, where human impacts are regarded within the problem shifting concept. This shift refers to situations where environmental solutions are implemented at the (un)intended expense of an individual or larger group's physiological health. The final problem shift is the social shift, in which a social group/community is negatively impacted due to the implementation of an environmental solution. As highlighted in the example, many communities can be inadvertently impacted due to the implementation of solutions, signifying the necessity to include human impacts within the conceptual framing of problem shifting.

This typology will be utilized in this assessment to not only expand upon the concept of problem shifting, but to also utilize it to categorize the various problem shifts that will be identified.

Methodology and Research Strategy

This section will be structured as follows, firstly, the primary types of data that will be utilized will be detailed, explaining what they pertain and the purpose that they each serve in the context of this research. Following, the research strategy will be outlined, in which the entire research process will be broadly explained, highlighting the key details for each phase of research and their core objectives. Finally, the specifications regarding the methods used, and systematic analysis of the content will be explained.

Data Types

The first subject of analysis within this research will be the National Reports published by the countries who have signed to adopt the Minamata Convention. National reports have been chosen as the primary subject of analysis as this is the document in which countries state their current practices regarding mercury usage, collection and disposal. Furthermore, via the Minamata Convention, countries are obligated to state the policies and other actions undertaken in response to the Convention within the national reports. The national reports all follow a similar format in which the countries specify the actions they have taken to comply with each article of the Convention. The national reports are expected to provide a plethora of information regarding the measures that countries have implemented, alongside which practices a country is doing which involve mercury usage. For this analysis, the number of national reports includes all countries which have submitted them as of 17 January 2023, when the data collection process began, resulting in an assessment of 92 percent of countries, or 123 national reports.

The last form type of data that will be used within this research is literature on problem shifting/shifts. This form of data will be extracted via an in-depth literature review. The literature on problem shifts will aim to describe how certain implementation measures can have unintended consequences to their implementation. Existing literature already covers some implementation measures associated with the Minamata Convention such as Kosai (2022). These forms of literature describe how various implementation measures result in problem shifts, and the magnitudes of those problem shifts. The utilization of existing literature on problem shifts related to various implementation measures for the Minamata Convention will allow for a comprehensive assessment to be made regarding what problem shifts do exist, and what areas/people/times will be impacted by those problem shifts.

Research Strategy

In order to answer the central research question, three sub-questions are utilized to separate the various phases of analysis, alongside the differing forms of data and methods used to answer each. Outlining the research process, figure 1 highlights the research strategy used in this analysis.

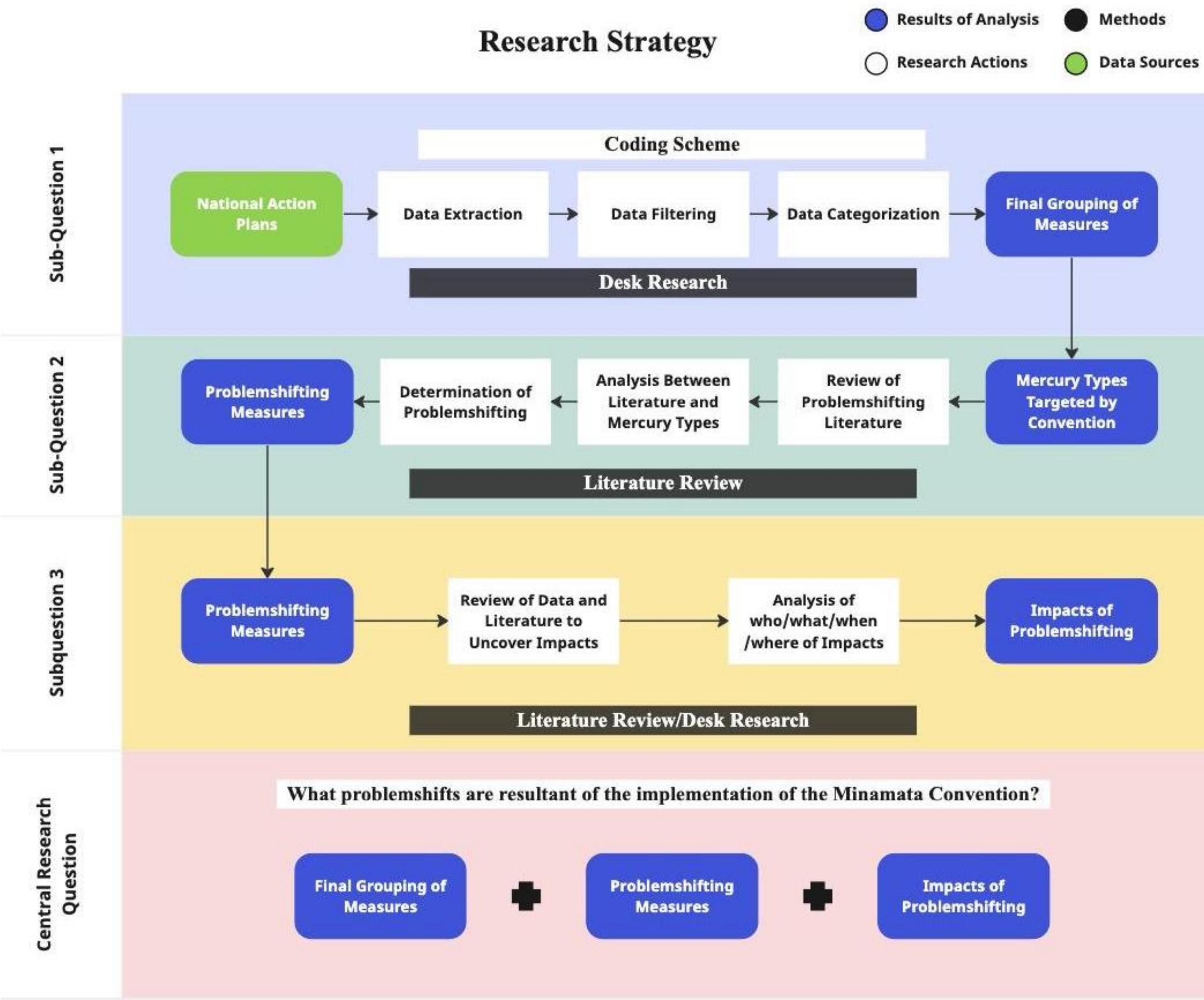


Figure 1: Research Strategy

As highlighted in figure 1, the research is divided into three distinct phases. The first phase answering sub-question 1 began with the national reports as the primary source of data. Utilizing a coding scheme, the relevant content was extracted, filtered and categorized from the national reports, resulting in an overview of the global implementation of measures resulting from the Minamata Convention. Next, the identified sources of mercury, and associated strategies to reduce their presence were assessed for the potential for problem shifting utilizing a semi-systematic literature review. Once the most prevailing problem shifts have been identified, the final phase of analysis determined the impacts of those problem shifts. As a result, utilizing the three primary results, stemming from the analysis of each of the sub-questions, the central research question could be answered.

For this research, primarily qualitative forms of data were used within the assessment. Qualitative data analysis is used across the board in environmental governance research. It serves as a tool which can allow for large-scale data analysis projects, which can allow for similar sets of questions and variables to be assessed across a multitude of cases. This potential allows for comparisons to be made cross-scale and cross-nationally (O'Neill et al., 2013). Qualitative analytical methods have been shown to be more "adept at capturing complexity, linkages, and scale in contemporary GEG that characterize, for example, the interactions across different issue areas" (O'Neill et al., 2013, p.449). Contemporary qualitative research utilizes various methodological approaches and attempts to combine said approaches, in which new analytical frameworks can be created. The abovementioned factors and capacity for qualitative research to produce overarching assessments of large-scale dynamics is central to the aims of this research and is justifiably used in this case. In the following section, the in-depth methodology and strategies used to conduct each phase of research will be outlined.

Methods

Sub-Question 1

Answering the first sub-question of: *Which measures have been implemented by countries in response to the Minamata Convention?* is primarily centered around the refinement and analysis of national reports. The key outcomes of this refinement process include the identification of implementation measures, and categorization of such based on the sources of mercury, and types of policy response used. This categorization provides useful insights into the policy response of the Convention and allows for the data to be utilized in the later stages of research.

To support this analytical process, content analysis was employed as the primary method to refine the data in a systematic manner. Content analysis as a strategy aims to refine large amounts of data into a manageable amount for analysis (Beck et al., 2010). The method of Content Analysis has been used in the field of environmental studies through the analysis of policy in technical reports or other forms of policy-related documents (Hall and Steiner, 2020).

Whilst various forms of content analysis exist, this research follows a mechanistic study in which a clear rule setting procedure is used to identify implementation measures amongst a large scale of qualitative data. This phase of research was conducted through a three-step process, in which the objective of systematically assessing the contents of the national reports could be met. Below, table 2 highlights the three-step process, with the various tasks/objectives associated with each step.

Table 2: Three Step Content Analysis

	1: Data Extraction	**2: Data Filtering**	**3: Data Categorization**
Strategies	1: Identification of relevant articles 2: Extraction of data	Rules procedure for data filtering	1: Coding procedure for categorization 2: Grouping Procedure
Outcomes	Raw Data	Implementation Measures	Coded Measures and Categorized Data

Data Extraction

The data extraction phase began with the assessment of national reports submitted to the Minamata Convention website. As of 17 January 2023, 92 percent of countries (123) have submitted national reports, which contain information regarding a country's current practices, and plans to manage mercury within their case. These documents have been collected as open source via the Official Minamata Convention website. The process of data extraction from these reports has two key steps, the identification of relevant articles for analysis, and the extraction of the appropriate text.

To determine the “relevancy” of each article of the Convention for this analysis, the core objectives of each article were assessed, alongside the information that would be provided within the national reports. Below, table 3 highlights each article of the Convention, the topic that each article covers, whether it was chosen to be part of this analysis, and the rationale behind the (non)selection for further analysis.

Table 3: Selection of Articles for Analysis

Article	**Topic**	**Selection**	**Rationale**
1	Objectives of the	No	Contents Define the Objective

Article	Topic	Selection	Rationale
	Convention		of Convention
2	Definitions	No	Contents are Based on Establishing Definitions
3	Mercury Supply Sources	No	Contents are for Informative Purposes
4	Mercury Added Products	Yes	National Policies are Outlined
5	Manufacturing Processes	Yes	National Policies are Outlined
7	Artisanal and Small-Scale Gold Mining	No	Number of Measures Exceeds This Research's Capacity
8	Emissions Sources	Yes	National Policies are Outlined
9	Releases of Mercury	Yes	National Policies are Outlined
10	Storage of Mercury	Yes	National Policies are Outlined
11	Mercury Wastes	Yes	National Policies are Outlined
12	Contaminated Sites	No	Contents Describe Decontamination Procedures
13	Financial Resources	No	Contents are for Informative Purposes
14	Capacity Building	No	Contents are for Informative Purposes
15	Implementation and Compliance Committee	No	Contents are for Informative Purposes
16	Health Aspects	No	Contents are for Informative Purposes
17	Information Exchange	No	Contents are for Informative Purposes
18	Public Awareness	No	Contents are for Informative Purposes
19	Research and Development	No	Contents are for Informative Purposes
20	Implementation Plans	No	Contents are for Informative Purposes
21	Reporting	No	Contents are for Informative

Article	Topic	Selection	Rationale
			Purposes
22	Effectiveness Evaluation	No	Contents are for Informative Purposes
23+	Convention Details	No	Contents are for Informative Purposes

As highlighted above, the selection of relevant articles for analysis was done with the core objectives of the research in mind. Because this research aims to identify problem shifts resulting from the policies implemented in response to the Convention, only articles containing/stating the national policies established by each country were selected. As shown above, many of the articles were not chosen for analysis due to their objectives pertaining to information exchange and definition setting. These objectives are not relevant for the case of this research as they do not provide any information pertaining to measures which have been implemented to manage mercury. Conversely, articles 4-11 were chosen (with the exemption of article 7) for assessment because the content provided within the national reports includes national policies (implementation measures for the management of mercury) that countries have established, thus rendering them useful for further assessment.

The following step after the selection of relevant articles was the extraction of data from each of the national reports. Due to the uniform format of every national report, the data could easily be extracted from each, allowing for further assessment to be conducted. The national reports were structured by each article of the Convention, and under each, countries were asked to specify their practices, in a qualitative format. The sections where countries would outline their practices, were extracted into an excel file, noting the country, and article from which the data was extracted. This bulk of data that was extracted was labeled as "raw data" which would be assessed and refined in the following stages. The uniformity of national reports also enhances the comparability of the data for further stages of analysis.

Data Filtering

Following the completed data extraction phase comes the data filtering phase, in which the raw data was filtered to extract only the "implementation measures" from all the data provided. Clear guidelines were not explicitly provided on how countries should report their current practices, therefore, much variation between the raw data was observed. Within the raw data, countries have provided information regarding measures or legal codes established, a country's current and past regulations, or current status of practices. Despite the resourcefulness of some of this information, this filtering process aimed to only extract the implementation measures.

In order to maintain consistency throughout the data filtering phase, this research chose to define “implementation measures” as a country’s policies, practices or actions implemented to manage mercury. The criteria which were used to filter the “implementation measures” from the rest of the unnecessary content is provided in table 4 below.

Table 4: Criteria for Filtering of Implementation measures

Content Regarded as Implementation Measures	Definition/Examples
Actions Taken	- Prohibitions/bans - Emissions limits/standards - Awareness programs - Phase out plans/National objectives - Promotion of alternatives - Management controls
Resolutions/Regulations	Any resolution/regulation/law implemented by countries, independent of any text explaining their objective *E.g., EU Regulation 2017/852*
Implemented Directives	The implementation of directives/rules/measures established in other Conventions/Frameworks/Directives *E.g., Basel Convention*

By utilizing the criteria for what can be regarded as an implementation measure, the large quantity of raw data was able to be filtered. For each raw data section, multiple measures could be extracted, as a result, from the filtering phase, approximately 1100 individual measures were extracted from the national reports.

Data Categorization

To fulfill the objectives of the content analysis, the 1100 measures were refined into a more manageable number, to make them more resourceful for analytical purposes. To do so, a large-scale categorization of the measures was conducted. The categorization process was conducted through a coding process, in which codes were attached to each measure, and the measures were organized based on the codes given. Coding is a widely used analytical tool in which codes are assigned to various words, phrases, sentences or paragraphs in relation to a specific setting (Basit, 2003).

Within the coding scheme, multiple codes were assigned to each measure to effectively categorize measures based on the type of mercury that is being targeted, and the type of measure that is being implemented. The two primary categories of mercury type and measure type were chosen due to their respective purposes of identifying the source of mercury targeted by each measure, and the mechanism/measure utilized to combat that source of mercury.

The coding process was done manually in excel. Whilst various programs can automate the coding process, the manual coding process was necessary due to the lack of uniformity in which countries have specified their practices. Furthermore, it was not clear what was targeted within each measure, so automated codes could not be preemptively assigned. Due to the lack of consistency, and the high variety of diction used by each country, the coding process was done manually. Alongside this, the codes were generated iteratively throughout the analytical process. Furthermore, due to instances of insufficient information to determine the actions taken within a policy, a utility category is used for individual purposes to determine and highlight which measures can be used for the analysis, based on the clarity of information provided. Below, table 5 provides an example of the coding process utilized in this research, and the contextual variables necessary for the proper attribution of codes to measures.

Table 5: Example of Coding Process

Country	Article	Measure	Mercury Type	Measure Type	Utility
Switzerland	4.4	It is prohibited to place on the market electrical and electronic appliances which contain batteries with more than 5 mg of mercury (Annex 2.15 ORRChem).	Batteries and Electronics	Mercury Content Limitation	Clear
Uganda	5.2	A person shall not use mercury or mercury compounds in Acetaldehyde production or import mercury or mercury compounds for the same purpose after the phase-out date of 2018	Acetaldehyde Production	Prohibition	Clear
Eswatini	9	The Water Pollution Control Regulations 2010 prohibits the release of effluent containing more than 0.001 mg/L of mercury.	Mercury Releases	Limitation	Clear

As highlighted above, in assigning codes to each measure, key phrases within the implementation measures were highlighted to identify either the type/source/product of mercury (highlighted in blue) and the type of measure that has been used to manage that source of mercury (highlighted in red). Utilizing the information provided in each measure, this method of coding was used to assign codes to each of the 1100 implementation measures, facilitating the proceeding categorization process.

The categorization process was done via grouping the measures based on the mercury type, and the measure type. After doing so, three key findings were made. Firstly, across all the implementation measures, only 28 sources of mercury were targeted. Along the same lines, only 20 types of measures were employed to combat those sources of mercury. Finally, of the 28 sources of mercury, and 20 measure types, 120 unique combinations of the two appeared across the implementation measures. These combinations were defined as "grouped measures" and were labeled using the combination of the mercury type and measure type, e.g. (Mercury type: Batteries, Measure type: Limitation, Measure Name: Limitation on Mercury Content in Batteries). The 120 grouped measures provide detailed information into the types of actions that countries have taken in order to regulate mercury within their case (provided in Annex D). Within the results section, these results are expanded upon.

Sub-Question 2

The implementation measures identified within the first phase of this research have come in the form of 28 mercury types, accompanied by 20 measure types. The identification of implementation measures has promoted a better understanding of how mercury is currently being managed in response to the Convention, however, a further assessment can be done on the potential pitfalls of this implementation. This section aims to address the methods used to answer the second research question of: *Which measures of the Convention induce problem shifting?* To do so, the results obtained whilst answering the first sub-question were utilized alongside relevant environmental literature to ascertain whether problem shifting is occurring in each instance. This section presents the methodology used to create this framing of problem shifting occurring within the Convention.

To answer the second sub-question, the 28 mercury types, and responses to manage such, were scanned across environmental literature to assess where problem shifts stem from. It is assumed that some measures have been sufficient in their objective of managing mercury. Subsequently, it is assumed that other measures do not fulfill their objective, and result in some degree of problem shifting, thus, this section will aim to highlight the methods of how those problem shifts are identified.

This assessment of problem shifting was conducted through a semi-systematic literature review (SSLR). Literature reviews as a research method have been found to be resourceful in many facets of academic work, as to systematically synthesize previous work, and to build a foundation for advancing a current conceptualization of knowledge (Snyder, 2019). This research has found this method of data collection as the most viable form due to its potential for knowledge synthetization, alongside the volume of information that must be collected for this phase of research.

The first phase of the SSLR was the selection of search terms. The selection of search terms is largely based on the results of the first sub-question, used in tandem with connotations of the term problem shifting. The objective of this SSLR is to determine whether the varying measure/mercury types have resulted in the generation of problem shifts. Therefore, the measure/mercury types are examined alongside terms relating to problem shifting (unintentional impacts). The literature search process, using the mercury types, boolean search operator, and problem shifting terminology is highlighted in table 6 below.

Table 6: SSLR Mercury Type Search Process

Mercury Keywords	Boolean Search Operator	Problem shifting Keywords
25 Mercury Types Identified in Sub-Question 1	And	Problem shifting Unintentional/Adverse + Impacts/Consequences Burden Shifting Tradeoff Risk/Benefit

Note: The 28 mercury types identified by sub-question 1 were reduced to 25 due to the exclusion of the mercury types: specified processes (a reiteration of CCP, CFI, CFB, SNR, WIF), unclear regulations and EU regulation 2017/852.

The SSLR search process highlighted in table 6 highlights the general search process utilized to identify literature which supports the notion that problem shifting is occurring in the varying cases of mercury management.

Firstly, within the first column, the primary target of analysis was the 25 types of mercury that have been identified in sub-question 1. This decision to prioritize the analysis of the mercury types compared to the other types of data identified in sub-question 1 is rationalized for a multitude of reasons. Primarily, the connection between the mercury types and the Convention is clear. Currently, no other conventions or actions target these types of products/sources of mercury, thus within the articles identified, the connection between the Minamata Convention and the effects of the type of mercury is present. Secondly, within the search process, the connection between management responses to the mercury sources is implicit, thus the resulting literature will also cover the associated response mechanisms to the sources of mercury.

This rationale is further supported due to the pitfalls of the other search processes that could have been utilized. Firstly, if measure types were chosen as the primary target of analysis, issues arise with the search strings becoming too long, or lacking a connection with the Minamata Convention. Without an additional keyword specifying the Minamata Convention in the search string, the measure types could relate to many other fields of political and environmental problems, with the resultant literature being very broad and in-applicable to the current research. Furthermore, the choice to use the 120 grouped measures was proposed, however, the process of scanning the 120 grouped measures against the many problem shifting keywords would result in the search phase being far too long. Due to the many aforementioned factors, the mercury types were used as the primary target of analysis.

Alongside the mercury types that are used in the search process, are the problem shifting keywords. The problem shifting keywords highlighted in table 6 are terms which were deemed to fit the purpose of this search process. Whilst problem shifting could be the one term applied, due to the low usage and recognition of this concept, this would likely result in a low number of articles which could be utilized for this analysis. Therefore, terms such as unintended impacts, or tradeoffs were utilized, as they share a similar definition to the concept of problem shifting, and results in a higher likelihood of relevant articles being found. The necessity for other terminology to be used is less of a limitation to this work, but rather, a lack in the concept of problem shifting being applied within current academia.

From the search process, there are several criteria which were aimed to be met. The first criterion is whether there is literature which covers the specified mercury type/source and the problem shifting keywords. If the search strings provided no results, then there are two possibilities. One is that there is no occurring/observable problem shift, or that there is no literature or studies which have assessed the potential of such. Regardless, the mercury sources with no relevant literature are assumed to be the former for simplicity purposes. If literature does exist, a minimum number of n=5 articles is necessary to derive that the phenomenon is somewhat present and has been identified by numerous/varying assessments. By utilizing the information found within the articles, a determination of the occurrence and type of problem shift was made, categorizing the shift as one of the seven types of shifts outlined in table 1, the problem shifting typology. Resultant of this search process, eight mercury types have been identified as significant sources of problem shifting. This identification of shifts was used for the answering of the third sub-question.

Sub-Question 3

To answer the third sub-question: *What are the impacts of the problem shifts resulting from the Convention?* A similar strategy of literature review is done; however, this search expands the types of literature used from only academic articles to governmental reports or findings regarding the phenomena of problem shifting currently occurring. This process aims to result in information regarding the mechanisms through which the problem shifts occur, the general impacts that can be felt as a result of the shift, followed by a scaling of the magnitude of those impacts.

Firstly, the articles identified in answer sub-question two will already provide some insights into the mechanisms, and types of impacts that would be felt from the resulting problem shift. Followed by examples of impacts felt in individual cases, the impacts of the shifts will be outlined in broader terms, highlighting how the problem shifts occur, through what mechanisms, and the end results of the problem shifts.

Whilst the identification of these impacts is central to the research, it is essential to also provide a scaling of the impacts, to highlight the magnitude of the shifts, and for which regions or groups of people the impact will be most felt. To provide a structured format from which the magnitude of the impacts of the problem shifts can be scaled, a self-modified version of the qualitative environmental impact assessment (EIA) provided by Toro et. al. (2013) was used. Whilst the full EIA utilizes a multitude of metrics to transform qualitative data to a quantitative full environmental impact rating, this research has chosen to utilize the scaling procedure for the variables of intensity and extension to determine the magnitude of the impacts. These variables address "incidence of the action on the environmental factor" and "area affected by the impact in relation to the total area of the surroundings" respectively. However, as EIAs address solely environmental impacts, and this research includes social, financial and temporal impacts in the analysis, these variables will be slightly modified to fit the broader nature of this research. Below table 7 highlights the variables, their modified definitions and the criteria by which they will be evaluated.

Table 7: Modified Qualitative Impact Assessment (Variables and Criteria)

Variables	**Intensity**	**Extension**
Definition	Incidence of the action on the [problem shifting] factor	Area [or group] affected by the impact in relation to the total area [or population]
Criteria	Low Medium High Very High	Isolated Partial Widespread Total

As highlighted in table 7, slight adjustments have been made to the definitions of the variables. Firstly, for intensity, the incidence on the action on the [environmental] factor was replaced with the [problem shifting] factor. This is done as each of the measures that have an identified problem shift, will also be attributed a certain type of problem shift, which has each of its own implications (e.g., financial problem shift, the action will have an influence of the financial factor). Whilst the problem shifts have extended impacts beyond the direct problem shift, each chosen factor will be clearly outlined within the respective sections in the problem shifting analysis. The intensity factor will then be scaled from low to very high. Whilst this judgment is challenging due to its subjective nature, as addressed by Toro, the research will justify the rationale based on the supporting evidence per measure. Secondly, regarding the variable of extension, alterations were made to include peoples in what is felt by the impact. Previously, the variable only regarded area impacted, as it is an environmental assessment criteria, however, due to the inclusion of social variables in this research, this variable was expanded to include groups of people within the impacts. The variable of extension will be scaled from isolated to total impact. Whilst this judgment faces similar complications regarding subjectivity, the same rationale based on context will be used. Using these two variables, the scale/magnitude of the problem shifts will be more structurally defined. Below the case of the transition towards biofuels will be utilized as an example of the magnitude assessment process.

The transition towards biofuels aims to reduce emissions via the replacement of traditional fossil fuels with the renewable form of biofuels, generated via the cultivation of corn, algae, and other crops. This transition, however, induces an environmental problem shift, via an increase in land transformation and nitrogen emissions. The inclusion of the impact of land use changes of first-generation biofuel crops potentially leads to GHG emissions targets not being met, with ranges of GHG emissions ranging per study from very small to very large (Jeswani et al., 2020). The potential changes in nitrogen increase have been found to potentially result in a net zero relative GHG emissions savings compared to petrol (Jeswani et al., 2020). Based on these aforementioned impacts, the [problem shifting] factor which will be utilized for the assessment on intensity will be the environmental impact. Concluding from the points highlighted in red, the environmental intensity of this shift can be labeled as medium, as the transition potentially results in a net zero change within the impact on GHG emissions. Regarding the extension of this impact, the total area could be considered on a national scale, as biofuel transitions typically stem via national policy. The impacts of emissions increase/reduction span across the entirety of a country, resulting in the impacts of this shift being widespread.

As highlighted above, the points of context highlighted in red have been applied to grade the intensity and extension of the impacts related to the problem shift of the transition to biofuels. Utilizing this procedure of scaling, the problem shifting analysis will aim to assess the magnitude of each shift in this manner.

The problem shifting section will conclude by highlighting the connection between the Convention, the mechanism through which the measure occurs, and the resulting implementation of the measure on a global scale. This analysis of the impacts will not conclusively determine the occurrence of problem shifting in each country's case; however, it rather aims to highlight the problem shift that can result from the implementation of the highlighted measure. Thus, for the countries which have implemented a problem shifting measure, they stand at a risk point where they could experience the highlighted impacts.

The results section will be structured as follows, firstly, the insights found regarding sub-question one will be covered. Whilst the first sub-question aims to identify which measures have been implemented, many other insights regarding implementation rates, most used strategies or most targeted mercury sources will be provided. Following this, sub-questions two and three will be answered together within the same section. This section will cover each of the problem shifts identified via the SSLR. Each problem shift will be discussed individually, highlighting the measure that induced the shift, the connection between the Convention in that measure, and the resulting implementation rate of such. Additionally, the mechanism through which the problem shift occurs is outlined, followed by the impacts of the shift. Finally, the criteria from the qualitative EIA will be used to scale the level of the impacts based on intensity and extension, rounding off the analysis.

Results

Implementation Measures

To answer sub-question one: *Which measures have been implemented by countries in response to the Minamata Convention*, the content analysis of the national reports was conducted in order to identify and extract the 1100 implementation measures that were reported by the 123 countries which submitted their reports. As a result of the content analysis, the 1100 measures consisted of the targeting of 28 types/sources of mercury, alongside the utilization of 20 types of measures to combat the aforementioned sources of mercury (definitions for both are provided in Annex B). Highlighting the prevalence of each type of mercury and measure, figures 2 and 3 present the most targeted forms/sources of mercury and the most used strategies to combat the sources of mercury.

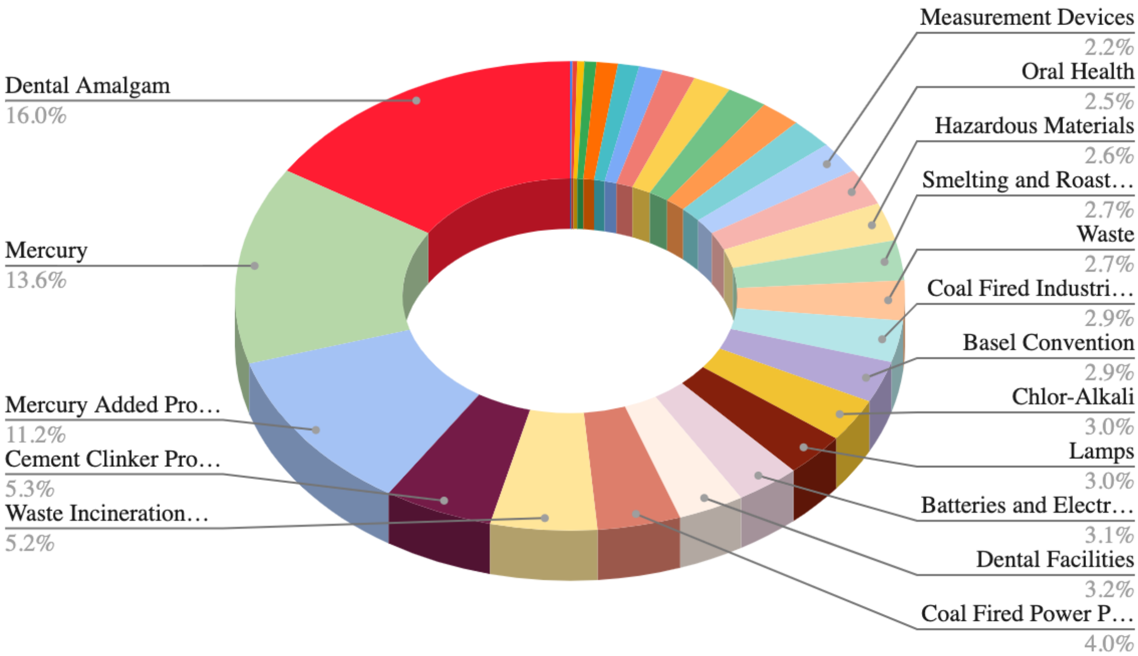


Figure 2: Overview of Mercury Types

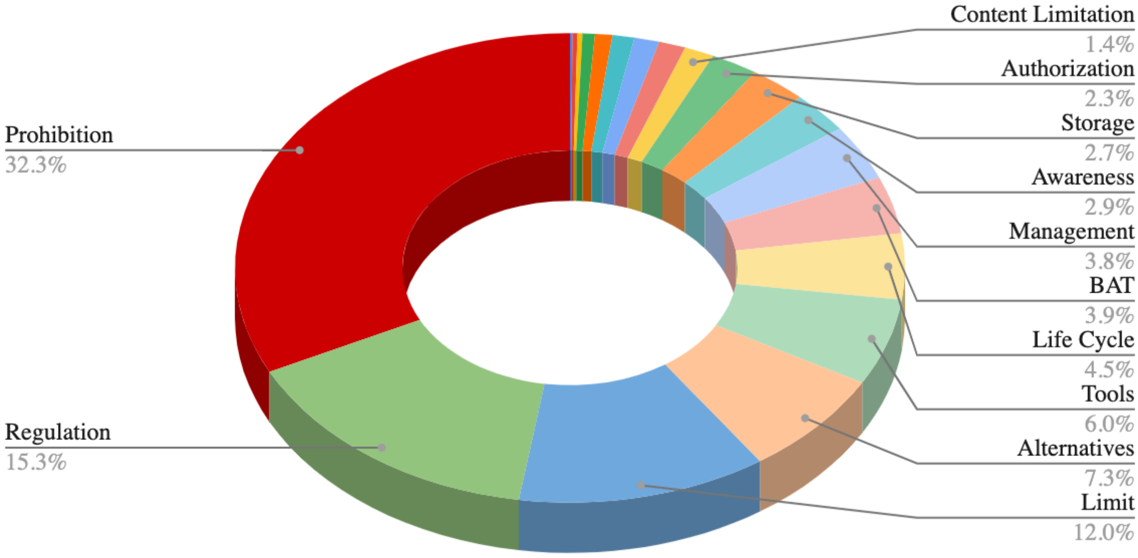


Figure 3: Overview of Measure Types

Firstly, as a result of the Convention, the most targeted sources of mercury are dental amalgam, elemental mercury, and mercury added products (MAPs), with 140, 119 and 98 measures being implemented in response to each respectively. The high occurrence of measures being implemented for these sources of mercury can be due to a multitude of factors. Firstly, some sources of mercury have multiple response mechanisms which can be used simultaneously. For example, in the case of dental amalgam, diverse mechanisms include but are not limited to, the prohibition of, regulation to the encapsulated form, and the requirement for the installation of separators. The multitude of mechanisms which can and are used, results in a high response rate to combat this source of mercury. Furthermore, a high potential of danger can also result in the high occurrence of measures being implemented in response, as seen in the case for elemental mercury. Finally, another rationale behind the high occurrence of measures can be the widespread utilization of a certain source of mercury, such as in the case of MAPs, with the many and diverse types of products in which mercury is used. Despite the multitude of factors, the fact that these sources were the most targeted symbolizes a universal concern over the potential dangers that they pose for human and environmental well-being, and that action must be taken to alleviate those dangers.

Regarding the actions taken, as identified in the analysis, the most commonly used measure to manage the various sources of mercury is a prohibition, consisting of 271 measures, or 32 percent of all measures. This result highlights a logical correlation between the measures implemented and the objectives of the Convention, as the central goal is to reduce/eliminate the usage of mercury, with one of the most direct ways of doing so is through a direct prohibition or the phase out of its usage. Furthermore, considering the various types of mercury that are targeted (products, uses of mercury, or forms of mercury), the direct prohibition of such is a direct method to avoid any further consequences related to those sources of mercury.

The second most used type of measure is a regulation, with 128 measures, and 15 percent of total implementation. The high usage of this approach can be due to the expansive nature of the definition of regulations, as they entail a broad rule set or list of actions taken. The definition of regulation provided in this research highlights a comprehensive and general approach for regulatory action. The observed high usage within the implementation measures highlights its broad applicability in the management of mercury, with regulations being used in response to 52 percent of the sources of mercury. Whilst the more general nature of regulations challenges the understanding of what is actually being implemented, they entail a "softer" form of policy in comparison to a prohibition (Brennan and Brooks, 2011), in which rules, principles or guidelines around the usage of mercury are established.

Following a similar form of "softer policy", the third most used measure type is a limit, consisting of 101 measures or 11 percent of implementation. A limit in this research characterizes a limitation on the usage of mercury, or the amount of mercury which can be released during a specified process. This approach has been observed primarily to be used in the context of the limitation of mercury emissions associated with the industrial installations mentioned in Article 8 of the Convention (Releases of Mercury). This approach, like regulations, establishes a set of rules which must be followed, allowing for the continuation of certain processes to occur, but under stricter conditions. The high utilization of this approach symbolizes an inability to stop certain processes which utilize/produce mercury, thus the central action taken is to reduce the amount of emissions as much as possible.

The rest of the types of measures, whilst combined only consist of a third of measures implemented, still serve their unique purposes in terms of managing the many ways in which mercury is currently utilized within our global system. Whilst not actively used in the rates shown with prohibitions, regulations, and limitations, each of the measures do have their own objective which contributes to the goal of mitigating mercury usage and the impacts that stem from that.

To expand upon the mercury sources, alongside the types of measures identified within the content analysis, table 8 presents an in-depth perspective of the implemented measures. To do so, the results are structured by mercury source, followed by the various types of measures utilized to combat that source of mercury (times implemented in parentheses). Furthermore, information regarding the articles in which the measures were implemented is presented, alongside the sum of measures implemented in response to each source of mercury, and the continental distribution of that implementation.

Table 8: Overview of Mercury Types, Methods of Intervention, and Implementation

* Symbols (E), (ME) and (II) as a prefix before some measures regards emissions, mercury emissions and industrial installations respectively

Mercury Source	Measures	Articles	Implementation	Continental Distribution
Acetaldehyde	Prohibition	5.2	10	1-AF 2-AS 7-EU
MA Batteries and Electronics	Life Cycle (1) Limit (10) Prohibition (12) Regulation (4)	4 4.4 4.5	27	2- AF 6-AS 13-EU 2-NA 4-SA
Chlor-Alkali	Alternatives (3) BAT (1) Decommissioning (5) Prohibition (14) Tools (3)	5.2	26	6- AF 1-AS 15-EU 1-NA 3-SA
MA Cosmetics	Content Limitation (3) Prohibition (13)	8.2	16	4-AF 6-AS 2-EU 3-NA 1-SA
Dental Amalgam	Awareness (6) Alternatives (29) Content Limitation (13) Life Cycle (15) Prohibition (52) Regulation (20)	4 4.2 4.5 9	140	26-AF 41-AS 56-EU OC-1 9-NA 7-SA
Dental Facilities	Alternatives (10) Life Cycle (18)	4.3 11	28	7-AF 4-AS 8-EU 7-NA 2-SA
Cement Clinker Production	(E) BAT (4) (E) Limit (8) (E) Regulation (2) (E) Tools (5) Inspection (1)	8.2	46	4-AF 7-AS 26-EU 5-NA 4-SA

Mercury Source	Measures	Articles	Implementation	Continental Distribution
	(II) BAT (9) (II) Authorisation (3) (ME) Limit (11) (ME) Regulation (3)			
Coal Fired Industrial Boilers	(E) Limit (6) (E) Regulation (4) (II) Regulation (4) (ME) Limit (11) (ME) Regulation (2) (ME) Tools (2)	8.2	25	3-AF 6-AS 12-EU 1-NA 3-SA
Coal Fired Power Plants	(E) BAT (4) (E) Limit (4) (E) Regulation (5) (E) Tools (4) (II) Decommissioning (2) (II) Regulation (4) (ME) Limit (4) (ME) Regulation (3) (ME) Tools (5)	8.2	35	4-AF 8-AS 19-EU 2-NA 2-SA
Smelting and Roasting	(E) Limit (3) (E) Regulation (6) (ME) BAT (5) (ME) Limit (2) (ME) Regulation (3) (ME) Tools (5)	8.2	24	1-AF 3-AS 16-EU 1-NA 3-SA
Waste Incineration Facilities	(E) BAT (6) (E) Limit (5) (E) Regulation (9) (E) Tools (4) (II) Regulation (4) (ME) BAT (2) (ME) Limit (13) (ME) Regulation (2)	8.2	45	6-AF 8-AS 21-EU 4-NA 5-SA 1-OC
Hazardous Chemicals	Authorization (2) Labeling (1) Management (7) Regulation (4) Storage (9)	10 11	23	2-AF 11-AS 1-EU 1-NA 8-SA
Hazardous Chemicals	Implementation of Basel Convention	11	25	5-AF 7-AS 8-EU 2-NA 3-SA
Hazardous	Implementation of EU	11	17	17-EU

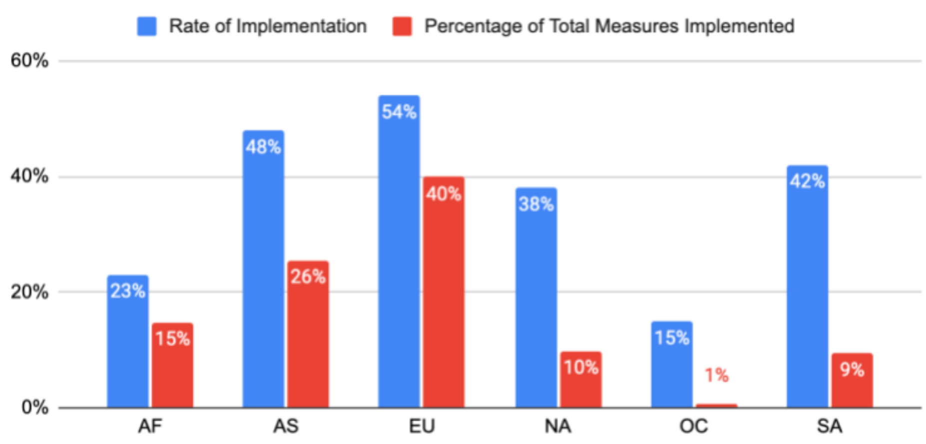
Mercury Source	Measures	Articles	Implementation	Continental Distribution
Chemicals	Regulation 2017/852			
MA Lamps	Alternatives (4) Content Limitation (3) Prohibition (12) Regulation (7)	4 4.4 4.5 11	26	8-AF 10-AS 1-EU 4-NA 3-SA
MA Measurement Devices	Alternatives (2) Authorization (1) Discontinued (2) Prohibition (13) Regulation (1)	4 4.4	19	2-AF 11-AS 2-EU 3-NA 1-SA
MA Medical Devices	Prohibition (4) Regulation (1)	4 4.4	5	1-AF 1-AS 1-EU 1-NA 1-SA
Mercury Added Products	Authorization (8) Alternatives (3) Awareness (4) Limit (3) Prohibition (59) Regulation (21)	4 4.4 4.5 11	98	15-AF 23-AS 40-EU 11-NA 7-SA 2-OC
Elemental Mercury	Alternatives (3) Authorization (8) Awareness (6) Disposal (5) Life Cycle (2) Limit (4) Management (11) Prohibition (40) Regulation (12) Storage (21) Transport (7)	4 4.3 4.4 4.5 9 10 11	119	12-AF 35-AS 43-EU 18-NA 10-SA 1-OC
Oral Health	Awareness (12) Prevention (10)	4.3	22	7-AF 2-AS 7-EU 4-NA 2-SA
MA Pesticides	Alternatives (1) Content Limitation (2) Prohibition (15)	4	18	2-AF 8-AS 2-EU 2-NA 4-SA
Polyurethane	Limit (1) Prohibition (8)	5.3	9	1-AF 1-AS 7-EU
Mercury Releases	Limit (10) Reporting (2) Standards (5)	9	17	2-AF 5-AS 6-EU 1-NA 3-SA

Mercury Source	Measures	Articles	Implementation	Continental Distribution
Safety	Regulations	3	3	2-EU 1-SA
Sodium/Potassium/Methylate/Ethylate	Limit (2) Prohibition (7)	9	9	9-EU
Specified Processes	Authorization	8.1	1	1-AS
Vinyl Chloride	Prohibition (12) Alternatives (2)	5.3	14	4-AS 10-EU
Mercury Waste	Disposal (4) Management (15) Transport (5)	11	24	4-AF 10-AS 6-EU 1-NA 3-SA
Unclear Regulations	Article 4 (7) Article 4.3 (12) Article 4.4 (7) Article 4.5 (13) Article 5.1 (12) Article 5.3 (3) Article 8.1 (2) Article 8.2 (50) Article 9 (14) Article 10 (10) Article 11 (16)		185	
EU Regulation 2017/852	Article 4 (14) Article 4.3 (5) Article 4.4 (9) Article 4.5 (13) Article 5.1 (3) Article 5.2 (10) Article 5.3 (3) Article 8.2 (14)		57	
Total			1113	125-AF 216-AS 338-EU 83-NA 80-SA 5-OC

Table 8 presents the 120 grouped measures, defined earlier, in a condensed format. The various combinations between sources of mercury and measures used are presented. Regarding the prevailing observations that can be made, in a very basic sense, the main sources of mercury come in the form of products or processes. This framing supports a broader correlation that can be made between the sources of mercury and the most commonly used management responses.

In terms of products, mercury sources such as MAPs, dental amalgam, electronics are all included. To manage mercury from these sources, the standard measures that have been applied include prohibitions, content limitations and regulations. The correlation between products and these types of measures highlights the ambition to realize a full transition away from the usage of mercury within products. Whilst a prohibition highlights a direct shift away, content limitations and regulations provide a period in which this transition can progressively occur. Ultimately, the goal is to eliminate these products from the market to avoid any negative impacts that these products cause. On the other hand, for processes such as waste incineration, vinyl chloride, and chlor-alkali production (mainly actions from Articles 5 and 8), the measures that have been applied include regulations, limits, BAT and tools. In this instance, this correlation presents a shift towards safer standards in which mercury is released or utilized. For these processes, the continuation of mercury releases has been deemed to be inevitable, thus the approach taken has been to minimize the releases from these sources via the utilization of best available technologies, and tools.

Alongside the correlative aspects between sources and measures highlighted in table 8, further insights regarding the continental distribution and rates of implementation are present. Below, figure 4 presents the response rates per continent for the Convention, the percentage of the total measures which each continent has produced, alongside the response rates per article of the Convention.



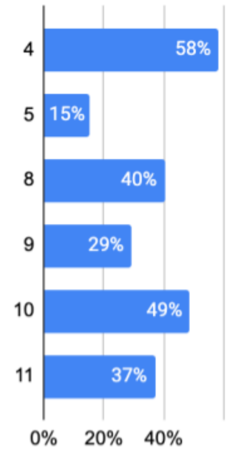


Figure 4: Continental and Article Implementation Rates

* Chart on left depicts the continental implementation rates, Chart on Right highlights the implementation rates per article of the Convention

Figure 4 highlights some important aspects of the research. Firstly, the total implementation rates across the various articles of the Convention and across all of the continents sits at approximately 37 percent on average. Generally speaking, time is necessary for the adoption of national policy after the ratification of MEAs (Nys et al., 2007), based largely on nationally contingent variables. Taking factors into account such as national capacity, and also instances in which certain practices are not present within countries, 37 percent is a decent implementation rate, early into the progress of the Minamata Convention. As highlighted by the bar chart on the right, it has been shown that articles 4, 8 and 10 have the highest implementation rates, symbolizing that mercury added products, emissions sources and the storage/trade of mercury are the most targeted aspects, aligning with the findings previously identified.

Europe, Asia and South America have also been found to have the highest response rates for all articles in the Convention. However, there is a slight disparity between the continental rates of implementation and the percentage of total measures implemented. In the case of South America which achieved an implementation rate of 42 percent, only has 9 percent of the total measures implemented, similarly observed in the case of North America. This can be due to either a lower number of countries on the continent compared to others, as well as fewer measures being established by countries per article. This finding highlights the need to show increased attention to the rates of implementation rather than the percentage of total measures implemented, as the former better highlights the progress made by the various regions of the world. Based on this understanding, Europe, Asia and South America have currently taken the most action to combat mercury.

To conclude, the implementation of the Minamata Convention has resulted in a large global response, in which over 1100 measures have been implemented to regulate mercury in the many forms it exists in. The primary measure type utilized to regulate the 28 identified sources of mercury has been a prohibition. Furthermore, the correlations between the two primary forms of mercury and types of measures used to combat them, highlight the capability to alleviate future concerns of mercury products, but a continuous concern over processes which include and release mercury. Whilst the effectiveness of the policies has not been assessed, the ratification of the Minamata Convention has highlighted a significant global effort in which the impacts of mercury are aimed to be mitigated. The following section will shine light on some of the potential pitfalls of this global effort, and highlight the adverse impacts that this implementation can result in.

Problem-Shifting Measures

The previous analysis provided insights into the 1100 measures that have been established in response to the Minamata Convention, highlighting the immense global action to tackle mercury. However, through the conduction of the SSLR, which resulted in 84 articles and reports, eight measures established in the Minamata Convention have been identified to potentially induce problem shifting. As a result, of the 1100 individual measures, 271 can result in some form of problem shifting, resulting in detrimental environmental, financial, physiological and social impacts. Within this section, sub-questions two and three will be answered by highlighting the problem shifts, how they occur, what type of impacts are felt and the magnitude of those impacts. This section will conclude with an overview of all eight shifts, their mechanism of occurrence, and impacts resulting from each.

Prohibition of Dental Amalgam

Based on the results of the SSLR, the prohibition of dental amalgam has been found to induce a financial and a physiological problem shift. Dental amalgam is a cheap and widely used dental filling material, however, due to the mercury within its composition, actions have been taken to reduce its usage. The implementation of prohibition of amalgam results in the immediate transition towards alternative dental filling materials, which have been found to have varying financial and physiological impacts onto consumers.

Firstly, the financial concerns related to alternatives are due to a multitude of factors, in which the costs are largely displaced onto the consumers. The currently studied alternatives to dental amalgam are resin-based composites (RBC) or glass-ionomers. The usage of these alternatives is more costly, due to the higher material costs, pricey adjunct technologies necessary to utilize RBC, and the necessity to teach the new filling procedures to dentists (Mulligan et al., 2018). Furthermore, the time taken to complete a procedure can last up to three times as long, also resulting in an increased price for consumers. Due to the forced transition to these alternatives, the price increase for consumers has been found to be at a minimum of 50 USD/Euro (Harjunmaa and Auero, 2019). In a U.S. study, a nationwide ban on amalgam, would result in 15 million fewer restoration procedures due to the change in cost (Beazoglou et al., 2007). This transition is further exacerbated due to the lack of financial support from insurance companies which may not support the usage of alternatives over amalgam (McGrath, 2013; Maag et al., 2007). The increased price of dental care results in a heavy financial burden on consumers

(Aggarwal et al., 2019), primarily those of lower socio-economic status, and due to the financial concerns, the avoidance of treatment can result in physiological impacts to the patients.

Alongside the present financial concerns that arise with the prohibition of dental amalgam, a further physiological shift to consumers is also induced. Due to the increased financial concerns, patients have been shown to either out of treatment (McGrath, 2013), or to choose to extract the tooth (Aggarwal et al., 2019; Maag et al., 2007). In either case, patients are faced with a degradation in the quality of their oral health, which is shown to have lasting impacts on their quality of life (Alzoubi et al., 2017; De La Fuente Hernández et al., 2015). The adjustment to the increased cost of restorations is more difficult for lower-income families, which already have a higher prevalence of oral disease, thus, the avoidance of treatment will worsen their conditions, and widen the oral health disparity between economic groups (Beazoglou et al., 2007). Aside from the financially related physiological impacts, other health impacts related to the alternatives are present. RBC and glass ionomers have been shown to have a reduced quality of fillings, and a reduced longevity, which results in the degradation of the filling, and the increased need for repeated fillings (Aggarwal et al., 2019). Degraded RBC has been shown to have potential health risks on consumers which are of concern, alongside polymer resins, as another alternative, which has been shown to potentially result in the growth of microorganisms existing in the fillings, leading to oral infections (Sattar, 2020). The increased need for repeated fillings also feeds into the financial concerns related to treatment.

The identified problem shift results in financial and physiological impacts, however, as these two factors are highly interrelated, due to the physiological health impacts being the end result of the shift, the physiological impact will be used as the problem shifting factor for scaling the intensity. Based on the high potential for the decrease in observed fillings, alongside the other physiological impacts of alternatives, the prohibition of amalgam would have a medium impact on the physiological health of citizens. In regard to the criteria of extension, due to the widespread usage of amalgam around the globe, and highest usage amongst lower-income groups, the extension of this problem shift would be partial amongst the entire population, and widespread for lower income groups.

As a result of the Convention, as targeted in Article 4, paragraph 3, 168 measures have been implemented related to the process of phasing out dental amalgam. The usage of alternatives (39), usage of the encapsulated form of amalgam (21), the installation of amalgam separators

(34), increased education to minimize the need for restorative action (6), minimizing its usage (14) or the prohibition/immediate phase out of amalgam (51), have all been used as methods of achieving this goal. Of these actions taken, the prohibition of dental amalgam has been shown to induce the aforementioned financial and physiological impacts. Below, the countries which have chosen to implement this measure are presented in figure 5.

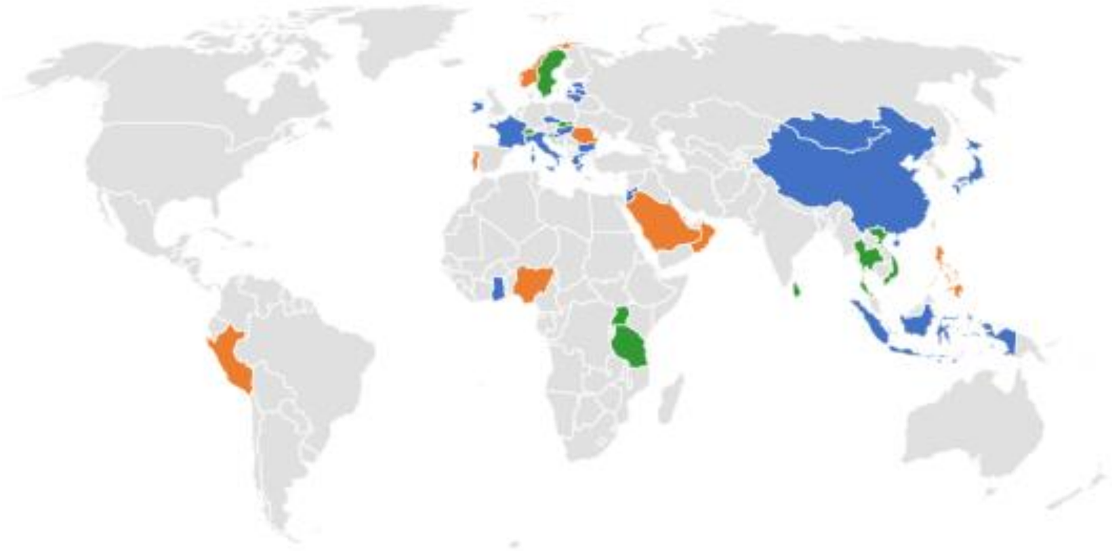


Figure 5: Global Implementation of Prohibition of Dental Amalgam

(Legend: Blue = Phase Out, Orange = Prohibition, Green = Prohibition for Under 15 and Pregnant Women)

Amalgam is a widely used treatment option around the world, with 85 percent of middle to lower income countries utilizing it (World Health Organization, 2018). Within all countries, amalgam is primarily utilized by lower income groups due to its lower cost and overall effectiveness (Smith et al., 2022; Mackey et al., 2014). The widespread implementation of the prohibition of dental amalgam exhibits a large concern for the financial and physical well-being of patients within the highlighted countries. Countries can and have been able to alleviate some concerns through the utilization of supporting policies such as the elimination of preferential insurance policies for amalgam. However, in large part, the prohibition of amalgam has a substantial impact on the lower-income communities within the countries which have chosen to implement the measure.

Prohibition of Mercury Added Products

The prohibition of Mercury Added Products (MAPs) has been shown to induce a delayed environmental impact, fitting the categories of a temporal and environmental problem shift. Mercury is utilized within a multitude of products, as such, they have been targeted by the Convention to remove them from circulation. The implementation of the prohibition of MAPs displaces attention away from the end-of-life management of the products, which indirectly results in the continuation of mercury pollution, encompassing a temporal and environmental problem shift.

The prohibition of MAPs is a long-term solution, in which the issue of future entries of MAPs entering our supply chain is resolved. Whilst the generation, transport and utilization of MAPs is managed by this approach, the disposal phase is largely under addressed, resulting in the many mercury containing products currently within our system being unmanaged. Highlighting the presence of this issue, complications within the disposal phase, and the extended consequences of mismanagement are presented.

For the majority of MAPs, the disposal phase is the predominant life-cycle phase in which mercury enters the environment via air, water, land, waste and sector specific disposal pathways (Martinez, 2023). The adequate separation of mercury from the products is a highly complex process. For compact fluorescent lamps, there is a seven-stage process to adequately recycle all components, involving multiple companies (Binnemans and Jones, 2014), and for other products, a multi-sectoral, highly coordinated system is necessary. Regardless of the financial capacity of developed or developing nations, all countries face similar issues regarding the coordination of bodies to sufficiently separate mercury from the waste of products. In the case of developed countries, issues are present within areas of awareness raising, funding and coordination which are all necessary to avoid mercury from entering the environment (M. S. Smith and Gray, 2010). On the other hand, in developing/middle-to-low-income countries, 80 percent of mercury containing e-waste is handled through informal “backyard recycling”, in which the improper management system results in mercury entering the environment (Basu et al., 2023; Cheng and Hu, 2012).

The prohibition of MAPs has been estimated to result in a reduction of usage by 70-95% in 2035 compared to 2010 levels (Pacyna et al.,2016; Habuer et al. 2019). Due to some essential uses of mercury, mercury is shown to be present in products up until 2050. Whilst there is a significant reduction in the consumption of MAPs, in both studies, the anticipated recycling of products was capped at 25 to 40 percent for Habuer (2019) and Pacyna (2016) respectively. This limitation in the expansion of recycling inherently results in the majority of waste being landfilled, where mercury will enter the environment. As of 2015, the global demand for mercury in MAPs is between 900 to 1350 tonnes (UN Environment, 2017), if disposal/recycling remains at the anticipated 25-40 percent, the release of the remaining mercury into the environment is devastating.

Alongside the global lack of sufficient disposal processes for MAPs, the prohibition of MAPs also doesn't completely resolve the issue of their presence within our system. Countries such as Japan have already taken the approach to remove MAPs from their system and have managed to dissipate mercury usage quite sufficiently. However, despite this, MAPs are still found to be the second largest contributor of mercury waste in their case, with approximately 7.6 tons of mercury waste from products being produced annually. (Takaoka, 2015). Despite the prohibition type measures, there is an apparent time lag that exists between products in usage and their eventual disposal. Whilst unique for each MAP, the approximate lifespan of products is around 10 years (Baldé et al., 2018), thus, with the little anticipated change in recycling patterns, much of the mercury waste is destined for landfills.

In the likely and worst case for MAPs to enter a landfilling facility at their end-of-life, the release of mercury into the environment is inevitable (Ryan-Fogarty et al., 2023; Qi et al., 2017; Chakraborty et al., 2013), resulting in a significant contribution to global mercury emissions (Gworek et al., 2015). Leachate from landfills is a significant source of mercury emissions, which can impact those in the surrounding environment via various pathways of soil, water, or air exposure (Lee et al., 2016; Nevondo et al., 2019; Zhengkai et al., 2017). Furthermore, across extended timespans (50-1000 years), the danger that mercury leakage presents to groundwater quality and human health is "substantial and unacceptable" (Xu et al., 2018), exemplifying the lasting impacts that the mismanagement of the disposal of mercury products has.

This measure has shown to induce a temporal and environmental problem shift. Due to the environmental impacts being the end result of the shift, the assessment of the intensity will be based on the environmental factor. Because of the long-term impacts that the avoidance of the disposal process has, due to the mere implementation of the prohibition of MAPs, the intensity of this problem shift is high. The unknown nature of the potential amount of mercury leakage into the environment in the future results in a very high level of intensity not being given. Moving onto the extension of the impact, due to the extensive capacity for mercury to distribute itself throughout the environment, alongside the widespread nature of the lack of disposal processes for MAPs, there is a widespread extension of the impacts.

To conclude, the approach to prohibit MAPs inadvertently divides attention away from the management of mercury waste, which results in a continuous and lasting release of mercury into the environment. As a result of Article 4, Paragraph 1 of the Convention, 47 countries have chosen to implement prohibitions regarding all products, including batteries, switches and relays, specified lamp types, cosmetics, pesticides, biocides and topical antiseptics, alongside specified measurement devices. These countries which have chosen to implement this measure, without proper end-of-life policies, inadvertently contribute to a lasting pollution process of these products. Below, figure 6 highlights the global implementation of this policy.

Figure 6: Global Implementation of Prohibition of MAPs (including lamps)

The countries highlighted in green within figure 6 have chosen to fully prohibit the manufacture, usage and transport of MAPs. Despite nearly all nations regulating MAPs in some manner, the attention diverted away from the end-of-life management results in lasting environmental impacts related to mercury pollution, wherever the waste of products is disposed of.

Prohibition of Mercury Added Lamps

Separate from the prohibition of other MAPs, the prohibition of mercury-added lamps has been shown to induce an environmental problem shift, related to the alternatives of the product. The transition to the existing alternatives of incandescent bulbs or LEDs results in the subsequent increase in energy consumption, or increase in rare-earth mineral consumption respectively, both of which negatively impact the environment.

The prohibition of mercury-added lamps directly targets the usage of CFLs or compact fluorescent bulbs (for domestic use). CFLs are a widely used bulb type as they are inexpensive, energy efficient, and have high lighting parameters. Whilst CFLs have these positive attributes, they contain mercury within them, which is essential to their functioning. Whilst many suitable and mercury-free alternatives exist for many of the other Annex A listed products (MAPs) (Friesen, 2007), the same cannot be held for lamps. The countries which have implemented this prohibition are forced to choose between two potential alternatives, either incandescent bulbs, or LEDs.

Firstly, a transition towards incandescent bulbs from CFLs would result in a sharp increase in the energy consumption within the global lighting industry, consequently increasing emissions. Unlike with other MAPs, the stage of life which holds the majority of environmental impact savings is the usage stage of bulbs (Principi and Fioretti, 2014). Whilst incandescent bulbs are the most common type of bulb used around the world, primarily due to their low cost, they are accompanied with high energy consumption and heat production. Highlighting the energy savings that are provided with CFLs, in the case of China, the transition towards CFLs (from incandescent bulbs) could induce a 75% reduction in cumulative mercury emissions due to the decreased energy consumption (Hu and Cheng, 2012). On a large scale, the type of bulb utilized holds a greater environmental impact than generally foreseen. Globally, lighting constitutes 20 percent of energy consumption (UNEP, 2013), signifying the large influence this industry has, and the impact that the type of bulb used holds on a larger dynamic. The exchange in energy consumption also holds a significant financial impact on homeowners. The transition to CFLs (from incandescent bulbs) can result in an 82 percent reduction in electricity bills (Khorasanizadeh et al., 2015).

Conversely, the transition to LEDs has been found to be the better alternative to CFLs, as promoted by the Convention. However, two primary concerns arise with LEDs, that being the resource consumption that a large-scale transition would demand, alongside financial concerns of the technology. Firstly, a large-scale transition towards LED bulbs can place pressure on global resource consumption “due to the insufficient availability of silver, gold, antimony, and copper resources” (Lim et al., 2013, p.1044). The total resource requirement of LEDs is twice that of CFLs within the production stage, due to the high necessity of aluminum, copper, antimony and gallium (Kosai et al., 2021). A large-scale, rapid transition to LEDs will induce a high material consumption compared to CFLs (Bergesen et al., 2016), resulting in the potential expansion of detrimental mining practices.

Whilst LEDs are more energy efficient than CFLs, are mercury-free, and have a longer lifetime, the high implementation cost deters consumers to transition to this bulb type (Hu and Cheng, 2012; Sangwan et al., 2014). For individual consumers, the payback period for adopting LEDs compared to CFLs is 6-9 years, resulting in some resistance to the adoption of this bulb type (Khorasanizadeh et al., 2015; Vahl et al., 2013). Higher-income households compared to lower-income have been shown to be more capable to invest in residential environmentally friendly improvements (Leelakulthanit, 2014). Whilst in the long-term, LEDs offer a higher savings potential, the upfront cost of the bulb results in this alternative being inaccessible for some communities, resulting in a delayed transition, or a transition back to incandescent bulbs, which have been shown to have the worst environmental impact of the bulb types.

As this measure induces an environmental problem shift, the intensity of it will be based on the environmental factor. This problem shift is multi-directional, in which two alternatives can be chosen, both with diverse impacts related to which pathway is chosen. However, considering the higher likelihood for LEDs to be chosen, due to their decreased cost in recent years and increased availability, the environmental factor will be determined based on a transition to LEDs. The prohibition of MA lamps results in the increased consumption of rare earth minerals needed for the production of LEDs, however, there is a decrease in energy consumption, thus the intensity of this problem shift is likely to be low. The intensity of the environmental impact is also determined by the availability of effective recycling processes, however, simply based on the transition to this alternative, the intensity is low. Furthermore, the extension of this impact would be widespread, due to the widespread usage of CFLs and necessity for them to be replaced following the prohibition of MA lamps.

The prohibition of mercury-added bulbs has been shown to induce an environmental problem shift, related to the energy consumption of incandescent bulbs and resource consumption of

LEDs. Financial complications associated with the adoption of LEDs may induce an increased transition rate back to incandescent bulbs, which worsens the environmental impacts of the lighting industry. The prohibition of mercury-added lamps is included in the categorization of MAPs provided in Article 4, Paragraph 1 of the Convention. Likewise, the countries which have implemented the prohibition of MAPs, include mercury-added lamps within their prohibition. Figure 6 presents the same implementation of the prohibition. Those countries implementing this measure are inadvertently contributing to these shifts. Whilst the global impacts are based on nationally contingent, and consumer-contingent variables, the widespread need and usage of lamps makes these shifts of great concern.

Prohibition of International Mercury Waste Transport

The prohibition of mercury waste transport has also been shown to induce a locational problem shift, in which the problem is transferred from one location to another. The intention of this prohibition is to avert the occurrence of the transport of waste, so that the countries in which the waste is produced must also manage such. This prohibition however, results in the unintentional increase in noncompliance of businesses/organizations to follow the according measures.

The implementation of regulatory policies for the trade of varying sources of waste can lead to unintended increase in the illegal transport of waste, or the illegal dumping of such waste (Parajuly and Fitzpatrick, 2020). Whilst many forms of illegal transport exist, such as the mislabeling, mixing of wastes, or transport without consent, they all violate the principles of legal waste transport set forth. Highlighting the incidence of the unintended increase in illegal waste transport, is the Basel Convention. In this case, the implementation of such has been insufficient in the management of illegal trading of e-waste and other hazardous wastes (Patil and Ramakrishna, 2020; Andeobu et al., 2021). After the establishment of regulatory policies within the Basel Convention, studies have identified the likely increase in illegal transport (Um et al., 2023; Shamim et al., 2015). As of the Minamata Convention, some countries have either chosen to use the Basel Convention as their regulatory response, or the prohibition of the transport of waste, which follows a similar fashion of policy. However, as shown, both are likely to result in the increase in illegal trafficking of mercury waste or mercury containing waste. As a result of such, approximately 25 percent of the current transport of waste is illegal (Parajuly and Fitzpatrick, 2020).

With the implementation of the prohibition of international mercury waste transport, an observed increase is shown in the illegal transport of waste. This transport of mercury containing waste results in the locational transfer of the impacts related to the management of that waste. Mercury waste is primarily transported within the waste content of electronics, stemming from developed to developing countries (Patil and Ramakrishna, 2020; Maes and Preston-Whyte, 2022). 75-80 percent of e-waste generated in developed countries is transported to Asian and African countries (Arya and Kumar, 2020), and is largely done in an illegal manner (Andeobu et al., 2021; Ilankoon et al., 2018). The regions of Central and South America, Central and West Africa, alongside Southeast Asia, are the primary destinations of the waste, which also results in those areas facing the many environmental impacts involved with such. These regions in which mercury waste is transported to is often handled in an improper manner, resulting in the eventual leakage of mercury into the environment (Lebbie et al., 2021; Palmeira et al., 2018; Kapoor et al., 2021).

Mercury has a large potential for long-distance travel through air or water streams, so if informally managed, extended and irreversible consequences can occur to the local and regional environment (K. Liu et al., 2023). With a greater area being exposed to mercury contamination, extended risks to humans are far more present. The observed societal and health related impacts of mercury are highly interrelated. Firstly, those working within close proximity to mercury waste face risks related to mercury exposure via either direct contact, or leakage (Purushothaman et al., 2021). Impacts related to mercury exposure can include the degradation of developmental and endocrine systems, along with ill effects on bone, kidney, reproductive and nervous system health (Kapoor et al., 2021). Children working in the e-waste industry are especially in danger due to the increased impact mercury has on their development (Kapoor et al., 2021).

The prohibition of mercury waste transport has induced a locational shift in the environmental impacts of mercury management; thus, the intensity of this shift will be evaluated based on the environmental factor. This problem shift increases the illegal rate of transport, but it has not been identified if the total rates of transport have decreased. Nevertheless, this increase in illegal transport also decreases the quality of the disposal process resulting in higher mercury leakage rates, therefore the intensity of this impact is medium/high. Because the nature and rate of mercury leakage is not fully known, which is also inhibited due to the lack of data on the rates of current illegal transport, a medium/high intensity is justified for the environmental impact of this shift. In terms of the extension of this impact, due to the impacts being felt across large waste destination areas of South America, West Africa and Southeast Asia, the impact is widespread.

The prohibition of the transport of waste has been shown to be ineffective in its goal, resulting in the locational transfer of the impacts of mercury waste management. As the primary concern of Article 11 of the Convention, each party should take measures to manage mercury waste in an environmentally sound manner, alongside prohibiting its movement across international boundaries. Pursuant to this section of the Convention, 33 countries have chosen to prohibit the transport of waste, 25 of which chose to directly utilize the Basel Convention as their management approach. Below, figure 7 highlights the global implementation of this measure, alongside presenting the areas impacted by the problem shift.

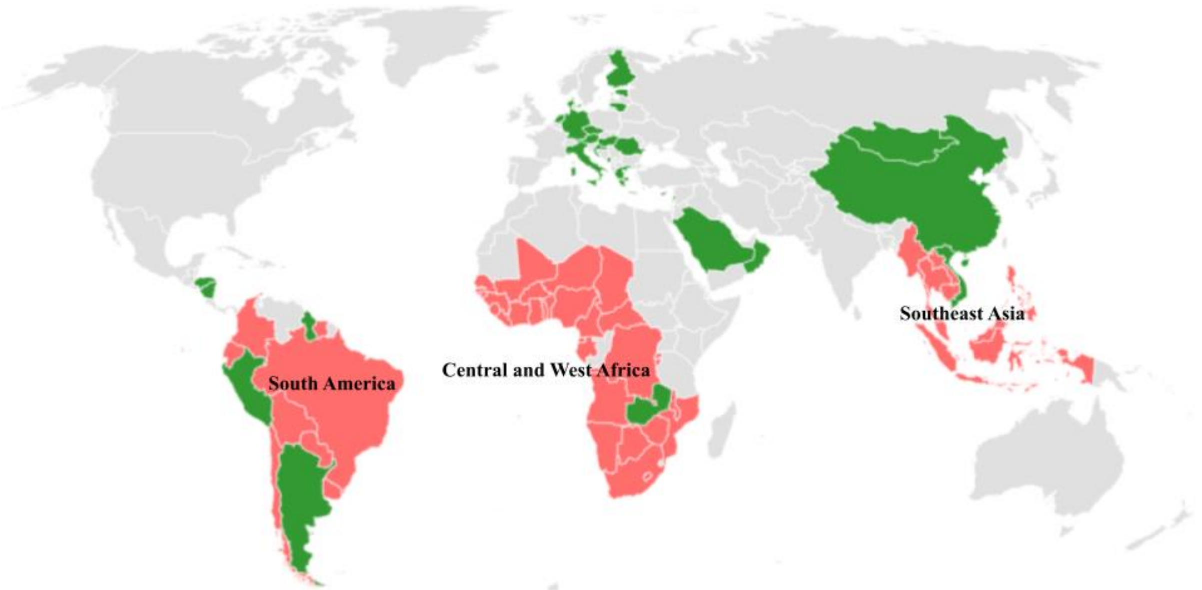


Figure 7: Global Implementation of the Prohibition of International Mercury Waste Transport

(Legend: Green = Implemented, Red = Impacted Areas)

As shown in figure 7, there is a wide distribution of countries which have implemented a prohibition on the transport of mercury waste. Europe shows the highest rate of implementation, followed by Asia and then South America. Whilst countries such as China, Argentina and Nigeria, which are often destinations of waste, despite the prohibitions, as shown in the case of China (1.16 MN tonnes of illegal waste from Europe imported in 2012 (Illés and Geeraerts, 2016)) they are likely unable to subvert the importation of such.

Implementation of Extended Producer Responsibility

The implementation of extended producer responsibility, an approach used to regulate the generation of mercury waste, has been shown to induce a management and locational problem shift. Extended producer responsibility entails that the producer, user, or generator of waste, is responsible thereof, including the associated costs, and must manage such mercury waste in an environmentally friendly manner. EPR has been regarded as a commonly accepted strategy for waste management liability, and an effective form of harmonizing the waste management system (Steenmans, 2019; Arya and Kumar, 2020). However, the displacement of responsibility from a more overarching governmental sense to individual responsibility, can lead to complications in the effective management of that waste. These complications can ultimately result in the insufficient management and transfer of waste to other regions.

The transfer of the waste is largely resultant of the many complications and challenges that exist within the implementation of this measure. Firstly, issues persist within the financial and technical capacity to implement such systems. Developed countries such as the U.S. and Canada have been able to apply EPR/producer-pays-principle to ensure the responsibility of corporations to manage their waste. Regardless of the technical capacity to implement this measure, a large financial burden generated by its implementation exists. Conversely, developing countries are unable/unlikely to implement such policies due to the lack of both financial and technical capacity (Diaz et al., 2020; Story and Yalkin, 2014). Furthermore, the effective implementation of EPR requires a high level of coordination between multi-sectoral bodies, a lack of which can result in the mismanagement of waste.

The technical, financial and organizational struggles associated with the implementation of EPR can inadvertently increase the rate of waste selling (J. Liu et al., 2020), or the illegal trade of waste (Gunarathne et al., 2020). The high-regulatory standards of recycling within developed countries, and the high costs associated with such, induce the high rate of waste transportation (K. Liu et al., 2023), to developing countries with lower regulatory standards, and for a fraction of the price (Palmeira et al., 2018). The transport results in waste destination countries facing the many consequences associated with the management of the waste, primarily in the form of environmental, health and social impacts which have been outlined in the previous problem shifting analysis.

EPR has been understood as an effective form to manage waste generation responsibility, under the correct conditions. Producer responsible organizations will likely utilize the cheapest solutions, not the most environmentally friendly (Winternitz et al., 2019). Such decisions result in the eventual transportation of waste to areas with lower regulatory standards, primarily developing countries in Africa, South America and Southeast Asia. Those countries are then burdened with the management responsibility of the waste, resulting in many environmental and social consequences.

Likewise, to that of the prohibition of mercury waste transport, the implementation of EPR holds a similar locational shift in the environmental impacts of mercury waste management. However, as EPR and the resulting transport of waste occurs at a lower frequency, the intensity of the impact is medium. Whilst the impacts are the same as that of the prohibition of mercury waste, due to the lower occurrence, the incidence of the action is lower, therefore resulting in a lower intensity. However, as the destinations of the waste are the same, this problem shift has the same widespread extension of the impact.

Whilst not directly enforced through the Convention, Article 11 does encourage the cooperation between organizations and other entities to manage mercury in an environmentally sound manner. As a result, 20 countries have implemented EPR as a management strategy. Below, figure 8 will highlight the global implementation of this measure, alongside the impact areas of the resultant locational problem shift.

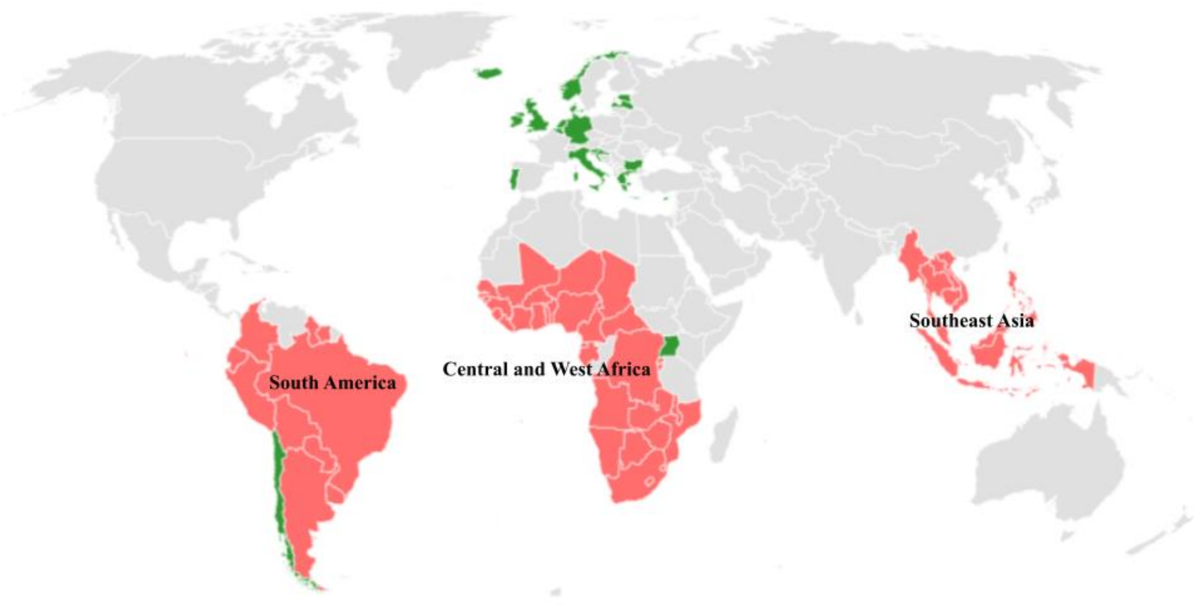


Figure 8: Global Implementation of Extended Producer Responsibility

(Legend: Green = Implemented, Red = Impacted Areas)

As shown in figure 8, Europe has much of the implementation of this measure, largely due to this measure being included within EU regulation 2017/852, which states the EU member states should implement EPR within their country. The EU wide implementation of this measure results in an un-tailored implementation of EPR, resulting in the cheapest options likely being chosen by organizations, and the eventual transport of waste to the destination countries highlighted in red.

Requirement to Utilize Emission Control Technologies/BAT

Another measure resulting in a financial problem shift is the utilization of emissions control technologies, or best available technologies (BAT) to reduce mercury emissions. Due to existent complications regarding the costs of these technologies, there is an observed resistance to implementation.

The primary strategies related to the implementation of BAT has been the introduction of end-of-pipe mercury-specific control technologies. Such technologies include activated carbon filters, acid gas scrubbers or flue gas desulphurization. The application of such technologies has been found to be effective in the mitigation of some forms of mercury emissions, however, much concern is held regarding the costs of the implementation of these control measures (Tian et al., 2012; Mader et al., 2001; Joy and Qureshi, 2022). Whilst prices vary based on the technologies used, and the scale of implementation, the cost of meeting mercury emission standards can range from 1.05 - 2.07 billion Euros for China (Ancora et al., 2015), to upwards of 9.6 billion USD in the U.S (Ancora et al., 2016). Developed countries have been found financially more capable of implementing such technologies, however, this financial barrier can result in the lack of implementation in developing countries.

“No technology, no matter its applicability and effectiveness, will be implemented if the economics, including both operating and capital costs, are not weighed” (Pavlish et al., 2010, p. 840). The observed high costs of implementation have been found to result in hesitancy to adopt policies. Due to ensuing regulatory standards that would be established, the Australian government was resistant to ratifying the Minamata Convention (Bramwell et al., 2018). The increased demand and cost of mercury control technologies complicates the primary objectives of achieving mercury regulation goals (Rallo et al., 2012; Masur and Posner, 2018; Sjostrom et al., 2010). Under unpredictable conditions, achieving maximum achievable control technology standards questions the applicability of these technologies on a larger global scale (Sikkema et al., 2011). Broadly speaking, complications with the implementation of BAT is of great concern for many countries.

The financial shift induced by such technologies results in a greater disparity between developed and developing countries, due to the difference in financial capacity to implement such control measures (Bartram et al., 2021; Ekholm et al., 2013). In some cases, the imposition of emissions limit standards can be deemed ineffective, as the penalty cost of exceeding emissions limits is lower than the implementation cost of the control technologies (Joy and Qureshi, 2022). Furthermore, the environmental impacts of avoiding implementation are further exacerbated due to developing countries utilizing fuel sources with higher mercury emissions (mostly coal) (Steckel et al., 2015). This financial burden results in the delayed or lack of implementation, and therefore increased environmental impact.

The implementation of BAT induces a financial problem shift, which results in the avoidance of implementation, therefore resulting in an increase in environmental degradation, due to the continuation of harmful practices. Under this framing, the intensity of the impact will be based on the environmental impact of the shift. Due to the disparity in the financial capacity of countries to be able to implement BAT, the resulting lack of implementation will result in a medium intensity related to the environmental impacts of such. As these conditions influence the decision making of primarily middle-low-income countries, the extension of the impacts is partial.

Stemming from Article 8 of the Convention, regarding the control of mercury emissions where feasible, each party shall for new and existing sources use best available techniques and best environmental practices to control emissions from the relevant sources. As a result, from the five specified emissions sources (CCP, CFI, CFP, WIF, and SNR), 35 countries have implemented such measures, and in some cases specified the technologies used. Figure 9 will highlight the global implementation of the usage of BAT.

Figure 9: Global Implementation of BAT

As shown in figure 9, there is a wide distribution of implementation, with a high rate of implementation in Europe, followed by scattered implementation across the Americas, Africa and Asia.

Decommissioning of Facilities that have Utilized Mercury

A unique risk identified for a small community, is the physiological impacts of the problem shift related to the measure of decommissioning facilities that have utilized mercury within their processes (chlor-alkali, polyurethane…).

Whilst the continuation of running these facilities poses an extended risk of mercury exposure to humans and the environment (Da Silva et al., 2017), the decommissioning of facilities can pose equally dangerous hazards. Whilst workers are generally safe during the standard operation of the facilities, the decommissioning process is a meticulous process which holds an increased risk for mercury exposure to workers on site (Besson et al., 2012). Whilst proper standards, and procedures exist, in the case of under-regulated areas (many in developing countries which face challenges regarding new technologies and unknown hazards), a serious risk is posed towards the health of workers (Baram, 2009). Furthermore, the management of the post-decommissioned industrially polluted sites poses many challenges in terms of the remediation of those areas, which can have an extended timespan for mercury release into the environment and neighboring communities (Hsu-Kim et al., 2018).

Due to the increased risk of mercury poisoning and other hazards related to the decommissioning of mercury facilities, the intensity will be based on the impacts on physiological health. As a result of the aforementioned risks, the intensity of this shift is high. Due to the low occurrence and minority group that is responsible for these practices, the extension of this impact is isolated.

Article 5 of the Convention establishes a prohibition on the usage of mercury within specified industrial processes of Annex B, as a result, in place of utilizing mercury-free technologies, the countries of Czech Republic, Peru, Portugal, Romania, Senegal, and Uruguay have chosen to decommission the now obsolete facilities. These countries induce an increased health risk for those responsible for the decommissioning of the facilities.

As time progresses, there is an expected increase in the decommission of such facilities, therefore the health-related risks associated with this activity should be of great concern for the impacted groups of workers. Whilst the problem shifting impact is smaller relative to the aforementioned measures, in regard to the Convention, such actions are significant and should be handled in great care to avoid the detrimental impacts associated with the mismanagement of these sites.

Prohibition of Mercury in ASGM

Finally, whilst Article 7, concerning artisanal and small-scale gold mining (ASGM), was excluded from the focus of this research, it must be briefly noted within the analysis on problem shifting. The Convention requires all nations which have citizens involved in this industry to draft a National Action Plan in which the steps will be outlined for how mercury usage will be reduced or eliminated in their case. As a result, currently 24 nations have submitted their plans for how mercury will be managed in their case. Of the many actions taken, the removal/prohibition of mercury will induce many lifestyle changes related to possible career opportunities and financial income (Zolnikov, 2020). Whilst the removal of mercury will likely result in a significant increase in the quality of health of workers, and environmental conditions, unless the transition is done in a manner which can allow the workers to maintain their livelihood and working status, the nearly 45 million workers globally in this industry could face negative financial repercussions (Y. Cheng et al., 2023; Mestanza-Ramón et al., 2022). Furthermore, there are many more dependents on the income from these workers, resulting in a much larger issue regarding the impacts that would be felt related to unemployment (Hilson et al., 2018), 80-100 million people rely directly or indirectly on ASGM for their livelihoods (Spiegel et al., 2014).

Due to the social impacts related to the prohibition of mercury within ASGM, the intensity of the impacts will be based on the occurrence of joblessness resulting from the measure. Due to the high number of workers within this industry, and the high consumption and necessity for mercury within these processes, the intensity related to joblessness because of the prohibition of mercury is medium. Whilst ASGM is a smaller industry, because of the expansive usage of mercury, the extension of the impact would be partial, in relation to the total group of ASGM workers.

Overview

Below in table 9, an overview of the measures, the type of problem shift induced, the mechanism through which the problem shift occurs, the magnitude of the shift, and the number of countries which have implemented the measures will be provided.

Table 9: Overview of Problem Shifts and Impacts

Measure	Problem Shift	Mechanism	Magnitude	Implementation (See Annex C)
Prohibition of Dental Amalgam	**Financial -** Increased treatment cost **Physiological -** Poor oral health	Forced and expensive alternatives → Reduction in treatment	**Intensity:** Medium **Extension:** Partial and Widespread	41
Prohibition of MAPs	**Temporal -** Continuation of waste production	Displaced attention → Increased mercury leakage	**Intensity:** High **Extension:** Widespread	47
Prohibition of MA Lamps	**Environmental** - Energy and Resource Usage	Alternatives → Higher energy/resource consumption	**Intensity:** Low **Extension:** Widespread	47
Prohibition of Mercury Waste Transport	**Locational -** Transport of waste to other countries	Increased Illegal Transport → Transfer of waste management	**Intensity:** Medium/High **Extension:** Widespread	33
Implementation of Extended Producer Responsibility	**Institutional -** Increased costs and responsibilities **Locational -** Transport of waste to other countries	Increased Cost and Regulations → Increase in Illegal Transport	**Intensity:** Medium **Extension:** Widespread	20
Requirement to Utilize Emissions Control Technologies/ BAT	**Financial -** High implementation costs	High Cost of Technology → Lack of implementation	**Intensity:** Medium **Extension:** Partial	35
Decommissioning of Facilities that have Utilized	**Physiological -** Increased	Decommission facilities →	**Intensity:** High	6

Measure	Problem Shift	Mechanism	Magnitude	Implementation (See Annex C)
Mercury	health risk	Workers hired are put at risk	**Extension:** Isolated	
Prohibition of Mercury in ASGM	**Social -** Potential job loss **Financial -** New technologies needed	Removal of mercury needed for operation → Joblessness	**Intensity:** Medium **Extension:** Medium	24 (37.5%)

These results have presented an overview of the measures implemented in response to the Minamata Convention which have induced one or multiple types of problem shifts. Whilst a high diversity exists in the types of problem shifts generated, the majority of the impacts stem from a financial barrier associated with the implementation of the measures. The implementing agents, that being the countries and their corresponding governments, are the ones largely responsible for the management of mercury in their case. Those with higher financial resources will be more capable of effectively managing mercury and will not have to deal with some of the unintended consequences associated with the aforementioned problem shifts.

Furthermore, as highlighted by the assessment into the magnitude of the problem shifts, five of the shifts had a widespread extension, symbolizing the expansive nature of the impacts that are felt. Furthermore, whilst no critical shifts have been identified, all of the shifts have a medium to high intensity, highlighting the severity of the impacts that are felt based on each respective problem shifting factor. The assessment of the magnitude of the problem shifts highlights the widespread nature of the impacts that can be felt, but also the significant intensity of the impacts.

Discussion and Recommendations

The aim of this research was to identify the impacts of the problem shifts that are resultant of the implementation of the Minamata Convention. As a result of this analysis, it has been identified that the implementation of response mechanisms to the Minamata Convention inadvertently contributes to the continuation of environmental degradation, inhibits the successful management of mercury through costly system transformations, and primarily impacts lower-income communities and countries. Alongside these key findings, insights regarding the types of response mechanisms used, the sources of mercury targeted in the Convention and rates of policy implementation have also been identified. These findings highlight the political outcomes of the implementation of the Convention and delve into the perceived most effective technical and political response mechanisms to combat mercury.

Interpreted Findings

Firstly, the primary type of measures that has been utilized by countries to combat the various sources of mercury has been a prohibition or phase out. This suggests that prohibition type measures are a universally agreed upon approach which can be utilized to manage the many types/sources of mercury that have been targeted in the Convention. However, considering that half of the identified problem shifts are resultant of prohibition type measures, there is an existent correlation between the two. Reflecting on prohibitions as a response mechanism, the primary objective is to prevent the continuation of a certain process/product which involves mercury, therefore alleviating the future concern of that process/product. However, as identified in the analysis, the management of the various sources of mercury is multifaceted, and the resolution of such issues cannot be completed in a simplistic, single stage process. Despite the widely applicable nature of prohibitions, its simplicity results in other components of the system at hand being un-addressed, resulting in the identified problem shifts. The apparent connection between this result, and that from response risks is also pronounced. Within the assessment of response risks, it is highlighted how “quick-fix” solutions result in maladaptation, and further the exposure and vulnerability to climate risks. Prohibitions can be understood as a type of this “quick-fix” solution, as they restrict the continuation of the usage of mercury, but due to the multi-faceted nature of these management systems, this quick-fix solution fails in its objective.

Secondly, there is a correlation between the various mechanisms through which the problem shifts occur. In almost all cases, there is a financial aspect which leads to the eventual negative degradation of the environment or human health. This identification highlights how finances play an integral part within our current resource management system. Whilst finances impact decision making processes from the individual level to the systemic level, it is the temporal aspect which has failed to be taken into consideration. In the *Implementation of BAT*, the high implementation costs of the technology dissuade (government owned) industrial facilities from implementing them. Likewise, for alternatives to mercury added lamps, consumers will also likely opt for incandescent bulbs (the cheapest alternative). In both instances, despite the high upfront costs that may distract or inhibit the decision-making process, in the long term, there is a high savings potential for both. Numerous studies have presented the long-term cost savings through health benefits that come with emissions control technologies (Giang & Selin, 2015), or the individual cost savings of LEDs (Khorasanizadeh et al., 2015). The issue with the financial aspect is a short-term financial evaluation that has enveloped our decision-making processes, hindering objectives which have implications for centuries into the future.

Finally, the measures that have induced a problem shift all have a connection to the Convention, in regards to the ways in which they have been formulated. Whilst it is logical that the policies that have been implemented in response to a Convention follow the guidelines that have been set forth in such, it highlights a systemic structure to the response mechanisms utilized. For each article, and each product/source of mercury mentioned within, guidelines were created by which measures should be implemented by countries to manage each. As a result, the measures that have resulted in a problem shift all have a (generally) large rate of implementation. The structure from which measures are generated and implemented, highlights the responsibility that the Convention holds in terms of generating policy, but also for the outcomes that are resultant of those policies.

This review of the insights identified in this analysis have shown the short-termism that hinders the success of the Minamata Convention. Whilst generally beneficial in terms of mercury management, recognition, and global collaboration, much is yet to be done before this problem is fully resolved. To support such, tailored recommendations regarding national policy action that can be taken, changes towards the Convention, and future research will be provided.

Political Implications

Firstly, regarding national policy implications of this research, changes can be made towards the approaches which are taken to manage our resources. Problem shifts 1-5 all have waste as a central issue that must be managed. With waste from dental amalgam, the disposal of MAPs, to the transport of waste, all of these measures pertain to the control of the generation and disposal of waste, instead of managing it in a sufficient manner. Whilst the implementation of EPR does attempt to do so, the shift in responsibility towards corporations ultimately leads to the mismanagement of such. Thus, as a policy response which should be considered in the realm of waste management is the integration of a circular waste economy. Our current open-ended economy results in the continuous consumption of natural resources and disposal of such which result in the negative degradation of the environment. Conversely, circular economy aims to un-couple the nature of economic growth from natural resource depletion, by utilizing the extracted resources for as long as possible, via various recycling, and reuse schemes (Hoffman et al., 2022). Whilst complications exist within the generation of new reusable and recyclable product designs, alongside the implementation of complex recycling systems, this larger system transformation will result in long-term environmental benefits and reduced resource consumption (Hoffman et al., 2022). Instead of attempting to manage the sources of products, which will eventually be replaced with other products also contributing to the waste cycle, if the disposal phase of the life cycle of these products is managed in a more environmentally friendly manner, benefits in terms of resource management and disposal will be proliferated, alongside the alleviation of many of the detrimental impacts that come with such. Furthermore, this approach integrates a long-term vision of waste management, as such systems will always be necessary moving into the future, with our growing global population and consumption patterns. This long-term perspective should also be applied to other systems such as that with emissions control technologies.

Secondly, this research presents a "post-evaluative implementation approach" towards design elements for the Minamata Convention, to alleviate the concerns regarding the hastiness and future implementation. Currently, the Convention outlines measures that should be taken to combat the various sources of mercury outlined in each of the articles. As of March 2023, the official progress report on activities has been published, highlighting updates to the list of prohibited MAPs, progress of implementation, and plans to begin monitoring the effectiveness of implementation. However, as highlighted in this report, 33 countries failed to take any measures (Minamata Convention on Mercury, 2023). Furthermore, within the Convention there is no established mechanism in which countries should re-evaluate their current activities and update the measures which they plan to enact. The Minamata Convention aims to fully mitigate the impacts of mercury, and in this sense, it is ignorant to assume that as time passes, no advancements will be made in the availability of technology, and national capacity, which would allow for more comprehensive measures to be implemented. Therefore, a progressive approach should be taken to this Convention, in which countries can and are enticed to continuously strengthen their activities, to ensure that mercury is best managed as time progresses.

To apply this post-evaluative implementation approach, it is suggested that evaluations of effectiveness be followed by reassessments of measures to be implemented. The structure of effectiveness evaluations is currently stated in Article 22, where the first evaluation shall occur six years after entry into force and will occur periodically in intervals yet to be decided upon (United Nations Environment Programme, 2013). Based on the resultant environmental, technical, and financial information produced from the evaluations, considerations based on the most prominent sources of mercury can then be made, in which measures are then reassessed. E.g., If industrial installations are still found to be a continuous and significant source of mercury emissions after the evaluation, stricter guidelines on the emissions limits can be set, alongside the implementation of new technologies which can better attain those emissions limits. As countries are responsible for submitting their own data on the progress which they have made, alongside their own sources of mercury, the reassessment of measures can be tailored to each individual country's needs, to ensure a comprehensive resolution of the mercury issue. As this approach is progressive in nature, it allows for sufficient time to be spent on the evaluation of effectiveness, and the proceeding tailoring of measures. Furthermore, in the context of this research, indicators regarding the problem shifting impacts should be included within the effectiveness evaluations, to take those unintended consequences into consideration. Despite the complexity and time cost of each evaluation and reassessment of measures, applying an optimistic framing towards policy development is necessary. If the comprehensive resolution of complications concerning mercury is the central objective of the Minamata Convention, settling for the bare minimum of approaches will not accomplish these goals. Countries should challenge themselves to do the best they can in their case, and as time progresses, technology advances, and capacity increases, countries can progressively implement more to support the global movement towards mercury management.

Future Research and Limitations

Some limitations exist in this work, primarily related to the assessment/determination of problem shifting and its impacts, the objectives of sub-questions two and three. The limitations of this assessment lie with the determination of the impacts resulting from the measures. Due to the structure of the literature review, the current availability of data, and the recency of the implementation of measures, there is limited proof to highlight the occurrence of problem shifts in each country's case. This analysis highlighted the potential for problem shifting to occur as a result of implementing a specific measure and highlighted the impacts via the utilization of various studies which have assessed such. This research then expanded the potential impacts resulting from those measures to the countries which have implemented them. Due to the multiplicity of factors that come with the occurrence of problem shifts, such as a countries financial capacity, the distribution of income groups in each country, alongside potential supporting policies that have been implemented, it cannot be conclusively stated that the problem shift is occurring in each country’s case that has implemented the measure. Nevertheless, due to the potential of problem shifting occurring, the implementation of the identified eight measures still poses the identified risks in each of those countries' cases.

One further limitation exists within the coding process utilized in the first stage of this research. The coding process in this research was done iteratively, meaning codes were created throughout the process/analysis. This was done, as there was no clear precursor to what sources of mercury would be identified in the measures, as well as the types of measures that would be utilized to combat those sources of mercury. As a result, there are some inconsistencies between the codes that were given to the first measures versus the codes that were established by the end of the coding process. As a result, there are sparse inconsistencies between the codes, however, generally they do not significantly impact the outcomes of the analysis.

Learning from the limitations of this research, future research projects should address the outcomes of problem shifting. Whilst this research provided a broad overview of the measures that can induce problem shifting, as well as assessing the impacts, it was lacking in the quantitative data to highlight instances in which the impacts of the problem shift were felt. Outcomes of problem shifting are one of the more complex aspects related to this concept, due to the nature of the impacts, the time it would take for those impacts to be felt, and the wide distribution of where they would be felt. Furthermore, the mechanism through which problem shifts occur is not a direct lineage, which results in complications in determining the causality of the impacts. However, despite the challenges that may exist with this assessment, the identification of quantitative outcomes of problem shifts acts as a driver in which the aforementioned recommendations are further supported and placed into action. Whilst this research was limited in this aspect, due to the recency in which measures were implemented by countries, the delayed impact in which they are felt, and further delayed availability of data, the identification of the sources of these problem shifts is a step forwards towards closing the cycle of negative impacts stemming from mercury.

Conclusion

This research aimed to identify the impacts of problem shifts that have resulted from the implementation of the Minamata Convention. This was done by determining what, how many, and which types of policies have been implemented in response to the Convention, followed by the assessment of those policies, to determine the potential occurrence and impacts of problem shifting. Based on the qualitative assessment of national reports, and analysis of literature and national data pertaining to the identified problem shifts, it can be concluded that the much progress has to be made to accomplish the objectives of the Minamata Convention. Irrespective of nationally contingent variables, the Minamata Convention aims to apply a universal framework for the management of mercury, which is not universally applicable. The lack of national framing results in the measures inadvertently contributing to the further degradation of the environment, and the degradation of health from those of lower-income and those in lower-income countries. These results have been concluded due to existing financial complications that impact decision making, alongside the dismissal of the disposal/waste stage of mercury and mercury added products. These results indicate a disparity within the financial capabilities of various groups/countries that are able to sufficiently transition to mercury-free technologies, alongside a short-termism view which has been taken in terms of the measures that have been implemented. Whilst limited by the availability of quantitative assessments on the performance and unintended impacts related to the measures that have been implemented in response to the Minamata Convention, this research has provided new insights into the current global political implementation response of the Minamata Convention, an identification of measures that have induced problem shifts, and the impacts that have been felt therefrom.

On a broader scale, this research has provided insights into the domains of problem shifting, risks emerging from response mechanisms, and MEAs. Firstly, regarding problem shifting, this research produced a typology of problem shifts, which assists in the realm of problem classification, and provides much needed attention and support to the concept of problem shifting. This contribution simultaneously supports an increase in awareness towards the issue of risks emerging from response mechanisms. The inherently intertwined relationship between the two concepts, and the result of this study further address an existing and emerging issue of unintended impacts related to the implementation of environmental policies. By highlighting this occurrence, further attention can be placed on the management and resolution of those newfound problems, whilst simultaneously highlighting potential inefficiencies within our current structures/systems for resource management. In this sense, MEAs are addressed as their profound global influence on policy generation towards the management of various resources has global, regional and local implications for human and environmental health. By addressing the inefficiencies in these systems and providing guidance on how such problem shifts can potentially be avoided, progress can be made by establishing mechanisms to achieve these goals, so that MEAs can reach their set outcomes.

Much responsibility is held within the management of our resources. Issues related to the impacts that certain products/processes have on human and environmental health, must be balanced by values of economic growth, global stability and organization, alongside the continuation of the resourcefulness that these processes/products have for our systems functioning. Carefully designing global conventions to manage these variables can generate unforeseen global collaboration, decision-making and progress towards achieving sustainability, however, the unintended consequences resulting from these response mechanisms challenge the effectiveness and benefits of these conventions. Understanding the influence that problem shifting has and integrating responses to avoid/combat the occurrence of such, allows our decision-making processes to become more effective by being aware of those outcomes that are not generally intended. In doing so, our mission to make our world safer, healthier, and to protect our people from the harm of climate change and other environmental dangers, is one step closer.

References

Aggarwal, V., Pavitt, S., Wu, J., Nattress, B., Franklin, P., Owen, J. M., Wood, D., and Vinall-Collier, K. (2019). Assessing the perceived impact of post Minamata amalgam phase down on oral health inequalities: a mixed-methods investigation. BMC Health Services Research, 19(1). https://doi.org/10.1186/s12913-019-4835-1

Aghalari, Z., Amouei, A., and Jafarian, S. (2020). Determining the amount, type and management of dental wastes in general and specialized dentistry offices of Northern Iran. Journal of Material Cycles and Waste Management, 22(1), 150–158. https://doi.org/10.1007/s10163-019-00924-3

Alzoubi, E. E., Attard, N. J., and Hariri, R. (2017). Oral Health Related Quality of Life Impact in Dentistry. Journal of Dental Health, Oral Disorders and Therapy, 6(6). https://doi.org/10.15406/jdhodt.2017.06.00221

Ancora, M. P., Zhang, L., Wang, S., Schreifels, J., and Hao, J. (2015). Economic analysis of atmospheric mercury emission control for coal-fired power plants in China. Journal of Environmental Sciences-china, 33, 125–134. https://doi.org/10.1016/j.jes.2015.02.003

Ancora, M. P., Zhang, L., Wang, S., Schreifels, J., and Hao, J. (2016). Meeting Minamata: Cost-effective compliance options for atmospheric mercury control in Chinese coal-fired power plants. Energy Policy, 88, 485–494. https://doi.org/10.1016/j.enpol.2015.10.048

Andeobu, L., Wibowo, S., and Grandhi, S. (2021). An assessment of e-waste generation and environmental management of selected countries in Africa, Europe and North America: A systematic review. Science of the Total Environment, 792, 148078. https://doi.org/10.1016/j.scitotenv.2021.148078

Andrews, T. M., Simpson, N. P., Mach, K. J., and Trisos, C. H. (2023). Risk from responses to a changing climate. Climate Risk Management, 39, 100487. https://doi.org/10.1016/j.crm.2023.100487

Arya, S. B., and Kumar, S. (2020). E-waste in India at a glance: Current trends, regulations, challenges and management strategies. Journal of Cleaner Production, 271, 122707. https://doi.org/10.1016/j.jclepro.2020.122707

Bahramian, M., Cinar, O., Mehrdad, N., and Veral, M. A. (2016). Investigation on the characteristics and management of dental wastewater in Tehran, Iran. ICOEST. International Conference on Environmental Science and Technology, Belgrade, Serbia. https://www.researchgate.net/publication/309232230_Investigation_on_the_characteristics_and_management_of_dental_wastewater_in_Tehran_Iran

Baldé, C. P., D'Angelo, E., Forti, V., and Kuehr, R. (2018). Waste mercury perspective, 2010-2035: from global to regional. United Nations University (UNU), United Nations Industrial Development Organization.

Bank, M. S. (2020). The mercury science-policy interface: History, evolution and progress of the Minamata Convention. Science of the Total Environment, 722, 137832. https://doi.org/10.1016/j.scitotenv.2020.137832

Baram, M. (2009). Globalization and workplace hazards in developing nations. Safety Science, 47(6), 756–766. https://doi.org/10.1016/j.ssci.2008.01.008

Bartram, S. M., Hou, K., and Kim, S. H. (2021). Real effects of climate policy: Financial constraints and spillovers. Journal of Financial Economics, 143(2), 668–696. https://doi.org/10.1016/j.jfineco.2021.06.015

Basit, T. (2003). Manual or electronic? The role of coding in qualitative data analysis. Educational Research, 45(2), 143–154. https://doi.org/10.1080/0013188032000133548

Basu, N., Bastiansz, A., Dórea, J. G., Fujimura, M., Horvat, M., Shroff, E., Weihe, P., and Zastenskaya, I. (2023). Our evolved understanding of the human health risks of mercury. AMBIO: A Journal of the Human Environment. https://doi.org/10.1007/s13280-023-01831-6

Beazoglou, T., Eklund, S. A., Heffley, D., Meiers, J. C., Brown, L. J., and Bailit, H. L. (2007). Economic Impact of Regulating the Use of Amalgam Restorations. Public Health Reports, 122(5), 657–663. https://doi.org/10.1177/003335490712200513

Beck, A. C., Campbell, D. K., and Shrives, P. (2010). Content analysis in environmental reporting research: Enrichment and rehearsal of the method in a British–German context. British Accounting Review, 42(3), 207–222. https://doi.org/10.1016/j.bar.2010.05.002

Belal, A. R., Cooper, S. L., & Khan, N. A. (2015). Corporate environmental responsibility and accountability: What chance in vulnerable Bangladesh? *Critical Perspectives on Accounting*, *33*, 44–58. https://doi.org/10.1016/j.cpa.2015.01.005

Bergesen, J. D., Tähkämö, L., Gibon, T., and Suh, S. (2016). Potential Long-Term Global Environmental Implications of Efficient Light-Source Technologies. Journal of Industrial Ecology, 20(2), 263–275. https://doi.org/10.1111/jiec.12342

Besson, J., Augarde, E., and Nasterlack, M. (2012). Worker Protection During Mercury Electrolysis Cell Plant Decommissioning. Arhiv Za Higijenu Rada I Toksikologiju. https://doi.org/10.2478/10004-1254-63-2012-2200

Binnemans, K., and Jones, P. B. (2014). Perspectives for the recovery of rare earths from end-of-life fluorescent lamps. Journal of Rare Earths, 32(3), 195–200. https://doi.org/10.1016/s1002-0721(14)60051-x

Bramwell, G., Wilson, F., and Faunce, T. (2018). Mercury Pollution from Coal-Fired Power Plants: A Critical Analysis of the Australian Regulatory Response to Public Health Risks. Journal of Law and Medicine, 26(2), 480–487.

Brennan, G., and Brooks, M. (2011). On the 'cashing out' hypothesis and 'soft' and 'hard' policies. European Journal of Political Economy. https://doi.org/10.1016/j.ejpoleco.2011.06.001

Chakraborty, L. B., Qureshi, A. H., Vadenbo, C., and Hellweg, S. (2013). Anthropogenic Mercury Flows in India and Impacts of Emission Controls. Environmental Science and Technology, 130726132711009. https://doi.org/10.1021/es401006k

Cheng, H., and Hu, Y. (2012). Mercury in Municipal Solid Waste in China and Its Control: A Review. Environmental Science and Technology, 46(2), 593–605. https://doi.org/10.1021/es2026517

Cheng, Y., Watari, T., Seccatore, J., Nakajima, K., Nansai, K., and Takaoka, M. (2023). A review of gold production, mercury consumption, and emission in artisanal and small-scale gold mining (ASGM). Resources Policy, 81, 103370. https://doi.org/10.1016/j.resourpol.2023.103370

Da Silva, R. F., Branco, J. C., Thomaz, S. M. T., and Cesar, A. (2017). Convenção de Minamata: análise dos impactos socioambientais de uma solução em longo prazo. Saúde Em Debate, 41(spe2), 50–62. https://doi.org/10.1590/0103-11042017s205

De La Fuente Hernández, J., Del Carmen Aguilar Díaz, F., and Del Carmen Villanueva Vilchis, M. (2015). Oral Health Related Quality of Life. InTech eBooks. https://doi.org/10.5772/59262

Diaz, F. A., Katz, L. E., and Lawler, D. F. (2020). Mercury pollution in Colombia: challenges to reduce the use of mercury in artisanal and small-scale gold mining in the light of the Minamata Convention. Water International, 45(7–8), 730–745. https://doi.org/10.1080/02508060.2020.1845936

Ekholm, T., Ghoddusi, H., Krey, V., and Riahi, K. (2013). The effect of financial constraints on energy-climate scenarios. Energy Policy, 59, 562–572. https://doi.org/10.1016/j.enpol.2013.04.001

Eriksen, H. K., and Perrez, F. X. (2014). The Minamata Convention: A Comprehensive Response to a Global Problem. Review of European, Comparative and International Environmental Law, 23(2), 195–210. https://doi.org/10.1111/reel.12079

Escobar-Pemberthy, N., & Ivanova, M. (2020). Implementation of Multilateral Environmental Agreements: Rationale and Design of the Environmental Conventions Index. *Sustainability*, *12*(17), 7098. https://doi.org/10.3390/su12177098

Esdaile, L. J., and Chalker, J. M. (2018). The Mercury Problem in Artisanal and Small-Scale Gold Mining. Chemistry – a European Journal, 24(27), 6905–6916. https://doi.org/10.1002/chem.201704840

Evers, D. C., Keane, S. P., Basu, N., and Buck, D. (2016). Evaluating the effectiveness of the Minamata Convention on Mercury: Principles and recommendations for next steps. Science of the Total Environment, 569–570, 888–903. https://doi.org/10.1016/j.scitotenv.2016.05.001

Friesen, K. (2007). Case Study: Standards for Mercury-containing Products. Pollution Probe. http://nulaodpadu.sk/files/Mercury%20Product%20Standards%20Case%20Study%20-%20May%202007.pdf

Galaz, V., Biermann, F., Folke, C., Nilsson, M., and Olsson, P. (2012). Global environmental governance and planetary boundaries: An introduction. Ecological Economics, 81, 1–3. https://doi.org/10.1016/j.ecolecon.2012.02.023

Giang, A., & Selin, N. E. (2015). Benefits of mercury controls for the United States. *Proceedings of the National Academy of Sciences*, *113*(2), 286–291. https://doi.org/10.1073/pnas.1514395113

Gunarathne, A. D. N., De Alwis, A., and Alahakoon, Y. (2020). Challenges facing sustainable urban mining in the e-waste recycling industry in Sri Lanka. Journal of Cleaner Production, 251, 119641. https://doi.org/10.1016/j.jclepro.2019.119641

Gworek, B., Dmuchowski, W., Gozdowski, D., Koda, E., Osiecka, R., and Borzyszkowski, J. (2015). Influence of a Municipal Waste Landfill on the Spatial Distribution of Mercury in the Environment. PLOS ONE, 10(7), e0133130. https://doi.org/10.1371/journal.pone.0133130

Habuer, Hamaguchi, D., Zhou, Y., Fujimori, T., and Takaoka, M. (2019). Future trends of excess mercury in Asia in response to Minamata Convention on Mercury. Journal of Environment and Safety, 10(2), 143–151. https://doi.org/10.11162/daikankyo.e19rp0303

Habuer, Zhou, Y., and Takaoka, M. (2018). Time-series analysis of excess mercury in China. Journal of Material Cycles and Waste Management, 20(3), 1483–1498. https://doi.org/10.1007/s10163-018-0712-y

Hall, D. M., and Steiner, R. (2020). Policy content analysis: Qualitative method for analyzing sub-national insect pollinator legislation. MethodsX, 7, 100787. https://doi.org/10.1016/j.mex.2020.100787

Harjunmaa, U., and Auero, M. (2019). Plan for the abolition of dental amalgam by 2030 (No. 978-952-00-4110–6). Finland Ministry of Social Affairs and Health. http://urn.fi/URN:ISBN:978-952-00-4110-6

Hilson, G., Zolnikov, T. R., Ortiz, D. R., and Kumah, C. (2018). Formalizing artisanal gold mining under the Minamata convention: Previewing the challenge in Sub-Saharan Africa. Environmental Science and Policy, 85, 123–131. https://doi.org/10.1016/j.envsci.2018.03.026

Hoffman, M., Schenck, C., and Herbst, F. J. (2022). Exploring the Intersection Where Business Models, a Circular Economy and Sustainability Meet in the Waste Economy: A Scoping Review. Sustainability, 14(6), 3687. https://doi.org/10.3390/su14063687

Hsu-Kim, H., Eckley, C. S., Achá, D., Feng, X., Gilmour, C. C., Jonsson, S., and Mitchell, C. P. J. (2018). Challenges and opportunities for managing aquatic mercury pollution in altered landscapes. AMBIO: A Journal of the Human Environment, 47(2), 141–169. https://doi.org/10.1007/s13280-017-1006-7

Hu, Y., and Cheng, H. (2012). Mercury risk from fluorescent lamps in China: Current status and future perspective. Environment International, 44, 141–150. https://doi.org/10.1016/j.envint.2012.01.006

Ilankoon, I., Ghorbani, Y., Chong, M. N., Herath, G., Moyo, T., and Petersen, J. (2018). E-waste in the international context – A review of trade flows, regulations, hazards, waste management strategies and technologies for value recovery. Waste Management, 82, 258–275. https://doi.org/10.1016/j.wasman.2018.10.018

Illés, A., and Geeraerts, K. (2016). Illegal Shipments of E–waste from the EU to China. In Palgrave Macmillan UK eBooks (pp. 129–160). https://doi.org/10.1057/978-1-349-95085-0_6

Jeswani, H. K., Chilvers, A., & Azapagic, A. (2020). Environmental sustainability of biofuels: a review. *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *476*(2243). https://doi.org/10.1098/rspa.2020.0351

Joy, A., and Qureshi, A. H. (2022). Reducing mercury emissions from coal-fired power plants in India: Possibilities and challenges. AMBIO: A Journal of the Human Environment, 52(1), 242–252. https://doi.org/10.1007/s13280-022-01773-5

Kapoor, N., Sulke, P., and Badiye, A. (2021). E-waste forensics: An overview. Forensic Science International: Animals and Environments, 1, 100034. https://doi.org/10.1016/j.fsiae.2021.100034

Kessler, R. (2013). The Minamata Convention on Mercury: A First Step toward Protecting Future Generations. Environmental Health Perspectives, 121(10). https://doi.org/10.1289/ehp.121-a304

Khorasanizadeh, H., Parkkinen, J., Parthiban, R., and Moore, J. D. (2015). Energy and economic benefits of LED adoption in Malaysia. Renewable and Sustainable Energy Reviews, 49, 629–637. https://doi.org/10.1016/j.rser.2015.04.112

Kim, R. E. (2016). Global governance: Problem shifting in the Anthropocene and the limits of international law. Research Handbook on International Law and Natural Resources, 473–495. https://doi.org/10.4337/9781783478330.00039

Kim, R. E., and Bosselmann, K. (2013). International Environmental Law in the Anthropocene: Towards a Purposive System of Multilateral Environmental Agreements. Transnational Environmental Law, 2(2), 285–309. https://doi.org/10.1017/s2047102513000149

Kosai, S., Badin, A. B., Qiu, Y., Matsubae, K., Suh, S., and Yamasue, E. (2021). Evaluation of resource use in the household lighting sector in Malaysia considering land disturbances through mining activities. Resources Conservation and Recycling. https://doi.org/10.1016/j.resconrec.2020.105343

Kosai, S., Nakajima, K., and Yamasue, E. (2023). Mercury mitigation and unintended consequences in artisanal and small-scale gold mining. Resources, Conservation and Recycling, 188, 106708. https://doi.org/10.1016/j.resconrec.2022.106708

Lebbie, T., Moyebi, O. D., Asante, K. A., Fobil, J. N., Brune-Drisse, M. N., Suk, W. A., Sly, P. D., Gorman, J. K., and Carpenter, D. O. (2021). E-Waste in Africa: A Serious Threat to the Health of Children. International Journal of Environmental Research and Public Health, 18(16), 8488. https://doi.org/10.3390/ijerph18168488

Lee, S. K., Lowry, G. V., and Hsu-Kim, H. (2016). Biogeochemical transformations of mercury in solid waste landfills and pathways for release. Environmental Science: Processes and Impacts, 18(2), 176–189. https://doi.org/10.1039/c5em00561b

Leelakulthanit, O. (2014). The Factors Affecting The Adoption Of LED Lamps. International Business and Economics Research Journal, 13(4), 757. https://doi.org/10.19030/iber.v13i4.8684

Lim, S., Kang, D. G., Ogunseitan, O. A., and Schoenung, J. M. (2013). Potential Environmental Impacts from the Metals in Incandescent, Compact Fluorescent Lamp (CFL), and Light-Emitting Diode (LED) Bulbs. Environmental Science and Technology, 47(2), 1040–1047. https://doi.org/10.1021/es302886m

Liu, J., Yu, S., and Shang, Y. (2020). Toward separation at source: Evolution of Municipal Solid Waste management in China. Frontiers of Environmental Science and Engineering, 14(2). https://doi.org/10.1007/s11783-020-1232-2

Liu, K., Tan, Q., Yu, J., and Wang, M. (2023). A global perspective on e-waste recycling. Circular Economy, 2(1), 100028. https://doi.org/10.1016/j.cec.2023.100028

Liu, S., Wang, X., Guo, G., and Yan, Z. (2021). Status and environmental management of soil mercury pollution in China: A review. Journal of Environmental Management, 277, 111442. https://doi.org/10.1016/j.jenvman.2020.111442

Maag, J., Hylander, L. D., Pirrone, N., Brooks, N., Gilkeson, J. S., and Smit, M. (2007). Mercury substitution priority working list. TemaNord. https://doi.org/10.6027/tn2007-541

Mackey, T. K., Contreras, J. T., and Liang, B. A. (2014). The Minamata Convention on Mercury: Attempting to address the global controversy of dental amalgam use and mercury waste disposal. Science of the Total Environment, 472, 125–129. https://doi.org/10.1016/j.scitotenv.2013.10.115

Mader, E. A., Knuffman, N., and Lutter, R. (2001, January 1). Regulating Mercury Emissions: What Do We Know About Costs and Benefits? ResearchGate. https://www.researchgate.net/publication/46454342_Regulating_Mercury_Emissions_What_Do_We_Know_About_Costs_and_Benefits/citations

Maes, T., and Preston-Whyte, F. (2022). E-waste it wisely: lessons from Africa. SN Applied Sciences, 4(3). https://doi.org/10.1007/s42452-022-04962-9

Martinez, C. B. (2023). Products with added mercury and risks for the environment and health. In Mercuryconvention. Ministry of Environment, Chile.

Masur, J. S., and Posner, E. A. (2018). Unquantified benefits and the problem of regulation under uncertainty. Cornell Law Review, 102(1), 87–138.

McGrath, K. (2013). A Toxic Mouthful: the Misalignment of Dental Mercury Regulations. Boston College Journal of Law and Social Justice, 33(2), 347. https://lawdigitalcommons.bc.edu/cgi/viewcontent.cgi?article=1044andcontext=jlsj

Medipars. (2020). Dental Filling in Iran - Affordable Dental Filling - Medipars. Medipars. https://www.medipars.com/dentistry/dental-filling/

Mestanza-Ramón, C., Mora-Silva, D., D'Orio, G., Tapia-Segarra, E., Gaibor, I. D., Parra, J. R. P., Velásquez, C. a. A., and Straface, S. (2022). Artisanal and Small-Scale Gold Mining (ASGM): Management and Socioenvironmental Impacts in the Northern Amazon of Ecuador. Sustainability, 14(11), 6854. https://doi.org/10.3390/su14116854

Minamata Convention on Mercury. (2023). *Minamata Convention in 2022: Progress report on activities*.

Mitchell, R. K., Andonova, L. B., Axelrod, M., Balsiger, J., Bernauer, T., Green, J. L., Hollway, J., Kim, R. E., & Morin, J. (2020). What We Know (and Could Know) About International Environmental Agreements. *Global Environmental Politics*, *20*(1), 103–121. https://doi.org/10.1162/glep_a_00544

Momeni, H., Fard, S. F. T., Arefinejad, A., Afzali, A., Talebi, F., and Salmani, E. R. (2018). Composition, Production Rate and Management of Dental Solid Waste in 2017 in Birjand, Iran. International Journal of Occupational and Environmental Medicine, 9(1), 52–60. https://doi.org/10.15171/ijoem.2018.1203

Morgan, V. L., McLamore, E. S., Correll, M., and Kiker, G. A. (2021). Emerging mercury mitigation solutions for artisanal small-scale gold mining communities evaluated through a multicriteria decision analysis approach. Environment Systems and Decisions, 41(3), 413–424. https://doi.org/10.1007/s10669-021-09808-0

Mulligan, S. P., Kakonyi, G., Moharamzadeh, K., Thornton, S., and Martin, N. G. (2018). The environmental impact of dental amalgam and resin-based composite materials. British Dental Journal, 224(7), 542–548. https://doi.org/10.1038/sj.bdj.2018.229

Nevondo, V., Malehase, T., Daso, A. P., and Okonkwo, O. (2019). Leachate seepage from landfill: a source of groundwater mercury contamination in South Africa. Water SA, 45(2 April). https://doi.org/10.4314/wsa.v45i2.09

Nys, H., Stultiëns, L., Borry, P., Goffin, T., & Dierickx, K. (2007). Patient rights in EU Member States after the ratification of the Convention on Human Rights and Biomedicine. *Health Policy*, *83*(2–3), 223–235. https://doi.org/10.1016/j.healthpol.2007.02.003

O'Neill, K., Weinthal, E., Marion Suiseeya, K. R., Bernstein, S., Cohn, A., Stone, M. W., and Cashore, B. (2013). Methods and Global Environmental Governance. Annual Review of Environment and Resources, 38(1), 441–471. https://doi.org/10.1146/annurev-environ-072811-114530

Pacyna, J. M., Travnikov, O., De Simone, F., Hedgecock, I. M., Sundseth, K., Pacyna, E. G., Steenhuisen, F., Pirrone, N., Munthe, J., and Kindbom, K. (2016). Current and future levels of mercury atmospheric pollution on a global scale. Atmospheric Chemistry and Physics, 16(19), 12495–12511. https://doi.org/10.5194/acp-16-12495-2016

Palmeira, V. N., Guarda, G., and Kitajima, L. F. W. (2018). Illegal international trade of e-waste - Europe. DOAJ (DOAJ: Directory of Open Access Journals). https://doi.org/10.26403/detritus/2018.13

Parajuly, K., and Fitzpatrick, C. (2020). Understanding the Impacts of Transboundary Waste Shipment Policies: The Case of Plastic and Electronic Waste. Sustainability, 12(6), 2412. https://doi.org/10.3390/su12062412

Patil, R. S., and Ramakrishna, S. (2020). A comprehensive analysis of e-waste legislation worldwide. Environmental Science and Pollution Research, 27(13), 14412–14431. https://doi.org/10.1007/s11356-020-07992-1

Pavlish, J. H., Hamre, L. L., and Zhuang, Y. (2010). Mercury control technologies for coal combustion and gasification systems. Fuel, 89(4), 838–847. https://doi.org/10.1016/j.fuel.2009.05.021

Phungrassami, H., and Usubharatana, P. (2021). Environmental Problem Shifting Analysis of Pollution Control Units in a Coal-Fired Powerplant Based on Multiple Regression and LCA Methodology. Sustainability, 13(9), 5142. https://doi.org/10.3390/su13095142

Prescott, G. W., Baird, M., Geenen, S., Nkuba, B., Phelps, J., and Webb, E. L. (2022). Formalizing artisanal and small-scale gold mining: A grand challenge of the Minamata Convention. One Earth, 5(3), 242–251. https://doi.org/10.1016/j.oneear.2022.02.005

Principi, P., and Fioretti, R. (2014). A comparative life cycle assessment of luminaires for general lighting for the office – compact fluorescent (CFL) vs Light Emitting Diode (LED) – a case study. Journal of Cleaner Production, 83, 96–107. https://doi.org/10.1016/j.jclepro.2014.07.031

Purushothaman, M., Inamdar, M. G., and Muthunarayanan, V. (2021). Socio-economic impact of the e-waste pollution in India. Materials Today: Proceedings, 37, 280–283. https://doi.org/10.1016/j.matpr.2020.05.242

Qi, C., Ma, X., Wang, M., Ye, L., Yang, Y., and Hong, J. (2017). A case study on the life cycle assessment of recycling industrial mercury-containing waste. Journal of Cleaner Production, 161, 382–389. https://doi.org/10.1016/j.jclepro.2017.05.023

Rallo, M., Lopez-Anton, M., Contreras, M. L., and Maroto-Valer, M. M. (2012). Mercury policy and regulations for coal-fired power plants. Environmental Science and Pollution Research, 19(4), 1084–1096. https://doi.org/10.1007/s11356-011-0658-2

Ryan-Fogarty, Y., Baldé, C. P., Wagner, M., and Fitzpatrick, C. (2023). Uncaptured mercury lost to the environment from waste electrical and electronic equipment (WEEE) in scrap metal and municipal wastes. Resources Conservation and Recycling, 191, 106881. https://doi.org/10.1016/j.resconrec.2023.106881

Saalidong, B. M., and Aram, S. A. (2021). Mercury Exposure in Artisanal Mining: Assessing the Effect of Occupational Activities on Blood Mercury Levels Among Artisanal and Small-Scale Goldminers in Ghana. Biological Trace Element Research, 200(10), 4256–4266. https://doi.org/10.1007/s12011-021-03025-1

Sangwan, K. S., Bhakar, V., Naik, S., and Andrat, S. N. (2014). Life Cycle Assessment of Incandescent, Fluorescent, Compact Fluorescent and Light Emitting Diode Lamps in an Indian Scenario. Procedia CIRP, 15, 467–472. https://doi.org/10.1016/j.procir.2014.06.017

Sattar, T. (2020). Brief Discussion on Mercury Poisoning, Its Sources and Remedies to Cure It. Journal of Chemical Health Risks, 12((2)), 131–142. https://10.22034/jchr.2020.1882004.1060

Scheller, F., Wiese, F., Weinand, J. M., Dominković, D. F., and McKenna, R. (2021). An expert survey to assess the current status and future challenges of energy system analysis. Smart Energy, 4, 100057. https://doi.org/10.1016/j.segy.2021.100057

Selin, H., Keane, S. P., Wang, S., Selin, N. E., Davis, K. L., and Bally, D. (2018). Linking science and policy to support the implementation of the Minamata Convention on Mercury.

AMBIO: A Journal of the Human Environment, 47(2), 198–215. https://doi.org/10.1007/s13280-017-1003-x

Shamim, A. M., K, A. S. M., and Rafiq, I. (2015). E-Waste Trading Impact on Public Health and Ecosystem Services in Developing Countries. International Journal of Waste Resources, 05(04). https://doi.org/10.4172/2252-5211.1000188

Shoaee, S., Moghaddam, S. S., Masinaei, M., Sofi-Mahmudi, A., Hessari, H., Heydari, M., Shamsoddin, E., Parsaeian, M., Ghasemian, A., Larijani, B., Fakhrzadeh, H., and Farzadfar, F. (2022). Trends in dental caries of deciduous teeth in Iran: a systematic analysis of the national and sub-national data from 1990 to 2017. BMC Oral Health, 22(1). https://doi.org/10.1186/s12903-022-02634-z

Sikkema, J. K., Alleman, J. E., Ong, S. L., and Wheelock, T. D. (2011). Mercury regulation, fate, transport, transformation, and abatement within cement manufacturing facilities: Review. Science of the Total Environment, 409(20), 4167–4178. https://doi.org/10.1016/j.scitotenv.2011.05.064

Simpson, N. P., Mach, K. J., Kawaguchi, S., Hess, J. J., Hogarth, R., Howden, M., Lawrence, J., Lempert, R. J., Muccione, V., Mackey, B., New, M., O'Neill, B. P., Otto, F. E. L., Pörtner, H., Reisinger, A., Roberts, D., Schmidt, D. N., Seneviratne, S. I., Strongin, S., . . . Trisos, C. H. (2021). A framework for complex climate change risk assessment. One Earth, 4(4), 489–501. https://doi.org/10.1016/j.oneear.2021.03.005

Sjostrom, S., Durham, M. D., Bustard, C., and Martin, C. R. (2010). Activated carbon injection for mercury control: Overview. Fuel, 89(6), 1320–1322. https://doi.org/10.1016/j.fuel.2009.11.016

Sloss, L. L. (2008). Economics of mercury control (ISBN 978-92-9029-453-5). IEA Clean Coal Centre. https://stg-wedocs.unep.org/bitstream/handle/20.500.11822/11681/Economics_of_Hg_control_in_Coal_power_plants.pdf?sequence=1

Smith, L., Ali, M., Agrissais, M., Mulligan, S., Koh, L., and Martin, N. F. (2022). A comparative life cycle assessment of dental restorative materials. Dental Materials, 39(1), 13–24. https://doi.org/10.1016/j.dental.2022.11.007

Smith, M. S., and Gray, F. (2010). Batteries, from Cradle to Grave. Journal of Chemical Education, 87(2), 162–167. https://doi.org/10.1021/ed800053u

Smith, N. M. (2019). "Our gold is dirty, but we want to improve": Challenges to addressing mercury use in artisanal and small-scale gold mining in Peru. Journal of Cleaner Production, 222, 646–654. https://doi.org/10.1016/j.jclepro.2019.03.076

Snyder, H. R. (2019). Literature review as a research methodology: An overview and guidelines. Journal of Business Research, 104, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Spiegel, S. J., Keane, S. E., Metcalf, S., and Veiga, M. M. (2014). Implications of the Minamata Convention on Mercury for informal gold mining in Sub-Saharan Africa: from global policy debates to grassroots implementation? Environment, Development and Sustainability, 17(4), 765–785. https://doi.org/10.1007/s10668-014-9574-1

Steckel, J. C., Edenhofer, O., and Jakob, M. (2015). Drivers for the renaissance of coal. Proceedings of the National Academy of Sciences of the United States of America, 112(29). https://doi.org/10.1073/pnas.1422722112

Steenmans, K. (2019). Extended Producer Responsibility: An Assessment of Recent Amendments to the European Union Waste Framework Directive'. Law, Environment and Development Journal, 15(2), 108. http://www.lead-journal.org/content/19108.pdf

Stern, S. A., and Korn, L. R. (2011). An Approach for Quantitatively Balancing Methylmercury Risk and Omega-3 Benefit in Fish Consumption Advisories. Environmental Health Perspectives, 119(8), 1043–1046. https://doi.org/10.1289/ehp.1002824

Story, R., and Yalkin, T. (2014). Federal contaminated sites cost. Canadian Electronic Library. https://policycommons.net/artifacts/1183975/federal-contaminated-sites-cost/1737098/

Takaoka, M. (2015). Mercury and mercury-containing waste management in Japan. Journal of Material Cycles and Waste Management, 17(4), 665–672. https://doi.org/10.1007/s10163-014-0325-z

Thakur, P. K., and Kumar, S. (2021). Evaluation of e-waste status, management strategies, and legislations. International Journal of Environmental Science and Technology, 19(7), 6957–6966. https://doi.org/10.1007/s13762-021-03383-2

Tian, H., Wang, Y., Cheng, K., Qu, Y., Hao, J., Xue, Z., and Chai, F. (2012). Control strategies of atmospheric mercury emissions from coal-fired power plants in China. Journal of the Air and Waste Management Association, 62(5), 576–586. https://doi.org/10.1080/10962247.2012.663733

Toro, J., Requena, I., Duarte, O., and Zamorano, M. (2013). A qualitative method proposal to improve environmental impact assessment. Environmental Impact Assessment Review, 43, 9–20. https://doi.org/10.1016/j.eiar.2013.04.004

Um, N., Park, Y. S., and Jeon, T. (2023). An improved strategy for effectively managing the transboundary movement of waste based on the basel convention: A case study in South Korea. Heliyon, 9(6), e16496. https://doi.org/10.1016/j.heliyon.2023.e16496

UN Environment. (2017). Global mercury supply, trade and demand (No. 978-92-807-3665–6). United Nations Environment Programme, Chemicals and Health Branch. https://wedocs.unep.org/bitstream/handle/20.500.11822/21725/global_mercury.pdf?sequence=1andisAllowed=y

UNEP. (2013). The rapid transition to energy efficient lighting: an integrated policy approach. United Nations Environment Programme. https://www.unep.org/resources/report/rapid-transition-energy-efficient-lighting-integrated-policy-approach#:~:text=Electricity%20for%20lighting%20accounts%20for,6%25%20of%20CO2%20emissions%20worldwide.

United Nations Environment Programme. (2013). *Minamata convention on mercury: text and annexes*. https://wedocs.unep.org/20.500.11822/8541.

Vahl, F. P., De Souza Campos, L. M., and Rosario, N. (2013). Sustainability constraints in techno-economic analysis of general lighting retrofits. Energy and Buildings, 67, 500–507. https://doi.org/10.1016/j.enbuild.2013.08.039

Van Der Voet, E., and Van Oers, L. (1997). Materials Management and Problem Shifting. Wuppertal Inst. for Climate, Environment and Energy. https://www.researchgate.net/profile/Rene-Kleijn/publication/295702085_Regional_and_National_Material_Flow_Accounting_From_Paradigm_to_Practice_of_Sustainability/links/56cc90f208ae1106370d9b7d/Regional-and-National-Material-Flow-Accounting-From-Paradigm-to-Practice-of-Sustainability.pdf#page=125

Wang, F., Outridge, P. M., Feng, X., Meng, B., Heimbürger-Boavida, L., and Mason, R. P. (2019). How closely do mercury trends in fish and other aquatic wildlife track those in the atmosphere? – Implications for evaluating the effectiveness of the Minamata Convention. Science of the Total Environment, 674, 58–70. https://doi.org/10.1016/j.scitotenv.2019.04.101

Wheatley, B., and Wheatley, M. J. (2000). Methylmercury and the health of indigenous peoples: a risk management challenge for physical and social sciences and for public health policy. Science of the Total Environment, 259(1–3), 23–29. https://doi.org/10.1016/s0048-9697(00)00546-5

Winternitz, K., Heggie, M., and Baird, J. (2019). Extended producer responsibility for waste tyres in the EU: Lessons learnt from three case studies – Belgium, Italy and the Netherlands. Waste Management, 89, 386–396. https://doi.org/10.1016/j.wasman.2019.04.023

Woodcock, A. (2023). Hydrofluorocarbons, Climate, and Health — Moving the Montreal Protocol beyond Ozone-Layer Recovery. *The New England Journal of Medicine*. https://doi.org/10.1056/nejmp2302197

World Bank. (2023). World Bank Country and Lending Groups – World Bank Data Help Desk. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

World Health Organization. (2021). Report of the informal global WHO consultation with policymakers in dental public health, 2021: monitoring country progress in phasing down the use of dental amalgam (ISBN 978-92-4-003842-4).

Xu, Y., Xue, X., Dong, L., Changxin, N., Liu, Y., and Huang, Q. (2018). Long-term dynamics of leachate production, leakage from hazardous waste landfill sites and the impact on groundwater quality and human health. Waste Management, 82, 156–166. https://doi.org/10.1016/j.wasman.2018.10.009

Yang, Y., Bae, J., Kim, J., and Suh, S. (2012). Replacing Gasoline with Corn Ethanol Results in Significant Environmental Problem-Shifting. Environmental Science and Technology, 46(7), 3671–3678. https://doi.org/10.1021/es203641p

Zhengkai, T., Shijin, D., and Chai, X. (2017). Mercury emission to the atmosphere from municipal solid waste landfills: A brief review. Atmospheric Environment, 170, 303–311. https://doi.org/10.1016/j.atmosenv.2017.09.046

Zolnikov, T. R. (2020). Effects of the government's ban in Ghana on women in artisanal and small-scale gold mining. Resources Policy, 65, 101561. https://doi.org/10.1016/j.resourpol.2019.101561

Annex A

Table of implementation rates for each article of the Convention (that has been assessed) based on continental distribution.

	4	4.3	4.4	4.5	5.1	5.2	5.3	8.1	8.2	9	10	11.1	11.2
Africa	38% (13)	50% (17)	21% (7)	26% (9)	18% (6)	6% (2)	3% (1)	26% (9)	38% (13)	15% (5)	21% (7)	32% (11)	0% (0)
Asia	84% (21)	80% (20)	56% (14)	48% (12)	12% (3)	20% (5)	12% (3)	32% (8)	52% (13)	36% (9)	72% (18)	92% (23)	24% (6)
Europe	91% (30)	88% (29)	79% (26)	76% (25)	12% (4)	45% (15)	24% (8)	18% (6)	76% (25)	42% (14)	67% (22)	85% (28)	3% (1)
North America	57% (8)	79% (11)	43% (6)	43% (6)	21% (3)	14% (2)	0% (0)	43% (6)	36% (5)	14% (2)	57% (8)	71% (10)	21% (3)
Oceania	40% (2)	40% (2)	20% (1)	20% (1)	0% (0)	0% (0)	0% (0)	0% (0)	40% (2)	20% (1)	20% (1)	0% (0)	0% (0)
South America	82% (9)	82% (9)	45% (5)	27% (3)	36% (4)	9% (1)	0% (0)	36% (4)	64% (7)	45% (5)	36% (4)	82% (9)	0% (0)
Total	67% (83)	72% (89)	48% (59)	46% (56)	16% (20)	20% (25)	10% (12)	28% (34)	53% (65)	29% (36)	49%(60)	66% (81)	8% (10)

Annex B

Table: Definitions of Types of Mercury/Mercury Sources

Mercury Type/Source	Definition
Acetaldehyde	Measures with this code regard mercury usage during Acetaldehyde production.
MA Batteries and Electronics	Measures with this code regard batteries and other electronics, such as switches, relays, bridges, and accumulators, that contain mercury.
Chlor-Alkali	Measures with this code regard mercury usage during Chlor-Alkali production.
MA Cosmetics	Measures with this code regard Cosmetics that contain mercury.
Dental Amalgam	Measures with this code regard the usage of dental amalgam (a dental restorative which contains mercury).
Dental Facilities	Measures with this code regard the management of mercury within dental facilities, largely related to the usage of dental amalgam.
Cement Clinker Production	Measures with this code regard mercury uses/releases/management during Cement Clinker Production, alongside other environmental standards set.
Coal Fired Industrial Boilers	Measures with this code regard mercury uses/releases/management within Coal Fired Industrial Boilers, alongside other environmental standards set.
Coal Fired Power Plants	Measures with this code regard mercury uses/releases/management within Coal Fired Power Plants, alongside other environmental standards set.
Smelting and Roasting Facilities	Measures with this code regard mercury uses/releases/management during Smelting and Roasting processes, alongside other environmental standards set.
Waste Incineration Facilities	Measures with this code regard mercury uses/releases/management within Waste Incineration Facilities, alongside other environmental standards set.
Hazardous Chemicals	Measures with this code regard practices around the usage, disposal, transport, of hazardous chemicals, primarily mercury.
MA Lamps	Measures with this code regard Lamps or other fluorescent devices that contain mercury.
MA Measurement	Measures with this code regard Measurement devices such as

Mercury Type/Source	Definition
Devices	manometers, sphygmomanometer and thermometers that contain mercury.
MA Medical Devices	Measures with this code regard Medical Devices that contain mercury.
Mercury Added Products	Measures with this code regard Mercury Added Products (MAPs) such as cosmetics, lamps, electronics, pesticides (Annex A products).
Elemental Mercury	Measures with this code regard Mercury as the element itself, unrelated to other products/processes.
Oral Health	Measures with this code regard actions taken towards Oral Health.
MA Pesticides	Measures with this code regard Pesticides that contain mercury.
Polyurethane	Measures with this code regard mercury usage during Polyurethane production.
Mercury Releases	Measures with this code regard Releases of mercury.
Safety	Measures with this code regard Safety within mercury related processes.
Sodium/Potassium Methylate/Ethylate	Measures with this code regard mercury usage during Sodium/Potassium/Methylate/Ethylate production.
Specified Processes	Measures with this code regard Specified Processes such as those outlined in Article 8.2
Vinyl Chloride	Measures with this code regard mercury usage during Vinyl Chloride production.
Mercury Waste	Measures with this code regard Mercury Waste
Unclear Regulations	Measures with this code are measures which do not have sufficient information provided to accurately categorize them into any of the mercury types.
EU Regulation 2017/852	Measures with this code regard measures that have not specified any information aside from the implementation of EU Regulation 2017/852.

Table: Definitions of Types of Measures

Measure Type	Definition
Alternatives	Measures with this code entail the promotion and usage of mercury free Alternatives.
Authorization	Measures with this code entail Authorization procedures necessary for mercury usage.
Awareness	Measures with this code entail actions taken to spread Awareness of mercury and its potential health and environmental impacts.
BAT	Measures with this code entail the implementation or defining of Best Available Techniques within mercury-involved processes.
Content Limitation	Measures with this code entail various mercury Content limitations for products.
Decommission	Measures with this code entail the Decommissioning of facilities which have included mercury within their processes.
Discontinue	Measures with this code entail the discontinued usage of specified products.
Disposal	Measures with this code entail Disposal procedures/standards.
Life Cycle	Measures with this code entail the management of mercury throughout a product's Life Cycle.
Labeling	Measures with this code entail the proper Labeling procedures for products containing mercury.
Limit	Measures with this code are related to emissions Limits established, or limitations set on the usage of mercury products.
Management	Measures with this code entail Management procedures for mercury or mercury products.
Prevention	Measures with this code entail the intended Prevention of negative impacts related to mercury, such as poor oral health or spills.
Prohibition	Measures with this code entail the prohibition of a product or practice related to mercury. Phase-out procedures are included in this code.
Regulation	Measures with this code entail general regulations established to regulate mercury.
Reporting	Measures with this code entail the reporting procedures for mercury spills.
Standards	Measures with this code entail the Standards for mercury releases.
Storage	Measures with this code describe the procedures for the storage of mercury/mercury waste.

Measure Type	Definition
Tools	Measures with this code describe the types of Tools used to manage mercury emissions.
Transport	Measures with this code entail the Transport of mercury, mercury products or waste.

Annex C

Table of countries which have implemented the problem shifting measures.

Dental Amalgam	MAP/Lamps	Emissions Control	Transport	EPR	ASGM
Bulgaria	Argentina	Bulgaria	Argentina	Belgium	Burkina Faso
China	Armenia	China	Austria	Bulgaria	Burundi
Croatia	Brazil	China (Hong Kong SAR)	China	Chile	Central African Republic
Czech Republic	Bulgaria	Croatia	Croatia	Croatia	Chad
Estonia	Bulgaria	Czech Republic	Cyprus	Cyprus	Congo
France	Canada	Denmark	Czech Republic	Denmark	Democratic Republic of the Congo
Ghana	China	Estonia	Denmark	Estonia	Ecuador
Greece	China (Hong Kong SAR)	Germany	Estonia	Germany	Eswatini (Kingdom of)
Hungary	Costa Rica	Ghana	Eswatini (Kingdom of)	Greece	Ghana
Indonesia	Côte d'Ivoire	Guinea-Bissau	Finland	Iceland	Guinea
Iran (Islamic Republic of)	Croatia	Guyana	Germany	Ireland	Guyana
Ireland	Cyprus	Honduras	Greece	Italy	Kenya
Italy	Czech Republic	Hungary	Guyana	Latvia	Kyrgyzstan
Japan	Ecuador	Indonesia	Honduras	Liechtenstein	Lao People's Democratic Republic
Jordan	Finland	Ireland	Hungary	Netherlands	Madagascar
Kuwait	France	Italy	Iran (Islamic Republic of)	Norway	Mali
Latvia	Ghana	Jamaica	Italy	Portugal	Mongolia
Liechtenstein	Honduras	Latvia	Lebanon	Slovenia	Nigeria
Lithuania	Hungary	Mexico	Liechtenstein	Uganda	Paraguay
Mauritius	Iceland	Mongolia	Lithuania	United Kingdom of Great Britain and Northern Ireland	Senegal
Mongolia	Indonesia	Namibia	Malta		Sierra Leone

Nigeria	Ireland	Netherlands	Mongolia		Uganda
Norway	Iran (Islamic Republic of)	Nicaragua	Montenegro		United Republic of Tanzania
Oman	Jamaica	North Macedonia	Netherlands		Zambia
Peru	Japan	Norway	Nicaragua		Zimbabwe
Philippines	Kuwait	Paraguay	Nigeria		
Portugal	Lesotho	Rwanda	Oman		
Qatar	Liechtenstein	Samoa	Peru		
Romania	Lithuania	Slovakia	Romania		
Samoa	Luxembourg	Slovenia	Saudi Arabia		
Saudi Arabia	Madagascar	Sweden	Seychelles		
Seychelles	Montenegro	Thailand	Viet Nam		
Slovakia	North Macedonia	Uganda	Zambia		
Slovenia	Norway	United Kingdom of Great Britain and Northern Ireland			
Sri Lanka	Oman	Viet Nam			
Sweden	Peru				
Switzerland	Philippines				
Thailand	Portugal				
Uganda	Qatar				
United Republic of Tanzania	Samoa				
Viet Nam	Slovakia				
	South Africa				
	Switzerland				
	Uganda				
	United Arab Emirates				
	United Kingdom of Great Britain and Northern Ireland				
	United Republic of				

	Tanzania				

Annex D

Table of 120 Grouped Measures, the unique combinations of mercury type/source and measure type. Includes the number of times implemented, a name given to the measure, alongside variances in diction observed.

Mercury Type	Measure Type	Number	Measure Name	Variance in Diction
Acetaldehyde	Prohibition	10	Prohibition of Mercury Usage in Acetaldehyde Production	- mercury/mercury compounds - as a catalyst
Batteries and Electronics	Content Limit	10	Mercury Content Limitation in Batteries	- 2%, 1%, 0.1%, 0.0005%, 0% - 20 mg, 5 mg - Batteries, electronics, switch, bridge, relay
Batteries and Electronics	Life Cycle	1	Safe Sustainable batteries throughout Life Cycle	
Batteries and Electronics	Prohibition	12	Prohibition of Mercury Added Batteries and electronics	- 6 Manufacture and transport - 2 prohibit over content limits
Batteries and Electronics	Regulation	4	Regulations on hazardous substances in Electronics	- batteries, accumulators, electronics
Chlor- Alkali	2017/852	3	EU Regulation 2017/852	
Chlor- Alkali	Alternatives	3	Use of Mercury Free Alternatives in Chlor-Alkali Facilities	- membrane cells
Chlor- Alkali	BAT	1	Establishing BAT for Chlor-Alkali Facilities	
Chlor- Alkali	Decommissionin g	5	Decommissioning of Chlor-Alkali Facilities	- closure, uninstalled, dismantling
Chlor- Alkali	Prohibition	14	Prohibition of Mercury Usage in Chlor-Alkali Production	3- Phase out - usage as an electrode 4- EU 2017/852
Chlor- Alkali	Tools	3	Installation of Pollution Management Systems	-Air/water pollution - control from dismantling process
Coal Burning	Regulation	2	Regulations on Coal Usage	- no coal under 5MW production
Cosmetics	Limit	3	Content Limitation in Cosmetics	-1ppm
Cosmetics	Prohibition	13	Prohibition of Mercury Added Cosmetics	4- manufacture and transport 1- EU 2017/852 - cosmetics, skin lightening products, personal hygiene

Dental Amalgam	Alternatives	29	Promotion of Alternatives to Dental Amalgam	- encourage to educate and use alternatives - alternatives should be considered - usage has been replaced - encourage insurance companies to better support alternatives -RnD on Restoratives
Dental Amalgam	Awareness	6	Awareness of Mercury Free Alternatives to Dental Amalgam	- research program - awareness programs - capacity building
Dental Amalgam	Life Cycle	16	Regulation of Life Cycle Impacts of Dental Amalgam	- amalgam separators - reduce releases into water or air
Dental Amalgam	Limit	14	Limit Usage of Dental Amalgam	- objective setting
Dental Amalgam	Prohibition	13	Prohibition of Amalgam for Vulnerable Groups	
Dental Amalgam	Prohibition	38	Prohibition/Phase out of Dental Amalgam	
Dental Amalgam	Regulation	19	Restriction of Dental Amalgam to Encapsulated Form	-pre-dosed capsules -encapsulated form
Dental Facilities	Alternatives	10	Promotion of Mercury Free Alternatives in Dental Facilities	- Encouragement/promotion - glass-ionomer cements/resin based composite
Dental Facilities	Life Cycle	19	Promoting BEP in Dental Facilities	- BEP - Amalgam separators - reduce releases - Specialized training
Emissions	BAT	4	Use of BAT to Control Emissions	
Emissions	Limit	3	Established Emissions Limit Values	
Emissions	Reduction	5	Measures to Reduce emissions	
Emissions	Regulation	2	Regulations to Control Emissions	- regulatory framework - Control of input materials
Emissions	Tools	5	Tools to Control Emissions	- electrostatic precipitators - dust recycling filters - simple particulate control systems
Industrial Installations	Authorization	2	Requirement for Facilities to operate under Environmental permits	
Industrial Installations	BAT	9	Implementation of BAT	- BAT/BEP - Promotion of usage/legal obligation/requested
Mercury Emissions	Limit	10	Limits on Mercury Emissions	
Mercury Emissions	Regulations	3	Regulations on Mercury Emissions	

Emissions	Limit	6	Established Emissions Limit Values	
Emissions	Regulation	4	Regulations on Emissions	- Rules on monitoring and reducing emissions - Rules on integrated prevention and reduction of Pollution
Industrial Installations	Regulation	4	Regulations on Industrial Installations	- Capacity of CFB - BAT - Integrated permit
Mercury Emissions	Limit	4	Limits on Mercury Emissions	
Mercury Emissions	Regulations	2	Regulations on Mercury Emissions	
Mercury Emissions	Tools	5	Tools to Control Mercury Emissions	Activated carbon Process - Electrostatic Precipitators - Flue gas desulphurization - Air Scrubber tech
Emissions	BAT	4	Implementation of BAT	
Emissions	Limit	4	Established Emissions Limit Values	
Emissions	Regulation	5	Regulations on Emissions	- Requires pollution prevention and control permit - Objectives to reduce emissions - Regulation of emissions
Emissions	Tools	4	Tools to Control Emissions	- Electrostatic Precipitators - Simple particulate matter control devices - Air Scrubber tech
Industrial Installations	Decommission	2	Decommissioning of Facilities	
Industrial Installations	Regulation	4	Regulations on Industrial Installations	- BAT - Integrated permit
Mercury Emissions	Limit	4	Limits on Mercury Emissions	
Mercury Emissions	Regulations	3	Regulations on Mercury Emissions	
Mercury Emissions	Tools	5	Tools to Control Mercury Emissions	-High efficiency and low emissions tech - Bag filters - desulfurize tech/ Activated carbon process - Electrostatic Precipitators
Emissions	Limit	3	Established Emissions Limit Values	
Emissions	Regulation	5	Regulations on Emissions	- quantified control objective - Reduction and monitoring of emissions

Industrial Installations	Authorization	1	Requirement for Facilities to operate under Environmental permits	
Mercury Emissions	BAT	5	BAT Principles for Mercury Emissions	
Mercury Emissions	Limit	2	Limits on Mercury Emissions	
Mercury Emissions	Regulations	3	Regulations on Mercury Emissions	
Emissions	BAT	6	Implementation of BAT	
Emissions	Limit	9	Mercury Emissions Limit	
Emissions	Regulations	5	Regulations on Emissions	- implementation of monitoring tools - Measures to reduce emissions
Emissions	Tools	4	Tools to Control Emissions	- selective non-catalytic reducers - spray drying absorbers - bag dust filters - acid gas scrubbers
Industrial Installations	Regulation	4	Regulations on Industrial Installations	- implementation of BAT - license application
Mercury Emissions	BAT	2	BAT Principles for Mercury Emissions	
Mercury Emissions	Limit	14	Limits on Mercury Emissions	
Mercury Emissions	Regulations	1	Regulations on Mercury Emissions	
Hazardous Materials	Authorization	2	Permits for Management of Mercury	
Hazardous Materials	Labeling	1	Classification of Products	
Hazardous Materials	Management	7	Environmentally sound storage of Mercury	
Hazardous Materials	Regulation	4	Safety Regulations	- production, trade, use, storage and transport. - Emergency response -mining regulations -ban of entry
Hazardous Materials	Regulations	25	Implementation of Basel Convention	
Hazardous Materials	Regulations	17	Implementation of Regulation 2017/852	
Hazardous Materials	Storage	9	Rules for safe storage of Hazardous Materials	
Lamps	Alternatives	4	Promotion of Mercury Free Lamps	- Campaign Launching - Support/promotion of Alternatives
Lamps	Content Limit	3	Limit on Mercury Content in Lamps	- 1 ppm - Maximum Limits

Lamps	Prohibition	11	Ban on Mercury Added Lamps	- 1 import - 8 manufacture and transport - Limits include 3.5, 5, 10 mg per lamp
Lamps	Regulation	7	Regulations on Mercury containing Lamps	- BEP - Stopped supply - Strategy for Reduction - Collection and Disposal Procedure for Lamps
Measurement Devices	Alternatives	2	Alternatives For measuring devices	- promotion - substitution
Measurement Devices	Authorization	1	Authorization of mercury containing Measurement Devices	- control of import
Measurement Devices	Discontinued	2	Usage of mercury containing Measurement Devices	- discontinued usage
Measurement Devices	Prohibition	12	Prohibition of mercury containing Measurement Devices	- 2 manufacture and transport
Measurement Devices	Regulation	1	Regulations on Mercury containing Measurement Devices	-Inform regulators on Regulations
Medical Devices	Prohibition	4	Prohibition of mercury containing Medical Devices	
Medical Devices	Regulation	1	Regulations on Mercury containing Measurement Devices	
Mercury	Alternatives	3	Alternatives for Mercury	-Studying alternatives -Encouraging
Mercury	Authorization	8	Authorization of Mercury Transport and Manufacture	
Mercury	Awareness	2	Awareness Raising on Risks of Mercury	
Mercury	Disposal	5	Disposal of Mercury	- Separation of MAPs from normal Waste - Environmentally sound manner
Mercury	Life Cycle	2	Regulations on Life Cycle of Mercury	-Crematoria - Health Institutions
Mercury	Limit	4	Limitation on Usage of Mercury	
Mercury	Management	11	Environmentally sound management of mercury	
Mercury	Prohibition	37	Prohibition on Usage, Manufacture, Transport of Mercury	
Mercury	Prohibition	2	Prohibition of Mercury as a Catalyst	

Mercury	Regulation	10	Regulations on Mercury	- reduce air emissions -transport control - controlled substances - Mercury in a closed system - recovery, recycling, re-use regulations
Mercury	Transport	6	Transport of Mercury Waste	- Prohibition - in accordance with guidelines of conventions - permitted approval of activities
Mercury	Storage	19	Regulations on the Storage of Mercury	- Safe confinement of mercury
Mercury Added Products	Alternatives	3	Alternatives to MAPs	- promote usage of products
Mercury Added Products	Authorization	8	Authorization of MAPs	
Mercury Added Products	Awareness	4	Awareness on MAP	- sensitization sessions -awareness campaigns - discouragement of usage
Mercury Added Products	Limit	3	Limit the Usage of MAPs	-Discouragement -permissible limits -provisions to seek reductions
Mercury Added Products	Prohibition	59	Prohibition of MAPs	
Mercury Added Products	Regulations	21	Regulations on MAPs	-control and monitoring -management
Mercury Emissions	Limit	4	Limits on Mercury Emissions	
Oral Health	Awareness	12	Awareness on health	- campaigns on impacts of mercury - PSAs - education in schools
Oral Health	Prevention	10	Prevention of Poor oral health	- reduce need for restoration
Pesticides	Alternatives	1	Alternatives for Pesticides	
Pesticides	Content Limitation	2	Limitation on Mercury in Pesticides	
Pesticides	Prohibition	15	Prohibition of Mercury Added Pesticides	
Polyurethane	Limit	1	Established limits for emissions in Polyurethane production	
Polyurethane	Prohibition	8	Prohibition of mercury in Polyurethane production	- mercury catalysts - 2017/852 n=3
Practices	Authorization	2	Authorization related to mercury usage	
Practices	BAT	2	Implementation of BAT	
Releases	Limit	10	Limits on Mercury Releases	- .001mg in water

Releases	Reporting	2	Reporting on mercury releases	
Releases	Standards	5	Mercury Release standards	- discharge standards - waste disposal - emissions reductions
Safety	Regulations	3	Safety Regulations	- Operators take appropriate measures to avoid incidents - Safety conditions
Sodium/Potassium Methylate/Ethylate	Limit	2	Capacity of current production cannot be exceeded	
Sodium/Potassium Methylate/Ethylate	Prohibition	7	Prohibition of production of Sodium/Potassium Methylate/Ethylate	
Specified Processes	Authorization	1	Application for License	
Storage	Regulation	2	Environmentally sound storage of Mercury	- waste - mercury, compounds, mixtures
Vinyl Chloride	Alternatives	2	Alternatives for production	- rnd - ethylene usage
Vinyl Chloride	Prohibition	12	Prohibition of mercury in Vinyl Chloride production	- n=2 ban on vinyl chloride production - n =4 2017/852
Waste	Disposal	4	Standards on the disposal of waste	
Waste	Management	15	Waste management standards	- generator of waste is responsible - MAP waste is not accepted at landfills - General guidelines on disposal
Waste	Transport	5	Transport of Waste	- Procedures for waste disposal
Unclear	Unclear	28	Additional Unclear Regulations	
Unclear	Unclear	16	Additional Unclear Regulations	
Unclear	Unclear	12	Additional Unclear Regulations	
Unclear	Unclear	12	Additional Unclear Regulations	
Unclear	Unclear	13	Additional Unclear Regulations	
Unclear	Unclear	3	Additional Unclear Regulations	
Unclear	Unclear	2	Additional Unclear Regulations	
Unclear	Unclear	56	Additional Unclear Regulations	
Unclear	Unclear	14	Additional Unclear Regulations	
Unclear	Unclear	13	Additional Unclear Regulations	
Unclear	Unclear	16	Additional Unclear Regulations	
Unclear	Regulation	14	Implementation of EU 2017/852	

Unclear	Regulation	5	Implementation of EU 2017/853	
Unclear	Regulation	8	Implementation of EU 2017/854	
Unclear	Regulation	14	Implementation of EU 2017/855	
Unclear	Regulation	1	Implementation of EU 2017/856	
Unclear	Regulation	1	Implementation of EU 2017/857	
Unclear	Regulation	1	Implementation of EU 2017/858	
Unclear	Regulation	10	Implementation of EU 2017/859	
Unclear	Regulation	3	Implementation of EU 2017/859	