USING PRTR INFORMATION TO EVALUATE PROGRESS TOWARDS THE SUSTAINABLE DEVELOPMENT GOAL 12

Series on Pollutant Release and Transfer Registers No. 25

OECD

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A cooperative agreement among **FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank and OECD**

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Foreword

In 2011, the OECD Task Force on PRTRs commenced to develop a framework that defines the role of PRTRs in sustainable development and illustrates how PRTR data and information can be used to assess progress towards global sustainability. The OECD published the result as a document, *Framework on the Role of Pollutant Release and Transfer Registers (PRTRs) in Global Sustainability Analyses* (OECD, 2017[1]) (hereinafter referred to as "*Framework*") in February 2017. Section 2.4 of the Framework describes the potential use of PRTR data to assess progress towards reaching some of the Sustainable Development Goals (SDGs) described in the United Nations' (UN's) publication, *Transforming our World: The 2030 Agenda for Sustainable Development* (UN, 2015[2]).

As a follow-up to the completion of the Framework, the OECD Working Group on PRTRs (WG-PRTRs) initiated a project in summer 2017, to apply the Framework to the most relevant SDGs as a demonstration of the utility of PRTR data for global-scale sustainability analysis. Following the publication of Action Plan for analysis of PRTR data for evaluating progress towards the SDGs in 2018 (OECD, 2018[3]), WG-PRTRs conducted the analysis of PRTR data from seven PRTR data systems in line with the Action Plan, and the results were summarised in this document. All these works including analysis, discussion, and drafting in this project were led by the US .

This document was prepared under the supervision of the WP-PRTRs and published under the responsibility of the Chemicals and Biotechnology Committee.

Abbreviations and acronyms

CFs	Pollutant-specific characterization factors
CTU	Comparative Toxicity Units
CTUe	Comparative Toxicity Units as harm to the environment
CTUh	Comparative Toxicity Units as harm to humans
Cr(0)	Chromium (0)
Cr(III)	Chromium (III)
Cr(VI)	Chromium (VI)
DEHP	Di(2-ethylhexyl) phthalate
E-PRTR	European Pollutant Release and Transfer Register
EPA	Environmental Protection Agency
EU	European Union
GDP	Gross Domestic Product
ISIC	International Standard Industrial Classification of All Economic Activities
NEI	National Emissions Inventory
PM	Particulate Matter
$PM_{2.5}$	Particulate matter - fraction of particles having an aerodynamic diameter of less than 2,5 µm
PM_{10}	Particulate matter - fraction of particles having an aerodynamic diameter of less than 10 µm
PRTR	Pollutant Release and Transfer Register
PVC	Polyvinyl chloride plastics
SDG	Sustainable Development Goal
SETAC	Society for Environmental Toxicology and Chemistry
SO_x	Sulphur oxides
TRI	Toxics Release Inventory
UN	United Nations
UNEP	United Nations Environment Programme
US	United States

Executive Summary

A **Pollutant Release and Transfer Register (PRTR)** is a system to collect and disseminate information on environmental releases and transfers of pollutants from industrial and other facilities. Among the most important applications of PRTRs is their use to inform decisions, gain insight, identify opportunities, and assess progress related to sustainability. OECD's *Framework on the Role of Pollutant Release and Transfer Registers (PRTRs) in Global Sustainability Analyses* (OECD, 2017[1]) describes the role of PRTRs in sustainable development and illustrates how PRTR data and information can be used to assess progress towards global sustainability. Based on the *Framework*, this analysis developed approaches for using PRTR data from multiple countries to conduct a global-scale analysis focused on assessing progress towards the U.N. Sustainable Development Goals (SDGs), specifically Goal 12, Target 12.4. This target focuses on sound chemical management, reducing releases of chemicals to the environment, and minimizing the adverse impacts of chemical releases on human health and the environment. In addition to the *Framework*, this analysis builds upon OECD efforts to improve harmonisation of different PRTR datasets for use in international-scale analysis and the follows the project's Action Plan (OECD, 2018[3]).

SDG Target 12.4

By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their releases to air, water and soil in order to minimize their adverse impacts on human health and the environment.

Analytical Approach

PRTRs are a rich source of data that have not previously been analysed for tracking progress toward the UN SDGs. Few, if any, analyses to date aggregate existing global PRTR data. This lack of global analysis may be due, in part, to the challenges in analysing data from PRTRs that have differing reporting requirements. To address these differences, this analysis limits itself to key, common elements of PRTRs: releases to air and water, releases from facilities in the manufacturing sector, and releases of specific key pollutants of concern that are widely included in PRTRs (shown in Table ES - 1). Focusing on these data elements removes some, although not all, of the differences in how data are reported among PRTRs. The report notes areas where differences in reporting requirements appear to impact the results of the analyses.

Parameters of the Analysis

The project uses data on 14 pollutants tracked by seven PRTRs. The data pertain to releases of the pollutants to air and water during 2008 through 2017 from facilities in the manufacturing sector.

The 14 pollutants included in the analysis fall into two groups:

- "Atmospheric pollutants"—that is, sulphur oxides (SO_x) and particulate matter (PM), both high-volume air pollutants primarily released as by-products from the combustion of fossil fuels at manufacturing facilities.
- "Toxic pollutants"—that is, the other 12 pollutants selected for this analysis.

This report uses those two terms to distinguish the two atmospheric pollutants with much larger-scale releases from the other pollutants in the analysis, so that the trends in releases of all of the pollutants can be examined without being eclipsed by the large-scale releases of SO_x and PM.

Table ES - 1. Pollutants and PRTRs included in the analysis

Pollutant	Australia	Canada	Chile	E-PRTR	Japan	Mexico	U.S.
1,2-Dichloroethane	✓	✓		✓	✓	✓	✓
Benzene	✓	✓	✓	✓	✓	✓	✓
Cadmium	✓	✓	✓	✓	✓	✓	✓
Chromium	✓	✓	✓	✓	✓	✓	✓
Di-(2-ethylhexyl) phthalate	✓	✓		✓	✓		✓
Dichloromethane	✓	✓		✓	✓	✓	✓
Ethylbenzene	✓	✓		✓	✓		✓
Mercury	✓	✓	✓	✓	✓	✓	✓
Nickel	✓	✓	✓	✓	✓	✓	✓
Particulate matter	✓	✓	✓	✓			✓*
Styrene	✓	✓			✓	✓	✓
Sulphur oxides	✓	✓	✓	✓			✓*
Tetrachloroethylene	✓	✓	✓	✓	✓		✓
Trichloroethylene	✓	✓		✓	✓	✓	✓

*Emissions of particulate matter and sulphur oxides are not tracked by the U.S.' PRTR system but are tracked by the U.S.' National Emissions Inventory. For additional detail on reporting of particulate matter and sulphur oxides, and how the speciation of chromium was addressed, see the full report.

Analysis

This report considers releases of pollutants in two ways: point-in-time "snapshot" analyses identify the sectors, geographic regions, and medium of release driving pollutant releases; and trend analyses review the change in releases over time.

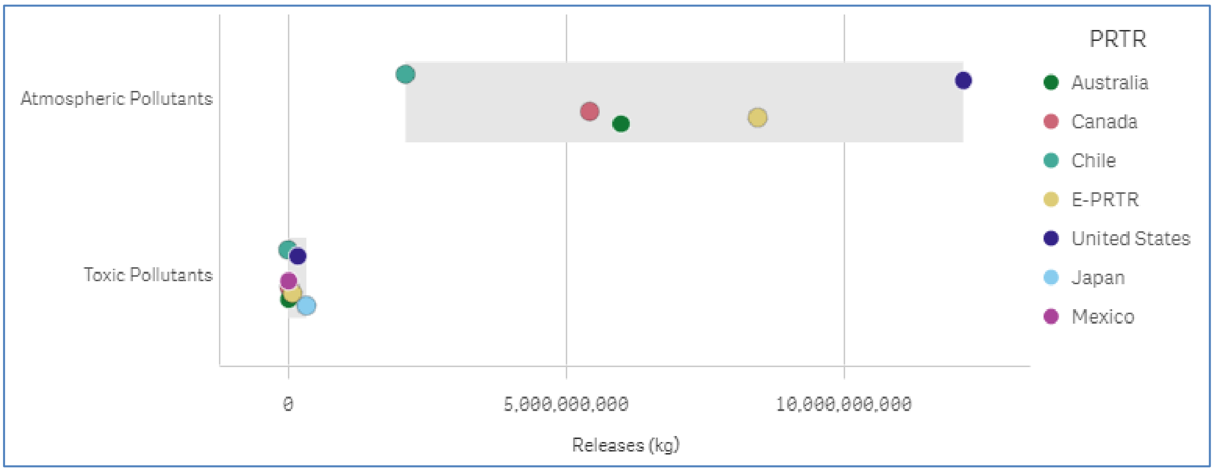
Snapshot analyses present combined results for the years 2008–2017 and found:

- By pollutant, releases were driven by the two atmospheric pollutants, as shown in Figure ES - 1 and Figure ES - 2.
- By medium, releases were mainly to air (>99%).
- By pollutant, metals were the main drivers of toxicity impact scores.
- By sector, releases were distributed across manufacturing subsectors.

- The basic metals sector (ISIC 24) released the largest quantities of atmospheric pollutants, and the rubber and plastics sector (ISIC 22) released the most toxic pollutants.
- Toxicity impact scores were driven by the basic metals sector (ISIC 24) and the chemical manufacturing sector (ISIC 20).

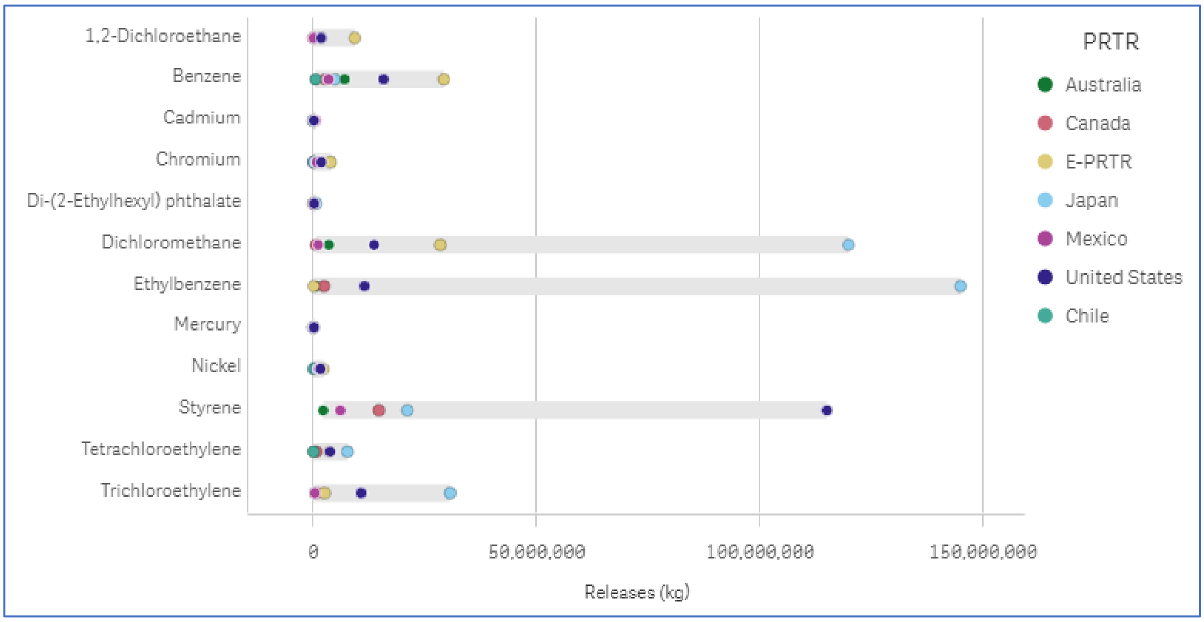
- By PRTR, releases were largest in the three PRTRs with the largest economies (the E-PRTR, the U.S., and Japan).

Figure ES - 1. Releases of atmospheric pollutants and toxics by PRTR, 2008 - 2017



Data on atmospheric pollutant releases are not available for Japan or Mexico.

Figure ES - 2. Releases of toxic pollutants by PRTR, 2008–2017



Trends analyses found:

- Including all pollutants in the study, releases decreased by 47% from 2008 to 2017, driven by reductions in the atmospheric pollutants (Figure ES - 3).
- Releases of the toxic pollutants decreased by 27% from 2008 to 2017 (Figure ES - 4).
- Releases of each individual pollutant in the analysis decreased from 2008 to 2017, and the trend was statistically significant for most of the pollutants.
- Releases of most pollutants decreased in most PRTRs.
- Releases normalized by manufacturing GDP also decreased from 2008 to 2017.
- Toxicity impact scores for cancer, non-cancer, and ecotoxicity decreased substantially (Figure ES - 5, Figure ES - 6 and Figure ES - 7).

Figure ES - 3. Trend in releases of atmospheric pollutants and toxics

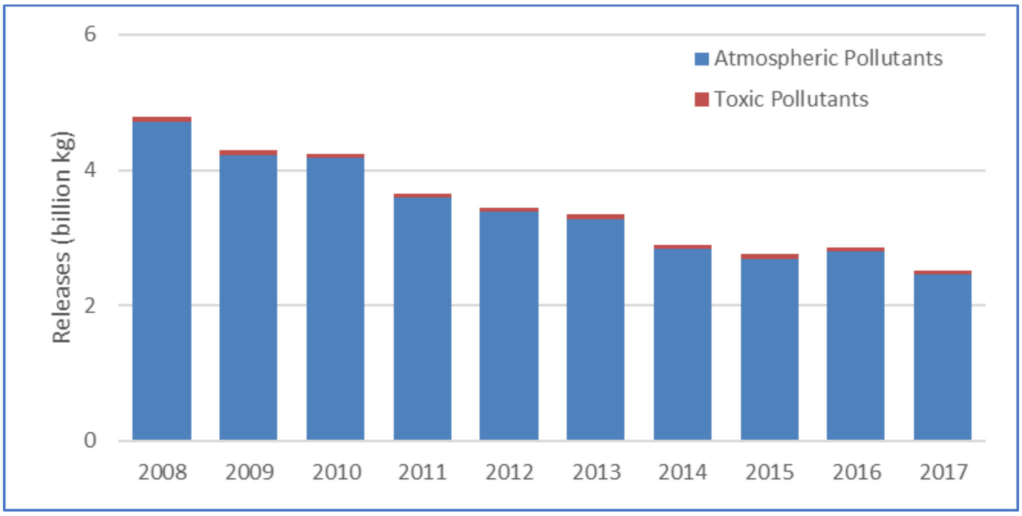


Figure ES - 4. Trend in releases of toxic pollutants

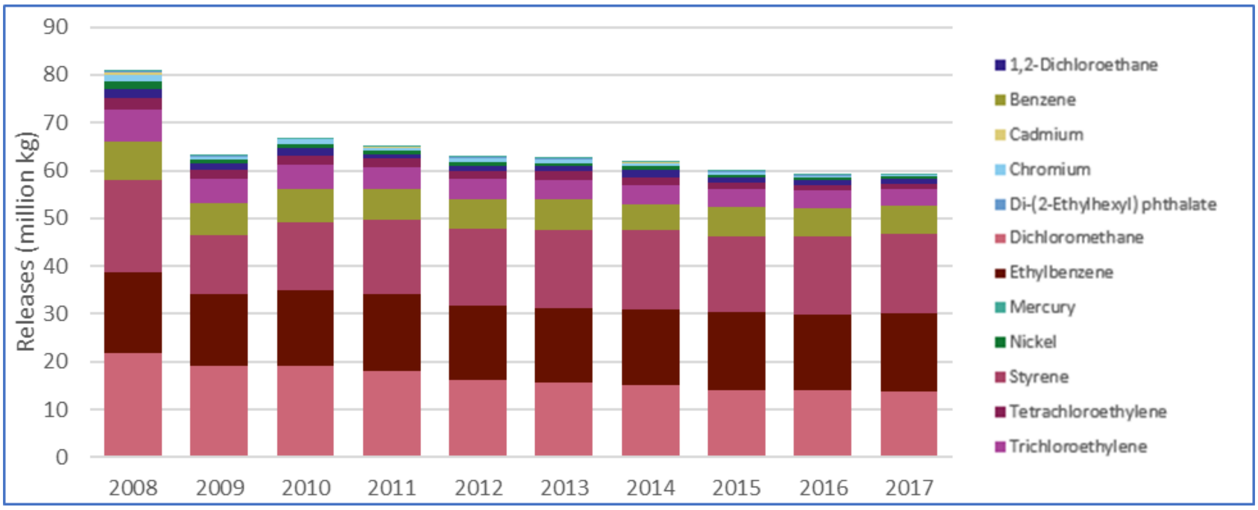
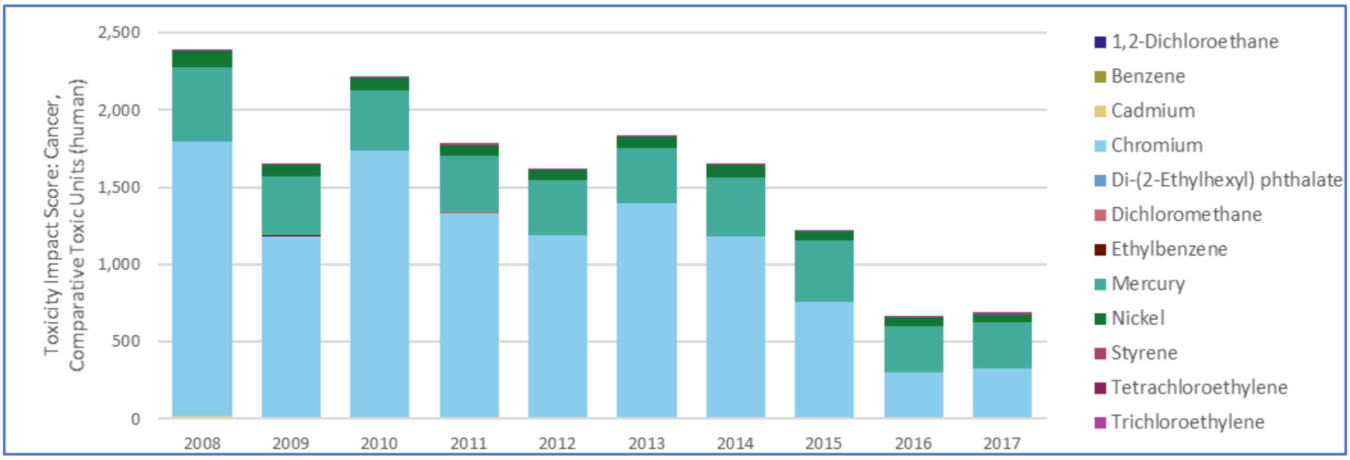
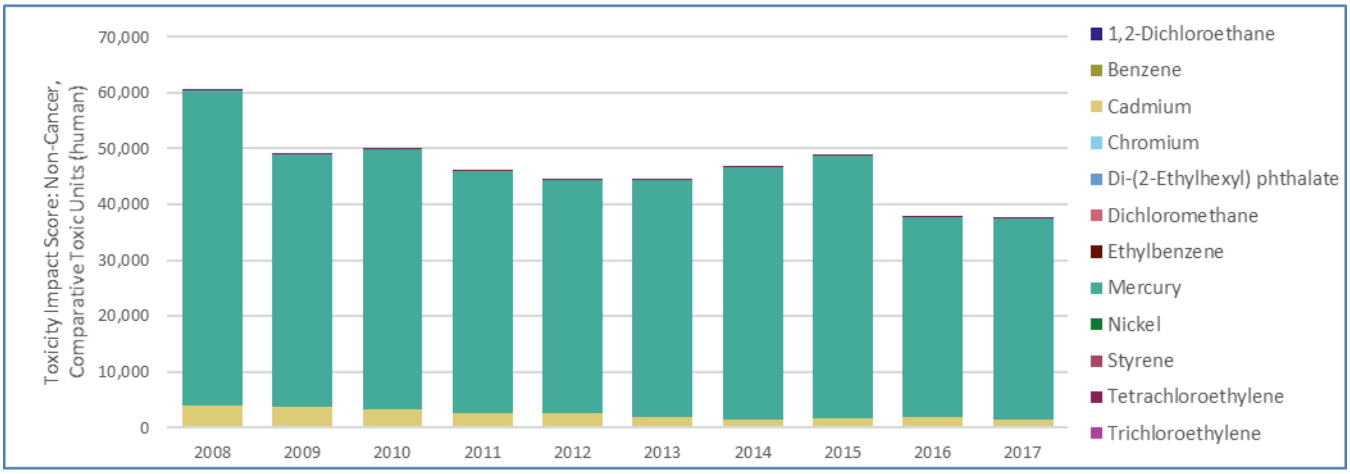


Figure ES - 5. Trend in cancer toxicity impact score by pollutant



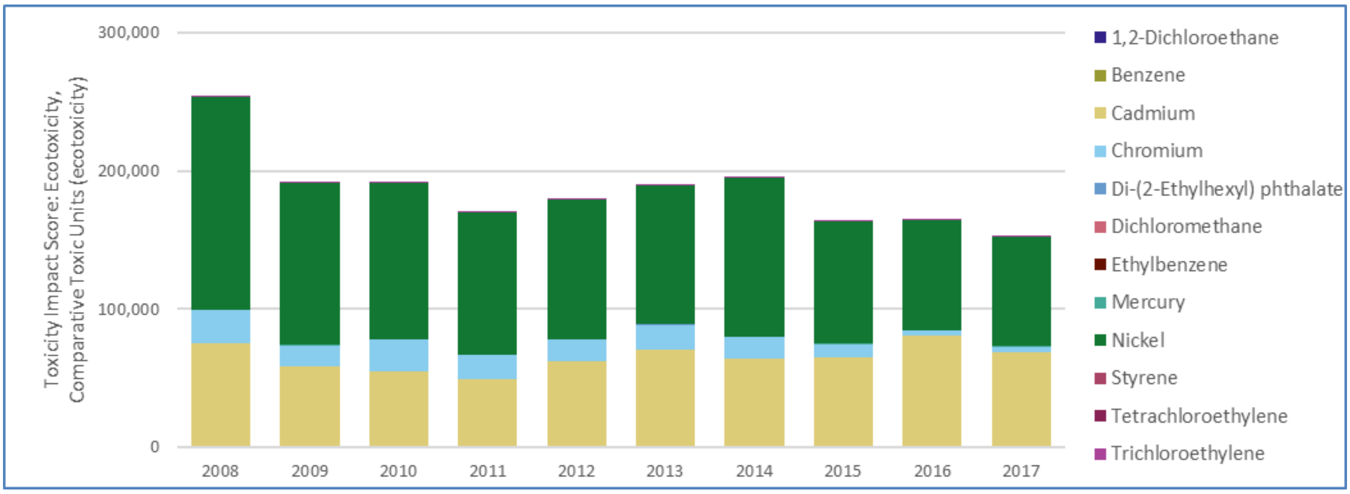
Atmospheric pollutants (sulphur oxides and particulate matter) and data from Mexico are excluded.

Figure ES - 6. Trend in non-cancer toxicity impact score by pollutant



Atmospheric pollutants (sulphur oxides and particulate matter) and data from Mexico are excluded.

Figure ES - 7. Trend in ecotoxicity impact score by pollutant



Atmospheric pollutants (sulphur oxides and particulate matter) and data from Mexico are excluded

Limitations

While existing PRTR data are the best source of information on pollutant releases in covered countries, there are limitations to consider, including:

- **Reporting requirements**. In analysing data across multiple PRTRs, this analysis considers the differences among the PRTR reporting requirements, such as differences in reporting thresholds. While it is not usually possible to quantify these impacts, they are addressed qualitatively.
- **Countries included**. The analysis includes established PRTRs, but it does not represent all global releases of the selected pollutants. Some countries with large manufacturing sectors, such as China and India, do not have PRTRs. The PRTRs in the analysis represent more than half of global manufacturing activity, but the analysis cannot assess release trends in countries without PRTRs.
- **Pollutants included**. This project reviews releases of 14 pollutants, while Target 12.4 aims to achieve reduced releases of seemingly all pollutants. While the results of the analyses indicate that releases to the environment of this group of pollutants are decreasing, these results cannot be extrapolated to assume that releases of all pollutants are decreasing.
- **Sectors included.** Each PRTR defines the requirements for which economic sectors are required to report. While these requirements differ among PRTRs, they generally include all or almost all manufacturing facilities; therefore, the analysis focuses on only the manufacturing sector to minimize the impact of sector coverage differences. E-PRTR requirements, however, are based on specific activities conducted at facilities, rather than on sectors. The reporting of only releases associated with covered activities rather than releases from all operations may be less inclusive than reporting of all activities at a covered facility, as in other PRTRs. While the results of the analyses indicate that releases to the environment of the selected pollutants by manufacturing facilities are decreasing, these results cannot be extrapolated to assume that releases of these pollutants from all sources are decreasing. Other industrial sources, such as electric power generation, as well as mobile and diffuse sources also release some of the same pollutants.

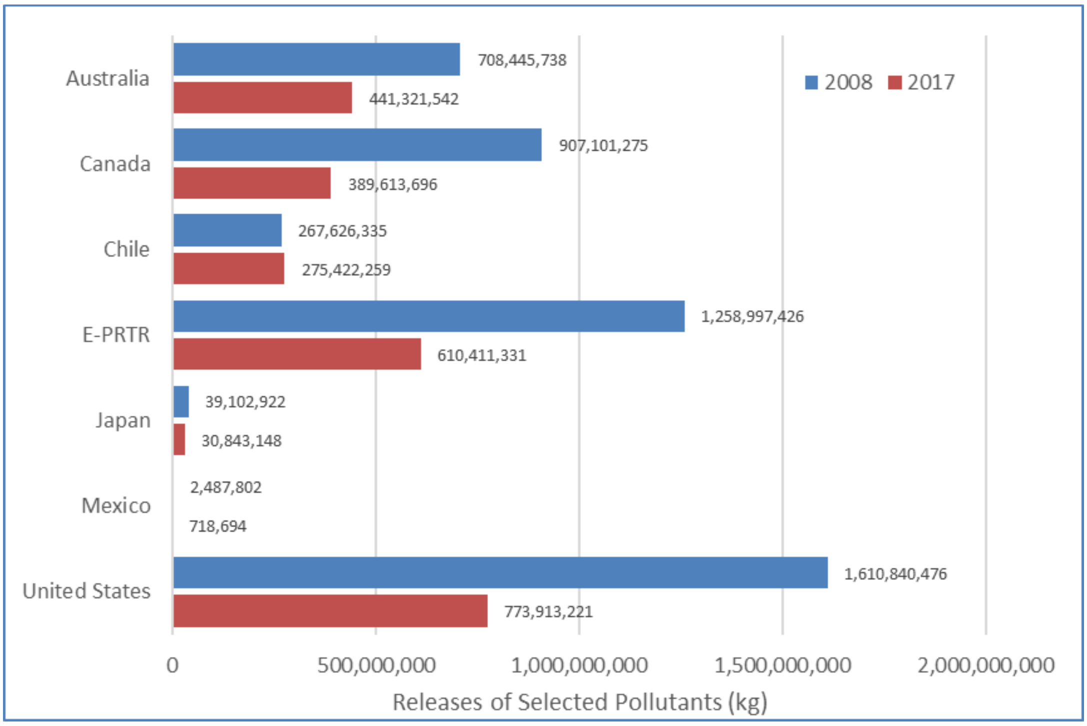
Discussion

The report's discussion focuses on the project's three objectives:

Objective: Develop approaches for using PRTR data for global-scale sustainability analyses. The project integrates the PRTR data from the seven PRTR data systems which required harmonising the sector definitions, chemical names, and releases data fields and transforming the data to a common format. Integration of the PRTR data on this scale had not been done previously. The integrated data format was designed so it can be readily updated when new data are available and could be used for other projects focused on global-scale sustainability analyses.

Objective: Assess progress towards SDG Target 12.4. The trends presented in the analysis are intended to assess progress toward "significantly reducing releases" of the pollutants in the study. As noted above, releases decreased by 47% from 2008 to 2017. The change over this time period by PRTR is shown in Figure ES – 8.

Figure ES – 8. Change in releases of 14 pollutants, 2008 to 2017



Objective: Accelerate progress towards meeting SDG Target 12.4. This project may serve to accelerate progress towards Target 12.4 in two ways. First, it can provide insight on where to focus global efforts. Second, it provides opportunities for knowledge transfer among countries.

Possible directions for future OECD analyses

This OECD study presents trends on releases of specific pollutants in countries that represent more than half of global manufacturing GDP, though future work could expand this project to include additional pollutants and economies. Additionally, six other SDG targets were identified in this project's Action Plan that are related to pollution, chemical management, and waste for which PRTR data may be relevant in tracking progress. While the OECD Working Party on PRTRs determined that Target 12.4 is the SDG target most closely aligned with available PRTR data and was selected as the focus of the initial phase of this study, future applications of this approach may address additional SDG targets and demonstrate the utility of PRTR information in assessing and promoting global sustainability.

Chapter 1. Introduction

1.1. Project overview and objectives

A Pollutant Release and Transfer Register (PRTR) is a system to collect and disseminate information on environmental releases and transfers of toxic pollutants from industrial and other facilities. In addition to facility releases, some PRTRs collect pollution-prevention-related information on toxic pollutants, and some PRTR systems include estimates of releases from diffuse sources (e.g., from vehicles or agriculture). PRTRs have been established worldwide, potentially allowing assessment of international trends in pollution and chemical waste management. This project was developed to provide a new metric in assessing progress towards the U.N. Sustainable Development Goals (SDGs), a set of goals to achieve a sustainable future for all, using data from PRTRs. Several of the SDGs relate to pollution, chemical management, and waste. After reviewing the goals and the targets for each goal (OECD, 2018[3]), the Organization for Economic Cooperation and Development (OECD) Working Party on PRTRs[1] determined that Goal 12, Target 12.4, is the most closely aligned with available PRTR data.

SDG Target 12.4

By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their releases to air, water and soil in order to minimize their adverse impacts on human health and the environment.

Goal 12 is to ensure sustainable consumption and production patterns. Target 12.4 focuses on sound chemical management and minimizing impacts of chemical releases. PRTRs include data on releases of certain chemicals to air, water, and soil. The only indicator currently tracked for Target 12.4 is the number of parties to international environmental agreements on hazardous waste (Ritchie et al., 2018[4]). While this information relates to the first part of the target ("achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, **in accordance with agreed international frameworks**"), it does not track quantities of chemical releases to the environment, as stated in the second part of the target (i.e., "significantly reduce their releases to air, water and soil in order to minimize their adverse impacts on human health and the environment"). With annual data from many countries on releases of chemicals to air and water, PRTR data can help fill this gap in tracking progress towards Target 12.4.

The objectives of this project are to:

- Develop approaches for using PRTR data for global-scale sustainability analyses based on the *Framework on the Role of Pollutant Release and Transfer Registers (PRTRs) in Global Sustainability Analyses* (OECD, 2017[1]).
- Assess progress towards SDG Target 12.4 and, eventually, other specific SDG targets through examination of global chemical pollution and waste management trends.
- Accelerate progress towards SDG Target 12.4 by investigating the drivers of observed trends and providing an opportunity for knowledge transfer among countries facing similar chemical pollution challenges.

Note

[1] This OECD group was a PRTR "Task Force" through 2018, then a PRTR "Working Group," then a PRTR "Working Party." This group provided comments throughout the development of this analysis, but for simplicity is referred to as the PRTR "Working Party" throughout this document, regardless of the group's title at the time the input was provided.

Chapter 2. Analytical Approach

PRTRs are a rich source of data that have not previously been analysed for tracking progress toward the UN SDGs. In fact, few if any analyses to date aggregate existing global PRTR data. This lack of global analysis may be due, in part, to the challenges in analysing data from PRTRs that have differing reporting requirements. To address these differences, this analysis limited itself to key, common elements of PRTRs: releases to air and water, releases from facilities in the manufacturing sector, and releases of select chemicals that are widely included in PRTRs. This section describes the parameters established for the analysis and the analytical approach.

2.1. Pollutant release and transfer register data included

Parameters of Analysis

The project uses data on 14 pollutants tracked by seven PRTRs. The data pertain to releases of the pollutants to air and water during 2008 through 2017 from facilities in the manufacturing sector.

This analysis included seven PRTR systems: those of Australia, Canada, Chile, Japan, Mexico, the U.S., and the European Union plus additional countries (referred to as the E-PRTR). These PRTR systems are all country-wide programs with reporting at least as early as 2008, with the exceptions of the E-PRTR and the Chilean PRTR.

- The E-PRTR is regional rather than country-specific. It was established by the European Commission as a central PRTR for Europe and, as of the 2017 reporting year, included data from all EU member states[1] as well as Iceland, Liechtenstein, Norway, Serbia, and Switzerland. Because the E-PRTR includes data from the EU plus additional countries, it would be inaccurate to reference the E-PRTR as an "EU" dataset. Additionally, the E-PRTR does not include some countries that are considered part of Europe (e.g., Turkey), so it would be inaccurate to call it a dataset for Europe. This analysis therefore refers to the "E-PRTR" even when other PRTRs are referenced by their country.
- Chile's data collection was established in 2005, based on data reported by facilities to multiple government agencies under a variety of regulations instead of direct reporting to the PRTR. Direct reporting to Chile's PRTR began in 2014. Although 2014 saw fewer reporting facilities and lower release quantities than 2013, by 2015 both numbers were similar to the 2013 numbers. The change in reporting methods did not have any obvious effect on reported releases, and this is the only available PRTR data from South America for this period, so the data from Chile were considered acceptable to include in the analysis.

While most established PRTRs are included in this analysis, some countries with large manufacturing economies, such as China and India, do not have PRTRs and therefore could not be included in the analysis. Even so, the PRTRs included in the analysis represent more than half of global manufacturing activity as measured by manufacturing GDP.[2]

2.2. Pollutants included

This project applies the concepts put forth in two documents recently published by the OECD Working Party on PRTRs, referred to as the *Framework* (OECD, 2017[1]) and the *Action Plan* (OECD, 2018[3]) in this document. This project is the first to use PRTR data to assess progress towards meeting a UN SDG target.

For this project, 14 pollutants (shown in Table 1) as reported to the seven PRTR systems listed above were studied. The included pollutants were chosen based on the following criteria:

- Inclusion by at least four of the seven PRTR systems.
- inclusion on a priority list or other consideration as a pollutant of priority in a country or region.
- Manufacture, processing, or other use by a variety of industry sectors or in a variety of applications.
- Known or believed ability to cause serious adverse effects to human health or the environment.

For further detail on the selection of these 14 pollutants, see Section 5 of this project's *Action Plan* (OECD, 2018[3]).

The 14 pollutants included in the analysis fall into two groups:

- "Atmospheric pollutants"—that is, sulphur oxides (SO_x) and particulate matter (PM), both high-volume air pollutants primarily released as by-products from the combustion of fossil fuels.
- "Toxic pollutants"—that is, the other 12 pollutants.

This report uses those two terms for practical reasons: to separate the two pollutants with much larger-scale releases from the other pollutants in the analysis, so that the trends in releases of all of the pollutants can be examined without being eclipsed by the large-scale releases of SO_x and PM. Use of this terminology is not intended to rank or distinguish the pollutants' potential adverse human health, ecological, or environmental effects.

Most of the pollutants in the analysis are reported to most of the seven PRTRs. The pollutants are listed in Table 1, with check marks indicating which pollutants are reported to each PRTR.

Table 1. Pollutants included in the analysis, by PRTR

Pollutant	Australia	Canada	Chile	E-PRTR	Japan	Mexico	U.S.
1,2-Dichloroethane	✓	✓		✓	✓	✓	✓
Benzene	✓	✓	✓	✓	✓	✓	✓
Cadmium	✓	✓	✓	✓	✓	✓	✓
Chromium	✓ Cr(III) and Cr(VI)	✓	✓	✓	✓ Cr(VI), Cr(0), and Cr(III)	✓	✓
Di-(2-ethylhexyl) Phthalate	✓	✓		✓	✓		✓
Dichloromethane	✓	✓		✓	✓	✓	✓
Ethylbenzene	✓	✓		✓	✓		✓
Mercury	✓	✓	✓	✓	✓	✓	✓
Nickel	✓	✓	✓	✓	✓	✓	✓
Particulate matter*	✓	✓	✓	✓			** (NEI)
Styrene	✓	✓			✓	✓	✓
Sulphur oxides	✓ (SO_2)	✓ (SO_2)	✓ (SO_2)	✓ (Total SO_x)			** (SO_2 in NEI)
Tetrachloroethylene	✓	✓	✓	✓	✓		✓
Trichloroethylene	✓	✓		✓	✓	✓	✓

*PM_{10} (particles with diameter of 10 microns or less) data were used in this analysis.
**Data were from a source other than the U.S.'s PRTR. NEI is the U.S. Environmental Protection Agency's National Emissions Inventory.

The atmospheric pollutants are reported to four PRTRs (the E-PRTR and the PRTRs of Australia, Canada, and Chile). While release data on these pollutants is not included in the U.S. PRTR, it is available in a different U.S. data system, the National Emissions Inventory (NEI). Data from the U.S. NEI on sulphur dioxide and PM emissions to air are included in this analysis. NEI data are compiled and released on a triennial basis, based on data submitted to the U.S. Environmental Protection Agency (EPA) by state and local agencies. Facilities typically report emissions directly to the state and local agencies, and the state and local agencies may revise data or add additional emissions estimates before submitting the data to EPA. The triennial nature of NEI data limits those data's use in trend analyses. Lack of data for the atmospheric pollutants from Mexico and Japan may also skew the results of these analyses.

Of the toxic pollutants, the metals (i.e., cadmium, chromium, nickel, and mercury) and benzene are reported to all seven PRTRs. Total release quantities may be somewhat undercounted for the other organic pollutants, which are not included on all PRTRs. The PRTRs that do not cover all 12 toxic pollutants are Chile, Mexico, and the E-PRTR:

- Chile's manufacturing sector is the smallest of the included countries/regions based on manufacturing GDP. For almost all pollutants that are reported to the Chilean PRTR, release quantities are lower for Chile than for any other PRTR. In most cases, releases from Chile are likely not a major contributor to total global release quantities.
- Mexico has a larger manufacturing sector than Chile, and its releases may contribute more significantly to global release trends. Still, for the non-metal toxic pollutants

examined that are included in Mexico's PRTR, reported releases from Mexico account for only a few percent of total reported releases from all PRTRs. Therefore, the lack of data from Mexico on three toxic chemicals is not expected to substantially skew the analyses.

- The E-PRTR does not have data for styrene—a lack that may have a more noticeable impact than missing data from other PRTRs. As measured by manufacturing GDP, the E-PRTR region has a larger manufacturing sector than any of the other PRTR countries, and releases reported for other pollutants from the E-PRTR contribute significantly to total releases for those pollutants.

The pollutants chosen for this study represent only a small subset of all potentially harmful pollutants reported to PRTRs, let alone all chemicals used and produced globally. The aim of this analysis is to use management of these 14 pollutants as a surrogate to evaluate management of chemical wastes more broadly. However, many factors could skew the results, even for the small group of chemicals examined. For example, facilities could be outsourcing processes using these chemicals to facilities in countries not covered by a PRTR. Alternatively, facilities could be replacing some of the 12 toxic pollutants considered in this study with other toxic pollutants not included in this analysis. These situations or others limit the degree to which these analyses can illustrate global trends in the management of all chemical pollution.

2.3. Sectors and release media included

The analysis was limited to the manufacturing sector for consistency across PRTRs and to allow for more detailed subsector analysis. This limitation improves the comparability of data across PRTRs, as not all PRTRs have the same reporting requirements for facilities outside the manufacturing sector. Each PRTR's sector designation system was translated to a common sector identification system—the International Standard Industrial Classification of All Economic Activities (ISIC) system established by the United Nations. Analyses either included the entire manufacturing sector or examined the data at the ISIC division level (i.e., *subsectors* of the manufacturing sector). While focusing on the manufacturing sector improves the consistency of the data analysis across PRTRs, this restriction means that some important sources of releases of these pollutants (e.g., electric power generation, diffuse sources) are not included in the analysis.

Only on-site releases to air and water were reviewed in this initial project. Facilities may also release chemicals to land (e.g., in landfills or direct applications to soil) or transfer chemicals off site for management or disposal at other facilities. However, coverage of land releases and off-site transfers varies significantly between PRTRs and is not as complete as coverage of releases to water and air. Moreover, compared to releases to land, releases of the pollutants to air and water are more likely to lead to exposure to humans and ecological receptors, so evaluating air and water releases will reflect the emissions that generally are more closely related to risk.

2.4. Timeframe of the analysis

This project uses data from 2008 through 2017, based on availability of data from the included PRTRs. The selection of a base year (i.e., 2008) can influence endpoint-to-endpoint trends, so regression analyses were also included to determine if the observed changes in release quantities were part of statistically significant trends. Some countries in this analysis had entered a period of economic recession in 2008, which may have affected reported release quantities. Releases in 2008 would be expected to be lower than in 2007 in countries that had entered an economic recession; this would make observed decreases in releases appear smaller than they would have if 2007 were used as the base year. Regression analysis helps determine whether observed changes from 2008 to 2017 were part of continuing trends.

Due to the time needed for facilities to compile and submit data and for PRTR staff to review, process, and publish the data, PRTR data are usually released one to two years after the end of a "reporting year." That is, for releases during 2017, most PRTR systems published the data in 2019. When this study's analyses were performed, the most recent year of data available from all seven of the PRTRs was 2017.

2.5. Toxicity data included

SDG Target 12.4 focuses not only on reducing chemical releases but on minimizing their adverse impacts on human health and the environment. To assess progress toward this target, this analysis examines the trends in releases and also couples the release data with pollutant-specific and pathway specific characterization factors to calculate toxicity impact scores. The project uses the characterization factors in USEtox® 2.1 for the analyses. For more information on USEtox, see Appendix 1.

Toxicity impact scores are a way of estimating the potential for harm to humans and the environment posed by pollutant releases. To calculate toxicity impact scores for each pollutant, this analysis multiplied a pollutant-specific characterization factor (from USEtox) by the relevant release quantity (from each PRTR in this analysis). For each pollutant, USEtox provides separate characterization factors for cancer and non-cancer impacts (for humans), and freshwater ecotoxicity impacts (for the environment). Characterization factors are also medium-specific, with different factors for air and water. For each type of characterization factor for each pollutant and each medium, this analysis calculated toxicity impact scores. These scores were then aggregated across pollutants and media, resulting in three scores: one for human health (cancer), one for human health (non-cancer), and one for ecotoxicity. The resulting toxicity impact scores allow comparisons among pollutants, providing insight into the relative possible impact of releases on human health and the environment. Toxicity impact scores estimate the potential for harm (measured in comparative toxicity units, or CTU) based on differing levels of toxicity and different environmental fate and transport pathways of different chemicals. Scores are descriptors of potential harm to humans (expressed as CTUh) or to the environment (expressed as CTUe). While USEtox provides the best available source of characterization factors to consider the toxicity impacts of the pollutant releases in this project, note that:

- Characterization factors are not available in USEtox for sulphur oxides and particulate matter.
- Characterization factors for the metals are available for specific oxidation states, which are not consistently reported across metals and PRTRs, as discussed in Appendix 1.
- Characterization factors for the metals are considered "interim" or "indicative" and have higher uncertainty than the "recommended" factors for the organic pollutants in the analysis.
- Characterization factors for the metals depend on oxidation state. For most metals, USEtox includes toxicity factors for the most common oxidation state only, and those metals are assumed to be released in that oxidation state. However, chromium toxicity is highly dependent on oxidation state. Chromium-VI is more toxic than other forms of chromium.

Some PRTRs (Japan, Australia, Canada, and Chile) require chromium-VI to be reported separately from other chromium species. For these PRTRs, chromium-VI toxicity factors were applied to the chromium-VI releases, and chromium-III toxicity factors were applied to all other chromium releases in those PRTRs. For PRTRs that do not require reporting of oxidation state for chromium (the US, the E-PRTR, and Mexico), default factors were applied based on chromium releases reported in Japan: 15% of air releases and 26% of water releases were assumed to be chromium-VI; the remaining quantities were assumed to be chromium-III.

2.6. Analyses conducted

This analysis reviewed data on pollutant releases in two ways. First, a snapshot analysis reviewed patterns in the data. Then, a trend analysis examined how releases have changed over time. Each of these is described below and the results are presented in Section 3. To inform the snapshot and trend analyses, profiles of each pollutant were also developed.

Snapshot analysis. The snapshot analyses the data across the pollutants and PRTRs in the study to identify which pollutants, PRTRs, and subsectors are driving releases and toxicity impact scores. This project's *Action Plan* (OECD, 2018[3]) proposed a snapshot focusing only on the most recent year of available data; this snapshot analysis instead uses all 10 years of data because, in some situations, release patterns can vary significantly from one year to the next. The variability may be due to changes in reporting from just one or a few facilities. The longer timeframe is expected to be more representative of actual releases for these pollutants, especially if facilities were near thresholds and reported releases some years but not others. The snapshot presents the patterns of releases by medium, sector, PRTR, and pollutant. These patterns give stakeholders a better understanding of:

- What types of facilities (i.e., subsectors) are releasing the pollutants?
- Where those facilities are located?
- Which environmental media (air or water) the pollutants are released to?
- Which subsectors and pollutants are driving the toxicity impact scores?

This information furthers understanding of the likely impacts of the pollutant releases on the environment and human health. The snapshot results are presented in Section 3.

Trend analysis. The identification and analysis of trends serves several purposes. First, trends show whether pollutant releases are remaining constant, increasing, or decreasing and, if so, by how much—a critical element in assessing whether countries are making progress towards significantly reducing chemical releases. Second, a trend analysis that reveals a change in chemical releases may also help identify drivers of that change, such as which subsectors and pollutants had the greatest impact. Understanding how release quantities changed in a subsector, or which subsectors had the greatest impact on overall releases, can facilitate knowledge transfer and targeted voluntary, regulatory, or legislative activities. Additionally, analysis of trends in each PRTR can provide insight into how facilities in one country compare to those in other countries. For robustness, this analysis considered trends as endpoint-to-endpoint changes (i.e., comparing 2017 values to 2008 values) as well as using linear regression. Linear regression helps identify whether changes were part of a statistically significant trend as opposed to random variation or one-time changes. Trends are considered in terms of:

- Absolute releases in units of kg released.

- Normalized releases (i.e., releases per dollar of manufacturing GDP) to account for changing economic conditions.
- Toxicity presented as toxicity impact scores.

The results of the trend analysis are also presented in Section 3.

Pollutant profiles. A profile was developed for each of the 14 pollutants. These profiles are presented in Appendix 2. Pollutant profiles provide a detailed look at releases and trends for each pollutant, as well as the PRTRs or subsectors driving the trends for the pollutant. They also indicate where differences in reporting requirements between PRTRs may affect reported releases. Information from the pollutant profiles served as input for the snapshot and trend analyses.

Notes

[1] Croatia joined the EU in 2013 and began reporting data to the E-PRTR for 2014. Data from Croatia for 2014 onward are included in this project's data. In 2017, releases reported in Croatia accounted for 1.3% of all releases of the included pollutants for the E-PRTR, indicating that the ascension of Croatia to the EU and its addition to the E-PRTR led to a small increase in releases reported to the E-PRTR.

[2] The included PRTR countries represent 56% of global manufacturing, based on World Bank manufacturing value added data for 2010 (https://data.worldbank.org/indicator/NV.IND.MANF.KD?most_recent_value_desc=true), accessed 20 March 2020.

Chapter 3. Analyses

This section presents the results of the snapshot and trend analyses described in Section 2. The "Snapshot" section presents combined results for the years 2008–2017. The "Trends" section presents annual data for each year from 2008 to 2017.

3.1. Snapshot

Snapshot results are presented in the text and graphics below. In summary:

- By pollutant, releases were driven by the two atmospheric pollutants.
- By medium, releases were mainly to air.
- By pollutant, metals were the main drivers of toxicity impact scores.
  - Cancer toxicity and ecotoxicity impact scores were driven by releases to water.
  - Non-cancer toxicity impact scores were driven by releases to air.
- By sector, releases were distributed across manufacturing subsectors.
  - The basic metals sector (ISIC 24) released the largest quantities of atmospheric pollutants, and the rubber and plastics sector (ISIC 22) released the largest quantities of toxic pollutants.
  - Toxicity impact scores were driven by the basic metals sector (ISIC 24) and the chemical manufacturing sector (ISIC 20).
- By PRTR, releases were largest in the three PRTRs with the largest economies (the E-PRTR, the U.S., and Japan).

By pollutant, releases were driven by the two atmospheric pollutants. The pollutants released in the greatest mass quantities (Figure 1) were sulphur oxides (85% of all air and water releases from the manufacturing sector) and particulate matter (13% of releases). These pollutants are generated and released in large quantities through a variety of common industrial activities, such as fossil fuel combustion. Because the release quantities of the atmospheric pollutants are so much larger than the releases of the toxic pollutants, they are considered separately for most analyses. Of the toxic pollutants, those released in the largest quantities were dichloromethane, ethylbenzene, and styrene (Figure 2).

Figure 1. Pollutants released by weight, all pollutants

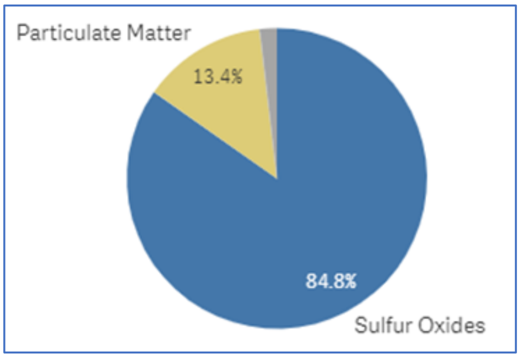
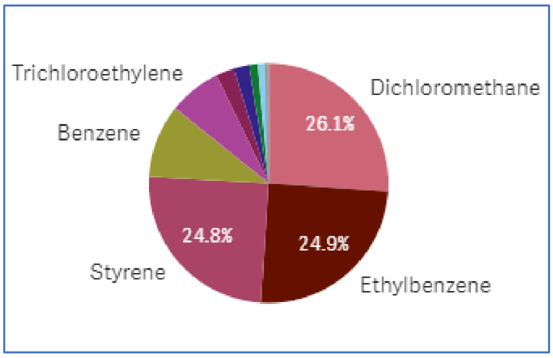


Figure 2. Pollutants released by weight, toxics only



By medium, releases were mainly to air. Essentially 100% of releases of the two atmospheric pollutants were to air (Figure 3). Particulate matter by definition is an air pollutant only, and sulphur oxides are typically considered air pollutants, although the E-PRTR includes some small releases to water. For the 12 toxic pollutants, 98.6% of total releases by mass were to air (Figure 4).

Figure 3. Releases of atmospheric pollutants by medium

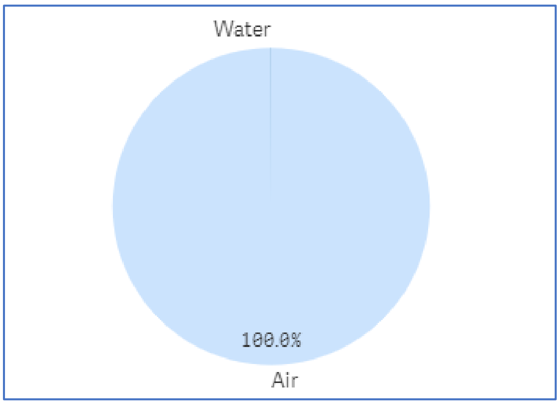
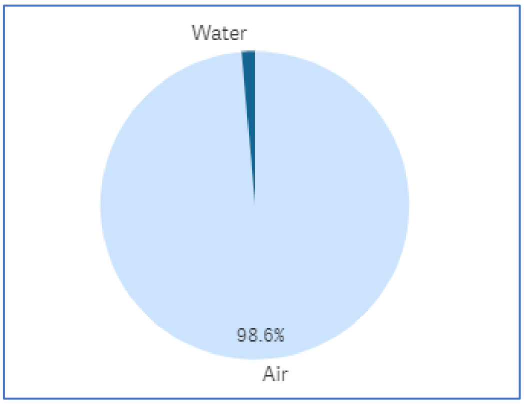


Figure 4. Releases of toxic pollutants by medium



By pollutant, metals were the primary drivers of toxicity impact scores. While non-cancer toxicity impact scores were driven by releases to air, the cancer and ecotoxicity impact scores were driven by releases to water. For all three types of toxicity impact scores (i.e., cancer, non-cancer, and ecotoxicity), results were driven by releases of the four metal toxic pollutants in this study (Figures 5, 6, and 7) even though quantities of metal releases were lower than most of the organic toxic pollutants. Metals usually have the highest characterization factors among the pollutants in this analysis, and in some cases, the characterization factors are dramatically higher for metals. As noted, the characterization factors for the metals are considered “interim” or “indicative” and have higher uncertainty than the “recommended” characterization factors for the eight organic toxic pollutants in this analysis. For ecotoxicity, the water characterization factors are greater than those for air releases for each of the pollutants in this analysis, leading to the higher contribution of water releases to ecotoxicity impact scores compared to release quantities. Chromium releases to water drive cancer toxicity scores, mercury releases to air drive non-cancer toxicity impact scores, and cadmium and nickel releases to water contributed most to ecotoxicity impact scores (Figure 7).

Figure 5. Cancer toxicity by pollutant

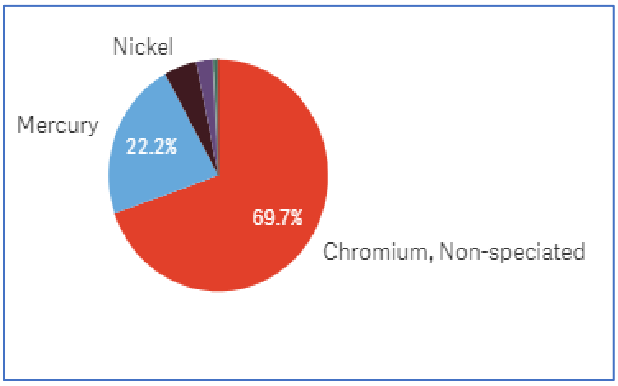


Figure 6. Non-cancer toxicity by pollutant

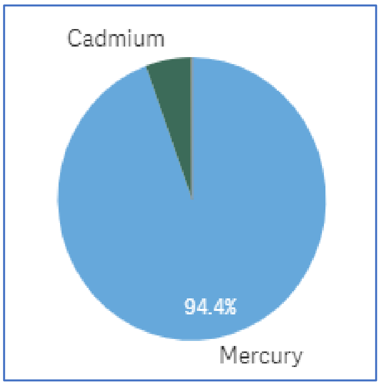
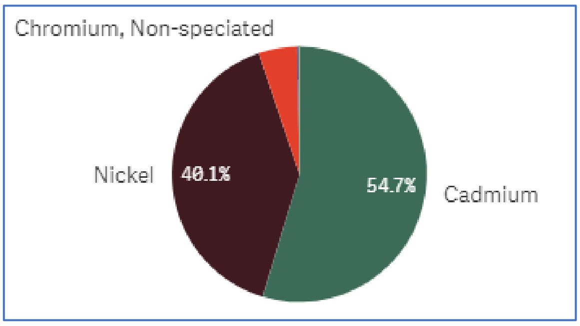


Figure 7. Ecotoxicity by pollutant



By sector, releases were distributed across manufacturing subsectors but were dominated by the basic metals, coke and refined petroleum products and chemical manufacturing subsectors for the two atmospheric pollutants (Figure 8). Releases of the 12 toxic pollutants were more distributed across the subsectors, with the largest release quantities from the rubber and plastics, chemical manufacturing, and other transportation equipment manufacturing subsectors (Figure 9). However, human toxicity impact scores (both cancer and non-cancer) were driven by the basic metals sector (Figures 10 and 11), and the chemical manufacturing subsector was the largest contributor to the ecotoxicity impact score (Figure 12).

Figure 8. Releases of atmospheric pollutant by subsector

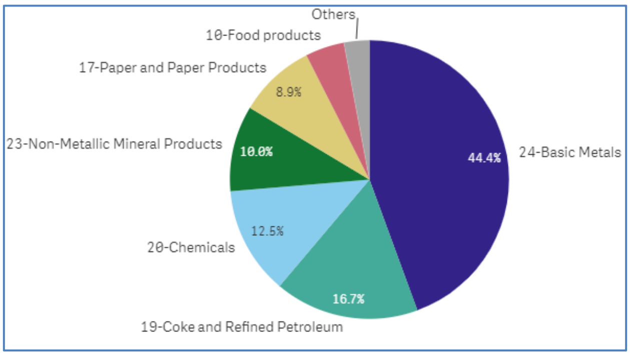


Figure 9. Releases of toxic pollutants by subsector

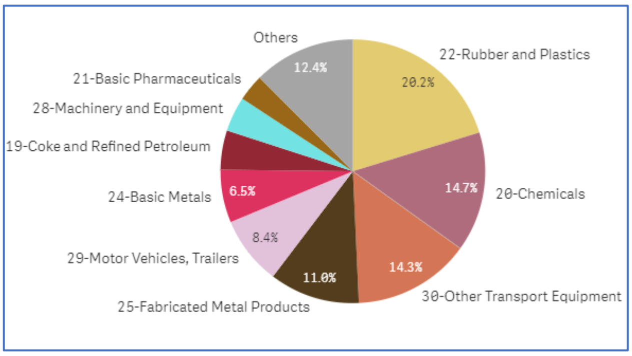


Figure 10. Cancer toxicity by subsector

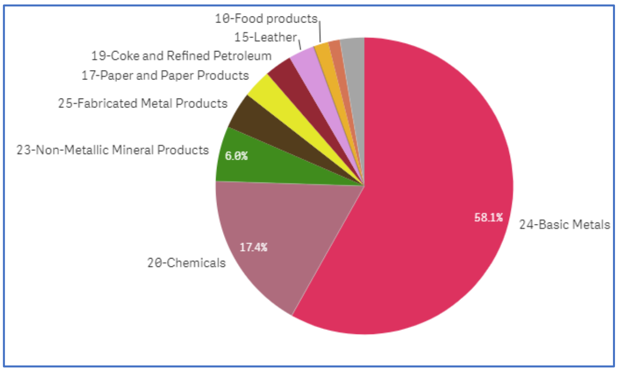


Figure 11. Non-cancer toxicity by subsector

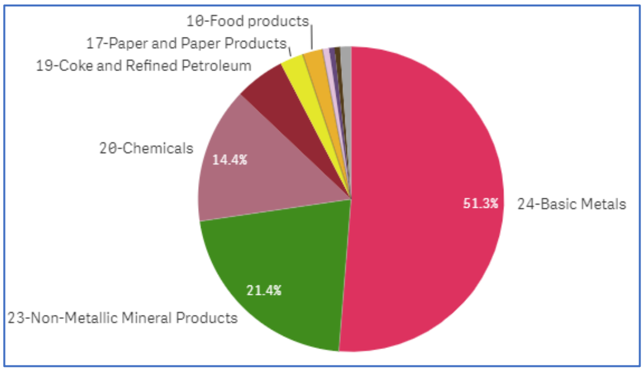
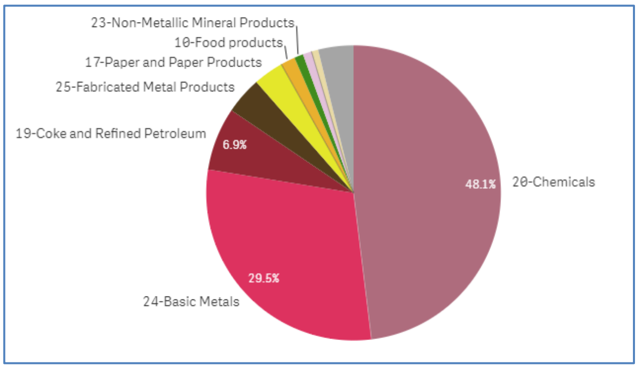
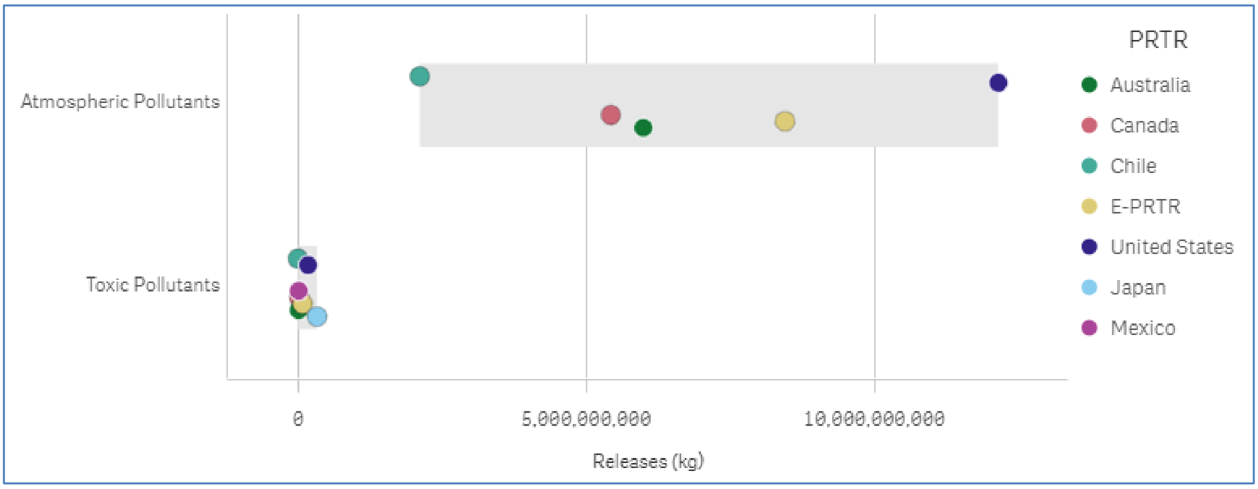


Figure 12. Ecotoxicity by subsector



By PRTR, releases were largest in the three PRTRs with the largest economies (the E-PRTR, the U.S., and Japan). For each pollutant, releases were largest in either the E-PRTR, the U.S., or Japan (Figures 13 and 14). Total release quantities for a pollutant were often driven by releases within just one PRTR (such as releases of ethylbenzene in Japan or styrene in the U.S.). In some cases, this may be the product of differing reporting requirements between the PRTRs. In other cases, larger releases from facilities in one PRTR may be due to different geographic concentrations of the facilities constituting the manufacturing subsectors, differences in processes or implementation of pollution prevention measures, or other factors.

Figure 13. Releases of atmospheric pollutants and toxics by PRTR, 2008 - 2017



Data on atmospheric pollutant releases are not available for Japan or Mexico.

Figure 14. Releases of toxic pollutants by PRTR, 2008–2017

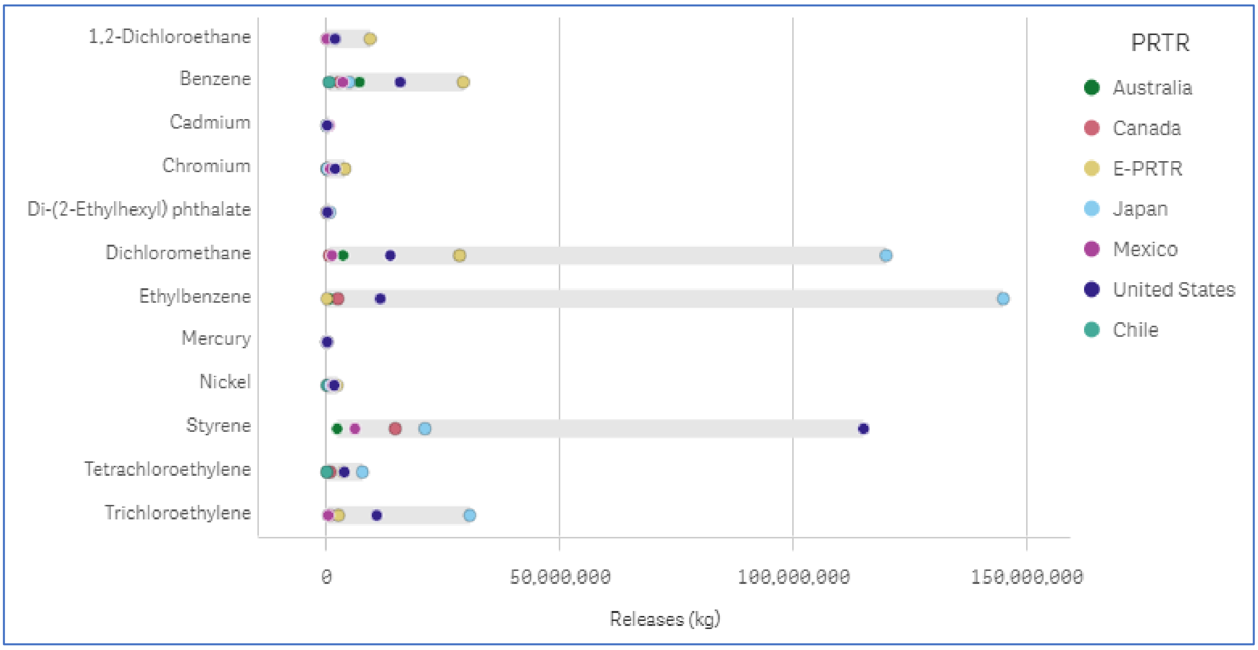


Table 2. Snapshot of releases to air and water from the manufacturing sector

	Atmospheric Pollutants*	Toxic Pollutants
Releases, 2017	2.5 billion kg	59 million kg
Releases by medium, 2008–2017	>99.9% to air	98.6% to air
Pollutants reported in the largest quantities, 2008–2017	SO_x: 29 billion kg PM: 4.7 billion kg	Dichloromethane: 167 million kg Ethylbenzene: 160 million kg Styrene: 160 million kg
Subsectors that reported the largest release quantities, 2008–2017	Basic metals (ISIC 24): 15 billion kg	Rubber and plastics (ISIC 22): 130 million kg Chemical manufacturing (ISIC 20): 94 million kg Other transportation equipment manufacturing (ISIC 30): 92 million kg
PRTRs with the largest reported release quantities, 2008–2017	U.S.: 12 billion kg E-PRTR: 8.5 billion kg	Japan: 332 million kg U.S.: 176 million kg E-PRTR: 80 million kg

*Includes data from the U.S. NEI.

3.2. Trends

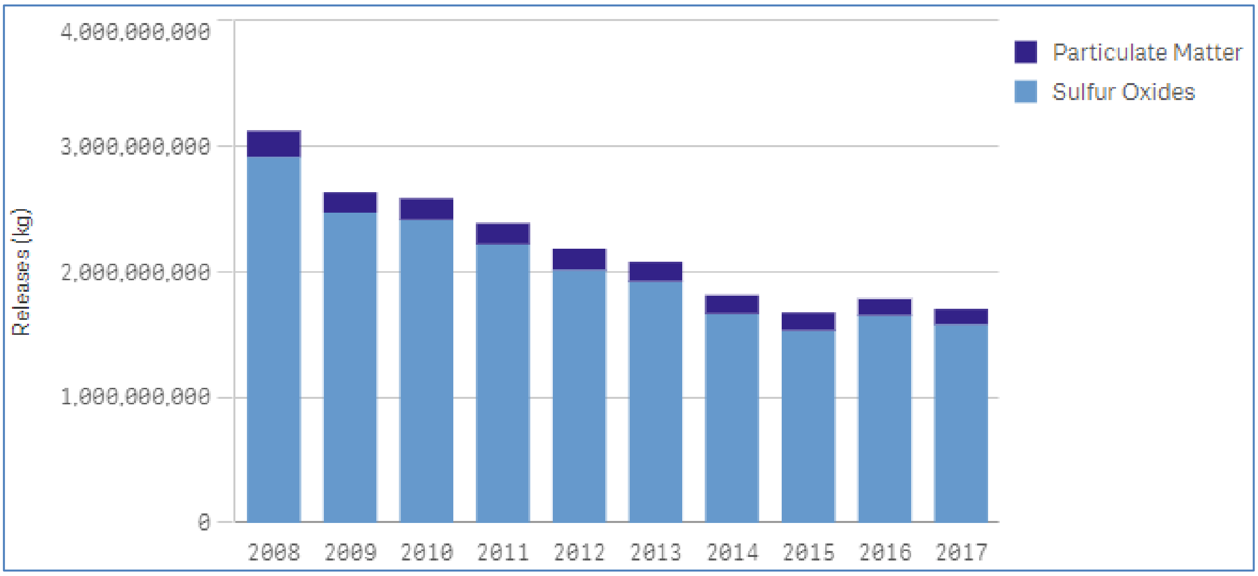
Results of the trend analyses are presented in text and graphics below. In summary:

- Including all pollutants in the study, releases decreased by 47% from 2008 to 2017, driven by reductions in the atmospheric pollutants.
- Releases of the toxic pollutants decreased by 27% from 2008 to 2017.
- Releases of each individual pollutant in the analysis decreased from 2008 to 2017, and the trend was statistically significant for most of the pollutants.
- By PRTR, releases of most pollutants decreased in most PRTRs.
- Releases normalized by manufacturing GDP also decreased from 2008 to 2017.
- Toxicity impact scores for cancer, non-cancer, and ecotoxicity decreased substantially.

Release trends

Including all pollutants in the study, releases decreased by 47% from 2008 to 2017, driven by reductions in the atmospheric pollutants. Total releases of the 14 pollutants decreased by 1.4 billion kg from 2008 to 2017, part of a statistically significant decreasing linear trend ($p<0.05$).[1] This decreasing trend in release quantities was driven by the atmospheric pollutants, which are released in much larger quantities than the toxic pollutants. Atmospheric pollutants showed a 45% decline over this period (Figure 15), excluding data from the U.S. NEI because those data are reported every three years and therefore are not suitable for an annual trend analysis. However, analysis of data in the U.S. NEI shows that releases of SO_2 and PM in the U.S. decreased by 52% over this period.

Figure 15. Trend in releases by atmospheric pollutant



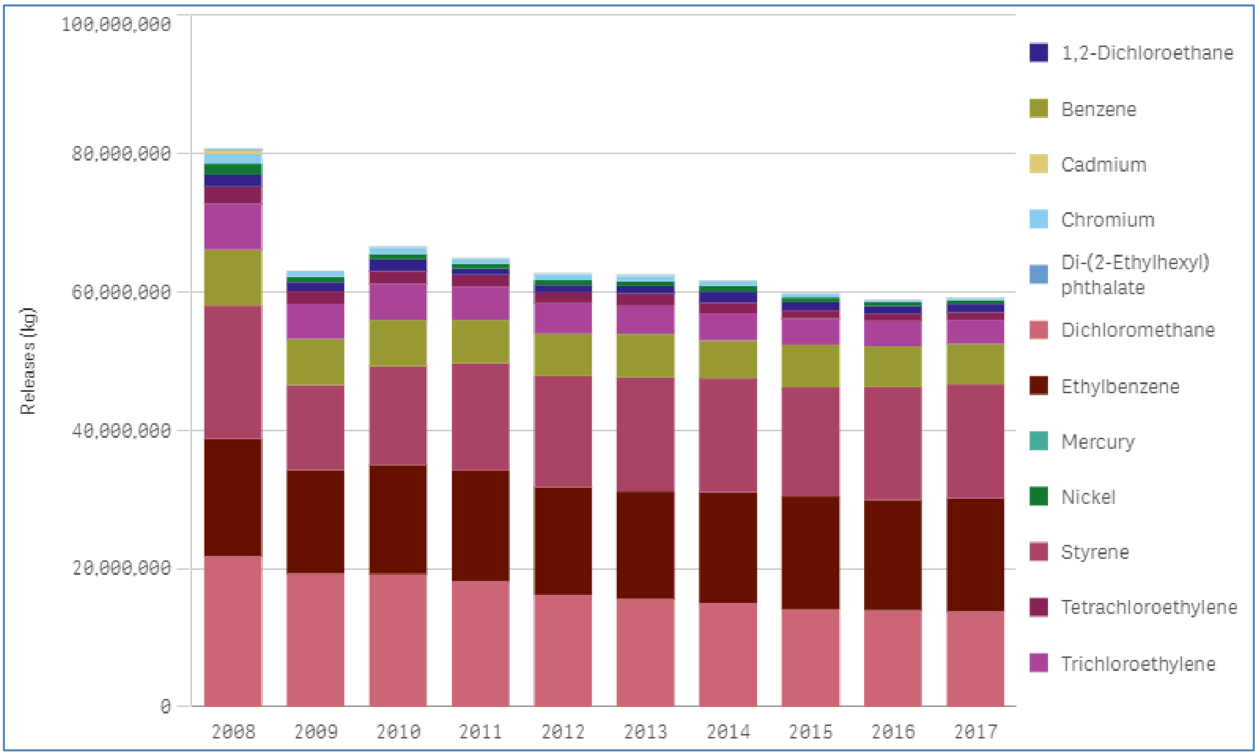
Excludes data from the U.S. NEI, which are not reported annually.

Releases of the toxic pollutants decreased by 27% from 2008 to 2017. While the total release trend is driven by the atmospheric pollutants, releases of the toxic pollutants also decreased, though less consistently. Total releases of the toxic pollutants decreased by 22 million kg (27%) from 2008 to 2017, driven by a decrease of 18 million kg (22%) from 2008 to 2009. Release trends for the 12 toxic pollutants are shown in Figure 16. Although the decrease in quantities released was driven by a few pollutants, releases of each of the 12 toxic pollutants were lower in 2017 than 2008, with decreases ranging from 4% to 79% (Table 2). For most of the toxic pollutants, the decrease in releases was part of a statistically significant ($p<0.05$) decreasing linear trend. The change in total release quantities is driven by a few pollutants with relatively large release quantities; release quantities vary widely between pollutants. For example, in 2017, reported releases of styrene (the pollutant with the largest total releases) were 16.5 million kg, while reported releases of mercury (the pollutant with the smallest total releases) were 31,000 kg.

The global economic recession may also have driven decreasing releases of these pollutants. Manufacturing activity (as measured by manufacturing GDP) decreased notably from 2008 to 2009 and began to rebound in 2010 for most of the countries included in this analysis. Following the change in manufacturing activity, releases dropped sharply for most pollutants from 2008 to 2009 and rebounded slightly in 2010. However, for most pollutants, releases remained about the same or decreased slowly from 2010 to 2017 even as the manufacturing economy grew in most countries.

Again, not every pollutant is required to be reported to every PRTR. Ethylbenzene, for example, is not reported to the PRTRs of Chile or Mexico (Table 1), but facilities in each of these countries probably release ethylbenzene to air and water. Inconsistencies in chemical coverage across the seven PRTR systems in this study undoubtedly have led to some undercounting of actual releases of some of the pollutants. In addition, reporting thresholds vary between PRTRs and even between pollutants within a single PRTR. For these reasons, comparisons between pollutants may not always reflect the reality of releases across the countries constituting the seven PRTRs considered in this analysis.

Figure 16. Trend in releases of toxic pollutants



Releases for each of the pollutants in the analysis decreased from 2008 to 2017. Due to the differences in reporting requirements, relative hazard, pollution prevention opportunities, technological changes, regulations, and pollutant-specific factors, reviewing trends by pollutant can provide a more nuanced picture of changes in chemical releases. Releases for all 14 pollutants decreased from 2008 to 2017 (Table 2), and the trend met the criteria for statistical significance for 11 of the 14 pollutants. In fact, since 2009, releases of ethylbenzene and styrene have increased. Although releases of the other three pollutants decreased in 2017 compared to 2008, they did not meet the criteria for statistical significance because release quantities in the interim years did not follow a downward trend. Because data from the U.S. NEI for SO_x and PM are not reported every year, the U.S. data for these two pollutants cannot be used in the regression analysis and are not included in this table, although releases of SO_x and PM in the U.S. decreased by 52% from 2008 to 2017. Data for releases of cadmium and nickel contain data identified by Mexican PRTR staff as "inconsistent" and are expected to be revised. Data from Mexico are excluded for changes in releases of cadmium and nickel to avoid skewing the results.

Table 3. Change in pollutant releases, 2008 to 2017

Pollutant	Percent Change, 2008 vs. 2017 (Endpoint to Endpoint)	Trend, 2008 Through 2017 (Linear Regression, p<0.05)
Benzene	-28%	Decreasing
Cadmium*	-37%	Decreasing
Chromium	-79%	Decreasing
Dichloromethane	-37%	Decreasing
DEHP	-68%	Decreasing
1,2-Dichloroethane	-34%	No trend
Ethylbenzene	-4%	No trend
Mercury	-37%	Decreasing
Nickel*	-53%	Decreasing
Styrene	-14%	No trend
Tetrachloroethylene	-55%	Decreasing
Trichloroethylene	-48%	Decreasing
SO_x**	-46%	Decreasing
PM**	-40%	Decreasing

*Excludes releases reported in Mexico, which contain an outlier.
**Excludes data from the U.S. NEI, which are not fully updated annually.

By PRTR, releases of most pollutants decreased in most PRTRs. PRTR-specific factors, such as different reporting requirements, can affect the results when releases of one chemical in two PRTRs are compared. Evaluating trends in releases within PRTRs can help control for these factors. In particular, reviewing the change in releases for a specific pollutant within a PRTR eliminates most potential sources of variability other than actual changes in releases.

Releases for most pollutants decreased in most PRTRs, as shown in the figures below. Most notably:

- Total release quantities decreased in all PRTRs—except Chile. Only in Chile did total quantities of atmospheric pollutants or toxic pollutants released increase. Other PRTRs show increases in release quantities for specific pollutants (e.g., releases of benzene increased in Australia). Total releases in Chile are much smaller than those reported in the other PRTRs, so increased releases by one or a few facilities may have outsized impacts on the total releases reported in Chile. As shown in Figures 17 and 18, the percent change in releases of the toxic pollutants was large in Chile (Figure 17), but the absolute change is negligible compared to the other PRTRs (Figure 18). Changes in the method of data collection for Chile may also contribute to the observed increase.
- Releases of the toxic pollutants in Mexico decreased by the largest percentage, partially due to outliers with unusually large releases reported in 2008.
- After Mexico, releases of the toxic pollutants decreased by the largest percentage in the E-PRTR, although releases of styrene are not reported to the E-PRTR. In other PRTRs, styrene was released in large quantities, which changed little compared to quantities of other pollutants. This may have affected the percent change in releases in the E-PRTR.
- Releases of the atmospheric pollutants decreased by the greatest percentages in Canada, the U.S., and the E-PRTR.

Figure 17. Percent change in releases of atmospheric pollutants and toxics by PRTR

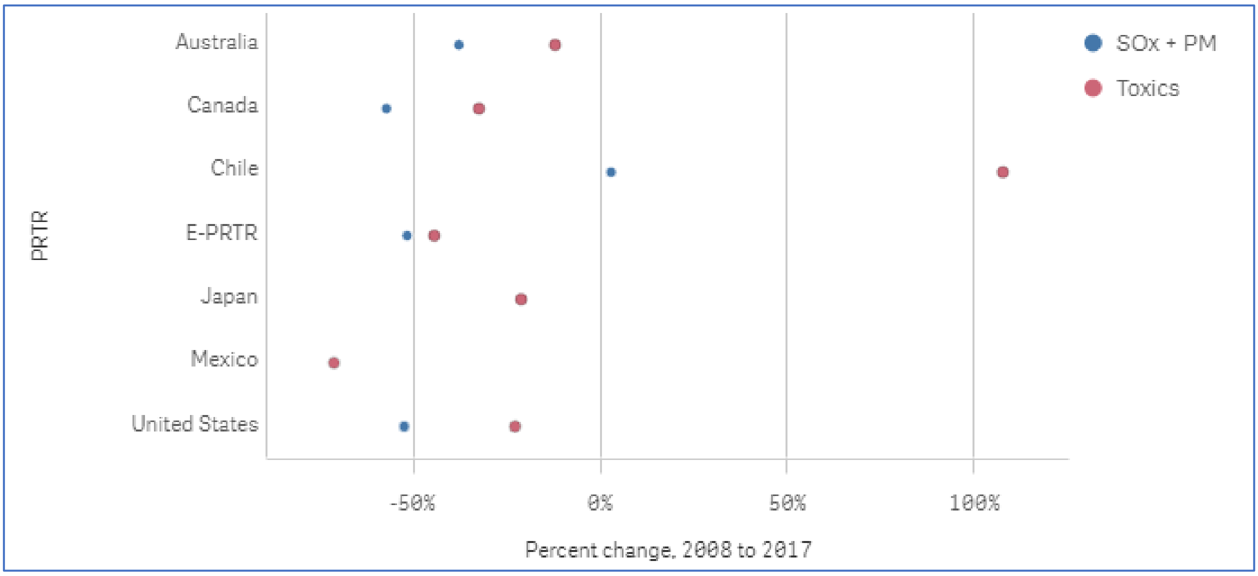
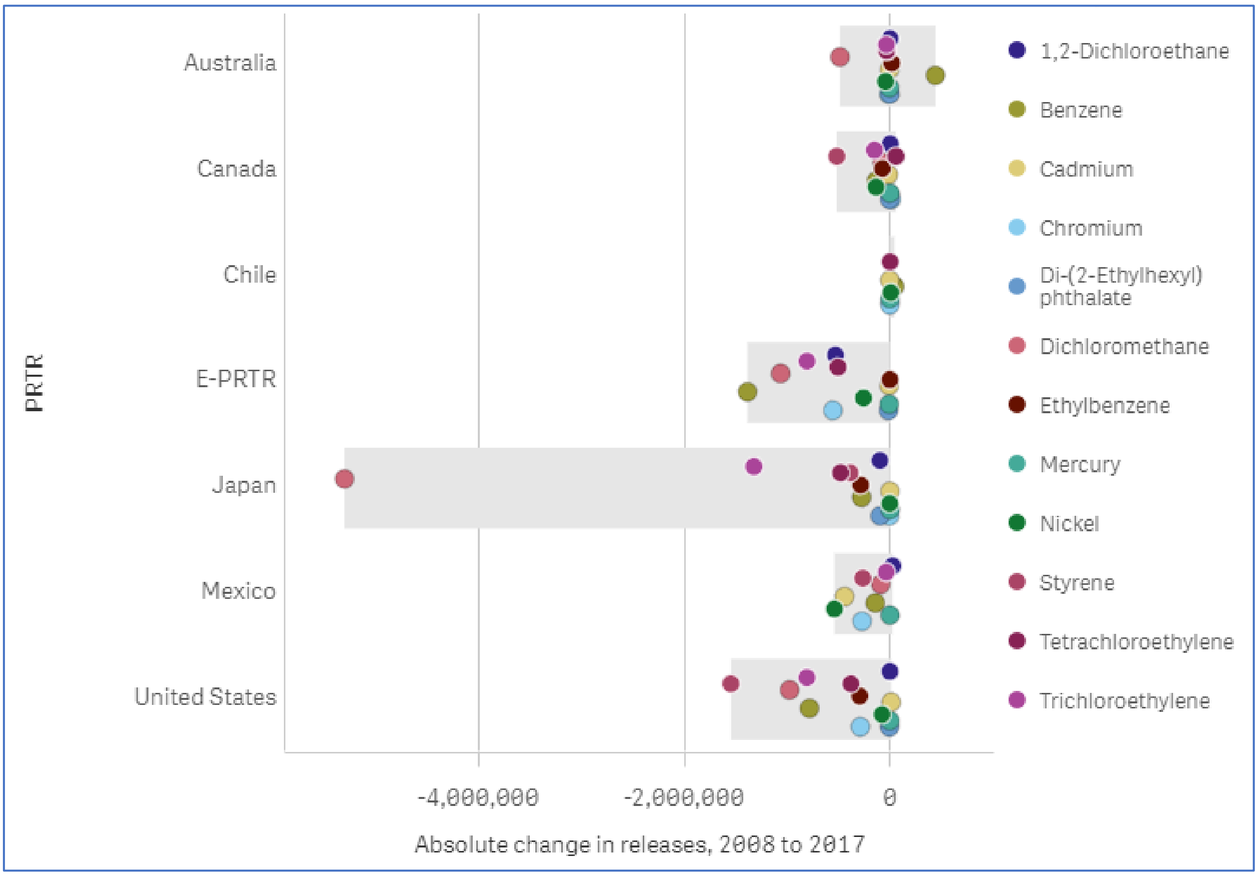


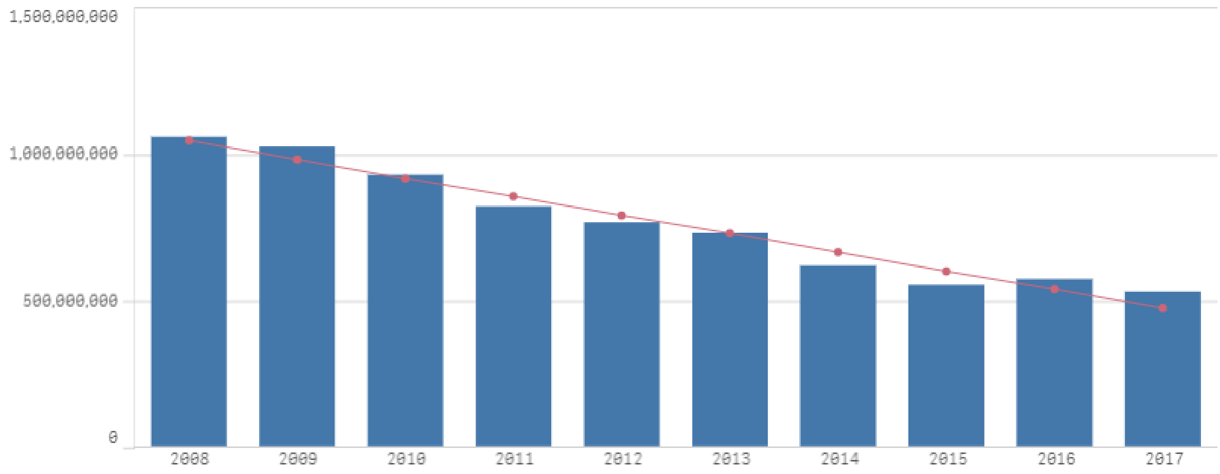
Figure 18. Change in releases of toxic pollutants by PRTR, kg



Normalized releases trend

Releases normalized by manufacturing GDP also decreased from 2008 to 2017. Normalizing releases by the manufacturing gross domestic product (GDP) provides a metric to assess releases across years or between PRTRs that may have different levels of manufacturing activity. Manufacturing GDP is used to estimate the amount of manufacturing activity in a country or region. Normalization is a way to compare releases between PRTRs and over time as though the amount of manufacturing activity were constant. Pollutant releases occur during manufacturing operations, so if the level of manufacturing activity increases without any change in operating practices, it is reasonable to assume that releases will increase. If facilities were releasing the same quantities of pollutants per unit of manufacturing activity, normalized releases would stay the same. From 2008 to 2017, total release quantities of the toxic pollutants decreased across the seven PRTRs, while the combined manufacturing GDP of the included countries increased. This means that, on average, facilities in the included PRTRs released less of the included pollutants per unit of manufacturing activity, even as manufacturing activity increased. As shown in Figure 19 and Figure 20, this resulted in decreases in normalized releases for the atmospheric releases and for the toxic pollutants.

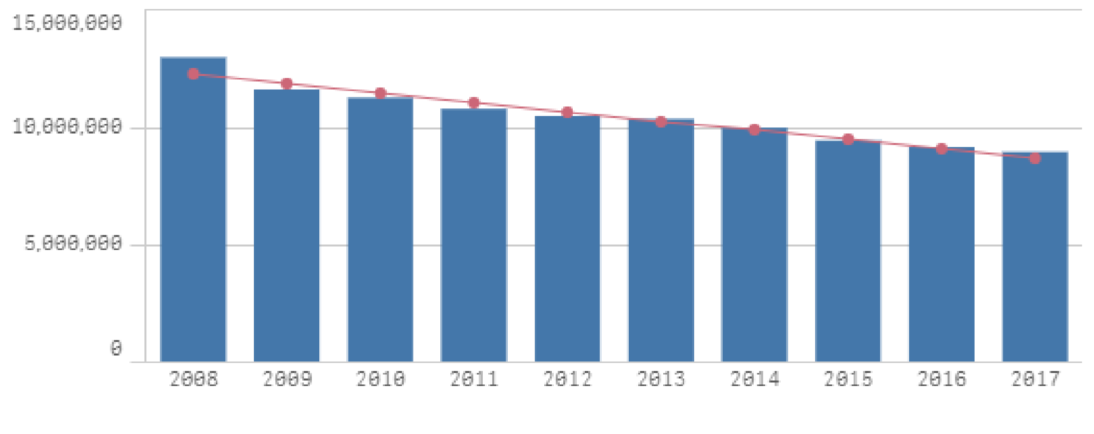
Figure 19. Trend in normalized releases of the atmospheric pollutants (kg/$1T GDP)*



**This figure uses the GDP specific to the manufacturing sector.*

Data from the U.S. NEI are excluded.

Figure 20. Trend in normalized releases of the toxic pollutants (kg/1$T GDP)*



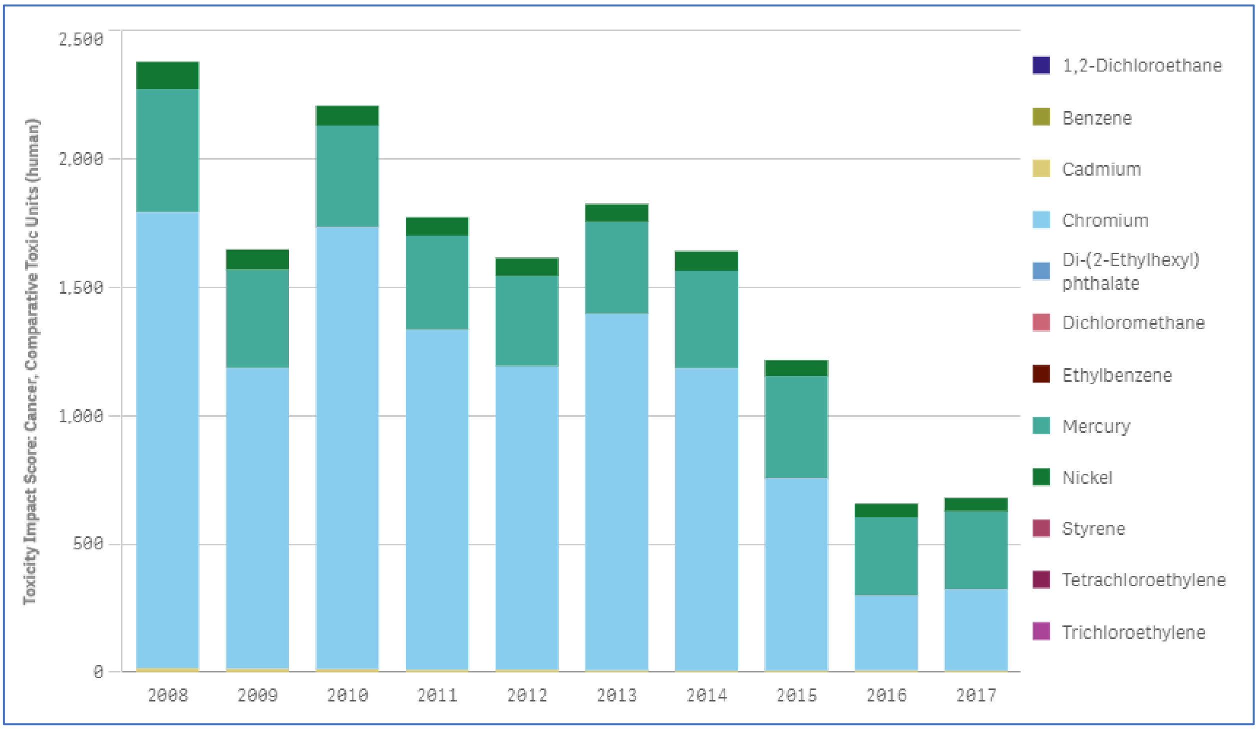
*This figure uses the GDP specific to the manufacturing sector.

Toxicity trends

Trends for all three toxicity impact scores (ecotoxicity, cancer, and non-cancer) are driven almost exclusively by releases of metals. The USEtox characterization factors for metals are considered interim or indicative, meaning there is a lower level of confidence in the toxicity scores for metals than for other chemicals. This uncertainty is amplified by the fact that toxicity of metals often depends on oxidation state, which is not disclosed when releases of metals are reported to PRTRs (with some exceptions, such as chromium in Australia and Japan; see Table 1). As previously discussed, data from Mexico include some potential outliers for releases of certain metals. Given that metals are strong drivers of toxicity, those outliers may have major impacts on observed trends in the toxicity impact scores. Therefore, data from Mexico are excluded in the following trend analyses of toxicity impact scores. Releases of sulphur oxides and particulate matter are also excluded because USEtox characterization factors are not available for those atmospheric pollutants.

The cancer toxicity impact score decreased by 71% from 2008 to 2017 (Figure 21). Cancer toxicity impact scores are driven by releases of chromium to water and releases of mercury[2] to air. The basic metals subsector was the largest contributor to cancer toxicity scores for every year from 2008 to 2017. The cancer toxicity impact score decreased by 71% (1,700 CTUh) from 2008 to 2017, part of a statistically significant decreasing trend ($p<0.05$).[3] The decrease was driven by decreased releases of chromium to water and mercury to air from facilities in the basic metals subsector in the E-PRTR.

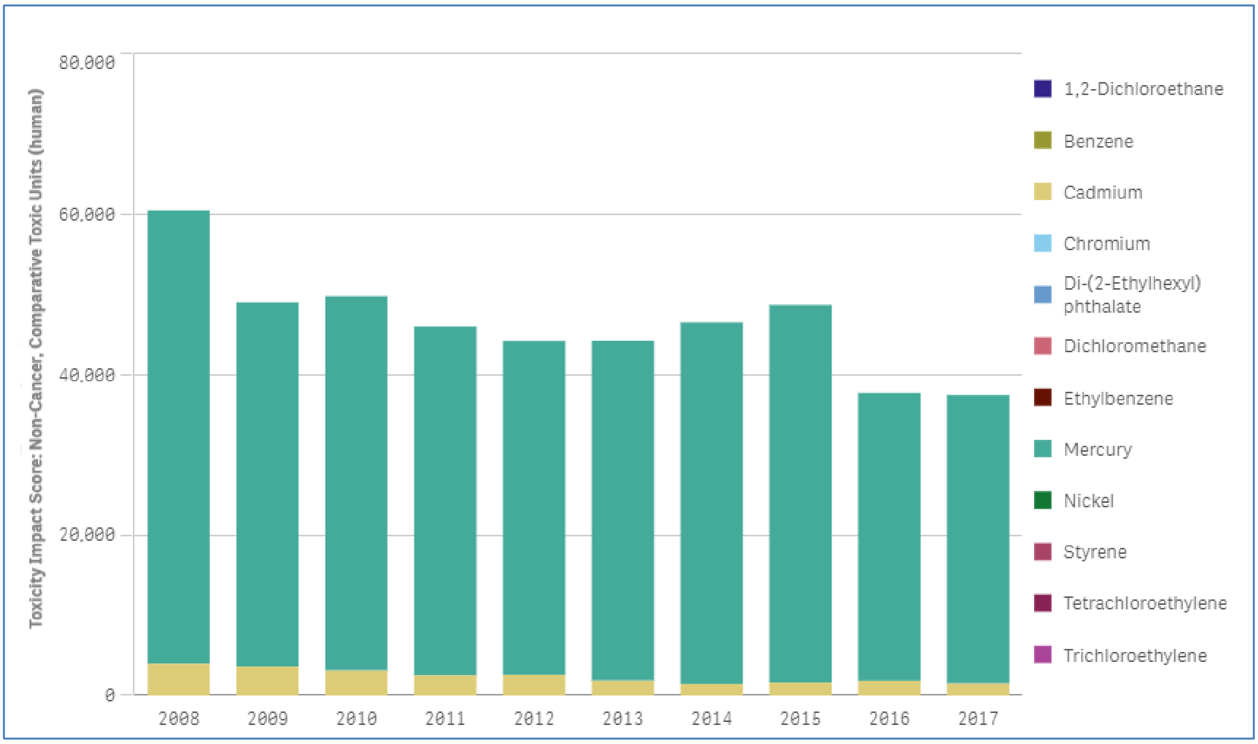
Figure 21. Trend in cancer toxicity impact score by pollutant



Atmospheric pollutants (sulphur oxides and particulate matter) and data from Mexico are excluded.

The non-cancer toxicity score decreased by 38% from 2008 to 2017 (Figure 22). Non-cancer toxicity impact scores are driven by air releases of mercury. Despite being released in the lowest quantities of any of the 12 toxic pollutants, mercury contributed 95% of the total non-cancer toxicity impact score for the toxic pollutants from 2008 to 2017. The non-cancer characterization factors for mercury (for both air and water releases) are higher than the other chemicals in this study. 94% of total release quantities of mercury and almost all non-cancer toxicity caused by mercury are releases to air. Non-cancer toxicity is driven by releases of mercury reported in the U.S. and the E-PRTR, and mercury is released in the greatest quantities by the basic metals subsector. (For more information on releases of mercury, see the mercury analysis in Appendix 2.) Non-cancer toxicity scores decreased in line with mercury releases from 2008 to 2017, decreasing by 38% (23,000 CTUh)—part of a statistically significant downward trend ($p<0.05$).[4]

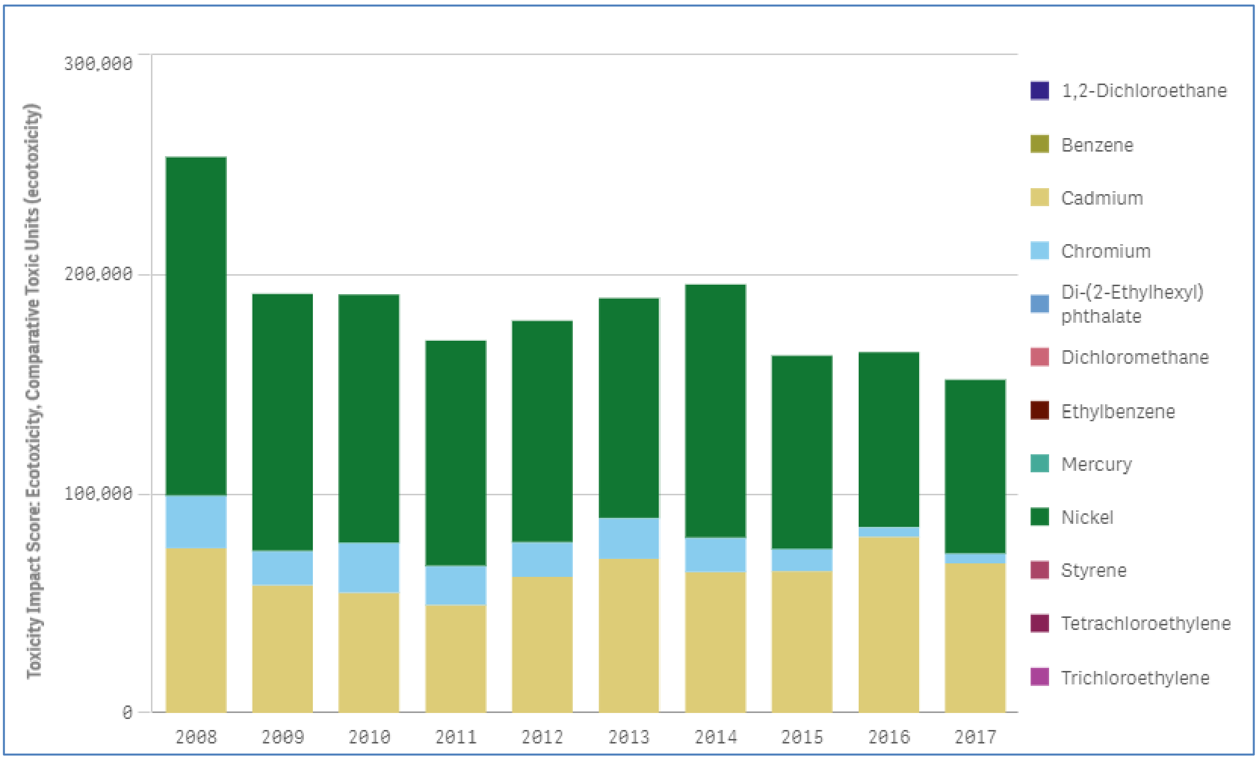
Figure 22. Trend in non-cancer toxicity impact score by pollutant



Atmospheric pollutants (sulphur oxides and particulate matter) and data from Mexico are excluded.

The ecotoxicity impact score decreased by 40% from 2008 to 2017 (Figure 23). Ecotoxicity was driven by releases of metals, especially nickel and cadmium. Releases to water were the largest contributor to ecotoxicity impact scores. Ecotoxicity impact scores were highest in the E-PRTR and the U.S. Releases from Canada, Australia, and Japan were also significant contributors to the total ecotoxicity impact score. The ecotoxicity impact score was driven by the basic metals subsector, although the relative contribution from that subsector has been decreasing since 2008 and the relative contribution by the chemical manufacturing sector has approached the contribution of the basic metals sector. Ecotoxicity impact scores decreased by 40% (101,000 CTUe) since 2008, driven by a large reduction from 2008 to 2009 and part of an overall statistically significant decreasing linear trend from 2008 to 2017 ($p<0.05$).[5]

Figure 23. Trend in ecotoxicity impact score by pollutant



Atmospheric pollutants (sulphur oxides and particulate matter) and data from Mexico are excluded.

Notes

[1]Slope = -1.54×10^{8}; R^2 = 0.916; p = 1.42×10^{-5}. Data from the U.S. NEI are excluded from the regression and decrease in total releases as NEI data are not reported annually.

[2] USEtox carcinogenic effect factors are typically based on effective doses 50% (ED50s) from IRIS and CPDB, however these values are not reported for certain metals, including mercury. When this is the case, carcinogenic effect factors are derived from closely related substances with molecular weight corrections. The ED50 for mercury (Hg[II]) used in this assessment is based on available information for mercuric chloride.

[3] Slope = -166; R^2 = 0.77; p = 0.0078.

[4] Slope = -1,757; R^2 = 0.66; p = 0.0044.

[5] Slope = -6,976; R^2 = 0.56; p = 0.012.

Chapter 4. Data Limitations and Considerations

4.1. Reporting requirements by PRTR

PRTR systems differ in when and what data are required to be reported. When compiling and analysing data across multiple PRTRs, analysts must consider the differences among the PRTR reporting requirements to account for impacts of these differences. The most significant differences are differences in reporting thresholds, sectors or activities covered, and pollutants covered by each PRTR.

Reporting thresholds vary among PRTRs. Generally, facilities must report to a PRTR only for pollutants they manufacture, use, or release to the environment above certain minimum threshold quantities. Some pollutants' thresholds vary substantially among PRTRs, which may have considerable impacts on reported releases. For example, facilities in Canada are required to report releases of mercury if they "manufactured, processed, or otherwise used" 5 kg or more of mercury within a calendar year, while facilities in Japan are required to report releases of mercury if they "handle" 1,000 kg or more of mercury within a calendar year. Beyond these thresholds, PRTRs may have other exemptions such as exemptions for research activities. These differences in thresholds and other reporting requirements are explained in further detail in the *Framework* (OECD, 2017[1]). It is not possible to quantify the impact of differences in reporting requirements—though impacts are sometimes qualitatively apparent, as with reported releases of mercury. The best way to control for these differences is to assess a pollutant trend within a PRTR rather than comparing absolute releases between PRTRs, as these factors are constant for each pollutant within a PRTR.

Sectors covered and sector categorizations differ across PRTRs. The PRTRs included in this analysis cover different sectors and also use different sector categorization schemes. Facilities are categorized by industrial classification codes: systems such as the International Standard Industrial Classification of All Economic Activities (ISIC) codes, which assign a standardized name and code to sectors and subsectors. When reporting to their PRTRs, facilities report sector codes using their local industrial classification schemes, although in the E-PRTR reporting requirements are based on activities at the facility rather than the facility's sector classification. Facilities are required to report to E-PRTR only those releases related to the covered activities, not all releases at the facility. This may mean that releases reported to E-PRTR are less inclusive than releases reported by similar facilities to other PRTRs. Despite differences in the exact requirements for facilities, the included PRTRs cover all or most manufacturing subsectors. However, differences in the sector classification systems used to categorize facilities may lead to some errors when facilities are assigned ISIC codes for this analysis. For this reason, subsector analysis is limited to the ISIC division level, since more detailed levels of classification are more likely to have mis-assigned facilities. These differences are not anticipated to have a major impact on the analyses; however, because of differences in the sectors covered and differences in thresholds, direct comparisons between reported releases in different PRTRs may not accurately reflect the actual differences in releases in those PRTRs.

Not all 14 of the pollutants included in the study are covered in all seven PRTR systems. This inconsistency results in lower release quantities of some pollutants and lower release totals in some PRTRs. These differences were considered when pollutants or PRTRs were compared, and the impact of the missing data is noted where appropriate.

4.2. Other data limitations

In addition to the limitations introduced by compiling and analysing release data from multiple PRTRs, PRTR data have inherent limitations that affect all PRTRs. For example, all data included in PRTRs are reported by facilities, which may use different methods to determine the quantities of pollutants released. Limitations inherent to PRTR data are discussed in detail in the *Framework* (OECD, 2017[1]). Data compiled in the US' National Emissions Inventory (NEI) has similar limitations. NEI data are provided to the US EPA by state, local, or tribal agencies, which use a variety of sources to create emissions estimates, including but not limited to data submitted by facilities. Reporting thresholds vary, based on actual emissions or potential to emit, and the air quality of the facility's location. With these differences, more facilities may be included in NEI than are in TRI. To minimize these impacts and better align with TRI reporting, the analysis only includes NEI point source facilities in manufacturing sectors.

For the toxicity impact score results presented, there is uncertainty in the USEtox characterization factors, particularly for metals. The USEtox model has some inherent uncertainty, as it models factors such as environmental fate and exposure; actual fate of and exposure to a chemical depend on factors specific to its release, such as the exact location and the prevailing environmental conditions there. Application of USEtox characterization factors in this analysis makes some assumptions, such as assuming that pollutant releases to air that are reported to PRTRs occur in rural locations rather than urban locations. See Appendix 1 for more information on USEtox and the characterization factors applied in this analysis.

Normalized releases are based on GDP for the manufacturing sector as reported by the United Nations Statistics Division, which includes many facilities that do not report to countries' PRTRs. Manufacturing GDP provides a rough estimate of the relative size and change over time of countries' manufacturing activity. It includes output from facilities country-wide, including those that do not meet PRTR reporting requirements or do not report for the 14 pollutants included in this analysis. Further, it is based on the amount of value added by a process or facility. The amount of value added depends on the product being manufactured and local conditions including wages; therefore, facilities engaging in the same processes can have different amounts of value added. Manufacturing value added or GDP provides an estimate of how much manufacturing activity occurs in a country, but it is not a direct measurement of manufacturing activity.

Chapter 5. Discussion

This section discusses the three project objectives, the extent to which each one has been met and presents possible directions for future analyses.

5.1. Objectives

Objective: Develop approaches for using PRTR data for global-scale sustainability analyses

This project's approach was based on the concepts originally presented in the OECD's *Framework* document (OECD, 2017[1]). The *Framework* describes how global sustainability analyses could be conducted using PRTR data, including the types of analyses and the factors to consider for international PRTR analyses. The initial approach for this project was presented to the OECD Working Party on PRTRs in 2017 as the next step in the implementation of the *Framework*. After modifications to address the Working Party's input, a revised approach was presented in 2018. Additional comments from the Working Party were incorporated and the approach was further developed and documented and, in 2018, published in the *Action Plan* for analysis of PRTR data for evaluating progress towards certain UN SDGs (OECD, 2018[3]).

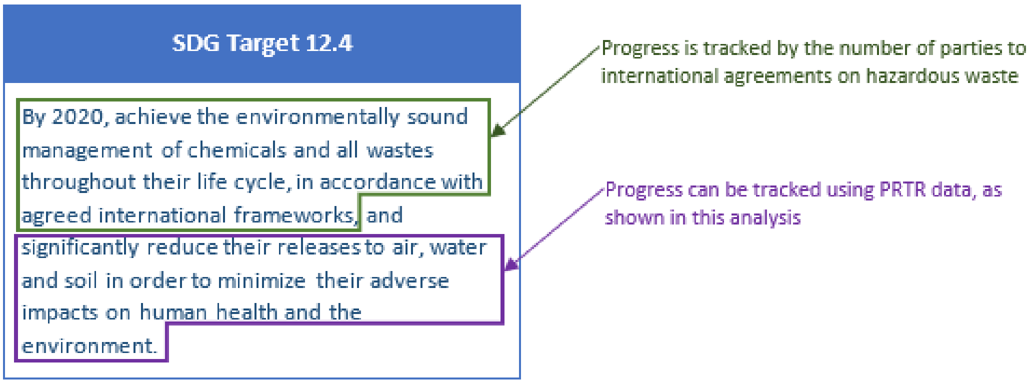
The *Framework* laid the groundwork on how data from multiple PRTRs could be integrated to perform global-scale analyses, such as the analyses presented here. This project accessed the data from the seven PRTRs in this study and conducted the data harmonisation and integration activities described in the *Framework*, such as:

- Selecting chemicals covered by most PRTRs.
- Harmonising the sector identifiers (each PRTR uses a different coding system to identify the facility's sector).
- Limiting the analysis to the media that were consistently reported across PRTRs (i.e., air and water releases).
- Transforming each PRTR database to a common format.

To facilitate the data integration, the project integrated the PRTR data from the seven separate PRTR data systems using a data visualization application, QlikSense, that allows for data presentation and facilitates data exploration. Sector codes, chemical names, and releases data fields were harmonised and then data from all seven PRTRs were transformed to a common format and uploaded to the QlikSense application. Integration of the PRTR data on this scale had not been attempted previously. With this established format in place, additional years of PRTR data can be added to the QlikSense application as they become available. Currently, the global PRTR application in QlikSense has been designed and used exclusively for this project, but the underlying integrated PRTR data could also be made available for other projects focused on global-scale sustainability analyses.

Objective: Assess progress towards SDG Target 12.4 through examination of global chemical pollution and management trends

SDG Target 12.4 aims to achieve environmentally sound management of chemicals and wastes and significantly reduce their releases to minimize adverse impacts on human health and the environment. The UN tracks progress for Target 12.4 based on the number of parties to international environmental agreements on hazardous waste. This information provides input to track the first part of Target 12.4: "*achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks*." The UN, however, does not mention an indicator to track the second part of Target 12.4, "*significantly reduce [chemical] releases to air, water and soil in order to minimize their adverse impacts on human health and the environment*." With detailed annual reporting on chemical releases, PRTRs provide invaluable data to directly assess release trends. As discussed in Section 4, the analysis of PRTR data has some limitations and cannot by itself reveal whether the world is on track to meet Target 12.4. However, PRTRs can provide more robust data than any other source in indicating whether countries are moving in the right direction on certain key pollutants.

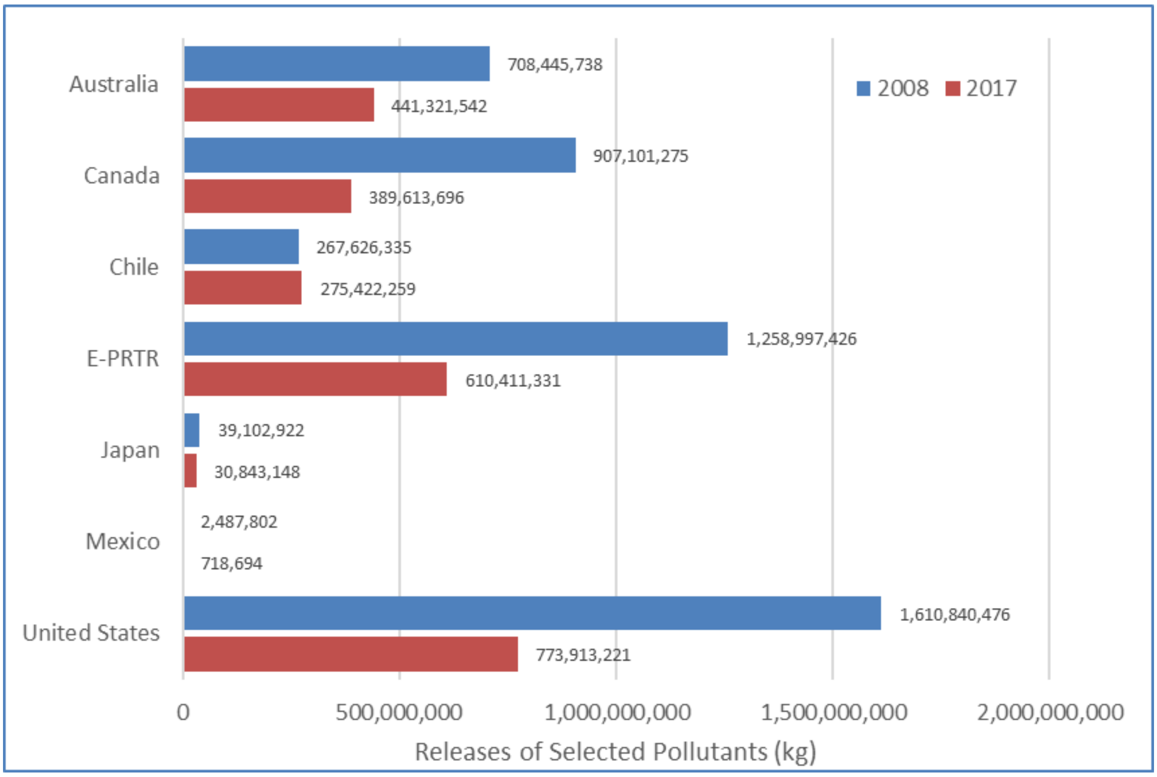


Assessing progress toward Target 12.4 is somewhat confounded by the imprecise wording of the target—in particular, what it means to "significantly reduce" releases and "minimize adverse impacts on human health and the environment." Additionally, the target has a 2020 end date but no starting year. For this analysis, the year 2008 was chosen as a starting point based on available data; this report presents trends in Section 3 to allow the reader to assess the significance of the progress observed. At the time of this analyses, the most recent data available for all PRTRs were from 2017. Therefore, the analysis assesses progress toward the goal through 2017. To assess progress toward Target 12.4, this discussion provides additional input on the trends observed for: 1) chemical releases to assess "significantly reducing releases" and 2) toxicity scores to assess "minimizing adverse impacts on human health and the environment."

To assess "significantly reducing releases," the analysis shows:

- For the seven PRTRs combined, the sum of the releases to air and water from manufacturing facilities of the 14 pollutants included in the analysis decreased substantially (47%) as shown in Figure 15, indicating progress toward Target 12.4. For most of the pollutants, the decrease was part of a statistically significant trend. Releases of the atmospheric pollutants, SO_x and PM, show especially large decreases.
- As shown in Figure 24, releases decreased considerably in six of the seven PRTRs chosen for this project. In Chile, releases increased slightly (by 3%). The substantial decreases in releases in Australia, Canada, the E-PRTR, and the U.S. indicate progress toward Target 12.4.

Figure 24. Change in releases of 14 pollutants, 2008 to 2017



- The data also indicate that economic conditions alone do not drive releases of these pollutants. Releases of all 14 pollutants decreased substantially from 2008 to 2009, likely due to the global economic recession, but releases of most of the 14 chemicals continued to decrease or remained about the same from 2009 through 2017 even as economies grew. This indicates that facilities may have made permanent changes to reduce releases in response to the economic downturn. These continued release reductions could be due to the implementation of pollution prevention, waste reduction, or other measures that facilities implemented as cost-saving measures. It could also be that facilities eliminated or reduced highly polluting processes and never restarted them, or that older facilities closed and were later replaced with facilities with more advanced processes and pollution control technologies.
- In interpreting these results, it is important to consider that this project reviewed air and water releases of 14 pollutants by manufacturing facilities, while Target 12.4 aims to achieve reduced releases of seemingly all chemicals. This makes it valuable to look at the trends for individual pollutants, which can provide insight on what may be occurring for other pollutants. Releases of each of the 14 pollutants were lower in 2017 than in 2008. This was part of a statistically significant trend for 11 of the pollutants. However, the trend was not significant for three pollutants: 1,2-dichloroethane, styrene, and ethylbenzene. In fact, since 2009, releases of ethylbenzene and styrene have increased. Because only 14 pollutants were examined of the many thousands of chemicals manufactured and used, and releases of some of the chemicals in the study are not decreasing, the data cannot be extrapolated to assume that releases of all industrial chemicals are decreasing.

- The PRTRs included do not represent all global pollutant releases. In particular, some countries with large and growing manufacturing sectors, including China and India, do not have PRTRs. While existing PRTR data are the best source of information on pollutant releases in covered countries, their use is limited in assessing release trends in countries without PRTRs.

While reduced chemical releases are required to meet Target 12.4, the target ultimately focuses on "minimizing adverse impacts on human health and the environment." Progress toward this outcome is tracked using toxicity impact scores for human health (cancer and non-cancer) and the environment. The analysis shows:

- All three toxicity impact scores[1] decreased considerably from 2008 to 2017:
  - Cancer toxicity impact score decreased by 71%
  - Noncancer toxicity impact score decreased by 38%
  - Ecotoxicity impact score decreased by 40%
- Toxicity impact scores decreased despite being driven by already-low releases of metals, which have unique properties and may be difficult to substitute.
- The toxicity impact score trends do not include the two atmospheric pollutants because characterization factors are not available for those pollutants. However, the trend in releases is driven by reductions of the atmospheric pollutants. If those pollutants were included in the toxicity score trends, even more substantial reductions in toxicity scores would be expected.

In interpreting these results, it is important to consider that toxicity impact scores serve as indicators of potential risk, not estimates or measures of risk. They are based on a model that uses assumptions, particularly about the locations of releases and their environmental fate and transport. Modelling is the most effective way to learn about potential impact using the vast amount of data reported to PRTRs—but it only provides relative potential impacts. Actual impacts may depend on many factors.

These analyses present progress through 2017, the most recent year where data were available from the seven PRTRs in the study. Target 12.4, however, has a target year of 2020. When 2020 data are available, these analyses can be updated to align with the end year in Target 12.4.

Objective: Accelerate progress towards meeting SDG Target 12.4

This project can accelerate progress towards Target 12.4 in two ways. First, it can provide insight on where to focus global efforts. Second, it provides opportunities for knowledge transfer among countries.

This project illustrates that health and environmental impacts globally are driven by the pollutants with the highest toxicity characterization factors; pollutants with lower toxicity factors may be of concern at local levels but are less likely to drive global toxicity trends. Despite higher release quantities, toxicity impact scores for the organic pollutants are orders of magnitude lower than for metals. This does not imply that releases of metals are always of greater concern than releases of organic compounds, as some organic compounds also have high toxicity. Rather, it implies that entities seeking to reduce the human and environmental health burdens imposed by chemical pollution should consider prioritizing releases of the more hazardous pollutants, rather than solely focusing on the pollutants released in the largest quantities. For the pollutants included in this analysis, the ones with the highest toxicity characterization factors (i.e., the metals) are already released in relatively low quantities. Further release reductions of these and other highly toxic chemicals—will help drive down global health and environmental impacts.

By comparing pollutant release trends among PRTRs, countries can also learn from each other to refine their approaches to accelerate pollution prevention. Countries in which large or increasing releases of a pollutant occur can learn from other countries that have reduced releases of that pollutant. For example, releases of SO_x and PM show especially large decreases in most countries. Chile, which had a small increase in releases of the atmospheric pollutants, could review other countries' efforts (e.g., technological developments, regulatory actions) to reduce such releases.

This analysis only included 14 pollutants; however, countries may be able to learn lessons from these pollutants that apply to other pollutants. For example, if countries implemented pollution prevention measures that successfully reduced releases of one of these 14 pollutants, similar measures could be effective in reducing releases of other pollutants, even if that other pollutant is not included in the PRTR. Even countries without PRTRs can use pollutant- and sector-specific data from the existing PRTRs to help identify relevant pollutants for key sectors in their economy to help focus their reduction efforts. Further, analysis of PRTR data may help countries without PRTRs see the value in establishing them.

5.2. Possible directions for future analyses

While these analyses present trends on releases of key pollutants in countries that represent more than half of global manufacturing GDP, future work could expand this project to include additional pollutants and additional economies. The feasibility of such an expansion depends on the availability and usability of underlying PRTR data. For example, adding pollutants requires identifying pollutants that are included in most of the PRTRs to provide a global representation. The PRTRs in these analyses all require reporting for more than just the 14 pollutants included in this project; however, not all pollutants are reported to all PRTRs, and some pollutants of concern are only reported to a few or even no PRTRs. The analysis could also be expanded to include facilities in sectors beyond manufacturing that report to most PRTRs, such as electric power generating facilities. Likewise, some countries have PRTRs that were not included in this analysis (e.g., South Korea, Israel); however, advancing this work to provide a significantly more comprehensive global picture would require the establishment of reliable, public PRTRs in key manufacturing economies such as China and India.

Additional analyses may be possible even when all requisite PRTR data are not available; for example, some PRTRs have data on releases to land, off-site transfers, and releases by facilities outside the manufacturing sector. While these data are not available in all of the PRTRs currently in this study, analysing the available data may allow an approximation of corresponding data from similar facilities in other PRTRs to give a rough estimate of the magnitude of those types of releases. Analysing chemical releases to land may be of particular interest for a future analysis because Target 12.4 focuses on "air, water and soil." The current analysis explores air and water releases because releases to these media are included in all of the PRTRs examined; future analysis may also consider releases to land.

The data sources used in this analysis are updated regularly. Any future analysis would be expected to use updated data on PRTR releases, USEtox characterization factors, and GDP data.

Lastly, as outlined in this project's *Action Plan,* six additional SDG targets were identified that are related to pollution, chemical management, and waste for which PRTR data may be relevant in tracking progress. Examples include Target 12.5 ("By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse") and Target 6.3 ("By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally"). While the OECD Working Party on PRTRs determined that Target 12.4 is the target most closely aligned with available PRTR data and was selected as the focus of the initial phase of this project, future iterations of this project may address additional SDG targets.

Note

[1] Changes in toxicity scores exclude Mexico to avoid skewing results due to potential outliers for releases of metals.

Appendix 1: USEtox® Toxicity Impact Scores

To assess progress toward Target 12.4, this analysis examines the trends in releases and also couples the data on chemical releases with pollutant-specific characterization factors (CFs) to calculate toxicity impact scores. The project used the CFs in USEtox 2.1. (Rosenbaum et al., 2008[5]; Hauschild et al., 2008[6]; Henderson et al., 2011[7]; Rosenbaum et al., 2011[8]) Developed under the United Nations Environment Program (UNEP) and the Society for Environmental Toxicology and Chemistry (SETAC) Life Cycle Initiative, USEtox is a model based on scientific consensus providing CFs for human and freshwater ecotoxicological impacts of chemicals. USEtox calculates CFs based on three factors:

- Environmental fate, which models the distribution and degradation of each substance.
- Exposure, which models the exposure of humans, animals, and plants.
- Effects, which models the inherent damage of the substance.

Toxicity impact scores were calculated for this analysis by multiplying release quantities (from each PRTR) by the USEtox CFs. CFs provided by USEtox and used in this project were human cancer toxicity, human noncancer toxicity, and freshwater ecotoxicity. Characterization factors are medium-specific, with different factors for air and water.

Toxicity impact scores presented in this analysis are scores at the toxicity potential (midpoint) level. Toxicity impact scores are presented in Comparative Toxicity Units, CTU. Scores are measured as harm to humans (CTUh) or to the environment (CTUe).

Considerations and assumptions:

- For releases to air, the CFs associated with emissions to rural air were applied because most manufacturing facilities are not expected to be in urban settings. This is not accurate for all facilities; however, more detailed modelling of release locations was beyond the scope of this project.
- For releases to water, the CFs for discharges to freshwater were used, as most manufacturing facilities are expected to discharge wastewater to freshwater bodies rather than to sea water. This is not accurate for all facilities; however, more detailed modelling of release locations was beyond the scope of this project.
- USEtox considers the CFs for metals to be “interim” or “indicative,” meaning they carry more uncertainty than the CFs for non-metals. Metals in the environment behave in a more complex way than the included organic compounds, leading to this higher uncertainty. USEtox documentation states that “The ‘indicative’ USEtox characterization factors should always be used together with the ‘recommended’ factors, as otherwise the substances concerned would be characterized with zero impact as no characterization factor is applied to their emissions. The flag “indicative” means a higher uncertainty of the characterization factor compared to the flag “recommended”, because not all the minimum requirements are met for the calculation. Therefore, when an emission characterized with indicative characterization factors is dominating the overall impact, it implies that the associated results have to be interpreted as having a lower level of confidence. (Bijster et al., 2018[9]).”
- Further, CFs for metals depend on the oxidation states of those metals. For most metals, CFs are available only for one oxidation state and most releases are assumed to be in that oxidation state or quickly transformed to that oxidation state after release. However, chromium (III) and chromium (VI) have very different CFs, particularly for human health

endpoints. This necessitates certain assumptions that add further uncertainty to the toxicity impact scores for chromium.

- In Australia, chromium (III) and chromium (VI) are each reported individually; the appropriate CF is applied to each release.
- In Japan, chromium (VI) is reported individually, and chromium (0) and chromium (III) are reported together. Releases of chromium (0), i.e., releases of elemental metallic chromium, are assumed to be negligible; the CF for chromium (VI) is applied to releases of chromium (VI) and the CF for chromium (III) is applied to releases of chromium and chromium (III) compounds.
- In Chile and Canada, chromium (VI) compounds are reported separately from all other chromium and chromium compounds. Again, releases of chromium species other than chromium (VI) and chromium (III) are assumed to be negligible; the CF for chromium (VI) is applied to releases of chromium (VI) and the CF for chromium (III) is applied to releases of all other chromium and chromium compounds
- In Mexico, the U.S., and the E-PRTR, oxidation states are not specified in reporting. Default percentages of chromium (III) and chromium (VI) were applied based on releases reported in Japan from 2008 to 2015: 15% of air releases by mass were assumed to be chromium (VI) and 26% of water releases by mass were assumed to be chromium (VI). The remaining mass of releases were treated as chromium (III).

For the metals in this analysis other than chromium – cadmium, nickel, and mercury – CFs are only available for one oxidation state, therefore, speciation impacts cannot be assessed.

Appendix 2: Analyses of Each Pollutant

- 1,2-Dichloroethane
- Benzene
- Cadmium
- Chromium
- Di-(2-ethylhexyl)phthalate
- Dichloromethane
- Ethylbenzene
- Mercury
- Nickel
- Styrene
- Tetrachloroethylene
- Trichloroethylene
- Particulate matter
- Sulphur oxides

1,2-Dichloroethane

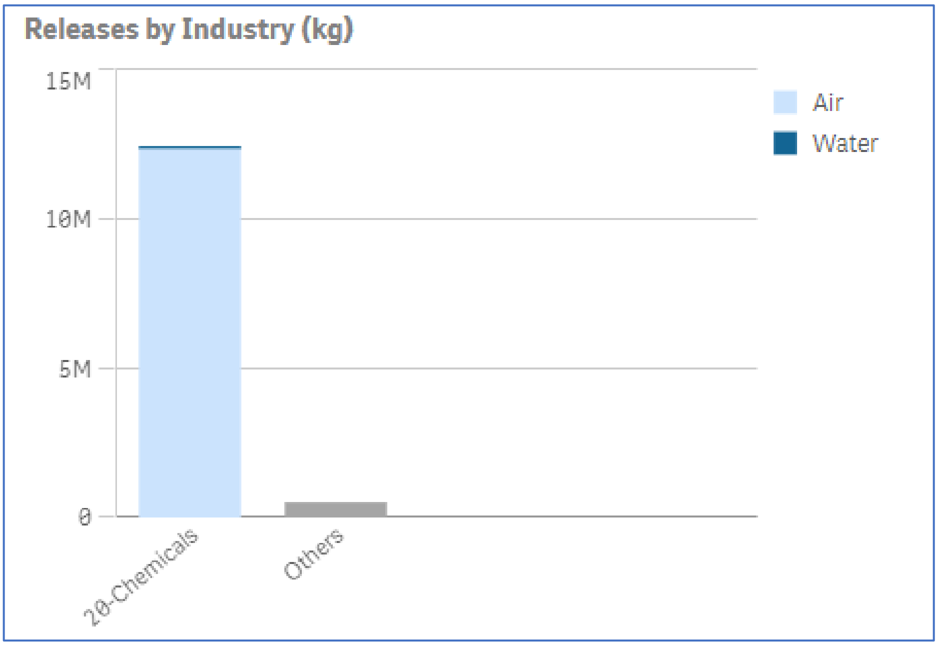
1,2-Dichloroethane (CAS 107-06-2) is a volatile, water-soluble organic chemical that is a liquid under ambient conditions (NCBI, 2021[10]).[1] It is not known to occur naturally in the environment. Synthetically produced 1,2-dichloroethane is a constituent in fumigants, leaded gasoline, cleaning products, and degreasers. It is used commercially in the production of vinyl chloride and many other chemicals (NCBI, 2021[10]). 1,2-Dichloroethane is considered harmful to aquatic life and is flammable. It is associated with a range of acute and long-term health effects including dermatitis, liver damage, and kidney impairment (ILO and WHO, 2013[11]).

This analysis focuses on 1,2-dichloroethane releases as reported to the following six of the seven pollutant release and transfer register (PRTR) systems chosen for these global scale analyses: the PRTR systems of Australia, Canada, Europe (i.e., the E-PRTR), Japan, the U.S., and Mexico. 1,2-Dichloroethane is not reported to the Chilean PRTR. As described in this project's Action Plan, the analysis focuses on releases of 1,2-dichloroethane to air and water by facilities in the manufacturing sector only (OECD, 2018[3]).

Snapshot Analyses

Across all PRTR systems combined, facilities in the manufacturing sector released 1,2-dichloroethane almost exclusively to air over the 2008 to 2017 timeframe. The largest releases reported from the manufacturing sector were almost exclusively from one International Standard Industrial Classification system (ISIC) Division, the chemical manufacturing subsector (ISIC 20), as shown in the figure below.[2] This subsector reported the largest quantities of 1,2-dichloroethane releases for every year from 2008 to 2017.

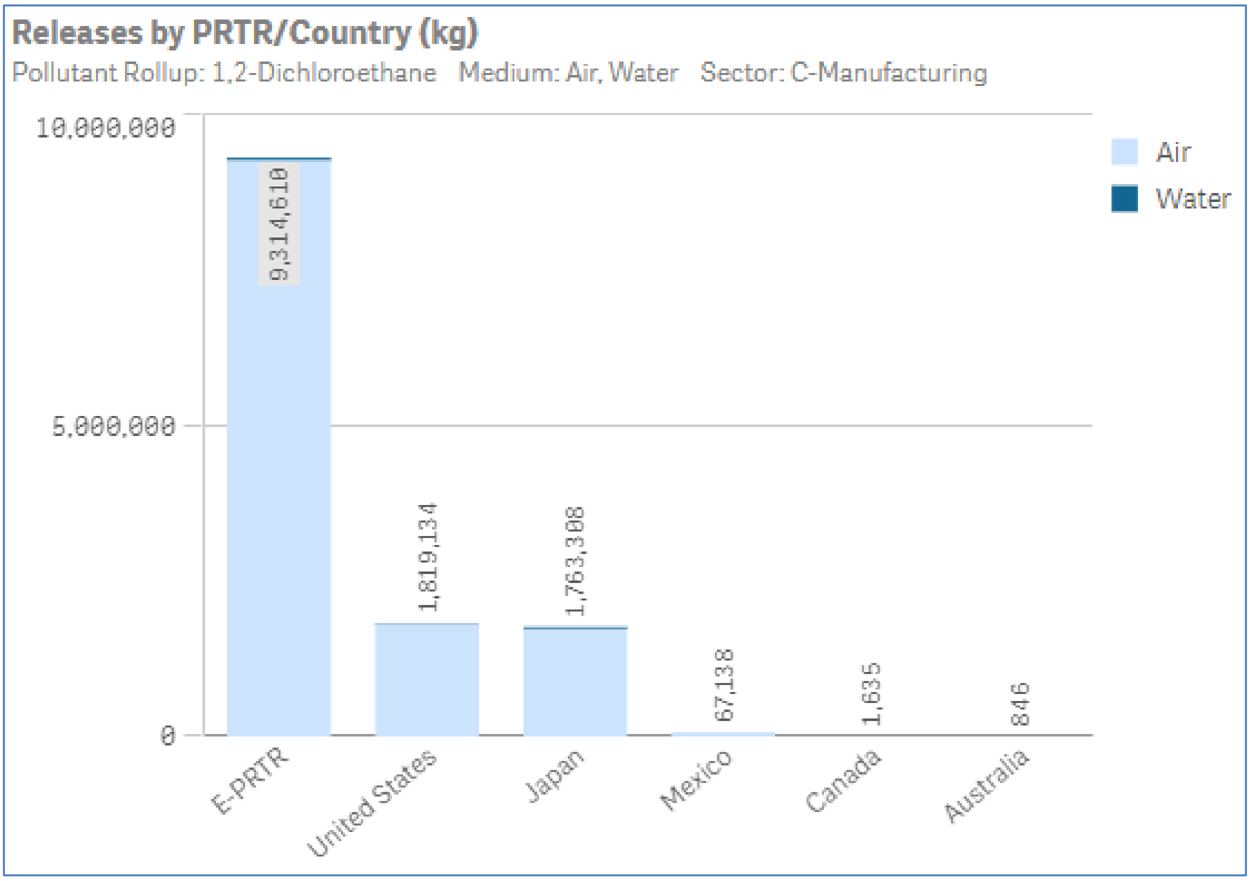
Across PRTRs, from 2008 to 2017, 1,2-dichloroethane releases were mainly from the chemical manufacturing subsector (ISIC 20)



"Others" includes combined air and water releases from all other manufacturing sectors.

Considered by PRTR, reported releases were largest in the E-PRTR, as shown in the figure below.

From 2008 to 2017, 1,2-dichloroethane releases were largest in the E-PRTR



Snapshot of 1,2-dichloroethane releases to air and water from the manufacturing sector	
Releases, 2017	1.2 million kg
Releases by medium, 2008–2017	99.3% to air
Subsector with the largest reported releases, 2008–2017	Chemical manufacturing (ISIC 20)
PRTR with the largest reported releases, 2008–2017	E-PRTR

Additional information:

Releases of 1,2-dichloroethane were almost exclusively reported by the chemical manufacturing subsector (ISIC 20) from 2008 to 2017.

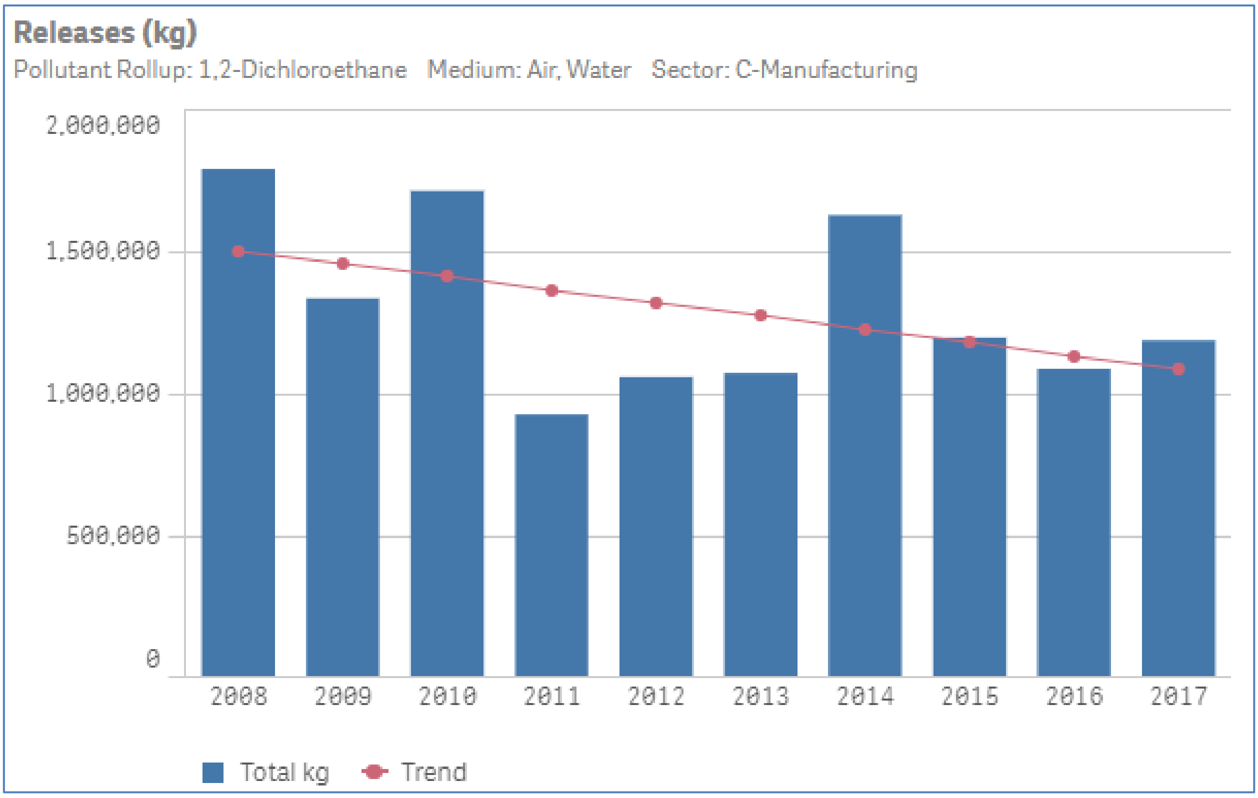
Releases in the E-PRTR accounted for 72% of all 1,2-dichloroethane releases reported from 2008 to 2017.

Few facilities reported releases of 1,2-dichloroethane in Australia (12 facilities), Canada (two facilities), and Mexico (six facilities) from 2008 to 2017. In Canada, some years had no facilities reporting releases of 1,2-dichloroethane.

Trend Analyses

Reported 1,2-dichloroethane releases across the six PRTRs over the 2008 to 2017 timeframe fluctuated. Reported releases of 1,2-dichloroethane decreased from 1.8 million kg in 2008 to 1.2 million kg in 2017, a 34% decrease. However, regression analysis indicates that the downward trend in releases was not part of a statistically significant trend based on all 10 years of data ($p>0.05$).[3]

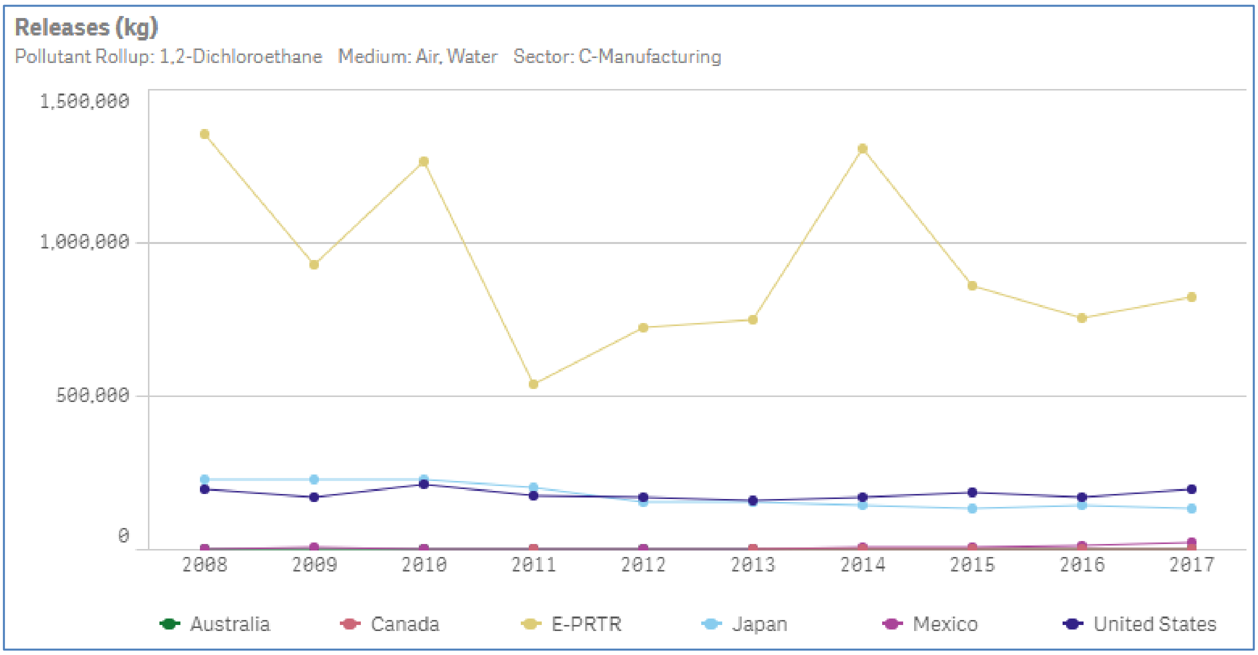
1,2-Dichloroethane releases showed no significant trend from 2008 to 2017



1,2-Dichloroethane release reductions across PRTRs from 2008 to 2017 were driven by the release quantities in the E-PRTR:

- Releases decreased considerably from 2008 to 2017 in the E-PRTR (530,000 kg decrease) and Japan (98,000 kg decrease).
  - 1,2-Dichloroethane releases in the E-PRTR were predominantly from a handful of facilities with large releases. For 2008–2017, 44% of 1,2-dichloroethane releases in the E-PRTR were from five facilities and 67% were from 10 facilities, all in the chemical manufacturing subsector. Most of these facilities did not report continuously to the E-PRTR for the 10-year period. Changes in releases reported by these facilities are responsible for the fluctuating 1,2-dichloroethane releases reported in the E-PRTR.
- Releases decreased by 1% in the U.S.
- Releases increased from 2008 to 2017 but remained very low in Australia, Canada, and Mexico.
  - Release quantities in Mexico are driven by one facility. Releases reported in Mexico spiked for 2017, when this facility reported 26,000 kg of 1,2-dichloroethane releases.
  - No releases of 1,2-dichloroethane were reported in Canada in 2008 and only 1 kg of 1,2-dichloroethane was reported as released in Australia in 2008.

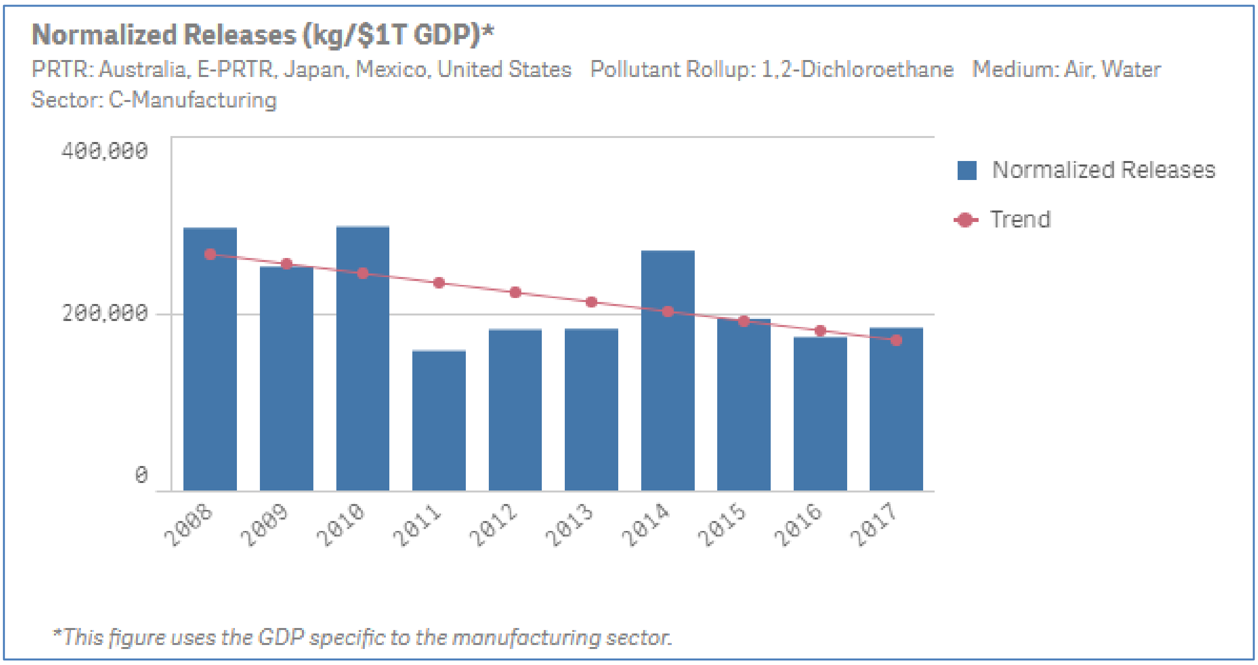
1,2-Dichloroethane releases were largest in the E-PRTR each year



This figure includes PRTRs with comparatively low releases (i.e., Australia, Canada, and Mexico), though they may not be visible at this scale.

Releases of 1,2-dichloroethane were normalized by the annual gross domestic product (GDP) for the manufacturing sector of the PRTR's country or region. Normalized releases provide a metric to compare a country's release levels per unit of economic activity in the country. Releases are related to economic activity, as higher manufacturing economic activity usually means more goods are being produced. Chemical releases are associated with these manufacturing processes, so more manufacturing is typically associated with more chemical releases. Normalizing releases controls for the differences in production levels between countries and over time. The trend in normalized releases approximates how releases would have changed if the amount of manufacturing activity had remained constant. As shown in the figure below, 1,2-dichloroethane releases across the six PRTRs, when normalized by the combined manufacturing GDPs of their respective countries/regions, do not show a statistically significant trend ($p>0.05$).[4] Note that no releases of 1,2-dichloroethane were reported in Canada for several years, so Canada is not included in the analysis of normalized releases.

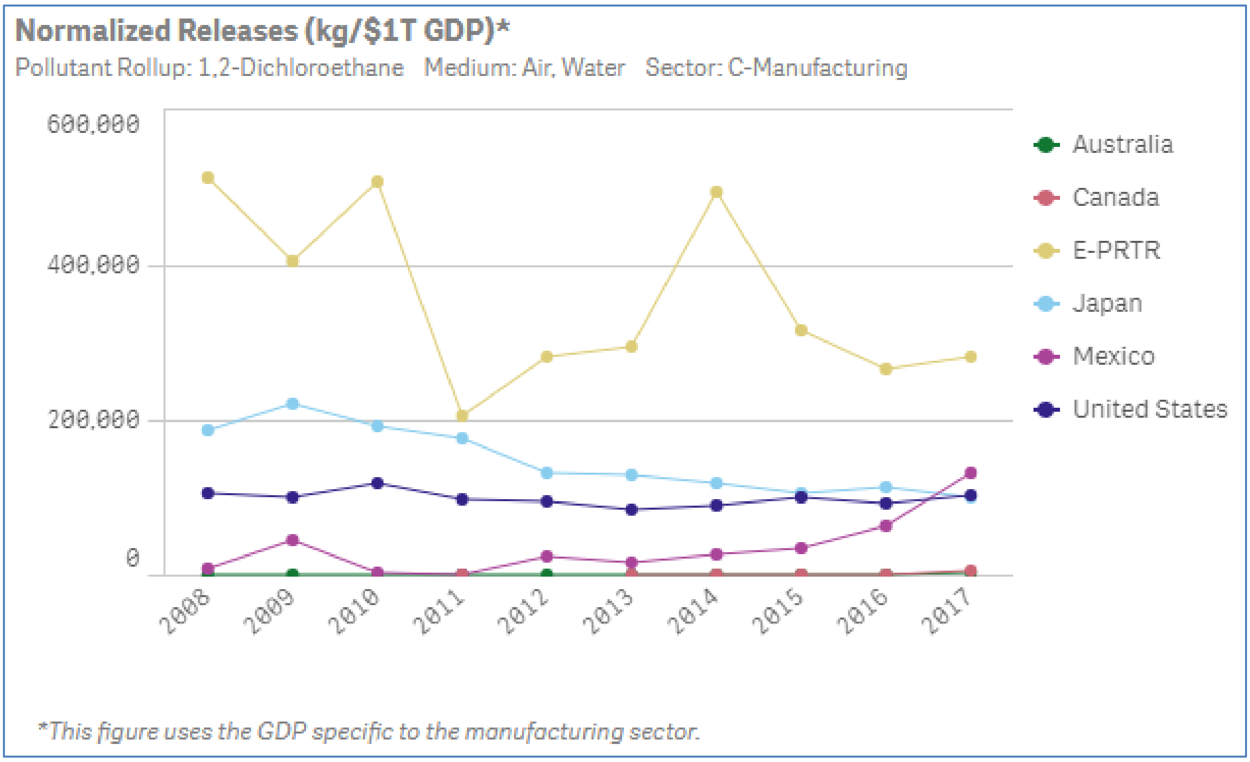
Normalized 1,2-dichloroethane releases showed no significant trend from 2008 to 2017



This figure does not include data from Canada's PRTR.

Compared among PRTRs, GDP-normalized trends in releases of 1,2-dichloroethane show that the E-PRTR had the highest normalized releases each year. Both normalized and absolute releases of 1,2-dichloroethane were larger in the E-PRTR than any other PRTR. High normalized releases indicate that facilities in E-PRTR countries released more 1,2-dichloroethane per unit of manufacturing activity than facilities in other countries. Releases in the E-PRTR fluctuated considerably since 2008, although releases decreased while manufacturing GDP increased by 10% from 2008 to 2017. If manufacturing activity were the primary driver of release trends, releases would be expected to increase as economic activity increased. The decrease in GDP-normalized releases indicates that factors other than total manufacturing economic activity were driving 1,2-dichloroethane releases in the E-PRTR.

Normalized 1,2-dichloroethane releases fluctuated in the six PRTRs



Trend in 1,2-dichloroethane releases to air and water from the manufacturing sector	
Overall change, 2008–2017	Releases decreased by 605,000 kg (34%). This was not part of a statistically significant trend.
PRTRs with the largest *percent* change in releases, 2008–2017	Australia: 300 kg increase (23,000%) Mexico: 25,000 kg increase (1,800%)
PRTR with the largest *absolute* change in releases, 2008–2017	E-PRTR: 530,000 kg decrease (39%)
Subsectors with the largest absolute change in releases, 2008–2017	Chemicals (ISIC 20): 610,000 kg decrease (35%) Basic pharmaceuticals (ISIC 21): 15,000 kg increase (950%)

Additional information:

Releases reported to the PRTRs of Australia, Canada, and Mexico were low in 2008 and higher in 2017. However, absolute releases in Australia, Canada, and Mexico remained much lower than for other PRTRs.

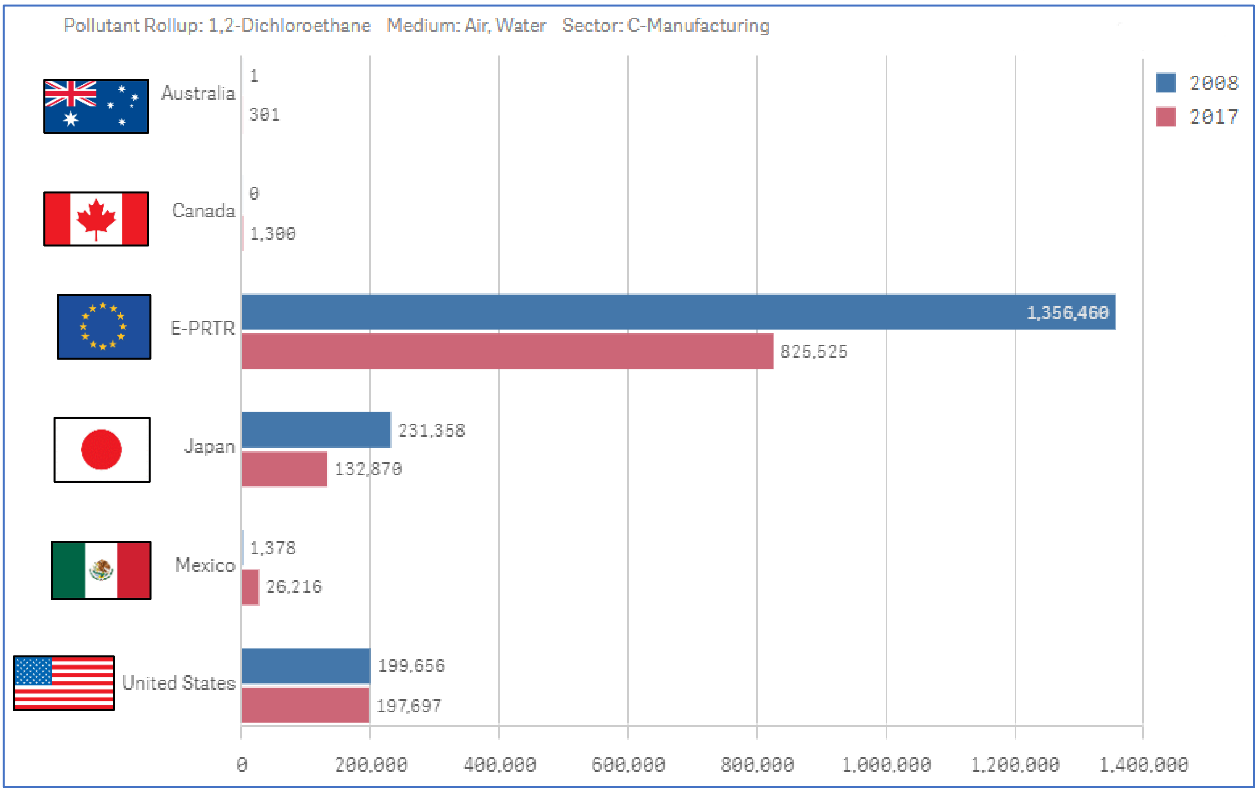
The percent change in releases was very large in Australia and Mexico because releases were very low in 2008.

Release trends for 1,2-dichloroethane are driven by the chemical manufacturing subsector and by releases in the E-PRTR.

Releases in the E-PRTR are driven by several facilities with large releases, which drop in and out of reporting 1,2-dichloroethane releases.

Summary

1,2-Dichloroethane releases from manufacturing facilities by PRTR (kg)



- Six of the seven PRTR systems contain information on 1,2-dichloroethane releases between 2008 and 2017: Australia, Canada, the E-PRTR, Japan, Mexico, and the U.S. The Chilean PRTR does not contain information on 1,2-dichloroethane releases.
- Across the six PRTRs combined, 1,2-dichloroethane releases to air and water as reported by facilities in the manufacturing sector fluctuated from year-to-year, with an overall decrease of 605,000 kg (34%) from 2008 to 2017.
  - No statistically significant trend in 1,2-dichloroethane releases was evident across these six PRTRs from 2008 through 2017.
- 1,2-Dichloroethane releases decreased from 2008 to 2017 in the two PRTRs with the largest releases reported for 2008 (E-PRTR and Japan).
  - Releases reported by the U.S. fluctuated but remained essentially unchanged from 2008 to 2017.
  - Few facilities reported releases of 1,2-dichloroethane in Australia, Canada, and Mexico, and releases remained very low in those PRTRs.
- Facilities in the chemicals (ISIC 20) subsector reported the largest release quantities of 1,2-dichloroethane. Almost all reported 1,2-dichloroethane releases were reported by facilities in the chemical manufacturing subsector. 1,2-Dichloroethane releases from the chemical manufacturing subsector decreased from 2008 to 2017.

Benzene

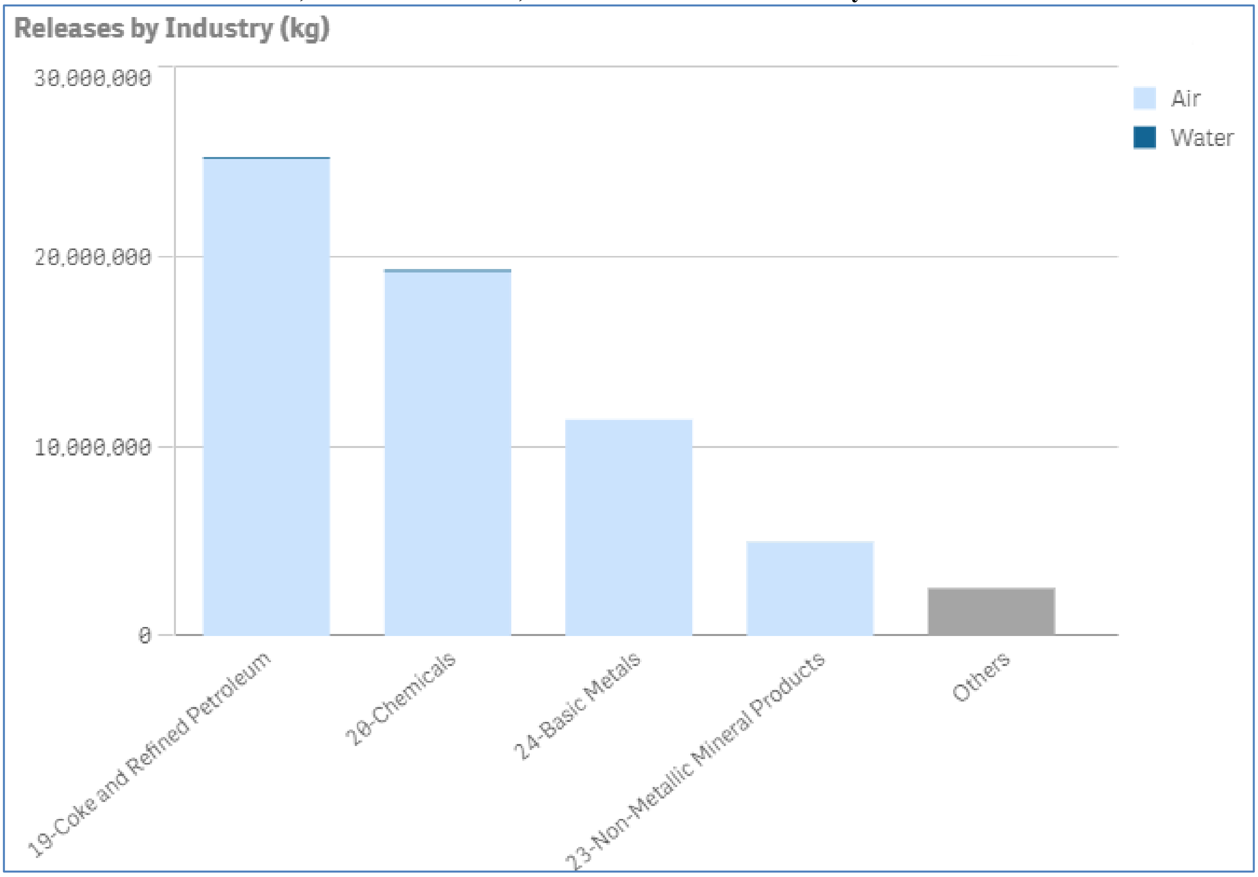
Benzene (CAS 71-43-2) is a volatile, aromatic organic chemical, is a liquid under ambient conditions (NCBI, 2021[12]). [5] It occurs naturally in the environment from volcanoes, as a constituent of crude oil, from forest fires, and as a plant volatile. It is also produced synthetically. It is found in petroleum products such as motor fuels and gasoline. It is used commercially as a solvent and as a feedstock in the production of ethylbenzene and styrene as well as many other chemicals. It is associated with a range of acute and long-term health effects including cancer and aplastic anemia. Benzene is also considered harmful to aquatic life and is flammable (WHO, 2021[13]).

This analysis focuses on benzene releases as reported to the seven pollutant release and transfer register (PRTR) systems chosen for these global scale analyses: the PRTR systems of Australia, Canada, Chile, Europe (i.e., the E-PRTR), Japan, Mexico, and the U.S. As described in this project's Action Plan, the analysis focuses on releases of benzene to air and water by facilities in the manufacturing sector only (OECD, 2018[3]).

Snapshot Analyses

Across all PRTR systems combined, facilities in the manufacturing sector released benzene almost exclusively to air over the 2008 to 2017 timeframe. The largest releases reported from the manufacturing sector were primarily from four International Standard Industrial Classification (ISIC) Divisions, as shown in the figure below.[6] The largest releases of benzene were from the coke and refined petroleum products (ISIC 19) and chemicals (ISIC 20) subsectors. Together, these two subsectors accounted for 70% of benzene releases reported from 2008 to 2017.

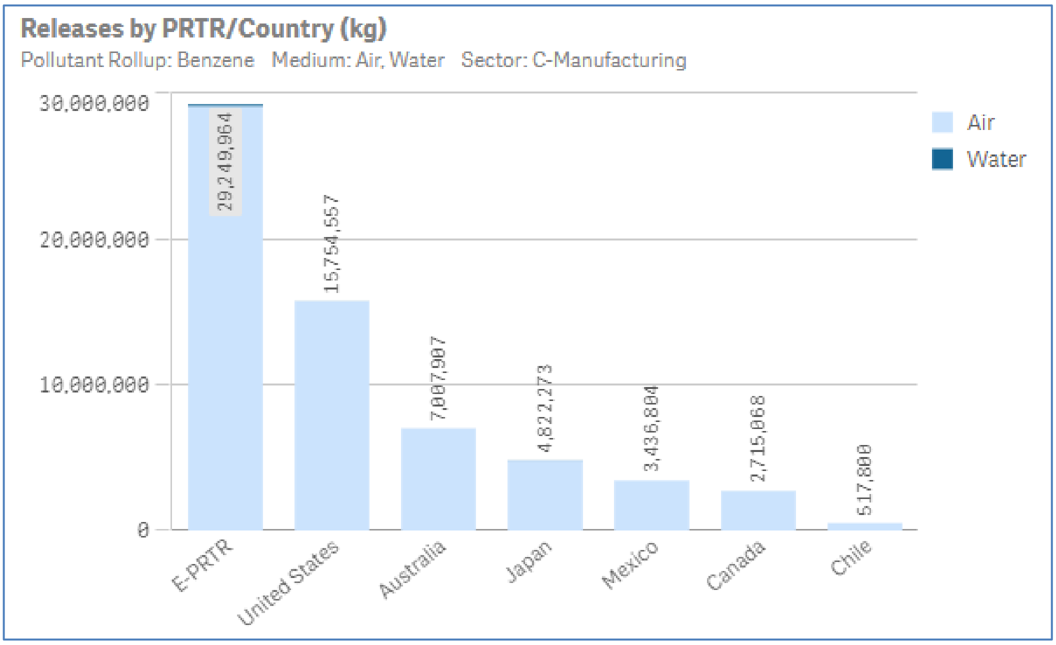
Across PRTRs, from 2008 to 2017, benzene releases were mainly from four subsectors



"Others" includes combined air and water releases from all other manufacturing sectors.

Considered by PRTR, reported releases were largest in the E-PRTR, followed by the U.S., as shown in the figure below.

From 2008 to 2017, benzene releases were largest in the E-PRTR and the U.S.

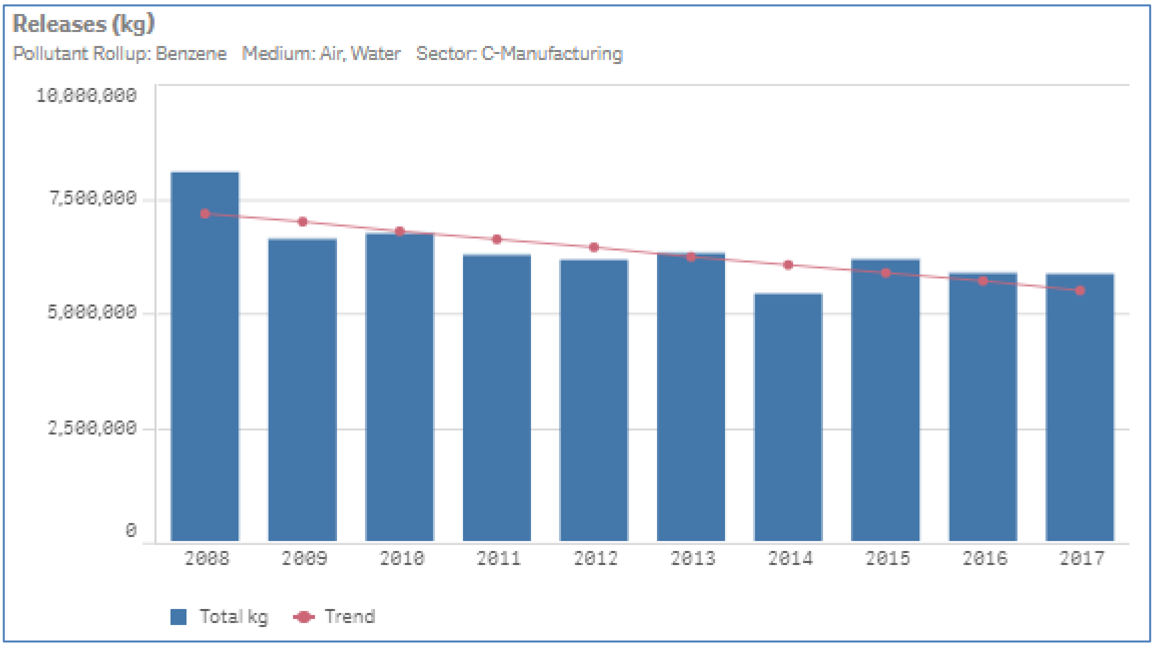


Snapshot of benzene releases to air and water from the manufacturing sector	
Releases, 2017	5.9 million kg
Releases by medium, 2008–2017	99.7% to air
Subsectors with the largest reported releases, 2008–2017	Coke and refined petroleum (ISIC 19) Chemical manufacturing (ISIC 20) Basic metals (ISIC 24) Non-metallic mineral products (ISIC 23)
PRTRs with the largest reported releases, 2008–2017	E-PRTR, U.S.
Additional information: More than 99% of releases were to air and less than 1% of releases were to water for all PRTRs from 2008 to 2017	

Trend Analyses

Reported benzene releases totalled across the seven PRTRs over the 2008 to 2017 timeframe have been trending down, from a high of 8.1 million kg in 2008 to 6.6 million kg in 2009 to 5.9 million kg in 2017—a 28% decrease overall. Regression analysis indicates that the downward trend in releases was statistically significant based on all 10 years of data ($p<0.05$).[7] Most of the decrease in benzene releases occurred from 2008 to 2009, with a much more modest decrease from 2009 to 2017. The trend was likely influenced by the global economic recession. The decline was driven by the coke and petroleum products (ISIC 19), chemicals and chemical products (ISIC 20), and basic metals (ISIC 24) subsectors.

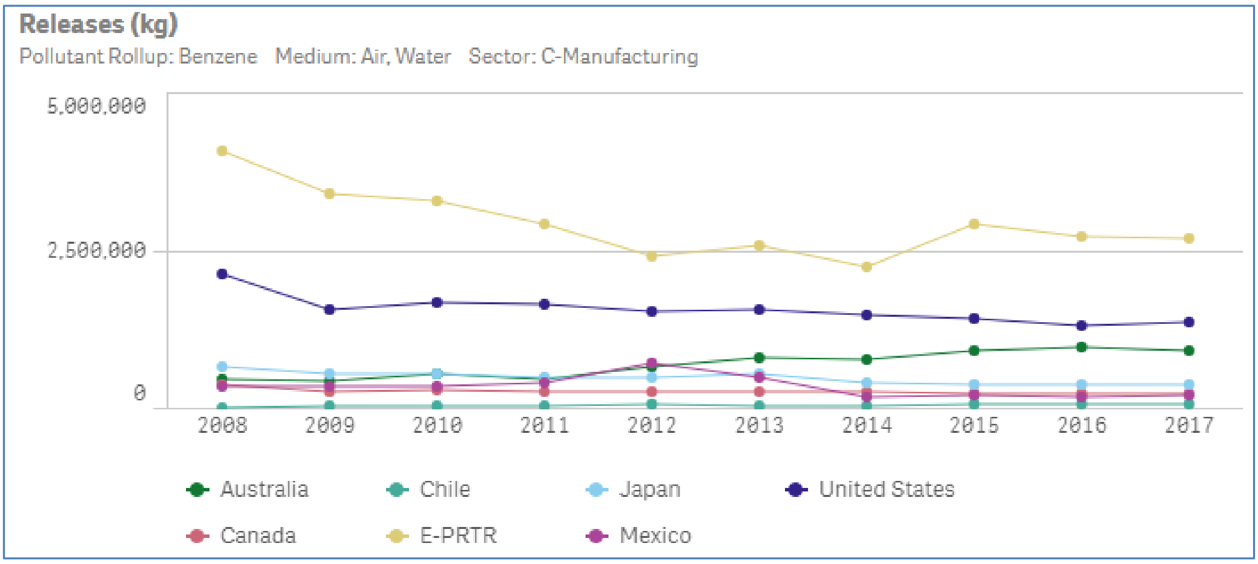
Benzene releases decreased significantly from 2008 to 2017



Benzene releases decreased for most PRTRs from 2008 to 2017:

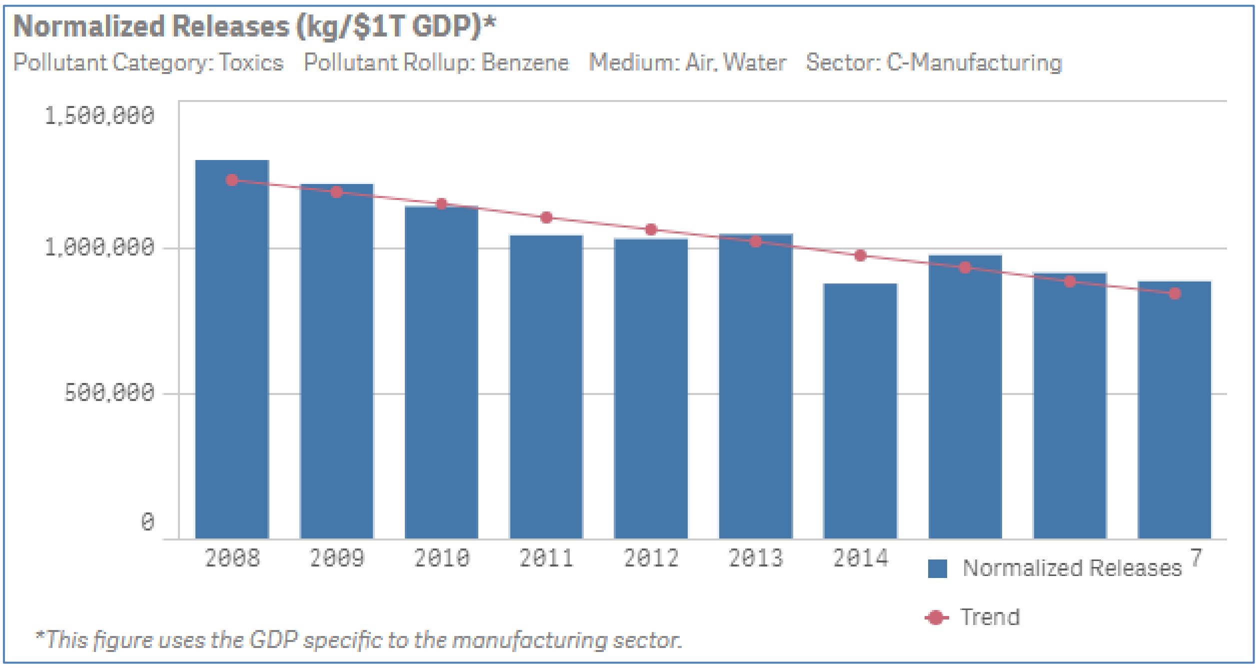
- Releases decreased considerably in the E-PRTR (1.4 million kg decrease) and the U.S. (783,000 kg decrease).
- Releases decreased by smaller amounts in Japan (277,000 kg), Mexico (144,000 kg), and Canada (123,000 kg).
- In Australia, releases increased by 441,000 kg (93%), driven by the chemical manufacturing subsector (ISIC 20), where releases increased by 532,000 kg (207%) since 2008. Within the subsector, benzene releases were driven by the "Industrial Gas Manufacturing" subsector. Specifically, releases increased by 484,000 kg (244%) at the Karratha Onshore Gas Treatment Plant in Western Australia. Natural gas production in Australia more than doubled from 2008 to 2017 (Australian Government, 2018[14]). This indicates that an increase in natural gas extraction and related activities was a likely driver of increased benzene releases in Australia. Releases of benzene from facilities in other subsectors in Australia, including basic metals (ISIC 24) and coke and refined petroleum products (ISIC 19), declined.
- In Chile, benzene releases increased by 43,000 kg (167%), with the largest increases reported by the subsectors that reported the largest benzene releases in 2008: paper and paper products (ISIC 17), non-metallic mineral products (ISIC 23), wood and wood products (ISIC 16), and food products (ISIC 10); as well, coke and refined petroleum products (ISIC 19) saw a spike in benzene releases in 2017.

Benzene releases decreased in most PRTRs



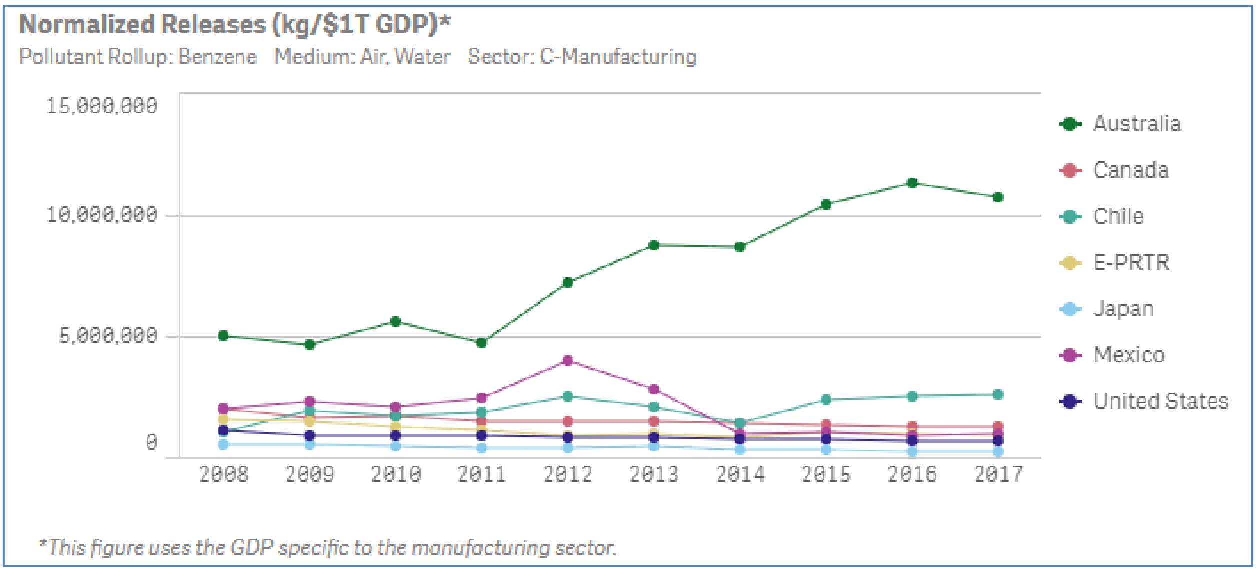
Releases of benzene were normalized by the annual gross domestic product (GDP) for the manufacturing sector of the PRTR's country or region. Normalized releases provide a metric to compare a country's release levels per unit of economic activity in the country. Releases are related to economic activity, as higher manufacturing economic activity usually means more goods are being produced. Chemical releases are associated with these manufacturing processes, so more manufacturing is typically associated with more chemical releases. Normalizing releases controls for the differences in production levels between countries and over time. The trend in normalized releases approximates how releases would have changed if the amount of manufacturing activity had remained constant. As shown in the figure below, benzene releases across the seven PRTRs, when normalized by the combined manufacturing GDPs of their countries/regions, show a statistically significant downward trend ($p<0.05$).[8]

Normalized benzene releases significantly decreased from 2008 to 2017



Compared among PRTRs, GDP-normalized trends in releases of benzene show that Australia had the highest normalized releases for every year, rather than the E-PRTR and the U.S. This indicates that facilities in Australia released more benzene per unit of manufacturing activity than facilities in other countries. Releases in Australia more than doubled from 2008 to 2017 as the country's GDP decreased by 10%. If manufacturing activity were the primary driver of release trends, releases would be expected to decrease as manufacturing activity decreased. The increase in GDP-normalized releases indicates that factors other than total manufacturing economic activity were driving benzene releases in Australia.

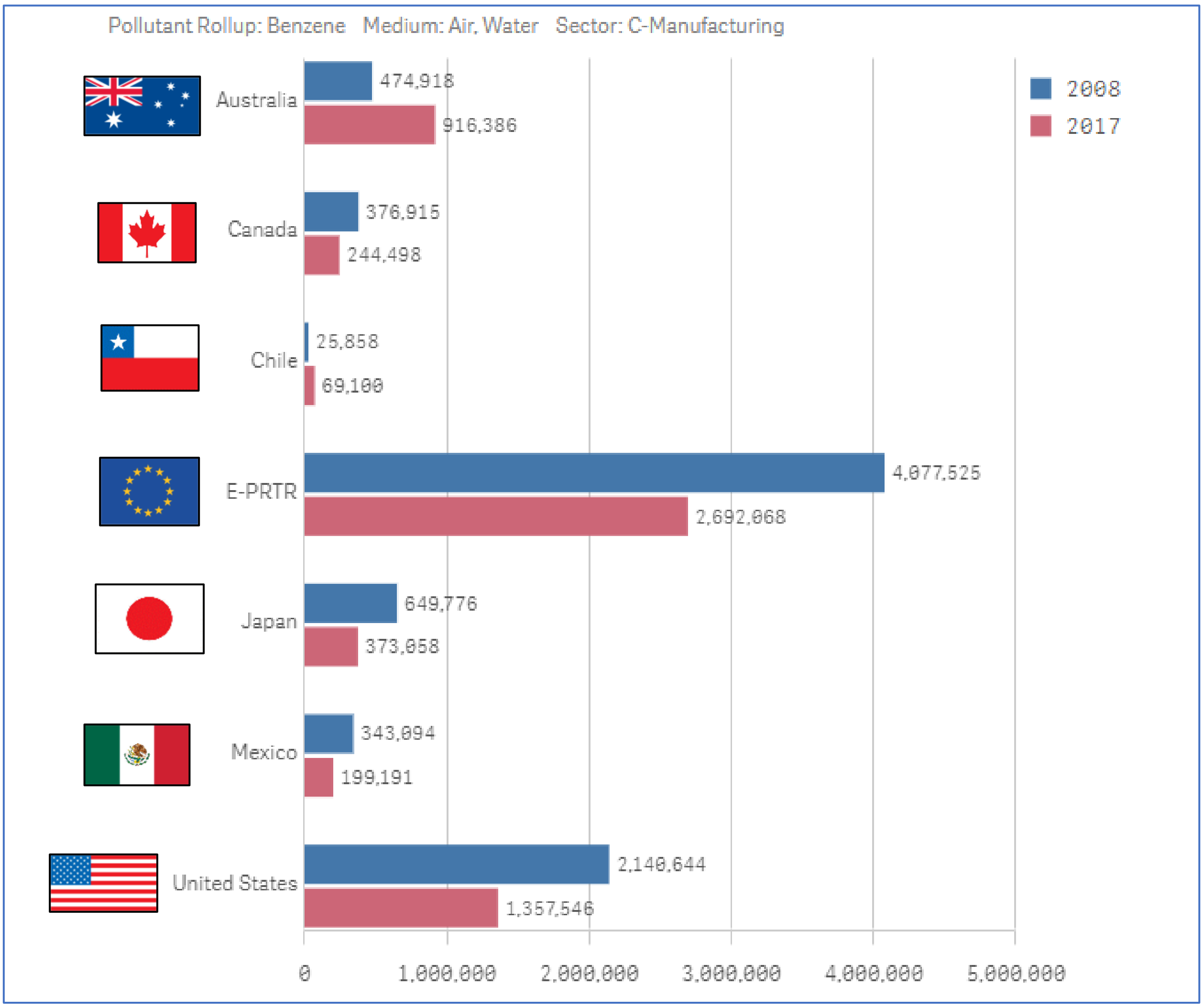
Normalized benzene releases increased in Australia but trended down across most PRTRs



Trend in benzene releases to air and water from the manufacturing sector	
Overall change, 2008–2017	Benzene releases decreased by 2.2 million kg (28%) from 2008 to 2017, with a considerable decline from 2008 to 2009. This was part of a significant trend of releases decreasing.
PRTRs with the largest *percent* change in releases, 2008–2017	Chile: 43,000 kg decrease (167%) Australia: 440,000 kg increase (93%) Japan: 280,000 kg decrease (43%)
PRTR with the largest *absolute* change in releases, 2008–2017	E-PRTR: 1.4 million kg decrease (34%)
Subsectors with the largest absolute change in releases, 2008–2017	Basic metals (ISIC 24): 860,000 kg decrease (51%) Coke and refined petroleum products (ISIC 19): 740,000 kg decrease (22%)
Additional information: Although the percent increase in releases was large in Chile and Australia, those countries had low benzene emissions in the base year of 2008 so the absolute increase in releases was relatively small. Releases decreased significantly in the E-PRTR (1.4 million kg decrease) and the U.S. (783,000 kg decrease) but the percent change was low because those countries had large releases in 2008. The 43% (277,000 kg) decrease in releases in Japan was driven by reduced releases from the chemical manufacturing sector.	

Summary

Releases of benzene from manufacturing facilities by PRTR (kg)



- All seven PRTR systems contain information on benzene releases between 2008 and 2017: Australia, Canada, Chile, Europe (i.e., the E-PRTR), Japan, Mexico, and the U.S.
- Across the seven PRTRs combined, benzene releases to air and water as reported by facilities in the manufacturing sector decreased by 2.2 million kg (28%) from 2008 to 2017. Much of the decrease occurred from 2008 to 2009, which may be attributable to effects of the global economic recession. The decrease in releases in more recent years is less pronounced but still significant.
  - The downward trend in benzene releases is more evident when one facility in Australia is excluded. Releases from that facility accounted for 12% of all air and water releases of benzene in 2017 from manufacturing facilities in the included PRTRs. This could indicate that many facilities and subsectors around the world are successfully decreasing their benzene emissions, but these gains are being offset somewhat by a few subsectors with increasing benzene releases.

- Benzene releases were lower in 2017 than 2008 in five of the seven PRTR systems examined: Canada, the E-PRTR, Japan, Mexico, and the U.S.
    - Releases of benzene increased from 2008 to 2017 in Australia and Chile.
- Facilities in the coke and refined petroleum product manufacturing (ISIC 19) and chemical manufacturing (ISIC 20) subsectors reported the largest release quantities of benzene. Releases from these two subsectors decreased from 2008 to 2017.

Cadmium

Elemental cadmium exists in ambient conditions as a silvery metal solid and is present at low concentrations in the Earth's crust (NCBI, 2021[15]).[9] Cadmium is associated with zinc, lead, and copper ores in nature and is naturally occurring in soil, water, coal, and petroleum. It occurs in nature as the result of volcanic activity, water transport and erosion, and weathering of rocks (WHO, 1992[16]). Cadmium and cadmium compounds are also present in human-made goods. They are found in electronics, food, fossil fuels, and tobacco products. They are used commercially in electroplating and the manufacturing of non-ferrous metals and batteries (WHO, 2019[17]). Cadmium and cadmium compounds are associated with a range of acute and long-term health effects including cancer, lung edema, and kidney impairment (ILO and WHO, 2005[18]). Cadmium and cadmium compounds are also considered toxic to aquatic life and have been observed to bioaccumulate in several marine and land invertebrate species (WHO, 1992[16]; NCBI, 2021[15]).

Cadmium can exist on its own (as elemental cadmium, Cd^0) or can form cadmium compounds by bonding to other elements. In some pollutant release and transfer registers (PRTRs), cadmium compounds are listed separately from elemental cadmium. In the other PRTRs, cadmium and cadmium compounds are listed together. Across PRTRs, when facilities report releases of cadmium compounds, they report the quantity of cadmium, not the weight of the entire compound. For simplicity, this analysis groups together all cadmium and cadmium compounds reported as released to the environment. Since facilities report the weight of cadmium and not the weight of the entire compound, these releases are all releases of cadmium. Therefore, in this analysis "releases of cadmium" refers to both releases of elemental cadmium and releases of the cadmium portion of cadmium compounds.

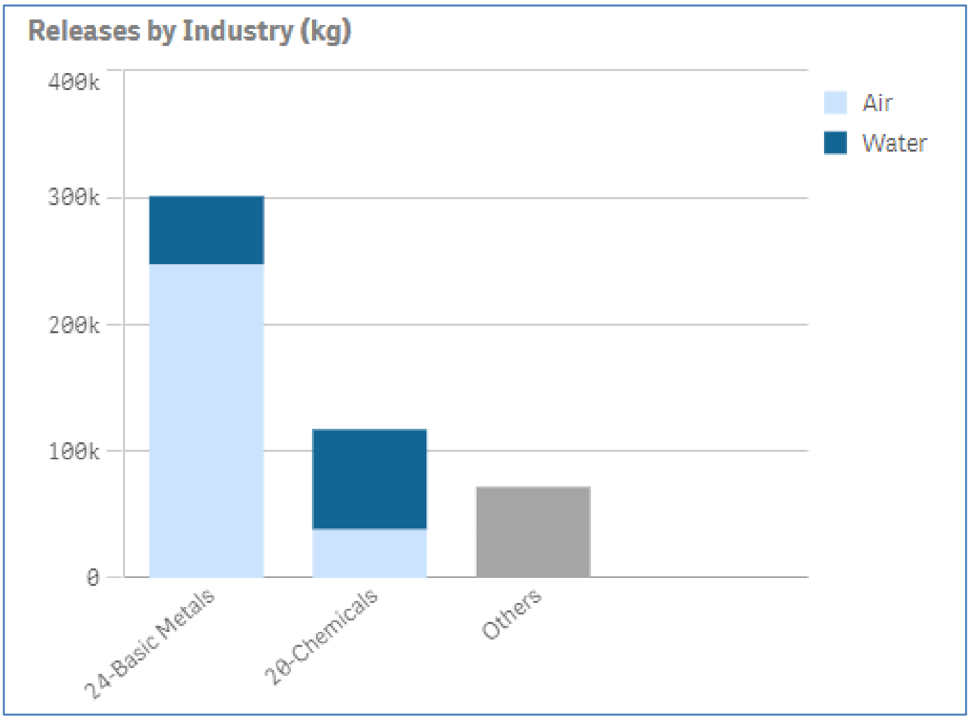
This analysis focuses on releases of cadmium as reported to the seven PRTR systems chosen for these global-scale analyses: the PRTR systems of Australia, Canada, Chile, Europe (i.e., the E-PRTR), Japan, the U.S., and Mexico. As described in this project's Action Plan, the analysis focuses on releases of cadmium to air and water by facilities in manufacturing sectors only (OECD, 2018[3]).

PRTR data from Mexico include a facility that reported very large releases of cadmium to water during 2008. This facility is in the chemical manufacturing subsector and reported releasing 440,000 kg of cadmium to water during 2008, almost as great a quantity as the combined total from all other facilities in all examined PRTRs from 2008 through 2017. Input from Mexico's PRTR staff indicates that the facility's reporting for cadmium is considered inconsistent and will not be included in the next data update of Mexico's PRTR database. Therefore, releases of cadmium reported by the Mexican PRTR are considered separately and are not included in the analyses that aggregate data across PRTRs.

Snapshot Analyses

Across the E-PRTR and the PRTR systems of Australia, Canada, Chile, Japan, and the U.S., facilities in the manufacturing sector released about two-thirds of cadmium to air over the 2008 to 2017 timeframe. The largest releases reported from the manufacturing sector were primarily from two ISIC Divisions, as shown in the figure below.[10] The largest releases of cadmium were from the basic metals subsector (ISIC 24). This subsector accounted for 61% of cadmium releases reported from 2008 to 2017.

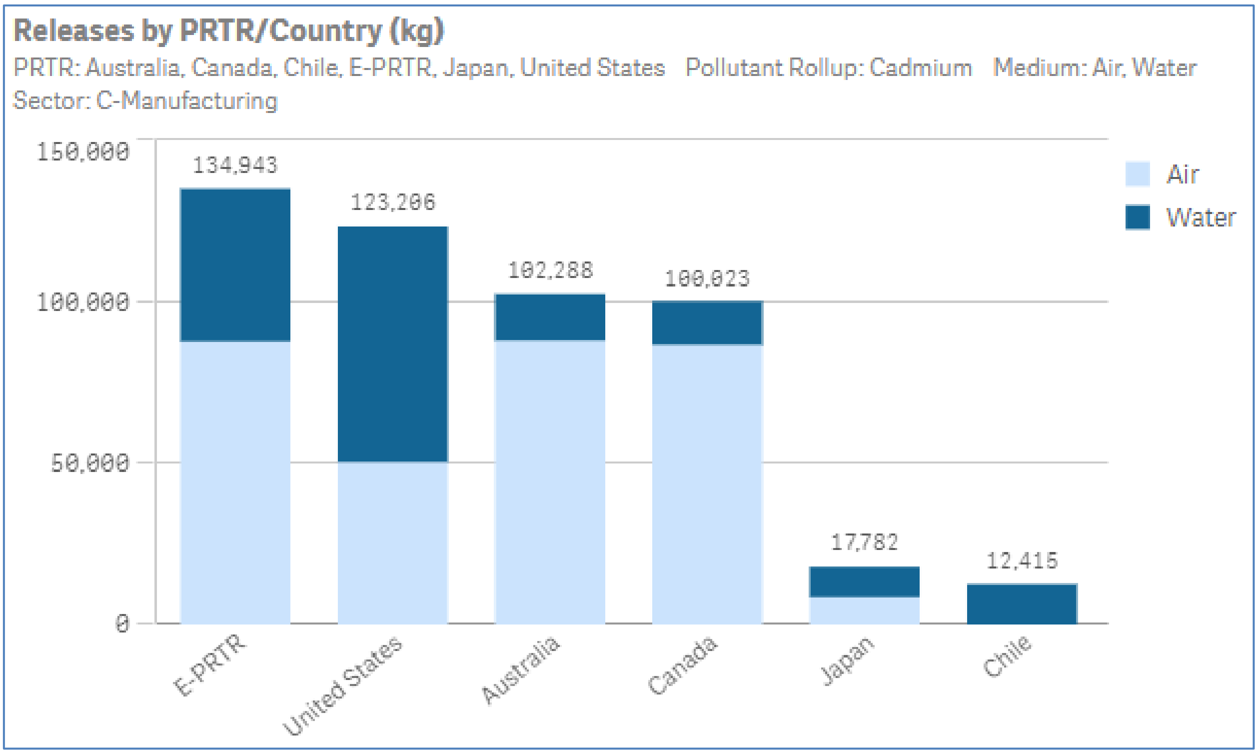
Across six PRTRs, from 2008 to 2017, releases of cadmium were mainly from two subsectors



This figure does not include data from Mexico's PRTR. "Others" includes combined air and water releases from all other manufacturing sectors.

Considered by PRTR, reported releases were largest in the E-PRTR and the U.S., followed by Australia and Canada, as shown in the figure below.

From 2008 to 2017, cadmium releases were largest in the E-PRTR and the U.S.



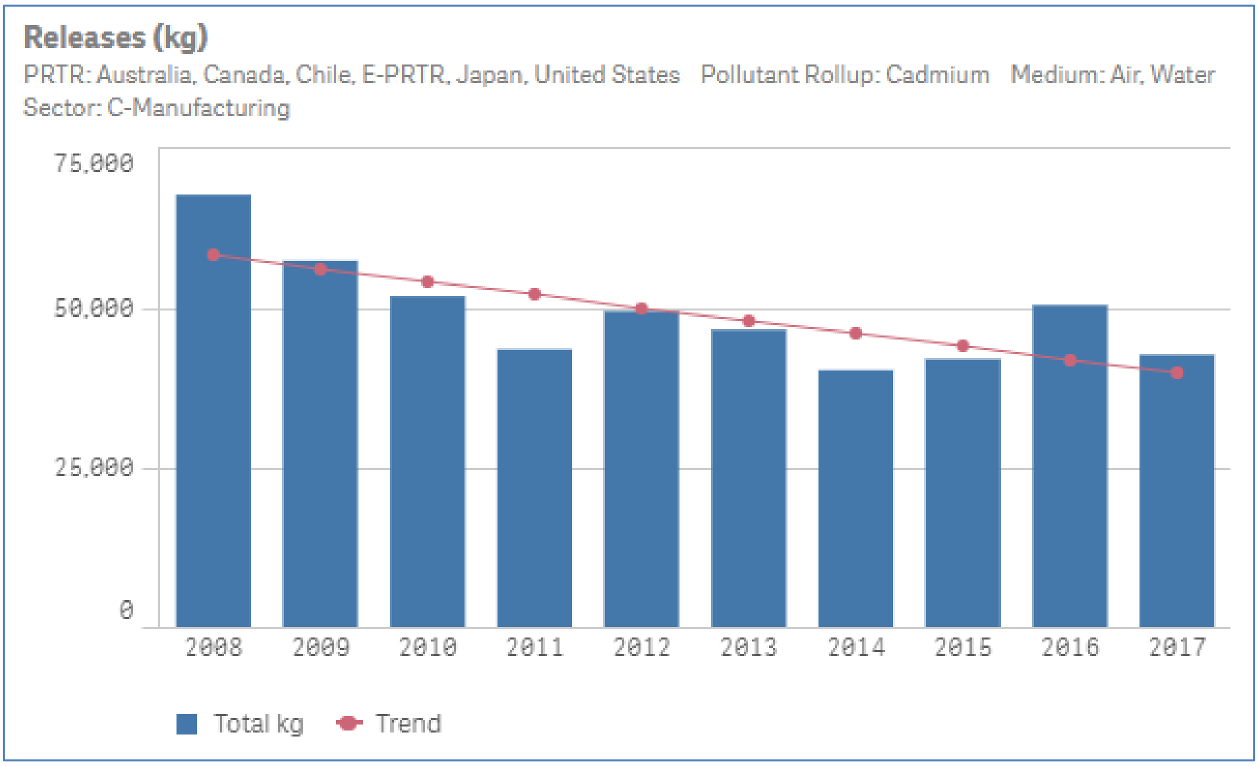
This figure does not include data from Mexico's PRTR.

Snapshot of cadmium releases to air and water from the manufacturing sector	
Releases, 2017	Excluding Mexico: 43,000 kg Including Mexico: 46,000 kg
Releases by medium, 2008–2017 (excluding Mexico)	65% to air
Subsectors with the largest reported releases, 2008–2017	Basic metals (ISIC 24) Chemical manufacturing (ISIC 20)
PRTRs with the largest reported releases, 2008–2017	E-PRTR, U.S.
Additional information: Releases reported by Mexico were elevated in 2008 due to very large release quantities reported by one facility. For 2009–2017, releases of cadmium in Mexico were reported mainly from the chemical manufacturing sector (ISIC 20) and basic metals sector (ISIC 24). Releases reported in Mexico from 2009 to 2017 were primarily to water, which accounted for 86% of releases reported to the Mexican PRTR system. From 2009 to 2017, 85,000 kg of cadmium were released in Mexico, which is similar to cadmium releases in Canada and Australia over the same timeframe (90,000 kg and 78,000 kg, respectively).	

Trend Analyses

Reported cadmium releases totalled across the E-PRTR and PRTRs of Australia, Canada, Chile, Japan, and the U.S. over the 2008 to 2017 timeframe have been trending down, from a high of 68,000 kg in 2008 to 43,000 kg in 2017—a 37% decrease. Regression analysis indicates that the downward trend in releases was statistically significant based on all 10 years of data ($p<0.05$).[11] The decline was driven by reduced releases from facilities in the basic metals subsector (ISIC 24), primarily in Canada, the E-PRTR, and Australia.

Releases of cadmium significantly decreased from 2008 to 2017

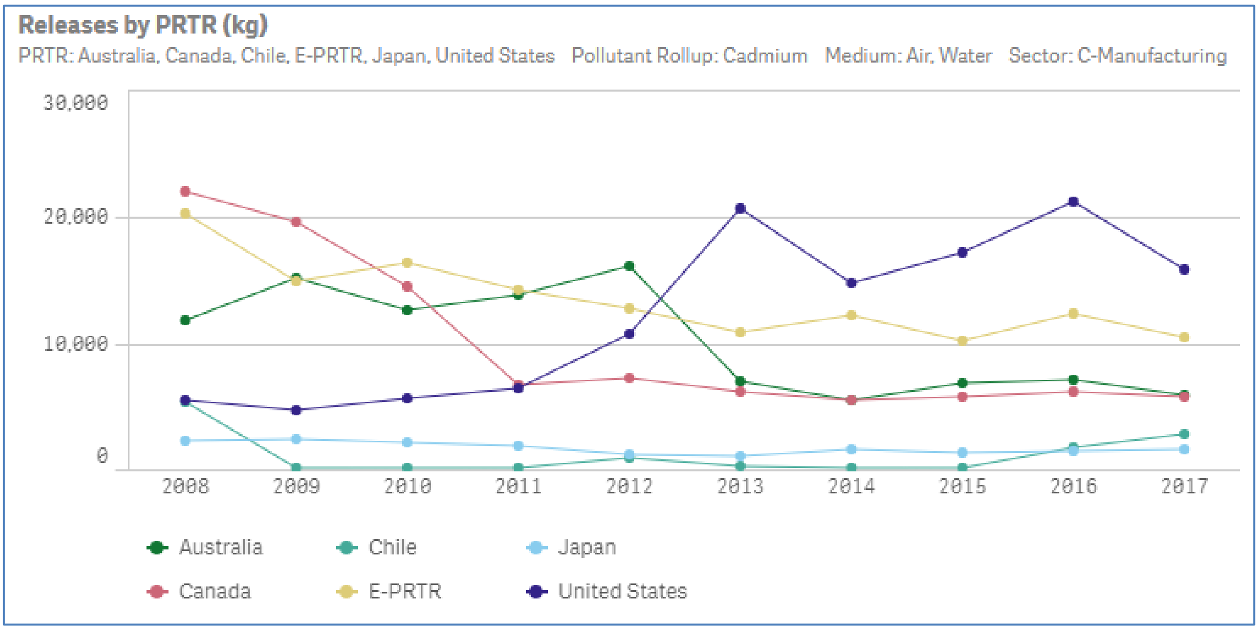


This figure does not include data from Mexico’s PRTR.

Cadmium releases decreased for most PRTRs from 2008 to 2017:

- Releases decreased the most in Canada (16,000 kg decrease) and the E-PRTR (9,700 kg decrease).
- Releases decreased by smaller amounts in Australia (5,900 kg decrease), Chile (2,700 kg decrease), and Japan (790 kg decrease).
- In the U.S., releases increased by 10,000 kg, driven by increased releases to water reported by the chemical manufacturing sector.
- In Mexico, cadmium releases decreased from 2008 to 2017 because releases in 2008 were abnormally high due to reporting by one facility. Releases from 2009 to 2017 decreased by 9,700 kg.

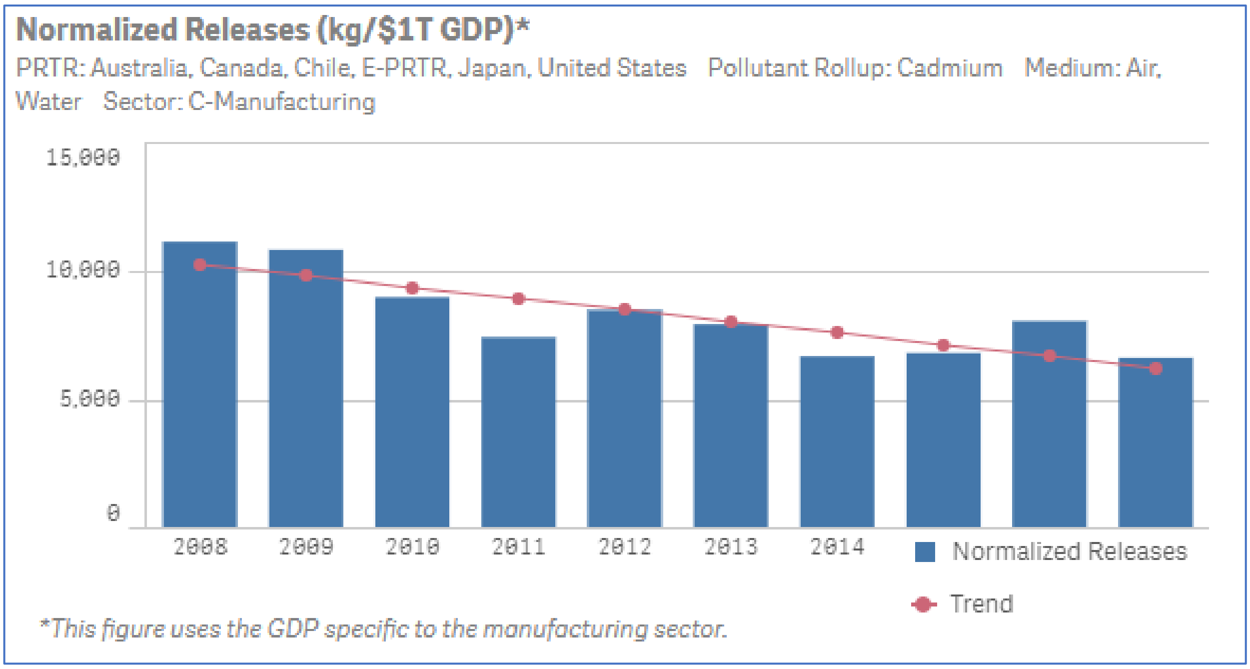
Releases of cadmium decreased in most PRTRs



This figure does not include data from Mexico's PRTR.

Releases of cadmium were normalized by the annual gross domestic product (GDP) for the manufacturing sector of the PRTR's country or region. Normalized releases provide a metric to compare a country's release levels per unit of economic activity in the country. Releases are related to economic activity, as higher manufacturing economic activity usually means more goods are being produced. Chemical releases are associated with these manufacturing processes, so more manufacturing is typically associated with more chemical releases. Normalizing releases controls for the differences in production levels between countries and over time. The trend in normalized releases approximates how releases would have changed if the amount of manufacturing activity had remained constant. As shown in the figure below, cadmium releases across the six PRTRs (excluding Mexico), when normalized by the combined manufacturing GDPs of their countries/regions, show a statistically significant downward trend ($p<0.05$).[12]

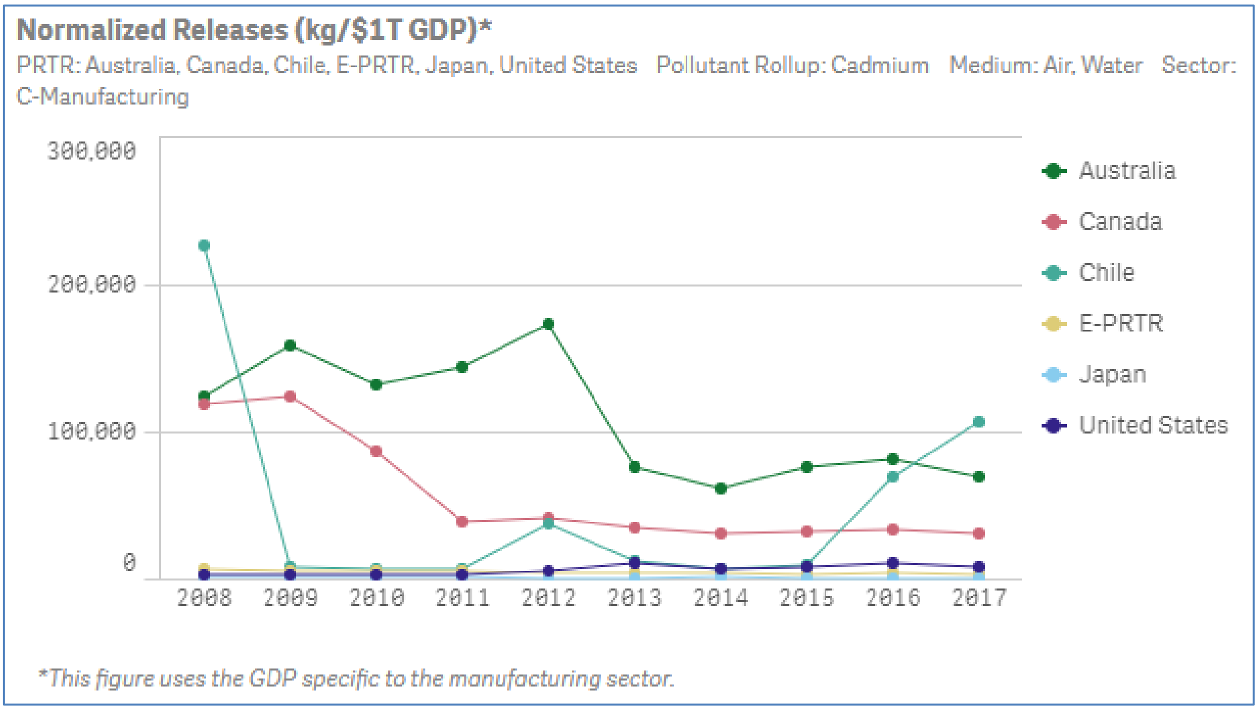
Normalized cadmium releases significantly decreased from 2008 to 2017



This figure does not include data from Mexico's PRTR.

Compared among PRTRs, GDP-normalized trends in releases of cadmium show that Australia and Chile had the highest normalized releases in recent years, rather than the E-PRTR and the U.S. This indicates that facilities in Australia and Chile released more cadmium per unit of manufacturing activity than facilities in the E-PRTR countries, Japan, and the U.S. Releases in Australia decreased by 50% from 2008 to 2017 while manufacturing GDP decreased by 10%. If manufacturing activity were the primary driver of trends in Australia, releases would be expected to decrease only as much as manufacturing activity decreased. Cadmium releases in Chile fluctuated but were lower in 2017 than 2008, even as manufacturing GDP increased by 10%. If manufacturing activity were the primary driver of release trends in Chile, releases would be expected to increase as manufacturing activity increased.

Normalized releases of cadmium trended down across most PRTRs

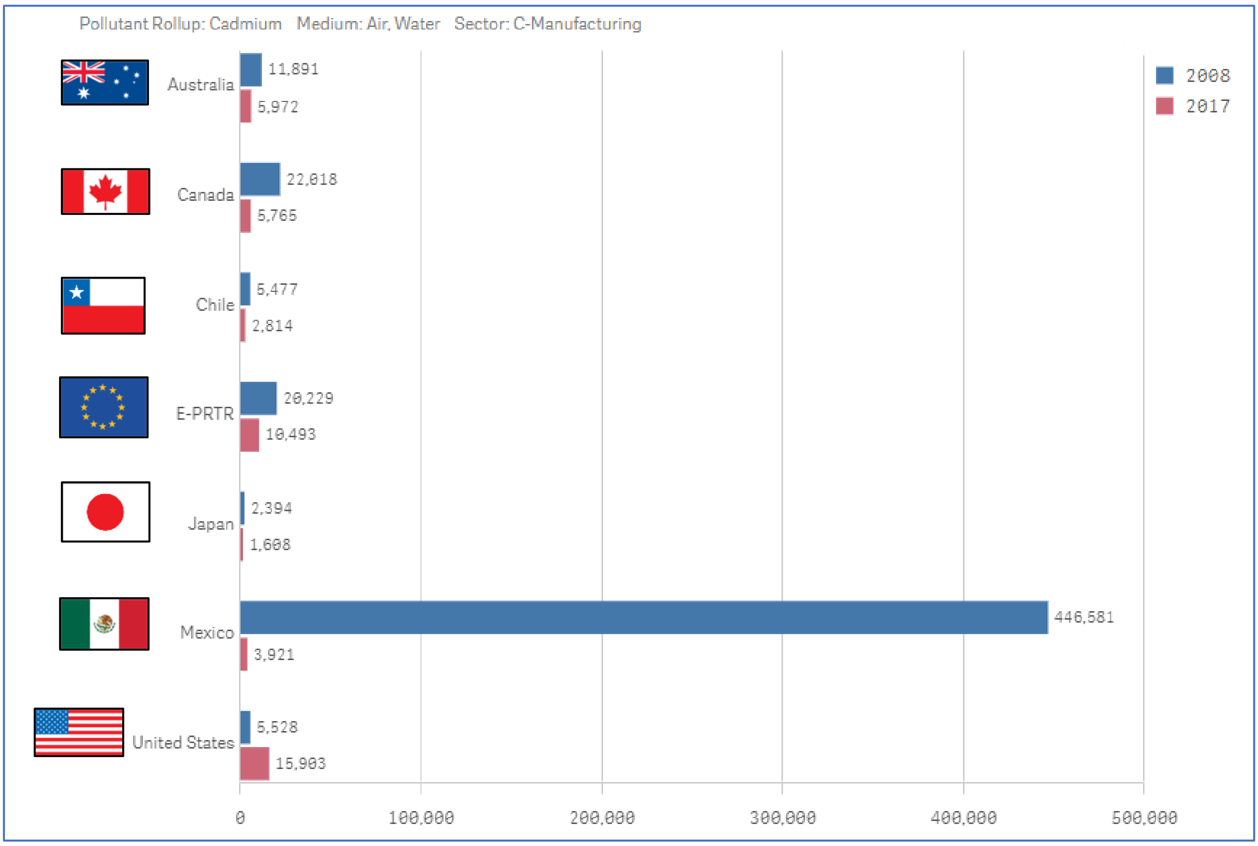


This figure does not include data from Mexico's PRTR.

Trend in cadmium releases to air and water from the manufacturing sector, excluding Mexico	
Overall change, 2008–2017	Releases across six PRTRs decreased by 25,000 kg (37%). This was part of a statistically significant trend.
PRTRs with the largest *percent* change in releases, 2008–2017	U.S.: 10,000 kg increase (188%) Canada: 16,000 kg decrease (74%)
PRTRs with the largest *absolute* change in releases, 2008–2017	Canada: 16,000 kg decrease (74%) U.S.: 10,000 kg increase (188%) E-PRTR: 9,700 kg decrease (48%)
Subsectors with the largest absolute change in releases, 2008–2017	Basic metals (ISIC 24): 34,000 kg decrease (64%) Chemical manufacturing (ISIC 20): 9,700 kg increase (172%)
Additional information: The increase in releases reported by the chemical manufacturing subsector is driven by increased releases reported by that subsector in the U.S. Releases reported by the basic metals subsector decreased across most PRTRs.	

Summary

Releases of cadmium from manufacturing facilities by PRTR (kg)



- All of the seven PRTR systems contain information on releases of cadmium and cadmium compounds between 2008 to 2017: Australia, Canada, Chile, Europe (i.e., the E-PRTR), Japan, Mexico, and the U.S.
  - In Mexico, cadmium releases decreased greatly from 2008 to 2017 because releases in 2008 were abnormally high due to one facility reporting very high releases in 2008. Input from Mexico's PRTR staff indicates that the facility's reporting for cadmium is considered inconsistent and will not be included in the next data update of Mexico's PRTR database, so releases reported to Mexico's PRTR system are not included in the following statements.
- Across the six PRTRs13 combined, cadmium releases to air and water as reported by facilities in the manufacturing sector decreased by 25,000 kg (37%) from 2008 to 2017.
  - Both normalized and absolute releases of cadmium decreased significantly across these six PRTRs from 2008 through 2017.
- Cadmium releases were lower in 2017 than 2008 in five of the six PRTR systems: Australia, Canada, Chile, the E-PRTR, and Japan.
  - Releases of cadmium increased from 2008 to 2017 in the U.S., driven by increased releases to water reported by the chemical manufacturing subsector (ISIC 20).
- Facilities in the basic metals (ISIC 24) and chemical manufacturing (ISIC 20) subsectors reported the highest release quantities of cadmium. Releases of cadmium from the basic metals subsector decreased from 2008 to 2017. Releases of cadmium from the chemical manufacturing sector increased from 2008 to 2017.

Chromium

Chromium is a common element in Earth's crust and is a solid under ambient conditions. It occurs naturally in the environment in volcanoes, rocks, and soil (WHO, 2013[19]). Chromium-containing compounds can occur naturally or be produced synthetically. Chromium and chromium compounds are found in many applications including building materials, personal care products, tobacco products, steel, and other metal products. They are used commercially in the manufacture and processing of metal products, preserving wood, and manufacturing pigments (NCBI, 2021[20]).

Chromium in compounds can be in a variety of forms called oxidation states, depending on the nature of the compound. The oxidation state of the metal affects its properties, including toxicity. Naturally occurring chromium exists primarily as chromium (III) (Barnhart, 1997[21]). Chromium (III) and chromium (VI) are the most common oxidation states of chromium in synthetic products, though other oxidation states of chromium also occur (Chemistry, 2021[22]). Elemental chromium, or chromium not bonded to any other elements or chemicals, is always chromium (0). Chromium (VI), called hexavalent chromium, is known to be more toxic than other oxidation states of chromium, both to humans and environmental endpoints; it is known to cause lung cancer in humans (IARC, 2012[23]). For this reason, some pollutant release and transfer registers (PRTRs) require separate reporting for chromium (VI) compounds as follows:

- In the E-PRTR, all chromium and chromium compounds are reported under one listing and oxidation state is not distinguished for PRTR reporting.
- In Mexico and the U.S., chromium and chromium compounds are listed separately and oxidation state is not distinguished for PRTR reporting.
- In Chile and Canada, chromium (VI) compounds are reported separately from all other chromium and chromium compounds.
- In Australia, chromium (III) and chromium (VI) compounds are reported separately and elemental chromium and chromium compounds with less common oxidation states are not reported.
- In Japan, releases of chromium and chromium (III) compounds are reported separately from releases of chromium (VI) compounds, and other oxidation states of chromium compounds are not reported.

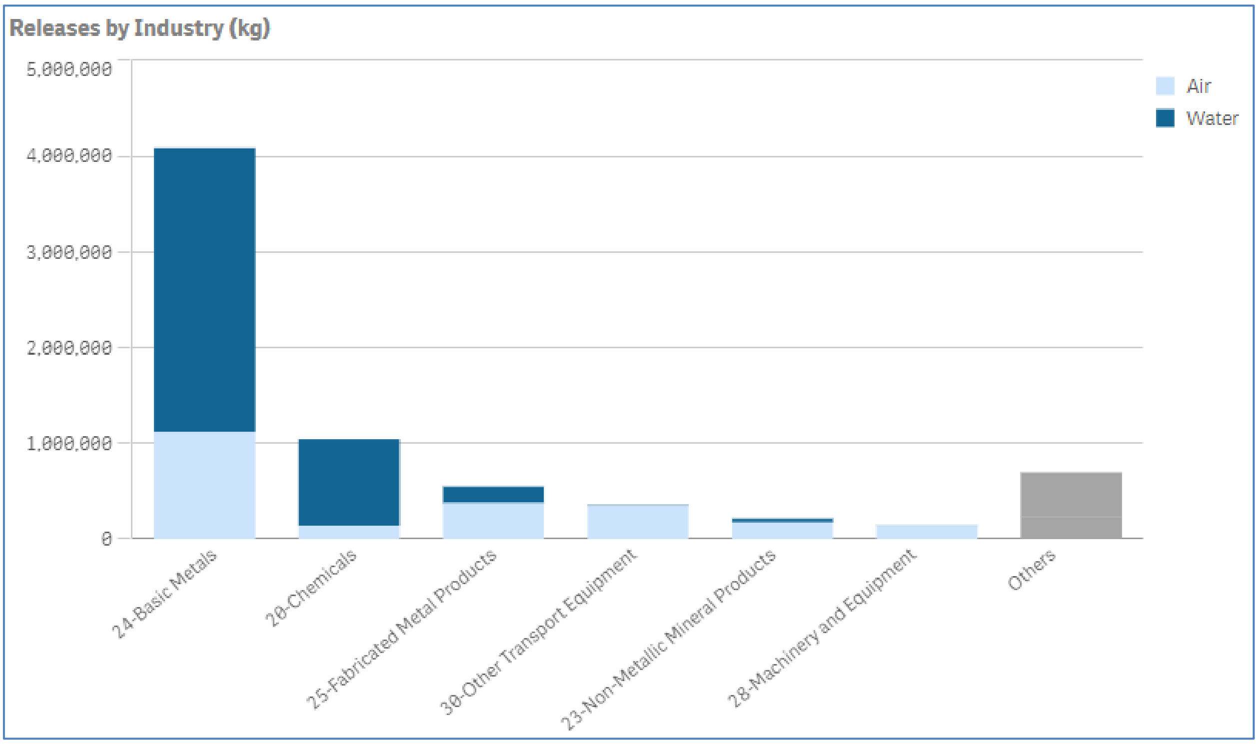
Across PRTRs, when facilities report releases of chromium compounds, they report the quantity of chromium, not the weight of the entire compound. For simplicity, this analysis groups together all forms of chromium (different oxidation states and chromium in elemental form or in compounds) reported as released to the environment. Since facilities report the weight of chromium and not the weight of the entire compound, these releases are all releases of chromium. Therefore, in this analysis "releases of chromium" refers to both releases of elemental chromium and releases of the chromium portion of chromium compounds.

This analysis focuses on releases of chromium as reported to the seven PRTR systems chosen for these global-scale analyses: the PRTR systems of Australia, Canada, Chile, Europe (i.e., the E-PRTR), Japan, Mexico, and the U.S. It recognizes that there are some differences among the PRTRs in how chromium is reported. As described in this project's Action Plan, the analysis focuses on releases of chromium to air and water by facilities in the manufacturing sector only (OECD, 2018[3]).

Snapshot Analyses

Across all PRTR systems combined, facilities in the manufacturing sector released more chromium to water than to air, with about two-thirds of releases reported as water releases over the 2008 to 2017 timeframe. However, quantities released to air were much larger than the quantities released to water in the U.S., Canada, and Australia. The largest releases reported from the manufacturing sector were primarily from one International Standard Industrial Classification system (ISIC) Division, the basic metals subsector (ISIC 24), as shown in the figure below.[14] This subsector, which includes steel manufacturing and casting of metals, accounted for more than 50% of chromium releases reported from 2008 to 2017. This subsector reported the largest release quantities of chromium for every year over this period.

Across PRTRs, from 2008 to 2017, chromium releases were mainly from the basic metals subsector (ISIC 24)

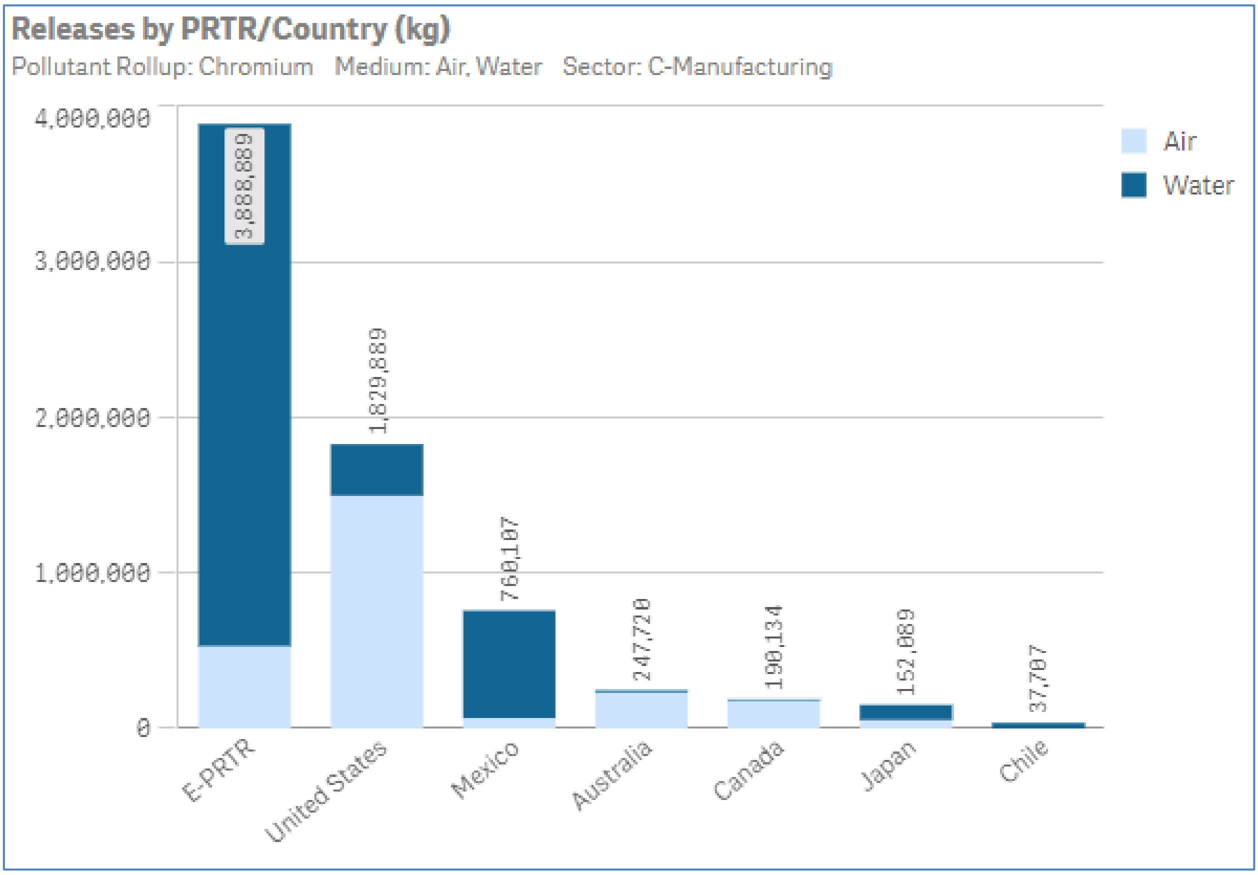


"Others" includes combined air and water releases from all other manufacturing sectors.

Considered by PRTR, reported releases were largest in the E-PRTR, as shown in the figure below. Some PRTRs have lower reporting thresholds for chromium than for most other chemicals, and these threshold differences may affect the proportion of the releases that are reported to the country or region's PRTR. For example, for the top PRTRs in the figure below:

- The E-PRTR has thresholds of 100 kg and 50 kg for air and water releases, respectively.
- The U.S. applies its standard thresholds of 25,000 lb (11,340 kg) manufactured or processed, or 10,000 lb (4,536 kg) otherwise used.
- Mexico has thresholds of 5 kg manufactured, processed, or otherwise used or 1 kg released.

From 2008 to 2017, chromium releases were largest in the E-PRTR

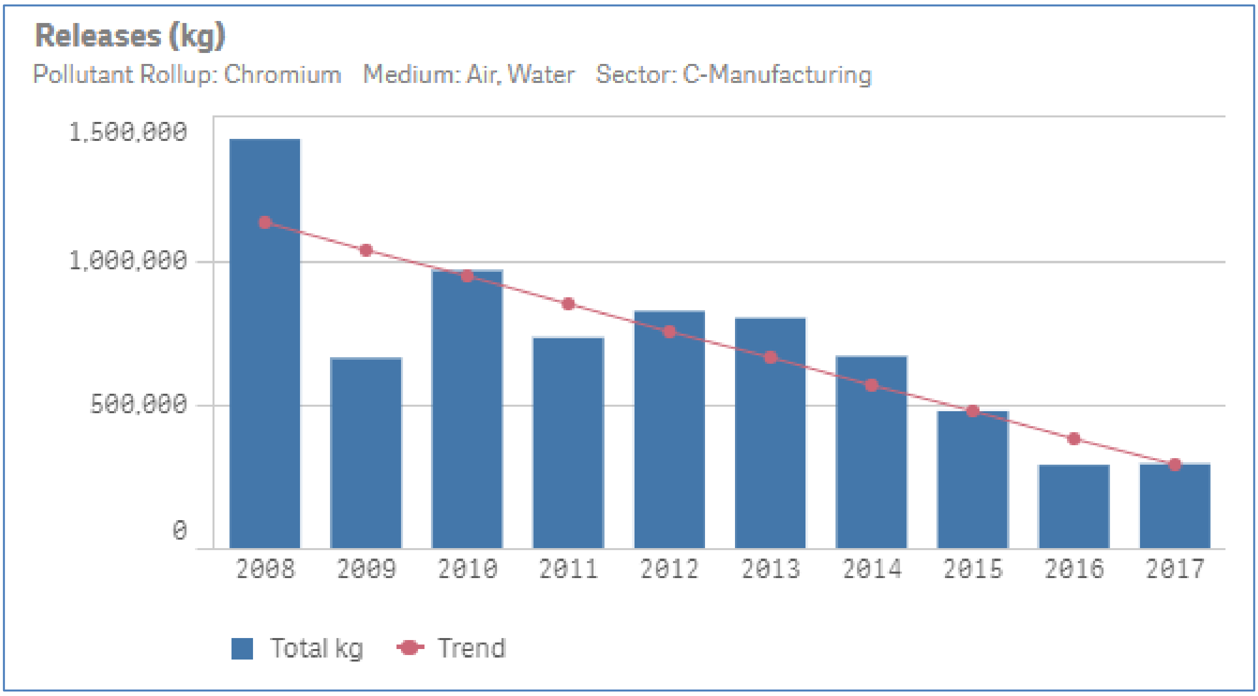


Snapshot of releases of chromium to air and water from the manufacturing sector	
Releases, 2017	292,000 kg
Releases by medium, 2008–2017	64% to water
Subsectors with the largest reported releases, 2008–2017	Basic metals (ISIC 24) Chemical manufacturing (ISIC 20) Fabricated metal products (ISIC 25)
PRTRs with the largest reported releases, 2008–2017	E-PRTR, U.S.
Additional information: Chromium reporting thresholds for the E-PRTR and Mexico's PRTR are lower than standard reporting thresholds in those PRTRs. Canada and Japan also have reduced thresholds for reporting chromium (VI). This may contribute to the relatively high releases of chromium reported in E-PRTR and Mexico. The reporting threshold for chromium releases in E-PRTR is medium-dependent, with a lower threshold for water releases than for air releases.	

Trend Analyses

Release quantities of chromium in the seven PRTRs over the 2008 to 2017 timeframe generally decreased, except for an increase in 2010 (possibly related to the recovery from the economic recession). Reported releases of chromium decreased from 1.4 million kg in 2008 to 290,000 kg in 2017, a 79% decrease. Releases of chromium show a statistically significant decreasing trend from 2008 to 2017 ($p<0.05$).[15] Although releases of chromium fluctuated somewhat from 2008 through 2017, releases have generally decreased and remained low in recent years.

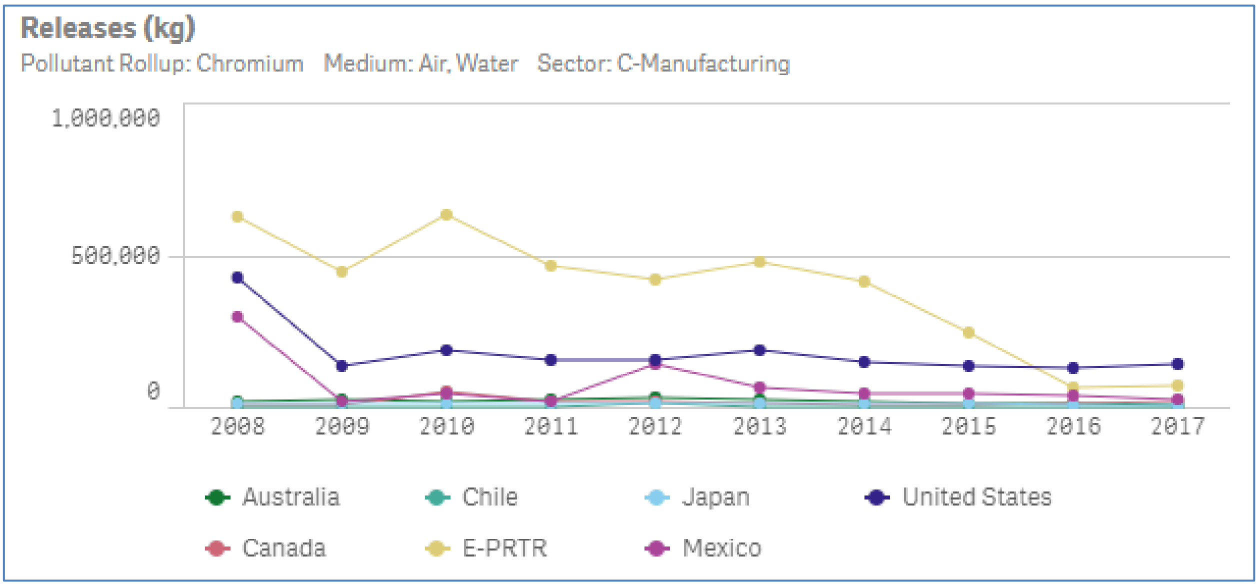
Releases of chromium significantly decreased from 2008 to 2017



Releases of chromium decreased for most PRTRs from 2008 to 2017:

- Releases decreased considerably in the E-PRTR (560,000 kg decrease), the U.S. (290,000 kg decrease), and Mexico (270,000 kg decrease).
- Releases decreased in Australia (13,000 kg decrease), Japan (4,800 kg decrease), and Chile (2,400 kg decrease) and increased in Canada (11,000 kg increase). Release quantities in these four PRTRs fluctuated but stayed consistently below the quantities released reported to the E-PRTR and in the U.S.
- Releases reported by most manufacturing subsectors decreased between 2008 to 2017.
    - The largest decrease in release quantities was in the basic metals subsector (ISIC 24), which reported 670,000 kg of chromium releases in 2008 and 88,000 kg of chromium releases in 2017, an 87% decrease. This decrease in releases was driven by decreased releases in the E-PRTR, but releases from this subsector decreased across most PRTRs.

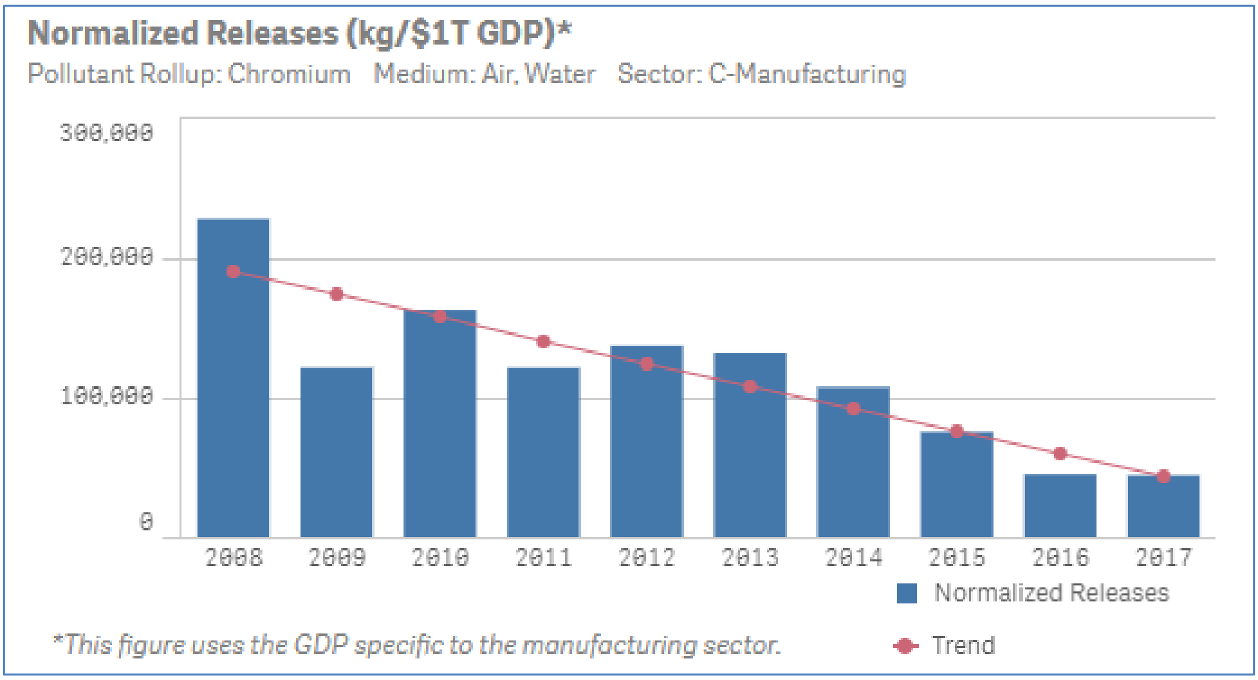
Releases of chromium decreased in most PRTRs



This figure includes PRTRs with comparatively low releases (i.e., Australia, Canada, Chile, and Japan), though they may not be visible at this scale.

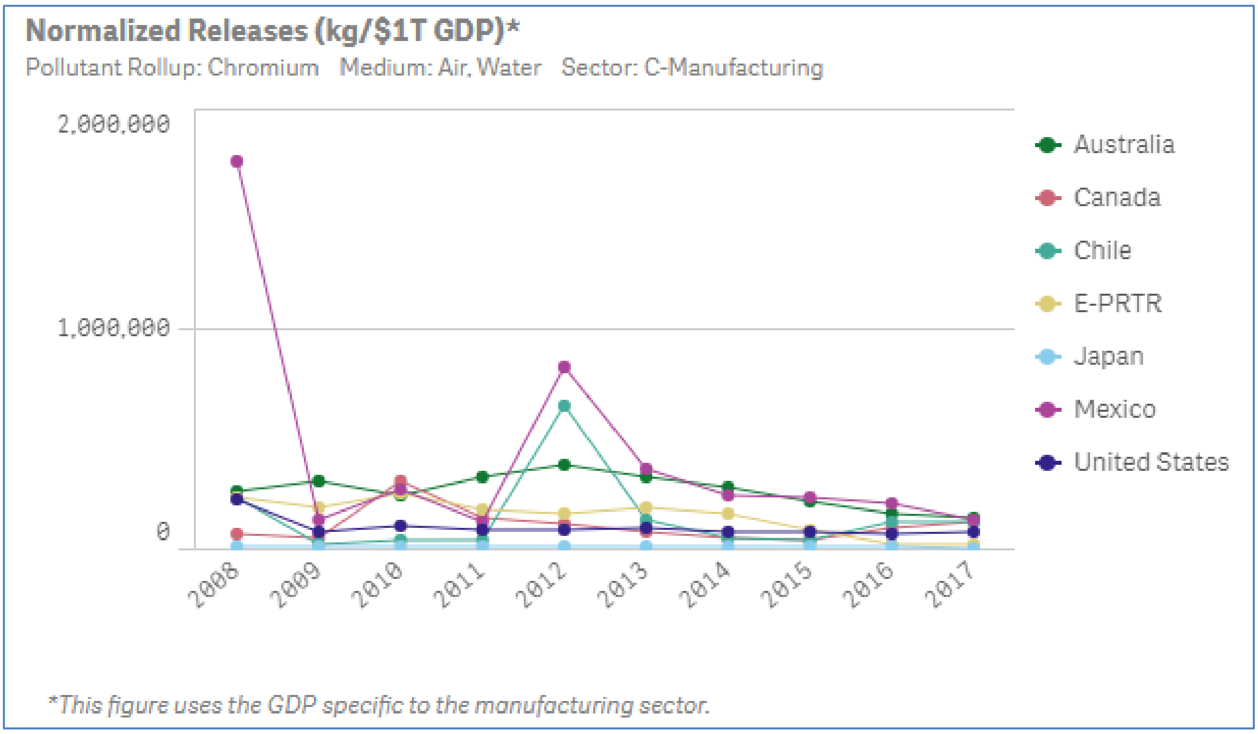
Releases of chromium were normalized by the annual gross domestic product (GDP) for the manufacturing sector of the PRTR's country or region. Normalized releases provide a metric to compare a country's release levels per unit of economic activity in the country. Releases are related to economic activity, as higher manufacturing economic activity usually means more goods are being produced. Chemical releases are associated with these manufacturing processes, so more manufacturing is typically associated with more chemical releases. Normalizing releases controls for the differences in production levels between countries and over time. The trend in normalized releases approximates how releases would have changed if the amount of manufacturing activity had remained constant. As shown in the figure below, chromium releases across the seven PRTRs, when normalized by the combined manufacturing GDPs of their countries/regions, show a statistically significant downward trend ($p<0.05$).[16]

Normalized releases of chromium significantly decreased from 2008 to 2017



Compared among PRTRs, GDP-normalized trends in releases of chromium show that Australia and Mexico had the highest normalized releases in recent years, rather than the E-PRTR and the U.S. This indicates that facilities in Australia and Mexico released more chromium per unit of manufacturing activity than facilities in other countries. Releases in Australia decreased by 52% while manufacturing GDP decreased by 10%. If manufacturing activity were the primary driver of trends in Australia, releases would be expected to decrease only as much as manufacturing activity decreased. Releases reported in Mexico also decreased substantially, while manufacturing GDP in Mexico increased. If manufacturing activity were the primary driver of release trends in Mexico, releases would be expected to increase as manufacturing activity increased. The decreasing trends in GDP-normalized releases indicate that factors other than manufacturing economic activity were driving the decreasing chromium releases in Australia and Mexico.

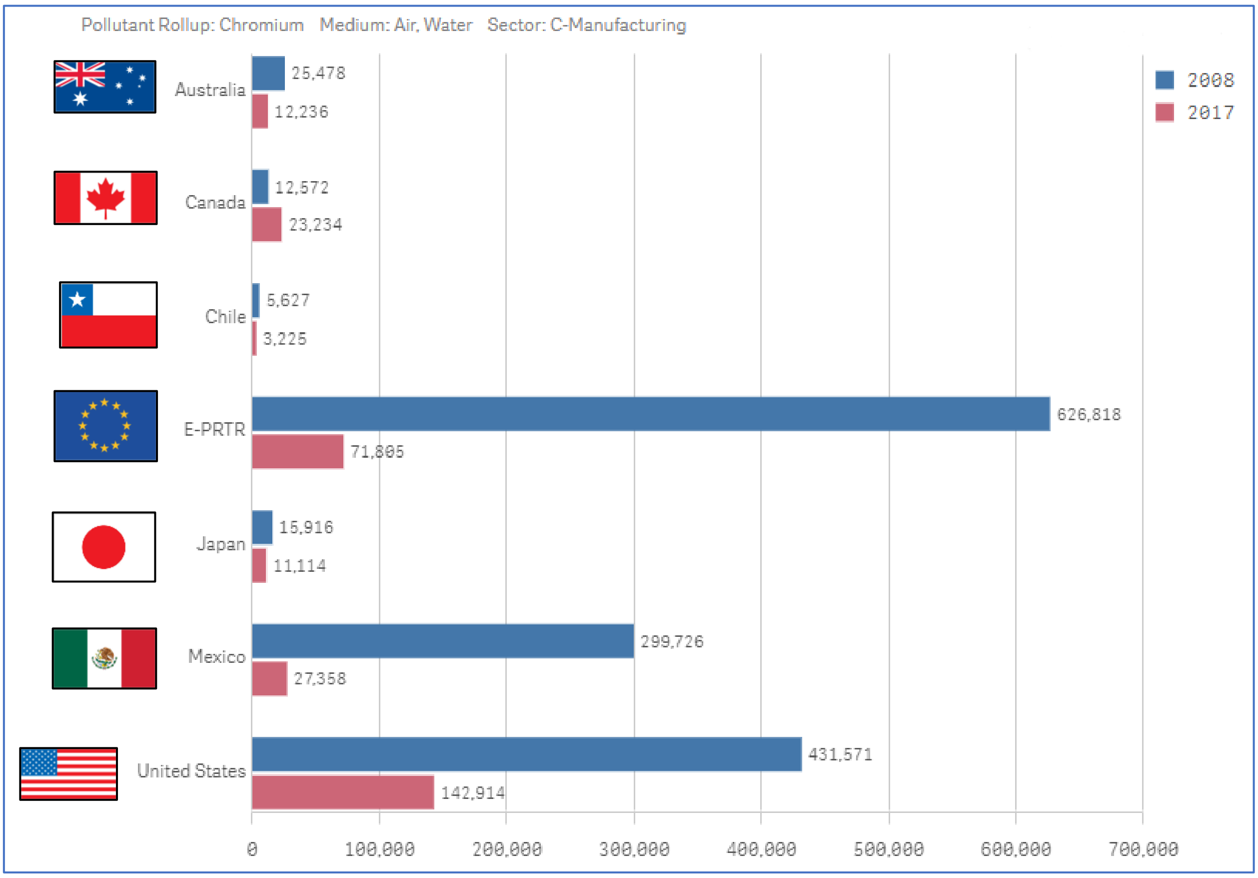
Spikes in Mexico dominated the trend in normalized releases of chromium by PRTR



Trend in chromium releases to air and water from the manufacturing sector	
Overall change, 2008–2017	Releases decreased by 1.1 million kg (79%). This was part of a significant trend of releases decreasing.
PRTRs with the largest *percent* change in releases, 2008–2017	E-PRTR: 560,000 kg decrease (89%) Mexico: 270,000 kg decrease (91%)
PRTR with the largest *absolute* change in releases, 2008–2017	E-PRTR: 560,000 kg decrease (89%)
Subsectors with the largest absolute change in releases, 2008–2017	Basic metals (ISIC 24): 580,000 kg decrease (87%) Fabricated metal products (ISIC 25): 210,000 kg decrease (87%) Chemicals (ISIC 20): 200,000 kg decrease (76%)
Additional information: Releases of chromium to both air and water decreased, but most of the reduction was in releases to water, which decreased by 780,000 kg (88%).	

Summary

Releases of chromium from manufacturing facilities by PRTR (kg)



- All seven PRTR systems contain information on benzene releases between 2008 and 2017: Australia, Canada, Chile, Europe (i.e., the E-PRTR), Japan, Mexico, and the U.S.
- Across the seven PRTRs combined, releases of chromium to air and water as reported by facilities in the manufacturing sector decreased by 1.1 million kg (79%) from 2008 to 2017.
- The decrease in releases was part of a statistically significant downward trend.
- Releases of chromium were lower in 2017 than 2008 in six of the seven PRTR systems examined: Australia, Chile, the E-PRTR, Japan, Mexico, and the U.S. Releases of chromium increased from 2008 to 2017 in Canada.
- Facilities in the basic metals (ISIC 24), chemical manufacturing (ISIC 20), fabricated metal products (ISIC 25), other transportation equipment (ISIC 30), and non-metallic mineral products (ISIC 23) subsectors reported the largest release quantities of chromium. Releases of chromium from all of these subsectors decreased from 2008 to 2017.

Di(2-ethylhexyl) Phthalate

Di(2-ethylhexyl) phthalate, or DEHP (CAS 117-81-7), is an aromatic organic chemical that is a liquid under ambient conditions (NCBI, 2021[24]).[17] It is not known to occur naturally in the environment (IARC, 2013[25]). Synthetically produced DEHP is used commercially as a plasticizer in the production of polyvinyl chloride plastics (PVC). It is found in household products, medical devices, and some building materials.

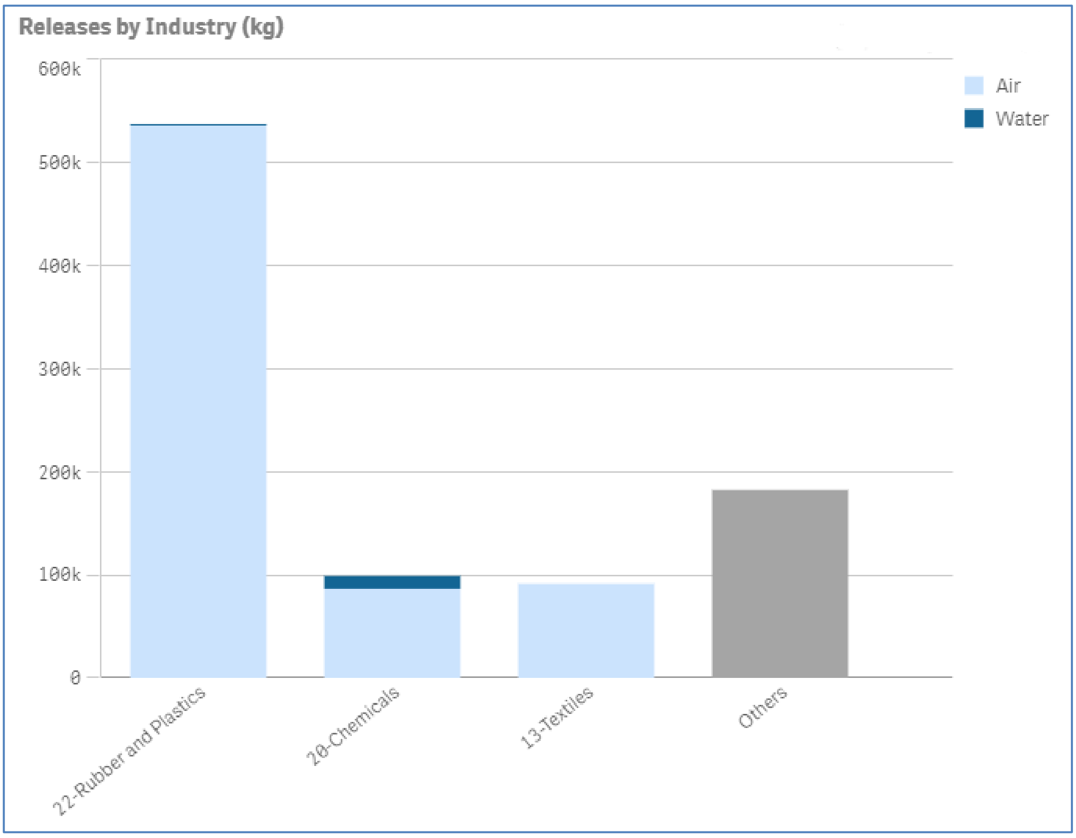
Long-term exposure or repeated exposure is considered potentially toxic to humans (NCBI, 2021[24]). DEHP is not considered highly mobile in soil or water but has been associated with bioaccumulation in seafood (NCBI, 2021[24]; ILO and WHO, 2001[26]).

This analysis focuses on DEHP releases as reported to the following five of the seven pollutant release and transfer register (PRTR) systems chosen for these global-scale analyses: the PRTR systems of Australia, Canada, Europe (i.e., the E-PRTR), Japan and the U.S. DEHP is not reported to the Chilean or Mexican PRTRs. As described in this project's Action Plan, the analysis focuses on releases of DEHP to air and water by facilities in the manufacturing sector only (OECD, 2018[3]).

Snapshot Analyses

Across the five PRTR systems combined, facilities in the manufacturing sector released DEHP almost exclusively to air over the 2008 to 2017 timeframe. The largest releases reported from the manufacturing sector were from one International Standard Industrial Classification (ISIC) Division, the rubber and plastics products subsector (ISIC 22), as shown in the figure below.[18] This subsector accounted for 59% of DEHP releases reported from 2008 to 2017.

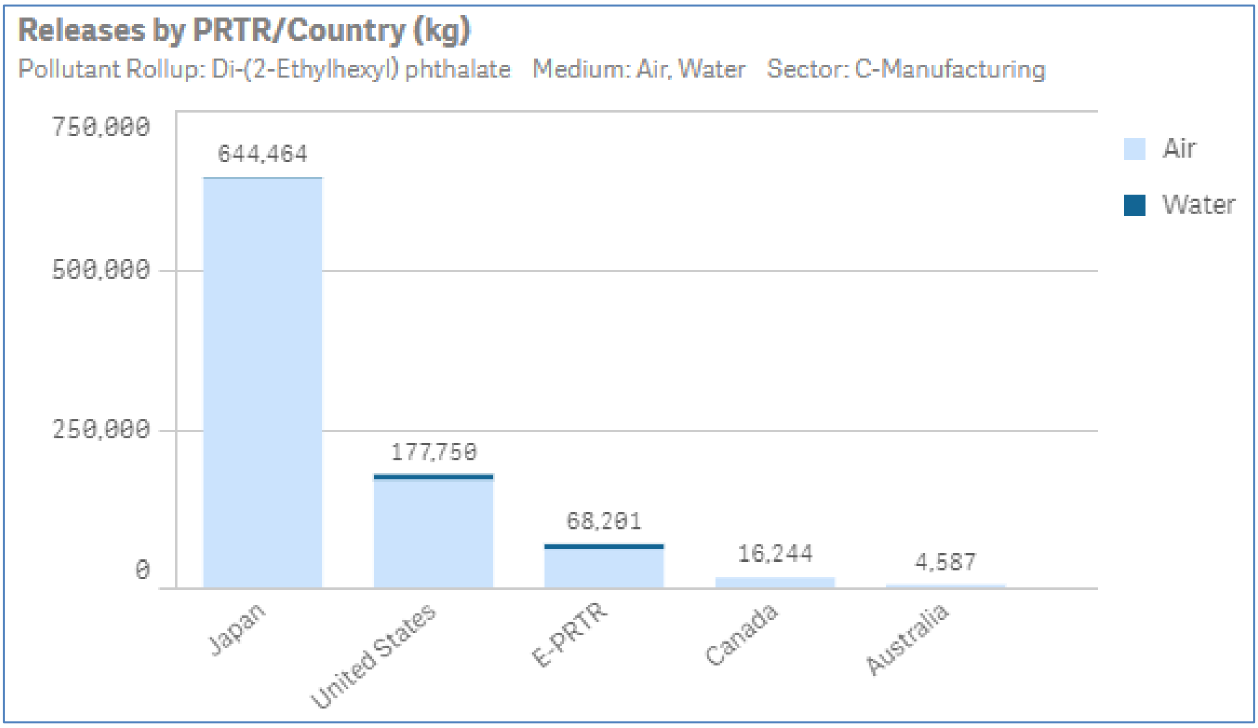
Across PRTRs, from 2008 to 2017, DEHP releases were primarily from the rubber and plastics subsector



"Others" includes combined air and water releases from all other manufacturing subsectors.

Considered by PRTR, reported releases were largest in Japan, followed by the U.S., as shown in the figure below. Note that reporting thresholds for DEHP vary significantly by PRTR and are lower in Japan and the E-PRTR than Australia, Canada, and the U.S. Facilities must report releases of DEHP to Japan's PRTR if they handled at least 1,000 kg of DEHP that year, and facilities must report to E-PRTR if they released at least 10 kg of DEHP to air or 1 kg to water. In Australia and Canada, facilities are required to report only if they handled at least 10,000 kg of DEHP that year. In the U.S., facilities must report if they manufactured or processed 25,000 pounds (11,340 kg) or otherwise used 10,000 pounds (4,535 kg) of DEHP. Because Japan and the E-PRTR have lower reporting thresholds, they can be expected to include a greater portion of the actual DEHP releases than Australia, Canada, and the U.S.

From 2008 to 2017, DEHP releases were largest in Japan

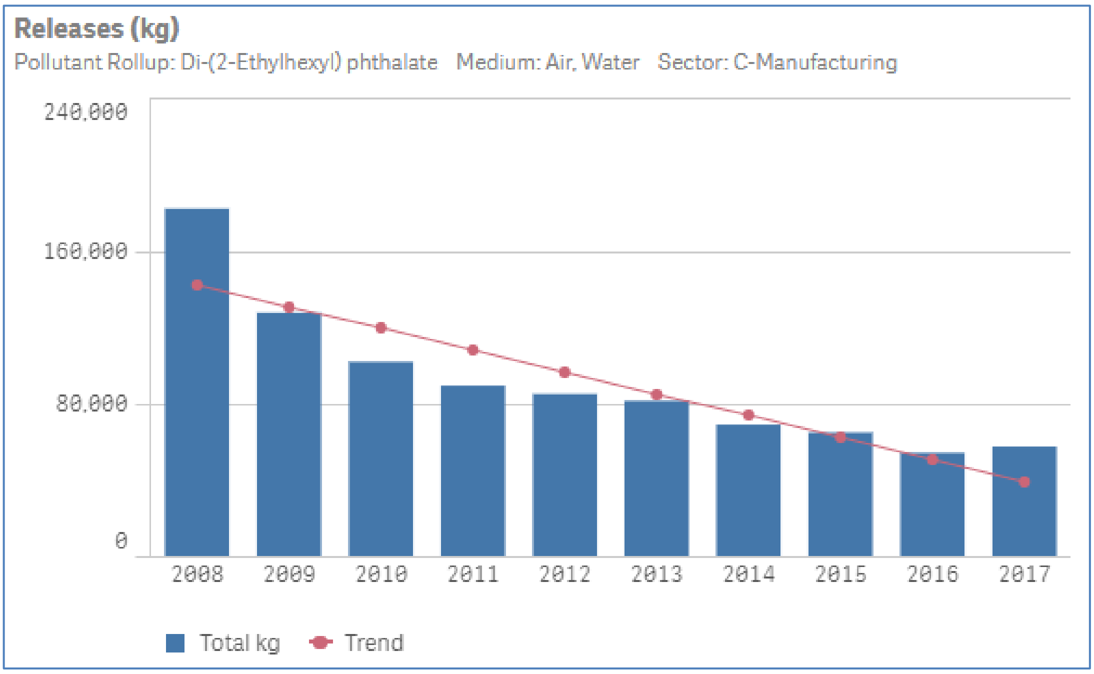


Snapshot of DEHP releases to air and water from the manufacturing sector	
Releases, 2017	57,000 kg
Releases by medium, 2008–2017	98% to air
Subsector with the largest reported releases, 2008–2017	Rubber and plastics (ISIC 22)
PRTR with the largest reported releases, 2008–2017	Japan
Additional information: Releases reported to Japan account for 71% of the DEHP releases reported to the five PRTRs in this analysis from 2008 to 2017.	

Trend Analyses

Reported DEHP releases totalled across the five PRTRs over the 2008 to 2017 timeframe have been trending down, from a high of 180,000 kg in 2008 to 57,000 kg in 2017—a 68% decrease. Regression analysis indicates that the downward trend in releases was statistically significant based on all 10 years of data ($p<0.05$).[19] After consistently decreasing every year from 2008 to 2016 due to decreasing releases in Japan, releases increased slightly from 2016 to 2017 due to increased releases in the U.S.

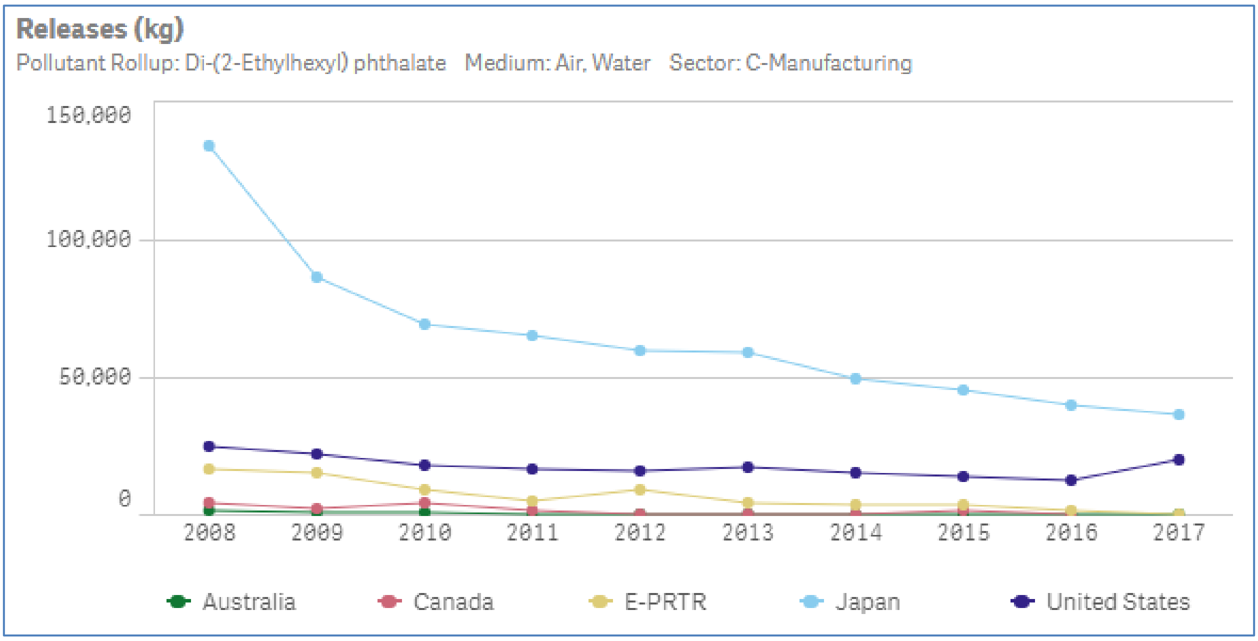
DEHP releases significantly decreased from 2008 to 2017



DEHP releases decreased for all PRTRs from 2008 to 2017:

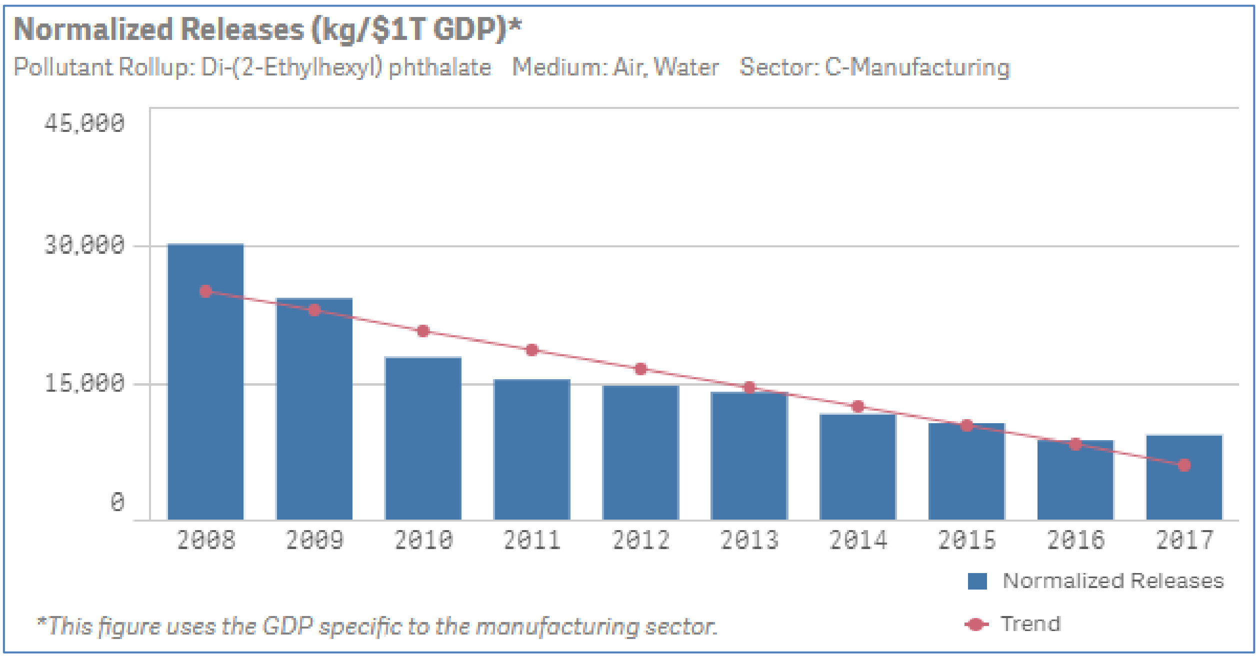
- Releases decreased considerably in Japan (98,000 kg decrease) and the E-PRTR (16,000 kg decrease).
    - Releases of DEHP decreased by 96% in the E-PRTR, from 16,000 kg to 620 kg.
- Releases also decreased in the U.S. (5,100 kg), Canada (4,700 kg), and Australia (1,500 kg).
    - Reported releases of DEHP were very low in Australia and Canada. No releases of DEHP were reported in Canada for 2017, and only 39 kg were reported in Australia for 2017.
- The decline in releases since 2008 was driven by the plastic and rubber products (ISIC 22) subsector. Releases in chemical manufacturing and textile manufacturing, the two other subsectors with considerable releases, also declined.

Releases of DEHP decreased in all PRTRs



Releases of DEHP were normalized by the annual gross domestic product (GDP) for the manufacturing sector of the PRTR's country or region. Normalized releases provide a metric to compare a country's release levels per unit of economic activity in the country. Releases are related to economic activity, as higher manufacturing economic activity usually means more goods are being produced. Chemical releases are associated with these manufacturing processes, so more manufacturing is typically associated with more chemical releases. Normalizing releases controls for the differences in production levels between countries and over time. The trend in normalized releases approximates how releases would have changed if the amount of manufacturing activity had remained constant. As shown in the figure below, DEHP releases across the four PRTRs with releases each year, when normalized by the combined manufacturing GDPs of their respective countries/regions, show a statistically significant downward trend ($p<0.05$).[20] Note that no releases of DEHP were reported in Canada for 2017, so Canada is not included in the analysis of normalized releases.

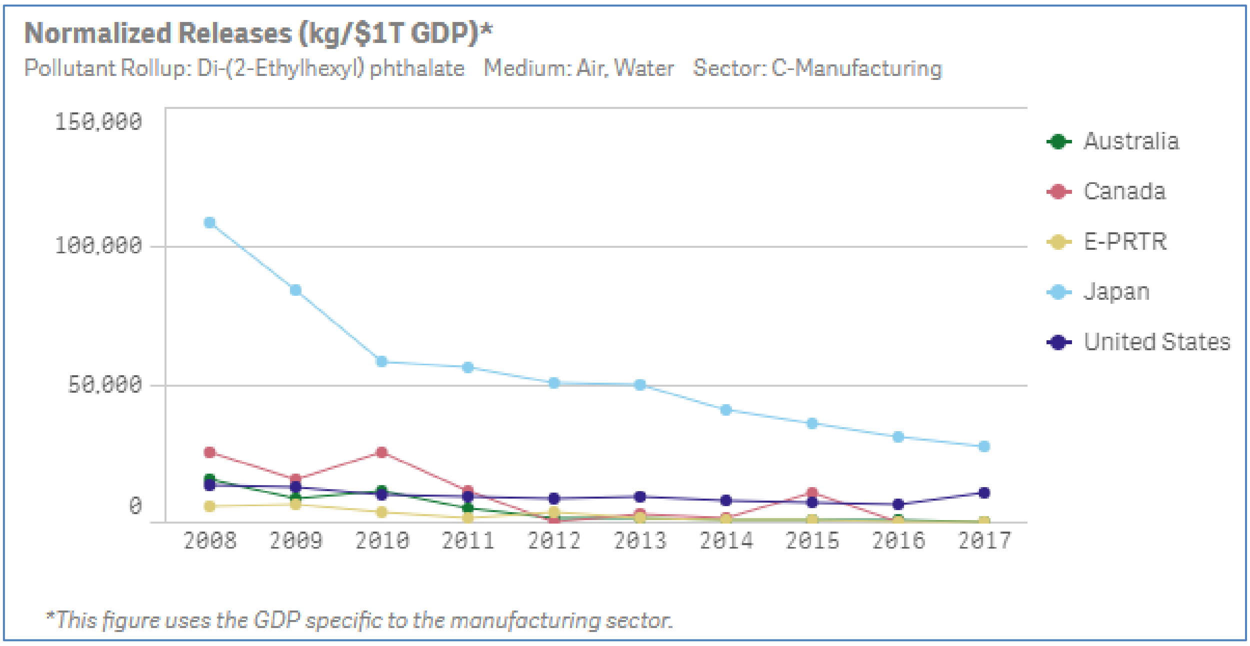
Normalized DEHP releases significantly decreased from 2008 to 2017



This figure does not include data from Canada.

Compared among PRTRs, GDP-normalized trends in releases of DEHP show that Japan had the highest normalized releases each year. Both normalized and absolute releases of DEHP were larger in Japan than any other PRTR. This indicates that facilities in Japan released more DEHP per unit of manufacturing activity than facilities in other countries. Releases in Japan decreased substantially from 2008 to 2017, while manufacturing GDP increased by 6%. If economic activity were the primary driver of release trends, releases would be expected to increase as economic activity increased. The decreasing trend in GDP-normalized releases indicates factors other than economic activity were driving the release reductions in Japan.

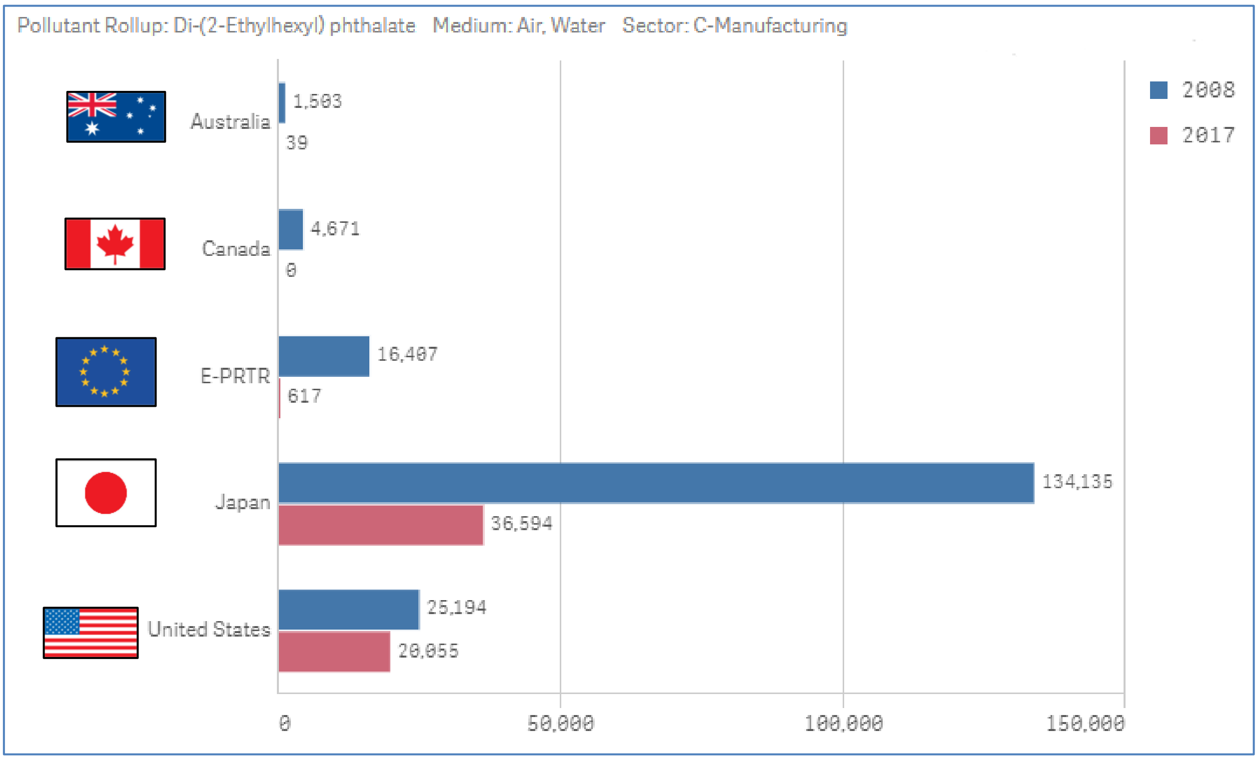
Normalized DEHP releases decreased across PRTRs



Trend in DEHP releases to air and water from the manufacturing sector	
Overall change, 2008–2017	Releases decreased by 120,000 kg (68%). This was part of a significant trend of releases decreasing.
PRTRs with the largest *percent* change in releases, 2008–2017	Canada: 4,700 kg decrease (100%) Australia: 1,500 kg decrease (97%) E-PRTR: 16,000 kg decrease (96%)
PRTR with the largest *absolute* change in releases, 2008–2017	Japan: 98,000 kg decrease (73%)
Subsectors with the largest absolute change in releases, 2008–2017	Rubber and plastics (ISIC 22): 79,000 kg decrease (71%) Textiles (ISIC 13): 19,000 kg decrease (81%)
Additional information: Releases of DEHP decreased in most subsectors. DEHP releases decreased to zero in Canada, to 39 kg in Australia, and to 620 kg in the E-PRTR by 2017.	

Summary

Releases of DEHP from manufacturing facilities by PRTR (kg)



- Five of the seven PRTR systems contain information on DEHP releases between 2008 and 2017: Australia, Canada, the E-PRTR, Japan, and the U.S. The Chilean and Mexican PRTRs do not contain information on DEHP releases.
- Across the five PRTRs combined, DEHP releases to air and water as reported by facilities in the manufacturing sector decreased by 120,000 kg (68%) from 2008 to 2017.
  - Both absolute and normalized releases of DEHP decreased significantly across the five PRTRs from 2008 through 2017.
- DEHP releases were lower in 2017 than 2008 in all five of the PRTR systems examined.
  - DEHP releases were largest and decreased by the most in Japan.
- Facilities in the plastic and rubber product manufacturing (ISIC 22) subsector reported the largest release quantities of DEHP. Releases from this subsector and most other subsectors decreased from 2008 to 2017.

Dichloromethane

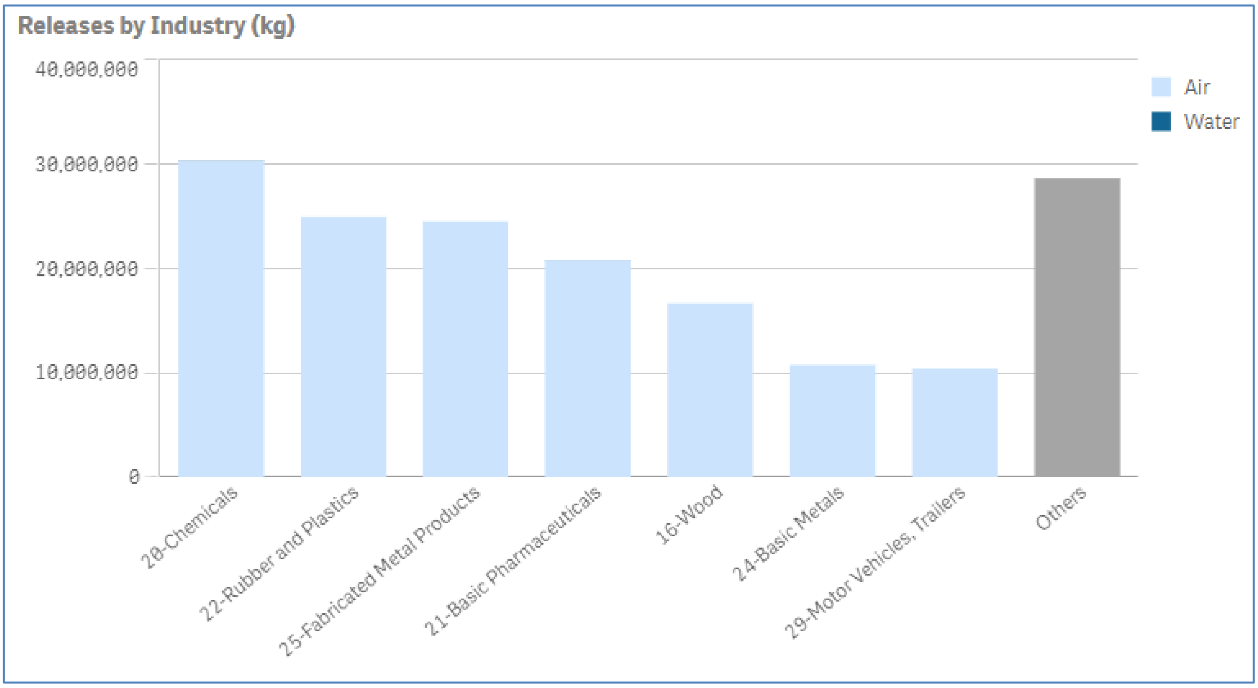
Dichloromethane (CAS 75-09-2) is a volatile organic chemical (NCBI, 2021[27]).[21] It occurs naturally in the environment from volcanic and phytoplankton activity (NCBI, 2021[27]). It is also produced synthetically. It is used commercially as an organic solvent and as a cleaning or thinning product in manufacturing processes such as the production of paint stripper and pharmaceutical products (WHO, 2000[28]). Under ambient conditions it exists as a liquid and is soluble in water. Dichloromethane is also considered highly mobile in soil and water environments and is flammable. Exposure to dichloromethane is associated with long-term adverse health effects on the central nervous system (WHO, 2003[29]). Dichloromethane is considered probably carcinogenic to humans (IARC, 2017[30]).

This analysis focuses on dichloromethane releases as reported to the following six of the seven pollutant release and transfer register (PRTR) systems chosen for these global scale analyses: the PRTR systems of Australia, Canada, Europe (i.e., the E-PRTR), Japan, the U.S., and Mexico. Dichloromethane is not reported to the Chilean PRTR. As described in this project’s Action Plan, the analysis focuses on releases of dichloromethane to air and water by facilities in the manufacturing sector only (OECD, 2018[3]).

Snapshot Analyses

Across all PRTR systems combined, facilities in the manufacturing sector released dichloromethane almost exclusively to air over the 2008 to 2017 timeframe. Releases of dichloromethane from the manufacturing sector were reported from many International Standard Industrial Classification system (ISIC) Divisions, as shown in the figure below.[22] The subsector with the largest releases was the chemical manufacturing subsector (ISIC 20).

Across PRTRs, from 2008 to 2017, dichloromethane releases were from a range of subsectors

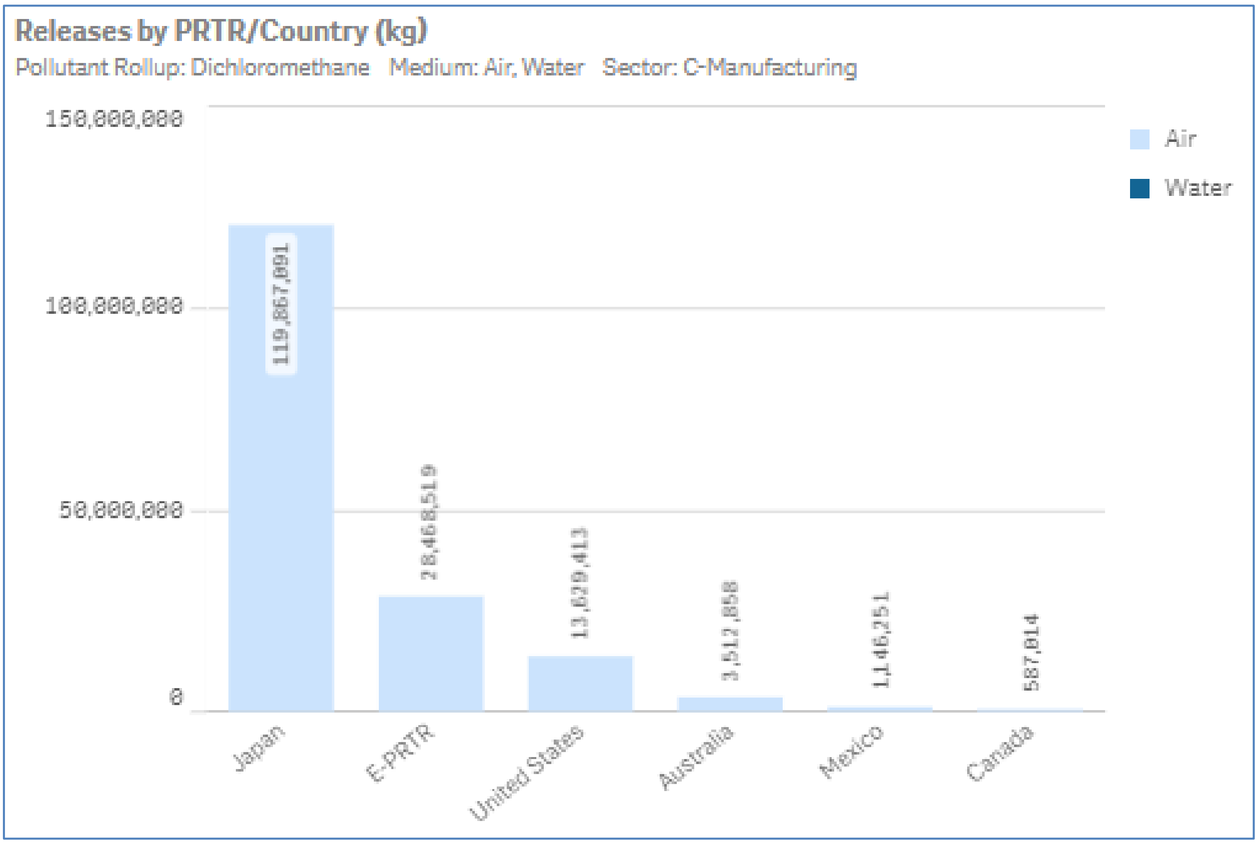


"Others" includes combined air and water releases from all other manufacturing subsectors.

Considered by PRTR, reported releases were largest in Japan, as shown in the figure below. Note that the reporting threshold for dichloromethane in Japan is lower than many of the other PRTRs examined. In Japan, facilities must report information about releases of dichloromethane if they handled 1,000 kg or more of the chemical that year. For comparison, facilities in the U.S. are required to report if they manufacture or process 25,000 pounds (11,340 kg) or otherwise use 10,000 pounds (4,536 kg) of dichloromethane in a given year. Facilities' releases of this chemical are included in the E-PRTR if they released at least 2,000 kg to air or at least 10 kg to water. Based on the differences in thresholds, the Japanese PRTR is expected to capture a larger portion of all releases in the country than other PRTRs. More facilities reported releases of dichloromethane to Japan's PRTR than any other PRTR.

One way to estimate the effect of thresholds is to exclude releases that would not have met reporting thresholds in other countries. For dichloromethane, the highest reporting threshold among the PRTRs in this analysis is the 25,000-pound (11,340-kg) threshold for manufacturing or processing in the U.S. Therefore, it is certain that any release of more than 11,340 kg would have met reporting thresholds for any of the six PRTRs. Even when considering only the dichloromethane releases of more than 11,340 kg (i.e., releases large enough that a facility would have to report in any of the six PRTRs), releases reported in Japan are more than for all five other PRTRs combined. Therefore, it appears that lower reporting thresholds are not the only reason why reported releases are largest in Japan.

From 2008 to 2017, dichloromethane releases were largest in Japan

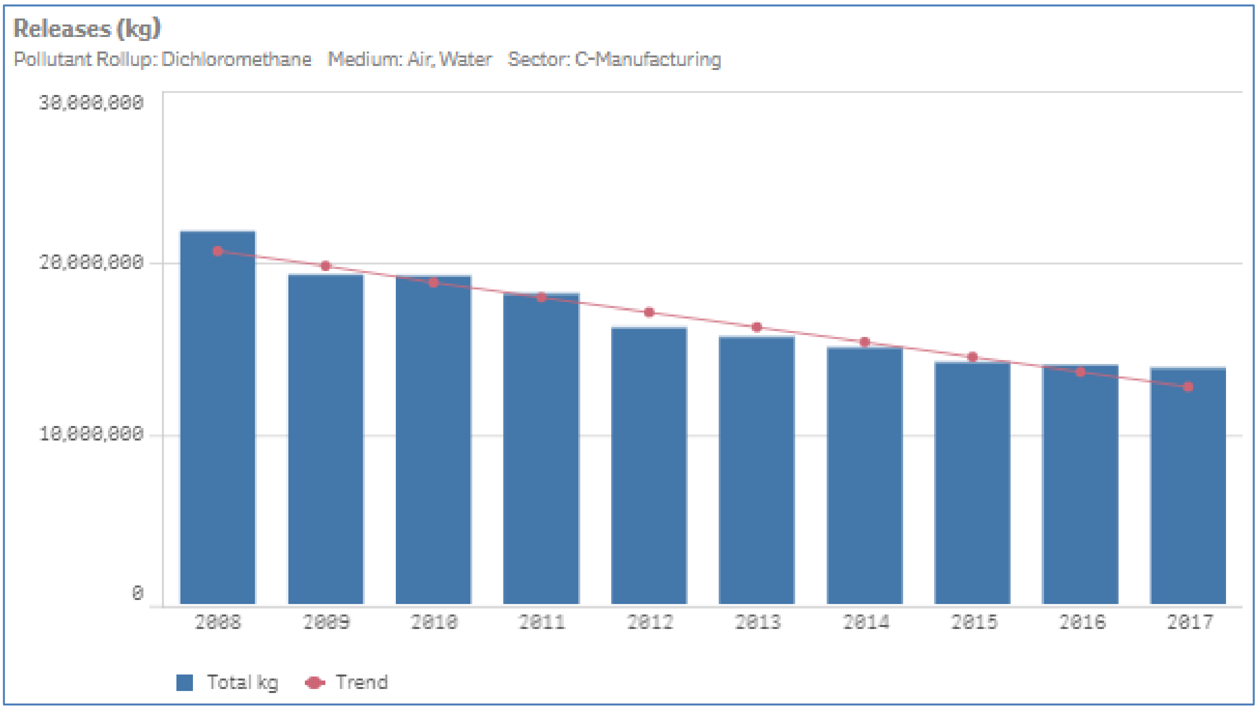


Snapshot of dichloromethane releases to air and water from the manufacturing sector	
Releases, 2017	13.8 million kg
Releases by medium, 2008–2017	99.9% to air
Subsectors with the largest reported releases, 2008–2017	Chemical manufacturing (ISIC 20) Rubber and plastics (ISIC 22) Fabricated metal products (ISIC 25)
PRTR with the largest reported releases, 2008–2017	Japan
Additional information: Releases reported to Japan's PRTR account for 72% of all dichloromethane releases reported to the six PRTRs in this analysis from 2008 to 2017.	

Trend Analyses

Reported dichloromethane releases across the six PRTRs over the 2008 to 2017 timeframe have been trending down, from a high of 22 million kg in 2008 to 14 million kg in 2017—a 37% decrease. Regression analysis indicates that the downward trend in releases was significant based on all 10 years of data ($p<0.05$).[23] The decline was driven by reduced releases in Japan.

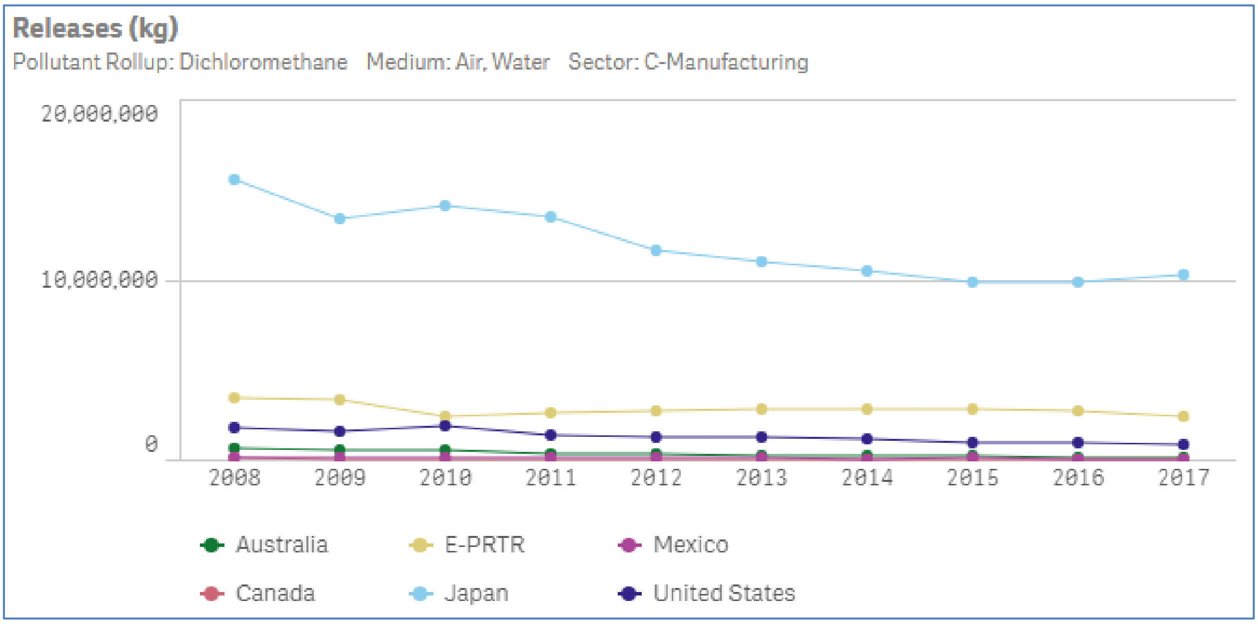
Dichloromethane releases significantly decreased from 2008 to 2017



Dichloromethane releases in each of the six PRTRs decreased from 2008 to 2017:

- Releases decreased substantially from 2008 to 2017 in Japan (5.3 million kg decrease), the E-PRTR (1.1 million kg decrease), and the U.S. (980,000 kg decrease).
- Releases decreased by smaller amounts in Australia (490,000 kg decrease), Mexico (91,000 kg decrease), and Canada (78,000 kg decrease).
- Releases reported by almost all manufacturing subsectors decreased between 2008 and 2017.
  - The largest decrease in release quantities was in the chemical manufacturing subsector (ISIC 20), which reported 4.3 million kg of dichloromethane released in 2008 and 2.3 million kg released in 2017, a 47% decrease.

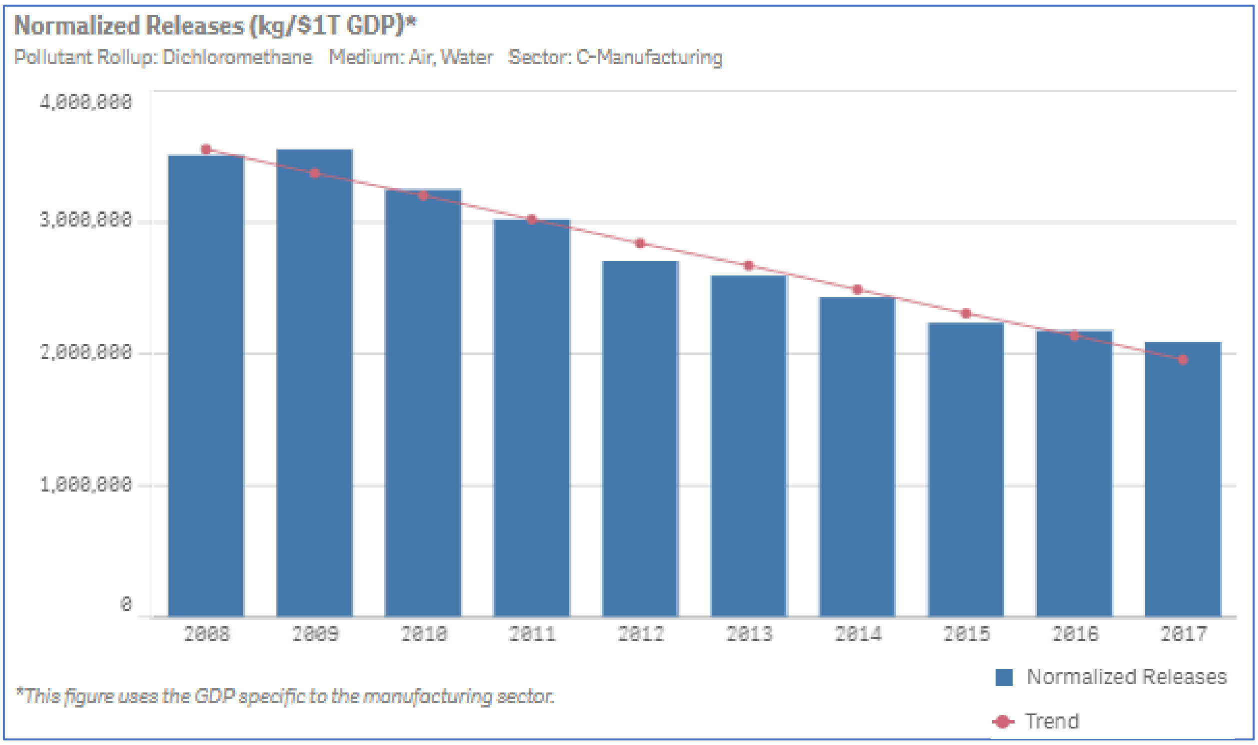
Dichloromethane releases decreased in all six PRTRs



This figure includes PRTRs with comparatively low releases (i.e., Australia, Canada, and Mexico), though they may not be visible at this scale.

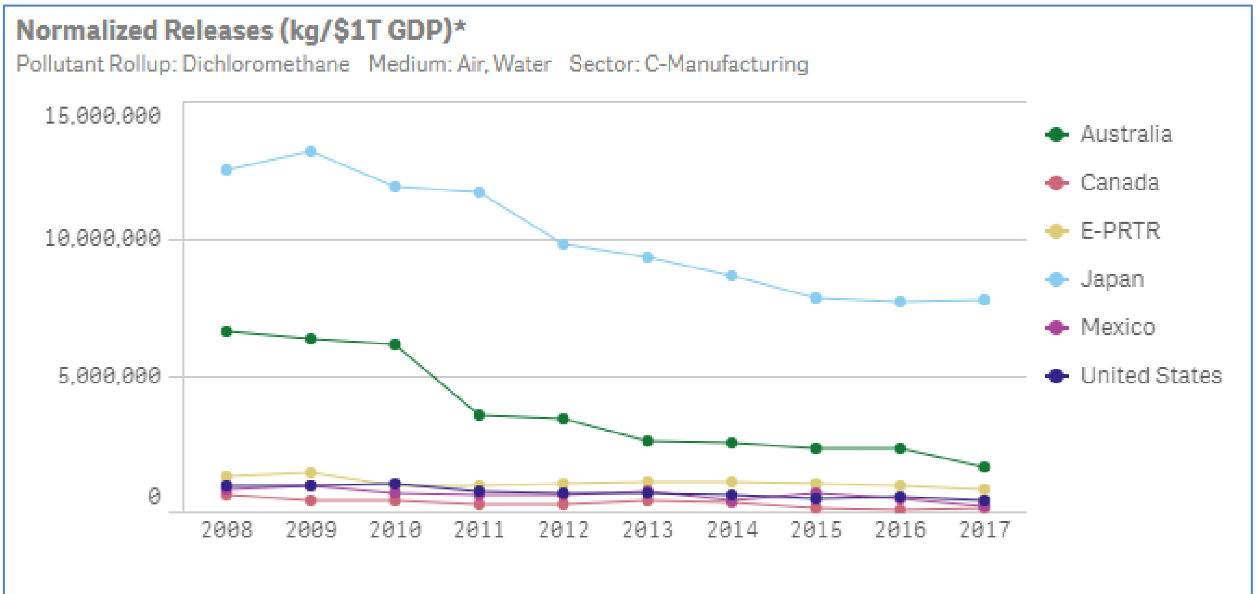
Releases of dichloromethane were normalized by the annual gross domestic product (GDP) for the manufacturing sector of the PRTR's country or region. Normalized releases provide a metric to compare a country's release levels per unit of economic activity in the country. Releases are related to economic activity, as higher manufacturing economic activity usually means more goods are being produced. Chemical releases are associated with these manufacturing processes, so more manufacturing is typically associated with more chemical releases. Normalizing releases controls for the differences in production levels between countries and over time. The trend in normalized releases approximates how releases would have changed if the amount manufacturing activity had remained constant. As shown in the figure below, dichloromethane releases across the six PRTRs, when normalized by the combined manufacturing GDPs of their countries/regions, show a statistically significant downward trend ($p<0.05$).[24]

Normalized dichloromethane releases significantly decreased from 2008 to 2017



Compared among PRTRs, GDP-normalized trends in releases of dichloromethane show that Japan had the highest normalized releases each year. Both normalized and absolute releases of dichloromethane were larger in Japan than any other PRTR. This indicates that facilities in Japan released more dichloromethane per unit of manufacturing activity than facilities in other countries. Releases in Japan decreased from 2008 to 2017, while manufacturing GDP increased by 6%. If manufacturing activity were the primary driver of the release trends in Japan, releases would be expected to increase as economic activity increased. The decreasing trend in GDP-normalized releases indicates factors other than economic activity were driving the release reductions in Japan.

Normalized dichloromethane releases decreased in all six PRTRs

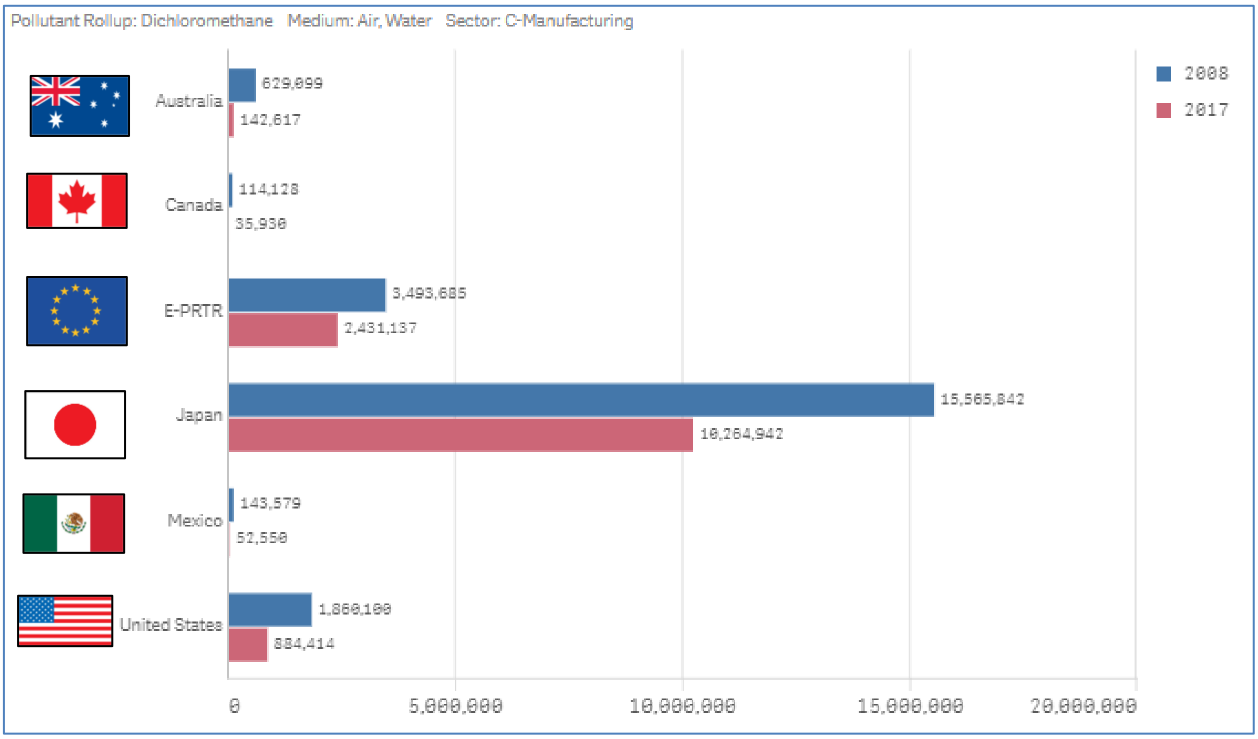


*This figure uses the GDP specific to the manufacturing sector.

Trend in dichloromethane releases to air and water from the manufacturing sector	
Overall change, 2008–2017	Releases decreased by 8.0 million kg (37%). This was part of a significant trend of releases decreasing.
PRTRs with largest *percent* change in releases, 2008–2017	Australia: 490,000 kg decrease (77%) Canada: 78,000 kg decrease (69%)
PRTR with the largest *absolute* change in releases, 2008–2017	Japan: 5.3 million kg decrease (34%)
Subsectors with the largest absolute change in releases, 2008–2017	Chemical manufacturing (ISIC 20): 2.0 million kg decrease (47%) Rubber and plastics (ISIC 22): 1.7 million kg decrease (47%) Fabricated metal products (ISIC 25): 1.2 million kg decrease (38%)
Additional information: Releases in almost all subsectors decreased between 2008 and 2017. The most significant decreases in releases were in the chemical manufacturing (ISIC 20) and rubber and plastics (ISIC 22) subsectors.	

Summary

Releases of dichloromethane from manufacturing facilities by PRTR (kg)



- Six of the seven PRTR systems contain information on dichloromethane releases between 2008 and 2017: Australia, Canada, the E-PRTR, Japan, Mexico, and the U.S. The Chilean PRTR does not contain information on dichloromethane releases.
- Across the six PRTRs combined, dichloromethane releases to air and water as reported by facilities in the manufacturing sector decreased by 8.0 million kg (37%) from 2008 to 2017.
  - Both normalized and absolute releases of dichloromethane decreased significantly across these six PRTRs from 2008 through 2017.
- Dichloromethane releases were lower in 2017 than 2008 in each of the six PRTR systems examined.
- Facilities in the chemical manufacturing (ISIC 20), rubber and plastics (ISIC 22), and fabricated metal products (ISIC 25) subsectors reported the largest release quantities of dichloromethane. Dichloromethane releases from each of these subsectors decreased from 2008 to 2017.

Ethylbenzene

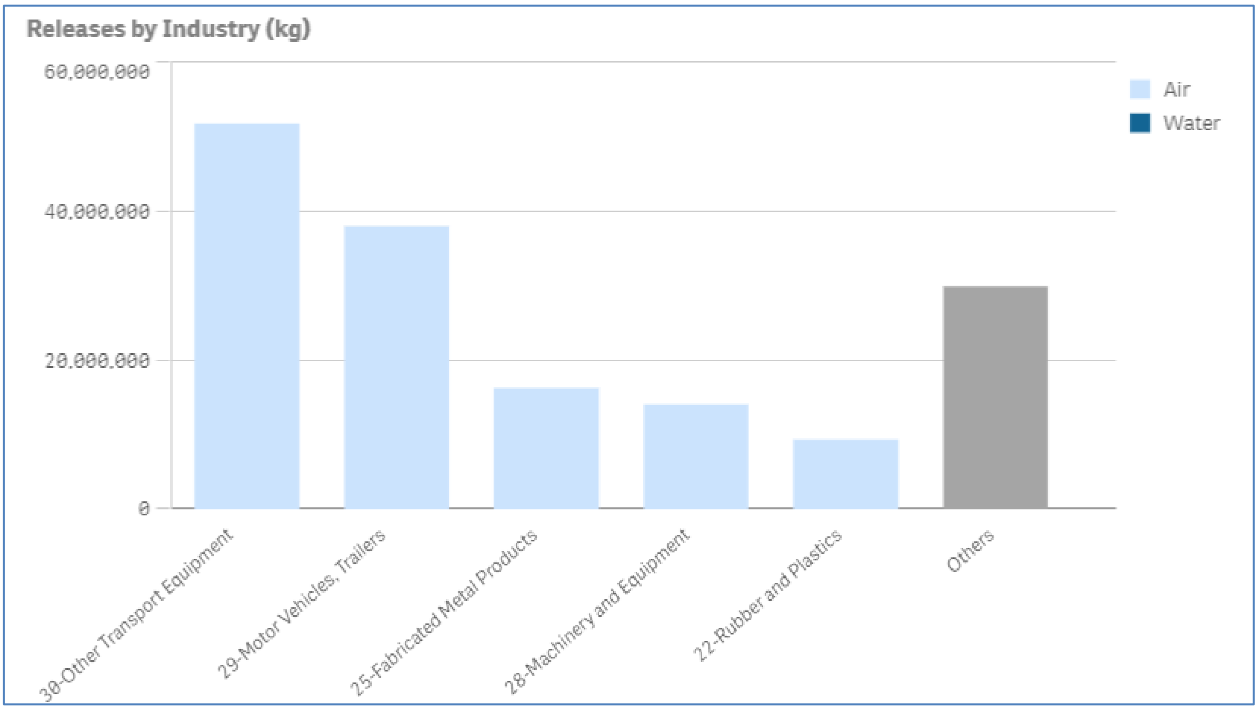
Ethylbenzene (CAS 100-41-4) is a volatile, aromatic organic chemical and is a liquid under ambient conditions (NCBI, 2021[31]).[25] It occurs naturally in the environment as a constituent of crude oil and as a plant volatile. Ethylbenzene is also produced synthetically. It is used commercially as a solvent and as a feedstock in the production of other commercial chemicals such as styrene. It is found in motor fuels, paints, stains, and sealants. It is associated with long-term health effects on the central nervous system (NCBI, 2021[31]). Ethylbenzene is also considered toxic to aquatic life and is flammable (ILO and WHO, 2007[32]).

This analysis focuses on ethylbenzene releases as reported to the following five of the seven pollutant release and transfer register (PRTR) systems chosen for these global scale analyses: the PRTR systems of Australia, Canada, Europe (i.e., the E-PRTR), Japan and the U.S. Ethylbenzene is not reported to the Mexican PRTR or the Chilean PRTR. As described in this project's Action Plan, the analysis focuses on releases of ethylbenzene to air and water by facilities in the manufacturing sector only (OECD, 2018[3]).

Snapshot Analyses

Across all five PRTRs combined, facilities in the manufacturing sector released ethylbenzene almost exclusively to air over the 2008 to 2017 timeframe. The largest releases reported from the manufacturing sector were primarily from two International Standard Industrial Classification system (ISIC) Divisions—the other transportation equipment manufacturing (ISIC 30) and motor vehicle and trailer manufacturing (ISIC 29) subsectors—as shown in the figure below.[26] These two subsectors together accounted for 56% of ethylbenzene releases reported from 2008 to 2017.

Across PRTRs, from 2008 to 2017, ethylbenzene releases were mainly from two subsectors

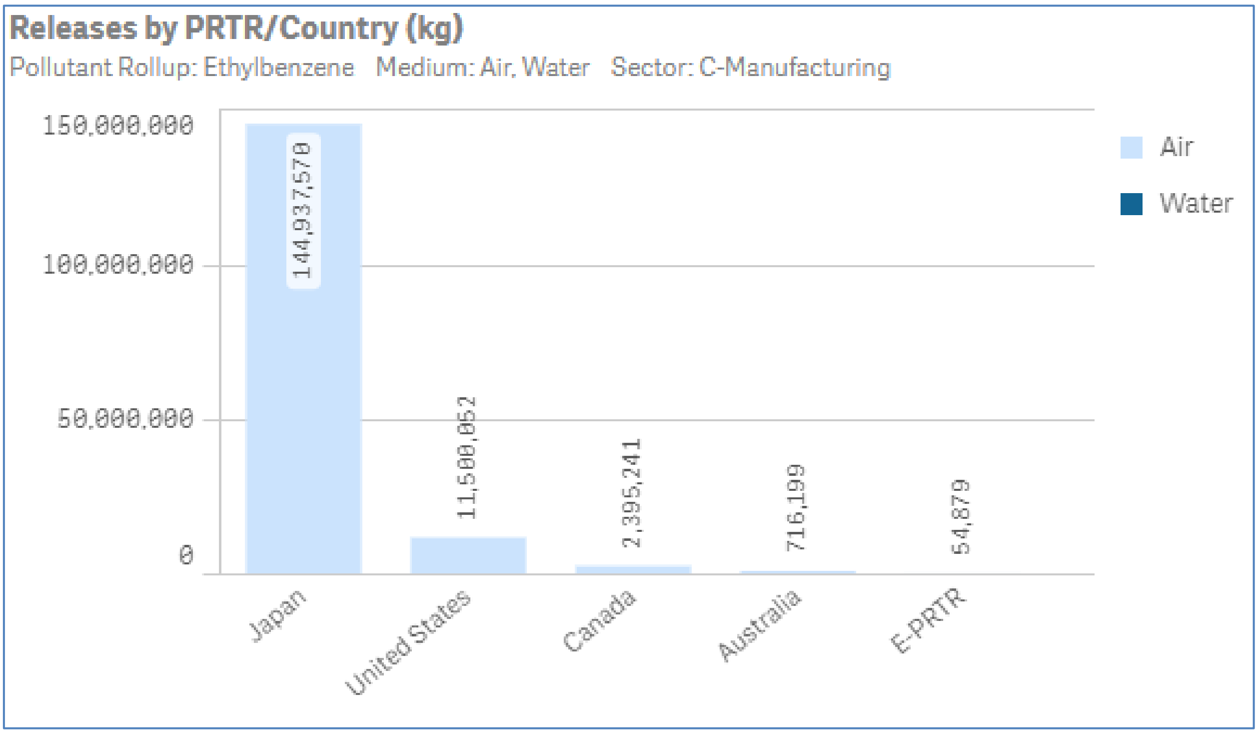


"Others" includes combined air and water releases from all other manufacturing subsectors.

Considered by PRTR, reported releases were largest in Japan, as shown in the figure below. Note that the reporting threshold for ethylbenzene in Japan is lower than in many of the other PRTRs examined. In Japan, facilities must report information about releases of ethylbenzene if they handled 1,000 kg or more of the chemical that year. For comparison, facilities in the U.S. are required to report if they manufacture or process 25,000 pounds (11,340 kg) or otherwise use 10,000 pounds (4,536 kg) of ethylbenzene in a given year. Facilities' releases of this chemical are included in the E-PRTR if they released 1,000 kg or more of ethylbenzene to air, or at least 200 kg total of BTEX chemicals (benzene, ethylbenzene, toluene, and xylene) to water. Based on the differences in thresholds, the Japanese PRTR is expected to capture a larger portion of all releases in the country than other PRTRs.

One way to estimate the effect of thresholds is to exclude releases that would not have met reporting thresholds in other countries. For ethylbenzene, the highest reporting threshold among the PRTRs in this analysis is the 11,340 kg threshold for manufacturing or processing in the U.S. Therefore, it is certain that any release of more than 11,340 kg would have met reporting thresholds for any of the five PRTRs. Even when considering only releases of more than 11,340 kg (i.e., releases large enough that a facility would have to report in any of the five PRTRs), ethylbenzene releases reported in Japan are much more than for all four other PRTRs combined. Therefore, it appears that lower reporting thresholds are not the only reason why reported releases are larger in Japan.

From 2008 to 2017, ethylbenzene releases were largest in Japan

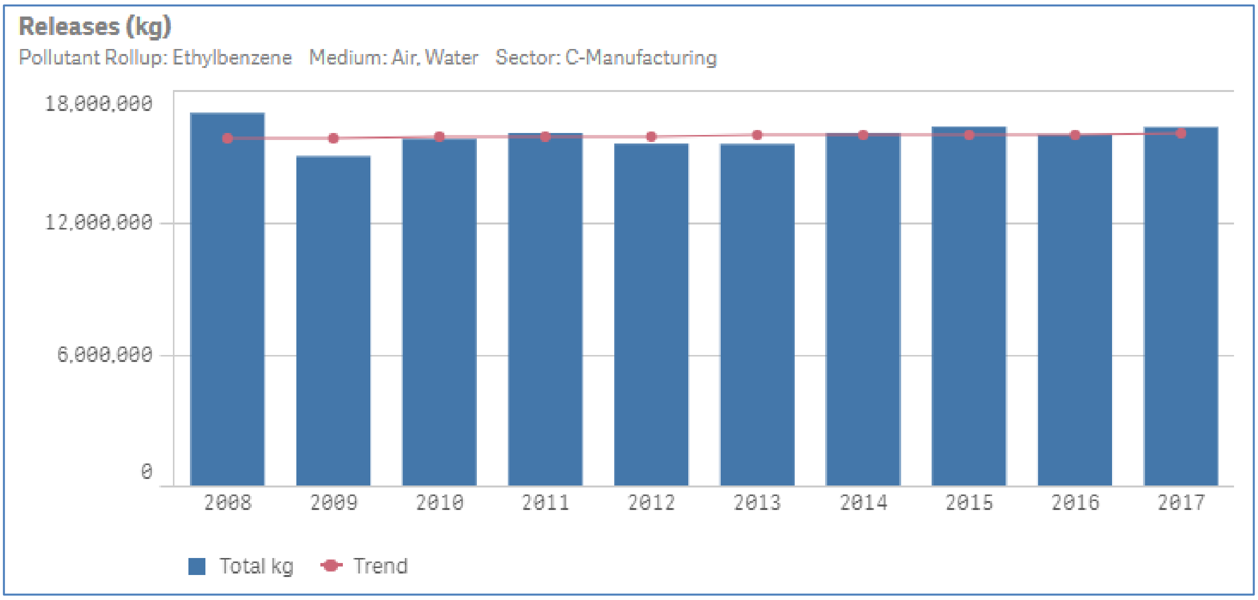


Snapshot of ethylbenzene releases to air and water from the manufacturing sector	
Releases, 2017	16.3 million kg
Releases by medium, 2008–2017	99.9% to air
Subsectors with the largest reported releases, 2008–2017	Other transportation equipment manufacturing (ISIC 30) Motor vehicles and trailers (ISIC 29)
PRTR with the largest reported releases, 2008–2017	Japan
Additional information: Releases reported to Japan account for 91% of the ethylbenzene releases reported to the five PRTRs in this analysis from 2008 to 2017.	

Trend Analyses

Reported ethylbenzene releases across the five PRTRs over the 2008 to 2017 timeframe decreased slightly, from a high of 17.0 million kg in 2008 to 16.3 million kg in 2017—a 4% decrease. Regression analysis indicates that the downward trend in releases was not statistically significant based on all 10 years of data ($p>0.05$).[27] The slight decrease in releases from 2008 to 2017 was driven by reduced releases in the U.S. and Japan.

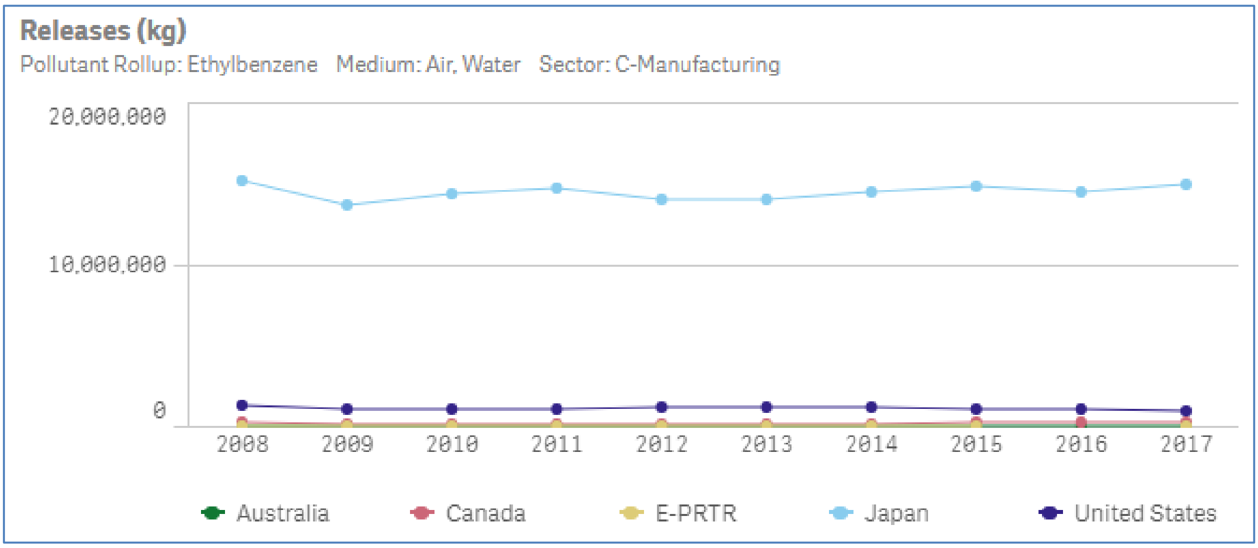
Ethylbenzene releases showed no significant trend from 2008 to 2017



Ethylbenzene releases in four of the five PRTRs decreased from 2008 to 2017:

- Releases decreased in the U.S. (295,000 kg decrease), Japan (285,000 kg decrease), Canada (75,000 kg decrease), and the E-PRTR (1,900 kg decrease).
- Releases increased slightly in Australia (17,000 kg increase). Releases reported in Australia remained lower than most other PRTRs, representing less than 1% of ethylbenzene releases from the five PRTRs from 2008 to 2017.
- Releases reported by most manufacturing subsectors decreased between 2008 to 2017.
    - The largest decrease in release quantities was in the motor vehicle and trailers manufacturing subsector (ISIC 29), which reported 4.2 million kg of ethylbenzene releases in 2008 and 3.9 million kg of ethylbenzene releases in 2017, a 7% decrease.
    - The largest increase in release quantities was in the rubber and plastics subsector (ISIC 22), where releases increased from 920,000 kg in 2008 to 1.2 million kg in 2017, a 28% increase.

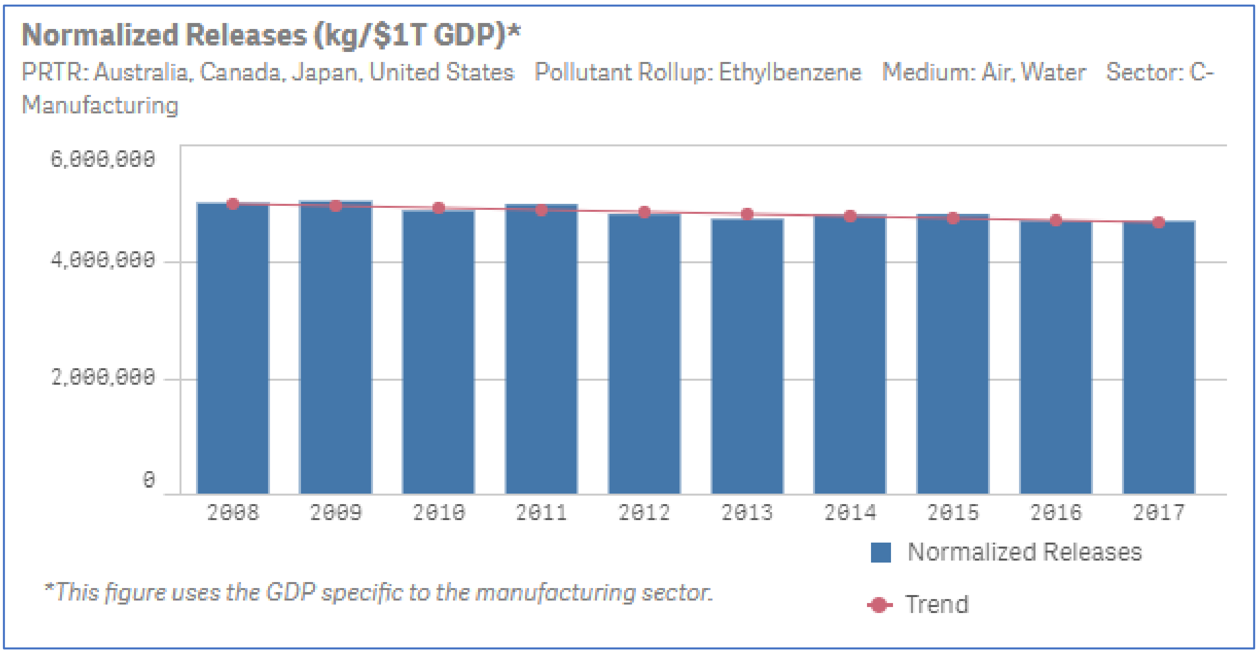
Ethylbenzene releases decreased slightly from 2008 to 2017 in most PRTRs



This figure includes PRTRs with comparatively low releases (i.e., Australia, Canada, and the E-PRTR), though they may not be visible at this scale.

Releases of ethylbenzene were normalized by the annual gross domestic product (GDP) for the manufacturing sector of the PRTR's country or region. Normalized releases provide a metric to compare a country's release levels per unit of economic activity in the country. Releases are related to economic activity, as higher manufacturing economic activity usually means more goods are being produced. Chemical releases are associated with these manufacturing processes, so more manufacturing is typically associated with more chemical releases. Normalizing releases controls for the differences in production levels between countries and over time. The trend in normalized releases approximates how releases would have changed if the amount manufacturing activity had remained constant. As shown in the figure below, ethylbenzene releases across the four PRTRs with releases each year, when normalized by the combined manufacturing GDPs of their respective countries/regions, show a statistically significant decreasing trend ($p<0.05$).[28] Note that no releases of ethylbenzene were reported in E-PRTR for 2016, so the E-PRTR is not included in the analysis of normalized releases. When absolute releases do not show a significant trend, but normalized releases do, this indicates that economic factors impacted releases. For example, releases of ethylbenzene decreased from 2008 to 2009, then increased from 2009 to 2010, following the broader pattern of economic decline during the global recession from 2008 to 2009 and the start of economic recovery from 2009 to 2010.

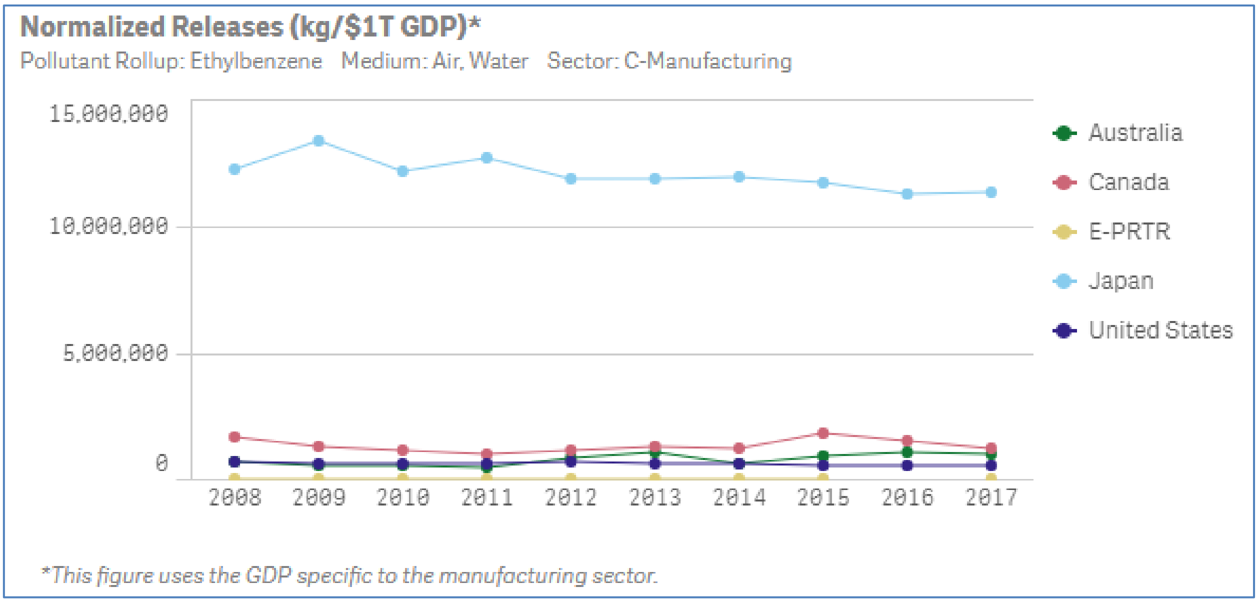
Normalized ethylbenzene releases showed no significant trend from 2008 to 2017



This figure does not include data from the E-PRTR.

Compared among PRTRs, the GDP-normalized trends in releases of ethylbenzene show that Japan had the highest normalized releases each year. Both normalized and absolute releases of ethylbenzene were larger in Japan than any other PRTR. This indicates that facilities in Japan released more ethylbenzene per unit of manufacturing activity than facilities in other countries. Releases in Japan decreased slightly from 2008 to 2017, while manufacturing GDP increased by 6%. If economic activity were the primary driver of release trends, releases would be expected to increase as economic activity increased. The decrease in GDP-normalized releases indicates factors other than total manufacturing economic activity were driving the ethylbenzene releases in Japan.

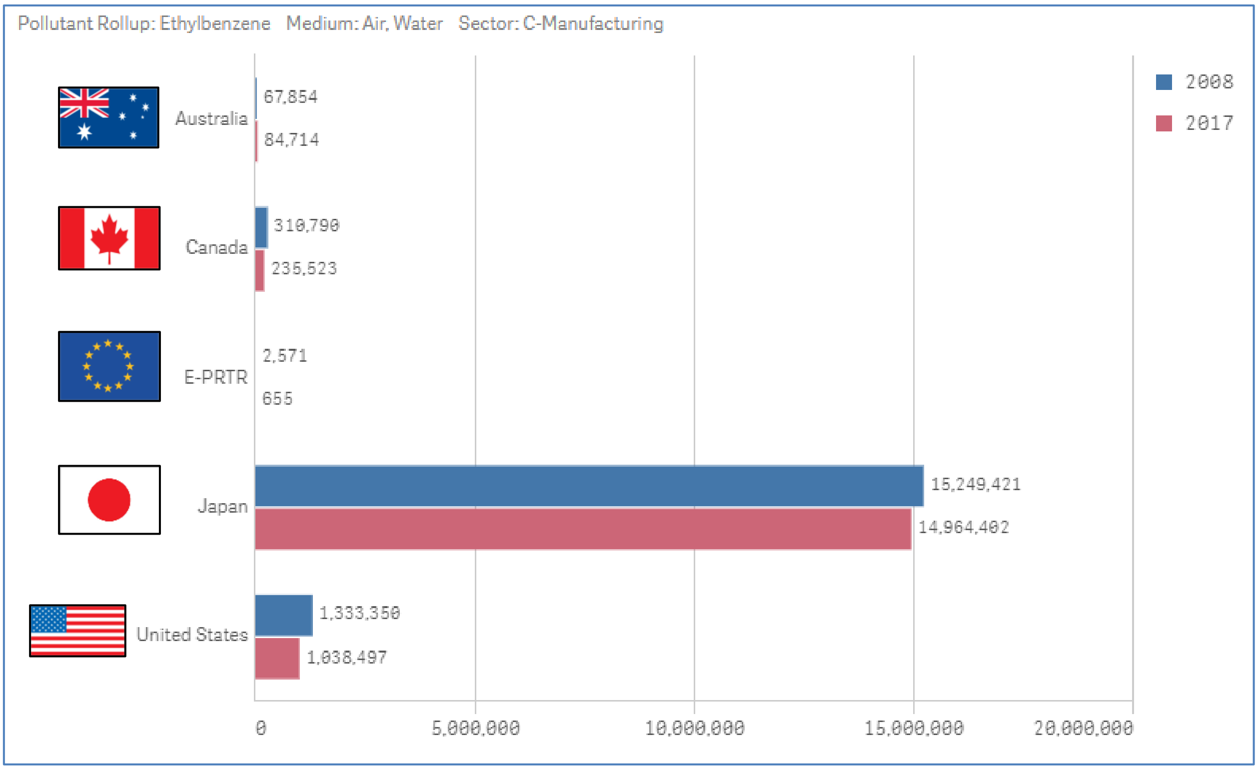
Normalized ethylbenzene releases decreased in Japan between 2008 and 2017



Trend in ethylbenzene releases to air and water from the manufacturing sector	
Overall change, 2008–2017	Releases decreased by 640,000 kg (4%). This was not part of a significant trend of releases increasing or decreasing.
PRTRs with the largest *percent* change in releases, 2008–2017	E-PRTR: 1,900 kg decrease (75%) Australia: 17,000 kg increase (25%)
PRTRs with the largest *absolute* change in releases, 2008–2017	U.S.: 295,000 kg decrease (22%) Japan: 285,000 kg decrease (2%)
Subsectors with the largest absolute change in releases, 2008–2017	Motor vehicles and trailers (ISIC 29): 290,000 kg decrease (7%) Rubber and plastics (ISIC 22): 260,000 kg increase (28%)
Additional information: Releases of ethylbenzene were lowest in the E-PRTR and Australia. Although these PRTRs show large percent change in releases from 2008 to 2017, absolute releases were low and did not consistently increase or decrease in either of these PRTRs.	

Summary

Releases of ethylbenzene from manufacturing facilities by PRTR (kg)



- Five of the seven PRTR systems contain information on ethylbenzene releases between 2008 and 2017: Australia, Canada, the E-PRTR, Japan, and the U.S. The Mexican and Chilean PRTRs do not contain information on ethylbenzene releases.
- Across the five PRTRs combined, ethylbenzene releases to air and water as reported by facilities in the manufacturing sector decreased by 640,000 kg (4%) from 2008 to 2017.
  - The decrease in absolute releases was not statistically significant. However, normalized releases had a statistically significant decreasing trend (excluding data from the E-PRTR because no releases were reported for 2016).
- Ethylbenzene releases were lower in 2017 than 2008 in four of the five PRTR systems examined. Releases were slightly higher in 2017 than 2008 in Australia.
- Facilities in the other transportation equipment manufacturing subsector (ISIC 30) reported the largest release quantities of ethylbenzene. Ethylbenzene releases from this subsector decreased from 2008 to 2017.

Mercury

Mercury is a volatile, odourless liquid metal that exists in inorganic and organic forms (NCBI, 2021[33]).[29] It occurs naturally in the environment from outgassing at the Earth's crust, volcanic activity, evaporation from surface water, and biological processes (NCBI, 2021[33]). Sources of mercury releases into the environment include metal mining, refining of metal ores, waste incineration, and disposal of products or wastes that contain mercury. Some electrical instruments and medical devices contain mercury. Mercury and mercury compounds are also used commercially in the extraction of gold (NCBI, 2021[33]). Under ambient conditions, elemental mercury exists as a liquid. Mercury is considered highly toxic and mercury compounds range in toxicity (WHO, 2007[34]). In humans, mercury and mercury compounds are associated with a range of acute and long-term effects including effects on reproductive and developmental health (WHO, 2007[34]). Mercury and mercury compounds are also considered toxic to aquatic life. Some mercury compounds bioaccumulate in aquatic species and biomagnify up the food chain (WHO, 2007[34]; ILO and WHO, 2019[35])

Mercury can exist on its own (as elemental mercury, Hg^0) or can form mercury compounds by bonding to other elements. In some pollutant release and transfer registers (PRTRs), mercury compounds are listed separately from elemental mercury. In the other PRTRs, mercury and mercury compounds are listed together. Across PRTRs, when facilities report releases of mercury compounds, they report the quantity of mercury, not the weight of the entire compound. For simplicity, this analysis groups together all mercury and mercury compounds reported as released to the environment. Since facilities that report releases of mercury compounds report the weight of mercury released and not the weight of the entire compound, these releases are all releases of mercury. Therefore, in this analysis "releases of mercury" refers to both releases of elemental mercury and releases of the mercury portion of mercury compounds.

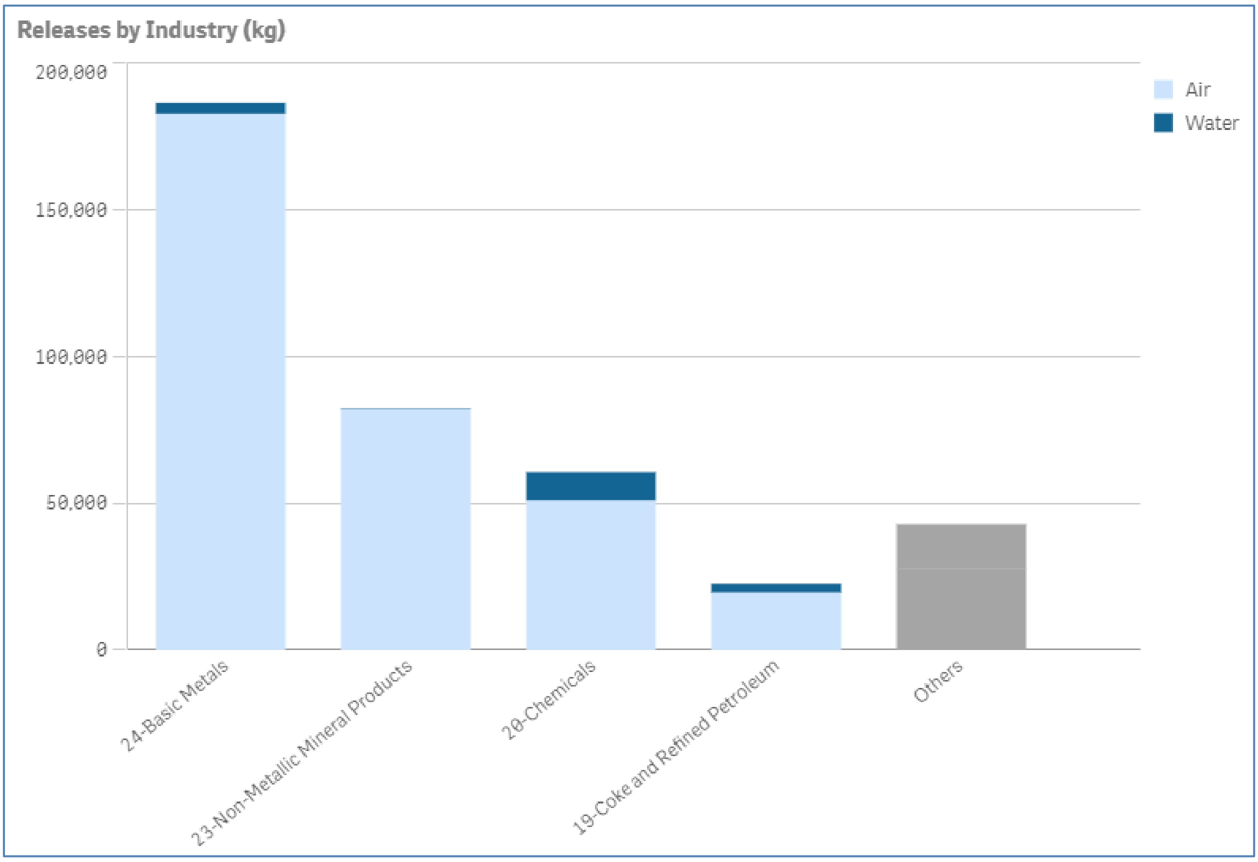
In most of the PRTRs in this analysis, mercury is considered a pollutant of particular concern, and reporting thresholds for mercury range from 1 to 10 kg of mercury handled or released for five of the seven PRTRs. The exceptions are Chile, which does not have reporting thresholds, and Japan, where facilities must report if they handle 1,000 kg or more of mercury that year. Therefore, due to lower reporting thresholds, the E-PRTR and the PRTRs of Australia, Canada, Chile, Mexico, and the U.S. may collect data on a greater portion of the mercury releases occurring in those countries than Japan's PRTR. Most releases reported by facilities in those PRTRs were much less than 1,000 kg, indicating that many facilities may be handling only small amounts of mercury. Similar facilities may exist in Japan, handling amounts of mercury under the 1,000 kg reporting threshold there. Although releases from those facilities may individually be small, they may add up to significant release quantities that are not reported to Japan's PRTR. The higher threshold in Japan may be one reason why reported releases in that country are much smaller than releases reported in the others.

This analysis focuses on releases of mercury as reported to the seven PRTR systems chosen for these global scale analyses: the PRTR systems of Australia, Canada, Chile, Europe (i.e., the E-PRTR), Japan, the U.S., and Mexico, recognizing some differences in reporting requirements across PRTRs. As described in this project's Action Plan, the analysis focuses on releases of mercury to air and water by facilities in the manufacturing sector only (OECD, 2018[3]).

Snapshot Analyses

Across all PRTR systems combined, facilities in the manufacturing sector released mercury primarily to air over the 2008 to 2017 timeframe. The largest releases reported from the manufacturing sector were from four International Standard Industrial Classification System (ISIC) Divisions, as shown in the figure below.[30] Releases of mercury were primarily driven by the basic metals subsector (ISIC 24), which reported larger quantities of mercury releases than any other subsector for every year from 2008 to 2017.

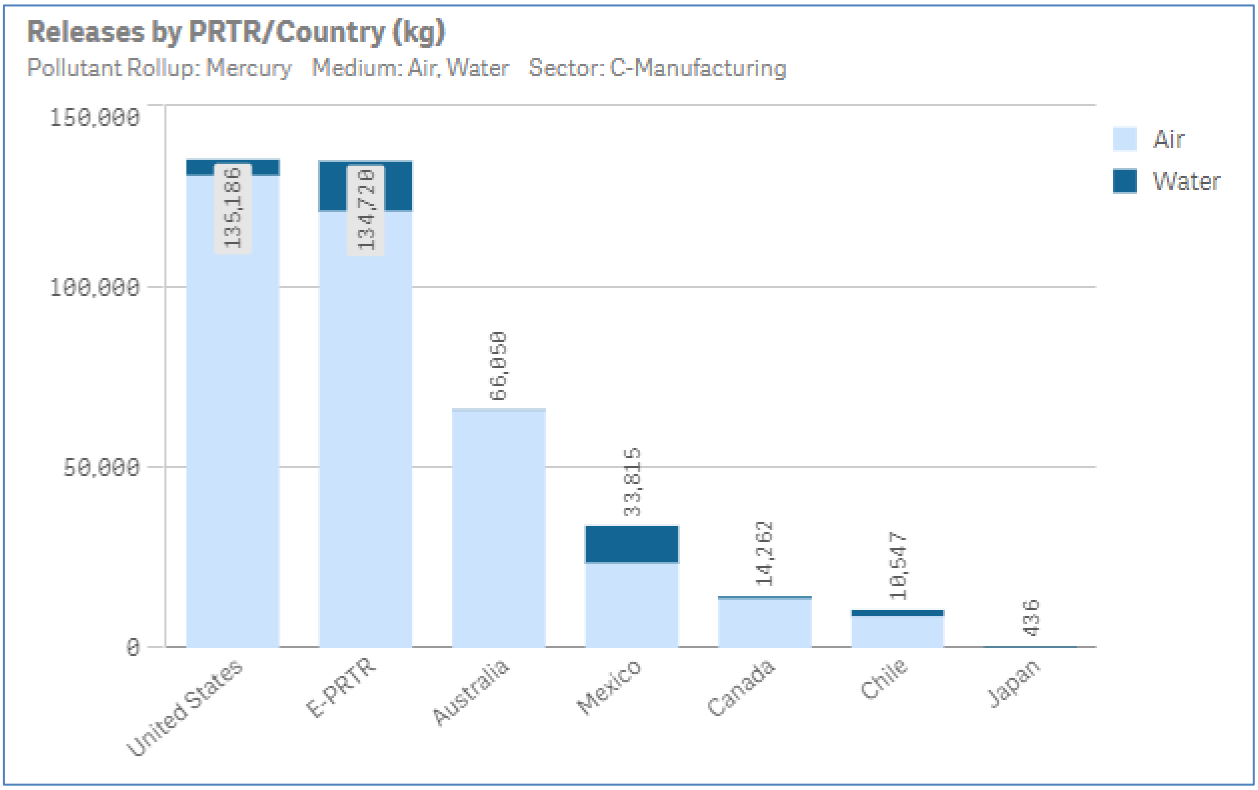
Across PRTRs, from 2008 to 2017, mercury releases were mainly from four subsectors



"Others" includes combined air and water releases from all other manufacturing sectors.

Reported releases were largest in the U.S. and the E-PRTR, as shown in the figure below. As discussed above, the reporting threshold for reporting mercury releases is higher in Japan than in the other PRTRs, which may be one reason why releases reported in Japan's PRTR are much lower than the other PRTRs.

From 2008 to 2017, mercury releases were largest in the U.S. and the E-PRTR

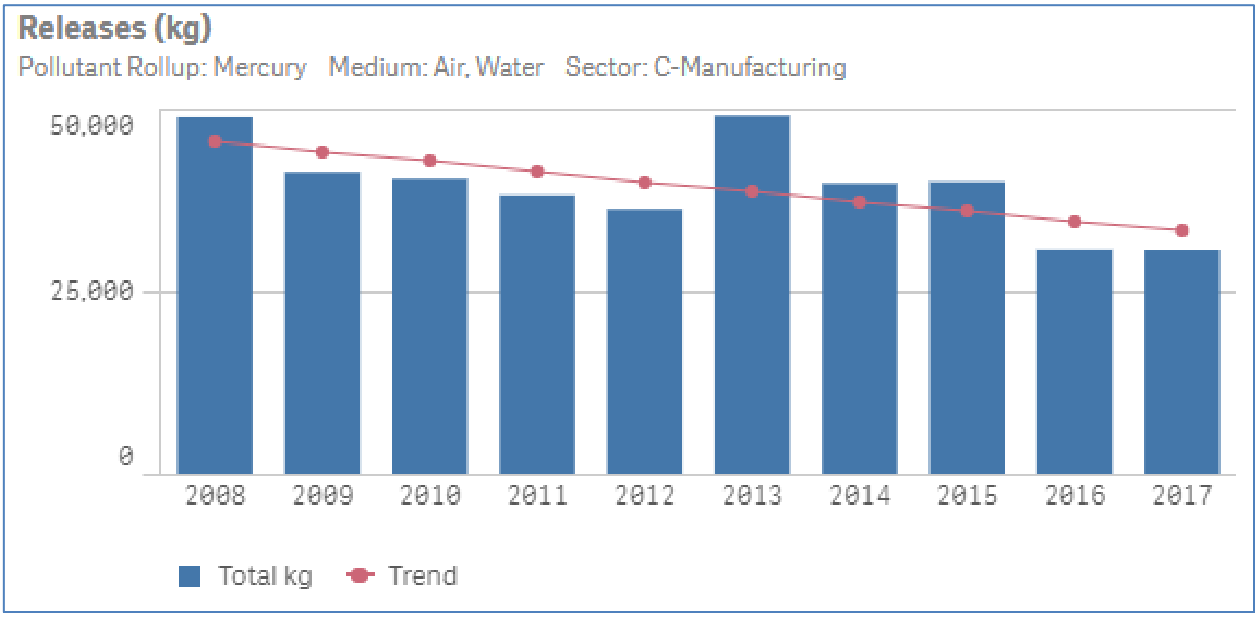


Snapshot of mercury releases to air and water from the manufacturing sector	
Releases, 2017	31,000 kg
Releases by medium, 2008–2017	92% to air
Subsectors with the largest reported releases, 2008–2017	Basic metals (ISIC 24) Non-metallic mineral products (ISIC 23) Chemical manufacturing (ISIC 20)
PRTRs with the largest reported releases, 2008–2017	U.S., E-PRTR
Additional information: Very low mercury release quantities were reported in Japan (440 kg from 2008 to 2017), possibly related to higher reporting thresholds than for other PRTRs.	

Trend Analyses

Reported mercury releases totalled across the seven PRTRs over the 2008 to 2017 decreased, driven by relatively large decreases from 2008 to 2009 and 2015 to 2016. Reported mercury releases decreased by 7,500 kg from 2008 to 2009 and by 9,300 kg from 2015 to 2016. Releases decreased by smaller amounts over other years, with some small increases. Releases in 2013 were unusually high, representing a 13,000 kg increase from 2012, and releases decreased by 9,300 kg from 2013 to 2014. Increased releases in 2013 were driven by large quantities of mercury releases reported that year by several facilities in Mexico. Overall, regression analysis indicates that the downward trend in releases was statistically significant based on all 10 years of data ($p<0.05$).[31] The decrease in mercury releases from 2008 to 2017 was driven by reduced releases in the E-PRTR and Australia. The reduced releases reported in Australia were driven by one facility that reported nearly 7,000 kg of mercury released in 2008 and almost none in 2017.

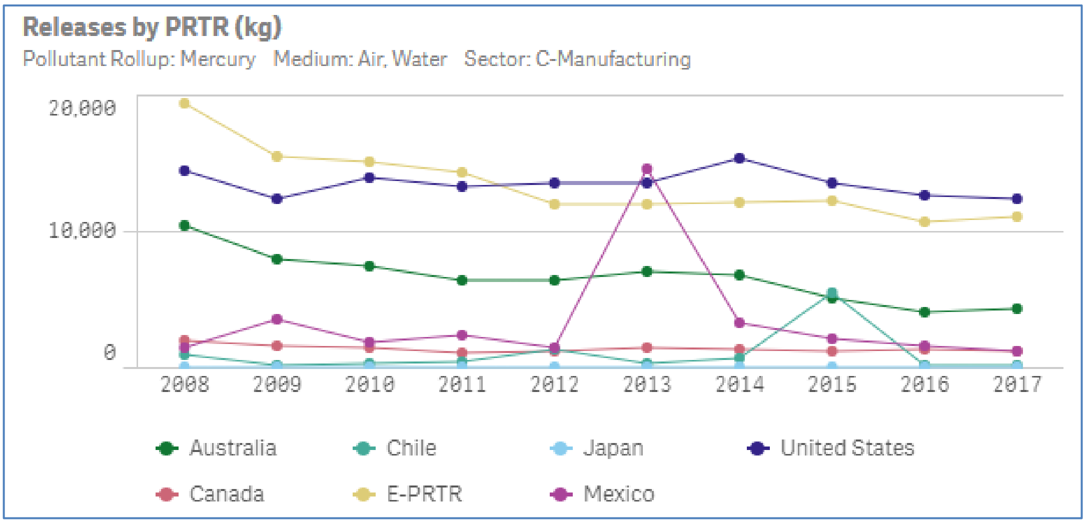
Mercury releases significantly decreased from 2008 to 2017



Mercury releases decreased for most PRTRs from 2008 to 2017:

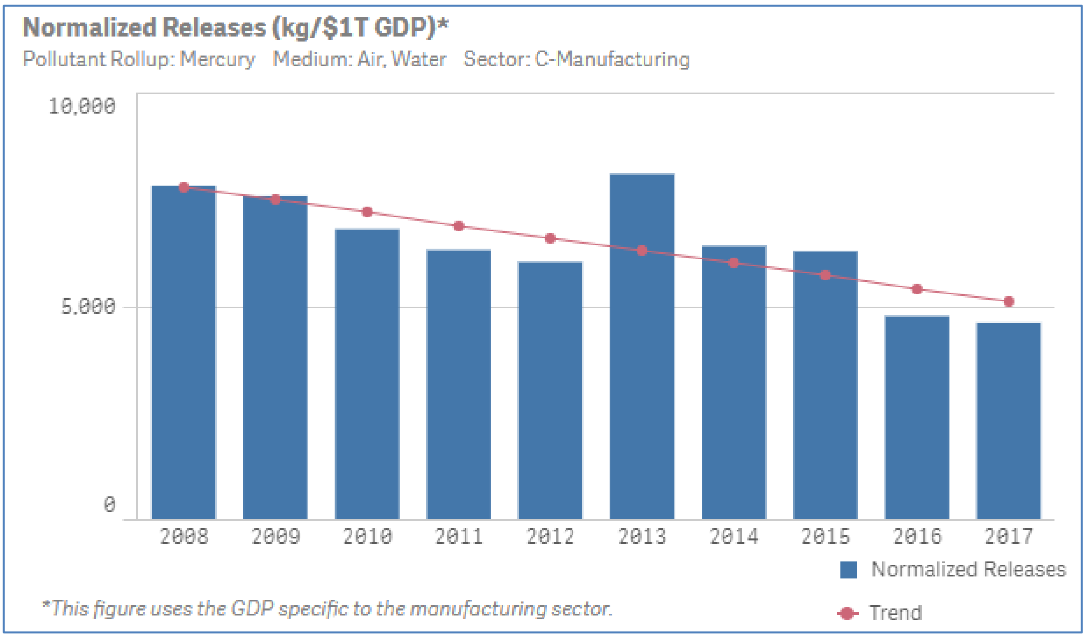
- Releases decreased substantially in the E-PRTR (8,300 kg decrease) and Australia (6,100 kg decrease). Decreased releases in these PRTRs were driven by decreased releases in the chemical manufacturing (ISIC 20) and basic metals (ISIC 24) subsectors, respectively.
- Releases decreased by smaller amounts in the U.S. (2,100 kg decrease), Canada (810 kg decrease), Chile (680 kg decrease), and Mexico (250 kg decrease).
- Releases increased slightly in Japan from 21 kg in 2008 to 96 kg in 2017. Releases reported to Japan's PRTR remain far below releases reported to other PRTRs. Reported releases in Japan may be affected by relatively high reporting thresholds.
- Releases reported by almost all manufacturing subsectors decreased between 2008 and 2017.
    - The largest decrease in release quantities was in the chemical manufacturing subsector (ISIC 20), which reported 11,000 kg of mercury releases in 2008 and 3,600 kg of mercury releases in 2017, a 67% decrease.

Mercury releases decreased in most PRTRs



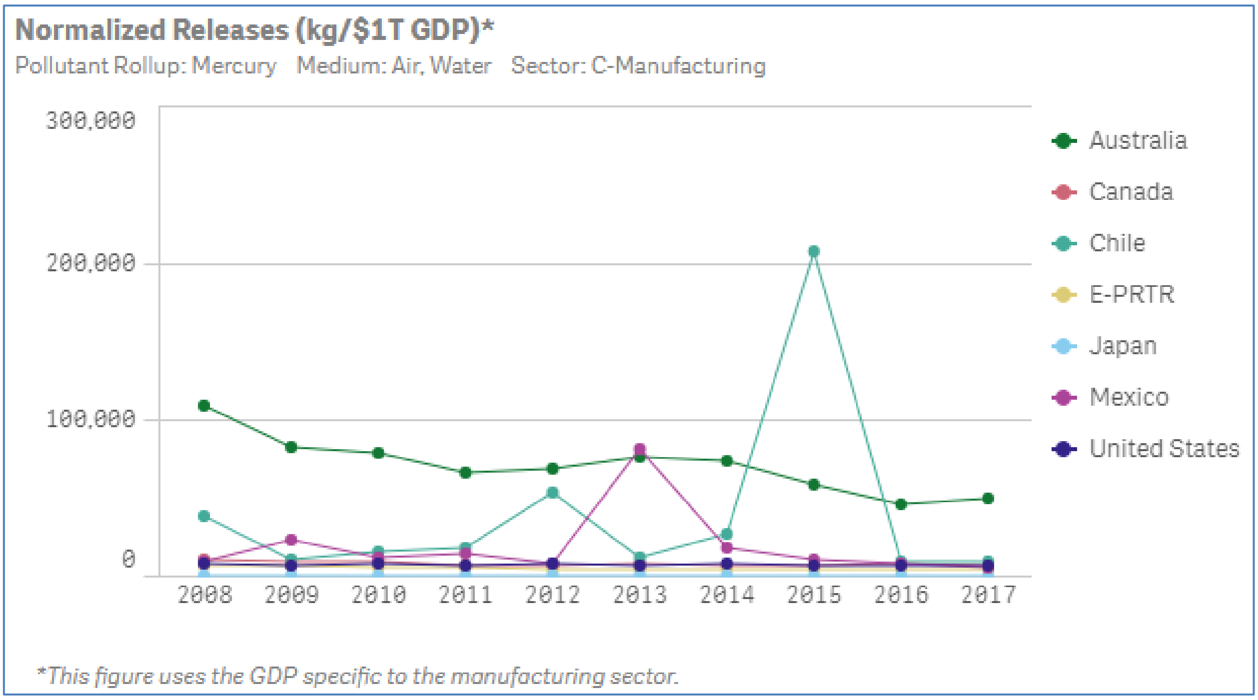
Releases of mercury were normalized by the annual gross domestic product (GDP) for the manufacturing sector of the PRTR's country or region. Normalized releases provide a metric to compare a country's release levels per unit of economic activity in the country. Releases are related to economic activity, as higher manufacturing economic activity usually means more goods are being produced. Chemical releases are associated with these manufacturing processes, so more manufacturing is typically associated with more chemical releases. Normalizing releases controls for the differences in production levels between countries and over time. The trend in normalized releases approximates how releases would have changed if the amount of manufacturing activity had remained constant. As shown in the figure below, mercury releases across the seven PRTRs, when normalized by the combined manufacturing GDPs of their countries/regions, show a statistically significant downward trend ($p<0.05$).[32]

Normalized mercury releases significantly decreased from 2008 to 2017



Compared among PRTRs, GDP-normalized trends in releases of mercury show that Australia and Chile had the highest normalized releases, rather than the E-PRTR and the U.S. This indicates that facilities in Australia and Chile released more mercury per unit of manufacturing activity than facilities in other countries. For Chile, normalized releases were high in 2015 due to unusually large releases reported by several facilities for that year. For Australia, mercury releases decreased by 59% from 2008 to 2017 while the country's manufacturing GDP decreased by 10%. If manufacturing activity were the primary driver of release trends in Australia, releases would be expected to decrease in line with decreasing manufacturing activity. The decrease in GDP-normalized releases indicates that in addition to decreasing manufacturing activity, other factors contributed to declining mercury releases in Australia.

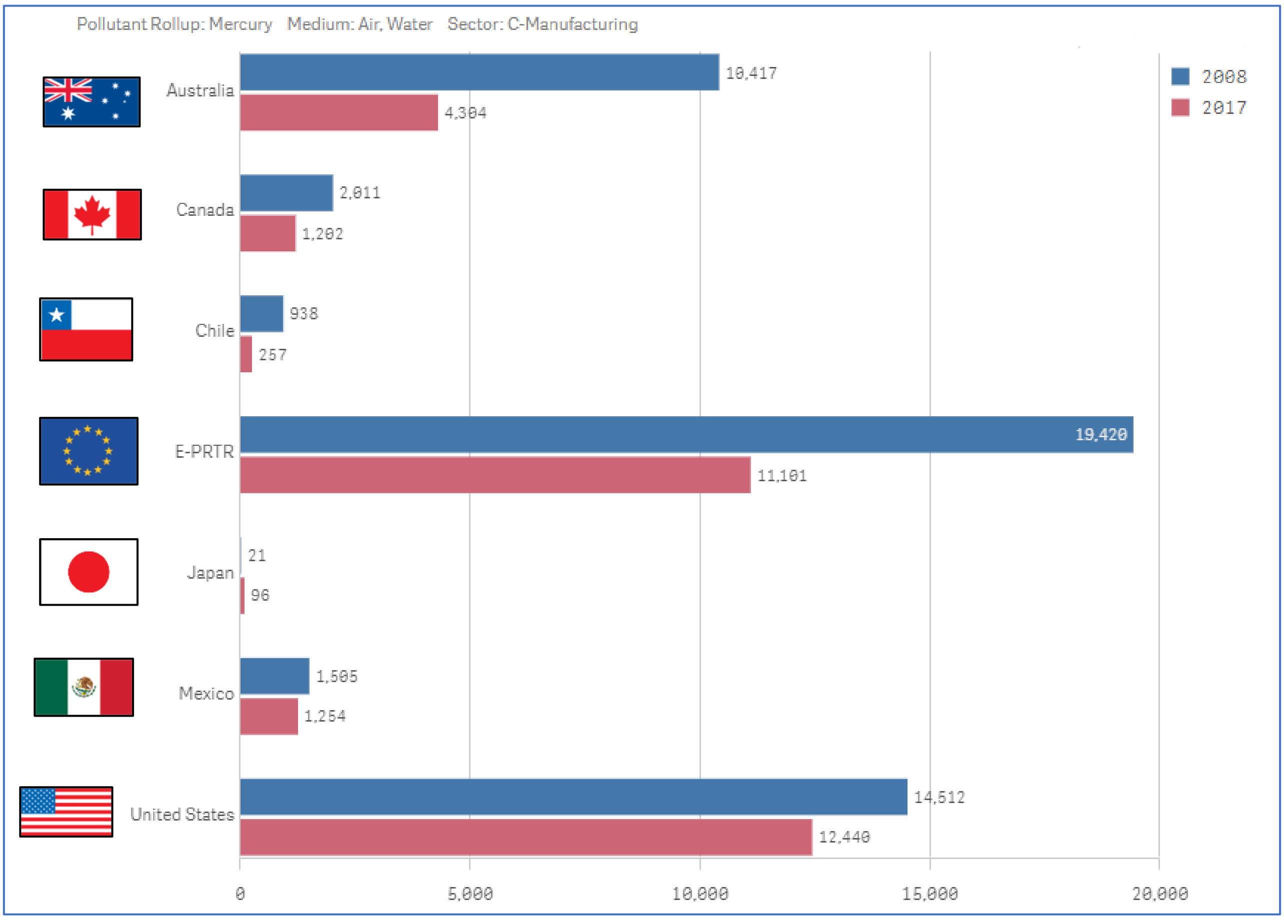
Normalized mercury releases were largest in Chile and Australia



Trend in mercury releases to air and water from the manufacturing sector	
Overall change, 2008–2017	Releases decreased by 18,000 kg (37%). This was part of a statistically significant trend of releases decreasing.
PRTRs with the largest *percent* change in releases, 2008–2017	Japan: 75 kg increase (360%) Chile: 680 kg decrease (73%)
PRTRs with the largest *absolute* change in releases, 2008–2017	E-PRTR: 8,300 kg decrease (43%) Australia: 6,100 kg decrease (59%)
Subsectors with the largest absolute change in releases, 2008–2017	Chemical manufacturing (ISIC 20): 7,300 kg decrease (67%) Basic metals (ISIC 24): 6,200 kg decrease (28%)
Additional information: The percent change in releases reported by Japan was high because releases were low in 2008, but the change in kg released reported in Japan was small. Releases reported in Japan were consistently lower than in any other PRTR. Mercury releases reported from almost all subsectors have decreased.	

Summary

Releases of mercury from manufacturing facilities by PRTR (kg)



- All seven PRTR systems contain information on mercury releases between 2008 and 2017: Australia, Canada, Chile, Europe (i.e., the E-PRTR), Japan, Mexico, and the U.S.
- Across the seven PRTRs combined, mercury releases to air and water as reported by facilities in the manufacturing sector decreased by 18,000 kg (37%) from 2008 to 2017.
  - Decreased mercury releases were driven by decreased releases reported in the E-PRTR and Australia.
- Mercury releases decreased from 2008 to 2017 in six of the PRTR systems examined and increased slightly in Japan.
- Facilities in the basic metals (ISIC 24), non-metallic mineral products (ISIC 23), and chemical manufacturing (ISIC 20) subsectors reported the largest release quantities of mercury. Mercury releases from these industries decreased from 2008 to 2017.

Nickel

Nickel exists in ambient conditions as a silver metallic solid and is a trace metal in the Earth's crust. Nickel and nickel compounds have low vapor pressure and are not expected to volatilize in contact with water.[33] They are found in the environment as components of plant and bacterial enzyme production and in soil as trace metals. Natural releases of nickel to the atmosphere occur as the result of volcanic and plant activity (NCBI, 2021[36]). Nickel and nickel compounds are also present in human-made products. They are used commercially in the production of stainless steel and other metal alloys. Repeated or long-term inhalation or dermal exposure to nickel and nickel compounds are associated with respiratory effects and skin sensitization, respectively. Nickel and nickel compounds are also considered to cause long-term harmful effects in aquatic environments (ILO and WHO, 2017[37]).

Nickel can exist on its own (as elemental nickel, Ni^0) or can form nickel compounds by bonding to other elements. In some pollutant release and transfer registers (PRTRs), nickel compounds are listed separately from elemental nickel. In the other PRTRs, nickel and nickel compounds are listed together. Across PRTRs, when facilities report releases of nickel compounds, they report the quantity of nickel contained in the nickel compounds that were released to the environment and not the weight of the entire compound. For simplicity, this analysis groups together all nickel and nickel compounds reported as released to the environment. Since facilities that report releases of nickel compounds report the weight of nickel released and not the weight of the entire compound, these releases are all releases of nickel. Therefore, in this analysis "releases of nickel" refers to releases of both elemental nickel and the nickel portion of nickel compounds.

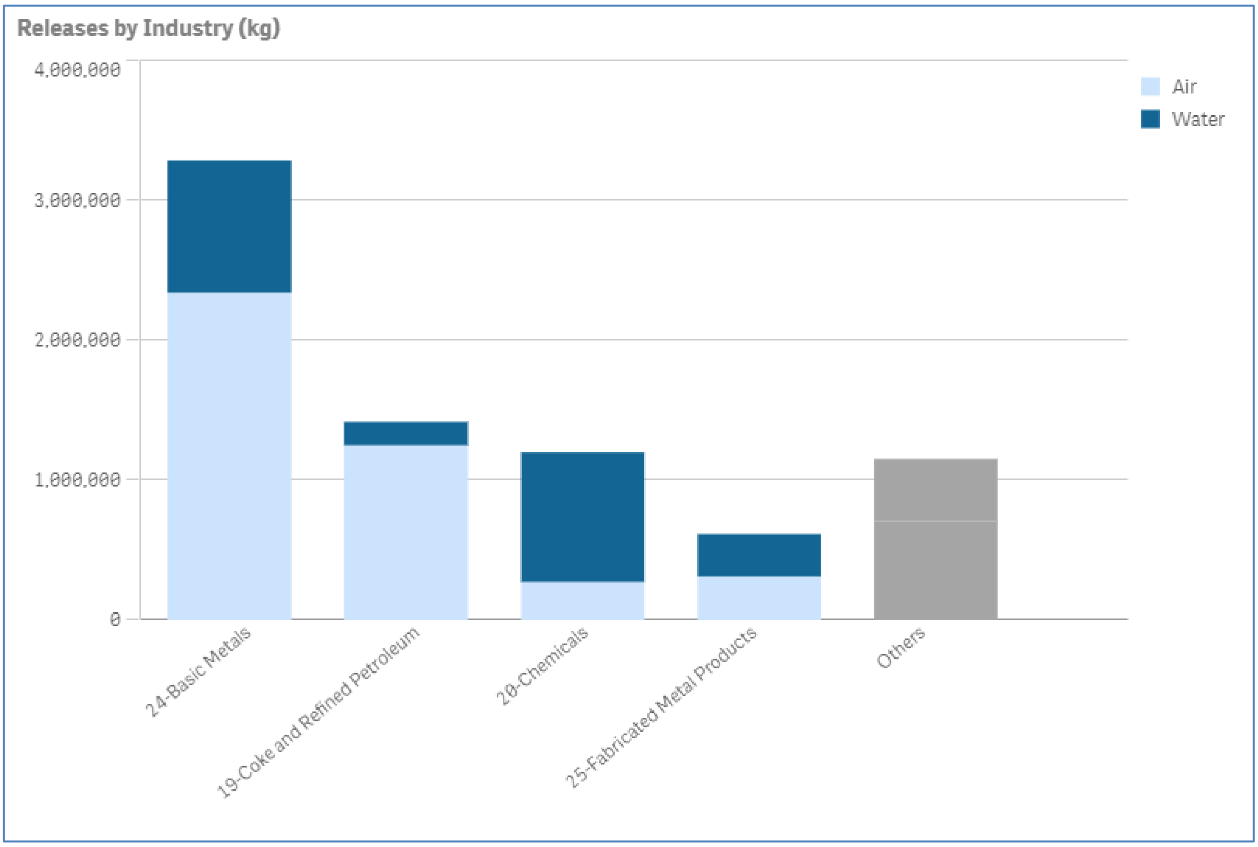
This analysis focuses on releases of nickel as reported to the seven PRTR systems chosen for these global-scale analyses: the PRTR systems of Australia, Canada, Chile, Europe (i.e., the E-PRTR), Japan, the U.S., and Mexico. As described in this project's Action Plan, the analysis focuses on releases of nickel to air and water by facilities in the manufacturing sector only (OECD, 2018[3]).

PRTR data from Mexico include a facility in the chemical manufacturing subsector that reported it released 450,000 kg of nickel to water during 2008, a quantity greater than the total releases reported to any other PRTR in any year. This unusually high release quantity may have a substantial impact on apparent trends. Input from Mexico's PRTR staff indicates that the facility's reporting for nickel is considered inconsistent and will not be included in the next data update of Mexico's PRTR database. Therefore, data from Mexico are excluded from some trend analyses in this report, where indicated.

Snapshot Analyses

Across all PRTR systems combined, facilities in the manufacturing sector mainly released nickel to air over the 2008 to 2017 timeframe. However, releases of nickel reported in Mexico, Japan, and Chile were primarily to water. The largest releases reported from the manufacturing sector were primarily from four International Standard Industrial Classification system (ISIC) Divisions, as shown in the figure below.[34] The basic metals subsector (ISIC 24) accounted for 43% of manufacturing air and water releases from 2008 to 2017.

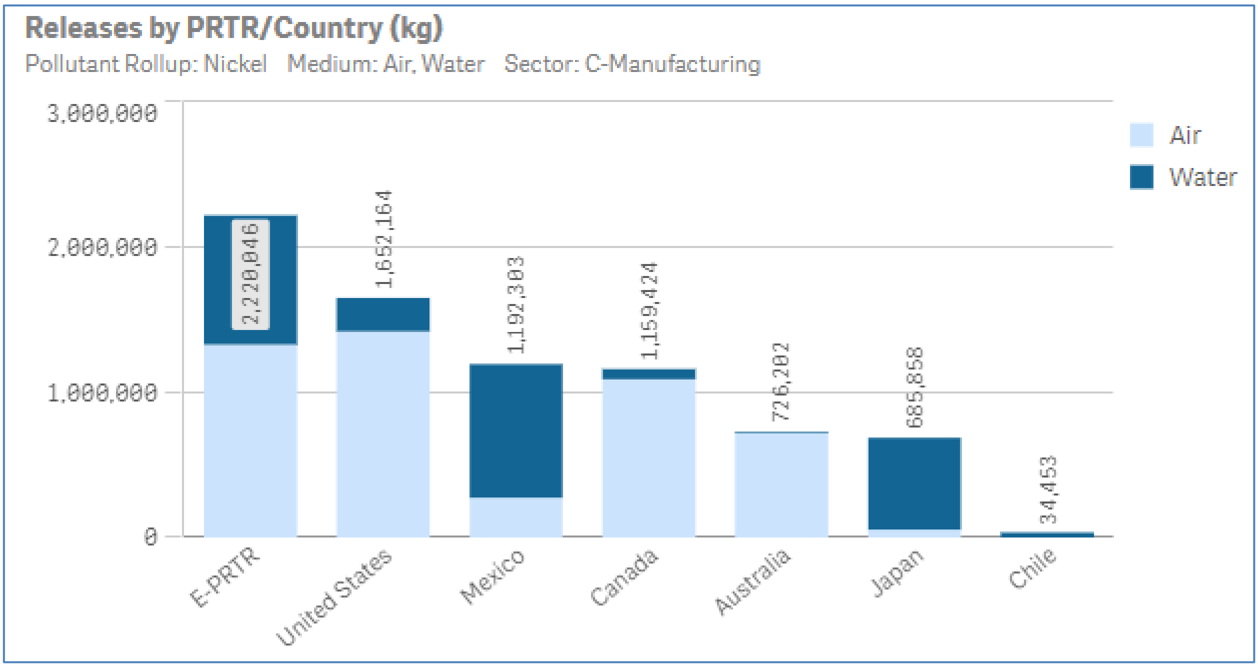
Across PRTRs, from 2008 to 2017, nickel releases were mainly from four subsectors



"Others" includes combined air and water releases from all other manufacturing sectors.

Considered by PRTR, reported releases were largest in the E-PRTR, followed by the U.S., as shown in the figure below.

From 2008 to 2017, nickel releases were largest in the E-PRTR



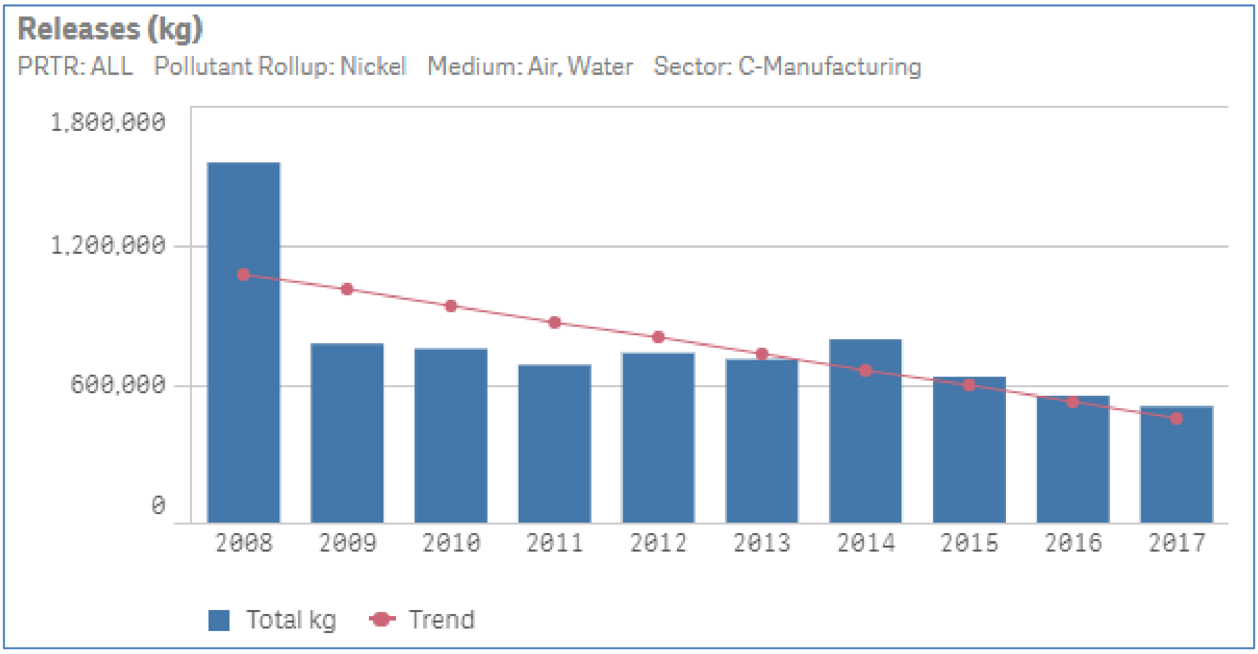
Snapshot of nickel releases to air and water from the manufacturing sector	
Releases, 2017	500,000 kg
Releases by medium, 2008–2017	64% to air
Subsectors with the largest reported releases, 2008–2017	Basic metals (ISIC 24) Coke and refined petroleum (ISIC 19) Chemical manufacturing (ISIC 20) Fabricated metals (ISIC 25)
PRTRs with the largest reported releases, 2008–2017	E-PRTR, U.S.

Additional Information:
Releases in Mexico are driven by one large release quantity to water reported by a chemical manufacturing facility for 2008. Excluding that quantity, releases in Mexico from 2008–2017 were similar to releases reported by Australia.

Trend Analyses

Reported nickel releases totalled across the seven PRTRs over the 2008 to 2017 timeframe decreased by 1.1 million kg (68%) from 2008 to 2017, driven by a considerable drop in releases reported by one facility in Mexico from 2008 to 2009. If releases reported by Mexico are excluded, releases across the other six PRTRs decreased from 970,000 kg in 2008 to 460,000 kg in 2017, a 53% decrease. Regression analysis indicates that the downward trend is statistically significant, regardless of whether releases reported by Mexico are included[35] or not[36] ($p<0.05$).

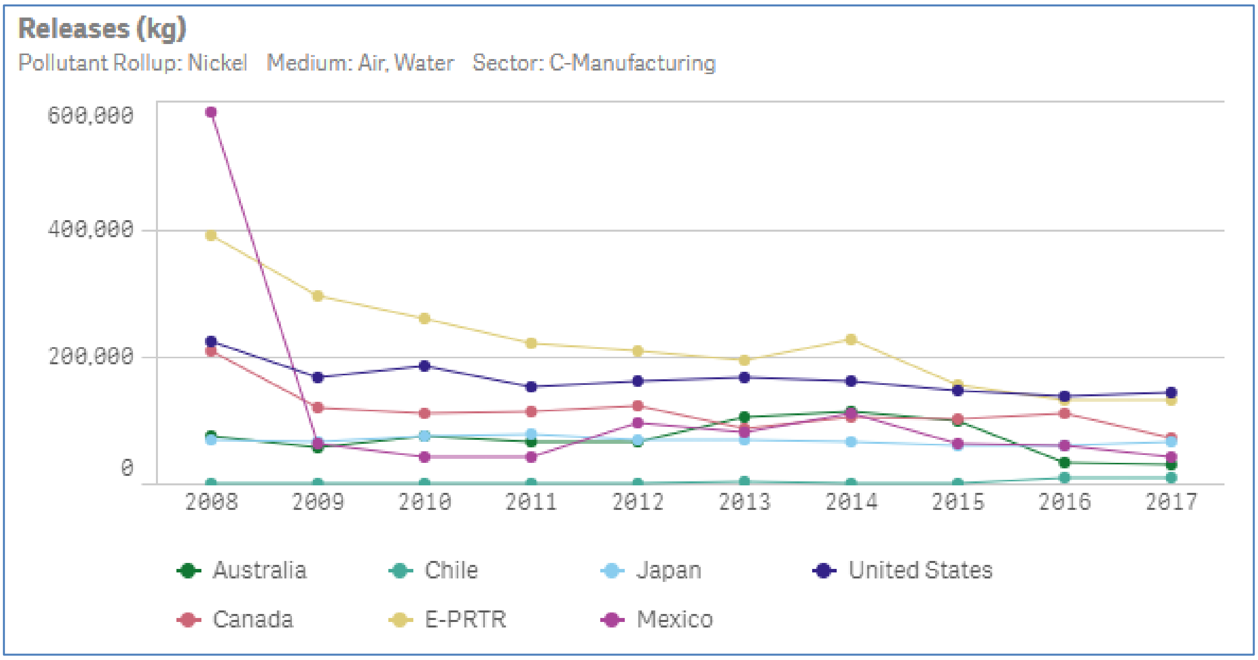
Nickel releases significantly decreased from 2008 to 2017



Nickel releases reported to most PRTRs decreased from 2008 to 2017:

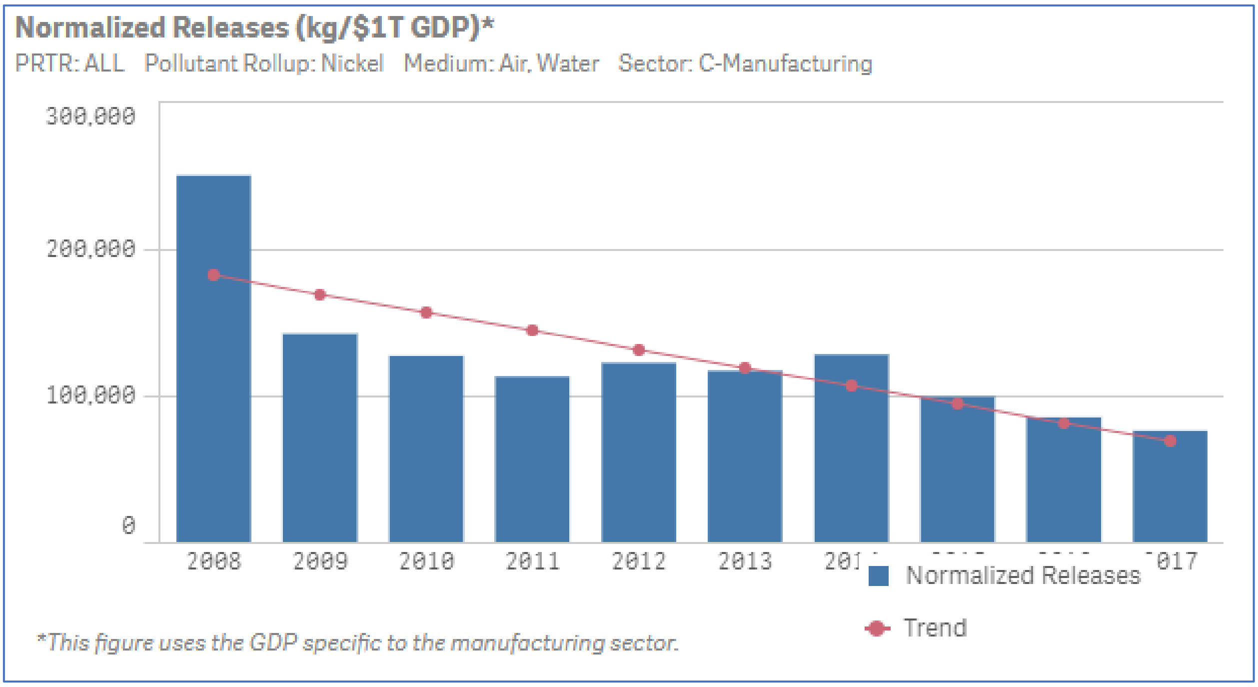
- Releases decreased by 540,000 kg in Mexico, driven by a 520,000 kg decrease from 2008 to 2009. Releases decreased by 19,000 kg in Mexico from 2009 to 2017.
- Releases decreased considerably in the E-PRTR (260,000 kg decrease) and Canada (140,000 kg decrease) from 2007 to 2017.
- Releases decreased by smaller amounts in the U.S. (78,000 kg), Australia (44,000 kg), and Japan (3,600 kg).
- In Chile, nickel releases increased by 6,400 kg (225%), but releases of nickel in 2017 were still only a fraction of the release quantities reported by other PRTRs.

Nickel releases decreased in most PRTRs



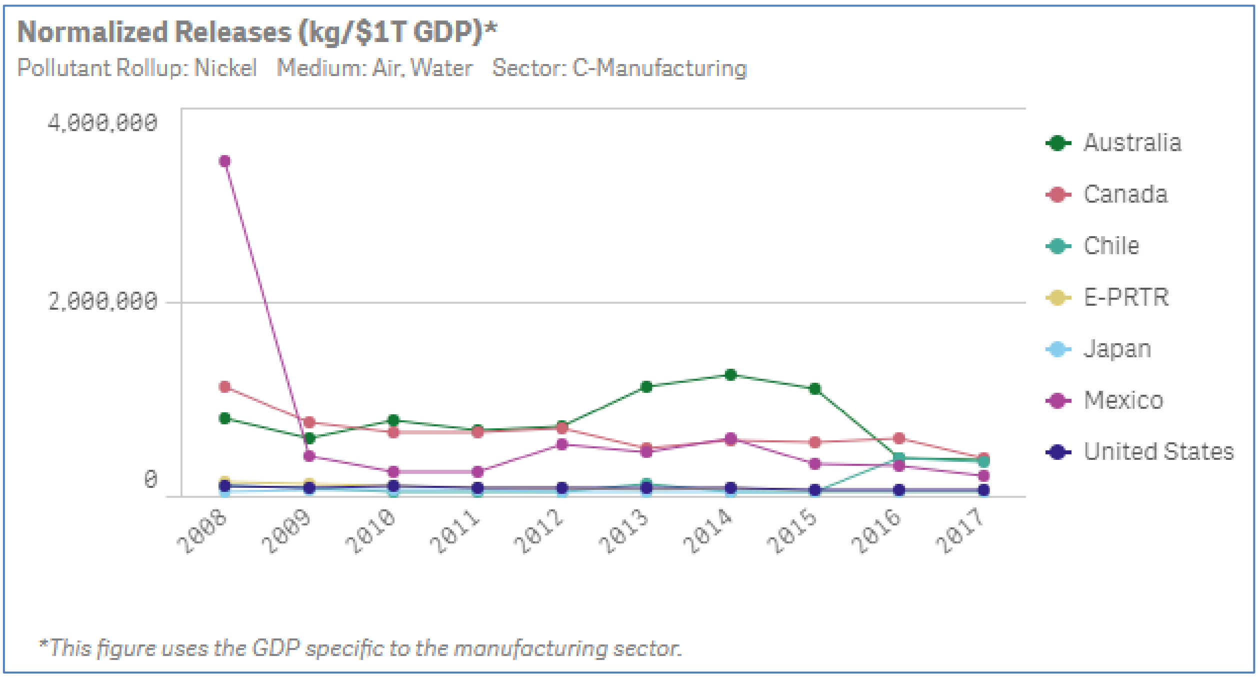
Releases of nickel were normalized by the annual gross domestic product (GDP) for the manufacturing sector of the PRTR's country or region. Normalized releases provide a metric to compare a country's release levels per unit of economic activity in the country. Releases are related to economic activity, as higher manufacturing economic activity usually means more goods are being produced. Chemical releases are associated with these manufacturing processes, so more manufacturing is typically associated with more chemical releases. Normalizing releases controls for the differences in production levels between countries and over time. The trend in normalized releases approximates how releases would have changed if the amount of manufacturing activity had remained constant. As shown in the figure below, nickel releases across the seven PRTRs, when normalized by the combined manufacturing GDPs of their countries/regions, show a statistically significant downward trend ($p<0.05$), whether releases reported by Mexico are included[37] or not.[38]

Normalized nickel releases significantly decreased from 2008 to 2017



Compared among PRTRs, GDP-normalized trends in releases of nickel among PRTRs show that Australia and Canada had the highest normalized releases, rather than the E-PRTR and the U.S. This indicates that facilities in Canada and Australia released more nickel per unit of manufacturing activity than facilities in other countries. Releases in Australia decreased by 58% while manufacturing GDP decreased by 10%. If manufacturing activity were the primary driver of trends in Australia, releases would be expected to decrease only as much as manufacturing activity decreased. Releases reported in Canada also decreased substantially, while manufacturing GDP in Canada increased. If manufacturing activity were the primary driver of release trends in Canada, releases would be expected to increase as manufacturing activity increased. The decreasing trends in GDP-normalized releases indicate that factors other than manufacturing economic activity were driving nickel releases in Australia and Canada.

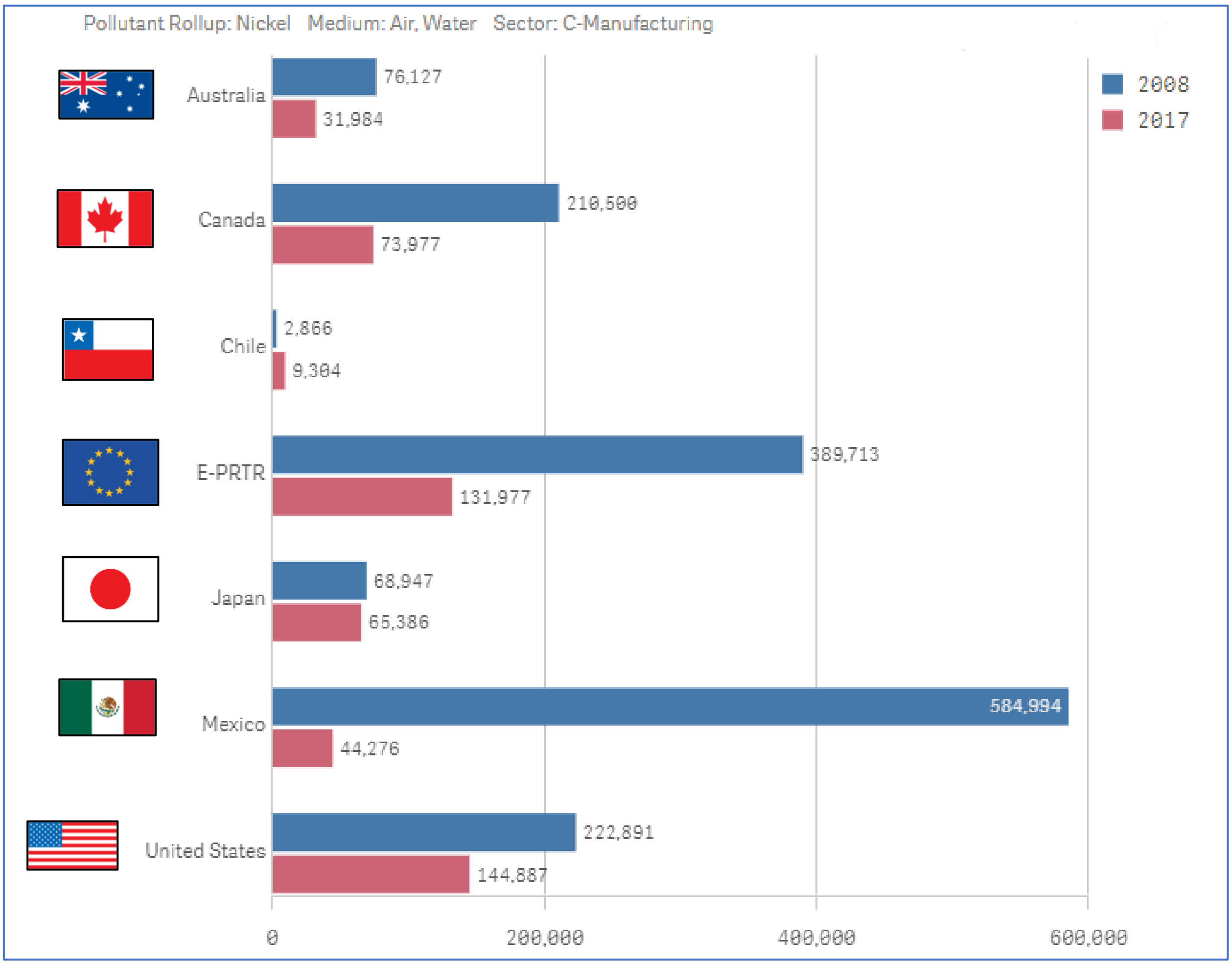
Normalized nickel releases decreased across most PRTRs



Trend in nickel releases to air and water from the manufacturing sector	
Overall change, 2008–2017	Nickel releases decreased by 1.1 million kg (68%) from 2008 to 2017, with a considerable decline from 2008 to 2009 primarily due to reporting by one facility in Mexico. This was part of a significant trend of releases decreasing.
PRTRs with the largest *percent* change in releases, 2008–2017	Chile: 6,400 kg increase (225%) Mexico: 540,000 kg decrease (92%) E-PRTR: 260,000 kg decrease (66%)
PRTRs with the largest *absolute* change in releases, 2008–2017	Mexico: 540,000 kg decrease (92%) E-PRTR: 260,000 kg decrease (66%)
Subsectors with the largest absolute change in releases, 2008–2017	Chemical manufacturing (ISIC 20): 480,000 kg decrease (89%) Basic metals (ISIC 24): 370,000 kg decrease (65%) Coke and refined petroleum products (ISIC 19): 160,000 kg decrease (ISIC 19)
Additional information: The change in releases in Mexico is driven by one facility that reported a 450,000 kg decrease in its releases of nickel from 2008 to 2009. From 2009 to 2017, nickel releases in Mexico decreased by 19,000 kg (30%). This facility also drove the change in releases in the chemical manufacturing subsector. When releases reported by Mexico are excluded, releases from the chemical manufacturing sector decreased by 34,000 kg (40%). Although the percent increase in releases was large in Chile, Chile had low emissions in the base year of 2008, so the absolute increase in releases was relatively small. The 66% (260,000 kg) decrease in releases in the E-PRTR was driven by reduced releases from the coke and refined petroleum products and basic metals manufacturing subsectors.	

Summary

Releases of nickel from manufacturing facilities by PRTR (kg)



- All seven PRTR systems contain information on nickel releases between 2008 to 2017: Australia, Canada, Chile, Europe (i.e., E-PRTR), Japan, Mexico, and the U.S.
- Across the seven PRTRs combined, nickel releases to air and water as reported by facilities in the manufacturing sector decreased by 1.1 million kg (68%) from 2008 to 2017. Much of the decrease is attributable to one facility in Mexico, which reported a decrease of 450,000 kg released from 2008 to 2009. The decrease in releases across the other PRTRs is smaller but still part of a statistically significant trend (510,000 kg decrease, 53%).
- Nickel releases were lower in 2017 than 2008 in six of the seven PRTR systems examined: Australia, Canada, the E-PRTR, Japan, Mexico, and the U.S.
    - Releases of nickel increased from 2008 to 2017 in Chile from 3,000 kg to 9,000 kg.
- Facilities in the basic metals (ISIC 24) and coke and refined petroleum product manufacturing (ISIC 19) reported the largest release quantities of nickel. Releases from these two subsectors decreased from 2008 to 2017.

Styrene

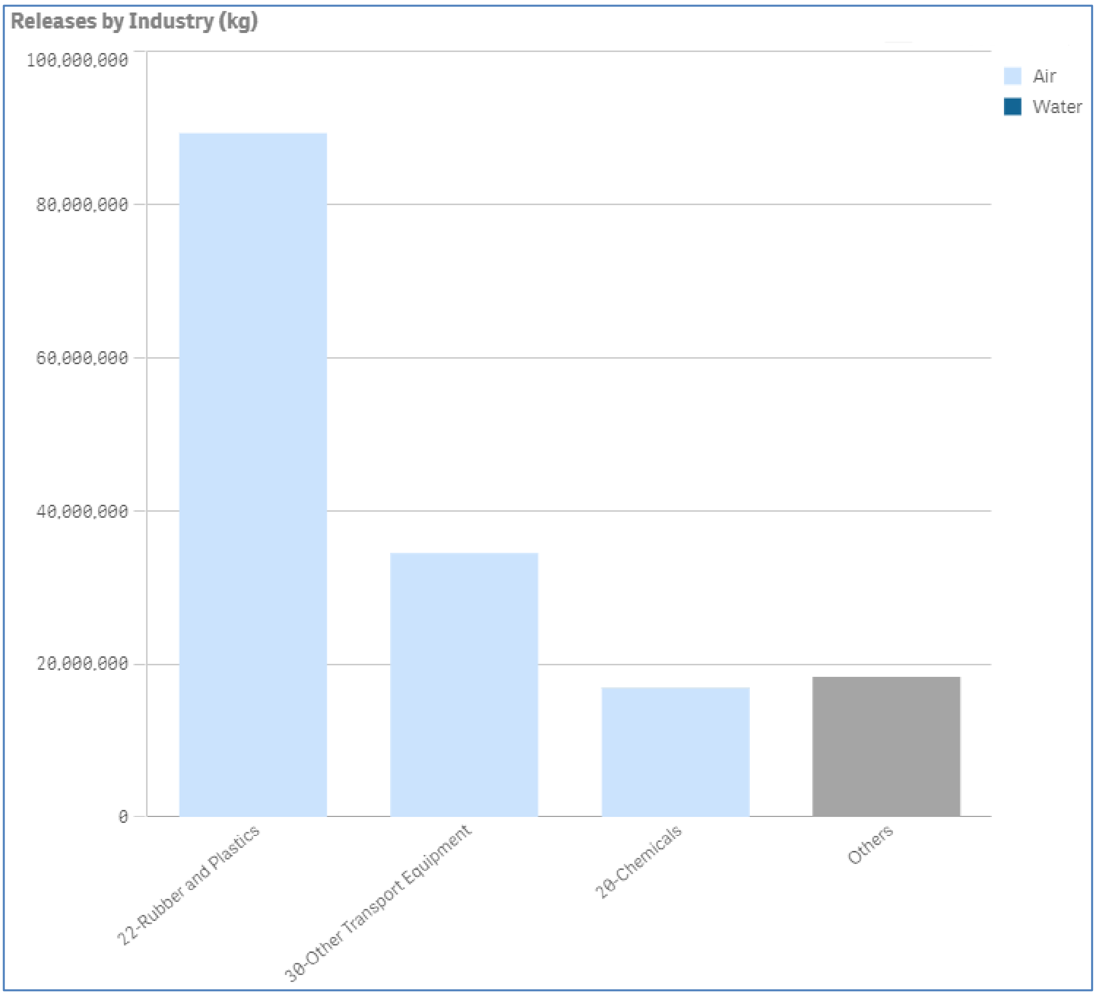
Styrene (CAS 100-42-5) is an aromatic organic chemical. It occurs naturally as a constituent in the sap of some trees, cinnamon, coffee beans, and peanuts, and as a constituent of various plant parts of a variety of plant species. It is also produced synthetically from direct dehydrogenation of ethylbenzene. It is widely used commercially as a feedstock in the production of a variety of products that include plastics, latex paints and coatings, synthetic rubbers, polyesters, and styrene-alkyd coatings, among others. Under ambient conditions it exists as a liquid (NCBI, 2021[38]).[39] According to UN Globally Harmonised System of Classification and Labelling of Chemicals criteria, styrene can be harmful if inhaled, causes skin and eye irritation, is suspected of causing cancer, and causes damage to the central nervous system and the liver following prolonged or repeated exposure (ILO and WHO, 2006[39]).

This analysis focuses on styrene releases as reported to five of the seven pollutant release and transfer register (PRTR) systems chosen for these global-scale analyses: the PRTR systems of Australia, Canada, Japan, the U.S., and Mexico. Styrene is not reported to the E-PRTR or the Chilean PRTR. As described in this project’s Action Plan, the analysis focuses on releases of styrene to air and water by facilities in the manufacturing sector only (OECD, 2018[3]).

Snapshot Analyses

Across all five PRTR systems combined, facilities in the manufacturing sector released styrene almost exclusively to air over the 2008 to 2017 timeframe. The largest releases reported from the manufacturing sector were primarily from three International Standard Industrial Classification (ISIC) system Divisions, as shown in the figure below.[40] The largest releases were from the rubber and plastics subsector (ISIC 22). This subsector reported the largest quantities of styrene releases to every PRTR system for every year from 2008 to 2017.

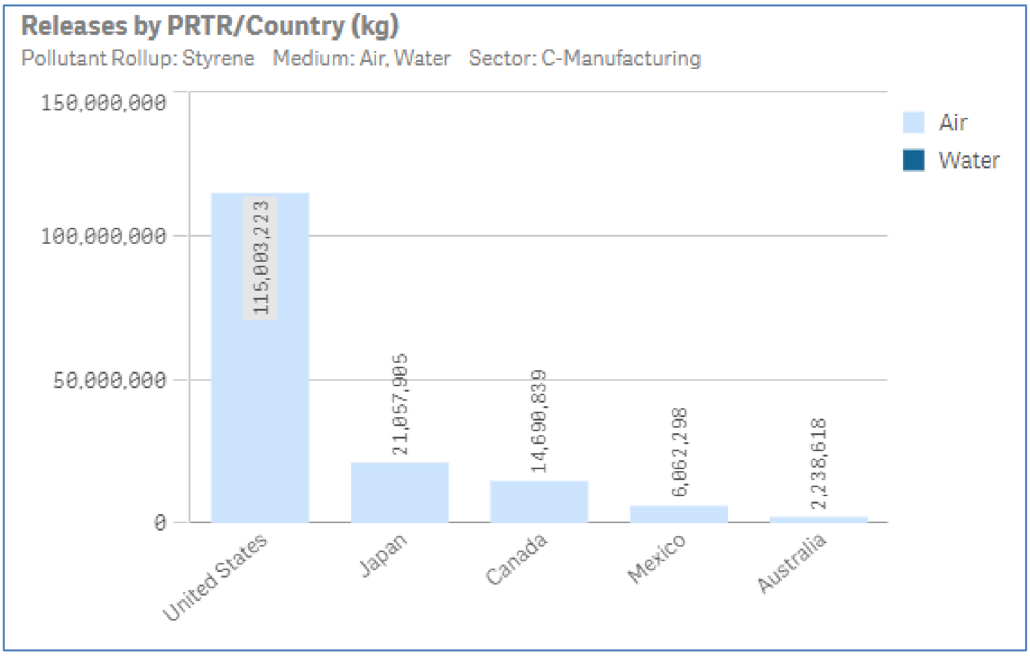
Across PRTRs, from 2008 to 2017, styrene releases were mainly from three subsectors



"Others" includes combined air and water releases from all other manufacturing sectors.

Considered by PRTR, reported releases were largest in the U.S., as shown in the figure below.

From 2008 to 2017, styrene releases were largest in the U.S.

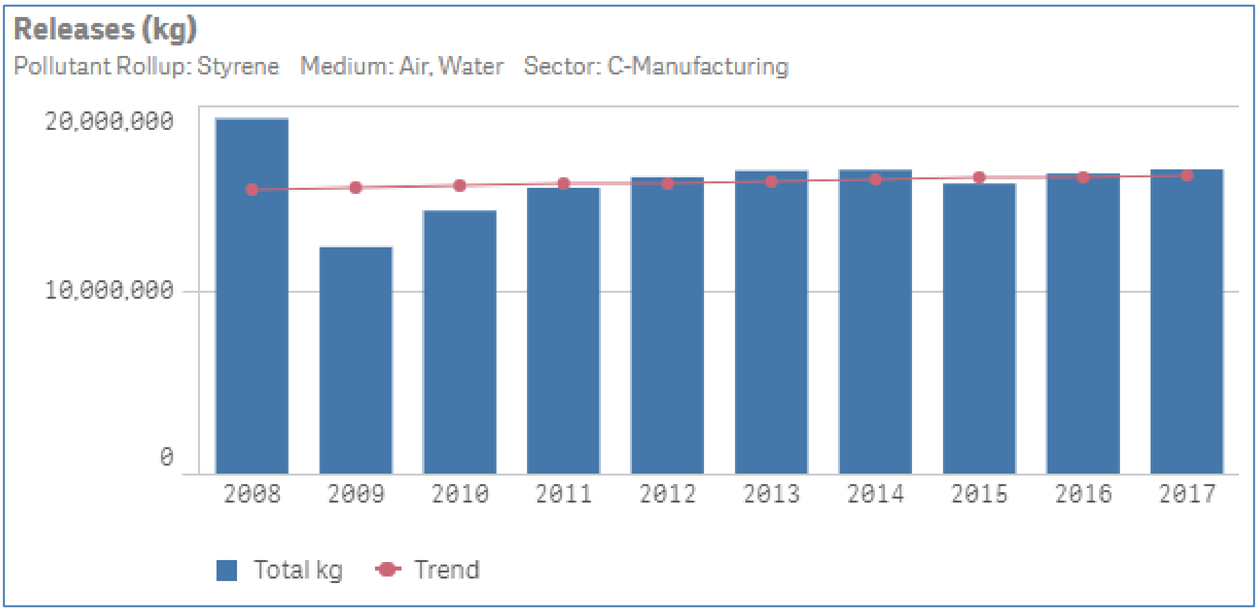


Snapshot of styrene releases to air and water from the manufacturing sector	
Releases, 2017	16.5 million kg
Releases by medium, 2008–2017	99.98% to air
Subsectors with the largest reported releases, 2008–2017	Rubber and plastics (ISIC 22) Other transport equipment (ISIC 30) Chemical manufacturing (ISIC 20)
PRTR with the largest reported releases, 2008–2017	U.S.
Additional information: More than 99% of releases were to air and less than 1% of releases were to water in each of the five PRTRs (i.e., Australia, Canada, Japan, U.S., and Mexico) from 2008 to 2017.	

Trend Analyses

Reported styrene releases across the five PRTRs over the 2008 to 2017 timeframe declined considerably from 2008 to 2009, then increased from 2009 to 2017. Reported releases of styrene decreased from 19 million kg in 2008 to 12 million kg in 2009, a 36% decrease. However, from 2009 onward, releases gradually and significantly trended upward as the global economy recovered from an economic recession ($p<0.05$).[41] Overall, styrene releases from 2008 to 2017 show no statistically significant trend ($p>0.05$).[42]

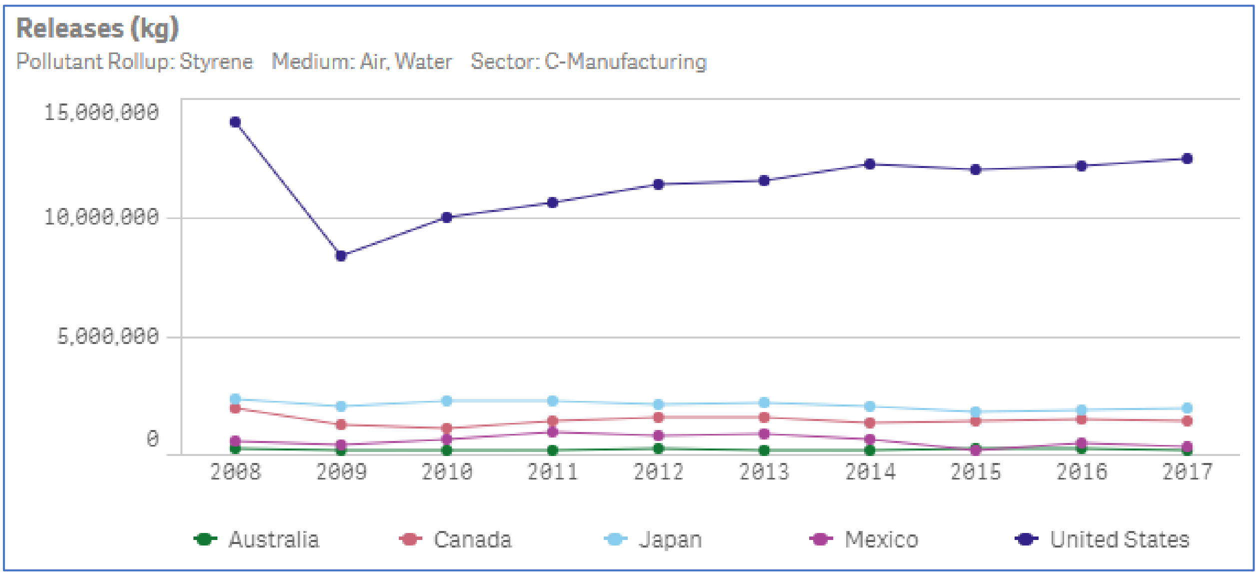
Styrene releases showed no significant trend from 2008 to 2017



Styrene releases decreased in each of the five PRTRs from 2008 to 2009, followed by increasing or fluctuating releases in each PRTR from 2009 to 2017:

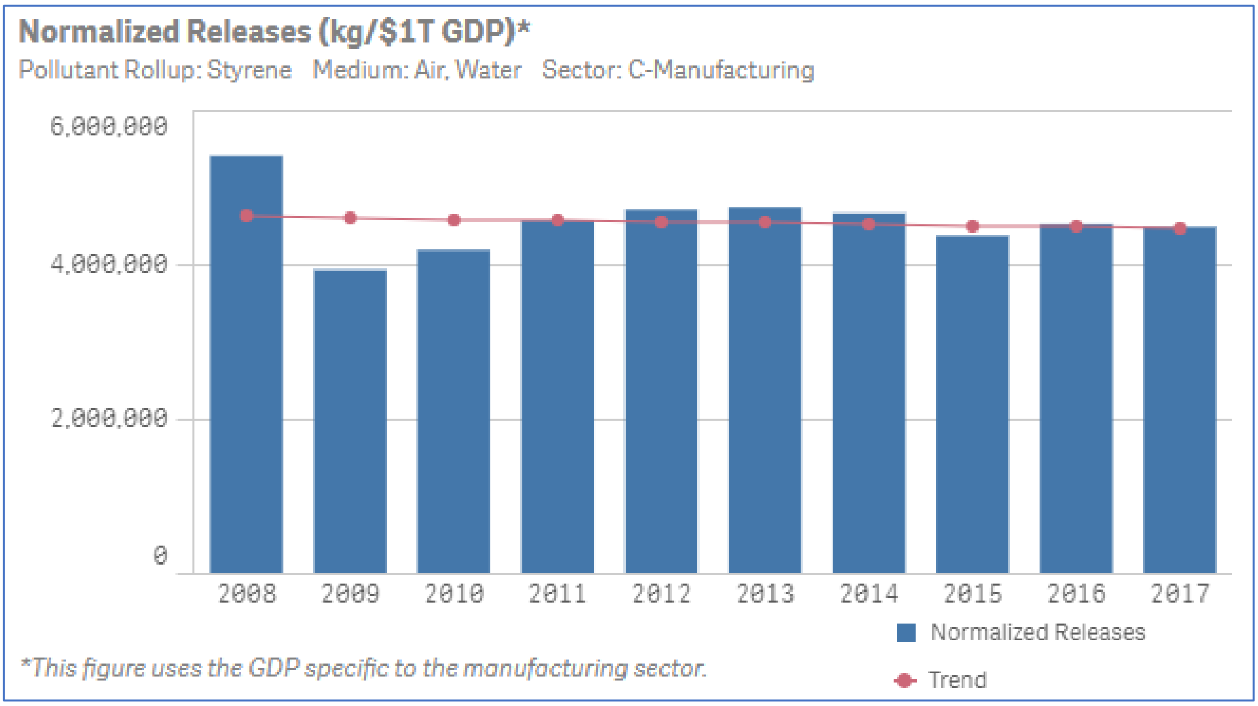
- Releases decreased considerably from 2008 to 2009 in all five PRTRs. Most countries in this analysis were suffering from the global economic recession at this time; the decrease in styrene releases may have been caused by decreased manufacturing activity.
- Releases decreased from 2008 to 2017 most substantially in the U.S. (by 1.5 million kg) based on a 5.7 million kg decrease from 2008 to 2009, followed by a 4.2 million kg increase in subsequent years. In the U.S., releases of styrene decreased in every manufacturing subsector from 2008 to 2009 but overall decreases were driven by large reductions in releases from the rubber and plastics (ISIC 22) and other transport equipment (ISIC 30) subsectors. From 2009 to 2017, large increases in styrene releases by those two subsectors drove the increased styrene releases in the U.S.
- Releases decreased by smaller amounts from 2008 to 2017 in Canada (520,000 kg decrease), Japan (390,000 kg decrease), Mexico (260,000 kg decrease) and Australia (27,000 kg decrease).

Styrene releases fluctuated in most PRTRs



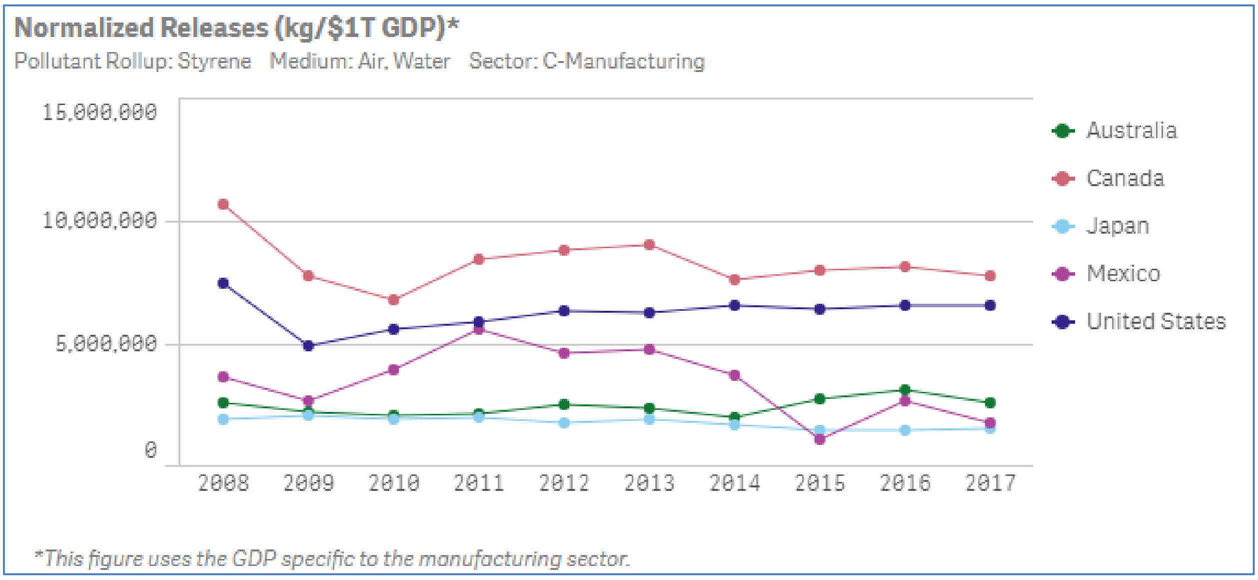
Releases of styrene were normalized by the annual gross domestic product (GDP) for the manufacturing sector of the PRTR's country or region. Normalized releases provide a metric to compare a country's release levels per unit of economic activity in the country. Releases are related to economic activity, as higher manufacturing economic activity usually means more goods are being produced. Chemical releases are associated with these manufacturing processes, so more manufacturing is typically associated with more chemical releases. Normalizing releases controls for the differences in production levels between countries and over time. The trend in normalized releases approximates how releases would have changed if the amount of manufacturing activity had remained constant. As shown in the figure below, styrene releases across the five PRTRs, when normalized by the combined manufacturing GDPs of their countries/regions, do not show a statistically significant trend (p>0.05).[43]

Normalized styrene releases showed no significant trend from 2008 to 2017



Compared among PRTRs, GDP-normalized trends in releases of styrene show that Canada had the highest normalized releases every year, rather than the U.S. This indicates that facilities in Canada released more styrene per unit of manufacturing activity than facilities in other countries. Releases in Canada generally followed the trend of manufacturing GDP in Canada, although Canada's manufacturing GDP increased from 2011 to 2017 while styrene releases slightly decreased. This indicates that manufacturing activity may be a driver of styrene releases in Canada, but other factors also affect the country's styrene releases.

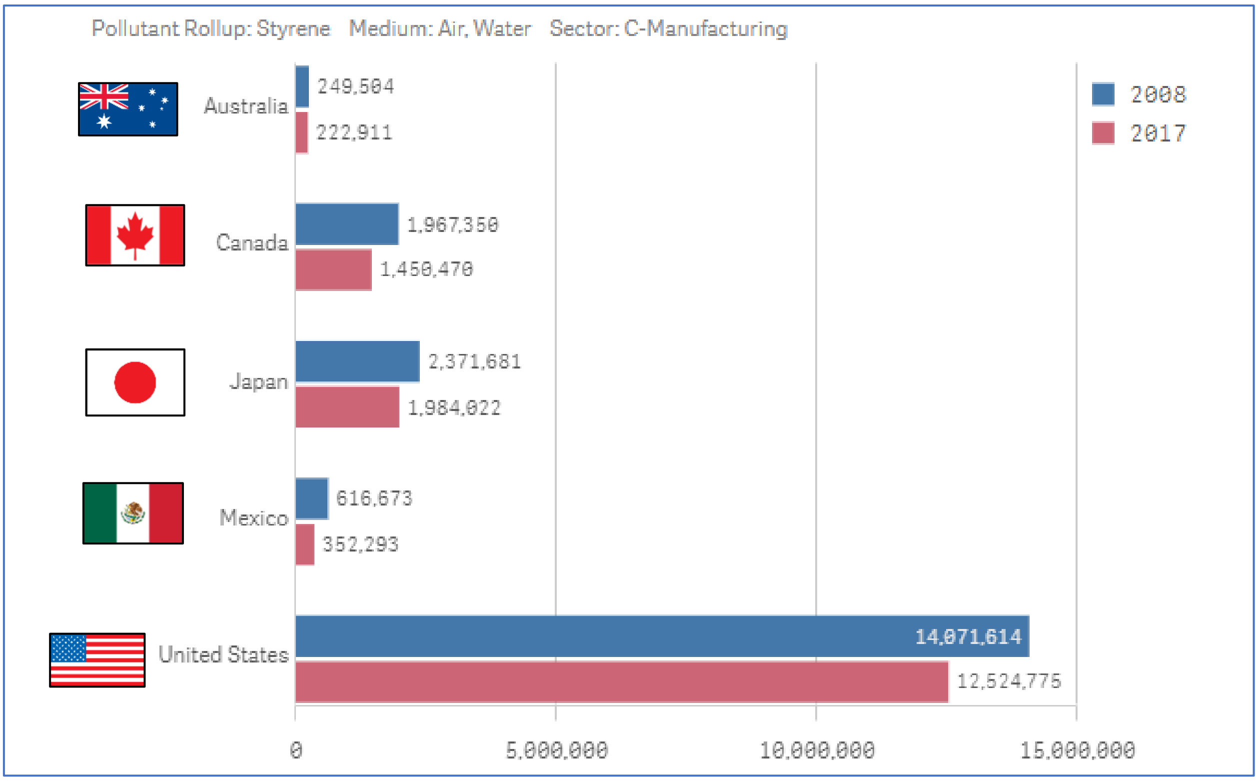
Normalized styrene releases fluctuated between 2008 and 2017



Trend in styrene releases to air and water from the manufacturing sector	
Overall change, 2008–2017	Releases decreased by 2.7 million kg (14%). This was not part of a significant trend of releases increasing or decreasing.
PRTRs with the largest *percent* change in releases, 2008–2017	Mexico: 260,000 kg decrease (43%) Canada: 520,000 kg decrease (26%)
PRTR with the largest *absolute* change in releases, 2008–2017	U.S.: 1.5 million kg decrease (11%)
Subsectors with the largest absolute change in releases, 2008–2017	Other transportation equipment (ISIC 30): 760,000 kg decrease (16%) Rubber and plastics (ISIC 22): 730,000 kg decrease (7%)
Additional information: Releases decreased in every country from 2008 to 2017 but increased overall from 2009 to 2017. The largest percentage decrease in styrene releases between 2008 and 2017 occurred in Mexico. Styrene releases in Mexico were driven by one facility, which did not report any styrene releases in 2017 after reporting more styrene release quantities than any other Mexican facility in most other years. This facility reported 270,000 kg of styrene releases in 2008, accounting for the country-wide decrease in styrene releases from 2008 to 2017.	

Summary

Releases of styrene from manufacturing facilities by PRTR (kg)



- Five of the seven PRTR systems contain information on styrene releases between 2008 and 2017: Australia, Canada, Japan, Mexico, and the U.S. The E-PRTR and Chilean PRTR do not contain information on styrene releases.

- Across the five PRTRs combined, styrene releases to air and water as reported by facilities in the manufacturing sector decreased by 2.7 million kg (14%) from 2008 to 2017.
    - Although styrene releases dropped sharply from 2008 to 2009, releases were only 14% lower in 2017 than 2008 due to increasing releases in other years. No significant trend in styrene releases was evident across these five PRTRs from 2008 through 2017.
- Styrene releases were lower in 2017 than 2008 in each of the five PRTR systems examined.
- Facilities in the rubber and plastics (ISIC 22), other transport equipment (ISIC 30), and chemicals (ISIC 20) subsectors reported the largest release quantities of styrene. Styrene releases from these subsectors decreased from 2008 to 2017.

Tetrachloroethylene

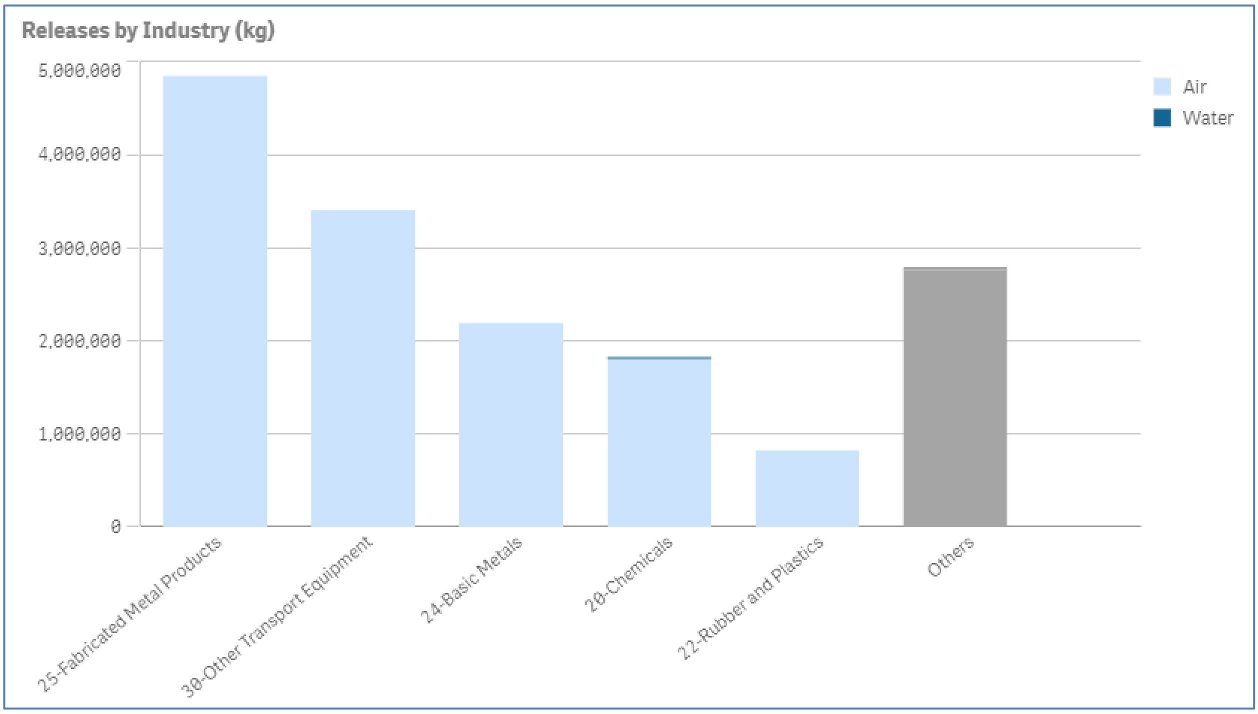
Tetrachloroethylene (CAS 127-18-4) is a volatile organic chemical that exists as a liquid under ambient conditions (NCBI, 2021[40]).[44] It is naturally produced in the environment by several species of marine algae (WHO, 2006[41]). Synthetically produced tetrachloroethylene is used commercially as a chemical intermediate in the production of other chemicals, a cleaning and degreasing agent, and a component of textile manufacture. It is found in household cleaning and adhesive products (NCBI, 2021[40]). Tetrachloroethylene is considered toxic to aquatic life with long-term effects. It is associated with a range of acute and long-term health effects including dermatitis, liver and kidney impairments, and central nervous system impairments (ILO and WHO, 2013[42]).

This analysis focuses on tetrachloroethylene releases as reported to the following six of the seven pollutant release and transfer register (PRTR) systems chosen for these global-scale analyses: the PRTR systems of Australia, Canada, Chile, Europe (i.e., the E-PRTR), Japan, and the U.S. Tetrachloroethylene is not reported to the Mexican PRTR. As described in this project’s Action Plan, the analysis focuses on releases of tetrachloroethylene to air and water by facilities in the manufacturing sector only (OECD, 2018[3]).

Snapshot Analyses

Across all PRTR systems combined, facilities in the manufacturing sector released tetrachloroethylene almost exclusively to air over the 2008 to 2017 timeframe. The largest releases reported from the manufacturing sector were from several International Standard Industrial Classification system (ISIC) Divisions, as shown in the figure below.[45] The largest releases were reported by the fabricated metal products (ISIC 25) and other transportation equipment manufacturing (ISIC 30) subsectors. These subsectors together accounted for 52% of tetrachloroethylene releases reported from 2008 to 2017.

Across PRTRs, from 2008 to 2017, tetrachloroethylene releases were mainly from five subsectors

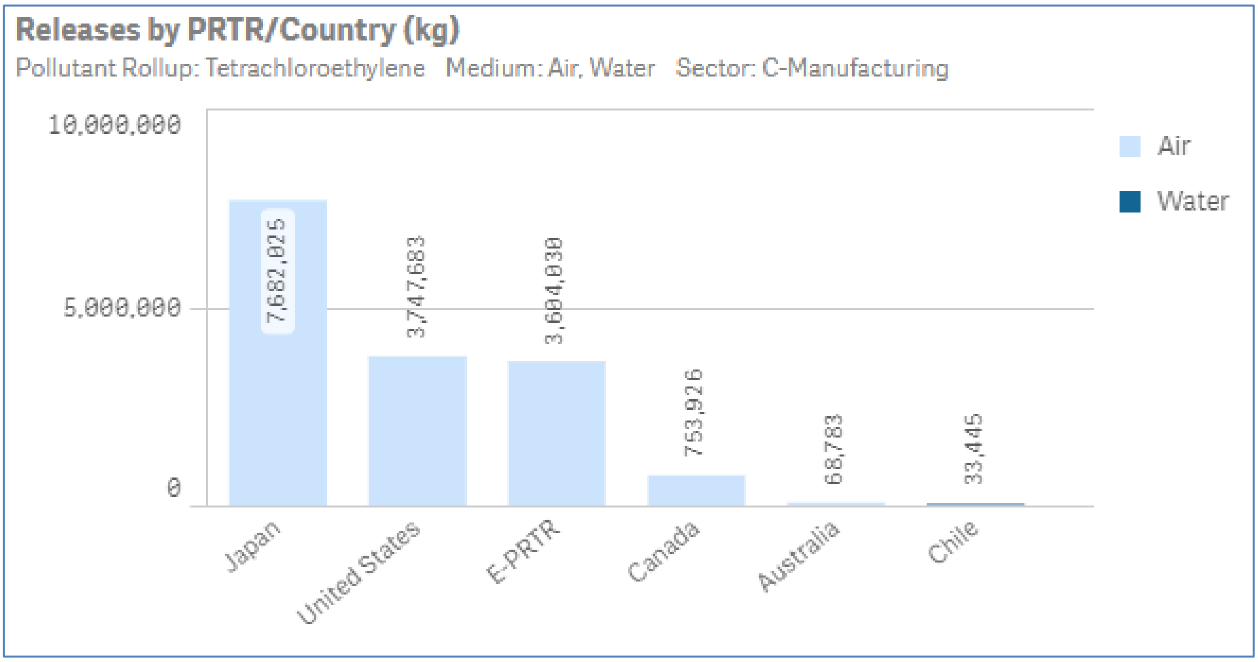


"Others" includes combined air and water releases from all other manufacturing subsectors.

Considered by PRTR, reported releases were largest in Japan, as shown in the figure below. Note that the reporting threshold for tetrachloroethylene in Japan is lower than for many of the other PRTRs examined. In Japan, facilities must report information about releases of tetrachloroethylene if they handled 1,000 kg or more of tetrachloroethylene that year. For comparison, facilities in the U.S. are required to report if they manufacture or process 25,000 pounds (11,340 kg) or otherwise use 10,000 pounds (4,536 kg) of tetrachloroethylene. Facilities' releases of this chemical are included in the E-PRTR if they released at least 2,000 kg to air or at least 10 kg to water. Based on the differences in thresholds, the Japanese PRTR is expected to capture a larger portion of all releases in the country than other PRTRs.

One way to estimate the effect of thresholds is to exclude releases that would not have met reporting thresholds in other countries. For tetrachloroethylene, the highest reporting threshold is the 25,000-pound (11,340-kg) manufacturing/processing threshold in the U.S. Therefore, it is certain that any release of more than 11,340 kg would have met reporting thresholds for any of the six PRTRs. Even when considering only releases of more than 11,340 kg (i.e., releases large enough that a facility would have to report in any of the six PRTRs), releases reported in Japan are still larger than for any other PRTR. Therefore, it appears that lower reporting thresholds are not the only reason why reported releases are largest in Japan.

From 2008 to 2017, tetrachloroethylene releases were largest in Japan

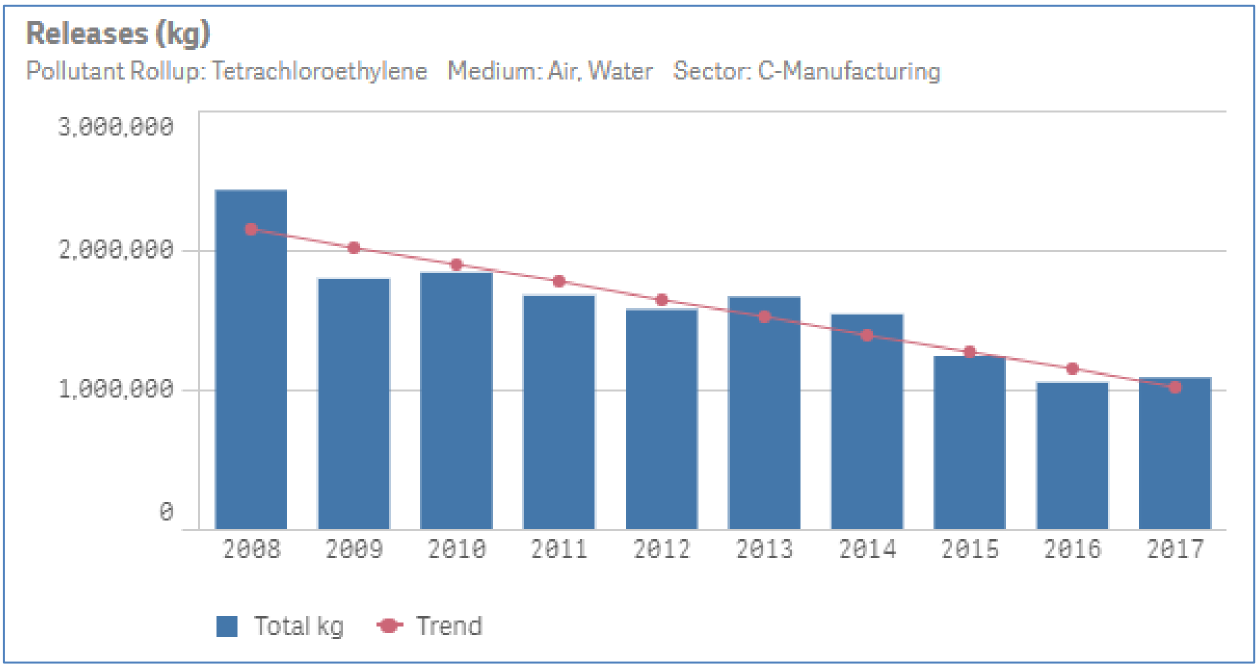


Snapshot of tetrachloroethylene releases to air and water from the manufacturing sector	
Releases, 2017	1.1 million kg
Releases by medium, 2008–2017	99.7% to air
Subsectors with the largest reported releases, 2008–2017	Fabricated metal products (ISIC 25) Other transportation equipment (ISIC 30)
PRTR with the largest reported releases, 2008–2017	Japan
Additional information: Releases of tetrachloroethylene reported by Chile were exclusively releases to water. Japan reported the highest tetrachloroethylene releases every year from 2008 to 2017. Releases reported to Japan account for 48% of the tetrachloroethylene releases reported to the six PRTRs in this analysis from 2008 to 2017. Releases from the fabricated metal products subsector accounted for the majority of releases in Japan.	

Trend Analyses

Reported tetrachloroethylene releases across the six PRTRs over the 2008 to 2017 timeframe have been trending down, from a high of 2.4 million kg in 2008 to 1.1 million kg in 2017—a 55% decrease. Regression analysis indicates that the downward trend in releases was statistically significant based on all 10 years of data ($p<0.05$).[46] The decline was driven by the fabricated metal products (ISIC 25) and other transportation equipment manufacturing (ISIC 30) subsectors. Reported releases were larger in 2008 than other years, with a 640,000 kg decrease between 2008 and 2009. This reduction in releases was likely driven by the global economic recession at this time.

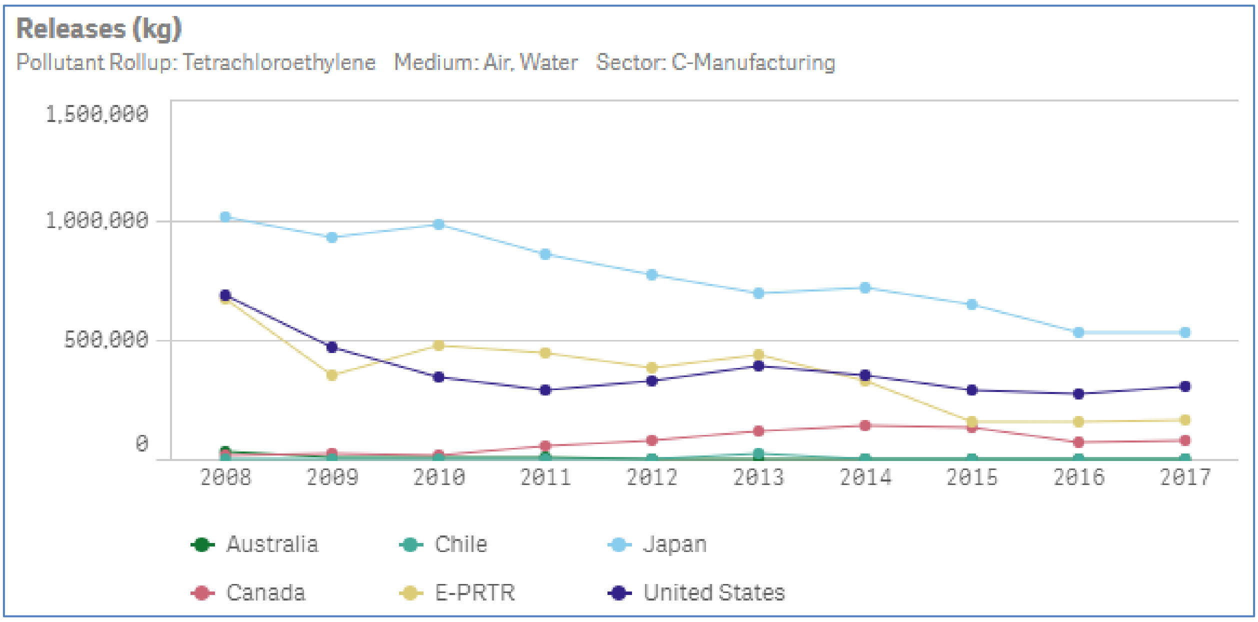
Tetrachloroethylene releases significantly decreased from 2008 to 2017



Tetrachloroethylene releases decreased for most PRTRs from 2008 to 2017:

- Releases decreased in the E-PRTR (510,000 kg decrease), Japan (480,000 kg decrease), the U.S. (380,000 kg decrease), and Australia (34,000 kg decrease).
- Releases increased in Canada (57,000 kg increase) and Chile (190 kg increase).
  - Releases in Chile were smaller than in any other PRTR—in the hundreds of kilograms most years.
  - Releases in Canada were driven by one facility that reported 62% of the country's tetrachloroethylene releases from 2008 to 2017.
- Releases reported by most manufacturing subsectors decreased from 2008 to 2017. The subsector with the largest decrease in releases was the other transportation equipment manufacturing subsector, which reported 640,000 kg released in 2008 and 190,000 kg released in 2017, a 71% decrease. The fabricated metals manufacturing subsector also reported a large decrease, of 410,000 kg (59%).

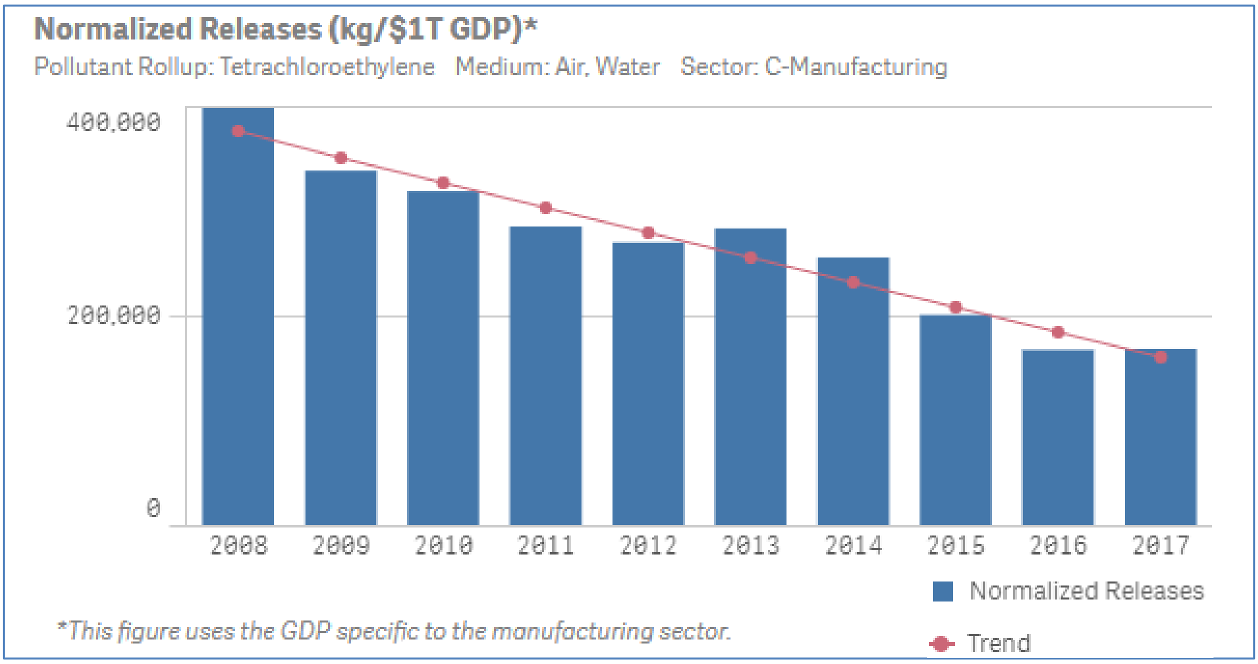
Tetrachloroethylene releases decreased in four of the six PRTRs



This figure includes PRTRs with comparatively low releases (i.e., Australia and Chile), though they may not be visible at this scale.

Releases of tetrachloroethylene were normalized by the annual gross domestic product (GDP) for the manufacturing sector of the PRTR's country or region. Normalized releases provide a metric to compare a country's release levels per unit of economic activity in the country. Releases are related to economic activity, as higher manufacturing economic activity usually means more goods are being produced. Chemical releases are associated with these manufacturing processes, so more manufacturing is typically associated with more chemical releases. Normalizing releases controls for the differences in production levels between countries and over time. The trend in normalized releases approximates how releases would have changed if the amount of manufacturing activity had remained constant. As shown in the figure below, tetrachloroethylene releases across the six PRTRs, when normalized by the combined manufacturing GDPs of their countries/regions, show a statistically significant downward trend ($p<0.05$).[47]

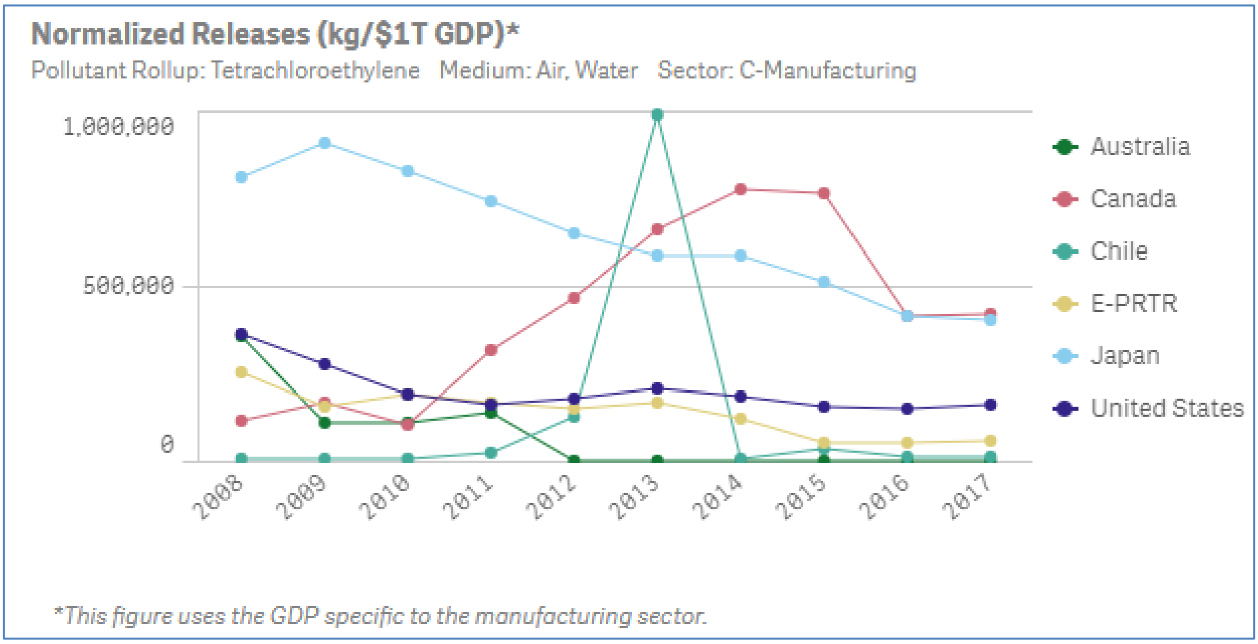
Normalized tetrachloroethylene releases significantly decreased from 2008 to 2017



Compared among PRTRs, GDP-normalized trends in releases of tetrachloroethylene show that Japan and Canada had the highest normalized releases in recent years. This indicates that facilities in Japan and Canada released more tetrachloroethylene per unit of manufacturing activity than facilities in other countries. Releases of tetrachloroethylene decreased in Japan from 2008 to 2017 as the country's manufacturing GDP increased by 6%. If manufacturing activity were the primary driver of release trends in Japan, releases would be expected to increase as manufacturing activity increased. In Canada, releases more than tripled from 2008 to 2017 as manufacturing GDP increased by 1.5%. If manufacturing activity were the primary driver of release trends in Canada, releases would be expected to increase only slightly as GDP increased slightly. The considerable increase in GDP-normalized releases in Canada indicates that factors other than total manufacturing economic activity were driving tetrachloroethylene releases in the country.

Normalized releases spiked in Chile in 2013 due to a 25,000 kg release reported by one facility. Although facilities in other countries often reported larger releases, this release quantity is large relative to other releases reported in Chile. While this release is small compared to the quantities released in other PRTRs, Chile's manufacturing GDP is much smaller than the other PRTRs, resulting in high normalized releases for 2013.

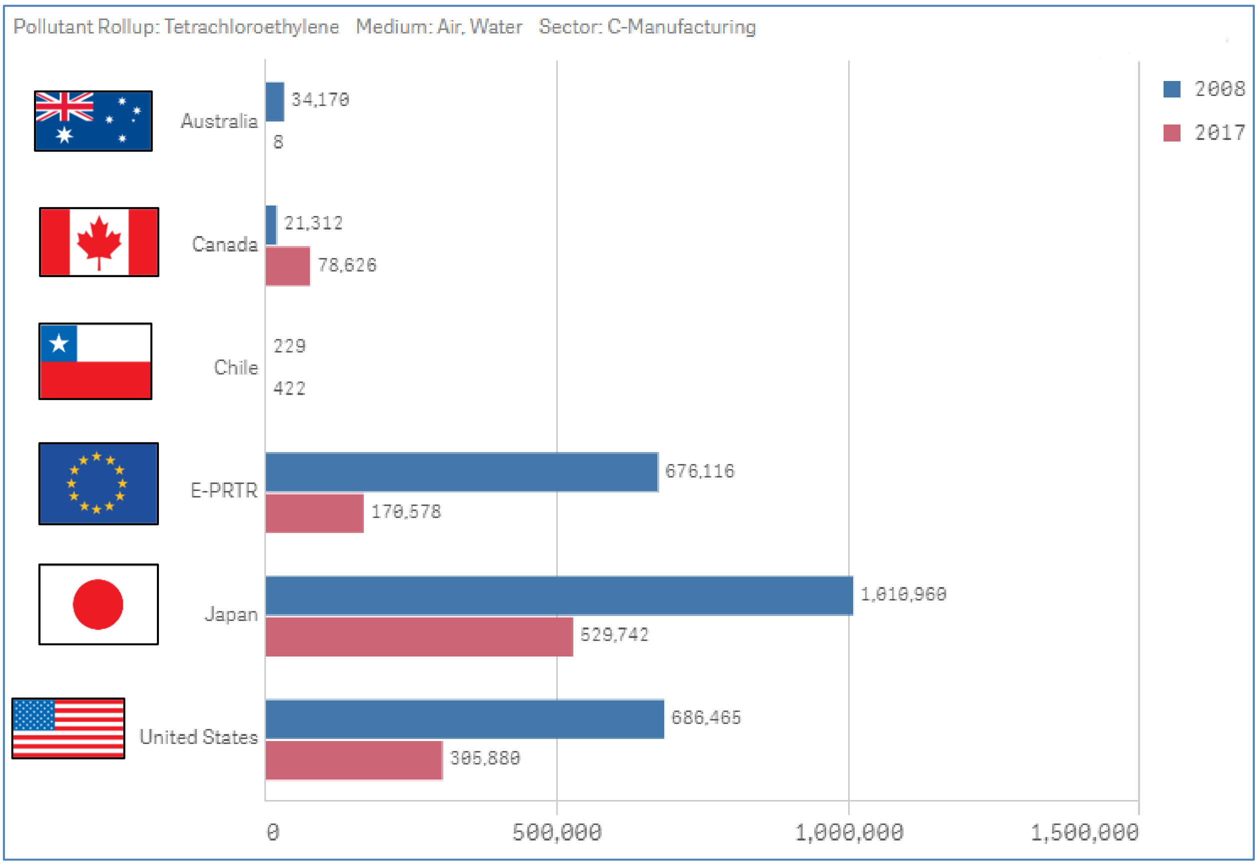
Normalized tetrachloroethylene releases decreased in four PRTRs and increased in two PRTRs



Trend in tetrachloroethylene releases to air and water from the manufacturing sector	
Overall change, 2008–2017	Releases decreased by 1.3 million kg (55%). This was part of a significant trend of releases decreasing.
PRTRs with largest *percent* change in releases, 2008–2017	Canada: 57,000 kg increase (270%) Australia: 34,000 kg decrease (99.98%) Chile: 190 kg increase (84%)
PRTRs with largest *absolute* change in releases, 2008–2017	E-PRTR: 510,000 kg decrease (75%) Japan: 480,000 kg decrease (48%)
Subsectors with the largest absolute change in releases, 2008–2017	Other transportation equipment (ISIC 30): 450,000 kg decrease (71%) Fabricated metals (ISIC 25): 410,000 kg decrease (59%)
Additional information: Releases in Canada were driven by a single facility. Releases in Australia decreased from 34,000 kg in 2008 to 8 kg in 2017. The absolute decrease in releases was driven by decreased releases in the E-PRTR, Japan, and the U.S.	

Summary

Releases of tetrachloroethylene from manufacturing facilities by PRTR (kg)



- Six of the seven PRTR systems contain information on tetrachloroethylene releases between 2008 and 2017: Australia, Canada, Chile, the E-PRTR, Japan, and the U.S. The Mexican PRTR does not contain information on tetrachloroethylene releases.
- Across the six PRTRs combined, tetrachloroethylene releases to air and water as reported by facilities in the manufacturing sector decreased by 1.3 million kg (55%) from 2008 to 2017.
  - Both normalized and absolute releases of tetrachloroethylene decreased significantly across these six PRTRs from 2008 to 2017.
- Tetrachloroethylene releases were lower in 2017 than 2008 in four of the six PRTR systems examined: Australia, the E-PRTR, Japan, and the U.S.
  - Releases of tetrachloroethylene increased by a very small amount in Chile and increased more substantially in Canada.
- Facilities in the fabricated metals subsector (ISIC 25) reported the largest release quantities of tetrachloroethylene. Releases from this subsector decreased from 2008 to 2017.

Trichloroethylene

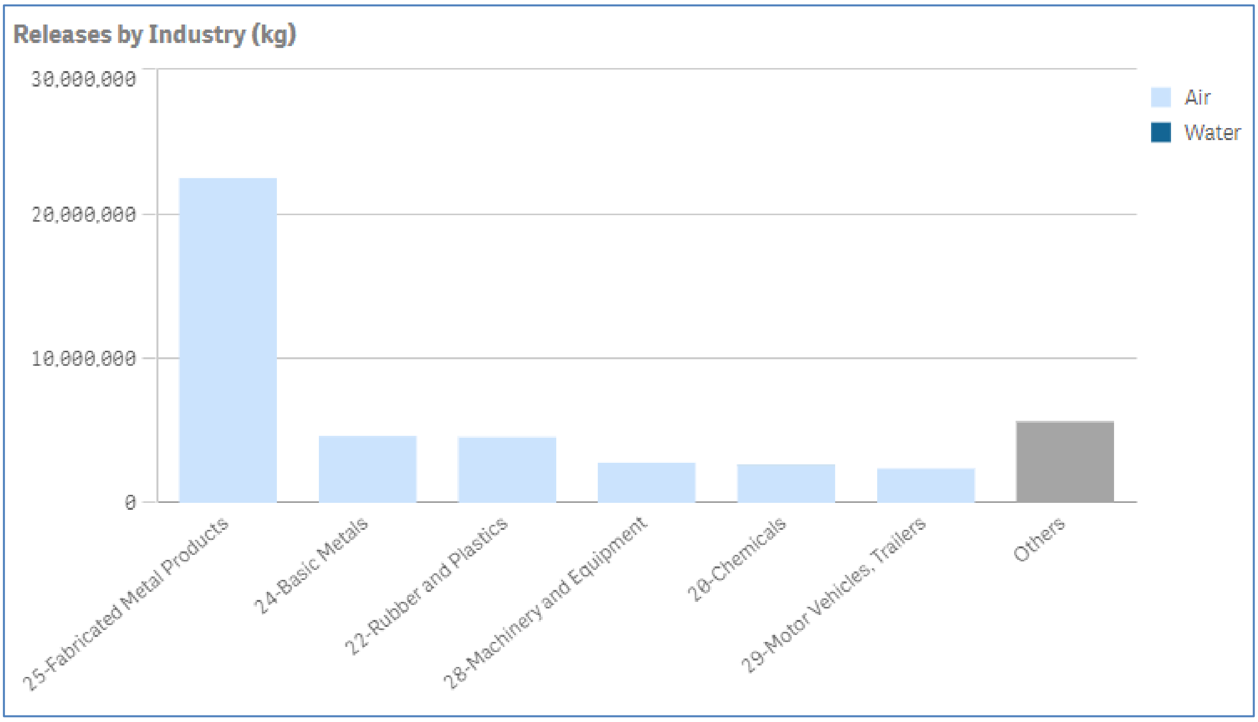
Trichloroethylene (CAS 79-01-6) is a volatile organic chemical that exists as a liquid under ambient conditions (NCBI, 2021[43]).[48] It is naturally produced in the environment by several species of marine algae (NCBI, 2021[43]). It is also synthetically produced. Trichloroethylene is a component of many paint solvents and degreasing agents, and it is used commercially in the production of other chemicals, home goods, and dry cleaning agents. Trichloroethylene is considered to have harmful long-term effects on aquatic life. It is also associated with acute and long-term health effects including cancer, immune system disorders, and central nervous system impairments (ILO and WHO, 2013[44]).

This analysis focuses on trichloroethylene releases as reported to six of the seven pollutant release and transfer register (PRTR) systems chosen for these global scale analyses: the PRTR systems of Australia, Canada, Europe (i.e., the E-PRTR), Japan, Mexico, and the U.S. Trichloroethylene is not reported to the Chilean PRTR. As described in this project's Action Plan, the analysis focuses on releases of trichloroethylene to air and water by facilities in the manufacturing sector only (OECD, 2018[3]).

Snapshot Analyses

Across all six PRTR systems combined, facilities in the manufacturing sector released trichloroethylene almost exclusively to air over the 2008 to 2017 timeframe. The largest releases reported from the manufacturing sector were primarily from one International Standard Industrial Classification system (ISIC) Division, the fabricated metal products subsector (ISIC 25), as shown in the figure below.[49] This subsector accounted for 50% of trichloroethylene releases reported from 2008 to 2017 and reported the largest release quantities for every year over this period.

Across PRTRs, from 2008 to 2017, trichloroethylene releases were mainly from the fabricated metal products subsector (ISIC 25)

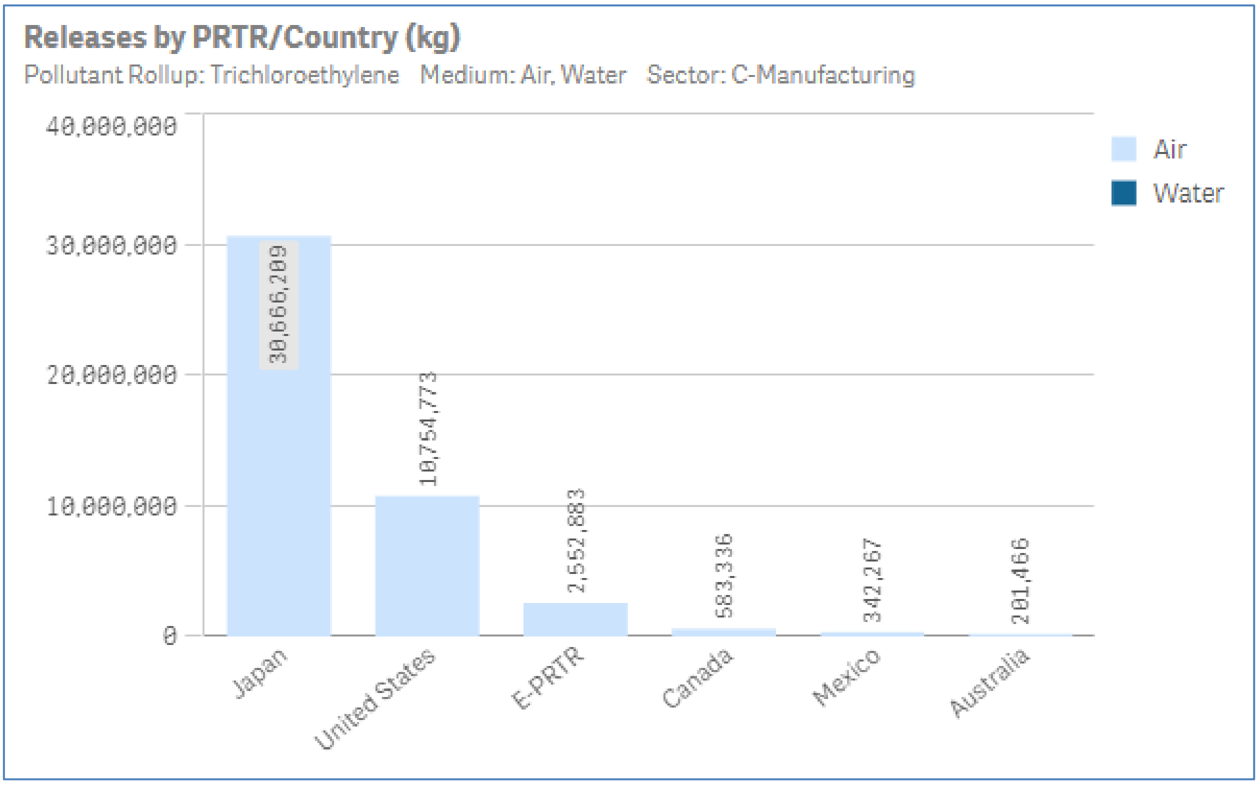


"Others" includes combined air and water releases from all other manufacturing sectors.

Considered by PRTR, reported releases were largest in Japan, as shown in the figure below. Note that the reporting threshold for trichloroethylene in Japan is lower than for many of the other PRTRs examined. In Japan, facilities must report information about releases of trichloroethylene if they handled 1,000 kg or more of trichloroethylene that year. For comparison, facilities in the U.S. are required to report if they manufacture or process more than 25,000 pounds (11,340 kg) or otherwise use more than 10,000 pounds (4,536 kg) of trichloroethylene in a given year. Facilities' releases of this chemical are included in the E-PRTR if they released at least 2,000 kg to air or at least 10 kg to water. Based on the differences in thresholds, the Japanese PRTR is expected to capture a larger portion of all releases in the country than other PRTRs. More than twice as many facilities reported releases of trichloroethylene to the Japanese PRTR than any other PRTR.

One way to estimate the effect of thresholds is to exclude releases that would not have met reporting thresholds in other countries. For trichloroethylene, the highest reporting threshold is the 25,000-pound (11,340-kg) manufacturing/processing threshold in the U.S. Therefore, it is certain that any release of more than 11,340 kg would have met reporting thresholds for any of the six PRTRs. Even when considering only releases of more than 11,340 kg (i.e., releases large enough that a facility would have to report in any of the six PRTRs), releases reported in Japan are more than for all five other PRTRs combined. Therefore, it appears that lower reporting thresholds are not the only reason why reported releases are largest in Japan.

From 2008 to 2017, trichloroethylene releases were largest in Japan



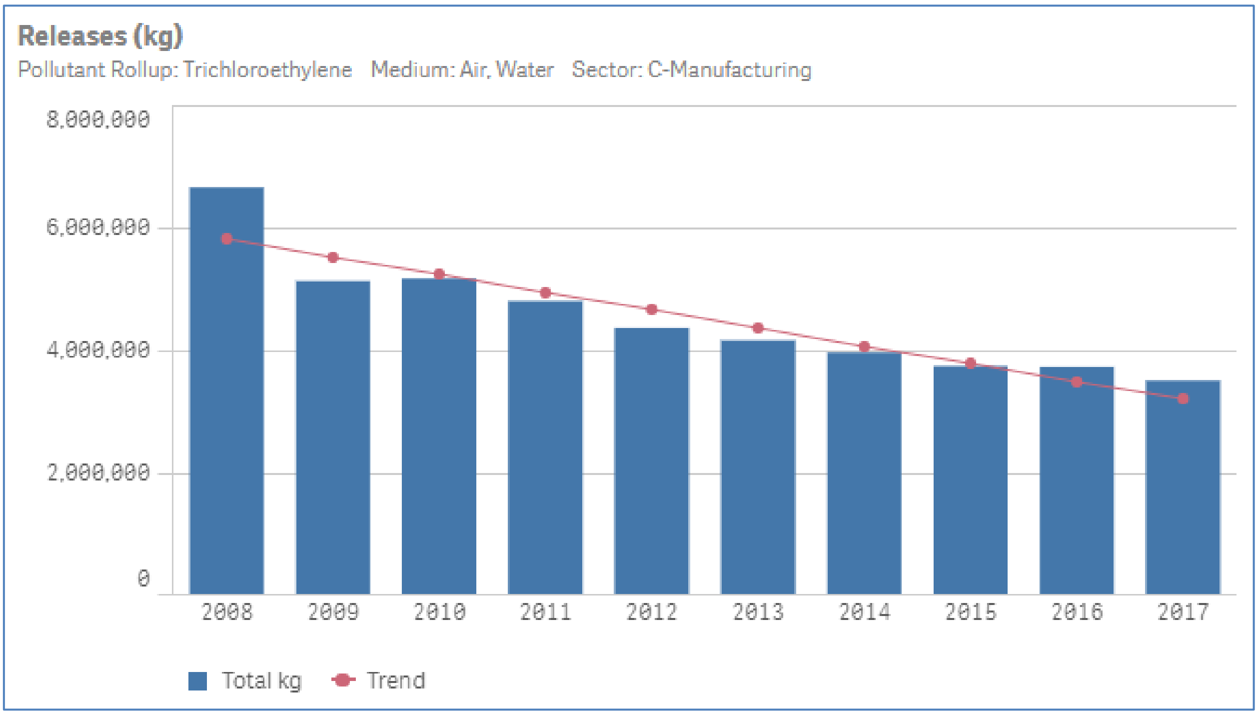
Snapshot of trichloroethylene releases to air and water from the manufacturing sector	
Releases, 2017	3.5 million kg
Releases by medium, 2008–2017	99.9% to air
Subsector with the largest reported releases, 2008–2017	Fabricated metal products (ISIC 25)
PRTR with the largest reported releases, 2008–2017	Japan

Additional information:
In each PRTR, more than 90% of releases were to air and less than 10% of releases were to water.
Releases reported in Japan accounted for 68% of all trichloroethylene releases across the six PRTRs between 2008 and 2017.
Facilities in Japan reported the largest trichloroethylene releases every year between 2008 to 2017.
Releases from the fabricated metal products subsector accounted for the majority of releases in Japan.

Trend Analyses

Reported trichloroethylene releases across the six PRTRs over the 2008 to 2017 timeframe have been trending down, from a high of 6.7 million kg in 2008 to 3.5 million kg in 2017—a 48% decrease. Regression analysis indicates that the downward trend in releases was statistically significant based on all 10 years of data ($p<0.05$).[50] The decline was driven by the fabricated metal products (ISIC 25) and basic metals (ISIC 24) subsectors. Reported releases were larger in 2008 than other years, with a 1.5 million kg decrease between 2008 and 2009. This reduction in releases was likely driven by the global economic recession at this time.

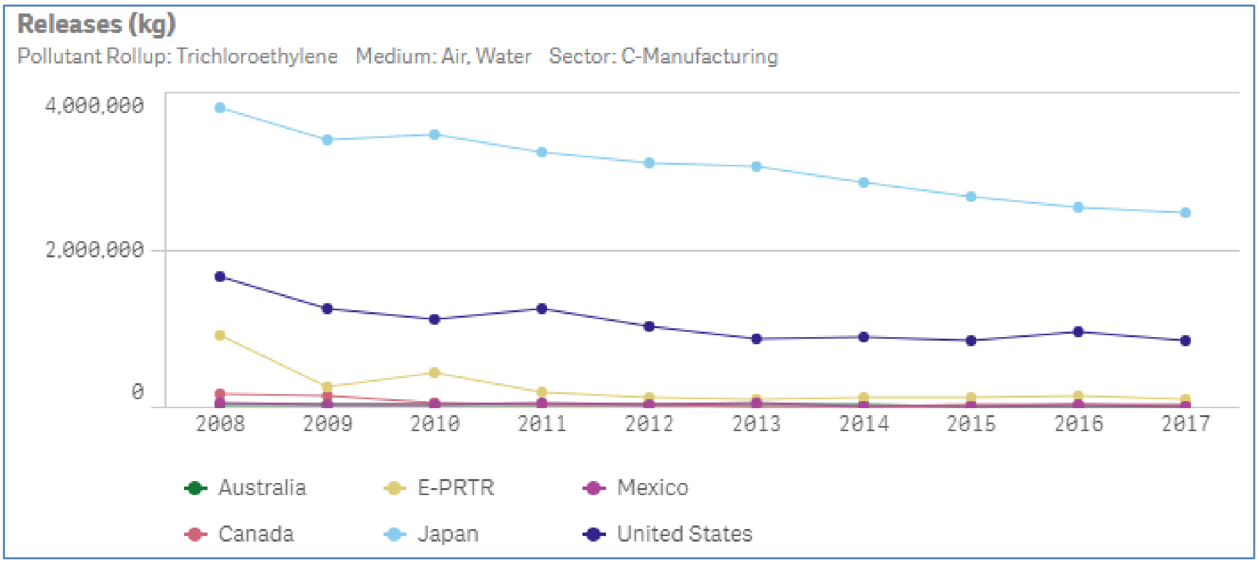
Trichloroethylene releases decreased significantly from 2008 to 2017



Trichloroethylene releases in each of the six PRTRs decreased from 2008 to 2017:

- Releases decreased substantially in Japan (1.3 million kg decrease), the U.S. (810,000 kg decrease), and the E-PRTR (810,000 kg decrease).
- Releases decreased by smaller amounts in Canada (150,000 kg decrease), Mexico (39,000 kg decrease), and Australia (36,000 kg decrease).
- Releases reported by most manufacturing subsectors decreased between 2008 to 2017.
  - The largest increase in release quantities was in the rubber and plastics subsector (ISIC 22), where releases increased from 448,000 kg in 2008 to 541,000 kg in 2017, a 21% increase.
  - The largest decrease in release quantities was in the fabricated metal products subsector (ISIC 25), which reported 3.1 million kg of trichloroethylene releases in 2008 and 1.6 million kg of trichloroethylene releases in 2017, a 48% decrease.

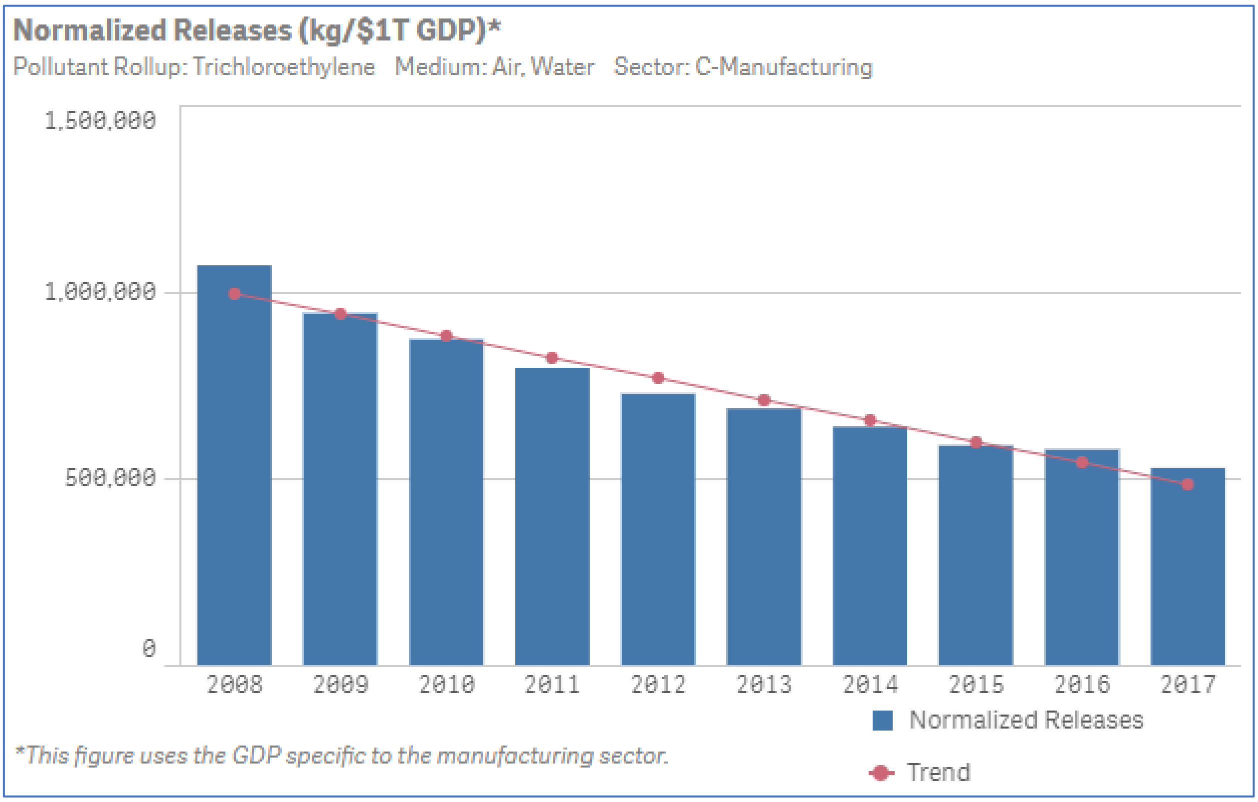
Trichloroethylene releases decreased in all six PRTRs



This figure includes PRTRs with comparatively low releases (i.e., Australia, Canada, and Mexico), though they may not be visible at this scale.

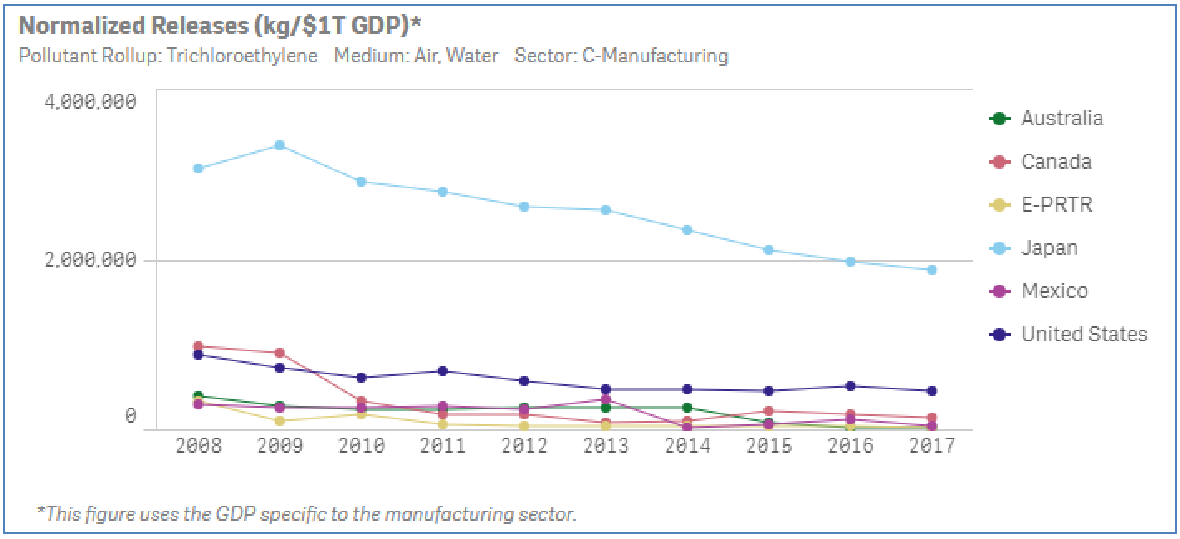
Releases of trichloroethylene were normalized by the annual gross domestic product (GDP) for the manufacturing sector of the PRTR's country or region. Normalized releases provide a metric to compare a country's release levels per unit of economic activity in the country. Releases are related to economic activity, as higher manufacturing economic activity usually means more goods are being produced. Chemical releases are associated with these manufacturing processes, so more manufacturing is typically associated with more chemical releases. Normalizing releases controls for the differences in production levels between countries and over time. The trend in normalized releases approximates how releases would have changed if the amount of manufacturing activity had remained constant. As shown in the figure below, trichloroethylene releases across the six PRTRs, when normalized by the combined manufacturing GDPs of their countries/regions, show a statistically significant downward trend ($p<0.05$).[51]

Normalized trichloroethylene releases significantly decreased from 2008 to 2017



Compared among PRTRs, GDP-normalized trends in releases of trichloroethylene show that Japan had the highest normalized releases each year. Both normalized and absolute releases of trichloroethylene were larger in Japan than any other PRTR. This indicates that facilities in Japan released more trichloroethylene per unit of manufacturing activity than facilities in other countries. Releases in Japan decreased from 2008 to 2017 while manufacturing GDP increased slightly from 2008 to 2017. If manufacturing activity were the primary driver of releases, release quantities in Japan would be expected to increase from 2008 to 2017 as manufacturing activity increased. The decreasing trend in GDP-normalized releases indicates factors other than economic activity were driving trichloroethylene releases in Japan.

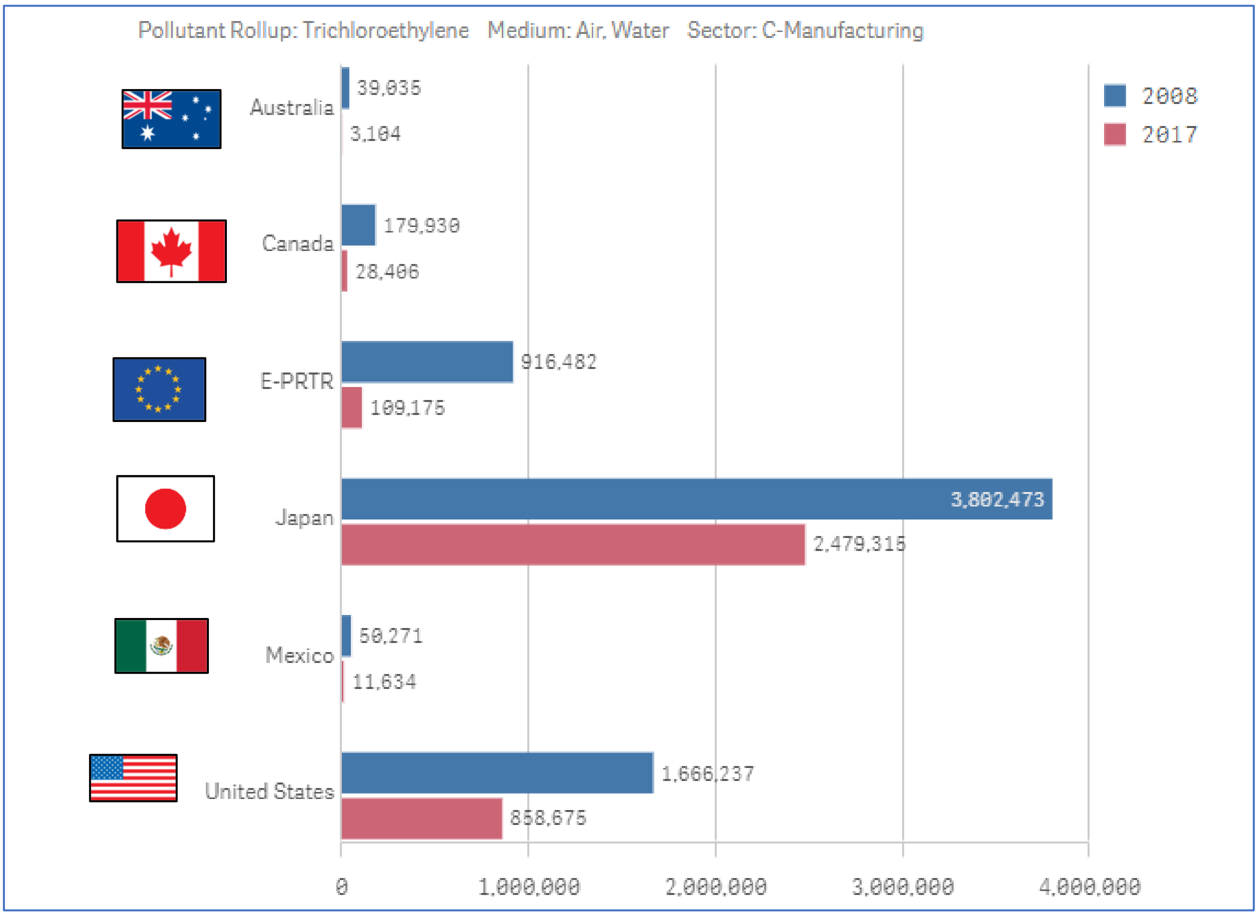
Normalized trichloroethylene releases decreased in all six PRTRs



Trend in trichloroethylene releases to air and water from the manufacturing sector	
Overall change, 2008–2017	Releases decreased by 3.2 million kg (48%). This was part of a significant trend of releases decreasing.
PRTRs with the largest *percent* change in releases, 2008–2017	Australia: 36,000 kg decrease (92%) E-PRTR: 810,000 kg decrease (88%) Canada: 152,000 kg decrease (84%)
PRTR with the largest *absolute* change in releases, 2008–2017	Japan: 1.3 million kg decrease (35%)
Subsectors with the largest absolute change in releases, 2008–2017	Fabricated metal products (ISIC 25): 1.5 million kg decrease (48%) Basic metals (ISIC 24): 699,000 kg decrease (71%) Chemical manufacturing (ISIC 20): 400,000 kg decrease (68%)
Additional information: The percent decrease in releases was largest in Australia because releases were low in 2008, but the absolute change in releases in Australia was small. The small quantities of trichloroethylene releases reported in Australia have minimal impact on the global trend. Release trends for trichloroethylene are driven by releases from the fabricated metal products subsector (ISIC 25), which reported 50% of all trichloroethylene releases between 2008 and 2017. The majority of facilities that reported releases in the fabricated metal products subsector are in Japan.	

Summary

Releases of trichloroethylene from manufacturing facilities by PRTR (kg)



- Six of the seven PRTR systems contain information on trichloroethylene releases between 2008 and 2017: Australia, Canada, the E-PRTR, Japan, Mexico, and the U.S. The Chilean PRTR does not contain information on trichloroethylene releases.
- Across the six PRTRs combined, trichloroethylene releases to air and water as reported by facilities in the manufacturing sector decreased by 3.2 million kg (48%) from 2008 to 2017.
    - Both normalized and absolute releases of trichloroethylene decreased significantly across these six PRTRs from 2008 through 2017.
- Trichloroethylene releases were lower in 2017 than 2008 in each of the six PRTR systems examined.
- Facilities in the fabricated metal products subsector (ISIC 25) reported the largest release quantities of trichloroethylene. Trichloroethylene releases from this subsector decreased from 2008 to 2017.

Sulphur Oxides

Sulphur oxides (SO_x) are a group of inorganic chemicals composed of sulphur and oxygen. The most common sulphur oxide is sulphur dioxide (CAS 7446-09-5) (NCBI, 2021[45]).[52] It occurs naturally in the environment from volcanic activity, biological decay, and sea spray. Combustion of fossil fuels leads to formation of sulphur dioxide and contributes to the release of sulphur dioxide into the atmosphere. Sulphur dioxide is also produced synthetically and is used commercially to produce sulphuric acid for paper, agriculture, wastewater treatment, and metal and oil refining industries (NCBI, 2021[45]). Under ambient conditions it exists primarily as a gas. Sulphur dioxide is considered harmful to aquatic life and water-soluble. Long-term exposure to sulphur dioxide is associated with asthma (ILO and WHO, 2006[46]).

Reporting for sulphur oxide releases varies by country/region as follows:

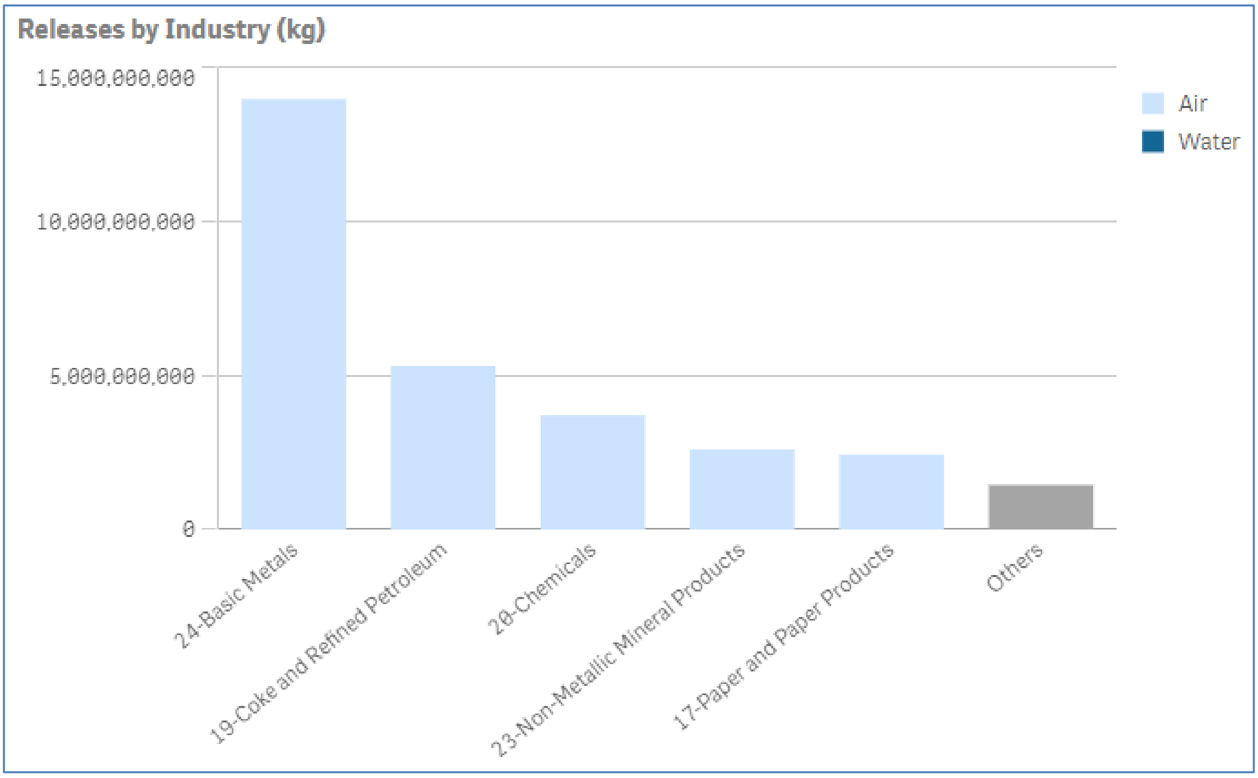
- Sulphur dioxide releases are reported to three of the seven pollutant release and transfer register (PRTR) systems chosen for these global-scale analyses: the PRTR systems of Australia, Canada, and Chile. No sulphur oxides other than sulphur dioxide are reported to these PRTRs.
- Releases of all sulphur oxides are reported to Europe's E-PRTR; although most releases of sulphur oxides are expected to occur as sulphur dioxide, E-PRTR data may include some releases of sulphur oxides that are not reported to other PRTRs.
- Sulphur oxides are not reported to the PRTRs of Japan and Mexico.
- In the U.S., sulphur oxide releases are not reported to the PRTR, but sulphur dioxide emissions to air are compiled in the U.S. National Emissions Inventory (NEI).53 NEI data are published every three years; the most recent NEI data available are for 2017. For this analysis, releases of sulphur dioxide to air from NEI data were applied to subsequent years for which NEI data do not exist (i.e., release data from 2008 were used for 2009 and 2010, data from 2011 were used for 2012 and 2013, and data from 2014 were used for 2015 and 2016). This may not accurately reflect releases in the U.S. for those years. Therefore, data from the U.S. are omitted from some trend analyses in this report.

This analysis focuses on releases of sulphur oxides as reported to the PRTR systems of Australia, Canada, Chile, and Europe (i.e., the E-PRTR) and compiled in the U.S. NEI. As described in this project's Action Plan, the analysis focuses on releases of sulphur oxides to air and water by facilities in the manufacturing sector only (OECD, 2018[3]).

Snapshot Analyses

Sulphur oxides were released almost exclusively to air by facilities in the manufacturing sector across all PRTR systems and the U.S. NEI. (Note that the U.S. includes emissions to air only.) Small quantities of water releases were reported to the E-PRTR in some years by three facilities in Norway; no other water releases of sulphur oxides were reported. The largest releases reported from the manufacturing sector were primarily from five International Standard Industrial Classification (ISIC) Divisions, as shown in the figure below.[54] Releases of sulphur oxides were driven by the basic metals subsector (ISIC 24), which reported larger releases than any other subsector for each year from 2008 to 2017.

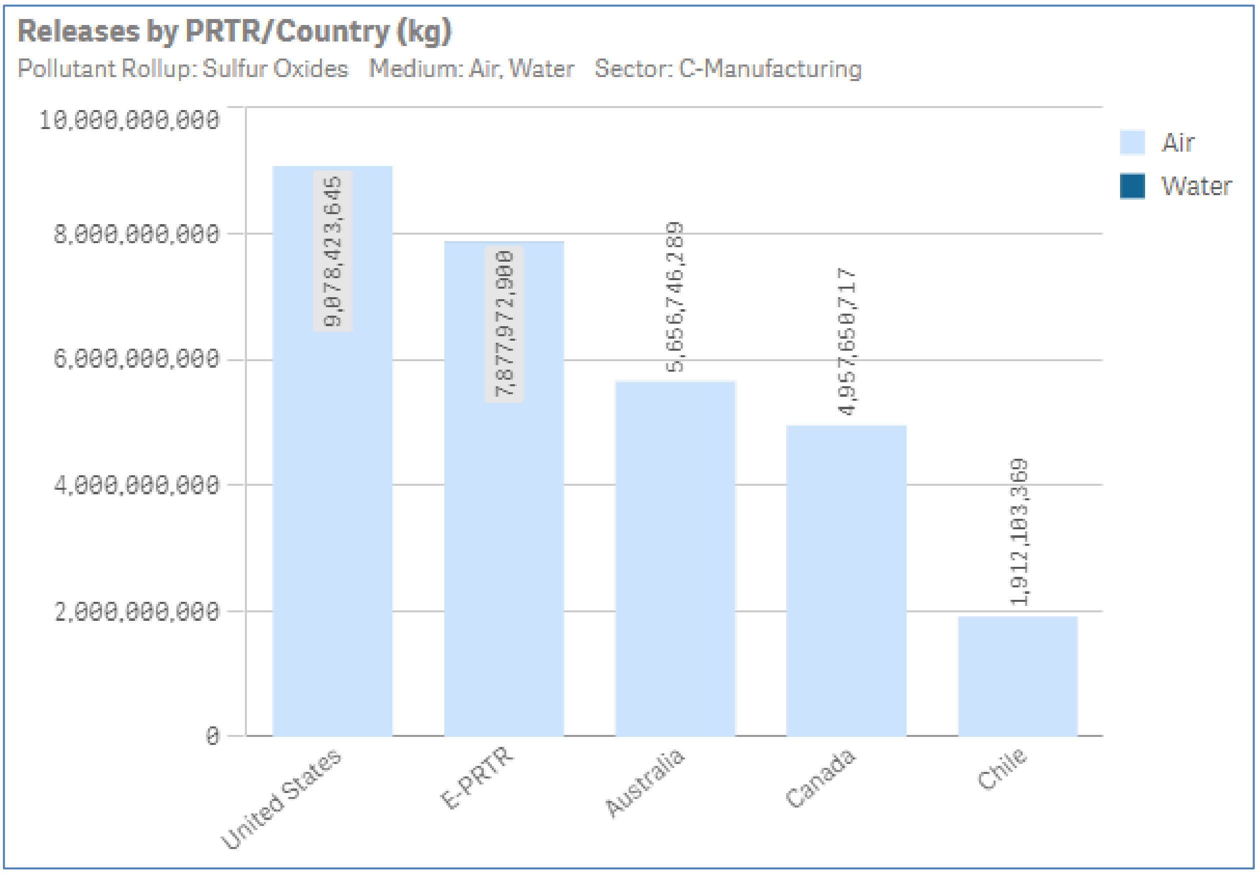
Across PRTRs, from 2008 to 2017, sulphur oxide releases were mainly from five subsectors



This figure includes U.S. data from the NEI. “Others” includes combined air and water releases from all other manufacturing subsectors.

Considered by PRTR, reported releases were largest in the U.S. and the E-PRTR, as shown in the figure below. Note that the figure may overestimate U.S. sulphur oxide releases due to the data limitations discussed above. Releases compiled in all PRTRs except the E-PRTR include only sulphur dioxide, not all sulphur oxides, so releases presented for those PRTRs somewhat underestimate total sulphur oxide releases.

From 2008 to 2017, releases of sulphur oxides were largest in the U.S. and the E-PRTR



This figure includes U.S. data from the NEI.

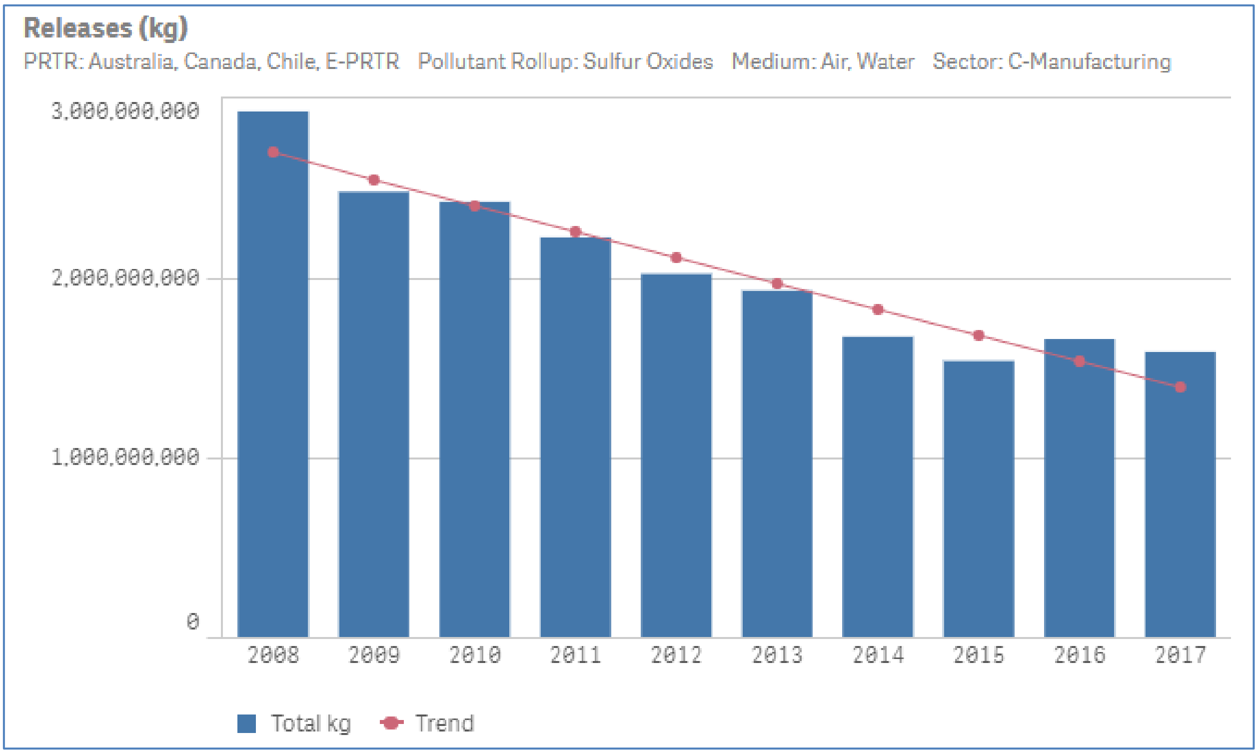
Snapshot of releases of sulphur oxides to air and water from the manufacturing sector	
Releases, 2017	2.1 billion kg
Releases by medium, 2008–2017	>99.9% to air
Subsectors with the largest reported releases, 2008–2017	Basic metals (ISIC 24) Coke and refined petroleum (ISIC 19) Chemical manufacturing (ISIC 20)
PRTRs with the largest reported releases, 2008–2017	U.S. NEI, E-PRTR
Additional information: Releases from the basic metals subsector (ISIC 24) accounted for 47% of reported releases from 2008 to 2017.	

This table includes U.S. data from the NEI

Trend Analyses

Reported sulphur oxide releases, totalled across the four PRTRs and the U.S. NEI, declined considerably from 2008 to 2017. Reported releases of sulphur oxides decreased from 4.1 billion kg in 2008 to 2.1 billion kg in 2017, a 49% decrease. Excluding the release quantities compiled in the U.S. NEI, which were not reported for every year between 2008 and 2017, releases decreased from 2.9 billion kg to 1.6 billion kg, a 46% decrease. Again excluding U.S. data, regression analysis indicates that the downward trend in releases was statistically significant based on all 10 years of data ($p<0.05$).[55] The decline was driven by the basic metals (ISIC 24) and coke and petroleum products (ISIC 19) subsectors. Releases reported in the U.S. also decreased each year the NEI database was updated.

Releases of sulphur oxides decreased significantly from 2008 to 2017

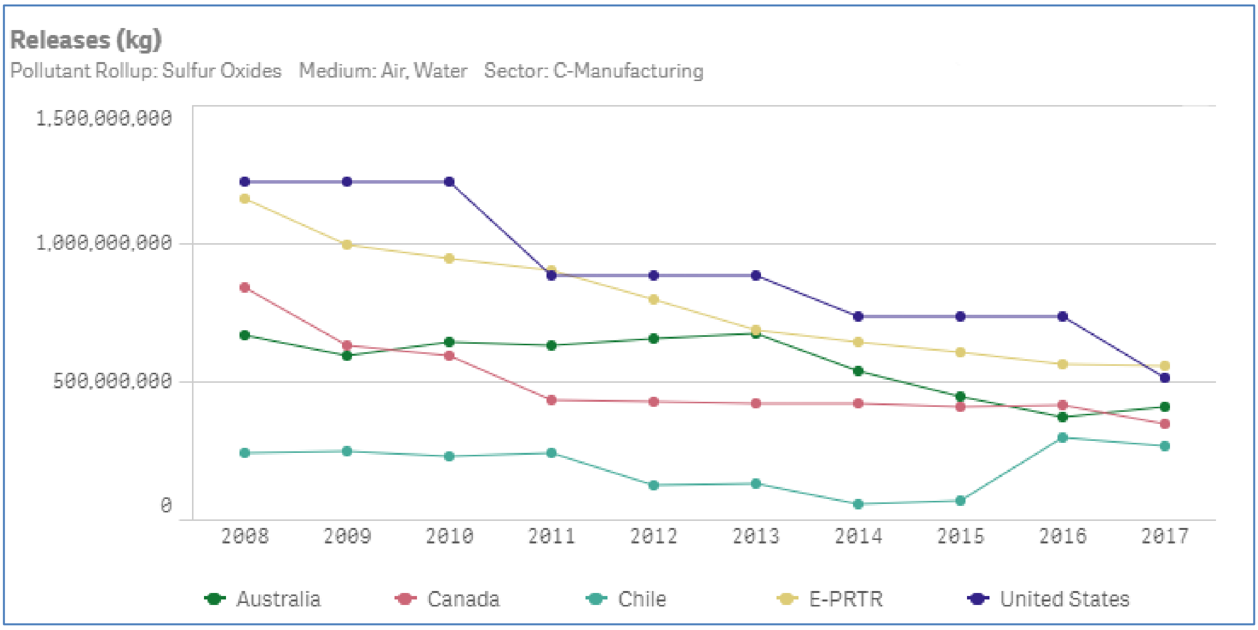


This figure does not include data from the U.S. NEI.

Releases of sulphur oxides decreased in most PRTRs and the U.S. NEI from 2008 to 2017:

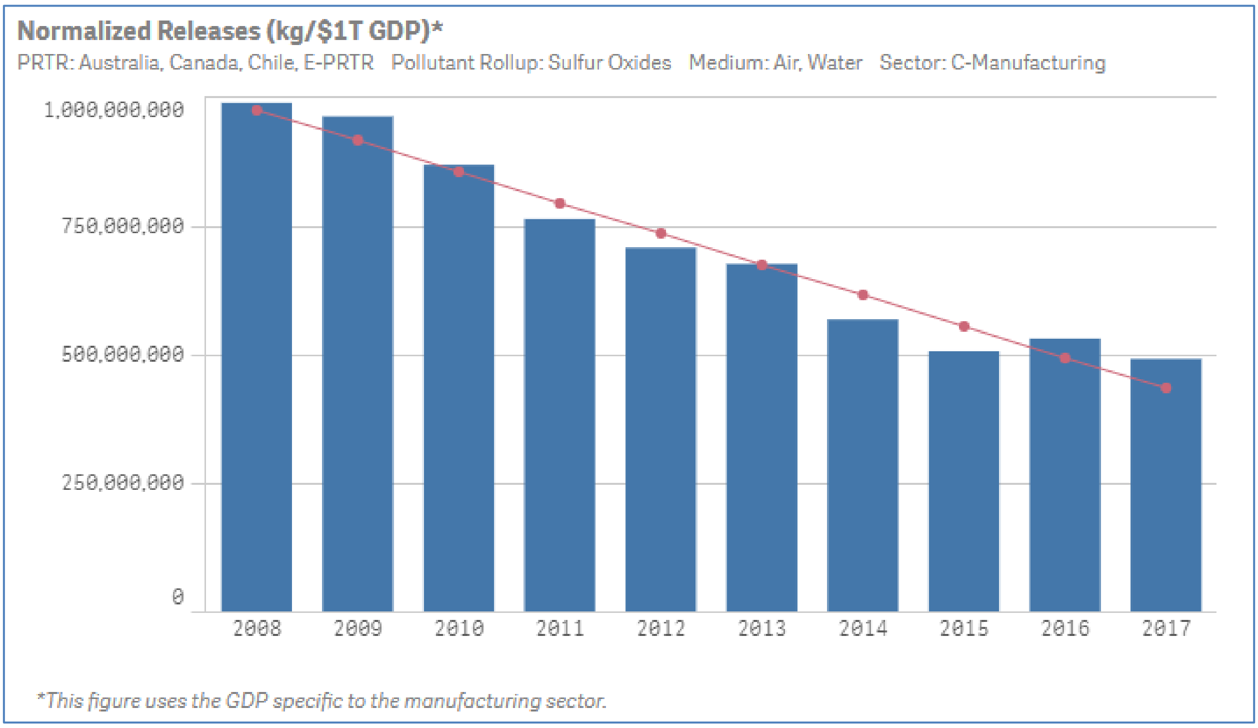
- Releases decreased by 710 million kg in the U.S., 600 million kg in the E-PRTR and 500 million kg in Canada.
  - Sulphur dioxide releases in Canada are driven by a few facilities with large releases. Two facilities in the basic metals subsector that released a total of 350 million kg of sulphur dioxide in 2008 both stopped reporting any releases of sulphur dioxide in 2011, driving most of the decrease.
- Releases of sulphur dioxide in Australia were fairly consistent from 2008 to 2013 but have since decreased; in 2017 they had fallen by 260 million kg from their 2008 level.
  - Releases of sulphur dioxide in Australia are driven by three facilities in the basic metals subsector: together, they reported 73% of Australia's total sulphur dioxide releases from the manufacturing sector from 2008 to 2017. One of these facilities drove the decrease in releases, reporting approximately 170 million kg of sulphur dioxide releases each year from 2008 to 2014, then reduced releases in 2015, then no releases in 2016 or 2017.
- Sulphur dioxide releases in Chile fluctuated between 2008 and 2017.
  - A few facilities drive sulphur dioxide releases in Chile, mostly in the basic metals subsector. Releases reported by these facilities have fluctuated, with many facilities reporting large releases in some years with low or no releases in other years.

Sulphur oxide releases decreased in most of the four PRTRs and the U.S. NEI



Releases of sulphur oxides were normalized by the annual gross domestic product (GDP) for the manufacturing sector of the PRTR's country or region. Normalized releases provide a metric to compare a country's release levels per unit of economic activity in the country. Releases are related to economic activity, as higher manufacturing economic activity usually means more goods are being produced. Chemical releases are associated with these manufacturing processes, so more manufacturing is typically associated with more chemical releases. Normalizing releases controls for the differences in production levels between countries and over time. The trend in normalized releases approximates how releases would have changed if the amount of manufacturing activity had remained constant. As shown in the figure below, sulphur oxide releases across the four PRTRs with annual data, when normalized by the combined manufacturing GDPs of their countries/regions, show a significant downward trend ($p<0.05$). [56]

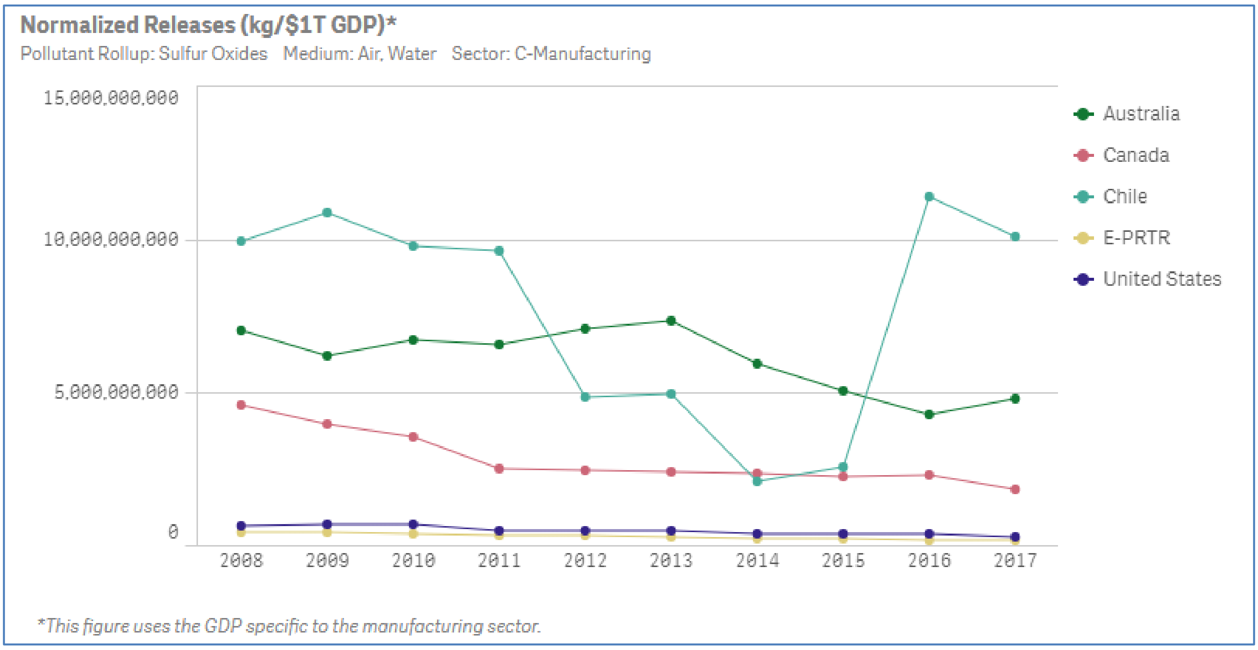
Normalized sulphur oxide releases significantly decreased from 2008 to 2017



This figure does not include data from the U.S. NEI.

Compared among PRTRs, GDP-normalized trends in releases of sulphur oxides show that Chile and Australia had the highest normalized releases. This indicates that facilities in Chile and Australia released more sulphur oxides per unit of manufacturing activity than facilities in other countries. Absolute releases of sulphur oxides in Chile increased by 10% while manufacturing GDP increased by 9%, so normalized releases in Chile were about the same in 2017 as 2008. This indicates that increasing manufacturing activity may have driven increased releases of sulphur oxides in Chile, although a drop in normalized releases from 2012 to 2015 shows that other factors also affected releases of sulphur oxides in Chile. The increase in normalized releases in Chile in 2016 was driven by several facilities reporting large increases in their sulphur dioxide releases that year. In Australia, absolute releases decreased by 39% while manufacturing GDP decreased by 10%. If manufacturing activity were the primary driver of release trends in Australia, releases would be expected to decrease only as much as manufacturing activity decreased. Normalized releases were low in the U.S. and the E-PRTR, indicating that facilities in those countries released less sulphur oxides per unit of manufacturing activity than facilities in other countries.

Normalized releases of sulphur oxides decreased in most of the four PRTRs and the U.S. NEI

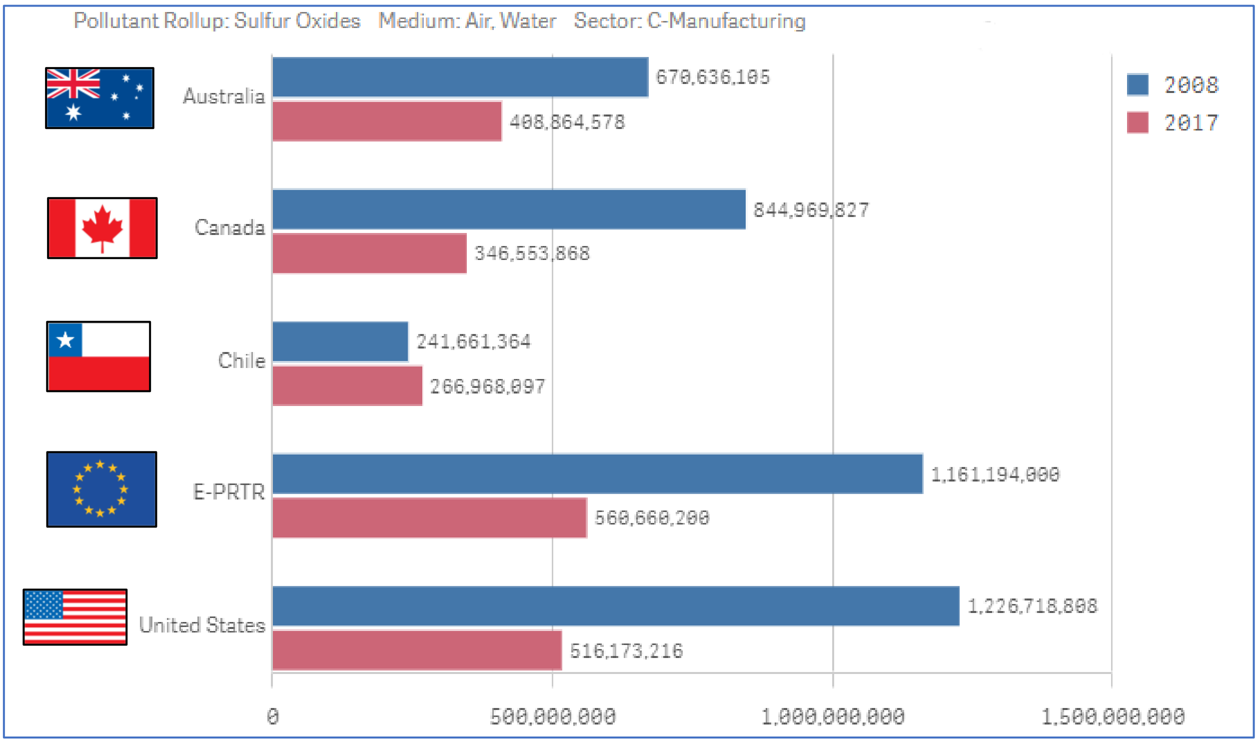


Trend in sulphur oxide releases to air and water from the manufacturing sector	
Overall change, 2008–2017	Releases decreased by 2.0 billion kg (49%). This was part of a significant trend of releases decreasing.
PRTRs with the largest *percent* change in releases, 2008–2017	Canada: 500 million kg decrease (59%) U.S. NEI: 710 million kg decrease (58%) E-PRTR: 600 million kg decrease (52%)
PRTRs with the largest *absolute* change in releases, 2008–2017	U. S. NEI: 710 million kg decrease (58%)
Subsectors with the largest change in releases, 2008–2017	Basic metals (ISIC 24): 880 million kg decrease (45%) Coke and refined petroleum (ISIC 19): 430 million kg decrease (52%)
Additional information: Releases of sulphur oxides decreased in all manufacturing subsectors. Releases of sulphur oxides decreased every year from 2008 to 2015 but were higher than 2015 levels in 2016 and 2017 due to increased releases in Chile.	

This table includes data from the U.S. NEI.

Summary

Releases of sulphur oxides from manufacturing facilities by PRTRs and the U.S. NEI (kg)



This figure includes data from the U.S. NEI.

- Four PRTR systems (the E-PRTR and the systems of Australia, Canada, and Chile) and the U.S. NEI contain information on sulphur oxide releases between 2008 to 2017. (Release data for sulphur oxides in the U.S. are published every three years in the NEI). The Japanese and Mexican PRTRs do not contain information on releases of sulphur oxides.
- Across the four PRTRs and the U.S. NEI combined, sulphur oxide releases as reported by facilities in the manufacturing sector decreased by 2.0 billion kg (49%) from 2008 to 2017.
  - Releases of sulphur oxides trended significantly downward across the four PRTRs that report data annually and decreased each time data were reported in the U.S.
- Releases of sulphur oxides decreased from 2008 to 2017 in Australia, Canada, the E-PRTR, and the U.S. Releases of sulphur oxides increased slightly in Chile.
- Facilities in the basic metals (ISIC 24), coke and refined petroleum (ISIC 19), and chemicals (ISIC 20) subsectors reported the highest release quantities of sulphur oxides. Releases of sulphur oxides from these subsectors decreased from 2008 to 2017.

Particulate Matter

The term "particulate matter" (PM) describes a mixture of solid and liquid particles in air. These particles come in many sizes and shapes and can be made up of hundreds of different chemicals or materials, such as sulphate, ammonia, nitrates, sodium chloride, black carbon, dust, and water, or other small particles. Particulate matter can occur naturally in the environment as the result of resuspension of dust and sand and volcanic activity (WHO, 2018[47]). Most particles form in the atmosphere as a result of complex reactions of chemicals such as sulphur dioxide and nitrogen oxides, which are pollutants emitted from power plants, industries, and automobiles. Some are emitted directly from a source, such as roads, industrial processes, smokestacks, or fires (WHO, 2013[48]). Measurements of particulate matter are considered a proxy indicator for air pollution. Exposure to high concentrations of particulate matter is closely associated with acute and long-term health effects (WHO, 2013[48]; WHO, 2018[47]; WHO, 2010[49]) including cancer, cardiovascular disease, and respiratory disease (WHO, 2010[49]; WHO, 2013[48]).

Types of particulate matter are commonly defined by the diameter of the particles: "$PM_{2.5}$" refers to particles with a diameter of 2.5 microns or less and "PM_{10}" indicates particles with diameter of 10 microns or less. This analysis considers emissions of PM_{10} only, not any other particulate matter; it uses the term "particulate matter" to refer specifically to PM_{10}.

PM_{10} is reported to four of the seven pollutant release and transfer register (PRTR) systems chosen for these global-scale analyses: the PRTR systems of Australia, Canada, Chile, and Europe (i.e., the E-PRTR). Particulate matter emissions are not reported to the PRTRs of Japan and Mexico. In the U.S., PM_{10} releases are not reported to the country's PRTR, but are compiled in the U.S. National Emissions Inventory (NEI).[57] NEI data are published every three years; the most recent NEI data available are for 2017. For this analysis, reported releases of particulate matter from NEI data were applied to subsequent years for which NEI data do not exist (i.e., release data from 2008 were used for 2009 and 2010, data from 2011 were used for 2012 and 2013, and data from 2014 were used for 2015 and 2016). This may not accurately reflect releases in the U.S. for those years. Therefore, data from the U.S. are omitted from some trend analyses in this report.

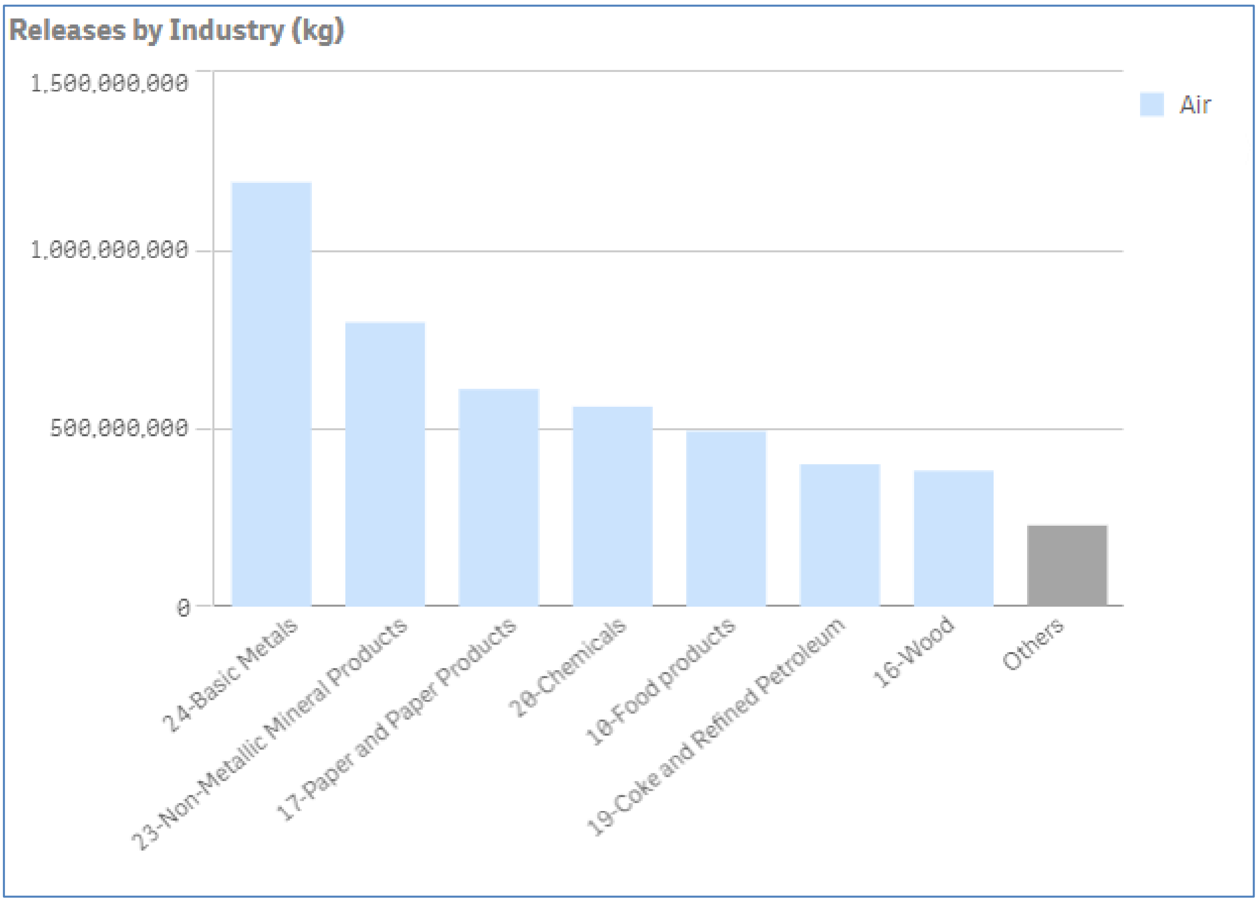
The way particulate matter releases are reported depends on how the releases are measured. For example, one common source of particulate matter is combustion, which releases particulate matter through a facility's smokestacks in solid, liquid, or gaseous form. Solid and liquid particles can be measured in the stack with a filter (and are therefore called filterable particulate matter). Gaseous particles are not trapped on filters in the hot stacks but may condense into solid or liquid particles when they meet cooler air; these particles are called condensable particulate matter. In the U.S., both filterable and condensable particulate matter are reported. In other PRTRs, only filterable particulate matter is reported. Because of this, particulate matter emissions data for the U.S. are more inclusive—a fact that contributes to the difference between the U.S. and other PRTRs.

This analysis focuses on particulate matter releases as reported to the PRTR systems of Australia, Canada, Chile, and Europe (i.e., E-PRTR) and as compiled in the U.S. NEI. As described in this project's Action Plan, the analysis focuses on releases to air and water by facilities in the manufacturing sector only (OECD, 2018[3]); since particulate matter is an air pollutant and only emissions to air were reported, this analysis is based on releases of particulate matter to air only.

Snapshot Analyses

Across all PRTR systems and the U.S. NEI combined, the largest air release quantities reported in 2008–2017 by facilities in the manufacturing sector were from the International Standard Industrial Classification (ISIC) Divisions shown in the figure below.[58] The largest releases of particulate matter were from the basic metals subsector (ISIC 24).

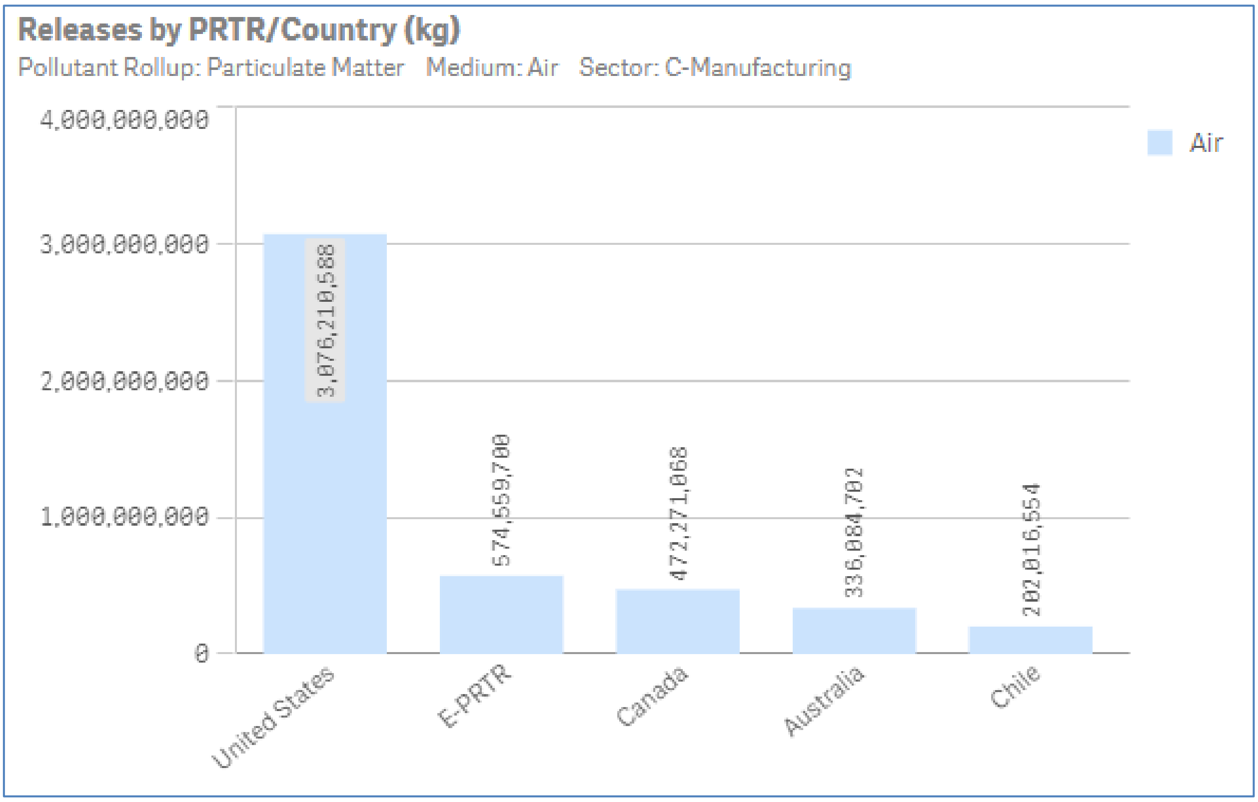
Across PRTRs, from 2008 to 2017, particulate matter releases were spread across many subsectors



This figure includes U.S. data from the NEI. "Others" includes air releases from all other manufacturing subsectors.

Considered by PRTR, releases were largest in the U.S., as shown in the figure below. Release quantities presented in this chart for the U.S. may overestimate actual particulate matter release quantities due to the data limitations discussed above.

From 2008 to 2017, particulate matter releases were largest in the U.S.



This figure includes U.S. data from the NEI.

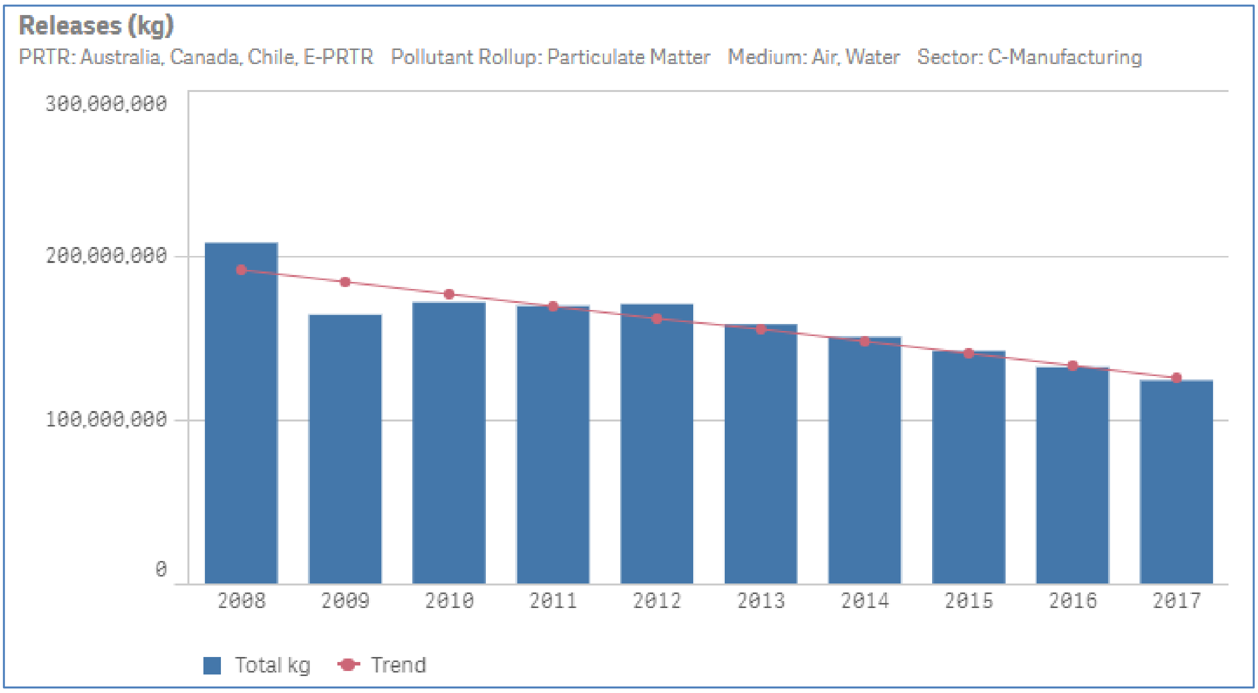
Snapshot of particulate matter releases to air from the manufacturing sector	
Releases, 2017	360 million kg
Subsectors with the largest reported releases, 2008–2017	Basic metals (ISIC 24) Non-metallic mineral products (ISIC 23) Paper and paper products (ISIC 17)
PRTR with the largest reported releases, 2008–2017	U.S. NEI
Additional information: Releases of particulate matter were exclusively to air.	

This table includes U.S. data from the NEI.

Trend Analyses

Total particulate matter release quantities across the four PRTRs and the U.S. NEI, over the 2008 to 2017 timeframe, declined from 570 million kg in 2008 to 360 million kg in 2017—a 36% decrease. Excluding the releases in the U.S., which were not compiled for every year between 2008 and 2017, releases decreased from 210 million kg in 2008 to 120 million kg in 2017, a 40% decrease. Again excluding data from the U.S., regression analysis indicates that the downward trend in releases was statistically significant based on all 10 years of data ($p<0.05$).[59] The decline was driven by the basic metals (ISIC 24) and non-metallic mineral products (ISIC 23) subsectors. Reported releases were larger in 2008 than other years, with a 65 million kg decrease from 2008 to 2009. This reduction was likely driven by the global economic recession.

Particulate matter releases decreased significantly from 2008 to 2017

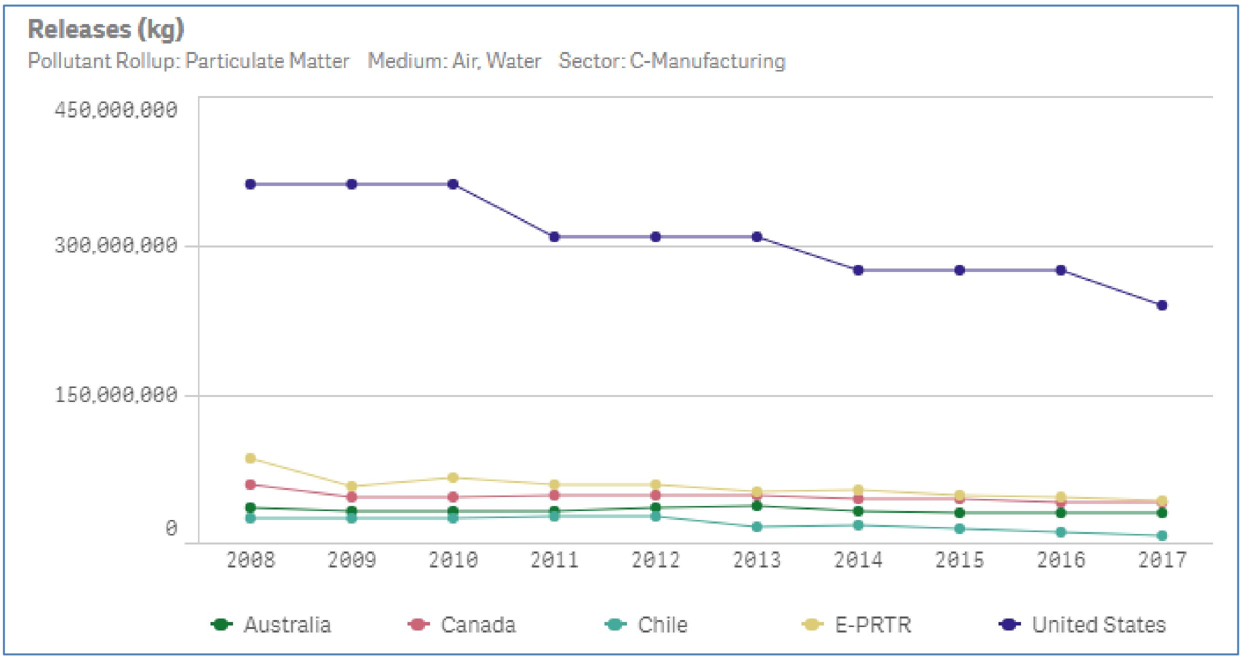


This figure does not include data from the U.S. NEI.

Releases of particulate matter decreased for all PRTRs and the U.S. NEI from 2008 to 2017:

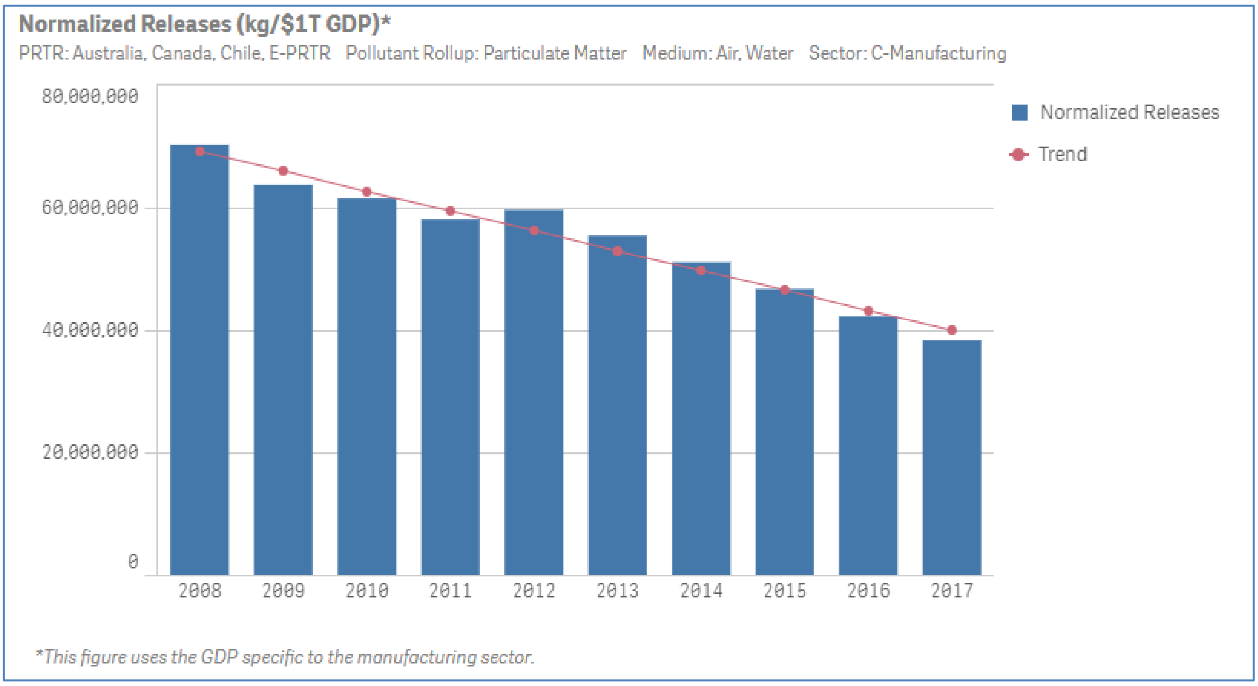
- Releases decreased most significantly in the U.S. (by 120 million kg from 2008 to 2017). This was driven by large decreases in the basic metals (ISIC 24), non-metallic mineral products (ISIC 23), and food products (ISIC 10) subsectors.
- Releases also decreased in the E-PRTR (43 million kg decrease), Canada (18 million kg decrease), Chile (18 million kg decrease), and Australia (5.2 million kg decrease).

Particulate matter releases decreased in all four PRTRs and the U.S. NEI



Releases of particulate matter were normalized by the annual gross domestic product (GDP) for the manufacturing sector of the PRTR's country or region. Normalized releases provide a metric to compare a country's release levels per unit of economic activity in the country. Releases are related to economic activity, as higher manufacturing economic activity usually means more goods are being produced. Pollutant releases are associated with these manufacturing processes, so more manufacturing is typically associated with larger pollutant releases. Normalizing releases controls for the differences in production levels between countries and over time. The trend in normalized releases approximates how releases would have changed if the amount of manufacturing activity had remained constant. As shown in the figure below, particulate matter releases across the four PRTRs with annual data, when normalized by the combined manufacturing GDPs of their respective countries/regions, show a significant downward trend ($p<0.05$).[60] Normalized releases of particulate matter reported in the U.S. also decreased with each triennial data release.

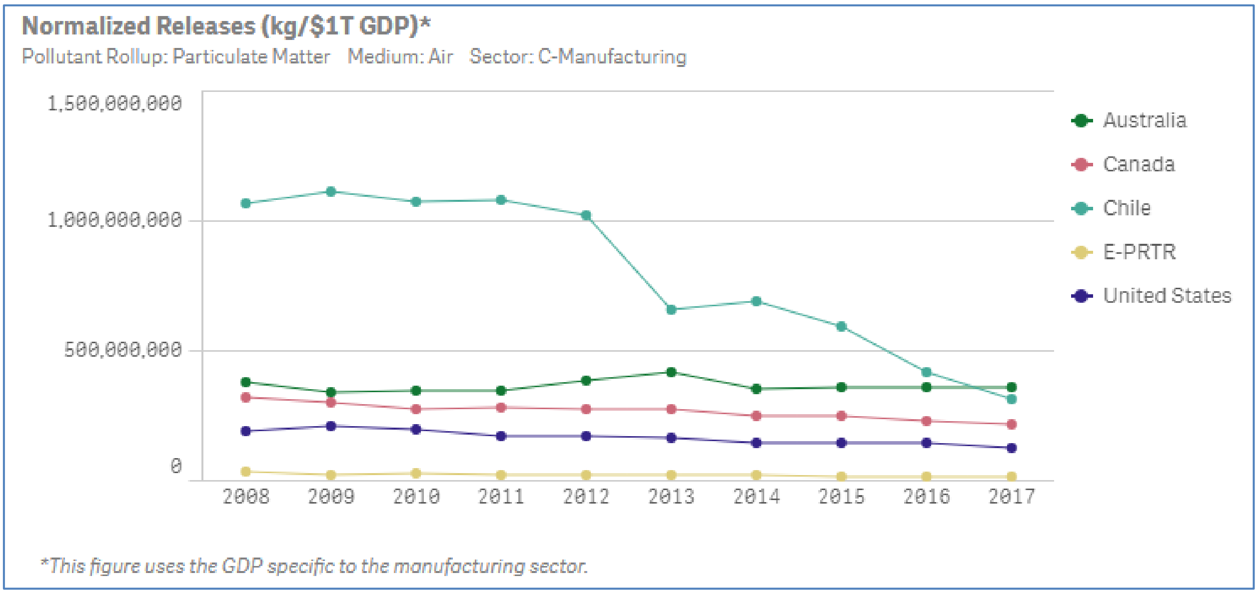
Normalized particulate matter releases significantly decreased from 2008 to 2017



This figure does not include data from the U.S. NEI.

Compared among PRTRs, GDP-normalized trends in releases of particulate matter show that Chile had the highest normalized releases almost every year. This indicates that facilities in Chile released more particulate matter per unit of manufacturing activity than facilities in other countries. Releases in Chile decreased from 2008 to 2017 while manufacturing GDP increased by 9%. If manufacturing activity were the primary driver of release trends, releases would be expected to increase as economic activity increased. The decrease in GDP-normalized releases indicates that factors other than total manufacturing economic activity were driving particulate matter releases in Chile.

Normalized particulate matter releases decreased in all four PRTRs and the U.S. NEI



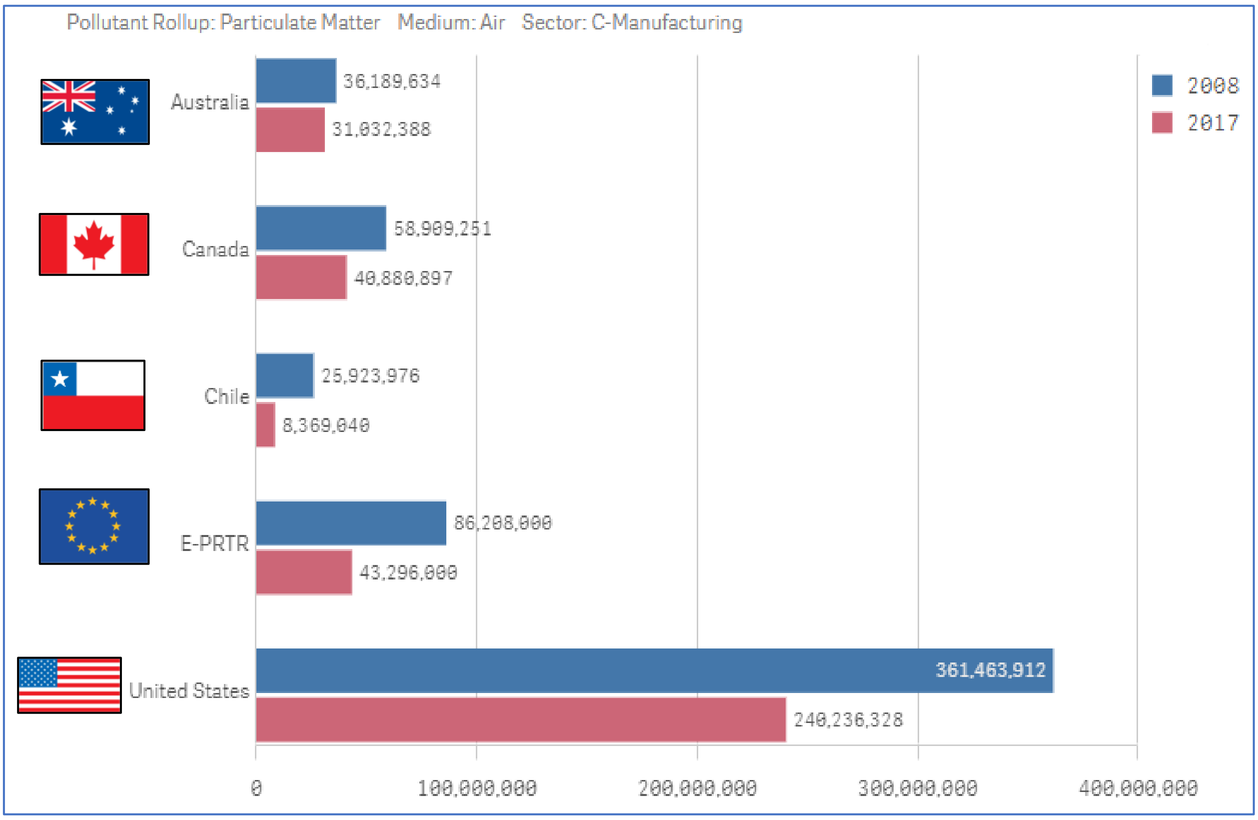
This figure includes data from the U.S. NEI.

Trend in particulate matter releases to air from the manufacturing sector	
Overall change, 2008–2017	Releases decreased by 200 million kg (36%). This was part of a significant trend of releases decreasing.
PRTRs with the largest *percent* change in releases, 2008–2017	Chile: 18 million kg decrease (68%) E-PRTR: 43 million kg decrease (50%)
PRTR with the largest *absolute* change in releases, 2008–2017	U.S.: 120 million kg decrease (34%)
Subsectors with the largest absolute change in releases, 2008–2017	Basic metals (ISIC 24): 65 million kg decrease (42%) Non-metallic mineral products (ISIC 23): 49 million kg decrease (45%)
Additional information: Releases of particulate matter decreased from 2008 to 2017 in almost every subsector. Releases of particulate matter decreased from 2008 to 2017 in every PRTR and the U.S. NEI.	

This table includes data from the U.S. NEI.

Summary

Releases of particulate matter from manufacturing facilities by PRTR (kg)



This figure includes data from the U.S. NEI.

- Four PRTR systems and the U.S. NEI contain information on particulate matter releases between 2008 to 2017. These are the PRTR systems of Australia, Canada, Chile, and Europe (i.e., E-PRTR) and the U.S. National Emissions Inventory (release data for particulate matter in the U.S. are published every three years in the NEI). The Japanese and Mexican PRTRs do not contain information on releases of particulate matter.
- Across the four PRTRs and the U.S. NEI combined, particulate matter (PM10) releases to air from facilities in the manufacturing sector decreased by 200 million kg (36%) from 2008 to 2017.
  - Releases of particulate matter trended significantly downward across the four PRTRs that report data annually and decreased each time data were reported in the U.S.
  - Releases of particulate matter decreased from 2008 to 2017 in each of the five systems examined.
- Facilities in the basic metals (ISIC 24) and non-metallic mineral products (ISIC 23) subsectors reported the largest release quantities of particulate matter. Particulate matter releases from these subsectors decreased from 2008 to 2017.

Notes

[1] Boiling point = 83.4°C; vapor pressure 78.9 mmHg at 25°C.
[2] The ISIC Divisions are subsectors of the manufacturing sector and hereafter are referred to as "subsectors."

[3] Slope = -46,385; R^2 = 0.21; p = 0.18.

[4] Slope = -10,606; R^2 = 0.35; p = 0.071.

[5] Boiling point = 80.08°C; vapor pressure 94.8 mmHg at 25°C.

[6] The ISIC Divisions are subsectors of the manufacturing sector and hereafter are referred to as "subsectors."

[7] Slope = -185,587; R^2 = 0.61; p = 0.0078.

[8] Slope = -43,505; R^2 = 0.87; p = 0.00010.

[9] Boiling point = 767°C.

[10] The ISIC Divisions are subsectors of the manufacturing sector and hereafter are referred to as "subsectors."

[11] Slope = -2,031; R^2 = 0.54; p = 0.015.

[12] Slope = -447; R^2 = 0.70; p = 0.0027.

[13] Mexico's PRTR not included.

[14] ISIC Divisions are subsectors of the manufacturing sector and hereafter are referred to as "subsectors."

[15] Slope = -93,156; R^2 = 0.72; p = 0.0020.

[16] Slope = -16,141; R^2 = 0.79; p = 5.9×10^{-4}.
[17] Boiling point = 384°C; vapor pressure 1.42×10^{-7} mmHg at 25°C.

[18] The ISIC Divisions are subsectors of the manufacturing sector and hereafter are referred to as "subsectors."

[19] Slope = -11,426, R^2 = 0.80, p=$5.2\text{x}10^{-4}$

[20] Slope = -2,086; R^2 = 0.85; p = 0.00016.

[21] Boiling point = 39.75˚C; vapor pressure 435 mmHg at 25˚C.

[22] The ISIC Divisions are subsectors of the manufacturing sector and hereafter are referred to as "subsectors."

[23] Slope = -874,087; R^2 = 0.93; p = 5.7×10^{-6}.

[24] Slope = -177,960; R^2 = 0.97; p = 3.2×10^{-7}.

[25] Boiling point = 136°C; vapor pressure 9.6 mmHg at 25°C.

[26] ISIC Divisions are subsectors of the manufacturing sector and hereafter are referred to as "subsectors."

[27] Slope = 23,625; R^2 = 0.02; p = 0.71.

[28] Slope = -37,155; R^2 = 0.89; p = 6.4×10^{-4}.

[29] Boiling point = 356.73°C; vapor pressure 2×10^3 mmHg at 25°C.

[30] ISIC Divisions are subsectors of the manufacturing sector and hereafter are referred to as "subsectors."

[31] Slope = -1,346; R^2 = 0.43; p = 0.040.

[32] Slope = -296; R^2 = 0.58; p = 0.010.

33 Boiling point = 2,730°C (International Labour Organization).

34 The ISIC Divisions are subsectors of the manufacturing sector and hereafter are referred to as “subsectors.”

35 Trend including Mexico: slope = -68,857; $R^2 = 0.51$; $p = 0.021$.

36 Trend excluding Mexico: slope = -41,117; $R^2 = 0.76$; $p = 0.00097$.

37 Slope = -12,486; $R^2 = 0.62$; $p = 6.7x10^{-3}$.

38 Slope = -8,119; $R^2 = 0.88$; $p = 5.3x10^{-5}$.

39 Boiling point = 145.3°C; vapor pressure 6.4 mmHg at 25°C.

40 The ISIC Divisions are subsectors of the manufacturing sector and hereafter are referred to as “subsectors.”

41 Slope = 396,373; $R^2 = 0.60$; $p = 0.014$.

42 Slope = 83,935; $R^2 = 0.02$; $p = 0.69$.

43 Slope = -17,538; $R^2 = 0.057$; $p = 0.51$

44 Boiling point = 121.2°C; vapor pressure 18.5 mmHg at 25°C.

45 ISIC Divisions are subsectors of the manufacturing sector and hereafter are referred to as “subsectors.”

46 Slope = -124,996; $R^2 = 0.86$; $p = 0.00010$.

47 Slope = -23,919, $R^2 = 0.94$, $p=3.5x10^{-6}$

48 Boiling point = 87.2°C; vapor pressure 69 mmHg at 25°C.

49 The ISIC Divisions are subsectors of the manufacturing sector and hereafter are referred to as “subsectors.”

50 Slope = -292,275; $R^2 = 0.86$; $p = 0.00013$.

51 Slope = -56,849; $R^2 = 0.96$; $p = 1.0\times10^{-6}$.

52 Boiling point = -10.05°C; vapor pressure 3.0×10^3 mmHg at 25°C.

53 The NEI includes data on the emissions of criteria and hazardous air pollutant emissions, submitted to the U.S. Environmental Protection Agency (EPA) by state and local agencies. Facilities typically report emissions directly to the state and local agencies, and the state and local agencies may revise data or add additional emissions estimates before submitting the data to EPA. The Air Emissions Reporting Rule has emissions thresholds above which states must report stationary emissions as “point” sources, with the remainder of the stationary emissions reported as “nonpoint” sources. Only “point” sources are included in this analysis. The NEI includes data for both sulphur dioxide and sulphur tetroxide (SO_4). Sulphur tetroxide was first included for reporting year 2014 data and therefore is not included to maintain consistency with earlier years.

54 The ISIC Divisions are subsectors of the manufacturing sector and hereafter are referred to as “subsectors.”

55 Slope = -1.4×10^8; $R^2 = 0.91$; $p = 1.7\times10^{-5}$.

56 Slope = -6.0×10^7; $R^2 = 0.96$; $p = 9.6\times10^{-7}$.

57 The NEI includes data on the emissions of criteria and hazardous air pollutant emissions, submitted to the U.S. Environmental Protection Agency (EPA) by state and local agencies. Facilities typically report emissions directly to the state and local agencies, and the state and local agencies may revise data or add additional emissions estimates before submitting the data to EPA. The Air Emissions Reporting Rule has emissions thresholds above which states must report stationary emissions as “point” sources, with the remainder of the stationary emissions reported as “nonpoint” sources. Only “point” sources are included in this analysis.

58 The ISIC Divisions are subsectors of the manufacturing sector and hereafter are referred to as “subsectors.”

59 Slope = -7.2×10^6; $R^2 = 0.85$; $p = 1.7\times10^{-4}$.

60 Slope = -3.2×10^6; $R^2 = 0.96$; $p = 4.7\times10^{-6}$.

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A Pollutant Release and Transfer Register (PRTR) is a system to collect and disseminate information on environmental releases and transfers of pollutants from industrial and other facilities. Among the most important applications of PRTRs is their use to inform decisions, gain insight, identify opportunities, and assess progress related to sustainability.

The OECD Framework on the Role of Pollutant Release and Transfer Registers (PRTRs) in Global Sustainability Analyses describes the role of PRTRs in sustainable development and illustrates how PRTR data and information can be used to assess progress towards global sustainability.

Based on the Framework, this analysis developed approaches for using PRTR data from multiple countries to conduct a global-scale analysis focused on assessing progress towards the United Nations Sustainable Development Goals (SDGs), specifically Goal 12, Target 12.4. This target focuses on sound chemical management, reducing releases of chemicals to the environment, and minimising the adverse impacts of chemical releases on human health and the environment.

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