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Methodologies applied to the CEIP GNFR gap-filling 2017

Part I: Heavy Metals (Pb, Cd, Hg)

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Project management

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CONTENTS

1. Introduction 5
2. Gap-filling methods 5
2.1. Gap-filling of National Total data 5
2.2. Gap-filling of sectoral data 7
3. Reasons for replacement of reported data 8
4. Improvements of the gap-filling procedure 8
5. Data availability and gap-filling method per country or area 8
5.1. Albania (AL) 8
5.2. Armenia (AM) 9
5.3. Asian Areas (AST) 9
5.4. Austria (AT) 10
5.5. Azerbaijan (AZ) 10
5.6. Bosnia and Herzegovina (BA) 10
5.7. Belgium (BE) 10
5.8. Bulgaria (BG) 11
5.9. Belarus (BY) 11
5.10. Switzerland (CH) 11
5.11. Cyprus (CY) 11
5.12. The Czech Republic (CZ) 11
5.13. Germany (DE) 11
5.14. Denmark (DK) 11
5.15. Estonia (EE) 11
5.16. Spain (ES) 12
5.17. Finland (FI) 12
5.18. France (FR) 12
5.19. The United Kingdom (GB) 12
5.20. Georgia (GE) 12
5.21. Greece (GR) 12
5.22. Croatia (HR) 12
5.23. Hungary (HU) 13
5.24. Ireland (IE) 13
5.25. Iceland (IS) 13
5.26. Italy (IT) 13
5.27. Kyrgyzstan (KG) 13
5.28. Kazakhstan (KZT) 14
5.29. Liechtenstein (LI) 14
5.30. Lithuania (LT) 15
5.31. Luxembourg (LU) 15
5.32. Latvia (LV) 15
5.33. Monaco (MC) 15
5.34. Republic of Moldova (MD) 15
5.35. Montenegro (ME) 16
5.36. The Former Yugoslav Republic of Macedonia (MK) 16
5.37. Malta (MT) 16
5.38. The Netherlands (NL) 16
5.39. Norway (NO) 16
5.40. North Africa (NOA) 16
5.41. Poland (PL) 17
5.42. Portugal (PT) 17

5.43. Russian Federation in the extended EMEP domain (RUE) 17
5.44. Romania (RO) 17
5.45. Serbia (RS) 17
5.46. Russian Federation in the former official EMEP domain (RU) 17
5.47. Sweden (SE) 18
5.48. Slovenia (SI) 18
5.49. Slovakia (SK) 18
5.50. Tajikistan (TJ) 18
5.51. Turkmenistan (TM) 18
5.52. Turkey (TR) 19
5.53. Ukraine (UA) 19
5.54. Uzbekistan (UZ) 20
6. References 21

1. Introduction

The EMEP Centre on Emission Inventories and Projections (CEIP) operates the UNECE/EMEP emission database (WebDab) which contains information on air pollutant emissions and projections from the Parties to the LRTAP Convention (UNECE 1979). Among these data sets, also emissions used in EMEP models (gap-filled emissions) and gridded emissions in Google maps are available from the CEIP website (www.ceip.at, CEIP 2017).

Data used by CEIP were reported by the Parties to the LRTAP Convention as sectoral emissions (NFR14) and National Total emissions according to the UNECE guidelines for reporting emissions and projections data under the Convention on long-range transboundary air pollution, Annex I (UNECE 2014). For the use by CEIP, the sector data were aggregated to 13 GNFR sectors. In several cases, no data were submitted by the countries, or the reporting is not complete. Before these emission data can be used by modelers, missing information has to be filled in. To gap-fill those missing data, CEIP typically applies different gap-filling methods. After the gap-filling, sector emissions are used for spatial emission mapping, i.e. the EMEP grid.

This documentation describes the gap-filling methods that have been used for the 2015 GNFR inventory (as reported in 2017) for lead, cadmium and mercury. It illustrates reasons of replacements of reported data, discusses problems of the procedure and gives an overview on the data availability and gap-filling of each country or area.

2. Gap-filling methods

2.1. Gap-filling of National Total data

The share of reported data and an overview of the gap-filling methods are shown in Figure 2.2. All report data up to the 20th March 2017 were included ([1]).

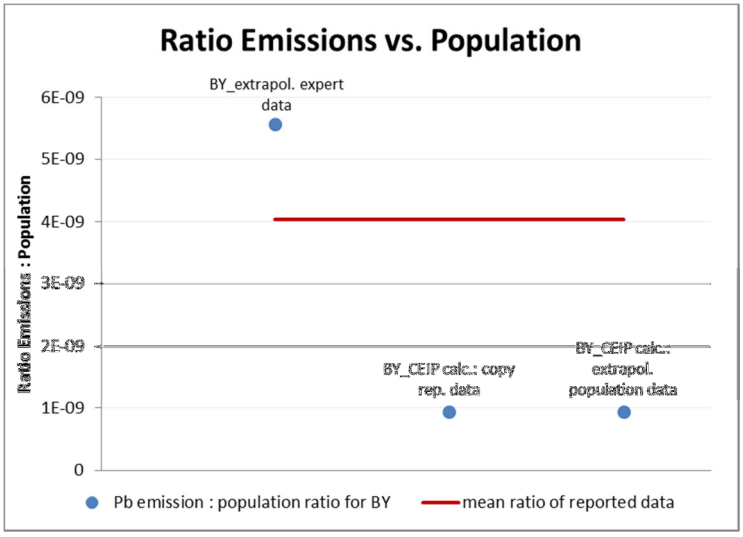
If a country made a submission, reported data are checked for plausibility by comparing with reported data of other countries, expert data and their ratio to population data, GDP and area in comparison with other countries. If plausibility was not given, reported data were replaced (see section 3).

If no submission is made, different estimates were made such as extrapolation of previous reported data, also by using reported PM_{10} data or population data, as these data highly correlate with heavy metal emissions (CEIP 2017). Further, expert estimates were used, as well as inter-, extrapolation or copy of expert estimates. The most important sources of expert estimates were data from the dutch institute TNO (Denier van der Gon et al. 2005). The study was published in 2005 and comprises emission data of lead, cadmium and mercury for the year 2000 and projections for lead, cadmium and mercury for the year 2010 and for lead for the year 2020. Another source of emission data were estimates from the Global Mercury Assessment (AMAP/UNEP 2013, UNEP 2013). Estimates were made for mercury emissions of the year 2010. Additionally, expert estimates were provided by MSC-E (MSC-E 2013). These estimates comprise data of the year 2011 for Kyrgyzstan, Kazakhstan, Tajikistan, Turkmenistan, Uzbekistan, as well as for the Asian Areas and North Africa.

([1]) Additional, a resubmission from Luxembourg on 31 March 2017 with correction of erroneous data is included.

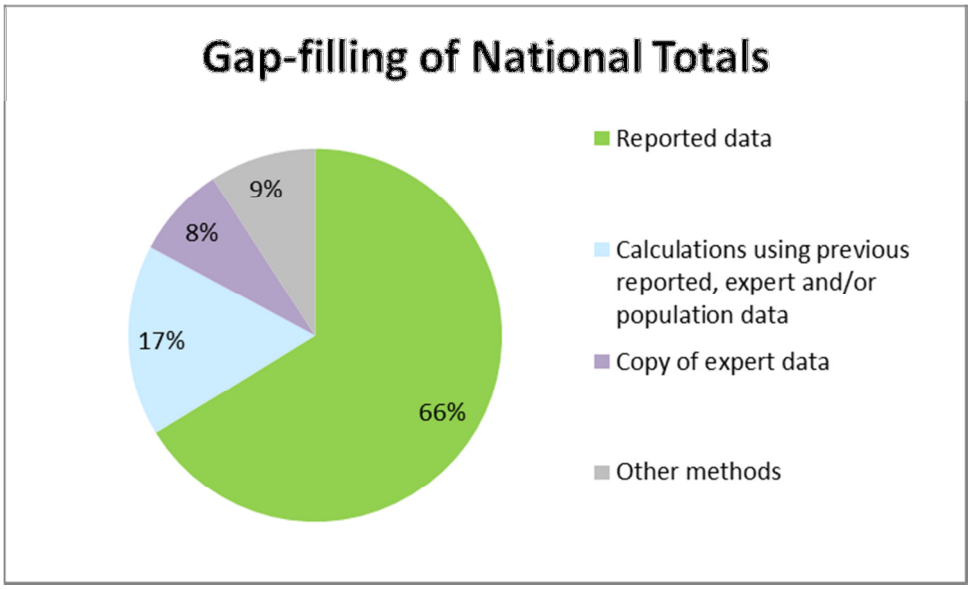
In several cases, not only one estimate is given for a country, and the question rose which estimate fits most. Therefore ratios for each pollutant between emissions and population data, GDP and area size were calculated by using only reported and plausible data. Then, the distance of the different estimates to this ratio is used to determine the best method. An example to determine the best method for lead estimates of Belarus (BY) is shown in Figure 2.1. In this case, extrapolation of expert data highlighted as the best method, i.e. is the closest result to the calculated ratio.

Figure 2.1 Example for different lead estimates for BY



The most common imputation methods were calculations using previous reported, expert and/or population data (see Figure 2.2). Further, a common imputation method was to copy expert estimates of previous years. Other methods were the calculation of emissions from other pollutants or countries by using a factor, the average of different expert estimates, or the sum of the sectors.

Figure 2.2 Overview of reported data and imputation methods for National Total data



2.2. Gap-filling of sectoral data

The share of reported data and an overview of the gap-filling methods are shown in Figure 2.3. All report data up to the 20th March 2017 were included ([2]).

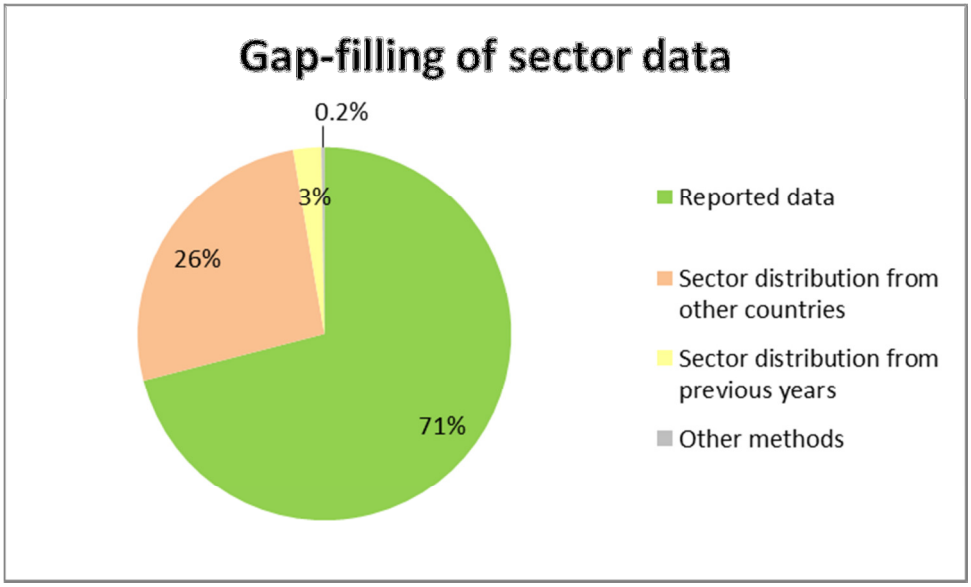
The most common imputation method to gap-fill sector data was to use the distribution ratio of sector emissions from similar countries (see Figure 2.3). To identify which countries are similar to each other, for all countries where data were available ([3]) a distance matrix using Euclidean distances was generated using GDP per capita ([4]) and gap-filled or reported National Total emissions from cadmium, mercury and lead as variables (z-transformed).

For the Asian Areas and North Africa, this analysis was not possible. Therefore, the sector data from all countries addressed in this report where sectoral data were available were used ([5]). In a first step, those sectors were determined where more than half of the countries reported data. For these sectors, the sum of the emissions from all countries was calculated and summed up to calculate in the next step the share of each sector.

For the Russian Federation in the extended EMEP domain (RUE) a similar sector distribution as for the Russian Federation (RU) was assumed.

Other gap-filling methods were applied only in individual cases. These methods were the use of the sector distribution of previous years and extrapolation of reported data.

Figure 2.3 Overview of reported data and imputation methods for sectoral data



([2]) Additional, a resubmission from Luxembourg on 31 March 2017 with correction of erroneous data is included.
([3]) This means all countries addressed in this report except AST (Asian Areas), NOA (North Africa), RUE (Russian Federation in the extended EMEP domain) and RU (Russian Federation in the former official EMEP domain).
([4]) Data source: The World Bank, World Development Indicators. Indicator name: GDP per capita (current US$), indicator code: NY.GDP.PCAP.CD. Values for 2015 are taken, except for Liechtenstein (2014) and Monaco (2011), as no other data were available.
([5]) These countries are: Austria, Azerbaijan, Belgium, Bulgaria, Switzerland, Cyprus, the Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, the United Kingdom, Georgia, Croatia, Hungary, Ireland, Iceland, Italy, Lithuania, Luxembourg, Latvia, the Republic of Moldova, the Former Yugoslav Republic of Macedonia, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Sweden, Slovenia, Slovakia and the Ukraine.

3. Reasons for replacement of reported data

For two countries, data submitted in 2017 were replaced: Mercury emissions from Kyrgyzstan and National Total data of all heavy metals from Kazakhstan.

Kyrgyzstan reported mercury emissions for 2015 only for the sector 'B_Industry' and the National Total. Due to this incomplete sector reporting these data are not very plausible, as also estimates from TNO are much higher (Denier van der Gon et al. 2005). Therefore, the reported National Total mercury data have been replaced by extrapolated data from TNO projections (National Totals) and the sector data have been replaced by sectoral data according to the distribution of the Republic of Moldova (see section 1.5.27).

Kazakhstan reported National Total and sectoral emission data for lead, cadmium and mercury. Sector reporting seems to be incomplete. The reported data are lower than all expert estimates. Therefore, the reported 2015 National Total values were replaced by values interpolated from 2010 and 2020 TNO data for lead. For mercury, data from the year 2010 from the GMA (AMAP/UNEP 2013) were used for the year 2015. Cadmium emissions are assumed to be proportional to the mercury emissions with a factor of 0.56 (information from MSC-E). Sectoral data have been replaced according to the distribution of Turkey (see section 1.5.28).

4. Improvements of the gap-filling procedure

Most countries (38 of 49 countries) submitted data that seem to be complete and plausible. Problems occur where no data at all are available, or when submitted data are not plausible.

When no data are available, different imputation methods were applied. This year, an improvement of the gap-filling procedure was the development of a method to detect the best estimate for missing emissions of a country (in case there are several estimates). This was done by using plausible reported data of other countries in comparison with population data, GDP and area size (see section 2.1).

Further improvements are additional data sources and advanced calculations. This year, data from the Global Mercury Assessment (AMAP/UNEP 2013, UNEP 2013) were considered as well. Calculations are further developed by including population data and reported PM_{10} emission data (see section 2.1).

5. Data availability and gap-filling method per country or area

5.1. Albania (AL)

Data availability

The most recent reported data includes only the year 2009 (for some categories from 2007). National Total data projected by TNO are available for the years 2000, 2010 and for lead also for 2020 (Dernier van der Gon et al. 2005). For mercury, national total data are available from the global mercury assessment (AMAP/UNEP 2013). Further, some unpublished expert data and extrapolations using population data or PM_{10} emission data are present.

Estimation of National Total data for Pb, Cd and Hg

The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was extrapolation of 2000 and 2010 TNO data for cadmium, and interpolation of 2010 and 2020 TNO data for lead. For mercury, extrapolation of reported data for the years 2004 to 2009 was made.

Estimation of sectoral data for Pb, Cd and Hg

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. To identify the most similar country, for all countries where data were available a distance matrix using Euclidean distances was generated using GDP per capita and gap-filled or reported National Total emissions from cadmium, mercury and lead as variables (z-transformed) (see section 2.2). For Albania, Georgia highlighted as the most similar country, therefore the GNFR sector distribution from Georgia was used to split the National Totals of Cd, Hg and Pb into GNFR sectors.

5.2. Armenia (AM)

Data availability

The most recent reported data includes only the year 2014. National Total data projected by TNO are available for the years 2000, 2010 and for lead also for 2020 (Dernier van der Gon et al. 2005). For mercury, national total data are available from the global mercury assessment (AMAP/UNEP 2013). Further, some unpublished expert data and extrapolations using population data are present.

Estimation of National Total data for Pb, Cd and Hg

The best method (see section 2.1 for an explanation) to calculate 2015 National Total data for lead was the extrapolation of 2014 emission data using population data. For cadmium, an extrapolation of 2000 and 2010 TNO data was made, and for mercury, extrapolation of reported 2007 and 2014 data was made.

Estimation of sectoral data for Pb, Cd and Hg

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. To identify the most similar country, for all countries where data were available a distance matrix using Euclidean distances was generated using GDP per capita and gap-filled or reported National Total emissions from cadmium, mercury and lead as variables (z-transformed) (see section 2.2). For Armenia, Albania highlighted as the most similar country, and the FYR of Macedonia as the second most similar country. As for Albania sectoral data are also not available, the second most similar country was used. Therefore the GNFR sector distribution from the FYR of Macedonia was used to split the National Totals of Cd, Hg and Pb into GNFR sectors.

5.3. Asian Areas (AST)

Data availability

As this area consists of several countries and part of countries, no reported data are available. Emissions for this area have been estimated by MSC-E in 2013 for the year 2011.

Estimation of National Total data for Pb, Cd and Hg

National Total emission data were copied from the estimations of the year 2011.

Estimation of sectoral data for Pb, Cd and Hg

To calculate the sector distribution for the Asian Areas, GNFR sector data from all countries addressed in this report where sectoral data were available were used (see section 2.2). In a first step, those sectors were determined where more than half of the countries reported data. For these sectors, the sum of the emissions from all countries was calculated and summed up to calculate in the next step the share of each sector. This sector shares were then used to split the National Total emissions of the Asian Areas into GNFR sectors.

5.4. Austria (AT)

The data of Austria reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.5. Azerbaijan (AZ)

The data of Azerbaijan reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.6. Bosnia and Herzegovina (BA)

Data availability

No reported data were available. National Total data projected by TNO are available for the years 2000, 2010 and for lead also for 2020 (Dernier van der Gon et al. 2005). For mercury, national total data are available from the global mercury assessment (AMAP/UNEP 2013). Further, some unpublished expert data and extrapolations of TNO data and GMA data using population data are present.

Estimation of National Total data for Pb, Cd and Hg

The best method (see section 2.1 for an explanation) to calculate 2015 National Total data for lead was the extrapolation using 2010 TNO data and population data. For cadmium, an extrapolation of 2000 and 2010 TNO data was made, and for mercury, extrapolation using 2013 GMA and population data was made.

Estimation of sectoral data for Pb, Cd and Hg

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. To identify the most similar country, for all countries where data were available a distance matrix using Euclidean distances was generated using GDP per capita and gap-filled or reported National Total emissions from cadmium, mercury and lead as variables (z-transformed) (see section 2.2). For Bosnia and Herzegovina, Serbia highlighted as the most similar country, therefore the GNFR sector distribution from Serbia was used to split the National Totals of Cd, Hg and Pb into GNFR sectors.

5.7. Belgium (BE)

The data of Belgium reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.8. Bulgaria (BG)

The data of Bulgaria reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.9. Belarus (BY)

Data availability and quality

The most recent reported data includes only the year 2014. National Total data projected by TNO are available for the years 2000, 2010 and for lead also for 2020 (Dernier van der Gon et al. 2005). For mercury, national total data are available from the global mercury assessment (AMAP/UNEP 2013). Further, some unpublished expert data and extrapolations using population data are present.

Estimation of National Total data for Pb, Cd and Hg

The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was extrapolation of 2000 and 2010 TNO data for cadmium, and interpolation of 2010 and 2020 TNO data for lead. For mercury, an average between two expert estimates was used.

Estimation of sectoral data for Pb, Cd and Hg

The sector distribution from the 2016 submission was used to split the National Totals into GNFR sectoral emissions.

5.10. Switzerland (CH)

The data of Switzerland reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.11. Cyprus (CY)

The data of Cyprus reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.12. The Czech Republic (CZ)

The data of the Czech Republic reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.13. Germany (DE)

The data of Germany reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.14. Denmark (DK)

The data of Denmark reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.15. Estonia (EE)

The data of Estonia reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.16. Spain (ES)

The data of Spain reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.17. Finland (FI)

The data of Finland reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.18. France (FR)

The data of France reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.19. The United Kingdom (GB)

The data of the United Kingdom reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.20. Georgia (GE)

The data of Georgia reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.21. Greece (GR)

Reported data were available only for the year 1996. National Total data projected by TNO are available for the years 2000, 2010 and for lead also for 2020 (Dernier van der Gon et al. 2005). For mercury, national total data are available from the global mercury assessment (AMAP/UNEP 2013). Further, some unpublished expert data and extrapolations using population data are present.

Estimation of National Total data for Pb, Cd and Hg

The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was extrapolation of 2000 and 2010 TNO data for cadmium, and interpolation of 2010 and 2020 TNO data for lead. For mercury, an average between two expert estimates were used.

Estimation of sectoral data for Pb, Cd and Hg

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. To identify the most similar country, for all countries where data were available a distance matrix using Euclidean distances was generated using GDP per capita and gap-filled or reported National Total emissions from cadmium, mercury and lead as variables (z-transformed) (see section 2.2). For Greece, the Ukraine highlighted as the most similar country, therefore the GNFR sector distribution from the Ukraine was used to split the National Totals of Cd, Hg and Pb into GNFR sectors.

5.22. Croatia (HR)

The data of Croatia reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.23. Hungary (HU)

The data of Hungary reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.24. Ireland (IE)

The data of Ireland reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.25. Iceland (IS)

The data of Iceland reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.26. Italy (IT)

The data of Italy reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.27. Kyrgyzstan (KG)

Data availability and quality

Reported data for Cd were available for the years 2010 to 2012 (only National Total). Reported data for Hg were available for the years 2010 to 2012 and 2014 to 2015 (National Total and sector 'B_Industry' only). Reported data for Pb were available for the years 1999 (only National Total) and 2010 to 2012 (National Total and sector 'B_Industry').

National Total data projected by TNO are available for the years 2000, 2010 and for lead also for 2020 (Dernier van der Gon et al. 2005). For mercury, national total data are available from the global mercury assessment (AMAP/UNEP 2013). Further, some unpublished expert data and extrapolations using population data are present. All reported data are lower than the expert estimates, and due to the uncomplete sector reporting the plausibility of the reported data is low.

Estimation of National Total data for Pb, Cd and Hg

The best method (see section 2.1 for an explanation) to replace 2015 National Total data of mercury was the extrapolation from 2000 and 2010 TNO data. Cadmium emissions are assumed to be proportional to the mercury emissions with a factor of 0.56 (information from MSC-E). For lead, interpolation of 2010 and 2020 TNO data was done.

Estimation of sectoral data for Pb, Cd and Hg

The only reported sectoral data were mercury emissions from 'B_Industry'. As these emissions were rather small, the plausibility of the reported data is low. Therefore, these sectoral data have been replaced.

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. To identify the most similar country, for all countries where data were available a distance matrix using Euclidean distances was generated using GDP per capita and gap-filled or reported National Total emissions from cadmium, mercury and lead as variables (z-transformed) (see section 2.2). For Kyrgyzstan, Albania, Armenia and the Republic of Moldova highlighted as the most similar country (in descending order). As for Albania and Armenia sectoral

data are also not available, the GNFR sector distribution from the Republic of Moldova was used to split the National Totals of Cd, Hg and Pb into GNFR sectors.

5.28. Kazakhstan (KZT)

Data availability and quality

Reported National Total data and data for some sectors were available for the years 2000, 2005 and 2010 to 2015. National Total data projected by TNO are available for the years 2000, 2010 and for lead also for 2020 (Dernier van der Gon et al. 2005). For mercury, national total data are available from the global mercury assessment (AMAP/UNEP 2013). Further, some unpublished expert data and extrapolations using population data are present. The reported data are lower than all expert estimates, and due to the incomplete sector reporting the plausibility of the reported data is low.

Estimation of National Total data for Pb, Cd and Hg

The reported 2015 National Total values were replaced by values interpolated from 2010 and 2020 TNO data for lead. For mercury, data from the year 2010 from the GMA (AMAP/UNEP 2013) were used for the year 2015. Cadmium emissions are assumed to be proportional to the mercury emissions with a factor of 0.56 (information from MSC-E).

Estimation of sectoral data for Pb, Cd and Hg

The reported sectoral emission data were rather small; therefore the plausibility of the reported data is low. For that reason, these sectoral data have been replaced.

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. To identify the most similar country, for all countries where data were available a distance matrix using Euclidean distances was generated using GDP per capita and gap-filled or reported National Total emissions from cadmium, mercury and lead as variables (z-transformed) (see section 2.2). For Kazakhstan, Poland highlighted as the most similar country, therefore the GNFR sector distribution from Poland was used to split the National Totals of Cd, Hg and Pb into GNFR sectors.

5.29. Liechtenstein (LI)

Data availability and quality

Reported data were available for the years 1990 to 2014. Only for a few GNFR sectors data were reported. Beside these previous reported emission data, extrapolations using population data are available.

Estimation of National Total data for Pb, Cd and Hg

The best method (see section 2.1 for an explanation) to calculate 2015 National Total data for lead, cadmium and mercury was the extrapolation of reported 2014 emission data using population data.

Estimation of sectoral data for Pb, Cd and Hg

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. To identify the most similar country, for all countries where data were available a distance matrix using Euclidean distances was generated using GDP per capita and gap-filled or reported National Total emissions from cadmium, mercury and lead as variables (z-transformed) (see section 2.2). For Liechtenstein, Monaco highlighted as the most similar country, and Luxembourg as the second most similar country. As for Monaco sectoral data are also not

available, the second most similar country was used. Therefore the GNFR sector distribution from Luxembourg was used to split the National Totals of Cd, Hg and Pb into GNFR sectors.

5.30. Lithuania (LT)

The data of Lithuania reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.31. Luxembourg (LU)

The data of Luxembourg reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.32. Latvia (LV)

The data of Latvia reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.33. Monaco (MC)

Data availability and quality

Reported data were available from 1990 to 2014. National Totals seemed to be plausible and were reported for all years, but sectoral data were given only for a few GNFR sectors. For mercury, national total data are available from the global mercury assessment (AMAP/UNEP 2013). Further, some unpublished expert data and extrapolations using population data are present.

Estimation of National Total data for Pb, Cd and Hg

The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was extrapolation of reported data. For cadmium and mercury, this was done using data of the years 1990 to 2014. As the trend for lead in former years differ strongly to the trends afterwards, extrapolation of the National Total was done using data for the years 2000 to 2014 only.

Estimation of sectoral data for Pb, Cd and Hg

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. To identify the most similar country, for all countries where data were available a distance matrix using Euclidean distances was generated using GDP per capita and gap-filled or reported National Total emissions from cadmium, mercury and lead as variables (z-transformed) (see section 2.2). For Monaco, Liechtenstein highlighted as the most similar country, and Luxembourg as the second most similar country. As for Liechtenstein sectoral data are also not available, the second most similar country was used. Therefore the GNFR sector distribution from Luxembourg was used to split the National Totals of Cd, Hg and Pb into GNFR sectors.

5.34. Republic of Moldova (MD)

The data of the Republic of Moldova reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.35. Montenegro (ME)

Data availability and quality

Reported data (National Totals and sectoral data) were available from 1990 to 2011. These data seemed to be plausible. Beside these previous reported emission data, some unpublished expert data and extrapolations using population data are available.

Estimation of National Total data for Pb, Cd and Hg

The best method (see section 2.1 for an explanation) to calculate 2015 National Total data for lead, cadmium and mercury was the extrapolation of reported 2011 emission data using population data.

Estimation of sectoral data for Pb, Cd and Hg

As the sector distribution of the latest reporting year (2011) is plausible, this distribution was used for 2015 to split National Total emissions into sectors.

5.36. The Former Yugoslav Republic of Macedonia (MK)

The data of the Former Yugoslav Republic of Macedonia reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.37. Malta (MT)

The data of Malta reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.38. The Netherlands (NL)

The data of the Netherlands reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.39. Norway (NO)

The data of Norway reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.40. North Africa (NOA)

Data availability

As this area consists of several countries and part of countries, no reported data are available. Emissions for this area have been estimated by MSC-E in 2013 for the year 2011.

Estimation of National Total data for Pb, Cd and Hg

National Total emission data were copied from the estimations for the year 2011.

Estimation of sectoral data for Pb, Cd and Hg

To calculate the sector distribution for the Asian Areas, GNFR sector data from all countries addressed in this report where sectoral data were available were used (see section 2.2). In a first step, those sectors were determined where more than half of the countries reported data. For these sectors, the sum of the emissions from all countries was calculated and summed up to calculate in the next step the share of each sector. This sector shares were then used to split the National Total emissions of the Asian Areas into GNFR sectors.

5.41. Poland (PL)

The data of Poland reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.42. Portugal (PT)

The data of Portugal reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.43. Russian Federation in the extended EMEP domain (RUE)

Data availability and estimation of National Total data for Pb, Cd and Hg

As the Russian Federation in the extended EMEP domain does not follow common borders, no reported data are available. Only emission estimates done in 2013 for the year 2011 from MSE-E are available.

National Totals of lead, cadmium and mercury from the Russian Federation in the extended EMEP domain (RUE) were assessed using emission data for the Russian Federation in the former official EMEP domain (RU) by keeping the ratio between the two parts derived from the Global lead inventory.

Estimation of sectoral data for Pb, Cd and Hg

For the Russian Federation in the extended EMEP domain a similar sector distribution as for the Russian Federation (in the former official EMEP domain) is assumed. Therefore, the sector distribution of RU is used to split the National Total emissions of RUE into the GNFR sectors.

5.44. Romania (RO)

The data of Romania reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.45. Serbia (RS)

The data of Serbia reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.46. Russian Federation in the former official EMEP domain (RU)

Data availability

Reported National Total data are available for 1990 to 2000, 2002 to 2006 and 2009. In the years 2002 to 2006 also data for the GNFR sector 'A_PublicPower' were reported, and for 2009 several sectoral data were available. The reported National Totals for the year 2009 are much lower than the trend of the years before. Sectoral data of the GNFR sector 'A_PublicPower', which is an important source sector for heavy metals, seems to be incomplete or too small for this year.

Estimation of National Total data for Pb, Cd and Hg

National Total emission data were calculated by the sum of the GNFR sectors.

Estimation of sectoral data for Pb, Cd and Hg

Sectoral data reported for 2009 were copied for the year 2015. Additional, data for the GNFR sector 'A_PublicPower' were extrapolated for 2015 from reported data of the years 2002 to 2006.

5.47. Sweden (SE)

The data of Sweden reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.48. Slovenia (SI)

The data of Slovenia reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.49. Slovakia (SK)

The data of Slovakia reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.50. Tajikistan (TJ)

Data availability

No reported data were available. Emission estimates from MSC-E done in 2013 for the year 2011 are available. For mercury, national total data are available from the global mercury assessment (AMAP/UNEP 2013). Further, some unpublished expert data and extrapolations using population data are present.

Estimation of National Total data for Pb, Cd and Hg

The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was for lead to copy National Total emission data from the estimations for the year 2011. For mercury, an average between two expert estimates were used. Cadmium emissions are assumed to be proportional to the mercury emissions with a factor of 0.56 (information from MSC-E).

Estimation of sectoral data for Pb, Cd and Hg

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. To identify the most similar country, for all countries where data were available a distance matrix using Euclidean distances was generated using GDP per capita and gap-filled or reported National Total emissions from cadmium, mercury and lead as variables (z-transformed) (see section 2.2). For Tajikistan, Turkmenistan highlighted as the most similar country, and Bulgaria as the second most similar country. As for Turkmenistan sectoral data are also not available, the second most similar country was used. Therefore the GNFR sector distribution from Bulgaria was used to split the National Totals of Cd, Hg and Pb into GNFR sectors.

5.51. Turkmenistan (TM)

Data availability

No reported data were available. Emission estimates from MSC-E done in 2013 for the year 2011 are available. For mercury, national total data are available from the global mercury assessment

(AMAP/UNEP 2013). Further, some unpublished expert data and extrapolations using population data are present.

Estimation of National Total data for Pb, Cd and Hg

The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was for lead to copy National Total emission data from the estimations for the year 2011. For mercury, an average between two expert estimates were used. Cadmium emissions are assumed to be proportional to the mercury emissions with a factor of 0.56 (information from MSC-E).

Estimation of sectoral data for Pb, Cd and Hg

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. To identify the most similar country, for all countries where data were available a distance matrix using Euclidean distances was generated using GDP per capita and gap-filled or reported National Total emissions from cadmium, mercury and lead as variables (z-transformed) (see section 2.2). For Turkmenistan, Tajikistan, Armenia, Albania and the FYR of Macedonia highlighted as the most similar countries (in descending order). As for Tajikistan, Armenia and Albania sectoral data are also not available, the GNFR sector distribution from the FYR of Macedonia was used to split the National Totals of Cd, Hg and Pb into GNFR sectors.

5.52. Turkey (TR)

Data availability

Reported data were not available for any year. National Total data projected by TNO are available for the years 2000, 2010 and for lead also for 2020 (Dernier van der Gon et al. 2005). For mercury, national total data are available from the global mercury assessment (AMAP/UNEP 2013). Further, some unpublished expert data and extrapolations using population data are present.

Estimation of National Total data for Pb, Cd and Hg

The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was for extrapolation of 2000 and 2010 TNO data for cadmium, and interpolation of 2010 and 2020 TNO data for lead. For mercury, data from the year 2010 from the GMA (AMAP/UNEP 2013) were used for the year 2015.

Estimation of sectoral data for Pb, Cd and Hg

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. To identify the most similar country, for all countries where data were available a distance matrix using Euclidean distances was generated using GDP per capita and gap-filled or reported National Total emissions from cadmium, mercury and lead as variables (z-transformed) (see section 2.2). For Turkey, Poland highlighted as the most similar country, therefore the GNFR sector distribution from Poland was used to split the National Totals of Cd, Hg and Pb into GNFR sectors.

5.53. Ukraine (UA)

The data of the Ukraine reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

5.54. Uzbekistan (UZ)

Data availability

No reported data were available. Emission estimates from MSC-E done in 2013 for the year 2011 are available. For mercury, national total data for 2010 are available from the global mercury assessment (AMAP/UNEP 2013). Further, some unpublished expert data and extrapolations using population data are present.

Estimation of National Total data for Pb, Cd and Hg

The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was to copy emission estimates from the year 2011.

Estimation of sectoral data for Pb, Cd and Hg

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. To identify the most similar country, for all countries where data were available a distance matrix using Euclidean distances was generated using GDP per capita and gap-filled or reported National Total emissions from cadmium, mercury and lead as variables (z-transformed) (see section 2.2). For Uzbekistan, the Ukraine highlighted as the most similar country, therefore the GNFR sector distribution from the Ukraine was used to split the National Totals of Cd, Hg and Pb into GNFR sectors.

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