CEIP umweltbundesamt

Methodologies applied to the CEIP GNFR gap-filling 2017

Part II: Persistent organic pollutants

(Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Dioxin and Furan, Hexachlorobenzene)

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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 Benzo(a)pyrene, Benzo(b)fluroanthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, PCDD/Fs and HCB. 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 reported 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. Further, the sum of reported Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene data is compared with reported data on Total PAHs. If plausibility was not given, reported data were replaced (see section 3).

If no submission is made, different estimates were made to fill the gaps. Copy of expert data from different literature sources were used, as well as calculations such as extrapolation of these data or previous reported data, also by using population data. Literature sources comprise

- the Norwegian final report of the POPCYCLING-Baltic project (Pacyna et al. 1999), were emission data for HCB for the years 1990 and 1995 were given
- emission projections from the dutch institute TNO (Denier van der Gon et al. 2005) for dioxin, PAHs and HCB for the year 2000 and 2010

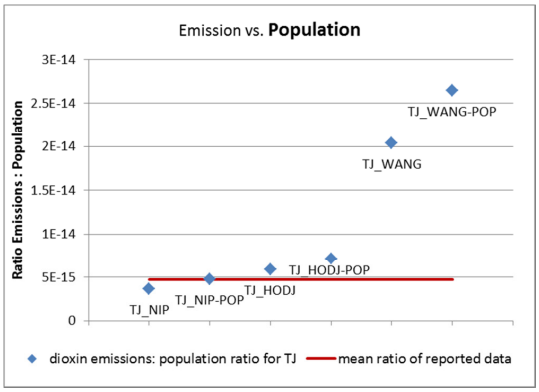
([1]) Additional, a resubmission from Luxembourg on 31 March 2017 is included.

- a study on uncertainties in dioxin emission estimates for central Europe (Pulles et al. 2006) that contains dioxin data for the year 2000
- a study on the determination of dioxins, furans, PCB sources and anti-POPs campaign in Central Asia (Hodjamberdiev 2006) including dioxin data for 2006
- the global POPs Inventories (Fiedler 2007) including data for dioxin and HCB for the year 2000
- the global atmospheric emission inventory of PAHs with for the year 2004 (Zhang & Tao 2009)
- a primary estimate of global PCDD/F release (Wang et al. 2016) with several dioxin data for the years 2000 to 2007
- data given by the Kyrgyz Republic, Tajikistan, Turkey, the Ukraine (Kyrgyz Republic 2006, Tajikistan 2006, Turkey 2010, Turkey 2014, Ukraine 2007) for the National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants.

Further, a common imputation method – only for the PAHs – was the split of reported Total PAH data into Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene. This method was used when no data for PAHs were given, but information on Total PAH was available. Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene data were calculated using a ratio to split Total PAH emissions. This sector splitting ratio was derived using data from other countries ([2]) by calculating the mean share of the reported PAH data on the Total PAH emissions. Data were only used from countries where the sum of the PAHs equals the reported Total PAH data.

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 dioxin estimates of Tajikistan (TJ) is shown in Figure 2.1. In this case, data from Tajikistan provided for the National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants (Tajikistan 2006) extrapolated using population data highlighted as the best method, i.e. is the closest result to the calculated ratio.

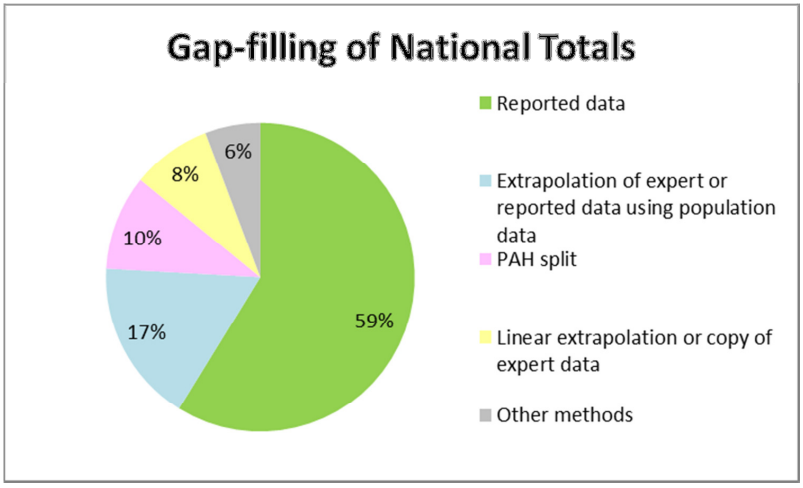
Figure 2.1 Example for different dioxin estimates for TJ



([2]) These countries are: Estonia, Hungary, Ireland, Poland, Romania, Switzerland and the United Kingdom.

The most common imputation methods were extrapolations with population data using previous reported or expert data (see Figure 2.2). Further, a common imputation method was PAH split (only for the PAHs) and the linear extrapolation or copy of expert data.

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 reported data up to the 20th March 2017 were included ([3]).

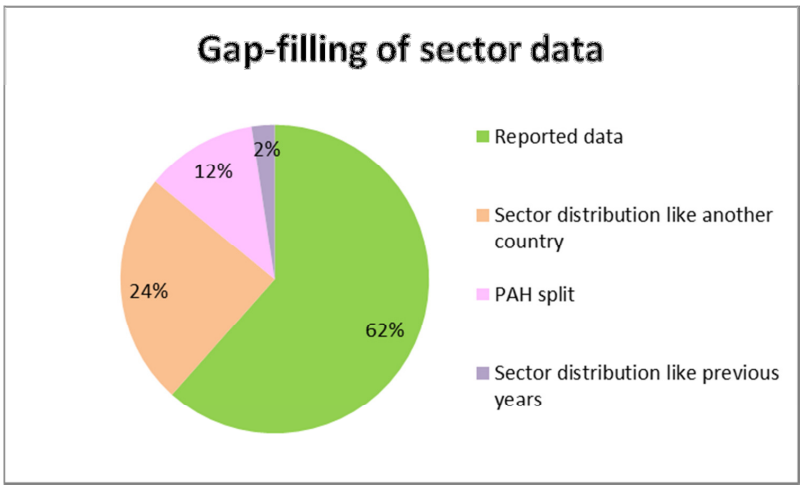
The most common imputation method to gap-fill sector data was to use the distribution ratio of sector emissions from similar countries (see Figure 2.3). To identify which countries are similar to each other, for all countries where data were available ([4]) a distance matrix using Euclidean distances was generated using GDP per capita ([5]) and gap-filled or reported National Total emissions from Total PAH, PCDD/F and HCB as variables (z-transformed). For the Russian Federation in the extended EMEP domain (RUE) a similar sector distribution as for the Russian Federation (RU) was assumed.

Further, a common imputation method – only for the PAHs – was the split of reported Total PAH data into Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene. This method was used when no data for PAHs were given, but information on Total PAH was available. Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene data were calculated using a ratio to split Total PAH emissions. This sector splitting ratio was derived using data from other countries ([2]) by calculating the mean share of the reported PAH data on the Total PAH emissions. Data were only used from countries where the sum of the PAHs equals the reported Total PAH data.

The only other gap-filling method was the sector distribution like in previous years (see Figure 2.3).

([3]) Additional, a resubmission from Luxembourg on 31 March 2017 is included.
([4]) This means all countries addressed in this report except RUE (Russian Federation in the extended EMEP domain).
([5]) 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.

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



3. Reasons for replacement of reported data

For four countries, data submitted in 2017 were replaced: PAH data of Germany, Kazakhstan, Portugal and Serbia and ~~HCB~~ PCDD/F data of Kazakhstan.

PAH data of these countries were replaced, as the sum of the four PAHs differ strongly with the reported Total PAH data. For Germany, Portugal and Serbia, the reported Total PAH emissions were used to split in Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene. The sector splitting ratio was derived using data from other countries ([2]) by calculating the mean share of the reported PAH data on the Total PAH emissions (Data were only used from countries where the sum of the PAHs equals the reported Total PAH data). In the case of Kazakhstan, estimates from Zhang & Tao (2009), extrapolated using population data were taken to estimate the National Totals. For the sector split, the sector distribution from Azerbaijan was used to split the National Total into GNFR sectors.

~~HCB~~ PCDD/F data of Kazakhstan were replaced, as the reported data were very low compared with expert data. National total data were replaced by copy of expert data for the year 2000 from the global POP inventories (Fiedler 2007). For the sector split, the sector distribution from Azerbaijan was used to split the National Total into GNFR sectors.

4. Improvements of the gap-filling procedure

Most countries (32 of 51 countries) submitted data that seem to be complete and plausible (four of them without data for the individual PAHs). 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. Calculations are further developed by including population data (see section 2.1).

5. Data availability and gap-filling method per country

5.1. Albania (AL)

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

The most recent reported data includes only the year 2009. The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was the extrapolation of 2000 and 2010 TNO data (Denier van der Gon et al. 2005) for PAHs and HCB, and extrapolation of data from the global POP inventories (Fiedler 2007) using population data for PCDD/F (these data are the same as TNO data for the year 2000).

Estimation of sectoral data for PAHs, PCDD/F and HCB

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 Total PAH, PCDD/F and HCB as variables (z-transformed) (see section 2.2). For Albania, Turkmenistan, Tajikistan and Georgia highlighted as the most similar country (in descending order). As for Turkmenistan and Tajikistan also no reported data are available, the GNFR sector distribution from Georgia was used to split the National Totals of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene, PCDD/F and HCB into GNFR sectors.

5.2. Armenia (AM)

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

The most recent reported data includes only the year 2014. The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was the extrapolation of 2000 and 2010 TNO data (Denier van der Gon et al. 2005) using population data for PAHs, and extrapolation of data from the global POP inventories (Fiedler 2007) using population data for PCDD/F (these data are the same as TNO data for the year 2000). For HCB, linear extrapolation of expert data from Pacyna et al. (1999) was used.

Estimation of sectoral data for PAHs, PCDD/F and HCB

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 Total PAH, PCDD/F and HCB as variables (z-transformed) (see section 2.2). For Armenia, Bosnia and Herzegovina, Montenegro and Bulgaria highlighted as the most similar country (in descending order). As for Bosnia and Herzegovina and Montenegro also no reported data are available, the GNFR sector distribution from Bulgaria was used to split the National Totals of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene, PCDD/F and HCB into GNFR sectors.

5.3. Austria (AT)

The data of Austria reported in 2017 seemed to be complete and plausible. Data for Total PAHs were available, but not for Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene.

Estimation of National Total and sector data for BaP, BbF, BkF and IP

Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene data were calculated using a ratio to split Total PAH emissions. This sector splitting ratio was derived using data from other countries ([2]) by calculating the mean share of the reported PAH data on the Total PAH emissions. Data were only used from countries where the sum of the PAHs equals the reported Total PAH data.

5.4. Azerbaijan (AZ)

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

5.5. Bosnia and Herzegovina (BA)

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

No reported data were available. The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was the extrapolation of 2000 and 2010 TNO data (Denier van der Gon et al. 2005) using population data for PAHs, and extrapolation of 2000 and 2010 TNO data for PCDD/F. For HCB, extrapolation of expert data from Pacyna et al. (1999) using population data was used.

Estimation of sectoral data for PAHs, PCDD/F and HCB

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 Total PAH, PCDD/F and HCB as variables (z-transformed) (see section 2.2). For Bosnia and Herzegovina, Armenia and Bulgaria highlighted as the most similar country (in descending order). As for Armenia also no reported data are available, the GNFR sector distribution from Bulgaria was used to split the National Totals of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene, PCDD/F and HCB into GNFR sectors.

5.6. Belgium (BE)

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

5.7. Bulgaria (BG)

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

5.8. Belarus (BY)

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

The most recent reported data includes only the year 2014. The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was the extrapolation of 2000 and 2010 TNO data (Denier van der Gon et al. 2005) for PAHs and the copy of reported data from 2014 for HCB and PCDD/F.

Estimation of sectoral data for PAHs, PCDD/F and HCB

To split the National Total emission data into GNFR sectoral emissions, the same sector distribution like for 2014 data was used.

5.9. Switzerland (CH)

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

5.10. Cyprus (CY)

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

5.11. 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.

5.12. Germany (DE)

The data of Germany reported in 2017 seemed to be complete and plausible, except that emissions of Total PAHs are much higher than the sum of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene. Therefore, data for the four individual PAHs were replaced.

Estimation of National Total and sector data for BaP, BbF, BkF and IP

Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene data were calculated using a ratio to split Total PAH emissions. This sector splitting ratio was derived using data from other countries ([2]) by calculating the mean share of the reported PAH data on the Total PAH emissions. Data were only used from countries where the sum of the PAHs equals the reported Total PAH data.

5.13. Denmark (DK)

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

5.14. Estonia (EE)

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

5.15. Spain (ES)

The data of Spain reported in 2017 seemed to be complete and plausible. Data for Total PAHs were available, but not for Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene.

Estimation of National Total and sector data for BaP, BbF, BkF and IP

Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene data were calculated using a ratio to split Total PAH emissions. This sector splitting ratio was derived using data from other countries ([2]) by calculating the mean share of the reported PAH data on the Total PAH emissions. Data were only used from countries where the sum of the PAHs equals the reported Total PAH data.

5.16. Finland (FI)

The data of Finland reported in 2017 seemed to be complete and plausible. Data for Total PAHs were available, but not for Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene.

Estimation of National Total and sector data for BaP, BbF, BkF and IP

Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene data were calculated using a ratio to split Total PAH emissions. This sector splitting ratio was derived using data from other countries ([2]) by calculating the mean share of the reported PAH data on the Total PAH emissions. Data were only used from countries where the sum of the PAHs equals the reported Total PAH data.

5.17. France (FR)

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

5.18. 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.

5.19. Georgia (GE)

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

5.20. Greece (GR)

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

No reported data were available. The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was the extrapolation of 2000 and 2010 TNO data (Denier van der Gon et al. 2005) using population data for PAHs, and extrapolation of 2000 and 2010 TNO data for HCB. For PCDD/F, copy of TNO data for the year 2010 data was used (as an extrapolation was not possible).

Estimation of sectoral data for PAHs, PCDD/F and HCB

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 Total PAH, PCDD/F and HCB as variables (z-transformed) (see section 2.2). For Greece, Slovakia highlighted as the most similar country, therefore the GNFR sector distribution from Slovakia was used to split the National Totals of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene, PCDD/F and HCB into GNFR sectors.

5.21. Croatia (HR)

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

5.22. Hungary (HU)

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

5.23. Ireland (IE)

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

5.24. Iceland (IS)

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

5.25. Italy (IT)

The data of Italy reported in 2017 seemed to be complete and plausible. Data for Total PAHs were available, but not for Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene.

Estimation of National Total and sector data for BaP, BbF, BkF and IP

Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene data were calculated using a ratio to split Total PAH emissions. This sector splitting ratio was derived using data from other countries ([2]) by calculating the mean share of the reported PAH data on the Total PAH emissions. Data were only used from countries where the sum of the PAHs equals the reported Total PAH data.

5.26. Kyrgyzstan (KG)

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

Only National Total data of Benzo(a)pyrene for the years 2010-2012 were available. The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was the extrapolation of 2000 and 2010 TNO data (Denier van der Gon et al. 2005) using population data for PAHs, and extrapolation of 2000 and 2010 TNO data for HCB. For PCDD/F copy of data for 2003 from the

National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants (Kyrgyz Republic 2006) was used.

Estimation of sectoral data for PAHs, PCDD/F and HCB

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 Total PAH, PCDD/F and HCB as variables (z-transformed) (see section 2.2). For Kyrgyzstan, Serbia highlighted as the most similar country, therefore the GNFR sector distribution from Serbia was used to split the National Totals of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene, PCDD/F and HCB into GNFR sectors.

5.27. Kazakhstan (KZT)

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

Kazakhstan reported PAH, HCB and PCDD/F data for the year 2015, but data for PAHs and HCB were replaced. PAH data were replaced as the sum of the four PAHs differ strongly with the reported Total PAH data, and ~~HCB~~ PCDD/F data were replaced as the reported data were very low compared with expert data.

The best method (see section 2.1 for an explanation) to calculate 2015 PAH National Total data were extrapolated estimates from Zhang & Tao (2009) using population data and copy of expert data for the year 2000 from the global POP inventories (Fiedler 2007) for PCDD/Fs (these data are the same as TNO data for the year 2000). For HCB, the reported data seemed to be complete and plausible and were not replaced.

Estimation of sectoral data for PAHs, PCDD/F and HCB

To split the ~~PAH and HCB~~ 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 Total PAH, PCDD/F and HCB as variables (z-transformed) (see section 2.2). For Kazakhstan, Azerbaijan highlighted as the most similar country, therefore the GNFR sector distribution from Azerbaijan was used to split the National Totals of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene, PCDD/F and HCB into GNFR sectors.

5.28. Liechtenstein (LI)

Reported data were available from 1990 to 2014. The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was the copy of reported data from 2014 (National Totals and sectoral data). For HCB, no data and no expert estimates were available; therefore gap-filling was not possible.

5.29. Lithuania (LT)

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

5.30. Luxembourg (LU)

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

5.31. Latvia (LV)

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

5.32. Monaco (MC)

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

Reported data were available from 1990 to 2014. The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was the extrapolation of estimates from Zhang & Tao (2009) using population data for PAHs, and for HCB and PCDD/F the copy of reported data from 2014.

Estimation of sectoral data for PAHs, PCDD/F and HCB

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 Total PAH, PCDD/F and HCB as variables (z-transformed) (see section 2.2). For Monaco, Liechtenstein and Luxembourg highlighted as the most similar country (in descending order). As for Liechtenstein also no reported data are available, the GNFR sector distribution from Luxembourg was used to split the National Totals of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene, PCDD/F and HCB into GNFR sectors.

5.33. 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.

5.34. Montenegro (ME)

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

Reported data were available from 1990 to 2011. The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was the extrapolation of reported data (2011) using population data for PAHs, PCDD/F and HCB.

Estimation of sectoral data for PAHs, PCDD/F and HCB

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 Total PAH, PCDD/F and HCB as variables (z-transformed) (see section 2.2). For Montenegro, Turkmenistan and the FYR of Macedonia highlighted as the most similar country (in descending order). As for Turkmenistan also no reported data are available, the GNFR sector distribution from the FYR of Macedonia was used to split the National

Totals of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene, PCDD/F and HCB into GNFR sectors.

5.35. 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.

5.36. Malta (MT)

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

5.37. The Netherlands (NL)

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

5.38. Norway (NO)

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

5.39. Poland (PL)

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

5.40. Portugal (PT)

The data of Portugal reported in 2017 seemed to be complete and plausible, except that emissions of Total PAHs are much higher than the sum of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene. Therefore, data for the four individual PAHs were replaced.

Estimation of National Total and sector data for BaP, BbF, BkF and IP

Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene data were calculated using a ratio to split Total PAH emissions. This sector splitting ratio was derived using data from other countries ([2]) by calculating the mean share of the reported PAH data on the Total PAH emissions. Data were only used from countries where the sum of the PAHs equals the reported Total PAH data.

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

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

As the Russian Federation in the extended EMEP domain does not follow common borders, no reported data are available. In previous years, the part of the Russian Federation in the extended EMEP domain were calculated for PCDD/F and PAHs by multiplying emissions of whole Russia with the factor 0.21, and for HCB by multiplying emissions of whole Russia with the factor 0.25. Using these factors, emissions were calculated from emission data of the Russian Federation in the former official EMEP domain.

Estimation of sectoral data for PAHs, PCDD/F and HCB

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.

5.42. Romania (RO)

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

5.43. Serbia (RS)

The data of Serbia reported in 2017 seemed to be complete and plausible, except that emissions of Total PAHs are much higher than the sum of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene. Therefore, data for the four individual PAHs were replaced.

Estimation of National Total and sector data for BaP, BbF, BkF and IP

Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene data were calculated using a ratio to split Total PAH emissions. This sector splitting ratio was derived using data from other countries ([2]) by calculating the mean share of the reported PAH data on the Total PAH emissions. Data were only used from countries where the sum of the PAHs equals the reported Total PAH data.

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

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

Only HCB and PCDD/F National total data for the years 1990 to 2000 and 2005, and sectoral data for 'Offroad' of Benzo(a)pyrene and Benzo(b)fluoranthene from the year 2009 were available. The best method (see section 2.1 for an explanation) to calculate PAH 2015 National Total data was the copy of expert estimates for the year 2007 from Shen et al. (2013) for Benzo(a)pyrene, and the calculation of the other PAHs using the PAH split factor (see section 2.2). For HCB, extrapolation of 2000 and 2010 TNO data were used, and for PCDD/Fs copy of expert estimates from Treger (2011) were used. All expert data were modified by multiplying emissions of whole Russia with the factor 0.79, and for HCB by multiplying emissions of whole Russia with the factor 0.75, to get data only for the part of the Russian Federation in the former official EMEP domain.

Estimation of sectoral data for PAHs, PCDD/F and HCB

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 Total PAH, PCDD/F and HCB as variables (z-transformed) (see section 2.2). For the Russian Federation in the former official EMEP domain, Turkey and Poland highlighted as the most similar country (in descending order). As for Turkey also no reported data are available, the GNFR sector distribution from Poland was used to split the National Totals of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene, PCDD/F and HCB into GNFR sectors.

5.45. Sweden (SE)

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

5.46. Slovenia (SI)

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

5.47. Slovakia (SK)

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

5.48. Tajikistan (TJ)

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

No reported data were available. The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was the extrapolation of estimates from Zhang & Tao (2009) using population data for PAHs, and the extrapolation of data from the National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants (Tajikistan 2006) using population data for PCDD/F. For HCB, data from the gap-filling made in 2015 were copied (i.e. expert estimates on the basis of GDP), as no other data were available.

Estimation of sectoral data for PAHs, PCDD/F and HCB

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 Total PAH, PCDD/F and HCB as variables (z-transformed) (see section 2.2). For Tajikistan, the Republic of Moldova highlighted as the most similar country, therefore the GNFR sector distribution from the Republic of Moldova was used to split the National Totals of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene, PCDD/F and HCB into GNFR sectors.

5.49. Turkmenistan (TM)

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

No reported data were available. The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was the extrapolation of estimates from Zhang & Tao (2009) using population data for PAHs, and the extrapolation of data from Hodjamberdiev (2006) using population data for PCDD/F. For HCB, data from the gap-filling made in 2015 were copied (i.e. expert estimates on the basis of GDP), as no other data were available.

Estimation of sectoral data for PAHs, PCDD/F and HCB

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 Total PAH, PCDD/F and HCB as variables (z-

transformed) (see section 2.2). For Turkmenistan, Albania and Georgia highlighted as the most similar country (in descending order). As for Albania also no reported data are available, the GNFR sector distribution from Georgia was used to split the National Totals of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene, PCDD/F and HCB into GNFR sectors.

5.50. Turkey (TR)

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

No reported data were available. The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was the extrapolation of 2000 and 2010 TNO data (Denier van der Gon et al. 2005) using population data for PAHs and HCB, and copy of expert estimates for the year 2006 from Wang et al. (2016) for PCDD/F.

Estimation of sectoral data for PAHs, PCDD/F and HCB

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 Total PAH, PCDD/F and HCB 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 Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene, PCDD/F and HCB into GNFR sectors.

5.51. Ukraine (UA)

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

Reported data for PAHs and HCB (National Totals and some sectors) were available only for the years 2010 to 2013. The best method (see section 2.1 for an explanation) to calculate 2015 National Total data for PAHs and HCB was the copy of data from the National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants (Ukraine 2007). For PCDD/Fs, the extrapolation of data for the years 1990 and 2002 reported within the National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants was taken.

Estimation of sectoral data for PAHs, PCDD/F and HCB

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 Total PAH, PCDD/F and HCB as variables (z-transformed) (see section 2.2). For the Ukraine, Bosnia and Herzegovina and Italy highlighted as the most similar country (in descending order). As for Bosnia and Herzegovina also no reported data are available, the GNFR sector distribution from Italy was used to split the National Totals of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene, PCDD/F and HCB into GNFR sectors.

5.52. Uzbekistan (UZ)

Data availability and estimation of National Total data for PAHs, PCDD/F and HCB

No reported data were available. The best method (see section 2.1 for an explanation) to calculate 2015 National Total data was the extrapolation of estimates from Zhang & Tao (2009) using population data for PAHs, and the extrapolation of data from Hodjamberdiev (2006) using population data for PCDD/F. For HCB, data from the gap-filling made in 2015 were copied (i.e. expert estimates on the basis of GDP), as no other data were available.

Estimation of sectoral data for PAHs, PCDD/F and HCB

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 Total PAH, PCDD/F and HCB as variables (z-transformed) (see section 2.2). For Uzbekistan, Tajikistan, Albania, Turkmenistan and Georgia highlighted as the most similar country (in descending order). As for Tajikistan, Albania, Turkmenistan also no reported data are available, the GNFR sector distribution from Georgia was used to split the National Totals of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene, PCDD/F and HCB into GNFR sectors.

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7. EMEP Country Codes

AL	Albania
AM	Armenia
AST	Asian areas in the extended EMEP domain
AT	Austria
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BE	Belgium
BG	Bulgaria
BY	Belarus
CH	Switzerland
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
EU	European Union
FI	Finland
FR	France
GB	United Kingdom
GE	Georgia
GR	Greece
HR	Croatia
HU	Hungary
IE	Ireland
IS	Iceland
IT	Italy
KG	Kyrgyzstan
KZT	Kazakhstan
LI	Liechtenstein
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
ME	Montenegro
MK	FYR of Macedonia
MT	Malta
NL	Netherlands
NO	Norway
NOA	North Africa
PL	Poland
PT	Portugal
RO	Romania
RS	Serbia
RU	Russian Federation in the former official EMEP domain
RUE	Russian Federation in the extended EMEP domain
SE	Sweden
SI	Slovenia
SK	Slovakia
TJ	Tajikistan
TM	Turkmenistan
TR	Turkey
UA	Ukraine
UZ	Uzbekistan