



# Atmospheric emissions of lead in the Baltic Sea region 1990–2023

  
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# Atmospheric emissions of lead in the Baltic Sea region

HELCOM Baltic Sea Environment Fact Sheet (BSEFS), 2025

**Authors:** Viktoria Koncz, Jan Gačnik, Oleg Travnikov, EMEP MSC-E

## Key Message

Annual atmospheric emissions of lead in the HELCOM Contracting Parties decreased by 91% between 1990 and 2023.

## Results and Assessment

### Relevance of the BSEFS for describing developments in the environment

This Fact Sheet presents the levels, spatial distribution, and temporal trends of lead emissions from anthropogenic sources in the HELCOM Contracting Parties, which are used in modelling lead deposition to the Baltic Sea (cf. BSEFS “Atmospheric deposition of lead to the Baltic Sea”).

### Policy relevance and policy references

The updated Baltic Sea Action Plan outlines the ecological objective that concentrations of hazardous substances in the environment should be close to background levels for naturally occurring substances. HELCOM Recommendation 42-43/6 identifies HELCOM priority substances for the Baltic Sea.

At the European level, the relevant policy for controlling heavy metal emissions to the atmosphere is set under the framework of the UN ECE Convention on Long-Range Transboundary Air Pollution (CLRTAP). The CLRTAP Protocol on Heavy Metals (1998) targets three particularly harmful metals: cadmium, lead, and mercury. One of the core obligations of the Protocol is to reduce emissions of these metals to levels below those recorded in 1990. The Protocol entered into force in 2003 and has been signed and/or ratified by 41 countries.

### Assessment

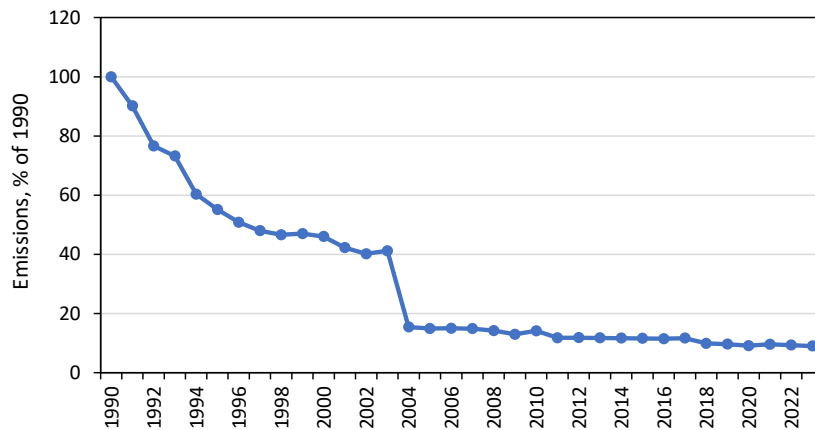
Annual anthropogenic lead emissions to the atmosphere from the HELCOM Contracting Parties decreased by 91% between 1990 and 2023 (Figure 1). The spatial distribution of lead emission fluxes for 1990 and 2023 is shown in Figure 2, with the highest fluxes observed along the southern and eastern coasts of the Baltic Sea.

The decrease in lead emissions from the HELCOM Contracting Parties during 1990-2023 was not uniform, with two distinct sub-periods showing different rates of decline: 1990-2003 and 2004-2023. The deposition trend in each sub-period was analysed using the Mann-Kendall test (Gilbert, 1987; Connor et al., 2012; Pohlert, 2023). Lead emissions show a statistically significant decreasing trend (negative monotonicity,  $p < 0.001$ ,  $\tau = -0.964$ ). Between 1990 and 2003, the strongest decline occurred, with an average annual decrease of about 8 tonnes per year (Sen’s slope,  $p = 0.001$ , 95% confidence interval). In the subsequent period (1998-2023), the annual decline slowed to about 0.5 tonnes (Sen’s slope,  $p < 0.001$ , 95% confidence interval).

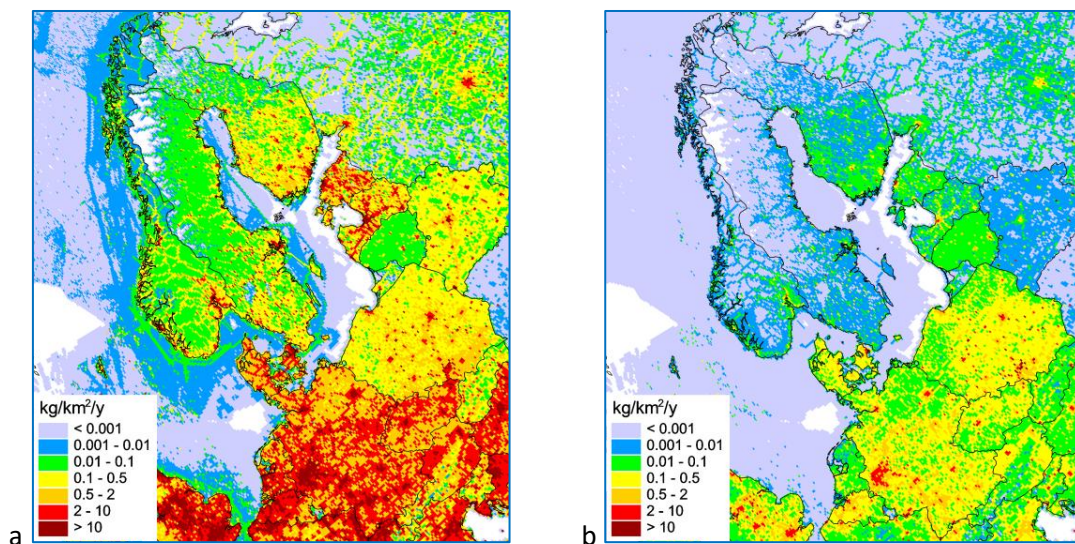
Time series of annual total lead emissions from the HELCOM Contracting Parties are shown in Figure 3. Among these countries, the largest reductions in lead emissions were observed in Estonia, Latvia, and Sweden (98% each), while the smallest decrease was recorded in Lithuania (52%).

In 2023, the total annual lead emissions of the HELCOM Contracting Parties amounted to 655 tonnes, with the largest contributions coming from Russia (36%), Poland (34%), and Germany (23%).

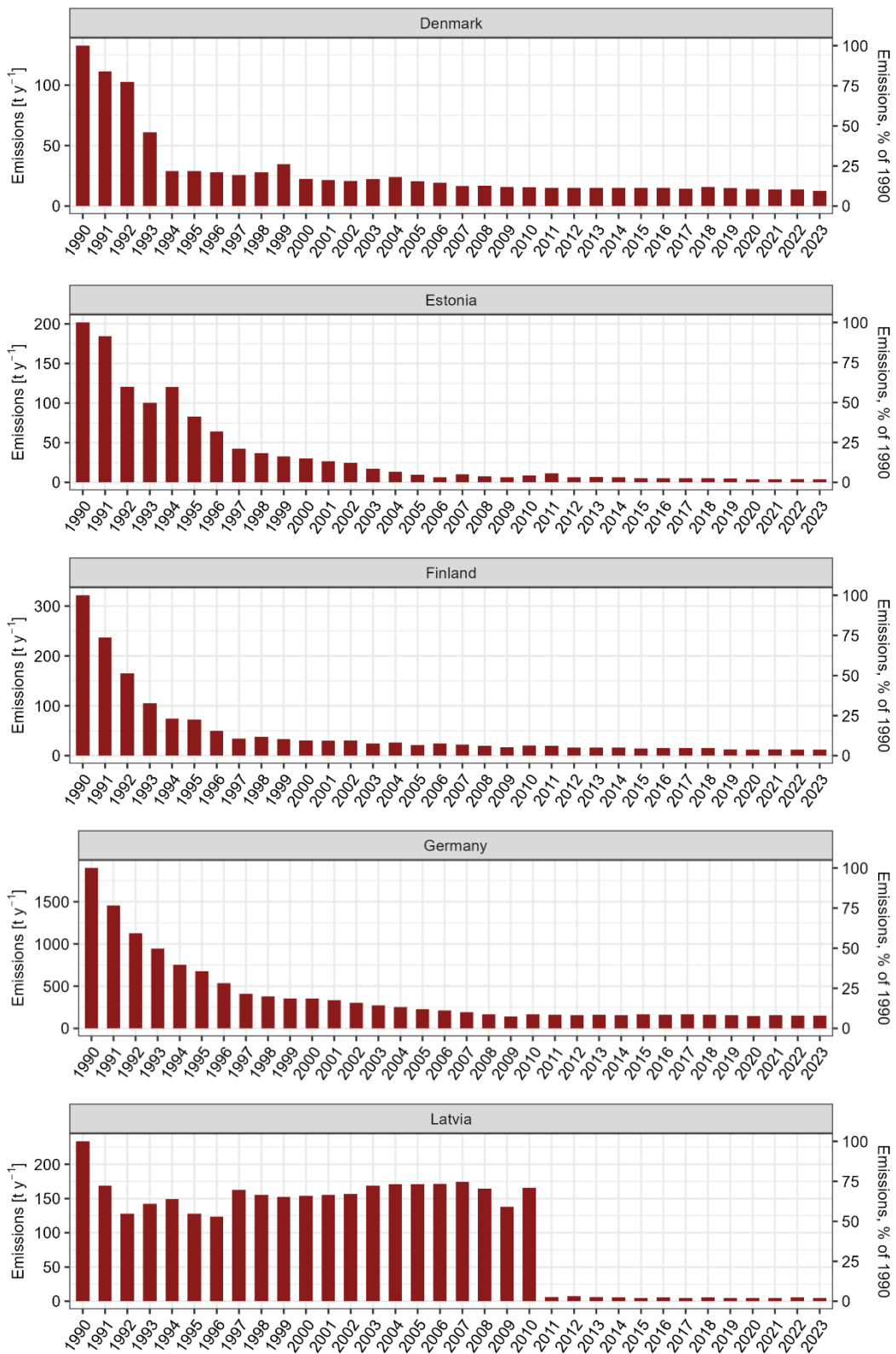
Given the generally high uncertainties in emission estimates and fragmented reported data for the Russian Federation (see Metadata), the uncertainty in the total lead emissions estimate for the HELCOM countries remains relatively high.



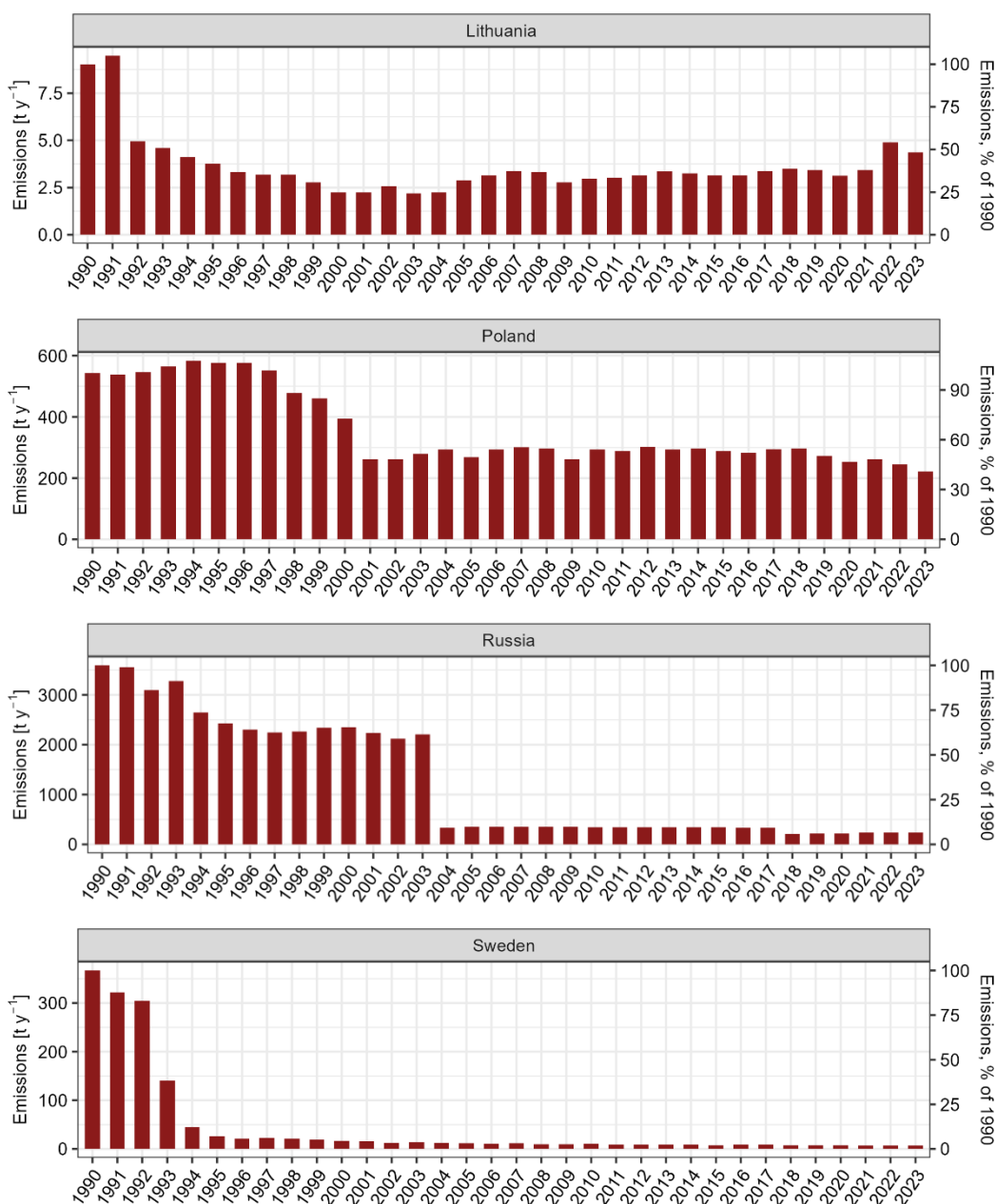
**Figure 1.** Relative changes of total annual emissions of lead to the atmosphere from the HELCOM Contracting Parties in period 1990-2023 (% of 1990).



**Figure 2.** Spatial distribution of annual anthropogenic lead emissions to the atmosphere in the Baltic Sea region in 1990 (a) and in 2023 (b).

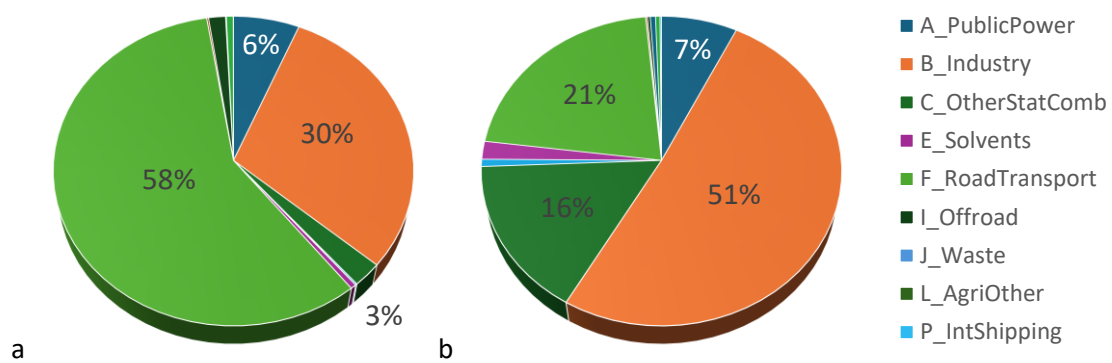


**Figure 3.** Atmospheric lead emissions from HELCOM Contracting Parties during the period 1990-2023. The emission data for Russia pertains to the territory within the EMEP domain.



**Figure 3 (continued).** Atmospheric lead emissions from HELCOM Contracting Parties during the period 1990-2023. The emission data for Russia pertains to the territory within the EMEP domain.

The main contributions to total emissions of lead from HELCOM Contracting Parties in 1990 came from road transport (58%), industrial sources (30%), and public power generation (6%) (Figure 4). In 2023, the contribution from road transport considerably decreased to 21%, mainly due to the phase-out of leaded gasoline, leading to an increased share of industrial sources (51%) and other agricultural sources (16%).



**Figure 4.** Contribution of emission sectors total annual emissions of lead to the atmosphere from the HELCOM Contracting Parties in 1990 (a) and 2023 (b).

## Data

Numerical data on anthropogenic lead emissions from HELCOM Contracting Parties are provided in the table below.

**Table 1.** Lead emissions from anthropogenic sources in HELCOM Contracting Parties from 1990 to 2023 Units: t y<sup>-1</sup>.

Year	DK	EE	FI	DE	LV	LT	PL	RU	SE	HELCOM	Others
1990	133	202	321	1899	234	9.0	542	3591	367	7297	21919
1991	111	184	237	1453	168	9.5	538	3553	323	6578	16807
1992	103	121	165	1127	128	4.9	546	3095	304	5593	13455
1993	61.2	100	105	947	142	4.6	565	3276	141	5343	12071
1994	28.9	120	74.0	752	149	4.1	583	2643	45.0	4400	11149
1995	29.0	82.9	72.7	679	128	3.8	576	2426	26.6	4024	9960
1996	27.9	64.3	49.2	537	124	3.3	577	2304	21.8	3708	8547
1997	25.8	42.6	34.3	409	163	3.2	552	2247	22.2	3499	7849
1998	27.7	37.2	37.2	378	155	3.2	477	2262	21.1	3399	6946
1999	34.5	32.6	33.7	354	152	2.8	460	2339	19.3	3428	5812
2000	22.5	29.9	30.7	355	154	2.2	394	2352	16.7	3357	3699
2001	21.5	27.0	29.8	334	155	2.2	262	2235	15.5	3082	2803
2002	21.0	24.5	30.7	303	156	2.6	262	2118	13.1	2931	2343
2003	22.3	17.1	24.9	270	169	2.2	278	2207	13.3	3005	2193
2004	24.0	13.2	26.5	253	171	2.2	292	330	12.6	1125	2132
2005	20.4	9.4	21.5	230	171	2.9	268	355	11.4	1090	2096
2006	19.4	6.6	24.9	210	172	3.2	293	355	11.0	1094	2017
2007	16.5	9.9	21.9	192	175	3.4	301	353	11.8	1085	2010
2008	16.9	7.5	19.8	167	165	3.3	296	352	10.2	1037	1820
2009	15.9	6.3	16.8	143	138	2.8	262	350	9.4	945	1500
2010	15.6	8.5	20.4	164	166	3.0	293	348	10.2	1030	1480
2011	15.2	11.2	19.2	160	6.3	3.0	289	347	9.1	860	1374
2012	15.0	6.4	16.3	159	7.7	3.2	302	345	9.0	863	1269
2013	15.2	6.9	16.0	162	6.1	3.3	294	343	8.6	856	1193
2014	15.1	6.3	16.6	158	5.4	3.3	296	342	8.8	851	1188
2015	15.1	5.1	14.7	165	5.1	3.2	289	340	8.2	844	1185
2016	15.0	5.3	15.7	162	5.3	3.2	282	338	9.0	836	1160
2017	14.5	5.5	15.6	167	5.2	3.4	295	337	9.1	852	1124
2018	16.0	5.3	15.4	161	5.3	3.5	296	212	8.0	723	1102
2019	14.7	4.6	13.2	159	5.3	3.4	273	221	8.3	703	1289
2020	13.9	4.0	11.6	144	4.9	3.1	253	222	7.7	665	1170
2021	13.7	3.9	12.6	156	4.9	3.4	262	236	6.7	699	968
2022	13.6	4.2	12.2	152	5.7	4.9	245	236	6.6	680	949
2023	12.7	3.6	12.1	151	4.8	4.4	221	239	6.8	655	1036

## Metadata

### Technical information

1. Source:

Meteorological Synthesizing Centre East (MSC-E) of EMEP, Centre on Emission Inventories and Projections (CEIP) of EMEP.

2. Description of data:

Official lead emissions data reported by the HELCOM Contracting Parties to the UN ECE Secretariat were used for the calculations and the emission trend analysis. These data are collected and made available by the EMEP Centre on Emission Inventories and Projections (EMEP/CEIP) (<http://www.ceip.at/>).

3. Geographical coverage:

EMEP region.

4. Temporal coverage:

Data on annual lead emission totals are available for the period from 1990 to 2023 for all HELCOM Contracting Parties, except the Russian Federation. For the Russian Federation, fragmented officially reported time series were supplemented with expert estimates based on the methodology provided by CEIP (Poupa, 2024).

5. Methodology and frequency of data collection:

National lead emissions data are submitted annually by the Parties to the LRTAP Convention to the UN ECE Secretariat. The methodology combines measurements of atmospheric releases with estimates based on activity data and emission factors. The submitted data undergo a quality assurance and quality control process before being stored in the UN ECE/EMEP emissions database at the EMEP/CEIP Centre. Gaps in emissions data are filled with expert estimated using methodology described in (Poupa, 2024).

### Quality information

6. Strengths and weaknesses:

Strength: National emissions data are submitted annually, quality checked, and stored at a specialised centre.

Weakness: The data contain gaps in the time series of national emissions, uncertainties in the reported figures, lack of gridded emissions, and incomplete sectoral distribution.

7. Uncertainty:

The evaluation of emission uncertainties is conducted by national experts from each country based on the methodology outlined in the EMEP/EEA Guidebook (EEA, 2019). This methodology accounts for uncertainties in both activity data and the emission factors applied to each emission sector. It is important to note that the uncertainties associated with emission factors are much higher than those for activity data. For heavy metals, the guidebook suggests a default emission factor uncertainty that exceeds 100%. Additionally, the estimates of uncertainties typically do not account for possible data incompleteness.

Among the HELCOM countries, the level of uncertainty in official data on lead emissions was reported by Denmark, Estonia, Finland, Latvia, Poland, and Sweden. The uncertainties in reported lead emissions by HELCOM Contracting Parties, expressed as a percentage relative to the mean emission value, are presented in Table 2. No uncertainty estimates are available for Germany, Lithuania and Russia.

**Table 2.** Uncertainty estimates for lead emissions reported by HELCOM Contracting Parties.

Country	Uncertainty
Denmark	612%
Estonia	46%
Finland	38%
Germany	n/a (*)
Latvia	11%
Lithuania	n/a
Poland	20%
Russia	n/a
Sweden	35%
Austria	34%
Belgium	187%
Croatia	165%
Cyprus	3%
France	141%
Slovakia	248%
UK	72%

(\*) Not available

#### 8. Further work required:

Further work is needed to refine national inventories of lead emissions, reduce uncertainties, fill gaps in emission trends, and improve the spatial distribution of emissions. Additionally, further studies to evaluate lead releases into the atmosphere from natural and secondary emission sources are important for assessing lead pollution levels.

## References

- EEA [2019]. EMEP/EEA air pollutant emission inventory guidebook 2019. Technical guidance to prepare national emission inventories. EEA Report No 13/2019.
- Poupa S. [2024] Methodologies applied to the CEIP GNFR gap-filling 2024. Part II: Heavy Metals (Cd, Hg, Pb) and Persistent Organic Pollutants (Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3- cd)pyrene, Total polycyclic aromatic hydrocarbons, Dioxin and Furan, Hexachlorobenzene, Polychlorinated biphenyls) of the year 2022. Technical Report CEIP 02/2024 (<https://www.ceip.at/ceip-reports/ceip-reports-2024>).