Atmospheric deposition of benzo(a)pyrene to the Baltic Sea

Baltic Marine Environment Protection Commission

Hazardous substances

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Authors: Oleg Travnikov, Jan Gačnik, EMEP MSC-E

Layout: Laura Ramos Tirado

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HELCOM Baltic Sea Environment Fact Sheet (BSEFS), 2024

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Key Message

Airborne B(a)P deposition to the Baltic Sea has been calculated for the period 1990–2022 using the EMEP MSC-E model (GLEMOS). According to the model calculations, annual total atmospheric deposition levels of B(a)P to the Baltic Sea decreased by 42% from 1990 to 2020, with a higher rate of decrease observed in the earlier part of the assessment period (1990-2002).

Results and Assessment

Relevance of the BSEFS for describing developments in the environment

This Fact Sheet presents the levels and trends of B(a)P atmospheric deposition to the Baltic Sea and its nine sub-basins during the period 1990-2022 based on the EMEP officially reported data. The most recent emission data reported by HELCOM Contracting Parties are described in the BSEFS report on "Atmospheric emissions of cadmium in the Baltic Sea region."

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 31E/1 identifies a list of regional priority substances for the Baltic Sea.

At the European level, the relevant policy for controlling B(a)P emissions to the atmosphere falls under the framework of the UN ECE Convention on Long-Range Transboundary Air Pollution (CLRTAP). The CLRTAP Protocol on Persistent Organic Pollutants (1998) targets a list of harmful organic substances, including B(a)P. Among its key obligations is the requirement to reduce B(a)P emissions to levels below those recorded in 1990. The Protocol, which entered into force in 2003, has been signed or ratified by 40 countries. In EU member states, B(a)P pollution is also regulated by European Directive 2004/107/EC.

Assessment

The model assessment of B(a)P long-range transport and deposition in the Baltic Sea region for the period 1990–2022 was based on anthropogenic emissions officially reported by HELCOM and other EMEP countries. Despite the relatively high uncertainties in official emissions from some HELCOM countries, the model's estimates of B(a)P pollution levels in the Baltic Sea region generally align well with observed air concentrations and wet deposition fluxes (within a factor of 2) (Travnikov et al., 2024).

Model simulations indicate that atmospheric B(a)P input to the Baltic Sea declined by 42% between 1990 and 2022 (normalized deposition; Figure 1, Table 1). The most substantial reductions occurred in the Kattegat sub-basin (60%) and the Sound sub-basin (59%) (Figure 2). At the same time, no significant changes of deposition are seen in the Bothnian Bay sub-basin (1%). The decrease of B(a)P deposition to the Baltic Sea was stronger in the period 1990-2002 comparing to subsequent period 2003-2020.

The deposition trend in each sub-period was analysed using the Mann-Kendall test [Gilbert, 1987; Connor et al., 2012; Pohlert, 2023]. B(a)P deposition shows a significantly decreasing trend (negative monotonicity, $p < 0.001$, $\tau = -0.698$). Between 1990 and 1997, the strongest decline occurred, with an average annual decrease of about 0.08 tonnes per year (Sen's slope, $p < 0.05$, 95% confidence interval). In the subsequent period (1998-2022), the annual decline slowed to about 0.04 tonnes (Sen's slope, $p < 0.001$, 95% confidence interval). All these statistical parameters indicate that B(a)P deposition is decreasing; however, the rate of decrease is slowing. Statistical parameters for deposition trends in individual sub-basins of the Baltic Sea are provided in Table 2.

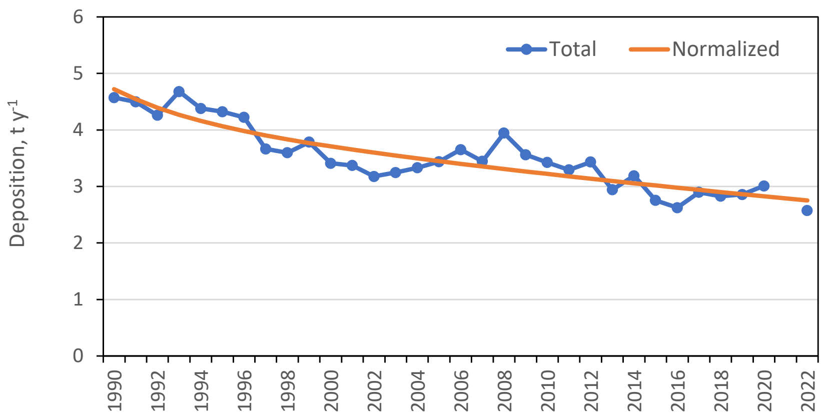

Figure 1. Changes in modelled (blue line) and normalised (orange line) total annual atmospheric deposition of B(a)P to the Baltic Sea for the period 1990-2020 (t y^{-1}). Normalised deposition trend is obtained using the methodology described below in Metadata section 5.

The highest total annual B(a)P deposition fluxes over the Baltic Sea in 2022 were estimated for the Gulf of Finland and the Sound sub-basins (Figures 2, 3), while the lowest flux was observed in the Bothnian Sea sub-basin. In 2022, anthropogenic emissions from HELCOM countries contributed approximately 72% to the total B(a)P deposition over the Baltic Sea (Table 3), with Poland (22%) and Finland (14%) accounting for the largest shares (Figure 4). The remaining 28% of total deposition comes from other European countries, as well as non-European anthropogenic sources and re-emission.

The main contribution to total B(a)P deposition comes from emissions in the Residential Combustion sector. According to officially reported data, in most EMEP countries, the dominant source of B(a)P emissions in this sector is wood combustion for domestic heating. However, in some countries, there is a substantial contribution from coal combustion (e.g. Poland). Other significant contributors include emissions from the Industry, Fugitive, and Agriculture sectors.

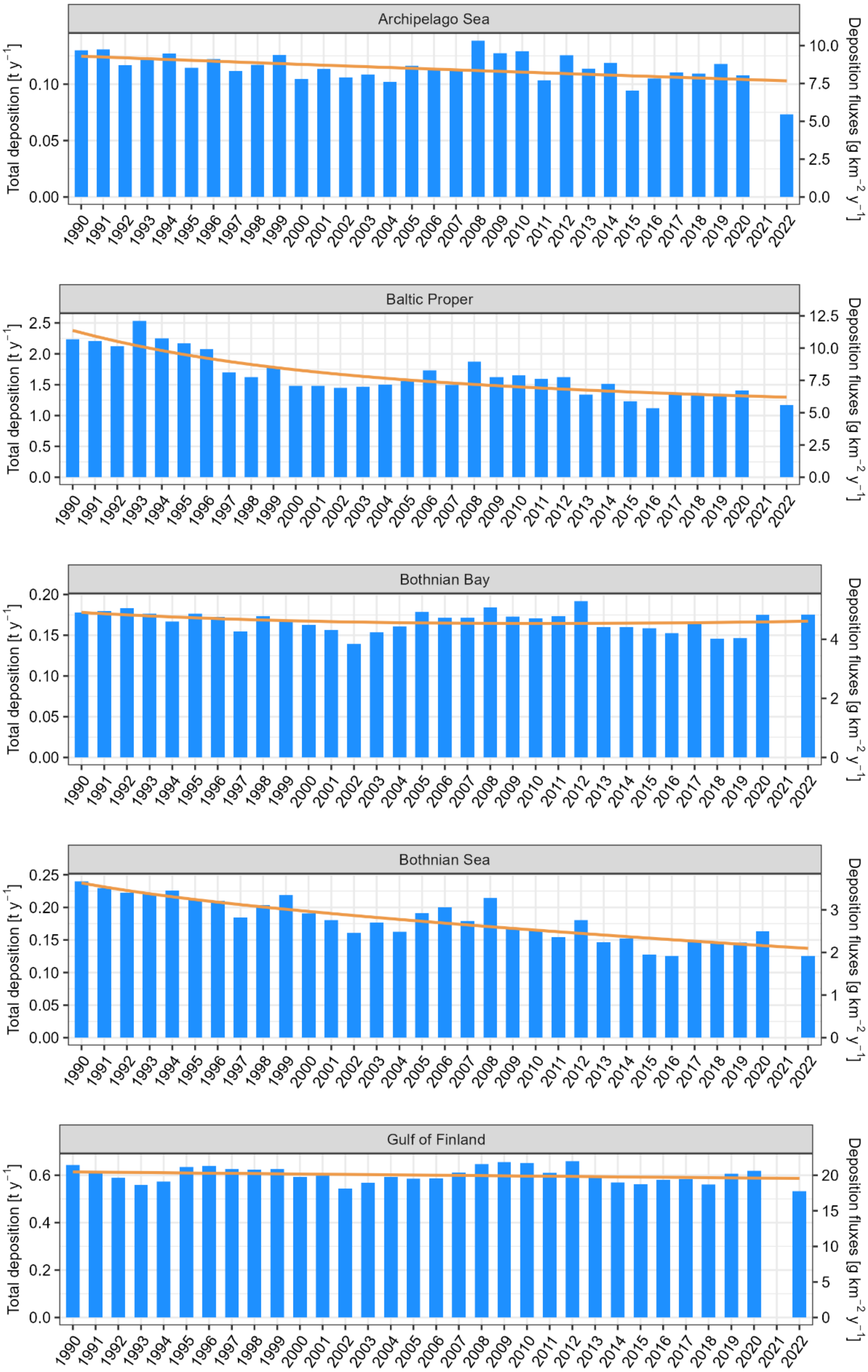

Figure 2. Time-series of calculated total annual atmospheric deposition of B(a)P to nine sub-basins of the Baltic Sea (left axis) and average deposition fluxes (right axis) for the period 1990-2022. Blue bars represent calculated values, and the orange line depicts the normalized trend. The B(a)P pollution in the Baltic region for 2021 was not assessed (see Section 2 of Metadata).

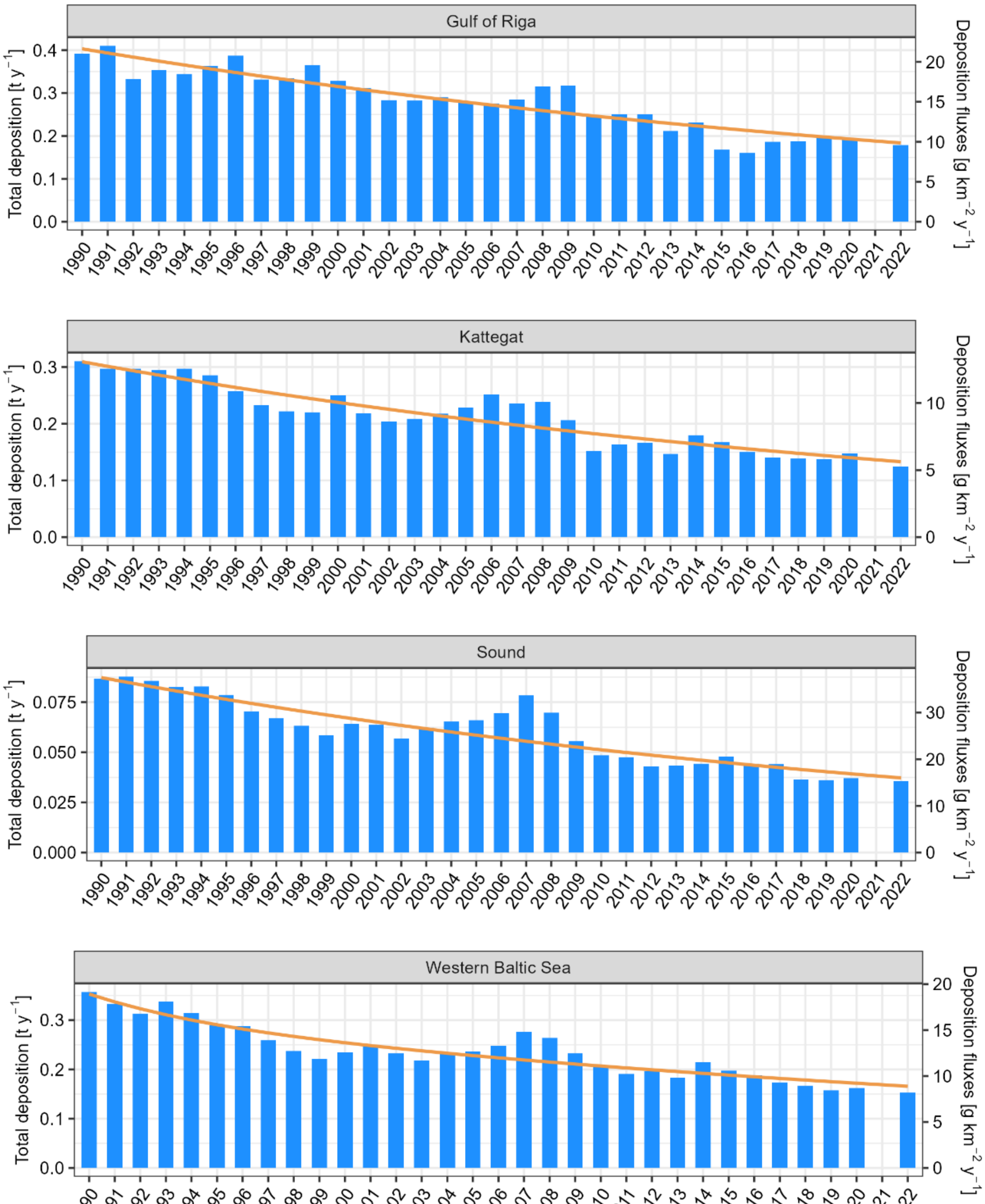

Figure 2 (continued). Time-series of computed total annual atmospheric deposition of B(a)P to nine sub-basins of the Baltic Sea (left axis) and average deposition fluxes (right axis) for the period 1990-2022. Blue bars represent calculated values, and the orange line depicts the normalized trend. The B(a)P pollution in the Baltic region for 2021 was not assessed (see Section 2 of Metadata).

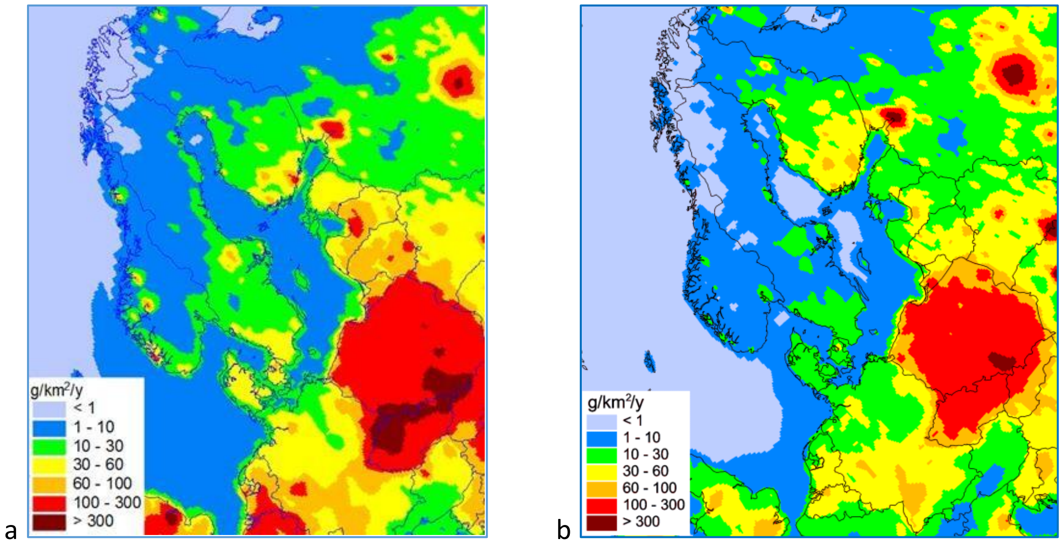

Figure 3. Spatial distribution of modelled annual total B(a)P deposition fluxes in the Baltic Sea region for 1990 (a) and 2022 (b).

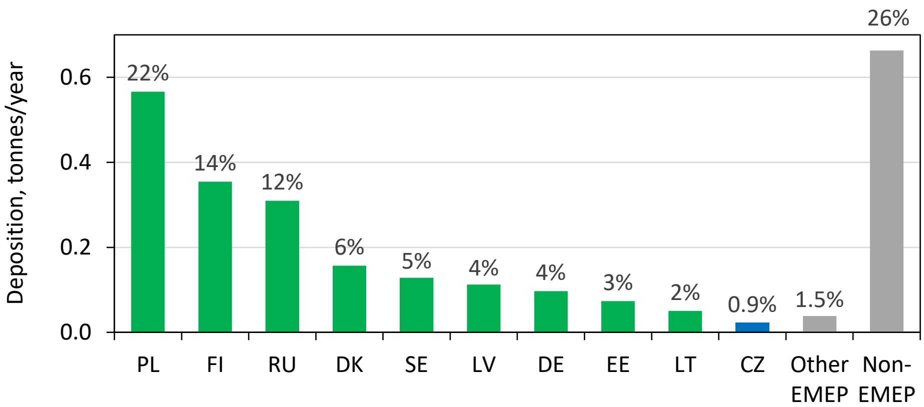

Figure 4. Top ten countries with the highest contributions to the annual total anthropogenic deposition of B(a)P to the Baltic Sea, estimated for 2022. Coloured bars indicate contributions from anthropogenic emissions by HELCOM contracting parties (green) and non-HELCOM countries (blue). The bar labelled ‘Other EMEP’ represents the combined contribution of anthropogenic emissions from other EMEP countries, while the bar ‘Non-EMEP’ depicts the total contribution from other anthropogenic emissions and re-emission.

Data

Supporting Excel here

Numerical data on calculated B(a)P deposition to the Baltic Sea are provided in the tables below.

Table 1. Total annual deposition of B(a)P to the nine Baltic Sea sub-basins, along with actual and normalized [(1)] deposition to the entire Baltic Sea (BAS) for the period 1990-2020. Units: t y^{-1}.

Year	ARC	BOB	BOS	BAP	GUF	GUR	KAT	SOU	WEB	BAS	Norm
1990	0.13	0.18	0.24	2.24	0.64	0.39	0.31	0.09	0.36	4.57	4.72
1991	0.13	0.18	0.23	2.21	0.62	0.41	0.30	0.09	0.33	4.50	4.54
1992	0.12	0.18	0.22	2.12	0.59	0.33	0.30	0.09	0.31	4.26	4.39
1993	0.12	0.18	0.22	2.53	0.56	0.35	0.29	0.08	0.34	4.68	4.27
1994	0.13	0.17	0.23	2.25	0.57	0.34	0.30	0.08	0.31	4.38	4.16
1995	0.11	0.18	0.21	2.17	0.63	0.36	0.29	0.08	0.29	4.32	4.06
1996	0.12	0.17	0.21	2.07	0.64	0.39	0.26	0.07	0.29	4.22	3.98
1997	0.11	0.15	0.18	1.70	0.63	0.33	0.23	0.07	0.26	3.66	3.90
1998	0.12	0.17	0.20	1.62	0.62	0.33	0.22	0.06	0.24	3.60	3.83
1999	0.13	0.17	0.22	1.78	0.63	0.37	0.22	0.06	0.22	3.78	3.77
2000	0.10	0.16	0.19	1.48	0.59	0.33	0.25	0.06	0.23	3.41	3.71
2001	0.11	0.16	0.18	1.48	0.60	0.31	0.22	0.06	0.25	3.37	3.65
2002	0.11	0.14	0.16	1.45	0.54	0.28	0.20	0.06	0.23	3.18	3.60
2003	0.11	0.15	0.18	1.47	0.57	0.28	0.21	0.06	0.22	3.25	3.55
2004	0.10	0.16	0.16	1.51	0.59	0.29	0.22	0.07	0.23	3.33	3.50
2005	0.12	0.18	0.19	1.56	0.59	0.28	0.23	0.07	0.24	3.44	3.45
2006	0.11	0.17	0.20	1.73	0.59	0.28	0.25	0.07	0.25	3.65	3.40
2007	0.11	0.17	0.18	1.49	0.61	0.28	0.24	0.08	0.28	3.44	3.35
2008	0.14	0.18	0.21	1.87	0.65	0.31	0.24	0.07	0.26	3.94	3.31
2009	0.13	0.17	0.17	1.63	0.66	0.32	0.21	0.06	0.23	3.56	3.27
2010	0.13	0.17	0.16	1.65	0.65	0.25	0.15	0.05	0.21	3.42	3.22
2011	0.10	0.17	0.15	1.60	0.61	0.25	0.16	0.05	0.19	3.29	3.18
2012	0.13	0.19	0.18	1.62	0.66	0.25	0.17	0.04	0.20	3.43	3.14
2013	0.11	0.16	0.15	1.34	0.60	0.21	0.15	0.04	0.18	2.94	3.10
2014	0.12	0.16	0.15	1.52	0.57	0.23	0.18	0.04	0.21	3.19	3.06
2015	0.09	0.16	0.13	1.23	0.56	0.17	0.17	0.05	0.20	2.75	3.02
2016	0.10	0.15	0.13	1.12	0.58	0.16	0.15	0.04	0.19	2.63	2.98
2017	0.11	0.16	0.15	1.34	0.58	0.19	0.14	0.04	0.17	2.90	2.94
2018	0.11	0.15	0.15	1.33	0.56	0.19	0.14	0.04	0.17	2.83	2.90
2019	0.12	0.15	0.15	1.31	0.61	0.20	0.14	0.04	0.16	2.86	2.86
2020	0.11	0.17	0.16	1.40	0.62	0.19	0.15	0.04	0.16	3.01	2.83
2021	n/a[(2)]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2.79
2022	0.07	0.18	0.13	1.17	0.53	0.18	0.12	0.04	0.15	2.57	2.75

[(1)] Normalized depositions were calculated using the methodology described below in Section 5 of Metadata.

[(2)] The B(a)P pollution in the Baltic region for 2021 was not assessed (see Section 2 of Metadata).

Table 2. Trends in B(a)P deposition to the Baltic Sea and its nine sub-basins for two periods: 1990-1997 and 1998-2022. Missing values indicate the absence of a statistically significant trend ($p > 0.05$, 95% confidence interval).

Basin	Deposition in 1990, t/y	Slope over 1990-1997, % 1990 / y	Deposition in 1998, t/y	Slope over 1998-2022, % 1998 / y
Archipelago Sea	0.13	-	0.12	-
Bothnian Bay	0.18	-1.4	0.17	-
Bothnian Sea	0.24	-2.2	0.20	-1.4
Baltic Proper	2.24	-	1.62	-0.9
Gulf of Finland	0.64	-	0.62	-
Gulf of Riga	0.39	-	0.33	-2.1
Kattegat	0.31	-2.7	0.22	-2.1
Sound	0.09	-3.2	0.06	-2.1
Western Baltic Sea	0.36	-3.6	0.24	-1.6
Baltic Sea	4.57	-1.7	3.60	-1.0

Table 3. Contribution by country to the annual total deposition of B(a)P to the nine Baltic Sea sub-basins for the year 2022. HELCOM: contribution from anthropogenic sources in HELCOM countries; EMEP: contribution from anthropogenic sources in other EMEP countries; Other: combined contributions from natural, secondary, and remote non-EMEP sources. Units: t y^{-1}.

Country	ARC	BOB	BOS	BAP	GUF	GUR	KAT	SOU	WEB	BAS
DK	1.54E-04	7.05E-05	4.79E-04	2.87E-02	1.47E-04	2.82E-04	5.42E-02	1.95E-02	5.35E-02	1.57E-01
EE	1.20E-03	1.86E-04	8.50E-04	8.65E-03	3.44E-02	2.83E-02	2.33E-05	2.25E-06	1.21E-05	7.36E-02
FI	4.30E-02	1.05E-01	5.18E-02	1.47E-02	1.35E-01	4.89E-03	1.04E-04	5.63E-06	2.90E-05	3.55E-01
DE	3.44E-04	1.01E-04	6.56E-04	5.29E-02	5.04E-04	9.26E-04	8.40E-03	1.66E-03	3.17E-02	9.72E-02
LV	9.92E-04	1.52E-04	9.48E-04	2.71E-02	5.00E-03	7.83E-02	5.44E-05	9.16E-06	5.06E-05	1.13E-01
LT	4.62E-04	1.06E-04	5.30E-04	3.74E-02	1.93E-03	9.96E-03	8.97E-05	2.08E-05	1.05E-04	5.06E-02
PL	2.60E-03	7.96E-04	2.26E-03	5.27E-01	5.62E-03	1.29E-02	5.07E-03	1.51E-03	7.70E-03	5.66E-01
RU	1.28E-03	8.38E-04	1.47E-03	7.15E-02	2.31E-01	3.68E-03	1.47E-04	3.04E-05	1.79E-04	3.10E-01
SE	3.35E-03	2.02E-02	3.48E-02	5.40E-02	8.44E-04	1.12E-03	1.22E-02	1.39E-03	5.38E-04	1.28E-01
AL	1.78E-10	1.92E-10	2.96E-10	2.61E-09	1.01E-09	1.22E-09	1.19E-11	2.68E-12	6.22E-11	5.59E-09
AM	9.37E-11	9.38E-11	1.29E-10	6.62E-10	4.26E-10	3.69E-10	9.23E-12	1.36E-12	1.11E-11	1.79E-09
AT	6.47E-06	2.29E-06	6.58E-06	4.33E-04	1.32E-05	2.57E-05	2.87E-05	5.14E-06	3.84E-05	5.60E-04
AZ	2.68E-09	1.74E-09	2.79E-09	1.04E-08	9.62E-09	4.63E-09	2.03E-11	1.43E-12	8.51E-12	3.18E-08
BA	1.01E-07	8.24E-08	1.44E-07	8.00E-06	5.57E-07	7.39E-07	1.14E-06	2.64E-07	7.66E-07	1.18E-05
BE	2.96E-05	1.64E-05	9.92E-05	1.88E-03	3.35E-05	5.49E-05	8.95E-04	8.77E-05	9.07E-04	4.00E-03
BG	2.44E-07	4.70E-07	6.08E-07	1.49E-06	6.57E-07	6.70E-07	1.11E-09	8.70E-10	2.29E-08	4.17E-06
BY	7.07E-05	2.85E-05	8.93E-05	3.41E-03	9.67E-04	9.57E-04	1.76E-05	4.81E-06	2.66E-05	5.57E-03
CH	1.75E-06	5.65E-07	2.96E-06	1.34E-04	2.58E-06	5.65E-06	1.88E-05	3.19E-06	2.58E-05	1.95E-04
CY	5.23E-12	7.87E-12	8.25E-12	3.17E-11	1.93E-11	1.97E-11	8.57E-14	5.82E-15	3.05E-14	9.22E-11
CZ	2.67E-04	9.17E-05	2.61E-04	1.78E-02	4.96E-04	9.56E-04	1.04E-03	1.82E-04	1.60E-03	2.27E-02
ES	2.18E-06	2.32E-06	8.09E-06	7.09E-05	1.75E-06	2.09E-06	2.73E-05	2.35E-06	2.45E-05	1.41E-04
FR	2.42E-05	1.07E-05	6.92E-05	1.57E-03	2.84E-05	5.07E-05	6.03E-04	6.47E-05	5.96E-04	3.02E-03
GB	7.76E-05	5.71E-05	2.71E-04	3.75E-03	8.20E-05	1.25E-04	1.84E-03	1.74E-04	1.60E-03	7.98E-03
GE	1.09E-08	7.18E-09	9.88E-09	9.09E-08	7.76E-08	8.30E-08	2.26E-10	3.91E-11	2.69E-10	2.80E-07
GR	7.19E-08	1.21E-07	1.70E-07	3.53E-07	1.62E-07	1.86E-07	6.82E-10	1.46E-10	2.96E-09	1.07E-06
HR	8.10E-07	3.57E-07	6.27E-07	5.79E-05	2.75E-06	4.22E-06	3.80E-06	8.22E-07	4.33E-06	7.56E-05
HU	1.05E-05	6.44E-06	8.13E-06	5.62E-04	3.15E-05	4.83E-05	1.50E-05	3.53E-06	2.60E-05	7.12E-04
IE	7.03E-06	9.39E-06	2.83E-05	2.92E-04	7.88E-06	1.10E-05	1.21E-04	1.20E-05	9.65E-05	5.85E-04
IS	6.47E-09	3.04E-08	3.85E-08	9.51E-08	8.23E-09	6.65E-09	5.43E-08	3.23E-09	2.06E-08	2.63E-07
IT	7.41E-07	3.09E-07	9.83E-07	6.78E-05	1.53E-06	3.39E-06	6.47E-06	1.47E-06	9.70E-06	9.24E-05
KY	6.57E-14	4.56E-13	9.57E-14	2.15E-13	9.40E-12	1.77E-13	2.58E-15	3.61E-16	3.79E-15	1.04E-11
KZ	2.04E-08	1.56E-08	3.37E-08	3.01E-07	1.50E-07	1.24E-07	2.80E-09	4.95E-10	2.92E-09	6.51E-07
LI	5.67E-09	1.71E-09	8.54E-09	4.76E-07	8.89E-09	2.05E-08	4.99E-08	8.36E-09	7.18E-08	6.51E-07
LU	1.13E-06	3.93E-07	2.76E-06	8.74E-05	1.49E-06	2.63E-06	2.98E-05	3.80E-06	3.49E-05	1.64E-04
MC	1.31E-12	1.03E-12	4.00E-12	4.27E-11	1.48E-12	1.90E-12	3.78E-11	2.50E-12	2.66E-11	1.19E-10
MD	8.45E-07	1.35E-06	1.43E-06	7.93E-05	8.15E-06	1.34E-05	5.53E-08	1.86E-07	1.95E-06	1.07E-04
ME	1.55E-09	1.67E-09	2.55E-09	3.29E-08	9.34E-09	1.25E-08	2.86E-10	6.51E-11	4.68E-10	6.14E-08
MK	2.55E-08	3.06E-08	4.74E-08	4.78E-07	1.44E-07	1.97E-07	3.73E-10	5.69E-10	1.30E-08	9.37E-07
MT	2.78E-11	2.16E-11	3.73E-11	3.38E-10	1.39E-10	1.87E-10	2.05E-13	1.21E-13	2.98E-12	7.54E-10
NL	4.72E-05	2.54E-05	1.57E-04	3.21E-03	5.29E-05	8.30E-05	1.58E-03	1.63E-04	1.94E-03	7.26E-03
NO	3.44E-05	7.60E-05	2.06E-04	3.29E-04	2.25E-05	1.90E-05	5.13E-04	1.49E-05	8.45E-05	1.30E-03
PT	3.29E-07	9.53E-07	1.41E-06	1.27E-05	3.92E-07	2.85E-07	3.00E-06	2.77E-07	2.78E-06	2.21E-05
RO	1.98E-06	3.63E-06	3.99E-06	1.40E-04	1.88E-05	2.39E-05	4.91E-07	3.60E-07	3.72E-06	1.97E-04
RS	6.74E-07	5.90E-07	7.74E-07	3.45E-05	4.67E-06	5.78E-06	6.98E-07	1.78E-07	1.06E-06	4.89E-05
SI	5.25E-07	2.14E-07	4.52E-07	3.41E-05	1.39E-06	2.17E-06	2.33E-06	4.76E-07	3.13E-06	4.48E-05
SK	3.59E-05	2.04E-05	3.30E-05	1.80E-03	9.81E-05	1.56E-04	7.12E-05	1.75E-05	1.05E-04	2.34E-03
TJ	1.16E-14	2.75E-14	4.11E-14	2.46E-14	4.61E-13	2.40E-14	1.41E-15	5.32E-17	2.61E-16	5.92E-13
TM	2.36E-10	1.21E-10	2.87E-10	1.49E-09	1.18E-09	8.22E-10	3.15E-11	1.48E-12	7.07E-12	4.18E-09
TR	1.79E-06	2.14E-06	2.78E-06	1.10E-05	6.91E-06	7.58E-06	1.58E-08	1.10E-09	3.87E-09	3.22E-05
UA	2.43E-05	2.24E-05	4.60E-05	2.98E-03	3.40E-04	4.28E-04	9.19E-06	7.68E-06	5.46E-05	3.92E-03
UZ	7.79E-11	3.21E-11	1.10E-10	6.62E-10	4.81E-10	3.88E-10	2.05E-11	9.47E-13	4.46E-12	1.78E-09
HELCOM	0.053	0.128	0.094	0.822	0.414	0.140	0.080	0.024	0.094	1.850
EMEP	0.001	0.000	0.001	0.039	0.002	0.003	0.007	0.001	0.007	0.061
Other	0.019	0.047	0.030	0.313	0.117	0.036	0.037	0.011	0.051	0.663
Total	0.073	0.176	0.126	1.174	0.533	0.179	0.124	0.036	0.152	2.573

Metadata

Technical information

1. Source:

   Meteorological Synthesizing Centre East (MSC-E) of EMEP.

2. Description of data:

   The atmospheric deposition of B(a)P to the Baltic Sea for the period 1990 to 2022 was estimated using the GLEMOS model (v2.2.2) developed by EMEP/MSC-E (https://github.com/glemos-model). Due to time constraints, recalculation of the deposition time series for 1990-2021 was not performed. Instead, trend analysis the entire period from 1990-2022 was conducted using previously calculated results. B(a)P pollution levels for 1990-2020 were previously simulated and published in BSEFS based on emission data officially reported by EMEP countries in 2021. These data are available in the WebDab database of the EMEP Centre on Emission Inventories and Projections (CEIP) (https://www.ceip.at/webdab-emission-database/). A detailed description of the emission data, gap-filling methods, and expert estimates can be found in the CEIP Technical Report [Poupa, 2021]. B(a)P pollution for 2022 was simulated using the same GLEMOS version and the most recent official emissions reporting from EMEP in 2024 [Travnikov et al., 2024]. Pollution of the Baltic region with B(a)P for 2021 was not assessed.

3. Geographical coverage:

   Atmospheric depositions of B(a)P were estimated for the European region and surrounding areas covered by the EMEP modelling domain.

4. Temporal coverage:

   Time-series of annual B(a)P atmospheric deposition were estimated for the continuous period 1990 – 2020 and 2022.

5. Methodology and frequency of data collection:

   The atmospheric input and source allocation budget of B(a)P deposition to the Baltic Sea was calculated using the GLEMOS model. GLEMOS is a multi-scale, multi-pollutant simulation framework developed for both operational and research applications within EMEP [Tarrason and Gusev, 2008; Travnikov et al., 2009; Jonson and Travnikov, 2010; Travnikov and Jonson, 2011]. The model simulates the dispersion and cycling of various pollutant classes, including heavy metals and persistent organic pollutants, with flexible options for simulation domains ranging from global to local scales and varying spatial resolutions. Vertically, the model domain extends up to 10 hPa (approximately 30 km), consisting of 20 irregular terrain-following sigma layers, 10 of which cover the lowest 5 km of the troposphere. The height of the lowest layer is about 75 metres. The model simulations of transport and deposition of the selected pollutants were conducted with a spatial resolution 0.2°×0.2°. Source-receptor matrices required for source attribution analysis were calculated based on model runs at a 0.4°×0.4° resolution.

   Anthropogenic B(a)P emission data used in the modelling were prepared based on gridded emission fields provided by CEIP for the EMEP longitude-latitude grid system with a spatial resolution of 0.1 x 0.1 degrees. These gridded emissions were supplemented with additional parameters required for model runs, such as seasonal variations, vertical distribution, and chemical speciation. Atmospheric concentrations of chemical reactants and particulate matter, which are required for the description of B(a)P gas-particle partitioning and degradation, were imported from the GEOS-Chem model [GEOS-

Chem, 2024]. Boundary conditions for model simulations over the EMEP domain were estimated using GLEMOS simulations on a global scale [Ilyin et al., 2022].

Meteorological data used for the calculations from 1990-020 and 2022 were obtained using the WRF meteorological data pre-processor [Skamarock et al., 2008], based on data from the European Centre for Medium-Range Weather Forecasts (ECMWF). Normalised annual deposition values for the period 1990-2022 were obtained using the results of model simulations and bi-exponential approximation described in [Colette et al., 2016]. The applied approximation method reflects the non-linear character of long-term deposition trends typical for heavy metals and POPs, showing a stronger reduction initially, followed by a slower reduction or even growth in the later part of the period. This method has been extensively tested for trend analysis within EMEP and used in pollution assessments (Maas and Grennfelt, 2016).

Quality information

6. Strengths and weaknesses:

Strength: annually updated information on atmospheric input of B(a)P to the Baltic Sea and its sub-basins based on officially reported emissions data.

Weakness: uncertainties in the provided model estimates due to both the incompleteness/uncertainties of the emissions data and the limitations of the applied modelling approaches.

7. Uncertainty:

The modelling approach for POPs, developed by MSC-E, has been verified through regular comparisons of model results with measurements from the EMEP monitoring network [Gusev et al., 2005, 2006; Shatalov et al., 2005; Ilyin et al., 2021; Ilyin et al., 2022; Travnikov et al., 2024]. These studies concluded that the modelling results were in satisfactory agreement with available measurements, with discrepancies generally not exceeding a factor of two. The model was thoroughly reviewed at a workshop held in October 2005, under the supervision of the EMEP Task Force on Measurements and Modelling (TFMM). The conclusion was that "the MSC-E model is suitable for the evaluation of long-range transboundary transport and deposition of POPs in Europe" [ECE/EB.AIR/GE.1/2006/4].

8. Further work required:

Further work is needed to reduce uncertainties in the B(a)P modelling approaches used in the GLEMOS model. This can be achieved through the combined efforts of the measurement, emission, and modelling communities.

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