Atmospheric deposition of PCB-153 on the Baltic Sea

HELCOM Baltic Sea Environment Fact Sheet (BSEFS), 2020

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Key message

Levels of annual atmospheric deposition of PCB-153 to the Baltic Sea have decreased in period from 1990 to 2018 by 71%, although the decrease was higher during the first half of the assessment period.

Results and Assessment

Relevance of the BSEFS for describing developments in the environment

This BSEFS shows the levels and trends in PCB-153 atmospheric deposition to the Baltic Sea. The deposition of PCB-153 represents the pressure of the emission sources on the Baltic Sea aquatic environment as described in the BSEFS "Atmospheric emissions of PCB-153 in the Baltic Sea region".

Policy relevance and policy reference

The Baltic Sea Action Plan states the ecological objectives that concentrations of hazardous substances in the environment are to be close to background values for naturally occurring substances. HELCOM Recommendation 31E/1 identifies the list of regional priority substances for the Baltic Sea.

The relevant policy to the control of emissions of PCB-153 to the atmosphere on European scale is set in the framework of UN ECE Convention on Long-Range Transboundary Air Pollution (CLRTAP). According to the CLRTAP Protocol on Persistent Organic Pollutants (1998), the emissions of PCB-153 must be reduced below the emission levels in 1990.

For EU member states the policy frame is set by the EU IED Directive, whereas for the Russian Federation the corresponding policy framework is embraced by the Russian Federal Act on the environmental protection and the Act on protection of atmospheric air.

Assessment

Airborne input of PCB-153 to the Baltic Sea has substantially decreased in the period from 1990 to 2018. Model simulations on the basis of officially reported emission data indicate that levels of annual net atmospheric deposition of PCB-153 to the Baltic Sea have decreased in period from 1990 to 2018 by 71% (Figure 1). The most substantial decrease of deposition can be noted for the Western Baltic sub-basin (82%). The highest level of PCB-153 deposition fluxes over the Baltic Sea in 2018 is noted for the Sound and the Western Baltic sub-basins (Figures 2). The HELCOM countries contributed to PCB-153 deposition over the Baltic Sea in 2018 about 24%, with largest contributions made by Finland and Sweden.

Reduction of atmospheric input of PCB-153 to the Baltic Sea is a result of various activities including abatement measures, economic contraction, and industrial restructuring, which took place in the HELCOM countries as well as other EMEP countries.

Presented model estimates of PCB-153 net deposition differ from previously published modelling results [Gauss et al., 2018]. Comparison of current and previous model estimates is discussed in the report [Guass et al., 2020].

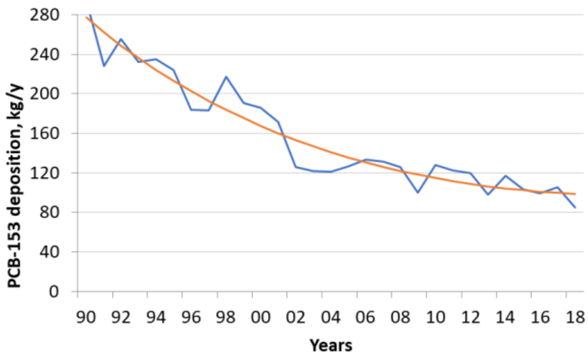

Figure 1. Changes of modelled (blue line) and normalized (red line) net annual atmospheric deposition of PCB-153 to the Baltic Sea for the period 1990-2018, (kg/year). Normalized depositions were obtained using the methodology described below in the metadata section 5.

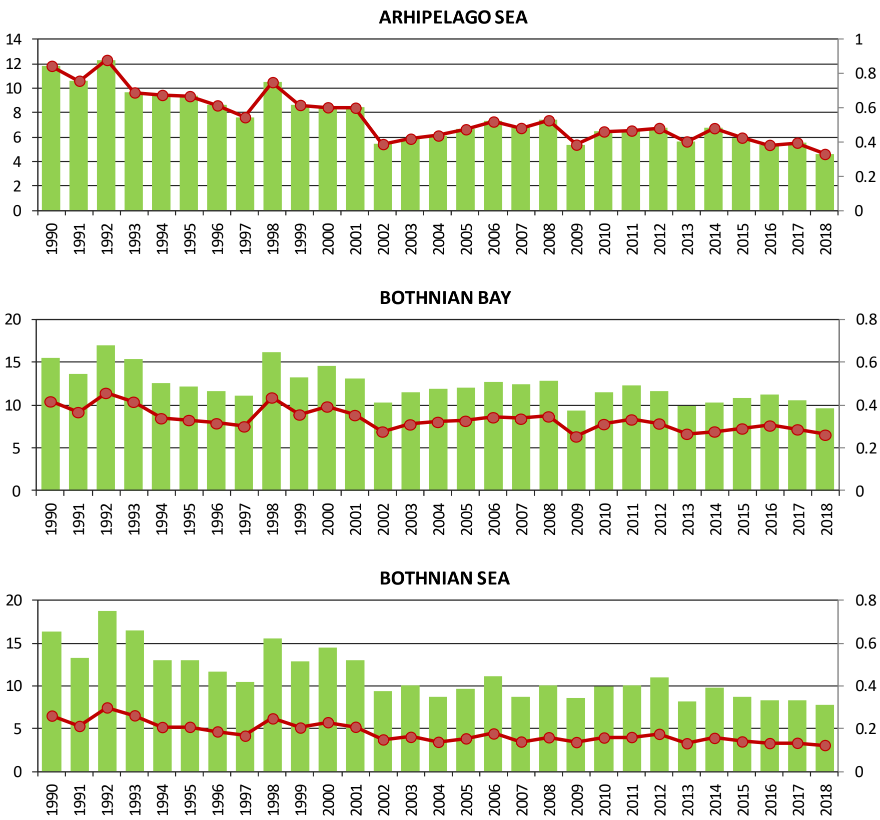

Figure 2. Time-series of computed net annual atmospheric deposition of PCB-153 to nine sub-basins of the Baltic Sea for the period 1990-2018 in kg/year as bars (left axis) and net deposition fluxes in $g/m^2/year$ as lines (right axis).

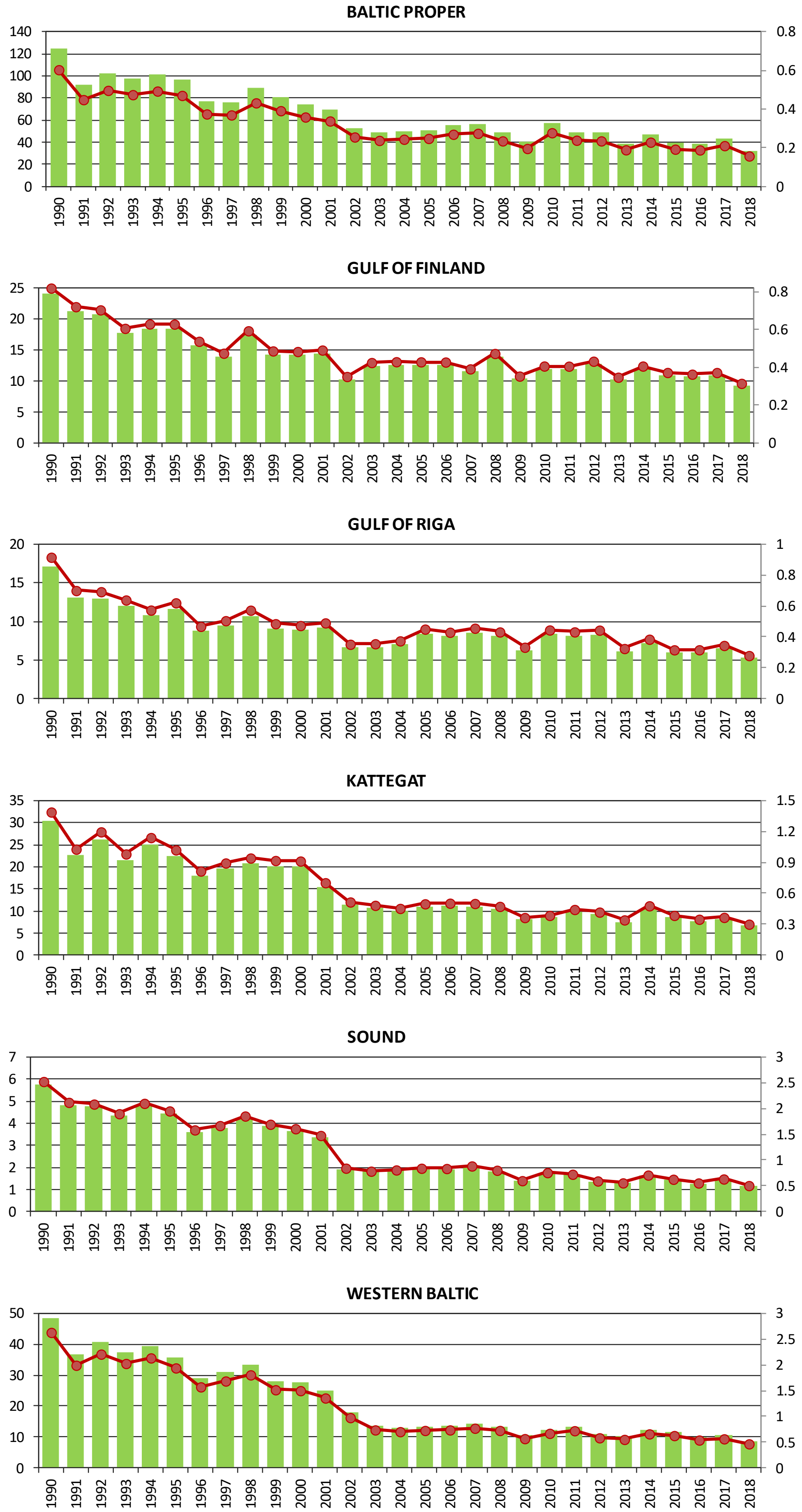

Figure 2. (continued). Time-series of computed net annual atmospheric deposition of PCB-153 to nine sub-basins of the Baltic Sea for the period 1990-2018 in kg/year as bars (left axis) and net deposition fluxes in g/m^2/year as lines (right axis).

Data

Numerical data on computed PCB-153 depositions to the Baltic Sea are given in the following tables.

Table 1. Computed net annual deposition of PCB-153 to nine Baltic Sea sub-basins, the whole Baltic Sea (BAS) and normalized deposition* to the Baltic Sea (Norm) for the period 1990-2018. Units: kg/year.

	ARC	BOB	BOS	BAP	GUF	GUR	KAT	SOU	WEB	BAS	Norm
1990	11.85	15.47	16.33	124.33	24.09	17.14	30.45	5.75	48.3	293.7	277.0
1991	10.63	13.61	13.30	92.37	21.19	13.11	22.56	4.83	36.6	228.2	262.5
1992	12.33	16.93	18.73	102.26	20.69	12.98	26.24	4.75	40.6	255.5	249.0
1993	9.67	15.40	16.41	97.67	17.81	11.97	21.54	4.33	37.3	232.0	236.2
1994	9.46	12.55	12.99	101.52	18.50	10.75	25.02	4.78	39.2	234.8	224.3
1995	9.37	12.24	13.04	96.86	18.47	11.63	22.41	4.45	35.7	224.1	213.2
1996	8.61	11.68	11.70	77.07	15.79	8.79	17.92	3.61	28.9	184.1	202.8
1997	7.64	11.14	10.45	76.02	13.93	9.47	19.62	3.80	31.0	183.1	193.0
1998	10.51	16.14	15.52	88.93	17.43	10.74	20.68	4.23	33.2	217.4	183.9
1999	8.64	13.19	12.83	80.58	14.29	9.10	20.15	3.86	27.9	190.5	175.4
2000	8.45	14.58	14.41	73.81	14.20	8.88	20.03	3.66	27.6	185.6	167.5
2001	8.41	13.10	13.06	69.57	14.42	9.20	15.43	3.37	25.0	171.5	160.1
2002	5.43	10.25	9.35	52.49	10.30	6.62	11.34	1.92	18.0	125.7	153.3
2003	5.87	11.48	10.11	48.81	12.47	6.68	10.63	1.79	13.6	121.5	146.9
2004	6.13	11.91	8.65	50.10	12.60	7.03	9.97	1.85	13.0	121.3	141.1
2005	6.65	12.10	9.67	50.94	12.59	8.45	10.95	1.92	13.4	126.7	135.7
2006	7.28	12.72	11.10	55.39	12.55	8.07	11.08	1.91	13.6	133.7	130.7
2007	6.75	12.47	8.73	56.40	11.49	8.56	11.02	2.02	14.2	131.7	126.1
2008	7.38	12.87	9.99	48.32	13.89	8.11	10.40	1.83	13.4	126.2	121.9
2009	5.38	9.40	8.58	40.22	10.36	6.26	8.04	1.37	10.5	100.1	118.1
2010	6.47	11.54	9.91	57.03	11.93	8.34	8.49	1.73	12.4	127.8	114.7
2011	6.54	12.34	10.06	49.03	11.91	8.11	9.75	1.66	13.3	122.7	111.6
2012	6.75	11.63	10.99	48.32	12.68	8.33	9.19	1.36	10.8	120.1	108.9
2013	5.65	9.86	8.24	38.81	10.19	6.10	7.54	1.28	10.2	97.9	106.4
2014	6.74	10.26	9.80	46.96	11.93	7.23	10.53	1.62	12.2	117.3	104.3
2015	5.96	10.78	8.77	39.48	10.93	5.95	8.50	1.44	11.6	103.4	102.5
2016	5.36	11.29	8.28	38.67	10.66	5.95	7.67	1.27	10.0	99.2	101.0
2017	5.55	10.63	8.36	43.27	10.92	6.47	8.07	1.45	10.4	105.2	99.7
2018	4.62	9.69	7.71	32.21	9.23	5.25	6.63	1.16	8.7	85.2	98.7

* - normalized depositions were obtained using the methodology described below in the metadata section 5.

Table 2. Computed contributions by country to annual deposition of PCB-153 to nine Baltic Sea sub-basins for the year 2018. Units: kg/year. HELCOM: contribution of anthropogenic sources of HELCOM countries; EMEP: contribution of anthropogenic sources in other EMEP countries; Other: contributions of secondary and remote non-EMEP emission sources.

Country	**ARC**	**BOB**	**BOS**	**BAP**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
DK	4.42E-03	1.73E-03	6.11E-03	3.26E-01	3.46E-03	4.68E-03	6.95E-01	3.52E-01	9.24E-01	2.32E+00
EE	3.22E-02	3.76E-03	1.38E-02	1.20E-01	1.28E+00	2.19E-01	1.26E-03	2.06E-04	1.57E-03	1.67E+00
FI	5.48E-01	4.34E+00	9.42E-01	1.18E-01	5.71E-01	1.79E-02	2.29E-03	2.46E-04	1.98E-03	6.54E+00
DE	2.21E-02	1.99E-02	4.70E-02	9.66E-01	2.50E-02	2.63E-02	1.49E-01	2.65E-02	1.04E+00	2.32E+00
LV	1.78E-03	2.73E-04	1.11E-03	3.58E-02	2.11E-03	5.23E-02	2.49E-04	5.97E-05	4.09E-04	9.41E-02
LT	6.84E-03	1.51E-03	5.76E-03	1.74E-01	6.07E-03	2.42E-02	1.80E-03	5.96E-04	4.17E-03	2.24E-01
PL	4.56E-02	2.37E-02	6.85E-02	1.20E+00	3.71E-02	4.35E-02	5.83E-02	1.04E-02	7.82E-02	1.56E+00
RU	9.41E-03	7.58E-03	1.59E-02	1.53E-01	5.31E-01	1.02E-02	2.13E-03	4.02E-04	3.65E-03	7.33E-01
SE	9.68E-02	1.13E-01	2.96E-01	3.02E+00	3.75E-02	7.81E-02	9.10E-01	2.69E-01	6.21E-02	4.89E+00
AL	3.95E-05	6.08E-05	1.11E-04	5.35E-04	9.89E-05	5.80E-05	4.98E-05	4.67E-06	4.52E-05	1.00E-03
AM	2.97E-05	3.76E-05	1.10E-04	3.16E-04	7.93E-05	3.08E-05	1.44E-05	1.45E-06	1.18E-05	6.31E-04
AT	6.36E-03	5.18E-03	1.66E-02	1.09E-01	1.03E-02	8.31E-03	1.83E-02	2.76E-03	1.54E-02	1.92E-01
AZ	8.51E-03	1.11E-02	2.92E-02	8.33E-02	2.46E-02	8.86E-03	3.74E-03	3.78E-04	3.31E-03	1.73E-01
BA	2.49E-05	3.51E-05	6.91E-05	3.07E-04	5.45E-05	2.74E-05	2.19E-05	2.47E-06	2.19E-05	5.64E-04
BE	9.52E-04	1.12E-03	2.37E-03	1.64E-02	1.13E-03	1.03E-03	4.77E-03	5.14E-04	6.87E-03	3.52E-02
BG	1.91E-04	2.38E-04	4.55E-04	2.41E-03	4.34E-04	3.17E-04	1.55E-04	1.70E-05	1.44E-04	4.36E-03
BY	3.03E-02	1.20E-02	3.36E-02	2.51E-01	5.80E-02	6.57E-02	8.12E-03	2.10E-03	1.57E-02	4.77E-01
CH	1.02E-03	9.96E-04	2.90E-03	1.75E-02	1.66E-03	1.39E-03	3.33E-03	3.57E-04	3.87E-03	3.30E-02
CY	5.14E-05	8.10E-05	1.91E-04	4.50E-04	1.34E-04	6.36E-05	2.36E-05	2.42E-06	1.94E-05	1.02E-03
CZ	1.65E-02	1.15E-02	3.19E-02	3.39E-01	1.71E-02	1.68E-02	3.61E-02	5.55E-03	4.25E-02	5.17E-01
ES	2.23E-02	4.14E-02	9.02E-02	3.44E-01	3.18E-02	2.30E-02	8.37E-02	8.00E-03	7.71E-02	7.22E-01
FR	2.19E-02	2.67E-02	5.72E-02	3.42E-01	2.86E-02	2.35E-02	9.71E-02	9.67E-03	1.20E-01	7.27E-01
GB	1.48E-02	1.44E-02	3.54E-02	2.16E-01	1.48E-02	1.34E-02	9.19E-02	8.17E-03	9.65E-02	5.05E-01
GE	4.05E-04	5.75E-04	1.42E-03	4.39E-03	1.29E-03	4.66E-04	2.02E-04	2.07E-05	1.68E-04	8.94E-03
GR	2.18E-03	3.03E-03	6.03E-03	2.34E-02	4.69E-03	3.73E-03	1.59E-03	1.51E-04	1.34E-03	4.61E-02
HR	5.90E-04	6.50E-04	1.66E-03	7.75E-03	1.15E-03	6.48E-04	5.06E-04	6.65E-05	5.35E-04	1.35E-02
HU	1.19E-04	8.25E-05	2.48E-04	1.80E-03	1.64E-04	1.14E-04	1.39E-04	1.71E-05	1.15E-04	2.80E-03
IE	3.63E-05	4.38E-05	9.71E-05	4.75E-04	3.48E-05	2.90E-05	1.79E-04	1.70E-05	1.87E-04	1.10E-03
IS	6.72E-04	1.11E-03	1.58E-03	3.92E-03	7.85E-04	4.89E-04	1.20E-03	1.11E-04	1.05E-03	1.09E-02
IT	1.84E-02	1.94E-02	5.66E-02	2.41E-01	3.50E-02	2.00E-02	1.91E-02	2.25E-03	2.17E-02	4.34E-01
KY	1.80E-05	1.60E-05	4.13E-05	1.24E-04	3.69E-05	1.81E-05	4.24E-06	4.11E-07	3.81E-06	2.63E-04
KZ	8.68E-04	8.68E-04	2.25E-03	6.52E-03	1.93E-03	9.36E-04	2.36E-04	2.62E-05	2.26E-04	1.39E-02
LI	3.23E-06	3.01E-06	9.70E-06	5.61E-05	4.72E-06	3.92E-06	1.07E-05	1.09E-06	1.27E-05	1.05E-04
LU	3.04E-05	3.77E-05	7.43E-05	5.59E-04	4.50E-05	3.56E-05	1.24E-04	1.27E-05	1.75E-04	1.09E-03
MC	8.59E-06	9.99E-06	2.93E-05	1.15E-04	1.69E-05	1.07E-05	1.47E-05	1.57E-06	1.44E-05	2.21E-04
MD	4.95E-04	3.44E-04	8.38E-04	4.14E-03	7.85E-04	5.81E-04	1.73E-04	2.70E-05	1.99E-04	7.58E-03
ME	4.44E-05	5.78E-05	1.11E-04	5.69E-04	1.14E-04	5.93E-05	4.41E-05	4.41E-06	3.95E-05	1.04E-03
MK	2.13E-05	2.61E-05	5.36E-05	3.19E-04	5.36E-05	3.49E-05	2.63E-05	2.66E-06	2.31E-05	5.61E-04
MT	1.12E-03	1.99E-03	3.82E-03	1.53E-02	2.55E-03	1.50E-03	1.77E-03	1.35E-04	1.62E-03	2.98E-02
NL	1.85E-04	1.76E-04	4.25E-04	3.42E-03	2.00E-04	2.02E-04	1.17E-03	1.33E-04	1.87E-03	7.78E-03
NO	8.51E-04	9.53E-04	1.95E-03	4.55E-03	6.31E-04	4.97E-04	3.96E-03	1.74E-04	1.24E-03	1.48E-02
PT	7.98E-05	1.45E-04	2.51E-04	1.24E-03	1.06E-04	6.88E-05	2.67E-04	2.71E-05	2.33E-04	2.42E-03
RO	2.67E-03	2.14E-03	4.79E-03	2.39E-02	4.55E-03	2.74E-03	1.41E-03	1.86E-04	1.48E-03	4.39E-02
RS	1.19E-03	1.15E-03	2.70E-03	1.52E-02	2.36E-03	1.23E-03	9.94E-04	1.13E-04	8.61E-04	2.58E-02
SI	1.53E-05	1.57E-05	4.20E-05	2.08E-04	2.70E-05	1.75E-05	1.89E-05	2.88E-06	1.51E-05	3.62E-04
SK	6.62E-03	4.14E-03	1.25E-02	1.11E-01	8.07E-03	6.85E-03	9.86E-03	1.41E-03	7.82E-03	1.68E-01
TJ	6.70E-06	6.20E-06	1.64E-05	5.19E-05	1.21E-05	6.17E-06	1.93E-06	1.70E-07	1.55E-06	1.03E-04
TM	2.16E-05	2.62E-05	9.67E-05	1.98E-04	4.10E-05	3.00E-05	7.48E-06	8.39E-07	7.59E-06	4.29E-04
TR	1.06E-04	1.63E-04	3.37E-04	9.48E-04	3.07E-04	1.93E-04	4.40E-05	4.48E-06	3.59E-05	2.14E-03
UA	6.15E-03	3.49E-03	9.90E-03	5.52E-02	9.53E-03	8.09E-03	2.18E-03	2.90E-04	2.14E-03	9.69E-02
UZ	4.01E-05	4.03E-05	1.21E-04	3.33E-04	7.38E-05	4.23E-05	1.28E-05	1.29E-06	1.29E-05	6.77E-04
Other	4.729	6.355	5.991	21.103	8.029	3.528	4.178	0.765	5.814	60.49
EMEP	0.166	0.165	0.408	2.249	0.263	0.211	0.393	0.043	0.425	4.32
HELCOM	0.767	4.512	1.396	6.114	2.489	0.476	1.820	0.659	2.115	20.35
Total	5.661	11.033	7.795	29.466	10.782	4.215	6.391	1.467	8.354	85.16

Metadata

Technical information

1. Source:

Meteorological Synthesizing Centre East (MSC-E) of EMEP

2. Description of data:

Assessment of transport and fate of PCBs in the EMEP region was made on the basis of the inventory of global PCB emissions [*Breivik et al.*, 2007] and emissions officially reported by the EMEP countries. Officially reported inventories of PCB emissions do not provide congener composition of emissions. Therefore, expert estimates of PCB emissions with information on particular congeners were applied [*Breivik et al.*, 2007]. The inventory provides consistent set of historical and future emissions of 22 individual PCB congeners from 1930 up to 2100. It included three scenarios of emissions, namely, minimum, average, and maximum, which represented the range of emission variations. For the evaluation of pollution levels maximum scenario of emissions was chosen since it permitted to obtain modelling results with more reasonable agreement with measurements comparing to average and minimum scenarios. Model simulations were carried out for the indicator congener PCB-153.

The spatial distribution of PCB-153 emissions within the EMEP region was prepared using gridded PCB emissions officially submitted by 24 EMEP countries, including some HELCOM Contracting Parties, namely Denmark, Finland, Latvia, Lithuania, Poland, and Sweden. For other countries spatial distribution of PCB-153 emission was made on the basis of gridded population density. Temporal variations of PCB-153 emissions in the period 1990-2018 were derived from the officially reported PCB emissions.

3. Geographical coverage:

Atmospheric deposition of PCB-153 were obtained for the European region and surrounding areas covered by the EMEP modelling domain.

4. Temporal coverage:

Time-series of annual atmospheric deposition of PCB-153 are available for the period 1990 – 2018.

5. Methodology and frequency of data collection:

Atmospheric input and source allocation budgets of PCB-153 to the Baltic Sea and its catchment area were computed using the latest version of GLEMOS model using the new EMEP domain (https://www.ceip.at/ms/ceip_home1/ceip_home/new_emep-grid/).

Global modelling framework GLEMOS is a multi-scale multi-pollutant simulation platform developed for operational and research applications within the EMEP programme [*Tarrason and Gusev,* 2008; *Travnikov et al.,* 2009, *Jonson and Travnikov*, 2010, *Travnikov and Jonson*, 2011]. The framework allows simulations of dispersion and cycling of different classes of pollutants (e.g. heavy metals and persistent organic pollutants) in the environment with a flexible choice of the simulation domain (from global to local scale) and spatial resolution. In the vertical the model domain covers the height up to 10 hPa (ca. 30 km). The current vertical structure consists of 20 irregular terrain-following sigma layers. Among them 10 layers cover the lowest 5 km of the troposphere and height of the lowest layer is about 75 m.

Anthropogenic emission data for modelling of PCB-153 have been prepared based on the gridded emissions fields provided by CEIP with spatial resolution 0.1x0.1 degree and complemented by additional emission parameters required for model runs. Atmospheric concentrations of chemical reactants and particulate matter, which are required for description of PCB-153 gas-particle partitioning and degradation, were imported from the MOZART model [*Emmons et al*., 2010]. Boundary conditions for the regional scale simulations of all considered pollutants have been obtained from the GLEMOS model runs on a global scale.

Meteorological data used in the calculations for 1990-2018 were obtained using WRF meteorological data pre-processor [*Skamarock et al*., 2008] on the basis of meteorological re-analyses data (ERA-Interim) of European Centre for Medium-Range Weather Forecasts (ECMWF).

Calculations of atmospheric transport and deposition of PCB-153 are provided on the regular basis annually two years in arrears on the basis of emission data officially submitted by Parties to LRTAP Convention.

Normalized values of PCB-153 deposition for the period 1990-2018 were obtained on the basis of results of model simulations using bi-exponential approximation [*Colette et al*., 2016].

Quality information

6. Strength and weakness:

Strength: annually updated information on atmospheric input of PCB-153 to the Baltic Sea and its sub-basins.

Weakness: uncertainties in officially submitted data on emissions of PCB-153.

7. Uncertainty:

Most of parameterizations of physical processes used in the GLEMOS model were transferred from the previous model MSCE-POP used in operational modelling under EMEP [*Gusev et al.,* 2005].

The MSCE-POP model was evaluated against the measurements of the EMEP monitoring network [*Gusev et al*., 2006; *Shatalov et al.,* 2005] and thoroughly reviewed at the workshop held in October, 2005 under supervision of the EMEP Task Force of Measurements and Modelling (TFMM). It was concluded that “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 required to reduce uncertainties in POP modelling approaches applied in the EMEP GLEMOS model.

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