Atmospheric deposition of PCB-153 on the Baltic Sea

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Key Message

Annual atmospheric deposition fluxes of PCB-153 over the Baltic Sea have decreased in period from 1990 to 2016 by 61%.

Results and Assessment

Relevance of the BSEFS for describing developments in the environment

This indicator shows the levels and trends in PCB atmospheric deposition to the Baltic Sea. Levels of atmospheric PCB deposition represent the pressure of emission sources on the Baltic Sea aquatic environment.

Policy relevance and policy references

HELCOM adopted a Recommendation in May 2001 for the cessation of hazardous substance discharges/emissions by 2020, with the ultimate aim of achieving concentrations in the environment near to background values for naturally occurring substances and close to zero for man-made synthetic substances.

Assessment

Annual atmospheric deposition fluxes of PCB-153 over the surface of the Baltic Sea have decreased in period 1990-2016 by 61% (Figure 1). The figure illustrates changes of computed total annual PCB-153 atmospheric deposition on to the Baltic Sea. Along with that the changes of normalized deposition are presented, which reflect the effect of emission variations without taking into account the influence of inter-annual variations of meteorological conditions. Values of normalized annual depositions for the period 1990-2016 were calculated using the normalization procedure, described in the Annex D of the Joint report of the EMEP Centres (Bartnicki et al., 2017).

The most significant change of PCB-153 atmospheric deposition can be noted for the Western Baltic (70%) and the Kattegat (69%). For other sub-basins the decrease of deposition varies from about 35% to 67% (Table 1).

According to modelling results the highest level of PCB-153 atmospheric deposition fluxes (0.48 $g/km^2/y$) over the Baltic Sea in 2016 can be seen in its southern-western part (the Sound), while the lowest one (0.05 $g/km^2/y$) over the Bothnian Sea. In other sub-basins the level of deposition fluxes varies from about 0.07 to 0.23 $g/km^2/y$. Among the HELCOM countries the most significant contributions to deposition over the Baltic Sea was made by Sweden and Finland.

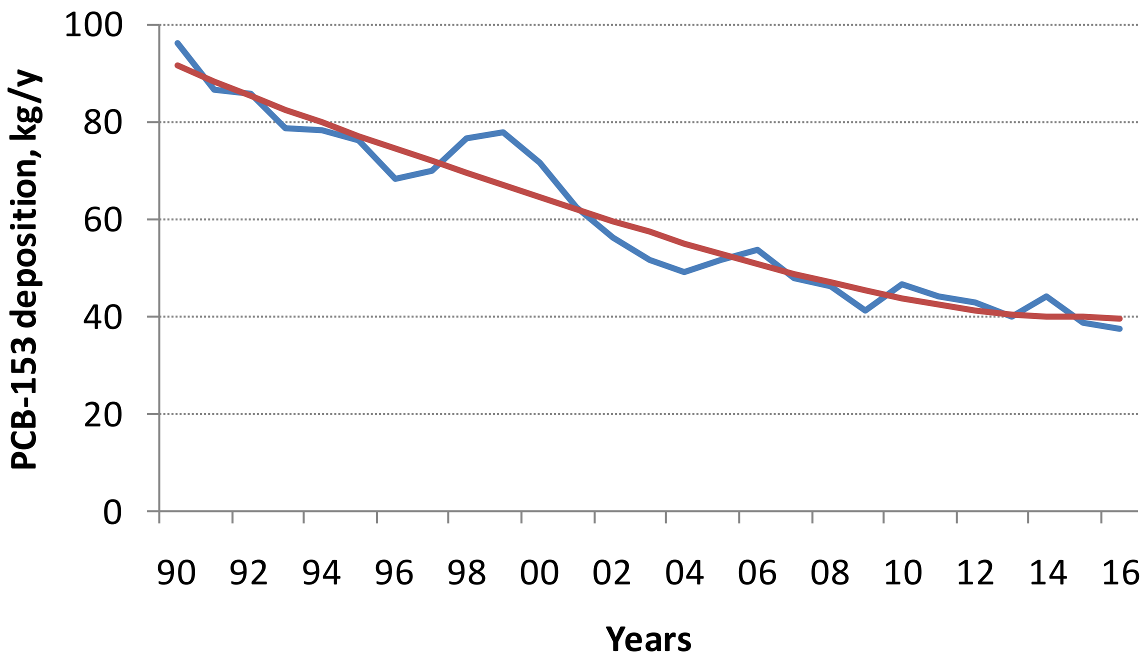

Figure 1. Changes of modeled (blue line) and normalized (red line) PCB-153 atmospheric deposition to the Baltic Sea for the period 1990-2016, (kg/y).

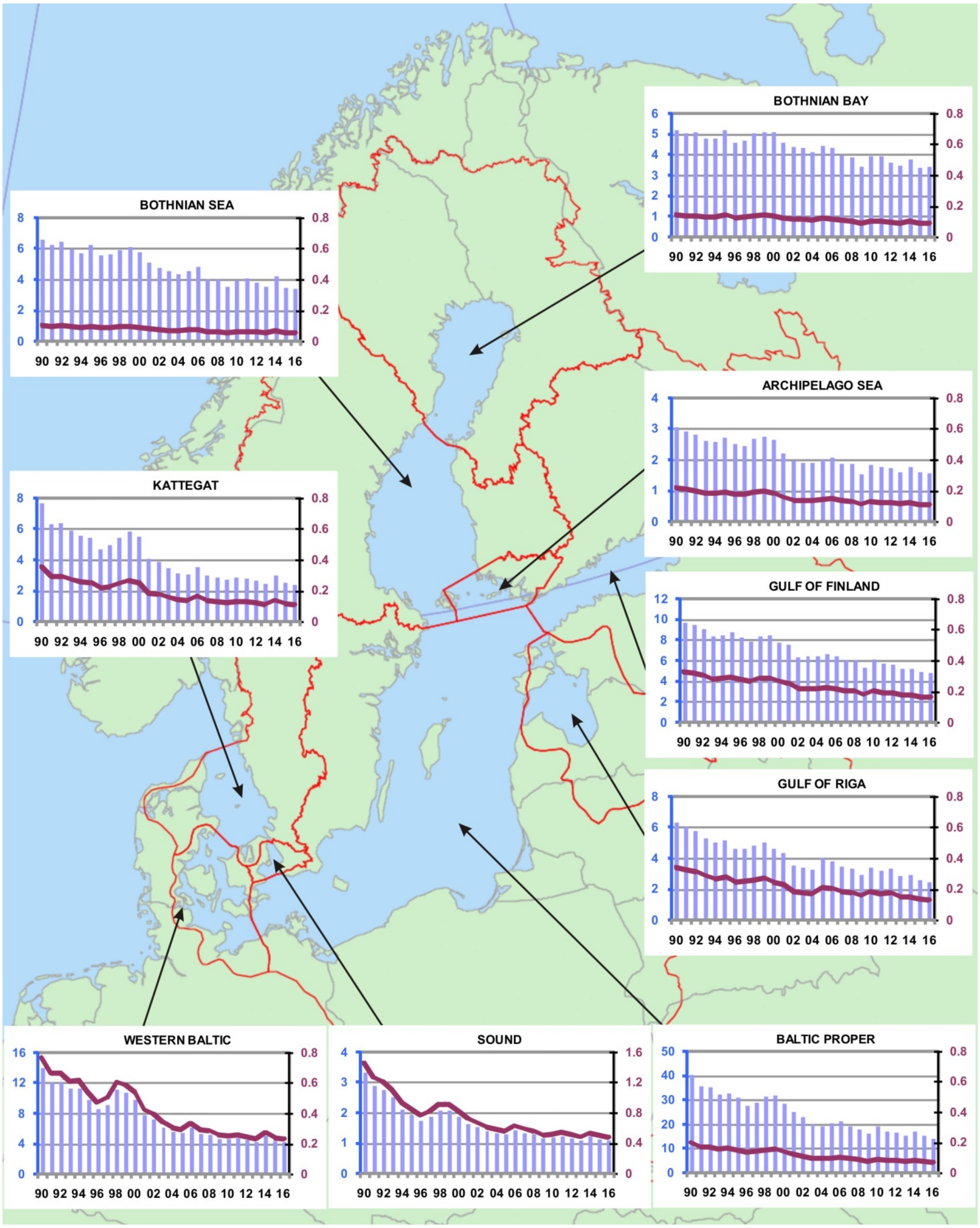

Figure 2. Time-series of computed annual atmospheric deposition of **PCB-153** over the six sub-basins of the Baltic Sea for the period 1990-2016 in kg/year as bars (left axis) and deposition fluxes in g/km^2/year as lines (right axis). Note that different scales are used for deposition in kg/year and the same scales for deposition fluxes.

References

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Data

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

Table 1. Computed annual atmospheric deposition of PCB-153 over the six Baltic Sea sub-basins, the whole Baltic Sea (BAS) and normalized deposition to the Baltic Sea (Norm) for period 1990-2016. Units: kg/year.

	ARC	BOB	BOS	BAP	GUF	GUR	KAT	SOU	WEB	BAS	Norm
1990	3.054	5.209	6.557	40.246	9.653	6.305	7.682	3.310	13.992	**96.0**	**91.6**
1991	2.914	5.055	6.264	35.394	9.426	6.052	6.334	2.892	12.092	**86.4**	**88.5**
1992	2.813	5.075	6.448	34.999	9.096	5.788	6.389	2.743	12.122	**85.5**	**85.5**
1993	2.604	4.788	5.971	32.128	8.323	5.256	5.907	2.513	11.206	**78.7**	**82.6**
1994	2.586	4.784	5.729	32.729	8.472	4.986	5.578	2.112	11.244	**78.2**	**79.8**
1995	2.711	5.202	6.206	30.819	8.723	5.134	5.447	1.932	9.826	**76.0**	**77.1**
1996	2.522	4.601	5.537	27.660	8.248	4.605	4.692	1.739	8.597	**68.2**	**74.5**
1997	2.444	4.668	5.604	28.758	7.828	4.629	4.925	1.851	9.144	**69.9**	**71.9**
1998	2.668	5.057	5.928	31.275	8.346	4.782	5.393	2.082	11.053	**76.6**	**69.3**
1999	2.736	5.105	6.089	31.935	8.421	5.048	5.812	2.078	10.702	**77.9**	**66.9**
2000	2.628	5.067	5.754	28.376	7.766	4.600	5.477	1.868	9.788	**71.3**	**64.4**
2001	2.211	4.566	5.113	25.110	7.529	4.321	4.061	1.633	7.721	**62.3**	**62.0**
2002	1.956	4.358	4.752	22.794	6.331	3.508	3.834	1.512	7.214	**56.3**	**59.6**
2003	1.914	4.344	4.515	19.839	6.428	3.374	3.441	1.390	6.147	**51.4**	**57.3**
2004	1.892	4.123	4.326	19.066	6.395	3.244	3.147	1.324	5.609	**49.1**	**55.1**
2005	2.004	4.431	4.554	20.158	6.588	3.971	3.032	1.279	5.384	**51.4**	**52.9**
2006	2.063	4.338	4.797	21.105	6.454	3.763	3.525	1.418	6.054	**53.5**	**50.8**
2007	1.873	3.965	3.981	18.958	6.001	3.460	2.962	1.324	5.342	**47.9**	**48.8**
2008	1.856	3.877	4.023	17.948	5.980	3.353	2.861	1.276	5.147	**46.3**	**46.9**
2009	1.542	3.419	3.556	15.897	5.279	2.897	2.682	1.138	4.665	**41.1**	**45.2**
2010	1.828	3.890	3.908	18.875	6.077	3.410	2.868	1.180	4.628	**46.7**	**43.7**
2011	1.766	3.916	4.058	16.901	5.708	3.174	2.803	1.227	4.683	**44.2**	**42.3**
2012	1.726	3.605	3.797	16.655	5.554	3.341	2.671	1.163	4.440	**43.0**	**41.2**
2013	1.602	3.477	3.548	15.396	5.219	2.827	2.447	1.084	4.270	**39.9**	**40.4**
2014	1.758	3.786	4.217	16.928	5.204	2.889	3.003	1.221	4.964	**44.0**	**39.9**
2015	1.583	3.374	3.454	15.050	4.886	2.609	2.481	1.135	4.302	**38.9**	**39.7**
2016	1.568	3.392	3.395	14.129	4.804	2.456	2.397	1.085	4.218	**37.4**	**39.5**

Table 2. Computed contributions by country to annual total deposition of PCB-153 to nine Baltic Sea sub-basins for the year 2016. Units: kg/year. HELCOM: contribution of anthropogenic sources of HELCOM countries; EMEP: contribution of anthropogenic sources in other EMEP countries;. NSR: contributions of sources other than primary anthropogenic emissions (natural, secondary (re-emission), and remote sources).

Country	**ARC**	**BOB**	**BOS**	**BAP**	**GUF**	**GUR**	**KAT**	**SOU**	**WEB**	**BAS**
DK	1.1E-02	1.1E-02	2.4E-02	4.3E-01	1.9E-02	2.5E-02	4.1E-01	4.0E-01	7.4E-01	2.1E+00
EE	7.6E-03	4.4E-03	1.0E-02	3.7E-02	2.9E-01	6.6E-02	9.8E-04	2.7E-04	1.4E-03	4.1E-01
FI	3.2E-01	1.0E+00	4.1E-01	2.1E-01	1.4E+00	1.1E-01	8.6E-03	2.0E-03	1.0E-02	3.5E+00
DE	1.8E-02	2.7E-02	4.7E-02	5.6E-01	3.6E-02	4.1E-02	8.9E-02	3.0E-02	2.8E-01	1.1E+00
LV	8.8E-04	5.4E-04	1.3E-03	1.3E-02	2.5E-03	3.9E-02	2.7E-04	8.2E-05	3.9E-04	5.8E-02
LT	1.6E-03	1.6E-03	3.1E-03	7.3E-02	5.0E-03	1.7E-02	1.5E-03	4.5E-04	2.2E-03	1.0E-01
PL	1.4E-02	1.7E-02	2.9E-02	9.6E-01	3.7E-02	5.0E-02	3.8E-02	1.6E-02	8.1E-02	1.2E+00
RU	9.7E-03	1.7E-02	2.2E-02	9.3E-02	3.5E-01	2.4E-02	3.1E-03	8.2E-04	4.6E-03	5.2E-01
SE	4.2E-01	7.7E-01	9.0E-01	2.0E+00	1.8E-01	1.8E-01	3.0E-01	9.0E-02	7.2E-02	4.9E+00
AL	2.2E-05	4.3E-05	5.4E-05	3.2E-04	8.4E-05	5.2E-05	2.9E-05	7.2E-06	4.0E-05	6.5E-04
AT	2.4E-03	3.5E-03	5.3E-03	5.8E-02	6.8E-03	6.1E-03	6.5E-03	1.8E-03	9.9E-03	1.0E-01
BE	8.7E-04	1.4E-03	2.4E-03	2.0E-02	1.8E-03	1.9E-03	4.7E-03	1.2E-03	1.0E-02	4.4E-02
BG	5.3E-05	1.2E-04	1.4E-04	6.9E-04	2.3E-04	1.3E-04	6.0E-05	1.5E-05	9.3E-05	1.5E-03
BA	3.7E-05	8.0E-05	1.1E-04	6.4E-04	6.3E-05	7.3E-05	3.9E-05	8.9E-06	4.7E-05	1.1E-03
BY	1.5E-02	1.6E-02	2.9E-02	2.4E-01	5.5E-02	8.0E-02	1.2E-02	3.2E-03	1.7E-02	4.6E-01
CH	3.2E-04	5.5E-04	8.1E-04	6.7E-03	7.7E-04	6.5E-04	1.1E-03	2.7E-04	1.7E-03	1.3E-02
CY	3.1E-05	7.0E-05	7.5E-05	2.4E-04	1.1E-04	6.4E-05	1.9E-05	4.2E-06	2.1E-05	6.4E-04
CZ	4.4E-03	6.1E-03	9.5E-03	1.3E-01	1.3E-02	1.3E-02	1.2E-02	3.8E-03	2.5E-02	2.2E-01
ES	1.7E-02	3.3E-02	4.6E-02	2.5E-01	4.0E-02	3.1E-02	4.6E-02	1.0E-02	6.6E-02	5.4E-01
FR	1.4E-02	2.3E-02	3.7E-02	2.6E-01	3.1E-02	2.9E-02	5.6E-02	1.3E-02	9.6E-02	5.6E-01
GB	1.2E-02	1.7E-02	2.9E-02	2.0E-01	2.7E-02	2.8E-02	5.5E-02	1.3E-02	9.2E-02	4.7E-01
GR	3.0E-03	7.3E-03	7.6E-03	3.4E-02	1.4E-02	6.7E-03	3.0E-03	7.3E-04	4.3E-03	8.1E-02
HR	2.0E-04	3.4E-04	4.6E-04	3.7E-03	6.4E-04	4.8E-04	3.8E-04	9.5E-05	5.3E-04	6.8E-03
HU	3.2E-04	5.0E-04	7.0E-04	8.1E-03	1.0E-03	9.1E-04	7.4E-04	2.1E-04	1.3E-03	1.4E-02
IE	1.2E-03	1.9E-03	3.0E-03	1.7E-02	2.7E-03	2.7E-03	4.3E-03	9.9E-04	6.6E-03	4.0E-02
IS	1.1E-04	2.6E-04	3.3E-04	1.3E-03	2.6E-04	2.4E-04	2.6E-04	6.3E-05	4.1E-04	3.2E-03
IT	7.9E-03	1.5E-02	2.0E-02	1.2E-01	2.4E-02	1.7E-02	1.5E-02	3.6E-03	2.1E-02	2.5E-01
LI	1.8E-06	3.2E-06	4.7E-06	4.0E-05	4.7E-06	3.9E-06	5.6E-06	1.4E-06	8.6E-06	7.4E-05
MD	3.6E-04	5.8E-04	8.3E-04	7.0E-03	1.1E-03	1.2E-03	5.4E-04	1.4E-04	8.0E-04	1.3E-02
MK	2.6E-06	5.6E-06	6.9E-06	3.4E-05	1.0E-05	5.7E-06	3.4E-06	8.1E-07	4.8E-06	7.4E-05
NL	5.9E-06	8.9E-06	1.6E-05	1.3E-04	1.2E-05	1.3E-05	3.5E-05	8.9E-06	7.9E-05	3.1E-04
NO	1.5E-03	2.7E-03	5.0E-03	1.4E-02	2.7E-03	2.4E-03	4.7E-03	6.6E-04	3.4E-03	3.7E-02
PT	5.7E-04	1.3E-03	1.7E-03	9.2E-03	1.3E-03	1.2E-03	1.7E-03	4.1E-04	2.3E-03	2.0E-02
RO	7.1E-04	1.2E-03	1.6E-03	1.3E-02	2.2E-03	1.9E-03	1.1E-03	3.1E-04	2.0E-03	2.4E-02
SK	4.0E-04	6.0E-04	8.9E-04	1.1E-02	1.3E-03	1.3E-03	9.5E-04	2.8E-04	1.9E-03	1.9E-02
SI	3.8E-04	6.9E-04	1.1E-03	4.9E-03	1.1E-03	9.2E-04	3.2E-04	6.7E-05	3.3E-04	9.8E-03
UA	1.5E-03	2.2E-03	3.2E-03	2.3E-02	5.3E-03	5.1E-03	1.7E-03	4.4E-04	2.6E-03	4.5E-02
RS	2.9E-04	5.3E-04	7.0E-04	5.1E-03	1.0E-03	7.1E-04	4.4E-04	1.2E-04	6.7E-04	9.6E-03
AM	1.1E-05	2.4E-05	3.2E-05	6.9E-05	3.1E-05	1.9E-05	6.5E-06	1.5E-06	9.4E-06	2.0E-04
AZ	4.3E-03	1.0E-02	1.3E-02	2.8E-02	1.3E-02	7.8E-03	2.6E-03	5.9E-04	3.8E-03	8.3E-02
KZ	5.8E-04	1.4E-03	2.0E-03	2.8E-03	1.5E-03	8.5E-04	2.5E-04	5.1E-05	2.9E-04	9.7E-03
GE	2.0E-04	4.6E-04	5.8E-04	1.4E-03	6.3E-04	3.7E-04	1.3E-04	2.8E-05	1.8E-04	3.9E-03
TR	4.0E-05	1.2E-04	1.1E-04	3.3E-04	1.9E-04	8.2E-05	3.0E-05	7.5E-06	4.8E-05	9.5E-04
LU	6.1E-05	1.1E-04	1.7E-04	1.2E-03	1.2E-04	1.2E-04	2.2E-04	5.8E-05	4.3E-04	2.5E-03
MC	4.8E-05	1.1E-04	1.9E-04	4.6E-04	8.7E-05	5.4E-05	4.0E-05	9.7E-06	6.7E-05	1.1E-03
KY	4.2E-06	1.1E-05	1.5E-05	2.3E-05	1.1E-05	5.4E-06	2.5E-06	4.2E-07	2.3E-06	7.4E-05
UZ	2.4E-05	5.3E-05	7.9E-05	1.2E-04	6.4E-05	3.4E-05	1.2E-05	2.3E-06	1.3E-05	4.1E-04
TM	1.8E-05	4.2E-05	6.1E-05	9.5E-05	5.0E-05	2.5E-05	9.0E-06	1.7E-06	1.0E-05	3.1E-04
TJ	3.0E-06	7.2E-06	1.1E-05	1.4E-05	7.4E-06	3.6E-06	1.6E-06	2.5E-07	1.3E-06	4.9E-05
MT	3.1E-03	7.3E-03	8.3E-03	3.8E-02	1.1E-02	6.2E-03	5.9E-03	1.3E-03	8.0E-03	9.0E-02
ME	1.3E-05	2.4E-05	3.2E-05	1.9E-04	4.5E-05	2.9E-05	1.8E-05	4.4E-06	2.5E-05	3.8E-04
AF	1.5E-04	3.2E-04	3.7E-04	1.9E-03	5.5E-04	3.0E-04	2.8E-04	6.7E-05	3.7E-04	4.3E-03
AS	1.2E-04	2.8E-04	4.0E-04	6.6E-04	3.0E-04	1.7E-04	6.4E-05	1.3E-05	6.9E-05	2.1E-03
NSR	0.668	1.355	1.726	8.216	2.278	1.650	1.306	0.491	2.646	20.3
EMEP	0.093	0.157	0.230	1.510	0.263	0.249	0.238	0.057	0.379	3.2
HELCOM	0.808	1.880	1.440	4.406	2.263	0.557	0.853	0.537	1.194	13.9
Total	1.568	3.392	3.396	14.132	4.804	2.456	2.397	1.085	4.218	37.4

Metadata

Technical information

1. Source:

EMEP/MSC-E

2. Description of data:

Annual atmospheric deposition fluxes of PCB-153 were obtained using the latest version of MSCE-POP model developed at EMEP/MSC-E (Gusev et al., 2005). Assessment of global scale transport and fate of PCBs was made on the basis of the inventory of global PCB emissions [Breivik et al., 2007] and emissions officially reported by the EMEP countries. The inventory of Breivik et al. [2007] provided consistent set of historical and future emissions of 22 individual PCB congeners from 1930 up to 2100. Model simulations for the period 1990 and 2013 were carried out for indicator congener PCB-153. The spatial distribution of PCB-153 emissions within the EMEP region was prepared using gridded PCB emissions officially submitted by 20 EMEP countries, including all HELCOM countries except Denmark and Russia, and the emission expert estimates worked out by TNO [Denier van der Gon et al., 2005]. Temporal variation of emissions were derived from the officially reported PCB emissions.

3. Geographical coverage:

Annual atmospheric deposition fluxes of PCB-153 were obtained for the EMEP region.

4. Temporal coverage:

Timeseries of annual atmospheric deposition are available for the period 1990 – 2016.

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 MSCE-POP model. MSCE-POP is the regional-scale model operating within the EMEP region. This is a three-dimensional Eulerian model which includes processes of emission, advection, turbulent diffusion, wet and dry deposition, degradation, gaseous exchange with underlying surface, and inflow of pollutant into the model domain. Horizontal grid of the model is defined using stereographic projection with spatial resolution 50 km at 60º latitude. The description of EMEP horizontal grid system can be found in the internet (http://www.emep.int/grid/index.html). Vertical structure of the model consists of 15 non-uniform layers defined in the terrain-following s-coordinates and covers almost the whole troposphere. Detailed description of the model can be found in EMEP reports (Gusev et al., 2005) and in the Internet on EMEP web page (http://www.emep.int/) under the link to information on Persistent Organic Pollutants. Meteorological data used in the calculations for 1990-2016 were obtained using MM5 meteorological data preprocessor on the basis of meteorological analysis of European Centre for Medium-Range Weather Forecasts (ECMWF).

Results of model simulation of atmospheric transport and annual 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 CLRTAP Convention and available expert estimates of emission.

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 emissions of PCBs.

7. Uncertainty:

The MSCE-POP model results were compared with measurements of EMEP monitoring network [Gusev et al., 2006, Shatalov et al., 2005]. The model was evaluated through the comparison with available measurements during EMEP TFMM meetings held in 2005. It was concluded that the MSCE-POP model is suitable for the evaluation of the long range transboundary transport and deposition of POPs in Europe.

8. Further work required:

Further work is required on reducing uncertainties in emission data and modeling approaches used in MSCE-POP model.