1. Executive Summary

Following decisions of the seventh HELCOM-MONAS meeting held in Tallinn in November 2004, the main goal of present 2005 Joint EMEP Report for HELCOM is to provide the routine annual data required by HELCOM, considering atmospheric input of selected pollutants to the Baltic Sea for one specific year - 2003. The report should also provide the input data for the indicator reports.

Annual 2003 depositions of all pollutants included in this report to the Baltic Sea basin and catchments are given in Table 1.1.

Table 1.1. Annual 2003 depositions of nitrogen, lead, cadmium, mercury and lindane to the Baltic Sea basin and catchment.

Compound	Basin	Catchment
Nitrogen (kt N yr^{-1})	217	1257
Lead (t yr^{-1})	134	934
Cadmium (t yr^{-1})	7	77
Mercury kt yr^{-1})	4.2	23
Lindane (kg yr^{-1})	0.5	3.3

Main points for each compound

Nitrogen

Measured NO_2, total nitrate and total reduced nitrogen concentrations show a decrease from south to north, which is due to the distance from the main emission sources. Measured NO_2 concentrations showed expected temporal patterns with winter maxima and a summer minima. During winter the atmospheric residence time is longer due to low photochemical activity ad reduced vertical mixing. A seasonal pattern is also observed in measurements for total nitrate with highest concentrations in February-April. NO_2 is reacting photochemically and the reaction product is total nitrate. This reaction is mostly dominating during spring. Total reduced nitrogen shows highest concentrations during February to May. This is due to agricultural activities.

Concerning nitrogen oxides emissions, out of nine HELCOM countries, reduction between 2% and 7.3% can be noticed in five countries from the year 2002 to 2003 (Table 4.1). The largest emission reduction, 14.9%, can be seen in the country which is an important contributor to nitrogen depositions into the some (especially GUB) sub-basins

and catchments of the Baltic Sea – Sweden. In three countries, Finland, Denmark and Lithuania, emissions of nitrogen oxides increased by 4.5%, 5.3% and 3.9%, respectively. In the Russian Federation emissions remained on the same level in 2002 as in 2003.

In case of ammonia (Table 4.1), compared to 2002, annual emissions in the year 2003 increased in only two HELCOM Parties, Latvia and Sweden by 36.4%, and 1.8%, respectively. In Denmark, Estonia, Germany, Lithuania and the Poland, annual emissions were, 3%, 11.1%, 2.1%,33.3% and 0.9% lower in 2003 than in 2002. Ammonia emissions in Estonia and Finland and the Russian Federation remained on the same level in 2003 as in 2002.

Only a relatively small part of nitrogen emitted from the HELCOM Parties is deposited to the Baltic Sea basin. In Figures 4.1 the percent of annual emissions of total nitrogen in 2003, deposited to the Baltic Sea is shown.

The largest part of nitrogen emissions, 12.1% and 11.2% is deposited to the Baltic Sea from Sweden and Denmark, respectively, and lowest, 3.9% and 0.6% from Germany and the Russian Federation, respectively.

Annual national nitrogen emissions (NO_2 and NH_3) are available at EMEP in 11 SNAP sectors. SNAP stands for Selected Nomenclature for Air Pollution and the SNAP sectors are defined in the EMEP-CORINAIR Emission Inventory Guidebook.

For all HELCOM Parties, transport and combustion are the main sources of nitrogen oxides emissions into the Atmosphere in 2003. The transport sectors, with the road transport being the major source of nitrogen oxides pollution, dominate in all HELCOM countries except Poland and the Russian Federation. In Poland and the Russian Federation, combustion in energy and transformation industry is the major contributor to emissions, however, road transport is the next on the list also in these countries.

For the HELCOM Parties, there is not much difference between contributions to annual nitrogen emissions form different emission sectors of nitrogen oxides in 2002 (Bartnicki et al., 2004) and in 2003. Small changes can be noticed in the Russian Fedreration, where the contribution from sector 4 (Production processes) is slightly reduced, whereas contribution from sector 3 (Combustion in manufacturing industry) slightly increased

In case of ammonia, emissions from the agriculture are much higher than emission from any other sector in all HELCOM countries. Contribution of agricultural emissions to annual total ammonia emissions in 2003 varies between 81% (Sweden) and 96% (Latvia) in different HELCOM Parties. Contribution from other sectors to ammonia emission is one order of magnitude lower.

No major changes can be noticed in contributions from different sectors to annual ammonia emissions in 2002 and 2003. The largest change could be observed in Estonia and Germany, where contributions of agriculture were reduced from 92% in 2002 to 90% in 2003.

There is a clear south-East to North-West gradient in the computed deposition fluxes for both 2002 and 2003. For all three: oxidized, reduced and total nitrogen, the highest deposition fluxes can be noted in the Belt Sea (BES) sub-basin/catchment and the lowest in the Bothnian Bay (BOB) sub-basin/catchment. Computed wet deposition of nitrogen is definitely larger than dry deposition over the entire Baltic Sea region.

In the previous EMEP calculations, the 1990 nitrogen oxides ship emissions had been used for all years until 2002. Nitrogen oxides emissions from the international ship traffic on the Baltic Sea have been updated for 2003 calculations. Total annual emissions of nitrogen oxides from the international shipping operation on the Baltic Sea are relatively high, 380 ktonnes as NO_2 compared to annual emissions from the individual HELCOM countries, for the same year.

Depositions to GUB, GUF, GUR and KAT sub-basins are respectively 16%, 22%, 1% and 5% higher in 2003 than in 2002. Depositions to the Baltic Proper and Belt Sea sub-basins are respectively 5% and 8% lower in 2003 than in 2002. Total nitrogen deposition to the entire basin of the Baltic Sea is 11% higher in 2003 than in 2002 and total nitrogen deposition to the entire catchment of the Baltic Sea is only 2% higher in 2003 than in 2002.

The largest part (56%) of nitrogen was deposited to the Baltic Proper sub-basin in 2003. The next receiver on the list was Gulf of Bothnia (16%). The lowest amount of nitrogen (4%) was deposited to the Gulf of Riga sub-basin.

Also in the case of catchments, the largest part (52%) of nitrogen was deposited to the Baltic Proper sub-basin in 2003, with the Gulf of Finland (16%) being number two on the list. The lowest amount of nitrogen (4%) was deposited to the Belt Sea catchment in 2003.

Like in the previous years, there is no clear seasonal pattern of computed deposition in 2003, but in general maxima of the deposition can be observed in May and November, and minima in February and March.

Monthly deposition patterns of total nitrogen to the Baltic Sea basin in 2002 and 2003 are similar with more pronounced differences in August, September and December, when 2002 depositions are significantly lower than 2003 depositions.

Source-receptor matrices for oxidized, reduced and total (oxidized + reduced) nitrogen deposition to the sub-basins and catchments of the Baltic Sea were calculated for the year 2003, and are presented in the Appendix C.

Comparison of 2000 and 2003 source-receptor matrices indicates that four major contributors to oxidized nitrogen deposition (Germany, Baltic Sea, Poland, United Kingdom), as well as four major contributors to reduced nitrogen deposition (Germany, Baltic Sea, Poland, United Kingdom) are the same in 2000 and 2003. Small changes can be observed for the remaining contributors. Sweden, Denmark and Finland, contribute more to oxidized deposition in 2003 than in 2000. Also, France, Finland and the United Kingdom contribute more to reduced nitrogen deposition in 2003 than in 2000.

Model results were compared with the available measurements at the HELCOM stations for each moth of 2003. The comparison between model and measurements for concentrations of nitrogen compounds is good and comparable to the model performance for the EMEP sites. The model provides a reliable tool in order to assess the nitrogen supply to the Baltic Sea.

Heavy metals

Measured cadmium and lead concentrations in air show a decrease from south to north, which as for the nitrogen compounds is due to the distance from the main emission sources. The seasonal pattern for cadmium, lead and mercury in measurements indicate a weak winter maxima which is due to reduced vertical mixing during winter.

Following the officially submitted data annual emission from anthropogenic sources of HELCOM countries in 2003 was accounted for 116 tonnes of cadmium, 61 tonnes of mercury, and 3271 tonnes of lead. Major contributions to the total emission of heavy metals from anthropogenic sources within the Baltic Sea region belonged to Poland, Germany, and Russia. In comparison to 2002 emissions of cadmium, lead, and mercury have slightly decreased.

Atmospheric input of cadmium, mercury and lead to the Baltic Sea in 2003 was evaluated on the basis of official information on heavy metals emissions using the latest version of MSCE-HM model. Total annual atmospheric depositions of heavy metals over the Baltic Sea in 2003 were about 7 tonnes of cadmium, 4.2 tonnes of mercury, and 134 tonnes of lead. The highest level of lead and cadmium depositions over the Baltic Sea was obtained for the Gulf of Riga sub-basin and of mercury depositions over the Belt Sea sub-basin. Elevated levels can also be noted for the Kattegat and southern part of the Baltic Proper sub-basin. In comparison to computed depositions for 2002 the total depositions over the Baltic Sea in 2003 have decreased by 10% for lead and by 5% for cadmium, while mercury depositions have increased by 35%.

Anthropogenic emission sources of heavy metals of HELCOM countries contributed to the depositions over the Baltic Sea in 2003 about 40-50%. Significant contribution to total depositions belonged to the input of re-emission and natural sources, especially for mercury. On the level of individual countries the most significant depositions of lead and cadmium were from the sources of Poland, Germany, and Russia. In case of mercury the most essential contributions to depositions over the Baltic Sea belonged to Germany, Poland, and Denmark. Essential contributions to depositions over the Baltic Sea were also obtained from the United Kingdom, France, Slovakia, and Czech Republic.

Results of the comparison of computed concentrations of lead and cadmium in air with measurements showed some underestimation of observed levels by a factor of 2. The underestimation of concentrations in precipitation is more significant accounting for a factor of 3-4 for lead and cadmium. The most likely reason of the underestimation of observed level of concentrations can be connected with the uncertainties in spatial distribution and seasonal variations of lead emissions, the influence of local sources, and differences between precipitation amount observed at the sites and used in modelling.

Additional reason of underestimation of lead and cadmium concentrations can be connected with the contribution originated from the ship traffic in the Baltic Sea. The inventory of these emissions is not currently available for modelling. Taking into account the results of comparison between measurements and model results actual atmospheric load of lead and cadmium to the Baltic Sea can be approximately twice higher than estimated depositions.

Comparison of model results for mercury with observations showed reasonable agreement between them. Annual and monthly computed air concentrations of mercury are in a good agreement with measured ones. Model results for mercury in precipitation are 40% higher than measured values on average.

Lindane

The measured concentrations of lindane in air show no significant differences between the two Swedish stations. Lindane shows a clear season pattern with highest concentrations during summer. In western countries the use of lindane in agricultural application is still allowed, explaining the summer maximum.

Following officially reported information on emissions lindane is no longer applied in the following HELCOM countries: Denmark, Estonia, Finland, Germany, Russian Federation and Sweden. No information is available for Latvia, Lithuania, and Poland. Major lindane emission sources are located outside the Baltic Sea region in the United Kingdom, Spain, Portugal, Greece, and Croatia.

Atmospheric input of lindane to the Baltic Sea and its catchment area was evaluated for 2003 using MSCE-POP model. Modelling was performed using available emission data officially reported by EMEP countries to the UN ECE Secretariat and expert estimates of lindane emissions. Evaluation of lindane long-range transport and depositions over the Baltic Sea area for 2003 was based on computations accounting for long-term accumulation of lindane in soil and seawater in period 1990-2003. Following the model results total annual deposition of lindane to the Baltic Sea accounted for 0.5 tonnes and to its catchment area about 3.3 tonnes for 2003. Most significant total deposition fluxes are obtained for the Belt Sea sub-basin while Lowest deposition rate can be noted for the Gulf of Bothnia sub-basin.

Reasonable agreement is found between computed and measured annual mean air concentrations of lindane for SE14 (Råö) and NO99 (Lista). At FI96 (Pallas) the model underestimates measured concentrations in air about a factor of 2. Computed concentrations of lindane in precipitation reasonably agree with measured ones at DE01 (Westerland) and DE09 (Zingst). At the same time the model underestimates concentrations of lindane in precipitation measured at BE04 (Knokke) and NL91 (De Zilk) about a factor of 3-4. The reason for the underestimation can be connected with the influence of local sources not taken into account in the emission data.