

## 1. Executive Summary

Following decisions of the sixth HELCOM-MONAS meeting held in Gdynia in October 2003, the main goal of present 2004 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 - 2002. The report should also provide the input data for the indicator reports.

### Main points for each compound

#### *Nitrogen*

Measured NO<sub>2</sub>, 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<sub>2</sub> 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 and reduced vertical mixing. A seasonal pattern is also observed in measurements for total nitrate with highest concentrations in spring. NO<sub>2</sub> is reacting photochemically and the reaction product is total nitrate. This reaction is mostly dominating during spring. Total reduced nitrogen shows highest concentrations during March-September. This is due to agricultural activities and reemission from ground due to higher temperatures.

Concerning nitrogen oxides emissions, out of nine HELCOM countries, reduction between 2% and 7.3% can be noticed in six countries from the year 2001 to 2002 (Figure 4.1). The largest emission reduction, 7.3%, can be seen in the country with a relatively small nitrogen oxides emissions – Lithuania. In two countries, Estonia and Russia, emissions of nitrogen oxides increased by 5.3% and 8.9%. In Poland emissions remained on the same level in 2002 as in 2001.

In case of ammonia (Figure 4.2), compared to 2001, annual emissions in the year 2002 increased in four HELCOM Parties, Germany, Lithuania, Poland and Sweden by 1.2%, 2%, 6.1% and 1.9%, respectively. In Denmark, Latvia and the Russian Federation, annual emissions were, 1%, 8.3% and 7.7% lower in 2002 than in 2001. Ammonia emissions in Estonia and Finland remained on the same level in 2001 as in 2002.

Only a relatively small part of nitrogen emitted from the HELCOM Parties is deposited to the Baltic Sea basin. In Figures 4.4 and 4.5 the percent of annual emissions of nitrogen oxides and ammonia in 2002 deposited to the Baltic Sea are shown, respectively.

The largest part of nitrogen oxides emissions, 8.8% and 8.7% is deposited to the Baltic Sea from Sweden and Denmark, respectively, and lowest, 4.9% and 0.6% from Germany and Russian Federation, respectively. The largest part of ammonia emissions, 18.2% and 16.4% is deposited to the Baltic Sea from Sweden and Denmark, respectively, and lowest, 5.3% and 1.9% from Germany and Russian Federation, respectively.

Part of ammonia emissions deposited to the Baltic Sea is larger than the part of nitrogen oxides emissions because emissions of ammonia come mainly from the low agricultural sources, whereas nitrogen oxides emissions come to large extent from the high combustion sources.

Annual national nitrogen emissions ( $\text{NO}_2$  and  $\text{NH}_3$ ) are reported to 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. The transport sectors dominate in all HELCOM countries except Poland and the Russian Federation with the road transport being the major source of nitrogen oxides pollution. 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.

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 2002 varies between 80% and 96% in different HELCOM Parties. Contribution from other sectors to ammonia emission is one order of magnitude lower.

There is a clear south-East to North-West gradient in the computed deposition fluxes for 2002. 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.

Computed 2002 annual depositions of both, oxidized and reduced nitrogen are lower than corresponding 2001 depositions in all six sub-basins of the Baltic Sea. The most likely reason for lower computed depositions in 2002 is probably meteorological situation in this year. However, also two other reasons have to be taken into account: 1) revision of the Unified EMEP model and 2) review and revision of the emissions.

Like in the previous years, there is no clear seasonal pattern of computed deposition in 2001, but in general maxima of the deposition can be observed in April, and minima in May.

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 2000, and are presented in the Appendix C.

Germany, Poland, Denmark, Russian Federation, Sweden, France and emissions from the Baltic Sea ship traffic are the main contributors to total nitrogen deposition to different sub-basins of the Baltic Sea. Finland, Germany, Poland, Denmark, Russian Federation, Sweden, Czech Republic and the United Kingdom are the main contributors to total nitrogen deposition to different catchments of the Baltic Sea.

Model results were compared with the available measurements at the HELCOM stations for each month of 2002. 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.

Atmospheric input of cadmium, mercury and lead to the Baltic Sea in 2002 was evaluated on the basis of official information on heavy metals emissions using the latest version of MSCE-HM model. Following the officially submitted data annual emission from anthropogenic sources of HELCOM countries in 2002 was accounted for 120 tonnes of cadmium, 65 tonnes of mercury, and 3320 tonnes of lead. The largest 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 2001 emissions of mercury and lead have somewhat decreased, while cadmium emissions left on the same level.

Total annual atmospheric depositions of heavy metals over the Baltic Sea in 2002 were about 7.4 tonnes of cadmium, 3.1 tonnes of mercury, and 149 tonnes of lead. The highest level of heavy metals depositions over the Baltic Sea was obtained for the Belt Sea sub-basin. Elevated levels can also be noted for the Kattegat, the Gulf of Finland, and southern part of the Baltic Proper sub-basin. Comparing these results with computations for 2001 it can be noted that cadmium depositions have decreased by about 10%, while mercury and lead depositions did not change significantly.

Anthropogenic emission sources of heavy metals of HELCOM countries contributed to the deposition over the Baltic Sea in 2002 about 40-50%. Significant contribution to total

depositions belonged to the input of re-emission and natural sources. 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.

Results of the comparison of computed lead and cadmium concentrations in air and precipitation with measurements showed some underestimation of observed levels by a factor of 2-3. The most likely reason of these differences can be connected with the underestimation of lead and cadmium emissions to air in officially submitted data. Additional contribution to atmospheric concentrations and depositions of lead and cadmium within the Baltic Sea region can be originated from the ship traffic. However 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. Computed mercury concentrations deviated from observed ones within a factor of 0.6-1.6.

### *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.

Atmospheric input of lindane to the Baltic Sea and its catchment area was evaluated for 2002 using MSC-E Eulerian multimedia POP transport model MSCE-POP. 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 2002 was based on computations accounting for long-term accumulation of lindane in soil and seawater in period 1970-2002. During the 1990-s the application of lindane in HELCOM countries was practically ceased. However, it is still applied in some countries within the European region (the United Kingdom, Portugal, Spain, and Croatia), and in North America, and in South-east Asia. According to model results concentrations of lindane in air within the Baltic Sea region have decreased significantly. For most of sub-basins of the Baltic Sea re-emission of lindane from seawater takes place exceeding the wet and dry deposition fluxes. Obtained results were compared with available monitoring data of lindane concentrations in air and precipitation in the Baltic Sea region.