EXECUTIVE SUMMARY

Persistent organic pollutants (POPs) are semi-volatile toxic compounds, resistant to degradation, and causing an array of harmful effects to human health and wildlife. In spite of declining of POP emissions in the past several decades, they still present in the environment and pose risks to humans as well as terrestrial and aquatic ecosystems. Reduction of unintentional releases of POPs is within the scope of the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP) activities since 1998, when the Aarhus Protocol on Persistent Organic Pollutants came into force. Monitoring of pollution levels, determination of emissions, and assessment of transboundary transport of POPs is performed within the Convention by scientific Centres of Co-operative Programme for Monitoring and Evaluation of Long-range Transmission of Air Pollutants in Europe (EMEP).

This Status Report presents the outcome of recent work of the EMEP Centres in the field of POP pollution assessment, performed in accordance with the bi-annual work-plan of the Convention for 2018-2019 [ECE/EB.AIR/GE.1/2017/20-ECE/EB.AIR/WG.1/2017/13]. Pollution levels of polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzo(p)dioxins and dibenzofurans (PCDD/Fs), polychlorinated biphenyls (PCBs), and hexachlorobenzene (HCB) in the EMEP region were evaluated for 2016 based on national emission inventories, modelling results, and measurements.

Monitoring of POP concentrations in the EMEP region in 2016 was performed by 39 monitoring sites of 17 Parties. While most of these sites reported measurements of PAH concentrations in air, data on HCB and PCBs were provided only by 12 sites of 7 Parties, which were mainly located in Northern and Central Europe. Measurements of POPs in air and precipitation under EMEP are complemented by relevant research and national/regional monitoring activities within Europe and beyond in other regions, which include active air monitoring (e.g. EU national air quality data collected in the EEA AIRBASE, UK network TOMPs) and various passive air sampling (e.g. Spanish POP monitoring network, Global Atmospheric Passive Sampling network (GAPS)).

Analysis of observed POP concentrations was mainly focused on the data for PAHs and PCBs. Levels of observed air concentrations of PAHs across the EMEP sites varied by more than an order of magnitude with relatively higher concentrations measured in Central and Eastern Europe and lower concentrations in other parts of EMEP domain. The highest level of B(a)P air concentrations was observed in the southern part of Poland (more than 10 ng/m^3). Unlike other POPs, included in the EMEP program, spatial variations of observed PAH concentrations are characterized by both relatively high and low concentrations reported by the stations in close proximity to each other.

The spatial patterns of observed PCB concentrations showed that lighter and more volatile congeners remained relatively more abundant in air at remote sites at high latitudes, compared to the less volatile ones, which appeared to be more abundant in densely populated areas, suspected to be source regions within Europe. Contemporary PCB concentrations in air may in part be a result of primary emissions which occurred long time ago as well as secondary emissions. While the observed PCBs often show decreasing time trends at monitoring sites within the EMEP domain, it is of importance to sustain the long-term monitoring even long time after intentional PCB production has been banned.

Model assessment of POP pollution in the EMEP countries for 2016 was carried out using the most recent emission data for 2015 available at the moment of the study, which were prepared by the Centre on Emission Inventories and Projections (CEIP)[1] . Supplementary characteristics of the emissions (e.g. vertical distribution and seasonal variations) as well as emission scenarios for global scale modelling were elaborated by MSC-E. Though the quality of national POP emission inventories is gradually improving, estimates of emissions of some of the EMEP countries are still subject of considerable uncertainties. To improve the quality of reported emission data detailed analysis of the consistency of applied methodologies and values of emission factors is required. Besides, air quality modelling can be applied as a tool for evaluation of reported emissions with regard to their magnitude and spatial distribution.

Assessment of PAH pollution levels in the EMEP countries has been carried out for the selected PAH compounds, namely, B(a)P, B(b)F, B(k)F, and IP, on the basis of modelling results and measurements. High levels of annual mean PAH air concentrations were predicted for countries in Central and Eastern Europe. Verification of modelling results against measurements at the EMEP monitoring sites demonstrated generally reasonable agreement of modelled and observed concentrations for the sum of 4 considered PAHs. However, model performance for particular PAHs was different, with relatively low deviations from measurements on average for B(a)P, B(b)F, and IP, and more significant under-prediction for B(k)F. The deviations found may indicate both inconsistency between the PAH compounds composition in the reported emission estimates and actual emissions, and uncertainties in physical-chemical properties of PAHs applied for modelling.

More detailed analysis of PAH pollution in the EMEP countries was carried out for B(a)P, which is considered as an indicator compound for the evaluation of exposure to carcinogenic PAHs. Model predictions of annual mean B(a)P air concentrations pointed out exceedances of the EU target value (1 ng/m^3) for Poland, Germany, the Czech Republic, Hungary, Romania, Portugal, Spain, northern Italy, the FYR of Macedonia, Bulgaria, and some of the EECCA countries (e.g. Republic of Moldova, Ukraine, and the Russian Federation). According to these results, about 9% of population of the EMEP countries were living in the areas with annual mean B(a)P air concentrations above the EU target level, and almost 75% in the areas with air concentrations above the WHO reference level (0.12 ng/m^3).

Evaluation of B(a)P pollution levels at national scale was performed in the framework of country-specific case study for Spain and France. Main emphasis at the current stage of the study was given to the analysis of discrepancies between B(a)P modelling results and observed pollution levels. Particularly, comparison of modelling results, based on official emission data, and observed B(a)P air concentrations revealed significant differences for some of the monitoring sites in Belgium, the Netherlands, Germany, Poland, Portugal, and Spain. Discrepancies found may be attributed to the uncertainties in estimates of B(a)P emissions from the 'Residential Combustion' and 'Field burning of agricultural residues' sectors in the national inventories of these countries. Test model simulations based on scenario emissions, assuming changes of releases for these sectors, showed improvement of the agreement with measurements and indicated the need of refinement of the emission inventories. Another reason of discrepancies may be related to the uncertainties in model parameterization of B(a)P

[1] *Update of the modelling results based on the new emission data for 2016 is available at the MSC-E web site [www.msceast.org].*

gas-particle partitioning and degradation that is planned to be analyzed at further stages of this B(a)P case study.

Assessment of environmental pollution by PCDD/Fs, PCB-153, and HCB was carried out for regional and global scales using nested model simulations. Model simulations indicate elevated levels of dioxins and furans air concentrations for the UK, northern Italy, countries of Central and Eastern Europe as well as in the Russian Federation, Ukraine, and Azerbaijan. The highest levels of modelled PCB-153 annual mean air concentrations were estimated for the countries in Western Europe (e.g. Germany, France, Belgium). Modelling results for HCB showed low spatial variability of annual mean air concentrations, which can be explained by longer residence time in the atmosphere comparing to other considered POPs.

Major attention in this study was paid to the evaluation of pollution by dioxins and furans. To explore the effect of uncertainties in the officially reported PCDD/F emissions, model simulations were made on the basis of both officially reported emission data and scenario emissions, representing maximum level of releases to the atmosphere. Analysis of modelling results showed that the use of maximum emission scenario led to improvement of agreement between the modelling results and measurements that can be considered as an indication of possible underestimation of officially reported PCDD/F emissions. However, it should be noted that measurement data for the evaluation of PCDD/F model predictions were available for limited amount of countries (Spain, the UK, and Sweden). Therefore, model predictions for other regions in the EMEP domain require further analysis with application of additional PCDD/F monitoring data.

Verification of model predictions for PCB-153 demonstrated reasonable agreement of modelled and measured concentrations with respect to spatial distribution of pollution levels. For 60% of the monitoring sites the difference between measured and modelled concentrations was within a factor of 2. At the same time, modelling results for HCB tended to under-predict observed air concentrations for most of the monitoring sites. The under-prediction was attributed to i) incomplete information on HCB emission sources in the inventories reported by the EMEP countries, ii) possible underestimation of HCB emissions in regions outside the EMEP domain applied in model simulations, and iii) uncertainties of model parameterizations for HCB degradation in media and air-surface exchange.

Source apportionment of PCDD/F, PCB-153, and HCB pollution in the EMEP countries was carried out taking into account primary anthropogenic emission sources and secondary emissions as well as non-EMEP emissions. The largest contribution of contemporary EMEP anthropogenic emission sources was estimated for PCDD/Fs (46%), followed by PCB-153 (36%), and HCB (2%). Secondary emission sources of PCDD/Fs, PCB-153, and HCB contributed to deposition in the EMEP countries about 50% - 70%. The contribution of non-EMEP emission sources was about 4% for PCDD/Fs and PCB-153, and about 30% for HCB.

Co-operation is an important component of research and operational pollution assessment performed by MSC-E to support countries with information on POP pollution levels in Europe and other regions. In this context MSC-E closely collaborates with Parties to the Convention and its Subsidiary Bodies, and exchanges information on POPs with various international organizations. In particular, progress of MSC-E work on the assessment of POP pollution in the EMEP region as well as in the national scale case study of B(a)P pollution was presented at the annual TFMM meeting. The Centre also contributed to

the work of the Task Force on Emission Inventories and Projections (TFEIP) presenting information on uncertainties in the official POP emissions and discussing application of air quality models for the evaluation of reported emissions. In the framework of co-operation with Helsinki Commission (HELCOM), MSC-E performed assessment of PCDD/F atmospheric input to the Baltic Sea.

National inventories of POP emissions, compiled under the Stockholm Convention, as well as development and improvement of methodologies for the estimation of POP emissions, represent important source of information for studies of environmental pollution by PCDD/Fs, PCBs, and HCB in the EMEP region and on the global scale. Therefore, further co-operation and sharing of information between the CLRTAP and the Stockholm Convention is highly appreciated.

Future activities of MSC-E will be directed to further improvement of the quality of POP pollution assessment for the EMEP region. Further development and evaluation of the Global EMEP Multi-media Modelling System (GLEMOS) will include analysis of key factors affecting uncertainties of model estimates of gas-particle partitioning and degradation in the atmosphere for PAHs as well as exchange between environmental compartments for PCDD/Fs, PCBs, and HCB. Country-specific case studies of B(a)P pollution will be continued for Spain and France as well as for some other EMEP countries (e.g. Poland, Croatia, Germany) in close cooperation with national experts. Besides, development and application of methodologies, based on complementary use of multiple regression analysis, fine resolution modelling, and measurements, for the evaluation of B(a)P pollution in urban areas will be continued. Particular attention will be given to the co-operation with subsidiary bodies of the Convention (TFMM, TFHTAP, TFEIP, and WGE), international organizations (AMAP, Stockholm Convention, HELCOM etc.) and national experts. These directions of future research activities are outlined in the MSC-E work-plan for 2018-2019 and the updated Mandate of the Centre.