EXECUTIVE SUMMARY

This year funding of MSC-E was suspended according to the decision of the CLRTAP Executive Body adopted at 42nd session in December 2022 [ECE/EB.AIR/150]. To support further EMEP activity on assessment of heavy metal and POP pollution, the Government of the Russian Federation decided to pay the assessed contribution to Russia for 2022 and 2023 in accordance with the obligations under 1984 Protocol to the Convention directly to the budget of MSC-E of EMEP (https://unece.org/sites/default/files/2023-08/Item%203%20Letter%20on%20MSC-E%20-%20en.pdf). This allowed MSC-E to resume its work in 2023 and prepare Status report.

General information

Heavy metals and persistent organic pollutants (POPs) are known for their toxicity and harmful effects on human health and the environment. In order to reduce levels of pollutants in the environment UNECE Convention on Long-range Transboundary Air Pollution (hereafter, CLRTAP or the Convention) was established. In the framework of the Convention a number of protocols have been developed. In particular, Protocol on Heavy metals and Protocol on POPs to the Convention, aimed at reduction of emissions of these pollutants to the atmosphere, were adopted in 1998 and amended in 2012 and 2009, respectively. According to the Protocols, the priority heavy metals and POPs are lead (Pb), cadmium (Cd) and mercury (Hg), polychlorinated biphenyls (PCBs), polychlorinated dibenzo(p)dioxins and dibenzofurans (PCDD/Fs), hexachlorobenzene (HCB) and polyaromatic hydrocarbons (PAHs). The considered PAHs comprise benzo(a)pyrene (B(a)P), benzo(b)fluoranthene (B(b)F), benzo(k)fluoranthene (B(k)F), and indeno(1,2,3-cd)pyrene (I(cd)P). According to the amendments made in 2009 a number of Contaminants of Emerging Concern (CECs) were also included to the POP Protocol.

EMEP Programme (Co-operative Programme for Monitoring and Evaluation of Long-range Transmission of Air Pollutants in Europe, www.emep.int) is aimed at scientific support of the implementation of the Protocols. Several EMEP Centres are focused on providing the Parties to the Convention with information on pollution levels and transboundary transport. In particular, information about emissions of heavy metals and POPs in the EMEP region is compiled by Centre on Emission Inventories and Projections (CEIP). Monitoring activity within EMEP is supported by Chemical Coordinating Centre (CCC). Model assessment of pollution levels and transboundary transport of heavy metals and POPs is performed by Meteorological Synthesizing Centre – East (MSC-E). The Working Group on Effects (WGE) is focused on evaluation of adverse impacts of the pollutants on the environment and human health.

Emissions

Emission data sets for modelling for 2021 were produced by MSC-E using the gridded sector data produced by CEIP and derived from CEIP WebDab data base, and additional information on temporal variability, vertical distribution and chemical speciation of emissions. Global-scale gridded emissions for modelling were also prepared by MSC-E using the results of the related research projects and expert estimates.

Monitoring

Information on observed concentrations in air, concentrations in precipitation and precipitation sums is available in the EBAS database coordinated by CCC of EMEP. In 2021 information on Pb and Cd concentrations measured in air was available from 51 stations, and measurements of concentrations in precipitation - from 58 stations. At 47 stations co-located measurements were carried out. Hg concentrations in air and precipitation were available from 10 and 21 stations, respectively. Concentrations of B(a)P, HCB and PCB-153 were measured at 30, 11 and 12 stations, respectively. Available monitoring data were analyzed by MSC-E. Most reliable measurements were further used for evaluation of modelling results against observations.

Status of heavy metal pollution in 2021

Pollution levels of heavy metals (Pb, Cd, Hg) and POPs (PAHs, PCDD/Fs, HCB) in 2021 were assessed for the EMEP region, its sub-regions and particular countries. The highest pollution levels are noted for the Central Europe. This sub-region is characterized by the highest levels of Pb, Cd, Hg, PAHs and HCB compared to the other sub-regions. The lowest pollution levels take place in Northern Europe and Caucasus and Central Asia. Evaluation of changes of pollution levels between 2020 and 2021 induced by meteorological variability shown that the changes in sub-regions of the EMEP domain did not exceed ±15%.

Evaluation of the modelling results against observations was carried out for air concentrations and wet deposition fluxes available from the EMEP monitoring network. For Pb and Cd, at majority of monitoring stations the difference between modelled and observed concentrations in air or wet deposition fluxes lies within a factor of two. The model tends to overpredict concentrations of Pb and Cd in air and wet deposition of Hg, and underpredict wet deposition fluxes of Pb and Cd . The agreement of Hg modeled and measured concentrations in air is within ±6% on average and ±25% for particular EMEP stations. Evaluation of the modelling results against EMEP measurements shows good agreement of modelled and observed concentrations of the sum of 4 PAHs with low bias and high spatial correlation. For about 80% of the monitoring stations, the differences between the modelling results and measured concentrations are within a factor of 2. Modelled PCB-153 air

concentrations are two-fold higher than the measured ones. For most of the stations the differences between modelled and observed HCB air concentrations are lower than a factor 2.

Pollution levels in the EMEP region are formed by three groups of sources such as 1) anthropogenic emissions of the EMEP countries, 2) secondary emissions from the EMEP territory (wind re-suspension, natural and legacy emissions, re-emissions) and 3) emission sources located outside the EMEP countries (non-EMEP sources). Deposition of Pb and Cd are mostly caused by EMEP anthropogenic emissions and secondary sources. Hg is global pollutant and thus its levels are formed basically by non-EMEP sources. In case of PAHs the largest contribution (more than 80%) to deposition is made by the EMEP anthropogenic sources, while other types of emission sources contributed less than 20%. The highest contribution to deposition fluxes of PCDD/Fs, PCB-153 and HCB is made by secondary emission sources of the EMEP domain. The second most important contributors for PCDD/Fs and PCB-153 are the EMEP anthropogenic emissions. For HCB the second most important contributor is the emission outside the EMEP domain boundaries.

MSC-E prepared information on ecosystem-dependent deposition fluxes of heavy metals in 2021. This information could be important for evaluation of critical load exceedances. Besides, exceedances of air quality guidelines for PAHs were assessed. It was shown that about 11% of the population of EMEP countries in 2021 were in areas with exceeded EU target level for annual mean B(a)P air concentrations. The WHO Reference level was exceeded for 63% of population of EMEP countries. In addition to this, atmospheric inputs and source apportionment of heavy metals and POPs for marginal seas (the Baltic, the North, the Mediterranean, the Black and the Caspian Seas) and to the Arctic were assessed. Finally, results of the global-scale simulations aimed at generation of boundary concentrations of the pollutants in the EMEP region were presented.

Research and development

The Eurodelta-Carb intercomparison study of B(a)P models initiated by the TFMM in 2021 in the framework of a broader scientific study on modelling of secondary organic aerosol and black carbon was continued. The main objectives of the Eurodelta-Carb study on B(a)P were to analyze performance of air quality models and uncertainties of their results. Four regional chemistry transport models (CHIMERE, GLEMOS, MINNI and SILAM) were applied to simulate the concentrations of B(a)P in Europe. Participated models have shown high spatial correlation of predicted and observed B(a)P concentrations. Besides, most of the models provided high correlation with observed intra-annual variation of B(a)P concentrations. Furthermore, the model simulations indicated overprediction of observed B(a)P concentrations in Spain and underprediction in Northern Europe (Finland, Latvia, Estonia), which is likely explained by the uncertainties of the reported B(a)P emissions. Further activities within the study can be focused on the sensitivity analyses, an evaluation of the meteorological drivers and an analysis of other model outputs such as B(a)P concentrations in precipitation and deposition fluxes and concentrations of species affecting B(a)P chemical transformations in the atmosphere.

An overview of information on some Contaminants of emerging concern (CECs), such as hexabromocyclododecane (HBCDD), polychlorinated naphthalenes (PCNs) and pentachlorobenzene (PeCB) was prepared. The overview included regulatory activities, their production, usage and emissions, as well as results of monitoring and model assessment of their transport and fate in the environment. It was demonstrated that information on physical-chemical properties of CECs, concentrations in environmental compartments, and levels of emission is not sufficient to perform detailed assessment of their transport and fate in the environment. Additional monitoring data and emission inventories and better understanding of processes governing fate and behavior of CECs are required for modelling of atmospheric pollution levels.

Cooperation

Information on MSC-E research activities in co-operation with TFMM and national experts in the framework of Eurodelta-Carb B(a)P model intercomparison study was presented at the EMEP Task Force on Measurements and Modelling. Updated modelling results on B(a)P of several modelling groups (EMEP/MSC-E, CIEMAT, INERIS, ENEA, FMI) and their evaluation against measurements were presented. Similarities and differences between the annual mean concentrations and intra-annual variations obtained by participated models and observed levels were examined. Further research and cooperation activities within the study are proposed.

MSC-E contributed to the work of the Task Force on Hemispheric Transport of Air Pollution (TF HTAP) aimed at Hg and POP pollution assessment. In particular, the Centre participated in TF HTAP collaborative activities focused on multi-model evaluation and attribution of Hg pollution trends and future scenarios as well as assessment of the impact of wildfires and biomass burning on contamination of the environment by multiple pollutants. Current TF HTAP activities focused on Hg pollution assessment are performed as a part of the Multi-Compartment Hg Modeling and Analysis Project (MCHgMAP). The project is aimed at comprehensive analysis of spatial and temporal trends of Hg pollution levels, source attribution and evaluation of future scenarios to inform effectiveness of the LRTAP Convention and the Minamata Convention on Mercury. MSC-E took part in development of the assessment program and preparation of the position paper at all stages of the project. In particular, it contributed to elaboration of the overall program of the model simulations and analysis, formulation of multi-model experiments and specifications of the output results.

In order to investigate the effect of the wildfires on Hg concentrations, deposition and intercontinental transport, and to improve model estimates of Hg levels, TF HTAP initiated process of development of Hg emissions from wildfires. MSC-E prepared a set of Hg emissions from wildfires for the period from 2010 to 2020. It was shown that the main regions of Hg emission are Southern Africa, South America and South-Eastern Asia, Siberian region of Russia and north-western part of North America. The major contributor to global wildfire emission (around 60% on average) is made by tropical forests followed by. grasslands and savanna (13 – 17%). Seasonal changes of global Hg emissions from wildfires is characterised by spring and autumn peaks. Further activity regarding the effects of wildfires on Hg levels will include comparison of Hg emissions based on different

databases. Besides, model experiments will be undertaken to identify the contribution of wildfires on Hg air concentrations and deposition in different regions of the globe.

MSC-E continued cooperation with international organizations. In particular, MSC-E continued data exchange with the Stockholm Convention on POPs. Evaluation of airborne pollution load of heavy metals and POPs to the Baltic Sea is carried out in the framework of long-term cooperation between EMEP and the Helsinki Commission (HELCOM). The compilation of data on atmospheric emissions and model assessment of atmospheric deposition of cadmium and B(a)P for the period 1990-2020 was prepared and discussed during the third informal consultation session of the HELCOM Pressure Working Group. In accordance with the contract between MSC-E and OSPAR Commission analysis of Pb, Cd and Hg emission sectors in 2020 in the OSPAR Contracting Parties was carried out. Besides, model assessment of atmospheric inputs of Pb, Cd and Hg to the OSPAR regions was performed. Results of the analysis of emission data and model assessment of deposition fluxes to the OSPAR area were presented at the hybrid meeting organized by OSPAR Commission.

Future research

MSC-E is planning to contribute to the research and cooperation activities in the field of assessment of heavy metal and POP pollution levels taking into account priorities of the Long-term Strategy for the Convention for 2020-2030. In particular, detailed analysis of spatial and temporal variations of PAH pollution in the EMEP region and improvement of modelling approach for PAHs will be continued as a part of the TFMM/EuroDelta-Carb multi-model intercomparison study. In order to complete the purposes of TF HTAP Multi-Compartment Hg Modeling and Analysis Project new global Hg multi-model experimental simulations of Hg will be organized. For evaluation of the impact of wildfires on pollution levels and intercontinental transport, TF HTAP is planning to design multi-model multi-pollutant (PM, POPs, metals, ozone) intercomparison study. Preparatory work for the assessment of CECs will be continued collecting information on physical-chemical properties, monitoring of their concentrations in different environmental media, and experimental modelling of their transport and fate. It is planned to continue joint analysis of measurements of heavy metals concentrations in mosses and deposition to various ecosystems in co-operation with ICP Vegetation, ICP Integrated Monitoring, and ICP Forests as well as data exchange with TF Health on PAH pollution levels and exceedances of air quality guidelines. Assessment of atmospheric pollution of the marine environment by heavy metals, POPs and CECs is an important direction of further research and co-operation with HELCOM and OSPAR.