

EXECUTIVE SUMMARY

Assessment of cadmium pollution levels over Poland for 2014 with spatial resolution of $0.1^\circ \times 0.1^\circ$ was carried out in the framework of country-specific case study. Similar studies for heavy metals or persistent organic pollutants have been carried out before for other countries such as the Czech Republic, Croatia, the Netherlands, Belarus, the United Kingdom, Spain and France. The studies allow taking into account specific features of countries' orography, meteorological conditions, and distribution of emission sources across the country as well as data from national monitoring programmes. This work was performed in close cooperation with national experts from Poland. The assessment includes analysis of national emission and monitoring data, model-based source apportionment in particular Polish voivodships and pollution in the selected cities.

Information about emissions and measurement data in Poland was provided by national experts. Annual total cadmium emission in 2014, as reported in 2016, amounted to 13.86 tonnes. Major contribution to national emission is made by sector '*Industry*' (about 70%) followed by '*Other Stationary Combustion*' (16.6%) and '*Public Power*' (5.1%). Regions with most significant emissions (Opolskie and Slaskie voivodships) are located in the southern part of the country.

Heavy metal measurements in Poland are coordinated by State Monitoring Program. For 2014 cadmium concentrations in air are available from 84 stations. Among them there are three background regional, two sub-urban and 79 background urban stations. Annual mean cadmium concentrations in air vary between 0.13 and 2.74 ng/m^3 , while the EU limit value is 5 ng/m^3 . The highest values are observed in most polluted and industrialized regions in the southern and south-western parts of Poland.

Modeling results based on official and national emission data were compared with the observed concentrations at the EMEP stations and Polish and Czech stations from national monitoring networks. It was found that observed air concentrations in warm period were well reproduced by the model, while the concentrations in the cold period were underestimated. Analysis of factors responsible for seasonal changes of pollution levels led to conclusion that the identified underestimation in cold period was linked with possible underestimation of cadmium emission from sector '*Residential Combustion*'.

In order to improve the model performance and to provide the national experts with the results which better agree with measurement values emission scenario has been developed. The suggested emission scenario assumes higher emissions in the southern and south-western part of Poland in cold period. Compared to national total value of the emission provided by national experts, annual scenario emission in Poland is 26% higher. This value is smaller than the uncertainty of annual national emissions estimated by national experts. Scenario emission values were used for calculation of country-specific information on cadmium pollution in Poland.

Concentrations and deposition of cadmium in Poland were calculated with spatial resolution $0.1^\circ \times 0.1^\circ$. Pollution levels in Poland are characterized by distinct south-north spatial gradient. The highest levels of annual mean concentrations (above 1 ng/m^3) in air and total deposition (above 150 $\text{g}/\text{km}^2/\text{y}$) are located in the southern and south-western parts of the country, while in the northern part the levels are much lower (0.15 ng/m^3 and 15 $\text{g}/\text{km}^2/\text{y}$, respectively). The highest cadmium

deposition takes place in Slaskie, followed by Opolskie and Malopolskie voivodships. From 60% to 75% of deposition in voivodships are caused by anthropogenic sources. The input from non-EMEP sources is relatively low (2-6%).

Special attention has been paid to source attribution of cadmium pollution in Poland. It was found that for the country as a whole around 20% of anthropogenic deposition comes from foreign sources while national sources are responsible for other 80%. Main foreign contributors to deposition in Poland are Germany, Russia and Slovakia. Besides, source-receptor relationships have been established for particular Polish regions (voivodships). The highest contribution of foreign sources is noted for Zachodniopomorskie (30%) and Lubuskie (29%) voivodships. In the central part of Poland the contribution of foreign sources ranges from 10% to 30%. In the regions near the state borders the contribution exceeds 50%. In most of voivodships more than 50% of anthropogenic deposition comes from foreign countries and other voivodships.

Emission values from different source categories have been provided by national experts. On the base of these data contributions of emissions to pollution levels have been estimated for the following sectors: *'Public Power'*, *'Industry'*, *'Residential Combustion'*, *'Fugitive'*, *'Road Transport'* and *'Remaining categories'*. For Poland as a whole the main contributor to cadmium deposition is emission source category *'Industry'* (43%) followed by *'Residential Combustion'* (29%). Other emission sectors contribute around 1-2%, and foreign emission sources – 21%. In four voivodships (Opolskie, Slaskie, Malopolskie, Swietokrzyskie) the contribution of *'Industry'* sector to anthropogenic deposition exceeds 50%. The highest contribution of *'Residential Combustion'* is noted for the western part of the country: Wielkopolskie and Lubuskie (40% each) followed by Dolnoslaskie (36%) voivodships. Besides, it has been shown that the contributions of particular large point sources to cadmium pollution in Poland and neighboring countries are relatively low.

Pollution in urban areas is currently one of the priorities of the Convention on Long-Range Transboundary Air Pollution. Source-receptor modelling was applied to evaluate cadmium concentrations in the selected Polish cities, distinguish contributions of city and external sources and analyze their seasonal changes. Annual mean observed concentrations of cadmium in the selected Polish cities were reproduced by the model with sufficient quality. Contribution of urban sources to concentrations in cities varies from 1% in small cities to 70% in large cities. Contribution of external sources is considerable even in large cities. Calculated seasonal variability of cadmium urban increments was successfully reproduced in cities where residential combustion constitutes substantial fraction of local emission.

The study demonstrated that the model can be used as a tool for evaluation of national emissions. Using modelling and observed information it is possible to identify regions where emission may need further improvement. However, this activity requires close cooperation with national experts and relevant EMEP centres and Task Forces.

Available official or national emission data contain uncertainties which affect results of assessment of pollution levels. The usage of emission scenarios or expert (non-official) emission estimates can produce more realistic, from viewpoint of comparison with the observed values, alternative results of pollution levels assessment. These alternative results could be presented along with the results based on official emission data.