Chapter 2. HEAVY METAL POLLUTION OF THE EMEP REGION IN 2016

Assessment of heavy metal pollution of the EMEP region is based on both measurement data and modelling results and includes evaluation of spatial patterns and transboundary transport of the pollution as well as contribution of various emission sectors and ecosystem-specific deposition fluxes.

2.1. Measurements of heavy metals at the EMEP monitoring network

Measurement network

In 2016, there were 36 sites measuring heavy metals (Cd or Pb) in both aerosols and precipitation, and altogether there were 66 measurement sites. Twenty nine sites were measuring Hg in either air and precipitation, 13 of these with co-current measurements in air and precipitation. In total, 21 Parties to the Convention reports heavy metal data to EMEP, 7 of these fulfil their monitoring obligations as defined in the EMEP monitoring strategy [UNECE, 2009] with at least one site of level 2 with both air and precipitation measurements of heavy metals in air and precipitation. A number of countries have been reporting heavy metals within the EMEP area in connection with different national and international programmes such as HELCOM, AMAP and OSPAR. Detailed information about the sites and the measurement methods are found in EMEP/CCC’s data report on heavy metals and POPs [Aas et al., 2018]. This report includes also other elements like Zn, Ni, As, Cu, Co, Cr, Mn, V, Fe, Al and more. All the data are available from the EBAS database [http://ebas.nilu.no/].

In the last year report (EMEP Status report 2/2017), we discussed the new reporting guidelines of Hg for a consistent definition of component names. Besides, additional metadata have been included to give important information on methodology and quality. There are few Parties that have yet taken the new guidelines into account. Thus, there is a need to follow up on this to improve the reporting as well as clean up historical data in the database so they are harmonised with the new guidelines especially on component names.

Observed concentration levels of Pb, Cd in 2016

Annual averages of Pb and Cd concentrations in precipitation and in air in 2016 are presented in Fig. 2.1-2.4. The lowest concentrations for all elements are generally found in Scandinavia, and the highest in Central and Eastern Europe. Some of the high concentrations are due to too high detection limit of the method, i.e. Cd in aerosols in Portugal.

For Pb, the highest concentration in aerosols is observed in Hungary followed by sites in Estonia, and in the Benelux. In precipitation, the highest volume weighted annual mean is observed in Denmark followed by Slovakia, Spain and the Benelux. For Cd, the highest concentration in aerosols in observed in Estonia followed by sites in Hungary and Belgium, if not considering the Portuguese sites with high detection limit. In precipitation, the highest level is seen in Slovakia followed by sites in France, Spain and Sweden.
Observed concentration levels of Hg in 2016

For total gaseous and elemental Hg, the highest concentration is seen in Poland followed by Germany and one site in the UK reflecting the source regions of Hg in Europe. In precipitation, the highest levels are seen in Latvia and Germany followed by sites in Sweden, the Netherlands, and Spain, if excluding the sites with high detection limits in Portugal and Ireland. Lowest concentrations are seen in Finland and Great Britain.
Strong seasonality in the concentrations of Hg in air is observed at several EMEP sites, with higher concentrations in winter whereas low concentrations are observed in summer. This strong seasonality is described for most temperate sites in the Northern Hemisphere [Temme et al., 2007; Sprovieri et al., 2016] and is generally explained by peaking primary anthropogenic Hg emissions in winter due to high energy demand [Temme et al., 2007] and faster atmospheric oxidation rates and subsequent deposition in summer [Holmes et al., 2010]. However, global Hg models have not yet been able to reproduce the wintertime high concentrations as current anthropogenic Hg emission inventories have no seasonal resolution and are kept constant through the year. Secondly, no seasonal oscillation is observed in the Southern Hemisphere [Slemr et al., 2015], questioning the dominant role of the atmospheric oxidation. Therefore a new study by Jisrka et al. [2018] proposed an alternative hypothesis; uptake of atmospheric Hg by vegetation, and that vegetation sequester as much as approximately 50% of primary anthropogenic emissions. They found that Hg correlates with CO₂, a tracer for gas exchange by vegetation, implying that Hg uptake by vegetation is controlled by gas exchange similar to CO₂. Further, they found a strong correlation between the normalized difference vegetation index (NDVI) and Hg that also points to uptake of Hg by vegetation. The correlation was stronger for inland terrestrial sites compared to coastal sites, supporting the theory that vegetation uptake is responsible for Hg depletion in summer when the vegetation activity is the highest. In Figure 2.7, we compare a monthly mean concentrations averaged for the last five years to avoid annual variations, at selected EMEP sites for different environment. There is a clear difference in seasonality for terrestrial and arctic sites.

This new hypothesis have large implications for the global Hg cycle and the forecasting and interpretations of long term trends, also suggesting that the decreasing atmospheric Hg concentration is not due to decreasing emissions but vegetation uptake and increased primary production. The effect of Hg uptake in vegetation related to climate change and land-use change must be considered in mitigation strategies to reduce human Hg exposure. The importance of Hg uptake as a deposition pathway demands revised Hg deposition monitoring strategies by environmental agencies [Jiskra et al., 2018].
2.2. Spatial patterns of heavy metal pollution

Information on pollution levels of Pb, Cd and Hg in 2016 was prepared on the base of model calculations with the GLEMos modelling system. Heavy metal emission data for the model are prepared by CEIP on the latitude-longitude grid (see Section 1.1). Full model-based information about heavy metal pollution levels with spatial resolution 0.1°x0.1° is allocated in the internet [www.msceast.org]. This section provides an overview of the main peculiarities of the heavy metal pollution levels in the EMEP region.

Heavy metal pollution levels in the EMEP countries are caused by three groups of emission sources. These are EMEP anthropogenic emissions of considered year, wind re-suspension of dust particles containing heavy metals, and emissions from sources located outside the EMEP region (non-EMEP sources). Contribution of these three groups of sources is calculated for each EMEP country on regular basis.

Spatial distribution of annual mean concentrations and total deposition of Pb, Cd and Hg over the EMEP region is highly non-uniform. Comparatively high levels of Pb air concentrations (15-30 ng/m³) are noted for the central part of Europe (southern Poland, western Germany) and northern part of Italy (Fig. 2.8a). In the Czech Republic, Hungary, Slovakia, the western part of the United Kingdom, the northern part of France the concentrations vary within 3-15 ng/m³. Relatively high levels (8-15 ng/m³) also take place in the Central Asian countries (south of Kazakhstan, Turkmenistan, Uzbekistan), which is caused by high contribution of wind re-suspension of dust. Regions with elevated air concentrations of Cd are similar to those of Pb, e.g. the southern part of Poland and the western part of Germany, where the concentrations exceed 0.5 ng/m³. Other ‘hot-spots’ with similar concentrations are in the Benelux countries and in a number of regions in Russia. Over most of the central European countries the levels vary from 0.1 to 0.2 ng/m³.

Spatial distribution of annual deposition fluxes in most countries is similar to that of air concentrations. Relatively high fluxes of Pb (above 2.5 kg/km²/y) are noted for some regions of southern part of Poland, northern Italy, the south of Kazakhstan and the west of Tajikistan (Fig. 2.8b). Over most of central, southern and south-eastern parts of Europe the deposition fluxes range from 0.6 to 2.5 kg/km²/y, and from 0.3 to 0.6 kg/km²/y over western and northern parts of Europe. Cadmium deposition is the highest (above 60 g/km²/y) in southern Poland, western Germany, the
western part of Turkey, and several regions in Russia (the Central part, south Urals, south-west of Siberia). Over most part of central, eastern and southern Europe deposition fluxes of Cd vary from 20 to 60 g/km²/y. In the western and the northern parts of Europe the levels are within 5-20 g/km²/y. Relatively low deposition of Pb and Cd are noted for the most part of Central Asia due to low atmospheric precipitation.

Unlike Pb and Cd, Hg is known for long (0.5-1 year) atmospheric lifetime. Therefore, Hg can travel and disperse over global scale distances. It results in relatively smooth spatial distribution of Hg over territory of the EMEP region. Its annual mean concentrations vary from 1.4 ng/m³ in the Arctic and Scandinavia to more than 1.8 ng/m³ in the southern part of Europe. Elevated levels in particular areas are explained by location of strong emission sources. Areas with relatively high concentrations of Hg in the southern parts of the EMEP region are also caused by natural emissions associated with the Hg geochemical belt [Gustin et al, 1999]. Deposition fluxes are mostly caused by short-lived oxidized Hg forms. Relatively high deposition fluxes (30-40 g/km²/y) in northern Italy, Poland, the central part of Russia, Balkan countries and the south-east of Europe are caused by combined effect of emissions and atmospheric precipitation.

Contributions of various groups of sources to deposition vary to high extent among the EMEP countries. For example, deposition from the EMEP anthropogenic sources of Cd contributes from 8% to 74% to total deposition (Fig. 2.9). In absolute terms the highest country-averaged deposition flux is noted for Poland (25 g/km²/y), followed by Slovakia (20 g/km²/y) and Slovenia (17 g/km²/y). The results for Pb are similar to those for Cd. Contribution of anthropogenic sources ranges from 6% to 63%. The highest contribution of Pb deposition is obtained for Poland (0.8 kg/km²/y), Slovakia (0.6 kg/km²/y), the Czech Republic (0.5 kg/km²/y), Bulgaria, Bosnia and Herzegovina (around 0.4 kg/km²/y).

Contribution of secondary sources to Cd and Pb deposition varies from 26% to 80%. Therefore, these sources contribute at least a quarter of total deposition in the EMEP countries. However, it should be kept in mind that the uncertainty of estimated contribution of secondary sources is higher than that of anthropogenic sources. The highest Cd deposition flux from these sources takes place in regions, which are characterized by significant pollution in previous decades and by high extent of urbanization, such as the Netherlands and Belgium. Besides, significant relative contribution of re-suspension is noted for Iceland due to considerable input from sea salt aerosols. The highest Pb
deposition caused by wind re-suspension occurs in the Mediterranean region, namely, in Montenegro and Monaco (0.6 kg/km²/y each), Bosnia and Herzegovina (0.5 kg/km²/y), Italy, Albania and Croatia (0.4 kg/km²/y each).

Contribution non-EMEP sources of Cd varies from 2% to 44%, and that of Pb - from 5% to 56%. The highest contribution, in absolute and relative terms, takes place in countries of southern and southeastern part of the Mediterranean region. For example, deposition from non-EMEP sources of Cd is the highest in Montenegro (9 g/km²/y), Albania (7 g/km²/y), Turkey (6 g/km²/y). Besides, elevated relative contribution is seen for countries in the Caucasus and Central Asia. For example, the non-EMEP contribution of Cd is 42% in Armenia, 33% in Kyrgyzstan and Georgia, around 30% in Uzbekistan and Turkmenistan. These high values in the EECCA countries is explained by emissions from non-EMEP anthropogenic sources and by re-suspension input from desert areas outside the EMEP domain.

Fig. 2.9. Country-averaged deposition fluxes of Cd from the European and Central Asian anthropogenic, secondary and non-EMEP emission sources in 2016

Mercury deposition fluxes differ from those of Pb and Cd. Due to strong influence of intercontinental transport the contribution of non-EMEP sources to total deposition in the EMEP counties is dominating, ranging from 50% to 95%. The contribution exceeds 50% in all EMEP countries and exceeds 75% in half of them. However, it should be noted that the contribution from intercontinental transport includes also some fraction of Hg from the EMEP sources, which is emitted and entered the global Hg pool. Contribution of EMEP anthropogenic sources to country mean Hg deposition fluxes varies from 4 to 19%. The highest deposition from this sources occurs in Poland (8.3 g/km²/y), followed by the Czech Republic (8 g/km²/y) and Slovakia (6.9 g/km²/y). The direct contribution of EMEP secondary (natural and re-emission) sources to deposition is small (below 1%).
2.3. Transboundary transport

Anthropogenic deposition to each country can be presented as a sum of two components: deposition from national emission sources and deposition caused by foreign emissions. Information about transboundary fluxes between the EMEP countries is prepared regularly. Since the EMEP countries report their national anthropogenic emissions, only the anthropogenic part is considered. Detailed information on source-receptor relationships is available in the Internet at [www.msceast.org]. For example, contribution of foreign sources to deposition of Pb in 2016 varies from 14% in Spain to 99% in Monaco and Liechtenstein (Fig. 2.10). High contribution of foreign sources to Cd in Monaco and Liechtenstein as well as in Iceland, Sweden, Kyrgyzstan, Lithuania is explained by small national emissions. Deposition from foreign sources exceeds deposition from national sources in 38 of 51 countries for Pb and Cd and in 40 countries for Hg.

![Image](image_url)

**Fig. 2.10. Relative contribution of the transboundary transport and national sources to anthropogenic Pb deposition in the European and the Central Asian countries and deposition values from anthropogenic emission sources in 2016**

Heavy metals emitted by national sources partly deposit within a country’s territory and partly contribute to transboundary pollution of territories of neighbouring EMEP countries or even transported to other regions. Fractions and magnitudes of national emissions deposited to a country’s own territory, to other EMEP countries and outside the EMEP countries vary considerably. Countries with large emissions make up significant absolute contribution to transboundary transport. For example, from about 700 tonnes of Pb emitted in Kazakhstan, around 233 tonnes is deposited to other EMEP countries and 204 tonnes – to areas outside the EMEP countries (Fig. 2.11). Other major counties importers of Pb are Poland, Turkey and Italy. As a rule, 60-100% of Pb and Cd emissions and 80-100% of Hg emissions are deposited outside the country’s territory.
Fig. 2.11. Distribution of Pb emitted in the EMEP countries between deposition to own territory, deposition to the other EMEP countries and deposition outside the EMEP countries in 2016. Red dots indicate relative fraction of national emissions involved into the transboundary pollution

2.4. Pollution from different emission sectors

Information on regularly reported source-receptor relationships in the EMEP countries can be extended by analysis of transboundary transport from different emission sectors. Contributions of Cd emissions from four groups of emission source categories to deposition in the EMEP countries were simulated. These groups include Public Power (sector A), Industry (sector B), Residential Combustion (sector C) and Remaining Sectors (sum of emissions from all other source categories). Emissions in countries from particular sectors were provided by CEIP.

Country-averaged deposition fluxes from sector ‘Public Power’ range from 0.2 g/km²/y (Malta) to 4.3 g/km²/y (Belarus) (Fig. 2.12). In most of the EMEP countries (43 of 51) the contribution of foreign sources exceeds the contribution of national sources. Contribution of national sources to deposition
from this sector ranges from 0 to 96%. The highest contributions of national sources are noted for Russia (96%), Spain (92%) and Switzerland (75%). Contribution of foreign emission sources to deposition from ‘Public Power’ sector varies from 4 to 100%. In Georgia, Lichtenstein, Iceland and Albania all deposition from this sector is caused by transboundary transport. In 20 countries (e.g., Belarus, Croatia, Finland, Kyrgyzstan etc.) the contribution of foreign sources to deposition from sector ‘Public Power’ exceeds 90%.

The main Cd emission sector in the EMEP region is Industry, which contributes 36% to total Cd emission. Therefore, deposition fluxes caused by this sector are generally higher than those caused by other sectors. The highest country-averaged deposition occurs in Poland (around 16 g/km²/y), followed by Portugal and Slovakia (around 11 g/km²/y each) (Fig. 2.13). The lowest deposition takes place in Turkmenistan (0.3 g/km²/y) and Iceland (0.4 g/km²/y). Contribution of national sources to Cd deposition from sector ‘Industry’ ranges from 0 to 91%, and of foreign sources – from 9 to 100%. In 39 countries contribution of foreign sources exceeds the contribution of national sources. In 20 countries this contribution exceeds 50%, and in Iceland and Malta all 100% deposition from Industry sector are caused by transboundary transport. In some countries (e.g., Poland, Portugal, Spain, Turkey) national sources dominate over transboundary input.

**Fig. 2.12.** Country-averaged deposition fluxes of Cd from sector ‘Public Power’ in 2016
The highest deposition caused by emission sector ‘Residential Combustion’ is noted for Slovenia (7.2 g/km²/y), the lowest – in Turkmenistan (0.1 g/km²/y) (Fig. 2.14). Contribution of national and foreign sources to deposition from sources of this sector varies markedly among the EMEP countries. Sources of ‘Residential Combustion’ sector contribute from 0 to 97% of deposition from national sources and from 3 to 100% from foreign sources. In Turkey, Italy, Portugal and the United Kingdom the contribution of national sources exceeds 80%, whereas in some countries (e.g., Malta, Iceland, Uzbekistan) all deposition from ‘Residential Combustion’ comes from foreign sources. In 34 countries deposition from foreign sources exceeds deposition from national sources.
Emission from remaining sectors makes about 20% from total Cd emission in the EMEP countries. The highest deposition from this sector occurs in Germany (3.8 g/km²/y), and the lowest – in Iceland (0.2 g/km²/y) (Fig. 2.15). In 41 countries the contribution of foreign sources exceeds 50%.

Fig. 2.15. Country-averaged deposition fluxes of Cd from remaining sectors in 2016

Composition of deposition in each country from viewpoint of emission sources and sectors differs largely. For example, main foreign contributors to anthropogenic deposition of Cd to the Czech Republic in 2016 are Poland (34%), Germany (19%) and Austria (7%) (Fig. 2.16a). Most of deposition (around 56%) from neighbouring countries is caused by sources of sector ‘Industry’. In particular, industrial sources of Poland contribute 28% (272 kg), of Germany – 10% (91 kg) of foreign deposition (Fig. 2.16b). The second in importance is ‘Residential Combustion’ sector (19%) followed by ‘Public Power’ sector (13%).

Fig. 2.16. Main countries-sources of anthropogenic deposition to the Czech Republic (a) and their sectoral composition (b)
Another situation takes place in Kazakhstan, which is located in the south-eastern part of the EMEP region. National sources contribute 38% to anthropogenic deposition, and the main foreign sources are Russia (48%), Uzbekistan (5%) and Turkey (3%) (Fig. 2.17a). Unlike the Czech Republic, the main foreign emission sector contributing to deposition is ‘Public Power’, followed by group ‘Remaining sectors’ in emissions of Russia (Fig. 2.17b).

Source-receptor matrices calculated regularly for each EMEP country were supplemented by information on contributions to deposition from main emission sectors of Cd, such as ‘Public Power’, ‘Industry’ and ‘Residential Combustion’. Contributions of national sources to deposition form particular emission sectors vary from zero, if this sector does not present in national emission data, to 98%. The contribution of foreign sources ranges from 3 to 100%. Fractions of deposition from emission sectors of neighbouring countries vary markedly among receptor countries. Further simulations can be carried out for other priority metals (Pb, Hg).

### 2.5. Ecosystem-dependent deposition

Lead, Cd and Hg are known for their harmful effects for human health and the environment. Lead and Cd affect biodiversity of soil species and microbe-mediated processes [de Vries et al., 2015a]. They also reduce growth of plants. Besides, these metals tend to accumulate into plant tissues and transfer to human organisms through food chains. Mercury in water bodies can transform to the highly toxic methylated form, which accumulates in fish and affect human health through fish consumption.

For evaluation of the effects of atmospheric heavy metal deposition on human health and environment a concept of critical loads is considered under the Convention. This concept assumes that known negative effects may occur at or above certain concentration of heavy metals in soil or water. This threshold concentration is called critical level. It is assumed that this concentration is a result of a steady-state balance between input flux to soil (e.g., atmospheric deposition, weathering of rocks) and output flux from soils (e.g., leaching, biomass uptake) [de Vries et al., 2015b].
Atmospheric deposition flux which leads to establishment of critical level concentration is called critical load. Exceedance of atmospheric deposition over critical load results to concentration in soil higher than critical level, which can give rise of negative effects for biota or human health.

In order to provide the Working Group on Effects with information relevant for evaluation of critical load exceedances atmospheric ecosystem-dependent deposition are calculated regularly by MSC-E. Seventeen classes of underlying surface are considered based on the MODIS land-cover data. Information on deposition of Pb, Cd and Hg to each ecosystem type in each EMEP country is available at the MSC-E website [www.msceast.org].

Deposition fluxes to particular land cover categories differ significantly. For example, annual Hg deposition flux to inland waters varies from 5 to 15 g/km²/y over most part of the EMEP region (Fig. 2.18a). In some regions of northern Italy, the Balkans and Caucasus the flux reach 30 g/km²/y. In Scandinavia the fluxes are the lowest falling below 5 g/km²/y. However, deposition fluxes to forests are much higher than that to inland waters exceeding 15 g/km²/y over most part of western and central Europe and more than 7 g/km²/y in Scandinavia and central and northern Russia (Fig. 2.18b).

Maps of critical load exceedances are resulted from comparison of ecosystem-dependent deposition maps with critical loads. According to calculations of the exceedances, negative effects of Hg and Pb deposition on human health and biota are most expected over major part of Europe [de Wit et al, 2015]. However, these results relate to 2010. In order to evaluate present-day effects of heavy metal depositions more contemporary calculations of the exceedances are needed.

2.6. Arctic pollution

Agreement between the Convention and AMAP has been reached at the joint meeting held in Potsdam, Germany in February 2016. On the base of this agreement MSC-E continued cooperation with AMAP in the field of analysis and assessment of heavy metal pollution in the Arctic region. MSC-E has calculated atmospheric deposition to the Arctic area within the new EMEP domain, estimated contributions to deposition caused by the EMEP anthropogenic, secondary and non-EMEP sources, identified main source countries and emission sectors contributed to anthropogenic deposition in the Arctic.
Fluxes of total deposition of Pb in the considered part of Arctic range mostly from 50 to 300 g/km²/y, and Cd – from 3 to 15 g/km²/y (Fig. 2.19a,b). The lowest levels of Pb and Cd are noted for Greenland where they fall below 20 and 2 g/km²/y, respectively. Besides, low Cd levels are noted in the northern Scandinavia, Franz-Josef Land and in some regions of the Arctic coast of Russian. Relatively high deposition fluxes take place over the North Atlantic, which is explained by high annual sums of atmospheric precipitation due to cyclonic activity. Besides, relatively high fluxes are noted for windward coasts (e.g., Iceland, Norway), where generation of precipitation is amplified by orographic effects. Finally, in case of Cd ‘hot-spots’ of elevated deposition fluxes (15-25 g/km²/y or even more) are associated with sources of significant anthropogenic emissions located on Kola Peninsula, Archangelsk region, the Republic of Komi and Norilsk.

Relatively high deposition fluxes along windward coasts of Scandinavian Peninsula and Iceland are also noted for Hg. However, spatial pattern of Hg deposition to the Arctic differs from that of Pb and Cd. Relatively high deposition fluxes (12-20 g/km²/y) occur over vast areas of the Arctic Ocean (Fig. 2.19c). These fluxes are caused by the Atmospheric Mercury Depletion Events (AMDE). However, it should be also taken into account that significant part of the deposited Hg is reduced and reemitted back to the atmosphere.

The Arctic region is remote from major anthropogenic sources of Pb in the EMEP countries. The contribution of these sources to total deposition is 23%, whereas secondary emissions contribute more than half of Pb deposition to terrestrial areas of the Arctic (Fig. 2.20a). About a quarter of deposition came from emission sources located outside the EMEP domain. Structure of Cd deposition

Fig. 2.19. Total deposition fluxes of Pb (a), Cd (b) and Hg (c) to the Arctic (within EMEP domain) in 2016.
Grey line denotes border of AMAP Arctic area
is different (Fig. 2.20b). A number of anthropogenic emission sources are located within the Arctic area (e.g., in the Russian Arctic). It makes contribution of these sources to be higher than that of Pb (51%). Contribution of secondary sources for Cd is 36%. Considerable contribution of Pb and Cd secondary sources is explained by influence of wind suspension of marine aerosols from sea surface. It provides more than a half of deposition from secondary sources. Most of Hg deposition (93%) is caused by intercontinental transport (Fig. 2.20c). However, it should be noted that this value includes Hg which was emitted by EMEP sources and then transported outside the EMEP domain entering global Hg pool.

The main source countries contributing to heavy metal deposition in the Arctic are Russia, Kazakhstan and Poland. Significant part of the Russian territory within the EMEP region relate to the Arctic region. Therefore, contribution of Russian sources to anthropogenic deposition varies from 31% (Pb) to 80% (Cd) (Fig. 2.21). The second largest source country is Kazakhstan. Although this country is located far from the Arctic region, its national emissions of Pb and Hg used for modelling are the highest among the EMEP countries, and Cd emissions are also among the highest. It should be pointed out that the source apportionment presented in Fig. 2.21 reflect average situation for the whole region, the picture can differ significantly among particular locations.

Main sector responsible for Cd pollution in the Arctic, contributing around 60% (1900 kg) to Cd deposition, is ‘Public power’ from Russian emissions (Fig. 2.22a). Contribution of this sector from
other EMEP countries is low (4%, 100 kg). The second largest contributor is the ‘Industry’ sector, which makes up 11% (around 360 kg) of total deposition. Contribution from ‘Residential Combustion’ is 4% (about 130 kg).

Deposition caused emission sector ‘Public Power’ are distributed unevenly over the Arctic region. The highest deposition fluxes are noted for European part of Russia (Kola Peninsula, Archangelsk region, the Republic of Komi), where the fluxes exceed 25 g/km²/y (Fig. 2.22b). In the Asian part of the Russian Arctic, northern Scandinavia and Svalbard the deposition from this sector range from 2 to 5 g/km²/y, or even below 2 g/km²/y in some regions. Along the western and southern coasts of Europe and over most of the Northern Atlantic the deposition fluxes range from 3 to 10 g/km²/y.

![Graph of deposition from sectors](image)

**Fig. 2.22. Cadmium deposition from sector ‘Public Power’ to terrestrial areas of Arctic within EMEP region from main countries-contributors in 2016**

The analysis of modelled heavy metal levels in the Arctic demonstrates that the pollution by Pb and Cd is strongly affected by secondary emission sources. Therefore, further investigation of the related processes and updating of their parameterizations are needed to improve results of the model assessment in the Arctic and to better understand the role of anthropogenic and secondary sources. Pollution of the Arctic by Hg is highly defined by *in situ* oxidation of Hg in the polar atmosphere. Further improvement of the Hg chemical scheme in the model could also improve quality of the pollution assessment for the Arctic.

![Map of deposition fluxes](image)