2017

AIR POLLUTION
IN THE SLOVAK REPUBLIC

Air quality monitoring department
SLOVAK HYDROMETEOROLOGICAL INSTITUTE

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Analyses of air and atmospheric precipitation samples were carried out in Testing laboratory of SHMÚ.

CONTENT

FOREWORD

Air quality issue is a part of sophisticated system of relations in the Earth environment. Substances releasing from the sources of pollution undergo to atmospheric transport, scattering and chemical changes. Part of these substances deposits on the Earth ground and penetrates into the underground waters, soil and sediments, from where they can be released back into the ambient air. In any part of cycle they can enter into the chemical reactions. Ambient air reacts quickest on the different changes. In case, the source of pollution fades, the ambient air becomes usually quickly clean. In the contrary, the polluted substances persist longest in soil and sediments.

Obviously, the problems of environment are not possible to constrain by political boundaries. Since decades, the transboundary character of air pollution was acknowledged by the international communities, resulting in signing of several international conventions. In 1979 was signed one of the basic documents in this field, Convention on Long-range Transboundary Air Pollution – CLRTAP.

Among the alarming problems of environment, which accompanied development of industry and growth of living level, belonged smog episodes in industrial regions and acid rain, originated mainly as a consequence of releasing oxides of sulphur and nitrogen from large energetic and industrial sources, at burning of fossil fuel with high content of sulphur. Appearance of photochemical smog was also disquieting. On this situation reacted European and consequently Slovakian legislation. At the end of last century, the rigid legislative measures entered into force, aiming at large and medium sources of air pollution. The most significant consequence was outstanding decrease of sulphur dioxide emissions, resulting in decrease of sulphur dioxide concentrations and mitigation of acid rain. At the territory of Slovakia, the concentrations of sulphur dioxide do not exceed the limit values, set by legislation. Measures, concerning road transport, resulted in cutting down the share of lead additives in petrol, up to the elimination of lead petrol production at all. Lead emissions from road transport decreased and lead concentrations in ambient air of Slovakia do not exceed limit value for the time being. Measures in road transport, including the strict emission limits, also contributed to the decreasing of oxides of nitrogen concentrations.

Application of strict emission limits guided to: implementation of separators for solid pollutants at large and medium air pollution sources; change of fuel base; gradual implementation of best available techniques. Emissions of solid pollutants decreased significantly as compared to the last decades of the 20th century and their concentrations decreased in breathing zone, as well.

Upon the evolution of knowing the mechanisms, how the solid pollutants affect the human health, the attention was shifted on their smaller size fractions. Present legislation contains the limit values for solid pollutants, with aerodynamic diameter less than 10 and 2.5 micrometres (PM_{10}, $PM_{2.5}$). These limit values are exceeded in Slovakia for the time being, similarly like in other European countries. However, the responsibility for high concentrations of solid pollutants in majority of regions was shifted from large industrial sources to the emissions, released from burning of solid fuels in the households and emissions related to road transport. With these sources are connected also high concentrations of further dangerous substance, benzo(a)pyrene, releasing into the atmosphere as a product of imperfect burning. Target value of benzo(a)pyrene is exceeded in more locations. Apart from the largest sources of benzo(a)pyrene – heating of households by solid fuels and traffic – in some locations contribute to its concentrations also industrial sources, such as coke production and thermal plants.

For air pollution sources are generally applied, the higher over the earth surface are they located, the better their emissions are scattered. For example, high industrial chimneys in its vicinity usually contribute very little to the high concentrations of solid matter in breathing zone. However, these matters are transported on long-range distances and contribute to regional and transboundary transport of pollution. In such a way, they become a part of the so-called regional background, which shares significant part in total measured concentrations of solid matter. On the contrary, the effect of low chimneys becomes evident in their vicinity. By effective emission mitigation of low situated pollution sources, such are local heating and traffic, the significant decrease of PM and benzo(a)pyrene is possible to reach, predominantly in outstanding polluted regions, where these sources dominate. However, for full-area of ambient air quality improvement is necessary to think also on emissions from other sources.

Open problem remains also the question of tropospheric ozone, which is not emitted directly into the atmosphere, but originates by photochemical reactions of other substances, natural and anthropogenic, the so-called ozone precursors. Situation is complicated by the fact, the precursors as well as tropospheric ozone undergo to the long-range transport in regional scale. Even though the emissions of anthropogenic ozone precursors decreased, the result is only decrease of concentrations during smog episodes. Within the last years, similarly like in other European countries of our geographical latitudes, the annual average concentrations are not changing significantly and reflect more extent of photochemical activity throughout the summer time.

Ministry of environment of the Slovak Republic upon the Act No. 137/2010 Coll. of Acts on air in wording of later prescriptions, with aim to secure information on air quality to the public, authorized the Slovak Hydrometeorological Institute by elaboration of:

- Report on air quality assessment in the Slovak Republic;
- Information on air quality and share of individual air pollution sources on air pollution at the territory of the Slovak Republic.

Slovak Hydrometeorological Institute as authorized organization fulfils by this Report commitments resulting from § 13 section 1 letters c) and d) cited Act and submits to the laic and expert public the Report, containing all belongings in such a way as requested in the Act No. 137/2010 Coll. of Acts on air in wording of later prescriptions.

INTRODUCTION

Ambient air quality in general is defined by the presence of pollutants in the atmosphere. Base point of origin for their assessment in Slovakia is measurement of pollutant concentrations, which is performed by the Slovak Hydrometeorological Institute (SHMÚ), at the stations of National monitoring network of air quality (NMSKO). Its part are also four stations of Cooperative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe (EMEP). For full-area air quality assessment in Slovakia are used also methods of mathematical modelling apart from measurements. Criteria for air quality assessment are set in Regulation of Ministry of Environment of the Slovak Republic on ambient air quality No. 244/2016 Coll. of Acts in wording the Regulation No. 296/2017 Coll. of Acts.

In following text will often appear two basic expressions – emissions and air quality

Under the expression emission is perceived each direct or indirect releasing of pollutant into the ambient air. It is introduced in volume units within the certain period, e.g. in tons per year. Chapter 6 is dedicated to the emissions of pollutants into the ambient air.

Air quality is characterized by the concentrations of pollutants (in older literature is sometimes used the expression imissions), expressed e.g. by weight mass of pollutant per one cubic meter of air. Their value is determined by measurements in breathing zone (monitoring stations of air quality), or it is calculated by the support of mathematical modelling. Chapter **0** is dedicated to the assessment of air quality upon the base of measurements.

Mathematical model connects causes with consequences upon the base of mathematical relationships describing physical and chemical processes in the atmosphere. Geographical distribution of emissions and meteorological data are input data for model. Spatial distribution of pollutant concentrations is output of model. Methods used at mathematical modelling of air quality and their results are described in Chapter **4**.

1 DESCRIPTION OF THE TERRITORY OF SLOVAKIA IN TERM OF AIR QUALITY

Pollutants of various physical and chemical properties are released into the atmosphere from natural sources or as a consequence of human activity. Air quality does not depend only on amount of emissions and spatial distribution of air pollution sources, but also on meteorological characteristics and properties of surrounding terrain.

Among the processes which influence air pollutants are included change of consistency (e.g. condensation of hot combustion products leaking from chimneys at cooling), chemical reactions (e.g. oxidation of NO to NO_2 from road transport), transport in horizontal and vertical direction (advection, convection), dry, wet and hidden deposition. Dry deposition performs interception of pollutant on the earth surface, or vegetation. Wet deposition means washing out by atmospheric precipitation, which by this way effectively diminishes air pollutant concentrations and enables their transport into the other components of environment – water, soil and sediments. Hidden deposition means interception of fog drops (eventually clouds) on various surfaces, mainly on plant surfaces. This kind of deposition plays more significant role in forest vegetation of mountainous locations.

Segmentation of terrain influences the air circulation velocity and direction and is one of the characteristics determining the conditions for dispersion of pollutants, which are unfavourable at the territory of Slovakia, mainly in closed mountain basins. Frequent appearance of inversions in these regions is the factor complicating pollutant dispersion and is one of the reasons of high pollutant concentration occurrence in winter season. Potential long-range transport of pollutants depends upon the weather conditions. Some of these pollutants can persist in air also several days. In following text is introduced the short characteristics of the territory of the Slovak Republic from the aspects of terrain segmentation and meteorological elements, which mostly influence the air quality.

Wind conditions

Direction of air circulation is mostly influenced by general air circulation in central Europe and country relief. In Slovakia prevails west and northwest air circulation (being modified in some locations, mainly in passes, valleys and basins as a consequence of relief). In Záhorie, southeast wind prevails over the northwest, in Danube lowlands, opposite. West convection dominates in middle Považie, Ponitrie and east Slovakia.

In the lowlands of west Slovakia, the annual average wind speed in height of 10 meters above the surface varies between 3 – 4 $m.s^{-1}$, on the east of Slovakia 2 – 3 $m.s^{-1}$.

In basins, the dustiness depends upon their location and openness towards the prevailing convection. Annual average wind velocity is in more open basins (e.g. Považie valley, Podtatranská basin, Košice basin) 2 – 3 $m.s^{-1}$, in more closed basins, where is the major occurrence of inversions (e.g. Zvolen basin, Žiar basin, Žilina basin) 1 – 2 $m.s^{-1}$ and in closed basins (e.g. Brezno basin, Rožňava basin, west part of Liptov basin in Ružomberok region) is more often occurrence of calm and average wind speeds are even often lower.

In mountains, the annual average wind velocity reaches 4 – 8 $m.s^{-1}$. In lower positions exist also localities (Košice, Bratislava) with annual average wind velocity higher than 4 $m.s^{-1}$. Bratislava belongs to the windiest cities in central Europe.

Well ventilated regions can be distinguished by lower pollutant concentrations, despite of close presence of air pollution sources.

Atmospheric precipitation

The amount of precipitation in Slovakia generally increases with elevation above sea level, approximately 50 – 60 mm on 100 m of height. Their annual sum varied from 500 mm (east part of Žitný ostrov, region Galanta and Senec) to 2 000 mm (the High Tatras).

Relatively low precipitation totals are in the so-called rain shadow of mountains. It does concern e.g. Spiš basins, which are relatively dry and protected from southwest up to northwest by the Low Tatras and from south by Slovak Rudohorie.

The major amount of precipitation occurs in June, July and August (40% – most rainy is June or July), in spring 25%, in autumn 20% and in winter 15% (the least amount of precipitation is in January, February and March).

Large precipitation variability within the year causes mainly in lowlands often and sometimes long-lasting periods of drought, forming conditions for erosion of soil, not covered by vegetation. The Danube lowland belongs to the driest ones and is the warmest and relatively windiest area of Slovakia.

1.1 ALLOCATION OF THE TERRITORY INTO AGGLOMERATIONS AND ZONES

Pollution sources are evenly distributed in the country. Due to the effective air quality assessment in coincidence with European parliament direction and Council 2008/50/EC about ambient air quality and cleaner air in Europe, as well as legal prescriptions of the Slovak Republic (e.g. Regulation of MoE SR No. 244/2016 Coll. of Acts on air quality, in wording of Regulation No. 296/2017 Coll. of Acts), the territory of the Slovak Republic is allocated into zones and agglomerations.

The list of agglomerations and zones is published in Appendix No. 11 to Regulation of MoE SR No. 244/2016 Coll. of Acts on air quality, in wording of Regulation No. 296/2017 Coll. of Acts) and is published on the SHMÚ webpage.

1.1.1 Allocation of the territory into zones and agglomerations for SO_2, NO_2, NO_X, PM_{10}, $PM_{2.5}$, benzene and CO

Agglomerations: Bratislava (territory of the capital of the Slovak Republic, Bratislava),
Košice (territory of Košice)

Zones: Banská Bystrica region (territory of region), Bratislava region (territory of region apart from territory of capital of the Slovak Republic, Bratislava), Košice region (territory of region apart from territory of city Košice), Nitra region (territory of region), Prešov region (territory of region), Trenčín region (territory of region), Trnava region (territory of region) and Žilina region (territory of region).

Chapter 1.1.1 involves the short characteristics of zones and agglomerations, in light of orography and air pollution sources

BRATISLAVA AGGLOMERATION

Bratislava is located in segmented terrain, of altitude from 126 m (Čuňovo) to 514 m (Devínska Kobyla). From southwest to northeast is extended the mountain of the Small Carpathians, west part of Bratislava is situated in Záhorie lowland and east and southeast part is occupied by the Danube lowland.

In domain of Devin gate, which separates the Hainburg hills and the Devin Carpathians and in domain of Lamač gate, between the Devin Carpathians and Pezinok Carpathians, commute to the orographic wind speed increasing, favourably affecting the city ventilation. The Danube river flows through Bratislava and is used for ship transport.

Air pollution sources in Bratislava agglomeration

Dominant source of air pollution in capital city is road transport. The most vehicles per day (more than 60 000 vehicles) in Bratislava overpass through by-pass city highway D1 (from port bridge in direction to Žilina), through by-pass city highway D2 behind the Lafranconi bridge in direction to Austria and Hungary, by road of the second class No. 572, in direction to Most at Bratislava and by road of the third class No. 1082, from Vajnory to Chorvátsky Grob.

For household heating in Bratislava is used (upon the data of inhabitant counting) predominantly natural gas, share of solid fuels is the lowest, as compared to the other zones (probably it deals about additional heating in intermediate annual seasons, using hearths).

Industrial air pollution sources are less significant from point of contribution to the local air pollution by basic pollutants.

KOŠICE AGLOMERATION

Košice city is situated in the Valley of Hornád River, in Košice basin. According to the orographic classification, it belongs to the belt of inner Carpathians. Slovenský kras interferes into this region from the southwest, Slovenské Rudohorie is situated in the north from city and Slánske vrchy in the east of city. Wind conditions are characteristic by the prevailing wind from the north directions, the region is relatively well ventilated.

Air pollution sources in Košice agglomeration

Air quality in Košice is influenced by the sources of pollution from close industrial complex (production of coke, iron, steel, cement), which is situated in distance about 10 km in southwest direction, out of cadastral territory of the city. Relatively favourable circumstance is prevailing convection from north directions.

Apart from the above mentioned, the source of air pollution in Košice is road transport with the major intensity (more than 60 000 vehicles per day) on the east of city on sally-road to Michalovce and on south sally-road directed to Hungarian border. On by-pass of city centre from north, east and south part of Kosice, the density of daily traffic is 25 000 – 40 000 vehicles.

Household heating is partly provided by the city heating plants; in case of individual heating, the predominant fuel is natural gas.

ZONE BRATISLAVA REGION (apart from Bratislava city)

Bratislava region is at the territory of Slovakia the smallest one among regions. It includes the south part of the Small Carpathians, Záhorie lowland and bigger part of Danube lowland. Surface is predominantly plain. The height above sea level of the territory varies in range from 126 m to 754 m (hill Vysoká). The most densely populated cities are regional cities Pezinok, Senec and Malacky. Average density of settlement in district Malacky is significantly lower, as compared to the other districts of Bratislava region.

Air pollution sources in zone Bratislava region

For household heating in this zone is used (upon the data of inhabitant counting) predominantly natural gas, share of solid fuels is the lowest, as compared to the other zones.

More significant source of emissions into ambient air is road transport, concentrating in major scale on highway drafts, reaching the intensity more than 80 000 vehicles daily (highway D1). Relatively least loaded is the highway D4, between Malacky and Bratislava.

Industrial sources of air pollution, apart from cement factories (their contribution can be manifested mainly in coarse size fraction of particulate matter), are less significant from point of contribution to the local air pollution by basic air pollutants.

ZONE TRNAVA REGION

Trnava region is predominantly of lowlands and uplands character. Two significant lowlands, the Danube lowlands and the Záhorie lowlands separate the Small Carpathians, which have outstanding influence on air convection. In northwest part, the territory of region is interfered by Považský Inovec. The highest point of region are Záruby, reaching 768 m a.s.l., however its predominant part lies in heights below 200 m a.s.l. Larger closed basins do not exist in Trnava region.

Air pollution sources in zone Trnava region

For household heating in this zone is used (upon the data of inhabitant counting) predominantly natural gas, share of solid fuels is the lowest one, as compared to the other zones. Consumption of fuel wood in more mountainous area of the Small Carpathians is slightly higher.

Road transport in Trnava region is the largest one (40 000 – 60 000 vehicles daily in 2015) on communications from Bratislava to Dunajská Streda and Veľký Meder, from Dunajská Streda to Galanta and from Trnava to Senica. Highway D1 is mostly overloaded on section Bratislava-Trnava (40 000 – 60 000 vehicles daily), while section Trnava-Piešťany and speed way Trnava-Nitra is daily used by 25 000 – 45 000 vehicles (2015). Dense tangle of road transport is directed into these cities – Trnava, Galanta, Sereď, Sládkovičovo, Dunajská Streda, Holíč and Skalica.

Industrial sources of air pollution are from point of contribution to local air pollution less significant, as compared to basic air pollutants.

ZONE NITRA REGION

Nitra region is extended from larger part on the Danube lowlands, partly interfered by mountains Považský Inovec, Tríbeč, Pohronský Inovec and Štiavnické vrchy. The highest point is Panská Javorina (943 m a.s.l.). The lowest altitude in Nitra region reaches about 100 m a.s.l. Area of region is from larger part ventilated well.

Air pollution sources in zone Nitra region

Dominant air pollution source in Nitra region is road transport. For household heating is used mainly natural gas. Share of solid fuels is smaller as compared to the other zones, apart from more mountainous area in the north of region (upon the data of inhabitant counting).

Characteristics of road transport: the most frequent roads of the first class in Nitra region – on average over 60 000 vehicles daily (2015) connect cities Topoľčany and Partizánske, Komárno and Hurbanovo. Such intensity is also on the initial section of roads Nitra-Vráble and Levice-Vráble. The high intensity (40 000 – 60 000 vehicles daily) reach roads Komárno-Veľký Meder, Nitra-Topoľčany, Levice-Tlmače, as well as the sections of roads Šurany-Nitra and Šaľa-Nové Zámky. While the highway D1 on section Nitra-Zlaté Moravce is of relatively lesser density of traffic (15 000 – 20 000 vehicles daily), behind Zlaté Moravce in direction on east overpass per one hour on average over 60 000 vehicles (2015).

Industrial air pollution sources are less significant from aspect of contribution to the local air pollution by basic pollutants. Depending on meteorological conditions, the influence of chemical industry can manifest in Nitra region.

ZONE TRENČÍN REGION

Relief of Trenčín region is mostly mountainous apart from the basin Horná Nitra. It includes Myjava uplands and White Carpathians, partly Považský Inovec, Javorníky, Vtáčnik and Strážovské vrchy. The highest point is Vtáčnik, of altitude 1 346 m a.s.l., the lowest point is 165 m a.s.l. Zone is from prevailing part well ventilated, minor wind speeds occur in valley of the Váh river.

Air pollution sources in zone Trenčín region

Household heating in more mountainous part of region is more significant source of pollution than in Trnava region, or Bratislava region. In bigger cities mainly natural gas is used, in mountainous north part of region fuel wood.

Characteristics of road transport: in this region from aspect of road transport density (over 60 000 vehicles daily on average in 2015) dominate the roads of the first class - from Trenčín to Bánovce nad Bebravou and to Dubnica nad Váhom, and from Prievidza to Nitrianske Pravno and to Handlová. Highway D1 in section Nové Mesto-Trenčín-Považská Bystrica represents frequention equal or less than 40 000 – 60 000 vehicles daily.

Industrial air pollution sources, apart from the cement factories, are less significant from aspect of contribution to local pollution by basic pollutants. Influence of heat power plant is demonstrating more significantly, however, depending on meteorological conditions it contributes more to regional background.

ZONE ŽILINA REGION

The territory of Žilina region is mostly mountainous, belonging to West Carpathians. The river Váh separates the area of region on north and south part. In north part are located mountains the High Tatras, West Tatras and Belianske Tatras, Skorušinské vrchy (hills), Oravské Beskydy, Oravská Magura, Oravská vrchovina (uplands), Chočské vrchy (hills), Krivánska Fatra, Kysucké Beskydy, Kysucká vrchovina (uplands) and Javorník, in south part the Low Tatras, Veľká Fatra, Lúčanská Fatra and Strážovské vrchy (hills). The highest point is Kriváň, in altitude 2 494 m a.s.l., the lowest point is 285 m a.s.l. The area is also characterised by the deep and closed basins, which unfavourably influence on ventilation and therefore on the pollutant dispersion in ambient air, as well.

Air pollution sources in zone Žilina region

In mountainous part of region, the significant source of air pollution is household heating by solid fuel. On the first place it is influenced by traffic, more than 60 000 vehicles daily (according the counting in 2015) on these road communications – Ružomberok-Martin, Žilina-Čadca, Dolný Kubín-Námestovo, Čadca-Turzovka and north by-pass highway of Martin. Very frequented (40 000 – 60 000 vehicles in 2015) are also road lines Žilina-Rajec and Ružomberok-Liptovská Osada and route from Martin in direction to Turčianske Teplice.

Industrial air pollution sources, such as paper mills, cement factories, lime or ferroalloy production, are less significant in this region from aspect of contribution to local air pollution by basic pollutants.

ZONE BANSKÁ BYSTRICA REGION

The territory of Banská Bystrica region is prevailingly mountainous, while mountain basins on this area are characterized in dependence on orography, by low wind velocity and frequent temperature inversions, mainly in winter season. At the north of this region are situated higher mountains the Low Tatras and spurs of Veľká Fatra. Relatively large part is occupied by the medium high mountains – Slovenské Rudohorie, Štiavnické vrchy and Krupinská planina (plain), in central part of region. South of the region is characterized by lower altitudes – there is found Juhoslovenská kotlina (basin) and Cerová vrchovina (uplands). The highest point of the region is Ďumbier, in elevation of 2 046 m a.s.l., the lowest point lies in 124 m a.s.l.

Air pollution sources in zone Banská Bystrica region

Dominant source of air pollution in Banská Bystrica region is household heating, mainly in north part of region, where the share of fuel wood is the highest, in comparison to the other regions. Locally also road transport is important. The most frequented road lines connect the region city with Brezno and Donovaly and city Zvolen with Detva.

Industrial sources of air pollution, such as metallurgy of non-ferrous metals, are less significant from aspect of contribution to local air pollution by basic pollutants. In dependence on meteorological conditions, the influence of heating plants can manifest in this region.

ZONE PREŠOV REGION

Prešov region is characterized prevailingly by mountainous relief, the highest point is Gerlachovský štít – height 2 655 m a.s.l., the lowest point is in altitude of 109 m a.s.l. Its territory is occupied predominantly by outer Carpathians (Spišská Magura, Podtatranská brázda, Spišsko-šarišské medzihorie, Levočské vrchy, Bachureň, Šarišská vrchovina, Pieniny, Ľubovnianska vrchovina, Čergov, Busov, Ondavská and Laborecká vrchovina, Beskydské predhorie and Bukovské vrchy). The High Tatras, our most significant mountains, do belong to the inner Carpathians.

Air pollution sources in zone Prešov region

Dominant source of air pollution in Prešov region is household heating, mainly in smaller districts of mountainous part of area, where the highest share of fuel wood is using, as compared to the other districts of region. Further emission source is road transport. The most vehicles (on daily average more than 60 000, in 2015) pass through highway D1 and on the roads connected Prešov and Sabinov, Prešov and Hanušovce, Poprad and Kežmarok.

Industrial air pollution sources in region are less significant from point of contribution to local air pollution by basic pollutants. In dependence on meteorological conditions, the influence of wood processing industry and heating plants, can manifest here.

ZONE KOŠICE REGION (apart from Košice city)

Relief of the east part of Košice region is predominantly of plain character, due to East Slovakian plain, which is separated from Košice basin by Slanské vrchy (hills). At the boundary with Prešov region are extended Vihorlatské vrchy (hills), from west to east spreads Hornádska kotlina (basin). In west, more mountainous part of region are extended the Volovské vrchy (hills), separated from Slovenský kras by Rožňavská kotlina (basin). Hornádska kotlina (basin) on the west part of territory interferes into the south part of Prešov region. Major point of Košice region is Stolica, the highest point of Stolica hills reaches altitude 1 476 m a.s.l., the lowest one 94 m a.s.l.

Air pollution sources in zone Košice region

In Košice region, at Veľká Ida, is located industrial complex, dedicated to metallurgy of iron, steel and coke production. This complex is the dominant industrial source of air pollution. Among the further industrial sources belong production of secondary copper and cement factories.

In mountainous area of west part of Košice region is significant source of air pollution household heating, using the solid fuels, mainly fuel wood. Situation is complicated by unfavourable dispersion conditions in areas with low wind speed.

The most overloaded road lines in Košice region – speed road connected Košice with state border of Hungary, Košice-Moldava nad Bodvou, sections of roads Košice-Michalovce-Sobrance, Strážske-Michalovce, Rožňava-Tornaľa and Spišská Nová Ves-Poprad.

In **Tab. 1.1** are summarized data about the area and settlements of respective regions according to data accessible on pages of ŠÚ SR (Statistical Office of SR).

Tab. 1.1 Area, settlement density and number of inhabitants in respective regions of SR.

	Area [km²]	Number* of inhabitants
Bratislava region	2 053	650 838
Trnava region	4 146	562 372
Trenčín region	4 502	587 364
Nitra region	6 344	678 692
Žilina region	6 809	691 023
Banská Bystrica region	9 454	649 788
Prešov region	8 973	823 826
Košice region	6 754	799 217

** Status to 31. 12. 2017 Source: Statistical office of SR*

1.1.2 Allocation of the territory into zones and agglomerations for arsenic, cadmium, nickel, lead, polycyclic aromatic hydrocarbons, mercury and ozone

Agglomeration: Bratislava (territory of the capital city of the Slovak Republic, Bratislava)

Zone: Slovakia (territory of the Slovak Republic apart from the territory of the capital city of the Slovak Republic, Bratislava)

For the time being, heavy metals As, Cd, Ni, Pb and Hg do not conceive the problem from point of exceeding limit or target values, at the territory of SR, in difference e.g. from Poland, where high share of heating by coal brings the problem with high concentrations of As, during cool half of year, which is reflected also in the high annual average values. However, the return to the solid fuel burning is possible to observe also in our territory, in difference from Poland, it is dealing mainly about wood, therefore high concentrations of arsenic are not observable.

Opposite situation occurs in relation to polycyclic aromatic hydrocarbons, which are released into the air from imperfect combustion, mainly of solid fuels and waste. Dominant source in SR for the time being is household heating by solid fuels, road transport (predominantly exhausted emissions from diesel combustion motors), further metallurgy and heating plants. From the completely big group of polycyclic aromatic hydrocarbons, which contains more potential carcinogens, benzo(a)pyrene (BaP) was chosen by the EU legislation. Determined target value for BaP is in Chapter 3. Zone for BaP is the whole territory of SR, due to the fact, that air pollution sources, such are household heating and road transport, occur in all regions. Bratislava was allocated as agglomeration.

Problem of tropospheric ozone is of regional character; significant is share of transport from stratosphere and transboundary transport is also not negligible. Road transport in bigger cities is the source of ozone precursors, on the contrary, oxides of nitrogen cause ozone titration (chemical reaction of ozone with oxides of nitrogen causes ozone decay) in vicinity of the most loaded communications. Target value for human health protection used to be exceeded at the territory of SR, especially in photochemical more active years, and possibilities to improve the situation by local measures are limited.

As zone for arsenic, cadmium, nickel, lead, polycyclic aromatic hydrocarbons, mercury and ozone, the whole territory of SR, without Bratislava, was chosen for simplification and Bratislava was allocated as agglomeration.

1.2 THE LIST OF AIR QUALITY MANAGEMENT AREAS FOR YEAR 2017

Zones and agglomerations create large territories and cover overall the whole territory of SR. In each zone is relatively variable spatial distribution of pollutant concentrations and usually implies areas with significant emission sources and deteriorated air quality, but also relatively clean areas without sources. Due to reason to make the air quality management easier, the so called areas of air quality management were defined. These areas are the subset of individual zones and each zone can contain several of them.

In case, the measured concentrations of some air pollutant on respective monitoring station exceeded limit or target value in monitored year, the respective area representing by measurement of its station, is (in coincidence with Act No. 137/2010 Coll. of Acts on air, in statutory text of later pre-scriptions), announced as Area of air quality management (ORKO). District office in establishment of region elaborates for this locality Programme for air quality improvement. In case, the limit or target values are exceeded for more pollutants, district office in establishment of region elaborates integrated programme.

Air quality monitoring and assessment is carried out by the Slovak Hydrometeorological Institute (SHMÚ) as accredited organization in all agglomerations and zones, for air pollutants, for which are stated limit values or target values and for ozone precursors, by manner of determined executive prescription according to § 33 letter d).

SHMÚ proposes annually the list of ORKO, upon the base of air pollution monitoring (for the period longer than one year), while the list of zones and agglomerations becomes unchanged.

Areas of air quality management in SR for 2017, proposed by SHMÚ, upon the base of air quality assessment in zones and agglomerations in years 2014 – 2016, are presented in **Tab. 2.1.**

Tab. 1.2 Areas of air quality management for year 2017, defined upon the base of measurements in years 2014 – 2016 (with respect to measurement results in previous years in case of not sufficient number of valid measurements).

AGGLOMERATION Zone	Delimited air quality management area	Pollutant	Area [km^2]	Number of inhabitants*
BRATISLAVA	Territory of capital of SR, Bratislava	PM_{10}, NO_2, BaP	368	429 564
KOŠICE Košice region	Territories of Košice city and municipalities Veľká Ida, Sokoľany, Bočiar a Haniska	PM_{10}, BaP	302	245 892
Banská Bystrica region	Territory of Banská Bystrica city	PM_{10}	103	78 484
	Territory of Jelšava city and municipalities Lubeník, Chyžné, Magnezitovce, Mokrá Lúka, Revúcka Lehota	PM_{10}	109	6 261
Košice region	Territory of Krompachy city	PM_{10}, BaP	23	8 828
Prešov region	Territory of Prešov city and Ľubotice municipality	PM_{10}, NO_2	79	92 530
Trenčín region	Territory of Prievidza city	BaP	43	46 408
	Territory of Bystričany municipality	PM_{10}	38	1 801
	Territory of Trenčín city	PM_{10}	82	55 537
Trnava region	Territory of Trnava city	NO_2	72	65 382
Žilina region	Territory of Ružomberok city and Likavka municipality	PM_{10}	145	29 896
	Territory of Žilina city	PM_{10}	80	80 978

** Status to 31. 12. 2017*

2 AIR QUALITY MONITORING NETWORK

Despite of the fact, the first air pollutant measurements were performed in the second half of the fifties in last century, systematic monitoring in our territory began in 1967, when the first Act on air protection (Act No. 35/1967 Coll. of Acts about measures against air pollution) entered into force. Measurements, which included at the beginning only SO_2 and dust fall in Bratislava, Košice and surrounding, were gradually amended for other air pollutants and locations. Legislation was changed more times. Present version is implementation of EU legislation (directions of European parliament and Council 2008/50/EC on ambient air quality and cleaner air in Europe).

As the aim of monitoring is to characterize air quality as best as possible, taking into account human health protection, the structure of monitoring network was proposed in such a way, as the individual stations characterize the extent of pollution in most loaded areas – in past, those were mainly locations in vicinity of large industrial air pollution sources. These stations are also now a part of monitoring network, similarly as locations loaded by emissions from road transport. Plan of monitoring is gradually enlarging also on measurements in the locations, where the dominant air pollution source is household heating.

Locations sufficiently distant from sources of anthropogenic air pollution are also covered by monitoring. Monitoring stations located in these areas are called regional background stations. Pollutants depending on their properties (e.g. sedimentation velocity, chemical reactivity), can persist in air even several days and according to air masses convection, can be transported on large distances. High concentrations of air pollutants can be therefore find also in relatively clean mountainous areas. Monitoring of air quality in regional background stations plays essential role also at the assessment of long-term air quality trends, because these are "covered" by the influence of local sources at the other stations.

Network of measurement stations under the name National monitoring air quality network (NMSKO) started to be building up already in ČSFR in 1991 and at present it comprises continual measurements by automatic instruments and manual measurements, based on the sampling and chemical analyses in the Testing laboratory of SHMÚ. Manual monitoring cover air measurements of heavy metals, volatile organic compounds VOC and polycyclic aromatic hydrocarbons – PAH and also air quality monitoring and analyses of precipitation quality on regional background stations with monitoring programme EMEP (Co-operative Programme for Monitoring and Evaluation of the Long-range Transport of Air Pollutants in Europe). Location of monitoring stations of network NMSKO and their measurements programme in year 2017, is presented in **Fig. 2.1**.

Detailed list of monitoring instruments and methods used for individual stations is in Annex A – Measurement stations of monitoring air quality networks – 2017.

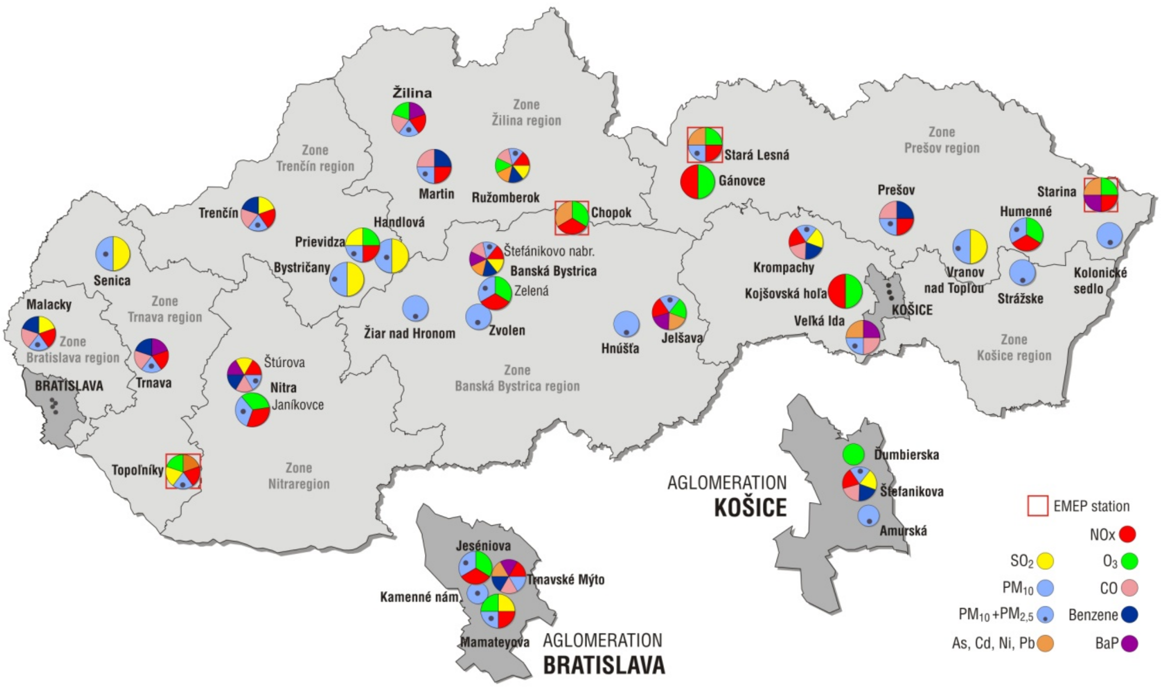
The UN ECE Convention on Long Range Transboundary Air Pollution (CLRTAP) was signed in Geneva in 1979. In frame of the Convention, eight protocols were signed until now. The first one among them was Protocol on Long-term Financing of the Co-operative Programme for Monitoring and Evaluation of the Long-range Transport of Air Pollutants in Europe (EMEP) (Geneva, 1984).

In accordance to the Convention, the EMEP is mandatory for all European countries. Its goal is to monitor, model, evaluate the long-range transport of air pollutants in Europe, and elaborate foundations for the strategy to reduce European emissions. The EMEP monitoring network comprises more than 200 regional stations and four EMEP stations in the territory of Slovakia belonging to the national monitoring air quality network (NMSKO) are at the same time also a part of EMEP network. The first EMEP station at the territory of present SR was established at Chopok meteorological observatory of SHMÚ, in elevation 2 008 m a.s.l. Measurements of air quality were put into operation in year 1977.

Station Chopok is part of EMEP and GAW/WMO (Global Atmosphere Watch/World Meteorological Organization) network since 1978. EMEP station Stará Lesná (elevation 808 m a.s.l.) is in operation from year 1988, since 1992 became part of EMEP network. EMEP station Starina is situated in area of water reservoir Starina, in vicinity of the state boundary with Ukraine and Poland, in elevation 345 m a.s.l. Measurements initiated on this station in 1994, at the same time it became a part of EMEP network. EMEP station Topoľníky is located close to small Danube river, 7 km southeast from village Topoľníky, in plain terrain of the Danube lowlands. Measurements are realized here from year 1983, since year 2000 it is part of EMEP network.

Monitoring programme in EMEP network was gradually extended. Measurements of sulphur compounds and precipitation were enhanced for oxides of nitrogen, nitrates, ammonium ions in ambient air, particulate matter and ozone. In 1994, the measurements of volatile organic compounds (VOCs) began to be carried out under the auspices of Chemical Coordinating Centre - NILU (Norwegian Institute for Air Research). Later on, also heavy metals (HMs) and persistent organic pollutants (POPs) have been included into the measurement programme.

Fig. 2.1 *National air quality monitoring network in year 2017.*



Tab. 2.1 contains the list of air quality monitoring stations, which do belong into the monitoring network of NMSKO, introduce international EOI code, characteristics of stations, in coincidence with the dominant air pollution sources (traffic, background, industrial) and at the same time, the type of region (urban, suburban, rural/regional), which the respective station monitor.

Tab. 2.1 National air quality monitoring network (NMSKO).

AGGLOMERATION Zone	District	Code EoI	Station name	Type of area	Type of station	Geographical longitude	Geographical latitude	Altitude [m]
BRATISLAVA	Bratislava I	SK0004A	Bratislava, Kamenné nám.	U	B	17°06'49"	48°08'41"	139
	Bratislava III	SK0002A	Bratislava, Trnavské mýto	U	T	17°07'44"	48°09'30"	136
	Bratislava III	SK0048A	Bratislava, Jeséniova	S	B	17°06'22"	48°10'05"	287
	Bratislava V	SK0001A	Bratislava, Mamateyova	U	B	17°07'31"	48°07'29"	138
KOŠICE	Košice I	SK0264A	Košice, Amurská	U	B	21°17'08"	48°41'25"	201
	Košice I	SK0267A	Košice, Štefánikova	U	T	21°15'32"	48°43'35"	209
	Košice I	SK0016A	Košice, Ďumbierska	S	B	21°14'42"	48°45'12"	240
Banská Bystrica region	Banská Bystrica	SK0214A	Banská Bystrica, Štefánik. nábr.	U	T	19°09'18“	48°44'06“	346
	Banská Bystrica	SK0263A	Banská Bystrica, Zelená	U	B	19°06'55“	48°44'01“	425
	Revúca	SK0025A	Jelšava, Jesenského	U	B	20°14'26"	48°37'52"	289
	Rimavská Sobota	SK0022A	Hnúšťa, Hlavná	U	B	19°57'06"	48°35'02"	320
	Zvolen	SK0262A	Zvolen, J. Alexyho	U	B	19°09'25"	48°33'30"	321
	Žiar n/Hronom	SK0268A	Žiar n/Hronom, Jilemnického	U	B	18°50'34"	48°35'59"	296
Bratislava region	Malacky	SK0407A	Malacky, Mierove nám.	U	T	17°01'09"	48°26'13"	197
Košice region	Gelnica	SK0042A	Kojšovská hoľa	R	B	20°59'14"	48°46'58"	1253
	Košice okolie	SK0018A	Veľká Ida, Letná	S	I	21°10'31"	48°35'32"	209
	Michalovce	SK0030A	Strážske, Mierová	U	B	21°50'15"	48°52'27“	133
	Spišská Nová Ves	SK0265A	Krompachy, SNP	U	T	20°52'26"	48°54'56"	372
Nitra region	Nitra	SK0269A	Nitra, Štúrova	U	T	18°04'37“	48°18'34"	143
	Nitra	SK0134A	Nitra, Janíkovce	U	B	18°08'27“	48°16'59"	149
Prešov region	Humenné	SK0037A	Humenné, Nám. Slobody	U	B	21°54'50“	48°55'51"	160
	Kežmarok	SK0004R	Stará Lesná, AÚ SAV, EMEP	R	B	20°17'22"	49°09'05"	808
	Poprad	SK0041A	Gánovce, Meteo.st.	R	B	20°19'22"	49°02'05"	706
	Prešov	SK0266A	Prešov, Arm. gen. L. Svobodu	U	T	21°16'00"	48°59'33"	252
	Snina	SK0006R	Starina, Vodná nádrž, EMEP	R	B	22°15'36"	49°02'34"	345
	Snina	SK0406A	Kolonické sedlo, Hvezdáreň	R	B	22°16'26“	48°56'06“	431
	Vranov n/Topľou	SK0031A	Vranov n/Topľou, M. R. Štefánika	U	B	21°41'15"	48°53'11"	133
Trenčín region	Prievidza	SK0013A	Bystričany, Rozvodňa SSE	S	B	18°30'51"	48°40'01"	261
	Prievidza	SK0027A	Handlová, Morovianska cesta	U	B	18°45'23"	48°43'59"	448
	Prievidza	SK0050A	Prievidza, Malonecpalská	U	B	18°37'41"	48°46'58"	276
	Trenčín	SK0047A	Trenčín, Hasičská	U	T	18°02'29"	48°53'47"	214
Trnava region	Dunajská Streda	SK0007R	Topoľníky, Aszód, EMEP	R	B	17°51'37"	47°57'34"	113
	Senica	SK0021A	Senica, Hviezdoslavova	U	T	17°21'47"	48°40'51"	212
	Trnava	SK0045A	Trnava, Kollárova	U	T	17°35'06"	48°22'17"	152
Žilina region	Liptovský Mikuláš	SK0002R	Chopok, EMEP	R	B	19°35'21"	48°56'37"	2008
	Martin	SK0039A	Martin, Jesenského	U	T	18°55'17"	49°03'35"	383
	Ružomberok	SK0008A	Ružomberok, Riadok	U	B	19°18'09"	49°04'45"	475
	Žilina	SK0020A	Žilina, Obežná	U	B	18°46'17"	49°12'41"	356

Type of area: U – urban, S – suburban, R – rural / regional
Type of station: B – background, T – traffic, I – industrial

Monitoring programme of air quality stations in NMSKO network is listed in **Tab. 2.2.** Automatic instruments of continuous monitoring provide average 1-hour concentrations of sulphur dioxide, ozone, oxides of nitrogen, carbon monoxide, benzene, PM_{10} and $PM_{2.5}$. In frame of manual monitoring, the Testing laboratory of SHMÚ analyses heavy metals and polycyclic aromatic hydrocarbons. The results are average 24-hour values. EMEP stations are exception; their monitoring programme is described in **Tab. 2.3** and **Tab. 2.4**.

Tab. 2.2 Measurement program in monitoring air quality networks of SR – 2017.

AGGLOMERATION Zone	Station name	Continuously							Manually	
		PM_{10}	$PM_{2.5}$	Oxides of nitrogen NO, NO_2, NO_X	Sulphur dioxide SO_2	Ozone O_3	Carbon monoxide CO	Benzene	Heavy metals, As, Cd, Ni, Pb	Polyaromatic hydrocarbons BaP
BRATISLAVA	Bratislava, Kamenné nám	x	x							
	Bratislava, Trnavské mýto	x		x			x	x	x	x
	Bratislava, Jeséniova	x	x	x		x				
	Bratislava, Mamateyova	x	x	x	x	x				
	Together 4 stations	**4**	**3**	**3**	**1**	**2**	**1**	**1**	**1**	**1**
KOŠICE	Košice, Amurská	x	x							
	Košice, Štefánikova	x	x	x	x		x	x		
	Košice, Ďumbierska					x				
	Together 3 stations	**2**	**2**	**1**	**1**	**1**	**1**	**1**		
Banská Bystrica region	Banská Bystrica, Štefánikovo nábr.	x	x	x	x		x	x	x	x
	Banská Bystrica, Zelená	x	x	x		x				
	Jelšava, Jesenského	x	x	x		x				
	Hnúšťa, Hlavná	x	x							
	Žiar nad Hronom, Jilemnického	x	x							
	Zvolen, J. Alexyho	x	x							
	Together 6 stations	**6**	**6**	**3**	**1**	**2**	**1**	**1**	**1**	**1**
Bratislava region	Malacky, Mierové nám.	x	x	x	x		x	x		
	Together 1 stations	**1**	**1**	**1**	**1**		**1**	**1**		
Košice region	Kojšovská hoľa			x		x				
	Veľká Ida, Letná	x	x				x		x	x
	Strážske, Mierová	x	x							
	Krompachy, SNP	x	x	x	x		x	x		
	Together 4 stations	**3**	**3**	**2**	**1**	**1**	**2**	**1**	**1**	**1**
Nitra region	Nitra, Štúrova	x	x	x	x		x	x		x
	Nitra, Janíkovce	x	x	x		x				
	Together 2 stations	**2**	**2**	**2**	**1**	**1**	**1**	**1**		**1**
Prešov region	Humenné, Nám. slobody	x	x	x		x				
	Stará Lesná, AÚ SAV, EMEP	x	x	x		x				
	Gánovce, Meteo. st.			x		x				
	Prešov, Arm. gen. L. Svobodu	x	x	x			x	x		
	Starina, Vodná nádrž, EMEP			x		x				
	Vranov nad Topľou, M. R. Štefánika	x	x		x					
	Kolonické sedlo	x	x							
	Together 7 stations	**5**	**5**	**5**	**1**	**4**	**1**	**1**		
Trenčín region	Prievidza, Malonecpalská	x	x	x	x	x				
	Bystričany, Rozvodňa SSE	x	x		x					
	Handlová, Morovianska cesta	x	x		x					
	Trenčín, Hasičská	x	x	x	x		x	x		
	Together 4 stations	**4**	**4**	**2**	**4**	**1**	**1**	**1**		
Trnava region	Topoľníky, Aszód, EMEP	x	x	x	x	x				
	Senica, Hviezdoslavova	x	x		x					
	Trnava, Kollárova	x	x	x			x	x		
	Together 3 stations	**3**	**3**	**2**	**2**	**1**	**1**	**1**		
Žilina region	Chopok, EMEP			x		x				
	Martin, Jesenského	x	x	x			x	x		
	Ružomberok, Riadok	x	x	x	x	x	x	x	x	
	Žilina, Obežná	x	x	x		x	x			
	Together 4 stations	**3**	**3**	**4**	**1**	**3**	**3**	**2**	**1**	
NMSKO altogether 38 monitoring stations		**33**	**32**	**25**	**14**	**16**	**13**	**11**	**4**	**4**

Air quality monitoring programme on EMEP stations in year 2017 is listed in **Tab. 2.3**. Ozone is measured continuously. Sampling interval for PM_{10}/TSP and heavy metals is one week, the other substances are analysed upon the base of 24-hour sampling.

Tab. 2.3 *Measurement programme of EMEP stations – air, 2017.*

	Ozone (O_3)	Sulphur dioxide (SO_2)	Nitrogen dioxide (NO_2)	Sulphates (SO_4^{2-})	Nitrates (NO_3^-)	Nitric acid (HNO_3)	Chlorides (Cl)	Ammonia, Ammonium ions (NH_3, NH_4^+)	Alkali ions (K^+, Na^+, Ca^{2+}, Mg^{2+})	VOC	PM_{10} / TSP*	Lead (Pb)	Arsenic (As)	Cadmium (Cd)	Nickel (Ni)	Chromium (Cr)	Cooper (Cu)	Zinc (Zn)
Chopok	x	x	x	x	x	x	x				x*	x	x	x	x	x	x	x
Topoľníky	x										x	x	x	x	x	x	x	x
Starina	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Stará Lesná	x										x	x	x	x	x	x	x	x

* *TSP – total suspended particles*

Precipitation quality (pH, conductivity, sulphates, nitrates, nitric acid, chlorides, and ammonium and alkali ions) is analysed from samples, collected on EMEP stations, according to the monitoring programme listed in **Tab. 2.4**, either upon daily base (Chopok, Starina) or weekly (Topoľníky, Stará Lesná). Results of analyses are daily or weekly average values in dependence on sampling interval.

Heavy metals occur in these locations in low concentrations, sampling precipitation intervals for heavy metal analyses are one month, apart from EMEP station Starina, where sampling interval is upon weekly sampling. For precipitation sampling are used precipitation collectors of two types: “wet-only”, or “bulk”. Precipitation collector “wet-only”, which cover is open only during rain and such samples serve for wet deposition assessment, type “bulk” precipitation collector samples dry and wet deposit at the same time. This kind of sampling is carried out on Chopok, where the precipitation sampling is performed into the open bucket.

Tab. 2.4 *Measurement programme of EMEP stations – precipitation, 2017.*

	pH	Conductivity	Sulphates (SO_4^{2-})	Nitrates (NO_3^-)	Chlorides (Cl^-)	Ammonium ions (NH_4^+)	Alkali ions (K^+, Na^+, Ca^{2+}, Mg^{2+})	Lead (Pb)	Arsenic (As)	Cadmium (Cd)	Nickel (Ni)	Chromium (Cr)	Copper (Cu)	Zinc (Zn)
Chopok	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Topoľníky	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Starina	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Stará Lesná	x	x	x	x	x	x	x	x	x	x	x	x	x	x

2.1 ASSESSMENT OF MONITORING EXTENT FOR INDIVIDUAL POLLUTANTS

- **Sulphur dioxide SO_2**

This pollutant was monitored on 14 stations. Minimum required extent of monitoring[1] was fulfilled. Sulphur dioxide monitoring was secured on all 14 stations continuously, by reference method. Required number of valid measured data (90%) was reached on 11 monitoring stations. (Note: On AMS Košice, Štefánikova, the monitoring program was enhanced about SO_2 in course of August 2017, which is in coincidence with the number of valid measurements). On AMS Nitra, Štúrova and Handlová, Morovianska road, the percentage of valid measurements 83%, resp. 88% was due to measurement breakdown. Servis and following calibration of measurement instruments is needed.

- **Oxides of nitrogen NO_2 and NO_X**

These pollutants were monitored on 25 stations. Minimum required extent of monitoring[1] was fulfilled. Oxides of nitrogen monitoring were secured at all 25 stations, continuously, by reference method. Required number of valid measured data (90%) was reached at 24 monitoring stations. (Note: On AMS Chopok, EMEP, the station was hit by lightening during thunderstorm. Problems connected with damage liquidation caused the breakdown of measurements).

- **Particulate matter PM_{10}**

This pollutant was monitored on 33 stations. Minimum required extent of monitoring[1] was fulfilled. Monitoring of PM_{10} was secured by equivalent, continuous method of oscillation microbalance, by instrument TEOM and by method of beta radiation absorption – BAM. Required number of valid measured data (90%) was reached on 32 monitoring stations. (Breakdown of measurements on AMS Bratislava, Kamenné nám., in 2017, was caused by failure of technically fatique instrument).

- **Particulate matter $PM_{2.5}$**

These particulates were monitored on 32 stations. Minimum required extent of monitoring[1] was fulfilled. $PM_{2.5}$ monitoring was secured by the same method as PM_{10} monitoring, by instruments TEOM and BAM. Required number of valid measured data (90%) was reached on 29 monitoring stations. (Note: On AMS Bratislava, Kamenné nám., the measurement instrument was installed in course of April 2017, which corresponds also to the number of valid measurements. On two AMS - Nitra, Štúrova and Martin, Jesenského, the breakdown of measurements was caused by technical failure).

- **Carbon monoxide CO**

This pollutant was monitored on 13 monitoring stations. Minimum required extent of monitoring[1] was fulfilled. CO monitoring was secured on 13 stations, continuously, by reference method. Required number of valid measured data (90%) was reached on 11 monitoring stations. (Note: failure of measurements on two AMS stations was caused by breakdown). Concentrations of CO are below the low limit for assessment, therefore the number of measurements is satisfactory.

- **Ozone O_3**

Ozone was monitored on 16 monitoring stations. Minimum required extent of monitoring[1] was fulfilled. Ozone monitoring was secured on all 16 stations, continuously, by reference method. Required number of valid measured data (90%) was reached on 12 monitoring stations. (Note: failure of measurements was caused by technical breakdown).

[1] *Number and location according to Appendix No. 6 to regulation of MoE SR No. 244/2016 Coll. A on air quality in reading of later directives*

- **Benzene**

  Benzene was monitored on 11 monitoring stations. Minimum required extent of monitoring[1] was fulfilled. Benzene monitoring was secured on all 11 stations, continuously, by reference method. Required number of valid measured data (90%) was reached at all 11 stations, as well.

- **Heavy metals (Pb, As, Cd, Ni)**

  Samples for heavy metal analyses are collected on nitrocellulose filter, each second day, during 24 hours and consequently analysed in the Testing laboratory of SHMÚ, by the ICP MS (inducted coupled plasma with mass spectrometer). In 2017, the samples for heavy metal analyses (Pb, As, Cd, Ni) were collected on one suburban station, four urban and four stations with monitoring program EMEP (Pb, As, Cd, Ni, Cr, Zn, Cu).

- **Polyaromatic hydrocarbons – benzo(a)pyrene**

  In 2017, the benzo(a)pyrene monitoring was provided on four monitoring stations. Collection of samples was realized on quartz filter each third day for 24 hours. Samples are analysed after extraction in the Testing laboratory of SHMÚ, by method of GC MS (gas chromatography with mass spectrometer).

- **VOC**

  Volatile organic compounds $C_2 - C_8$ or the so called light hydrocarbons, began to be sampled on station Starina in autumn 1994. Starina is one of a few European stations, included into EMEP network, with regular volatile organic compound monitoring. They are analysed and assessed in coincidence with NILU method GC MS in EMEP manual.

- **Air quality monitoring on EMEP stations**

  Air quality measurements were realized on four EMEP monitoring stations in coincidence with EMEP monitoring strategy, according to the approved monitoring programme (**Tab. 2.3**).

- **Atmospheric precipitation monitoring on EMEP stations**

  Precipitation quality measurements were realized on four EMEP monitoring stations, in coincidence with EMEP monitoring strategy, according to the approved monitoring programme (**Tab. 2.4**).

Apart from air quality monitoring stations in NMSKO network are at the territory of SR also monitoring stations, established by operators of the large air pollution sources (VZZO), for purposes of air pollution level monitoring. Decision for establishment of VZZO stations is delivered by the District office, in settlement of region. VZZO data from monitoring stations, which passed through function tests (**Tab. 2.5**), serve as supplementing data to the measurements from NMSKO network, for the air quality assessment in cases, the data were gained by reference, or equivalent method. Concentrations of those pollutants, monitored at VZZO by different method, represent on contrary to it, the important information for air quality assessment.

Tab. 2.5 *Monitoring stations of other operators of large air pollution sources (VZZO).*

AGGLOMERATION Zone	District	Station name*	Type		Geographical		Altitude [m]
			area	station	longitude	latitude	
BRATISLAVA	Bratislava II	Bratislava, Vlčie Hrdlo (Slovnaft, a.s.)	S	I	17°10'10“	48°08'00“	134
	Bratislava II	Bratislava, Pod. Biskupice (Slovnaft, a.s.)	U	B	17°12'20“	48°08'05“	132
KOŠICE	Košice II	Košice, Haniska (U.S. Steel, s.r.o.)	S	I	21°15'07“	48°36'54“	212
	Košice II	Košice, Poľov (U.S. Steel, s.r.o.)	R	B	21°11'54“	48°39'40“	271
Bratislava region	Senec	Rovinka (Slovnaft, a.s.)	S	B	17°13'40“	48°06'15“	133
Košice region	Košice - okolie	Veľká Ida (U.S. Steel, s.r.o.)	S	I	21°10´12“	48°33´35“	208
	Trebišov	Leles (Slovenské elektrárne, a.s.)	R	B	22°01´23“	48°27´46“	100
Nitra region	Šaľa	Trnovec nad Váhom (Duslo, a.s.)	S	B	17°55'43“	48°08'60“	114
Trenčín region	Prievidza	Oslany (Slovenské elektrárne, a.s.)	S	B	18°28´12“	48°37´60“	228
Žilina region	Ružomberok	Ružomberok (Mondi a.s. - Supra)	U	I	19°19'12“	49°04'43“	478

** Next of station name is quoted owner of station in bracket*

Type of area: U – urban, S – suburban, R – rural / regional
Type of station: B – background, I – industrial

3 AIR QUALITY ASSESSMENT IN AGGLOMERATIONS AND ZONES OF SLOVAKIA

3.1 INTRODUCTION

Problems concerning environment, accompanied the technological progress of mankind since ancient times. Environmental disasters connected with endangering of human life and health, stimulated common procedure to search the solution of this issue. Due to the fact, the pollutants can be transported via air on large distances, the coordinated procedure of the major number of countries at air quality monitoring and assessment showed to be the essential basis to accept the measures. These activities resulted in the international conventions, as well as in European legislation, implemented consequently into the legislation of SR.

Air quality assessment, according to the requirements of § 6 of Act No. 137/2010 Coll. of Acts on air, in wording of later prescriptions, is realized by SHMÚ upon the base of air quality monitoring, using the mathematical modelling.

Chapter 3 introduces the processed results of air quality monitoring. Air quality assessment processed by the mathematical modelling is in Chapter 4.

In Chapter **3.3** are assessed the results of air quality measurements in cities and countryside, according to limit and target values for human health protection. Chapter **3.4** processes the results of measurements from monitoring stations with monitoring programme EMEP, according to limit values for vegetation protection. Programme EMEP comprises also atmospheric precipitation quality analyses.

3.2 AIR QUALITY ASSESSMENT CRITERIA

Air quality (according to § 5 section 4 of Act No. 137/2010 Coll. of Act on air in wording of later prescriptions – later only Air act) is considered for good, if the air pollution level is lower than limit value or target value.

Limit value is (in coincidence with § 5 section 5 of Air act) air pollution level, determined upon the base of scientific knowledge, with aim to protect, prevent or decrease harmful effects on human health or environment as a whole. This air pollution level shall be reached in given time and from this time it must not be exceeded. Limit values and conditions of their validity are determined by the executive prescription, according to § 33 letter b) for sulphur dioxide, nitrogen dioxide, carbon monoxide, lead, benzene, particulate matter PM_{10} and particulate matter $PM_{2.5}$.

Target value is (in coincidence with § 5 section 11 of Air act) air pollution level, determined upon the aim to protect, prevent or decrease harmful effects on human health, or environment as a whole. This air pollution level shall be reached in given time, if possible. Target value is determined by the executive prescription according to § 33 letter b) for ozone, arsenic, cadmium, nickel and benzo(a)pyrene.

Warning threshold is (according § 12 section 6 of Air act) air pollution level and when exceeded it, the risk of human health deterioration exists, already under the short-term exposition. At exceedance of warning threshold is necessary to issue the warning in front of the serious smog situation. Warning thresholds are determined by the executive prescription according to § 33 letter b) for sulphur dioxide, ozone and particulate matter PM_{10}.

Critical level for purposes of air quality assessment is (according § 5 section 10 of Air act) air pollution level, determined upon the base of scientific knowledge, at exceedance of which can occur direct or indirect effects on trees, other plants, or natural ecosystems, apart from people. Critical level is determined by the executive prescription (according to § 33 letter b) for sulphur dioxide and nitrogen dioxide.

Method, which is necessary to use for air quality assessment in respective location, depends on the extent of air pollution in given location. For this purpose, the low and upper limits were established for each monitored pollutant, for pollution level assessment.

Upper limit for air pollution level assessment is (according § 6 section 8 of Air Act) determined as air pollution level, under which is possible to use the combination of continuous measurements and mathematical modelling, or also indicative measurements for air quality assessment.

Low limit for air pollution level assessment is (according § 6 section 8 of Air Act) determined as air pollution level, under which is possible to use mathematical modelling or techniques of objective estimation for air quality assessment.

In **Tab. 3.1** are presented limit values for human health protection and critical levels for vegetation protection, upper and low limits for ambient air pollution level assessment of SO_2, NO_2, NO_X, PM_{10}, $PM_{2.5}$, Pb, CO and benzene. **Tab. 3.2** presents target values for human health protection and vegetation protection for As, Cd, Ni and benzo(a)pyrene (BaP).

Tab. 3.1 *Limit values for human health protection and critical levels for vegetation protection, upper and low limits of pollutants for ambient air pollution level assessment.*

	Receptor	**Interval of averaging**	**Limit value*** [μg.m⁻³]		**Limit for assessment** [μg.m⁻³]			
					Upper*		**Low***	
SO_2	Human health	1h	350	(24)				
SO_2	Human health	24h	125	(3)	75	(3)	50	(3)
SO_2	Vegetation	1y. winter season	20	(-)	12	(-)	8	(-)
NO_2	Human health	1h	200	(18)	140	(18)	100	(18)
NO_2	Human health	1r	40	(-)	32	(-)	26	(-)
NO_X	Vegetation	1r	30	(-)	24	(-)	19.5	(-)
PM_{10}	Human health	24h	50	(35)	35	(35)	25	(35)
PM_{10}	Human health	1r	40	(-)	28	(-)	20	(-)
Pb	Human health	1r	0.5	(-)	0.35	(-)	0.25	(-)
CO	Human health	8h (maximum)	10 000	(-)	7 000	(-)	5 000	(-)
Benzene	Human health	1r	5	(-)	3.5	(-)	2	(-)
$PM_{2.5}$	Human health	1r	25**		17		12	

* *Permitted number of exceedances is listed in brackets*
** *Limit value for $PM_{2.5}$ until 1.1.2020: 25 μg.m^{-3}*
Limit value for $PM_{2.5}$ since 1.1.2020: 20 μg.m^{-3}

Tab. 3.2 *Target values for human health protection and vegetation protection for As, Cd, Ni and BaP.*

	Averaging season	**Target value** [ng.m⁻³]
As	1y	6
Cd	1y	5
Ni	1y	20
BaP	1y	1

3.3 AIR QUALITY MONITORING RESULTS LOCAL AIR POLLUTION

In **Tab. 3.3** is introduced the share of valid data from air quality measurements in monitoring network NMSKO for SO_2, NO_2, PM_{10}, $PM_{2.5}$, CO, benzene and O_3.

Tab. 3.3 *Share of valid data* in % in year 2017.*

AGGLOMERATION Zone	Pollutant	SO_2	NO_2	PM_{10}	$PM_{2.5}$	CO	Benzene	O_3
BRATISLAVA	Bratislava, Kamenné nám.			83	51			
	Bratislava, Trnavské mýto		91	90		72	90	
	Bratislava, Jeséniova		94	97	97			93
	Bratislava, Mamateyova	96	95	99	98			95
KOŠICE	Košice, Štefánikova	35	95	99	99	97	99	
	Košice, Amurská			97	99			
	Košice, Dumbierska							98
Banská Bystrica region	Banská Bystrica, Štefánik. nábr.	98	94	97	98	96	98	
	Banská Bystrica, Zelená		93	98	96			91
	Jelšava, Jesenského		96	96	94			91
	Hnúšťa, Hlavná			98	96			
	Zvolen, J. Alexyho			100	100			
	Žiar n/H, Jilemnického			100	100			
Bratislava region	Malacky, Mierove nám.	97	99	98	92	99	100	
Košice region	Kojšovská hola		97					95
	Veľká Ida, Letná			99	98	97		
	Strážske, Mierová			98	99			
	Krompachy, SNP	92	97	98	99	92	100	
Nitra region	Nitra, Janíkovce		95	98	97			86
	Nitra, Štúrova	83	96	94	85	96	92	
Prešov region	Gánovce, Meteo. st.		96					95
	Humenné, Nám. Slobody		96	99	100			92
	Prešov, Arm. gen. L. Svobodu		95	99	99	88	99	
	Vranov n/T, M. R. Štefánika	96		99	98			
	Stará Lesná, AÚ SAV, EMEP		96	100	99			
	Starina, Vodná nádrž, EMEP		96					93
	Kolonické sedlo, Hvezdáreň			98	97			
Trenčín region	Prievidza, Malonecpalská	94	97	99	99			82
	Bystričany, Rozvodňa SSE	95		95	96			
	Handlová, Morovianska cesta	88		96	99			
	Trenčín, Hasičská	94	96	98	98	95	99	
Trnava region	Senica, Hviezdoslavova	93		95	97			
	Trnava, Kollárova		98	94	97	95	99	
	Topoľníky, Aszód, EMEP	97	98	97	97			
Žilina region	Chopok, EMEP		51					46
	Martin, Jesenského		97	99	84	96	95	
	Ružomberok, Riadok	91	97	99	98	94	99	90
	Žilina, Obežná		98	100	100	98		89

** ≥90% of valid measurements (requested by our legislation after implementation of EU legislation in Regulation of MoE SR No. 244/2016 Coll. of Acts on air quality, in wording of Regulation 296/2017 Coll. of Acts)*

Air quality assessment according to limit values (LV) for human health protection for SO_2, NO_2, PM_{10}, $PM_{2.5}$, CO and benzene for individual monitoring stations and pollutants in year 2017 is introduced in Tab. 3.4. In this table are at the same time introduced the numbers of warning threshold exceedances.

Tab. 3.4 Air quality assessment according to limit values for human health protection and numbers of warning thresholds exceedances – 2017.

AGGLOMERATION Zone		Health protection									WT 2)	
	Pollutant	SO_2		NO_2		PM_{10}		$PM_{2.5}$	CO	Benzene	SO_2	NO_2
	Averaging period	1 h	24 h	1 h	1 year	24 h	1 year	1 year	8 h 1)	1 year	3 h consecutively	3 h consecutively
	Parameter	number of exceedances	number of exceedances	number of exceedances	average	number of exceedances	average	average	average	average	number of exceedances	number of exceedances
	Limit value [µg.m⁻³]	350	125	200	40	50	40	25	10 000	5	500	400
	Maximum number of exceedances	24	3	18		35						
BRATISLAVA	Bratislava, Kamenné nám.					0	19	11				
	Bratislava, Trnavské mýto			0	39	24	25		1004	0.5		0
	Bratislava, Jeséniova			0	14	25	20	14				0
	Bratislava, Mamateyova	2	0	0	24	25	23	15			0	0
KOŠICE	Košice, Štefánikova	0	0	0	31	55	33	23	2148	1.6	0	0
	Košice, Amurská					36	28	19				
Banská Bystrica region	Banská Bystrica, Štefánik.nábr.	0	0	0	38	67	33	23	2238	1.4	0	0
	Banská Bystrica, Zelená			0	13	19	20	16				0
	Jelšava, Jesenského			0	10	82	37	27				0
	Hnúšťa, Hlavná					42	27	19				
	Zvolen, J. Alexyho					32	24	18				
	Žiar n/H, Jilemnického					20	19	15				
Bratislava region	Malacky, Mierové nám.	0	0	0	29	20	23	17	1601	1.2	0	0
Košice region	Kojšovská hola			0	3							0
	Veľká Ida, Letná					62	36	25	2470			
	Strážske, Mierová					30	27	22				
	Krompachy, SNP	0	0	0	18	38	27	21	2033	2.6	0	0
Nitra region	Nitra, Janíkovce			0	14	25	24	19				0
	Nitra, Štúrova	0	0	0	35	27	28	14	1466	0.5	0	0
Prešov region	Gánovce, Meteo. st.			0	9							0
	Humenné, Nám. slobody			0	11	36	26	22				0
	Prešov, Arm. gen. L. Svobodu			0	38	51	34	24	2214	2.5		0
	Vranov n/T, M. R. Štefánika	0	0			29	26	20			0	
	Stará Lesná, AÚ SAV, EMEP			0	4	2	13	11				0
	Starina, Vodná nádrž, EMEP			0	3							0
	Kolonické sedlo, Hvezdáreň					13	18	11				
Trenčín region	Prievidza, Malonecpalská	0	0	0	19	24	26	18			0	0
	Bystričany, Rozvodňa SSE	0	0			30	27	19			0	
	Handlová, Morovianska cesta	0	0			25	23	18			0	
	Trenčín, Hasičská	0	0	0	31	41	30	13	3686	1.1	0	0
Trnava region	Senica, Hviezdoslavova	0	0			25	25	16			0	
	Trnava, Kollárova			0	37	29	24	17	1584	1.1		0
	Topoľníky, Aszód, EMEP	0	0	0	8	27	24	16			0	0
Žilina region	Chopok, EMEP			0	3							0
	Martin, Jesenského			0	26	29	28	22	2136	1.5		0
	Ružomberok, Riadok	0	0	0	21	44	30	24	3091	0.8	0	0
	Žilina, Obežná			0	25	44	30	26	2156			0

≥ 90% of valid measurements

Exceedances of limit value are marked by red colour

1) *maximum 8-hour concentration*

2) *limit values for warning thresholds (WT)*

Tab. 3.5 *Assessment of air pollution by heavy metals (As, Cd, Ni a Pb) – 2017.*

			As	Cd	Ni	Pb
AGGLOMERATION Zone	Pollutant	[ng.m-3]	As	Cd	Ni	Pb
	Target value	[ng.m-3]	6.0	5	20	-
	Limit value	[ng.m-3]	-	-	-	500
	Upper limit for assessment	[ng.m-3]	3.6	3	14	350
	Low limit for assessment	[ng.m-3]	2.4	2	10	250
BRATISLAVA	Bratislava, Trnavské mýto		0.2	0.3	1.1	7.1
Slovakia	Banská Bystrica, Štefánikovo nábr.		1.1	0.5	0.8	9.7
	Veľká Ida, Letná		0.7	0.7	1.0	123.0
	Ružomberok, Riadok		0.5	0.2	0.3	5.8

In **Tab. 3.6** are quoted annual average concentrations of benzo(a)pyrene (BaP) in air, according to measurements in years 2013 – 2017. In 2017 the target value for BaP was exceeded on AMS Banská Bystrica, Štefánikovo nábr; Veľká Ida, Letná and Nitra, Štúrova.

Tab. 3.6 *Assessment of air pollution by benzo(a)pyrene.*

AGGLOMERATION Zone			2013	2014	2015	2016	2017
	Target value	[ng.m-3]	1.0	1.0	1.0	1.0	1.0
	Upper limit for assessment	[ng.m-3]	0.6	0.6	0.6	0.6	0.6
	Low limit for assessment	[ng.m-3]	0.4	0.4	0.4	0.4	0.4
BRATISLAVA	Bratislava, Jeséniova		1.0	0.7	0.6		
	Bratislava, Trnavské mýto		**1.1**	0.6	0.8	**1.2**	0.4
Slovakia	Banská Bystrica, Štefánikovo nábr.					**4.4**	**2.9**
	Veľká Ida, Letná		**5.3**	**4.1**	**6.2**	**3.8**	**4.3**
	Krompachy, SNP		**2.8**	**2.1**	**1.9**		
	Prievidza, Malonecpalská		**1.9**	**1.5**	**1.4**		
	Trnava, Kollárova		**1.3**	0.7	0.8		
	Nitra, Štúrova					**1.3**	**1.3**

Limit value exceedance is marked by red colour

Occurrence and period of pollution duration at the level of warning thresholds for SO_2 during last 5 years is presented in **Tab. 3.7**. Warning threshold for SO_2 in NMSKO was exceeded last time in year 2013 on AMS Bystričany, Rozvodňa SSE. Warning threshold for NO_2 was not exceeded in this period.

Tab. 3.7 *Assessment of air pollution by SO_2, according to the occurrence and duration of warning threshold exceedance within the years 2013 – 2017 on station Bystričany, Rozvodňa SSE.*

Year	2013	2014	2015	2016	2017
Number of warning threshold exceedances	2	0	0	0	0
Duration in hours	7	0	0	0	0

Air quality assessment is carried out by continuous measurements in agglomerations and zones, in such places, where the air pollution level is higher than the upper limit for air pollution level assessment.

In case, the sufficient data are at disposal, the upper and low limit exceedances for air pollution level assessment have to be determined upon the base of concentrations, measured within last five years. Limit for air pollution level assessment is considered for exceeded, if exceedance appears at least over three years from last five years.

In case, the less than five years data are at disposal, exceedances of upper and low limits for air pollution level assessment are possible to determine by combination of the results from measurement campaigns of shorter duration, executed within one year in locations with probably the highest air pollution levels and results gained from emission inventories and modelling (Regulation of MoE SR No. 244/2016 Coll. of Acts on air quality, in wording of Regulation of MoE SR No. 296/2017 Coll. of Acts). Classification of monitoring stations according to upper and low limits for assessment is listed in **Tab. 3.8** and **Tab. 3.9**.

Tab. 3.8 Classification of AMS according to upper limits (ULA) and low limits (LLA) for assessment to determine manner of air quality assessment within years 2013 – 2017.

AGGLOMERATION zone	Station	ULA and LLA with regard to human health protection																							
		SO_2			NO_2						PM_{10}						$PM_{2.5}$			CO			Benzene		
		24h average			1h average			annual average			24h average			annual average			annual average			8h maximum			annual average		
		> ULA	≤ ULA; >LLA	≤ LLA	> ULA	≤ ULA; >LLA	≤ LLA	> ULA	≤ ULA; >LLA	≤ LLA	> ULA	≤ ULA; >LLA	≤ LLA	> ULA	≤ ULA; >LLA	≤ LLA	> ULA	≤ ULA; >LLA	≤ LLA	> ULA	≤ ULA; >LLA	≤ LLA	> ULA	≤ ULA; >LLA	≤ LLA
BRATISLAVA	Bratislava, Kamenné nám.		`								x				x				x						
	Bratislava, Trnavské mýto					x		x			x			x								x			x
	Bratislava, Jeséniova						x			x	x				x			x							
	Bratislava, Mamateyova			x		x				x	x				x			x							
KOŠICE	Košice, Štefánikova			x		x			x		x			x			x					x			x
	Košice, Amurská										x				x		x								
Banská Bystrica region	Banská Bystrica, Štefánikovo nábr.			x			x	x			x			x			x					x			x
	Banská Bystrica, Zelená						x			x		x			x			x							
	Zvolen, J. Alexyho										x				x			x							
	Jelšava, Jesenského						x			x	x			x			x								
	Hnúšťa, Hlavná										x				x		x								
	Žiar nad Hronom, Jilemnického											x				x		x							
Bratislava region	Malacky, Mierové nám.			x			x			x	x				x		x					x			x
Košice region	Veľká Ida, Letná										x			x			x					x			
	Kojšovská hoľa*						x			x															
	Strážske, Mierová										x				x		x								
	Krompachy, SNP			x			x			x	x			x			x					x		x	
Nitra region	Nitra, Janíkovce						x			x	x				x			x							
	Nitra, J. Štúrova			x			x	x			x				x			x				x			x
Prešov region	Humenné, Nám. slobody						x			x		x			x		x								
	Prešov, Arm. gen. L. Svobodu					x		x			x			x			x					x			x
	Gánovce, MS SHMÚ*						x			x															
	Starina, Vodná nádrž, EMEP*						x			x															
	Vranov n/Topľou, M. R. Štefánika			x							x				x		x								
	Stará Lesná, AÚ SAV, EMEP*						x			x			x			x			x						
	Kolonické sedlo, Hvezdáreň											x				x			x						
Trenčín region	Prievidza, Malonecpalská			x			x			x	x				x		x								
	Bystričany, Rozvodňa SSE			x							x			x			x								
	Handlová, Morovianska cesta			x							x				x			x							
	Trenčín, Hasičská			x			x		x		x			x			x					x			x
Trnava region	Senica, Hviezdoslavova			x							x				x			x							
	Trnava, Kollárova					x		x			x				x		x					x		x	
	Topoľníky, Aszód, EMEP*			x			x			x		x			x			x							
Žilina region	Martin, Jesenského						x			x	x				x			x				x			x
	Chopok, EMEP*						x			x															
	Ružomberok, Riadok			x			x			x	x			x			x					x			x
	Žilina, Obežná						x			x	x			x			x					x			

** Stations indicate regional background level*

Tab. 3.9 Classification of monitoring stations, on which heavy metals and benzo(a)pyrene were monitored in coincidence with upper (ULA) and low limit (LLA) assessment to determine manner of air quality assessment within years 2013 – 2017.

AGGLOMERATION zone	Station	As			Cd			Ni			Pb			BaP		
		> ULA	≤ ULA; >LLA	≤ LLA	> ULA	≤ ULA; >LLA	≤ LLA	> ULA	≤ ULA; >LLA	≤ LLA	> ULA	≤ ULA; >LLA	≤ LLA	> ULA	≤ ULA; >LLA	≤ LLA
BRATISLAVA	Bratislava, Jeséniova														x	
	Bratislava, Trnavské mýto			x			x			x			x	x		
Slovakia	Banská Bystrica, Štefánikovo nábr.			x			x			x			x	x		
	Veľká Ida, Letná			x			x			x			x	x		
	Krompachy, SNP						x			x			x			
	Prievidza, Malonecpalská	x					x			x			x			
	Trnava, Kollárova													x		
	Ružomberok, Riadok			x			x			x			x			
	Nitra, Štúrova													x		

In **Tab. 3.10** are listed annual average concentrations of tropospheric ozone in years 2007 – 2017, as compared to photochemical extraordinary active year 2003.

Tab. 3.10 Annual average concentrations of surface ozone (µg.m^{-3}) in years 2003, 2007–2017.

Station	2003	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Bratislava, Jeséniova	71	59	59	60	61	63	65	62	60	71	56	64
Bratislava, Mamateyova	53	49	48	48	46	51	53	48	46	54	36	51
Košice, Ďumbierska	68	57	56	81	63	73	62	61	55	57	55	55
Banská Bystrica, Zelená				53	56	60	66	66	58	48	45	57
Jelšava, Jesenského	55	56	51	49	44	-	-	41	36	45	48	49
Kojšovská hoľa	91	79	76	85	90	87	83	78	75	61	81	80
Nitra, Janíkovce				74	53	-	62	58	52	63	43	60
Humenné, Nám. slobody	66	56	55	59	53	53	55	60	40	41	50	52
Stará Lesná, AÚ SAV, EMEP	67	68	74	61	67	65	63	71	56	66	58	63
Gánovce, Meteo. st.	68	60	65	62	63	64	66	67	58	66	38	53
Starina, Vodná nádrž, EMEP	73	62	59	58	51	59	60	64	55	64	58	60
Prievidza, Malonecpalská		48	53	50	49	51	52	50	53	54	39	51
Topoľníky, Aszód, EMEP	67	58	60	59	55	-	59	64	51	51	49	47
Chopok, EMEP	109	91	92	90	87	96	93	96	52	88	91	98
Žilina, Obežná	48	44	46	48	47	48	49	53	42	36	43	38
Ružomberok, Riadok											37	37
Average	**65**	**62**	**61**	**62**	**59**	**61**	**63**	**63**	**53**	**58**	**52**	**57**

≥ 90% requested valid data

Regulation of MoE SR No. 244/2016 Coll. of Acts on air quality, in wording of Regulation No. 296/2017 Coll. of Acts, determines ozone target value for human health protection as follows: "120 μg.m^{-3} will not be exceeded more than 25 days in calendar year on average of three years*". Number of days exceeding target value of surface ozone is quoted in **Tab. 3.11**.

**Methodical remark*:
Average period is the major daily 8-hour medium value (chosen by investigation of 8-hour moving averages calculated from hourly data and actualized each hour. Each 8-hour average calculated in such a way, will be allocated to the day, in which it finishes, i.e. the first calculated period for any day is period from 17.00 hour of former day until 1.00 hour of the given day; the last calculation period for any one day is period since 16.00 hour until the end of a given day).

Tab. 3.11 *Number of days with exceedance of surface ozone target value for human health protection.*

Station	2015	2016	2017	Average 2015 – 2017
Bratislava, Jeséniova	60	11	38	36
Bratislava, Mamateyova	38	6	22	22
Košice, Ďumbierska	24	8	10	14
Banská Bystrica, Zelená	*6	2	17	10
Jelšava, Jesenského	2	9	11	7
Kojšovská hoľa	*2	20	23	22
Nitra, Janíkovce	39	17	42	33
Humenné, Nám. Slobody	0	3	7	3
Stará Lesná, AÚ SAV, EMEP	15	4	3	7
Gánovce, Meteo. st.	*1	0	0	0
Starina, Vodná nádrž, EMEP	*4	5	3	4
Prievidza, Malonecpalská	24	*0	19	22
Topoľníky, Aszód, EMEP	7	7	8	7
Chopok, EMEP	27	28	*31	28
Žilina, Obežná	0	6	3	3
Ružomberok, Riadok	-	0	0	0

** Year was not calculated in the average due to lack of data in summer season*
≥ 90% requested valid data
Exceedance of target value is marked by red colour

Tab. 3.12 *Number of exceedances (in hours) of information threshold (IT) and warning threshold (WT) for surface ozone to draw attention and warning of inhabitants.*

Station	IT1h = 180 μg.m^{-3}			WT1h = 240 μg.m^{-3}		
	2015	2016	2017	2015	2016	2017
Bratislava, Jeséniova	12	2	6	1	0	0
Bratislava, Mamateyova	2	0	6	0	0	0
Košice, Ďumbierska	0	0	0	0	0	0
Banská Bystrica, Zelená	0	0	0	0	0	0
Jelšava, Jesenského	0	0	0	0	0	0
Kojšovská hoľa	0	0	0	0	0	0
Nitra, Janíkovce	0	0	0	0	0	0
Humenné, Nám. slobody	0	0	0	0	0	0
Stará Lesná, AÚ SAV, EMEP	0	0	0	0	0	0
Gánovce, Meteo. st.	0	0	0	0	0	0
Starina, Vodná nádrž, EMEP	0	0	0	0	0	0
Prievidza, Malonecpalská	0	0	0	0	0	0
Topoľníky, Aszód, EMEP	0	0	0	0	0	0
Chopok, EMEP	0	0	0	0	0	0
Žilina, Obežná	0	0	0	0	0	0
Ružomberok, Riadok		0	0	0	0	0

≥ 90% requested valid data

Values of surface ozone AOT40 for vegetation protection are presented in **Tab. 3.13**. AOT40 is the sum of exceedances of level 80 µg.m^{-3} calculated from 1-hour concentrations, during the day (from 8 00 to 20 00 hour MET) since 1st May to 31st July. Target value is 18 000 µg.m^{-3} (relating to average five calendar years, following one after another). This value was exceeded at four stations (i.e. on these stations the average of values AOT40 during years 2013 – 2017 exceeded value 18 000 µg.m^{3}).

Tab. 3.13 *Values of surface ozone AOT40 for vegetation protection (May – July). Target value AOT40 is 18 000 µg.m^{-3}.*

Station	2015	2016	2017	Average 2013 – 2017
Bratislava, Jeséniova	28 166	13 612	25 042	**21 677**
Bratislava, Mamateyova	20 418	4 450	21 525	15 932
Košice, Ďumbierska	15 111	15 560	11 557	14 025
Banská Bystrica, Zelená	*2 526	*9 771	17 198	**21 263**
Jelšava, Jesenského	6 111	*14 597	12 756	9 434
Kojšovská hoľa	*4 098	18 259	13 056	14 750
Nitra, Janíkovce	21 800	18 684	25 925	**21 315**
Humenné, Nám. slobody	315	13 008	14 209	10 580
Stará Lesná, AÚ SAV, EMEP	9 441	13 151	13 197	11 360
Gánovce, Meteo. st.	*13 719	2 678	7 020	7 766
Starina, Vodná nádrž, EMEP	*10 528	10 235	12 154	11 627
Prievidza, Malonecpalská	*16 823	*5 835	16 167	16 976
Topoľníky, Aszód, EMEP	9 545	11 812	9 334	14 060
Chopok, EMEP	15 557	23 014	29 820	**19 286**
Žilina, Obežná	5 269	14 359	10 956	11 387
Ružomberok, Riadok		3 875	2 801	3 338

** Given year was not calculated into the average, due to lack of data in summer season*
Exceedance of target value is marked by red colour

According to assessment of measurements from monitoring stations of other operators (industrial stations apart from NMSKO), the limit value for PM_{10} was exceeded on the Veľká Ida location (**Tab. 3.14**).

Tab. 3.14 *Air pollution assessment according to limit values for human health protection in year 2017 from industrial stations of other operators – VZZO.*

AGLOMERATION Zone	Pollutant / Averaging period / Limit value [µg.m^{-3}] (number of exceedances)	Health protection: SO_2 1 h 350 (24)	SO_2 24 h 125 (3)	NO_2 1 h 200 (18)	NO_2 1 rok 40	PM_{10} 24 h 50 (35)	PM_{10} 1 rok 40	CO 8 h [1)] 10000
BRATISLAVA	Bratislava, Pod. Biskupice (Slovnaft, a.s.)	1	0	0	19	15	19	1 470
	Bratislava, Vlčie Hrdlo (Slovnaft, a.s.)	3	0	0	21	20	22	1 389
KOŠICE	Košice, Poľov (U.S. Steel, s.r.o.)	0	0	0	12	**53**	33	6 202
	Košice, Haniska (U.S. Steel, s.r.o.)	0	0	2	18	32	25	4 148
Bratislava region	Rovinka (Slovnaft, a.s.)	3	1	0	16	9	19	1 182
Košice region	Veľká Ida (U.S. Steel, s.r.o.)	0	0	0	15	**69**	38	3 152
	Leles (Slovenské elektrárne, a.s.)	0	0	0	7			
Nitra region	Trnovec nad Váhom (Duslo, a.s.)	0	0	0	17	32	25	
Trenčín region	Oslany (Slovenské elektrárne, a.s.)	1	0	0	13			
Žilina region	Ružomberok (Mondi a.s. - Supra)					22	23	

1) maximum 8- hour concentration
Limit value exceedance is marked by red colour

3.3.1 Air quality assessment according to limit and target values for human health protection, concerning SO_2, NO_2, PM_{10}, $PM_{2.5}$, benzene and CO, in classification on agglomerations and zones

In following text, the results of measurements are assessed, in regard to limit and target values of individual pollutants for human health protection. Air pollution quality assessment is a complex problem and to solve it, the mathematical modelling methods are used, apart from monitoring. Those data serve as added information about spatial distribution of pollutant concentrations and in case the input data are at disposal, also about relation to emission pollutant sources. Air quality assessment with the aid of mathematical modelling is presented in Chapter 4.

- **Agglomeration Bratislava**

In year 2017, the limit values for human health protection for SO_2, NO_2, NO_X, PM_{10}, $PM_{2.5}$, benzene and CO were not exceeded in agglomeration Bratislava.

- **Agglomeration Košice**

Daily limit value for PM_{10} was exceeded in agglomeration Košice on AMS Košice, Štefánikova and Košice, Amurská in year 2017. Limit values for annual average concentration of PM_{10} as well as SO_2, NO_2, NO_X for human health protection, were not exceeded. Target value for $PM_{2.5}$ was not exceeded in agglomeration Košice in year 2017.

- **Zone Banská Bystrica region**

Daily average concentrations of PM_{10} exceeded the limit value on AMS: Jelšava, Jesenského; Banská Bystrica, Štefánikovo nábrežie and Hnúšťa, Hlavná. Limit value for annual average concentration of PM_{10} was not exceeded on any station in this zone. Target value for $PM_{2.5}$ was exceeded on AMS Jelšava, Jesenského. High number of daily limit value exceedances for PM_{10} (82 exceedances of daily limit value on AMS Jelšava is the highest number reached on AMS in NMSKO in 2017) and exceedance of target value for $PM_{2.5}$ is possible to assign mainly to heating by solid fuel in this area, where situation is even worse by extremely unfavourable scatter conditions. Limit values in this zone for SO_2, NO_2, NO_X, benzene and CO were not exceeded.

- **Zone Bratislava region**

Limit values in this zone for concentrations of SO_2, NO_2, NO_X, PM_{10}, benzene and CO were not exceeded, similarly also target value for annual average concentrations of $PM_{2.5}$ were not exceeded.

- **Zone Košice region**

In zone Košice region, the daily limit value for human health protection for PM_{10} was exceeded on station Krompachy, SNP and station Veľká Ida, Letná, where the number of 24-hour limit value exceedances of PM_{10} for human health protection reached value 62, in year 2017.

Concentrations of SO_2, NO_2, NO_X, PM_{10}, benzene and CO were not exceeded limit values in this zone, equally also target value for annual average concentration of $PM_{2.5}$ in zone Košice region was not exceeded.

- **Zone Nitra region**

Concentrations of SO_2, NO_2, NO_X PM_{10}, benzene and CO were not exceeded limit values in this zone, as well as target values for $PM_{2.5}$ concentrations were not exceeded in year 2017.

- **Zone Prešov region**

  Limit value for human health protection of daily average PM_{10} concentrations was exceeded in year 2017 on AMS Humenné, Nám. slobody and Prešov, Arm. gen. L. Svobodu. Limit value of annual average concentration for PM_{10} was not exceeded in this zone, similarly as limit values for SO_2, NO_2, NO_X, benzene and CO and target value for $PM_{2.5}$.

- **Zone Trenčín region**

  Limit value for human health protection, concerning daily average concentration of PM_{10}, was exceeded in year 2017 on AMS Trenčín, Hasičská. Limit value for annual average concentration of PM_{10} was not exceeded in this zone, similarly as limit values for SO_2, NO_2, NO_X, benzene and CO and target value for $PM_{2.5}$.

- **Zone Trnava region**

  Limit values for $SO_{2.,}$ NO_2, NO_X, $PM_{10,}$ benzene and CO concentrations were not exceeded in this zone. Also target value for PM2.5 was not exceeded in year 2017.

- **Zone Žilina region**

  Limit value for daily average concentrations of PM_{10} was exceeded in 2017 on AMS Ružomberok, Riadok and Žilina, Obežná. Limit value for annual average concentration of PM_{10} was not exceeded in this zone, similarly as limit values for SO_2, NO_2, NO_X, benzene and CO. Target value for $PM_{2.5}$ was exceeded on AMS Žilina, Obežná.

3.3.2 Air quality assessment according to limit and target values for human health protection, concerning Pb, As, Cd, Ni, BaP, Hg and O_3 in classification on agglomeration and zones

- **Agglomeration Bratislava**

  Limit value for Pb as well as target values for As, Cd, Ni, BaP were not exceeded in agglomeration Bratislava.

  Target value for ozone (8 hour concentration of surface ozone 120 $\mu g.m^{-3}$, permitted number of exceedances is 25 days in calendar year on average of three years) was exceeded at monitoring station Bratislava, Jeséniova. In year 2017, the information threshold was exceeded on two stations: Bratislava, Jeséniova and Bratislava, Mamateyova. Warning threshold was not exceeded.

- **Zone Slovakia**

  Zone allocates the territory of the Slovak Republic, apart from the territory of capital of SR, Bratislava.

  Limit value for Pb and target values for As, Cd and Ni were not exceeded in zone Slovakia. Annual average concentrations of Hg are at level corresponding to background concentrations.

  Target value of surface ozone was exceeded in zone Slovakia on monitoring stations Nitra, Janíkovce and Chopok. In year 2017, the information and warning thresholds for surface ozone were not exceeded in any station of zone Slovakia.

3.4 REGIONAL MONITORING

Regional air pollution is a pollution of a boundary layer of a rural country at a sufficient distance from local industrial and urban sources. The boundary layer of the atmosphere is a mixing layer, extending itself from the Earth surface up to the height of about 1 000 m. In regional positions, the industrial emissions are more or less evenly vertically dispersed in the entire boundary layer and ground level concentrations are smaller than those ones, in cities. In the following text are presented results from EMEP regional monitoring stations, Chapter **3.4.1** contains the air quality monitoring results and Chapter **3.4.2** is devoted to the atmospheric precipitation quality.

3.4.1 Air

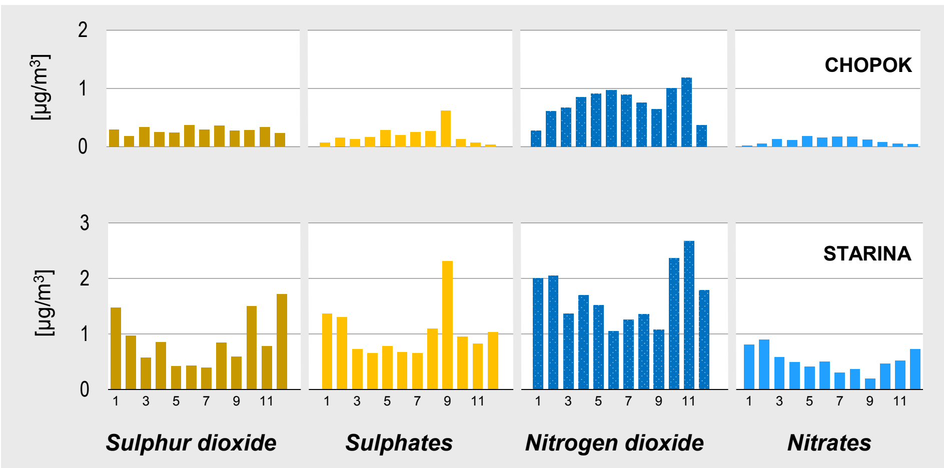
- **Sulphur dioxide, sulphates**

In year 2017, the regional level of sulphur dioxide concentrations recalculated on sulphur, was 0.29 $\mu g.m^{-3}$ on the Chopok station and 0.88 $\mu g.m^{-3}$ on the Starina station (**Tab. 3.15**, **Fig. 3.1**). In coincidence with Annex No. 2 to the Regulation of the Ministry of Environment of the Slovak Republic on air quality No. 244/2016 Coll. of Acts, in wording of Regulation No. 296/2017 Coll. of Acts, the critical level for protection of vegetation is 20 $\mu g\ SO_2.m^{-3}$ in calendar year and winter season. This level was exceeded neither in the calendar year (Chopok 0.6 $\mu g\ SO_2.m^{-3}$ and Starina 1.8 $\mu g\ SO_2.m^{-3}$), nor in winter season (Chopok 0.5 $\mu g\ SO_2.m^{-3}$ and Starina 1.6 $SO_2.m^{-3}$). Annual average concentration of sulphates, recalculated in sulphur, was 0.2 $\mu g.m^{-3}$ on the Chopok station and 1.03 $\mu g.m^{-3}$ on the Starina station (**Tab. 3.15**, **Fig. 3.1**).

- **Nitrogen dioxide, nitrates**

Nitrogen dioxide concentrations recalculated on nitrogen on regional stations in year 2017, presented 0.76 $\mu g.m^{-3}$ on the Chopok station and 1.68 $\mu g.m^{-3}$ on the Starina station (**Tab. 3.15**, **Fig. 3.1**). In coincidence with Annex No. 2 to the Regulation of the Ministry of Environment of the Slovak Republic No. 244/2016 Coll. of Acts on air quality, in wording of Regulation No. 296/2017 Coll. of Acts, the critical level for protection of vegetation is 30 $\mu g\ NO_X.m^{-3}$ in calendar year. This level was not exceeded during the calendar year (Chopok 2.5 $\mu g\ NO_2.m^{-3}$ and Starina 5.5 $\mu g\ NO_2.m^{-3}$). Nitrates on Chopok and on Starina (**Tab. 3.15**, **Fig. 3.1**) were predominantly in particulate form, at comparison to gas nitrates, the difference on Starina is in favour of particulate nitrates more expressive than on Chopok. Gas and particulate nitrates are collected on filters and measured separately. Their phase division is depended on ambient air temperature and humidity. The higher the temperature is, the higher the tendency in favour of gas phase dominates, i.e. HNO_3 formation and vice versa, the higher the humidity is, the higher the tendency in favour of particulate phase dominates, i.e. NO_3^-.

Fig. 3.1 *Monthly average concentrations of air pollutants – 2017 (recalculated on sulphur, resp. nitrogen).*



Ammonia, ammonium ions and ions of alkali metals

In coincidence with the requests of EMEP monitoring strategy for the EMEP stations "level one", the measurements of ammonia, ammonium ions, and ions of sodium, potassium, calcium and magnesium in ambient air started to be measured in May 2005 on the Stará Lesná station. These measurements were finished in September 2007. Since July 2007, the measurements started to be measured at the Starina station. Annual concentrations of the above mentioned components (NH_3 and NH_4 recalculated in nitrogen) from the Starina station in 2017 are listed in **Tab. 3.15**. Annual concentrations of ammonia represent 0.78 µgN.m^{-3} and ammonium ions 1.54 µgN.m^{-3}.

Tab. 3.15 *Annual average concentrations of pollutants [µg.m^{-3}] in air on EMEP stations – 2017.*

	SO_2	SO_4^{2-}	NO_2	NO_3^-	HNO_3	Cl^-	NH_3	NH_4^+	Na^+	K^+	Mg^{2+}	Ca^{2+}
Chopok	0.29	0.20	0.76	0.11	0.07	0.17	-	-	-	-	-	-
Starina	0.88	1.03	1.68	0.52	0.13	0.37	1.54	0.78	0.27	0.19	0.02	0.11

SO_2, SO_4^{2-} – recalculated on sulphur, NO_X, NO_3^-, HNO_3, NH_3, NH_4^+ – recalculated on nitrogen

Heavy metals, atmospheric aerosol

Values of heavy metals lead, copper, cadmium, nickel, chromium, zinc and arsenic concentrations in year 2017 are listed in **Tab. 3.16**. The highest concentration values of copper, lead and zinc were recorded in the Topoľníky station and on the contrary the lowest values were measured in the Chopok station. Annual averages of PM_{10}, resp. TSP from regional stations are not presented due to insufficient number of samples as a consequence of frequent failures of old and new balance system, in case of Starina also by backward beginning of PM_{10} measurements by MPNS.

Tab. 3.16 *Annual average concentrations of ozone [µg.m^{-3}] and heavy metals [ng.m^{-3}] in air on EMEP stations – 2017.*

	O_3	Pb	Cu	Cd	Ni	Cr	Zn	As
Chopok	*98	1.32	0.65	0.04	0.25	0.28	4.54	0.11
Topoľníky	47	6.06	2.12	0.11	0.40	0.46	12.29	0.34
Starina	60	4.16	1.22	0.11	0.30	0.35	7.21	0.25
Stará Lesná	63	3.69	1.39	0.09	0.26	0.22	9.51	0.22

** Less than 90% of valid data*

Ozone

The longest time series of ozone measurements is in Stará Lesná station, from 1992. The measurements of ozone in Topoľníky, Starina and Chopok began to be carried out later, in 1994. In 2017, the annual ozone average concentration at the Chopok station reached 98 µg.m^{-3}, in Topoľníky 47 µg.m^{-3}, in Stará Lesná 63 µg.m^{-3} and in Starina 60 µg.m^{-3} (**Tab. 3.16**).

Volatile Organic Compounds

VOCs (Volatile Organic Compounds) C_2–C_8, (the so-called light hydrocarbons) started to be sampled in autumn 1994 at the Starina station. Starina is one of the few European stations, included into the EMEP network with regular sampling of volatile organic compounds. They are measured and assessed according to the EMEP method, elaborated by CCC-NILU. Their concentrations ranged within one order of magnitude from the tenths of ppb up to several ppb. VOCs and NO_X are precursors of ozone formation. The 2017 annual VOC data are listed in **Tab. 3.17**, however, they do not represent the complete year.

Tab. 3.17 Annual average of volatile organic compound concentrations [ppb] on EMEP station Starina – 2017.

ethane	ethene	propane	propene	i-butane	n-butane	acetylene	trans-2-butene	1-butene
1.465	1.194	0.591	0.293	0.469	0.162	0.023	0.039	0.600
cis-2-butene	**2-metylbutane**	**n-pentane**	**1.3-butadiene**	**trans-2-pentene**	**1-pentene**	**i-hexane**	**n-hexane**	**isoprene**
0.033	0.114	0.283	0.084	0.011	0.022	0.010	0.057	0.051
n-heptane	**benzene**	**i-octane**	**n-octane**	**toluene**	**ethylbenzene**	**m+p-xylene**	**o-xylene**	
0.034	0,296	0.015	0.040	0,811	0.128	2.976	0,208	

3.4.2 Atmospheric precipitation

Quality of atmospheric precipitation is monitored apart from four EMEP stations also at the Bratislava, Koliba station, which serves as the comparison to the regional stations.

- **Major ions, pH, conductivity**

In 2017, the amount of precipitation recorded at background stations ranged from 504 to 1 414 mm. The upper level of precipitation amount belongs to the highest situated station Chopok and low one to Topoľníky, the lowest situated station. Acidity of atmospheric precipitation dominated at the Starina station, with the low level of pH range 5.10 – 5.68 (**Tab. 3.18**). Time series and pH trend within a longer time period on station Chopok (**Fig. 3.2**), indicate clearly the decrease of acidity. Conductivity of atmospheric precipitation is reflection of cations and anions presence, which are conductive. Concentrations of dominant sulphates in precipitation recalculated in sulphur presented on EMEP stations the range 0.28 – 0.47 mg.l^{-1} (**Tab. 3.18**, **Fig. 3.3**). Concentrations of sulphates are at the low level of concentration range at the Topoľníky station and slightly higher at the other stations. Total decrease of sulphates in long-term time series corresponds to the SO_2 emission reduction since 1980. Nitrates, which share on precipitation acidity in smaller extent than sulphates, record concentration range on EMEP stations recalculated on nitrogen 0.24 – 0.38 mg.l^{-1} (**Tab. 3.18**, **Fig. 3.3**). Low level of concentration range is represented by Chopok and upper one by Starina. Ammonium ions also do belong to the major ions and their concentration range on EMEP stations presented 0.34 – 0.41 mg.l^{-1} (**Tab. 3.18**).

Tab. 3.18 Annual weighted averages of pollutants in atmospheric precipitation – 2017.

	Precipitation [mm]	pH	Conductivity [µS.cm^{-1}]	SO_4^{2-} [mg.l^{-1}]	NO_3^- [mg.l^{-1}]	NH_4^+ [mg.l^{-1}]	Cl^- [mg.l^{-1}]	Na^+ [mg.l^{-1}]	K^+ [mg.l^{-1}]	Mg^{2+} [mg.l^{-1}]	Ca^{2+} [mg.l^{-1}]
Chopok	1 414	5.63	10.4	0.372	0.241	0.338	0.216	0.388	0.045	0.028	0.162
Topoľníky	504	5.68	12.5	0.284	0.320	0.360	0.162	0.258	0.045	0.040	0.306
Starina	821	5.10	15.4	0.466	0.381	0.373	0.219	0.411	0.107	0.041	0.307
Stará Lesná	865	5.44	13.4	0.454	0.297	0.405	0.179	0.240	0.062	0.032	0.390
Bratislava, Koliba	545	5.73	26.4	0.479	0.602	0.857	0.352	0.229	0.407	0.216	1.138

SO_4^{2-} – recalculated on sulphur, NO_3^-, NH_4^+ – recalculated on nitrogen

Fig. 3.2 pH in atmospheric precipitation – Chopok.

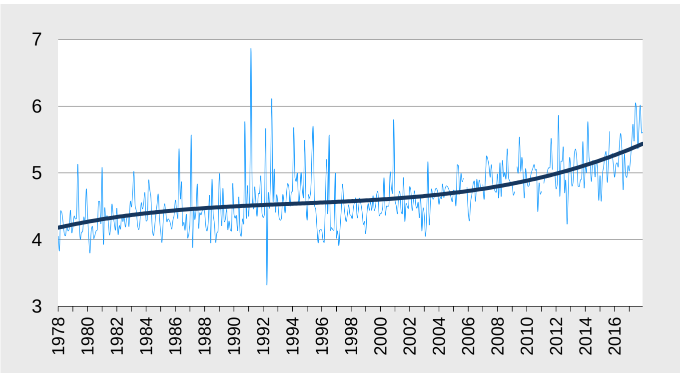
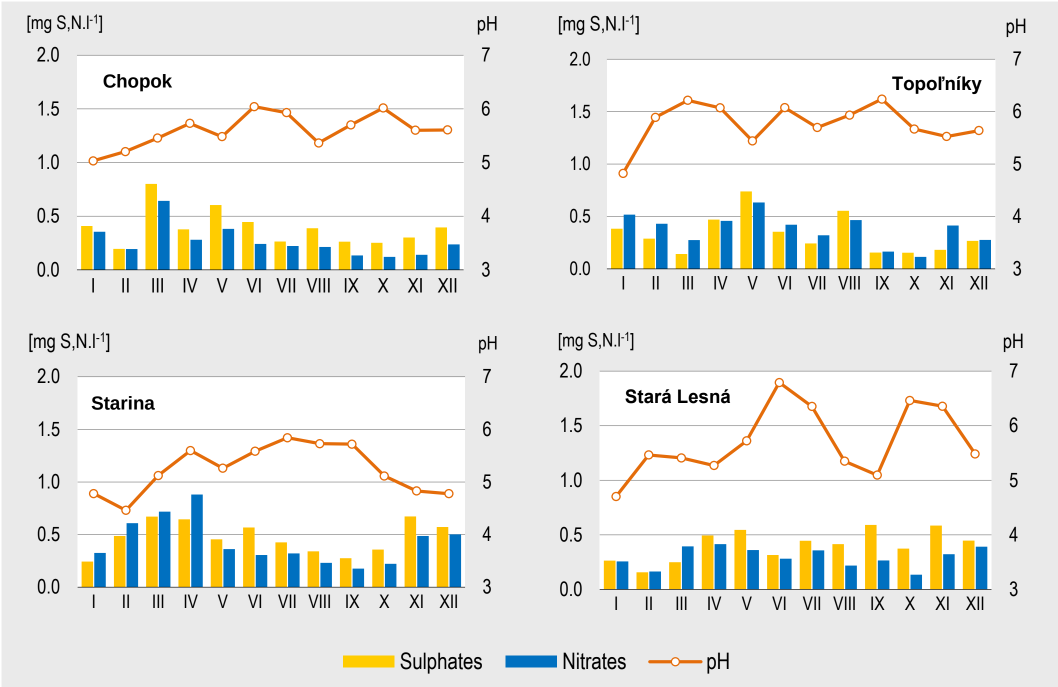


Fig. 3.3 *Atmospheric precipitation – 2017.*



Heavy metals in atmospheric precipitation

Since 2000 the measurement programme of heavy metals in precipitation has been gradually modified and more adopted to meet the requirements of the CCC EMEP (EMEP Chemical Co-ordinating Centre) monitoring strategy. In frame of EMEP programme, for the stations of "level one", the following heavy metals were included: lead, copper, cadmium, nickel, chromium, zinc and arsenic. In Bratislava, Koliba station the measurements of the same set of heavy metals in precipitation were implemented as in background stations of Slovakia. This station serves for comparison and is not considered as the background station. The results of annual weighted means of heavy metals in atmospheric precipitation in year 2017 are presented in **Tab. 3.19**. Zinc, lead and copper have higher representation among the monitored metals than the other metals, similarly as metals in ambient air (**Tab. 3.16**). Long lasting trend of heavy metals shows the decreasing tendency.

Tab. 3.19 *Annual weighted averages of heavy metal concentrations in atmospheric precipitation – 2017.*

	Precipitation [mm]	Pb [µg.l-1]	Cd [µg.l-1]	Cr [µg.l-1]	As [µg.l-1]	Cu [µg.l-1]	Zn [µg.l-1]	Ni [µg.l-1]
Chopok	1 226	1.49	0.02	0.35	0.11	2.73	17.61	0.46
Topoľníky	437	0.95	0.03	0.24	0.07	1.37	38.14	0.20
Starina	922	2.03	0.03	0.38	0.08	2.54	10.16	0.81
Stará Lesná	659	0.98	0.01	0.10	0.05	1.51	5.68	0.25
Bratislava, Koliba	661	2.00	0.03	0.33	0.12	6.15	21.89	0.78

3.5 SUMMARY

- **SO_2**

Limit values for average hourly and average daily SO_2 were not exceeded at any agglomeration or zone, in year 2017. At the same time, no case of warning threshold exceeding was recorded on monitoring stations of SR this year.

Critical value for vegetation protection is 20 $\mu g.m^{-3}$ in calendar year and winter season. This limit value was not exceeded, in year 2017 on any EMEP stations in calendar year or winter season. All values were below low limit for vegetation protection assessment.

- **NO_2**

In year 2017, neither annual, nor hourly limit values were exceeded on any monitoring station. Exceeding of limit value for human health protection for hourly concentrations was not recorded on any monitoring station. In year 2017, was not recorded even the case of NO_2 warning threshold exceeding.

Critical value for vegetation protection (30 $\mu g.m^{-3}$ in calendar year expressed as NO_X) was not exceeded on any of EMEP stations, in year 2017. Values were deeply below low limit for vegetation protection assessment.

- **PM_{10}**

Monitoring of PM_{10} sufficiently covers the territory of Slovakia. The exceedance of limit value for annual average concentration of PM_{10} was not recorded on any monitoring station, in year 2017. Exceedances of limit value for human health protection for 24 hour concentrations were recorded on 12 AMS: Košice, Štefánikova; Košice, Amurská; Banská Bystrica, Štefánikovo nábrežie; Jelšava, Jesenského; Hnúšťa, Hlavná; Veľká Ida, Letná; Krompachy, SNP; Humenné, Nám. Slobody; Prešov, Arm. gen. L. Svobodu; Trenčín, Hasičská; Ružomberok, Riadok; Žilina, Obežná.

- **$PM_{2.5}$**

For $PM_{2.5}$ is determined limit value 25 $\mu g.m^{-3}$ (for annual average concentration), valid from 1. 1. 2015. (Executive decision of Commission 2011/850/EU, Annex 1, point 5). This value was exceeded in year 2017 on monitoring stations Jelšava, Jesenského and Žilina, Obežná. In Jelšava, this fact was probably caused by household heating with solid fuel, demonstrated in cold January. Surroundings of Jelsava is characterised by low wind speed and frequent occurrence of calm. On AMS Žilina, Obežná manifested the influence of road transport.

Health consequences, resulting from air pollution, depend on size and composition of solid pollutants (particles). The smaller the particles are, the more serious health consequences appear. European and after the implementation also Slovakian legislation therefore dislocate the centre of attention on $PM_{2.5}$. One of indicators, which shall characterize the loading of inhabitants by higher concentrations of $PM_{2.5}$, is indicator of average exposition (IAE), which is defined for respective year as continuous middle value of concentration averaging for all sampling places on city background stations, in last three years. According to Annex No. 4 to Regulation No. 244/2016 Coll. of Acts, in wording of Regulation No. 296/2017 Coll. of Acts, the limit value 20 $\mu g.m^{-3}$ has to be reached in year 2020. In **Tab. 3.20** are quoted values of this indicator from year 2010, which is for IAE reference year.

National target of exposition decrease for particles $PM_{2.5}$

Target of exposition decrease concerning average exposition indicator in year 2010		Year, in which the target of exposition decrease shall be reached
Beginning concentration in μg.m⁻³	Aim of decrease	
≤ 8.5	0%	2020
> 8.5 – < 13	10%	
= 13 – < 18	15%	
= 18 – < 22	20%	
≥ 22	All convenient measures to reach 18 μg.m⁻³	

Commitment of decreasing concentration exposition for particles $PM_{2.5}$

Commitment of decreasing concentration exposition valid from year 2015	**20 μg.m⁻³**

Tab. 3.20 *Indicator of $PM_{2.5}$ averaging exposition.*

Year	2010	2011	2012	2013	2014	2015	2016	2017
IPE [μg.m⁻³]	23.8	24.6	24.0	23.2	20.7	19.1	18.4	18.3

- **CO**

CO limit value was not exceeded on any of monitoring stations in Slovakia, in year 2017 and level of air pollution during previous period of years 2011 – 2017 is below the low assessment limit of this level.

- **Benzene**

The major level of benzene was measured on stations Krompachy, SNP and Prešov, arm. gen. Ľ. Svobodu, in year 2017. However, the values of annual average concentrations were significantly below limit value 5 μg.m^{-3}.

- **Ozone**

Target value of surface ozone was exceeded at measurements on three stations: Bratislava, Jeséniova; Nitra, Janíkovce and Chopok. Information threshold was exceeded in year 2017 on stations Bratislava, Jeséniova and Bratislava, Mamateyova. Warning threshold was not exceeded.

- **Pb, As, Ni, Cd**

Neither limit nor target values were exceeded in year 2017.

Annual average concentrations of heavy metals measured on NMSKO stations are mostly only fragment of target, respectively limit value.

- **BaP**

Annual average value of BaP concentration on stations Veľká Ida, Letná; Banská Bystrica, Štefánikovo nábrežie; Žilina, Obežná and Jelšava, Jesenského exceeded target value 1 ng.m^{-3}. Exceeding of target value on AMS in Veľká Ida can be assigned to industrial activity (mainly coke production) and partly also household heating and on the other monitoring stations to the influence of household heating by solid fuels and the road transport, mainly to diesel motors.

4 AIR QUALITY MODELLING

The procedure and criteria for air quality assessment are given by Act No. 137/2010 Coll. of Acts, in full compliance with EU legislation. According to its rules, the mathematical modelling can be used for air quality assessment as a supplementary method. The basis for air quality assessment are data, measured in the National air quality monitoring network (NMSKO).

CEMOD, air quality dispersion model is used for spatial assessment of SO_2, NO_2, NO_X, CO and benzene, while IDW-A interpolation scheme for ozone, PM_{10} and $PM_{2.5}$.

4.1 BRIEF DESCRIPTION OF THE MODELS, USED FOR AIR QUALITY ASSESSMENT

CEMOD, air quality dispersion model

The CEMOD model is based on the US EPA-ISC methodology for calculation of air pollution from stationary sources and the US EPA-CALINE methodology for line (mobile) sources, up to 30 km from the sources. For larger distances it uses a sectoral approach, with the sector angle increasing with distance from source and taking into account the complexity of terrain, in accordance with the ISC methodology. The methodology includes a correction factor for decrease of pollution concentration with altitude, which is determined upon the base of measurements from regional background stations.

The chemical transformation of NO_X to NO_2 is calculated in accordance with the TA-Luft 2002 methodology, for all stationary sources, outside urban environment and in urban environment, for sources, with an effective height of sources, more than twice the mean installation height.

The cited methodology is improved by the correction coefficient taking into account the density and structure of the urban areas (surface roughness) for mobile sources and stationary sources with an effective height of sources less than twice the mean of build-up height. CEMOD requires hourly meteorological and emission input data. Model output contains hourly concentrations for each grid point, which are used to calculate the eight-hour means, daily and annual concentrations and respective percentiles, corresponding to hourly and daily limit exceedances.

Input data:

- **Geographical data,** e.g. computational domain, grid node coordinates and altitudes, altitude and coordinates of receptor points, structure of urban areas, geometry of selected street.
- **Emissions** from large and medium air pollution sources and chimney parameters from NEIS database, road traffic intensities and emissions according to vehicles emission standards, velocities and road types.
- **Meteorological data** – hourly meteorological input data, measured at meteorological stations and output of the meteorological model.
- **Background concentrations** – measured data from the EMEP stations. These concentrations are used as long range air pollution.

Model output:

- Concentrations of pollutants in the regular grid and for the reference points (monitoring stations).
- Derived characteristics, required by the legislation (percentiles are used instead of number of daily or hourly exceedances).

When interpreting the results, it is necessary to keep in mind the used spatial resolution of 1 km – model calculates concentrations in a regular grid with a node distance of 1 km.

- **Anisotropic inverse distance weighted interpolation scheme (IDW-A)**

The IDW-A, interpolation scheme was used for those pollutants, for which is difficult or impossible to obtain usable input data for the CEMOD dispersion model. In the interpolation scheme is implemented an environmental anisotropic factor, taking into account the impact of orography on dispersion of pollutants. The measured concentrations were used as input data for calculation. Smoothing and exponent of the horizontal representativeness were defined for each input. Regionalization (spatial representativeness) of measurements was introduced. The measured concentrations were interpolated into the reference altitude, by empirically obtained formula – relation between the concentrations and the altitude based on the measurements of EMEP monitoring stations. The IDW-A interpolation scheme thus enables the 3D spatial distribution of the specific derived air pollution characteristics, based on measured data.

Input data:

- Measured and derived data from air quality monitoring stations.
- Anisotropy factors, reflecting the impact of the orography on pollutant dispersion at a given site.
- Attributes for each measuring point – significance of local air pollution sources, geographical parameters, urban areas, smoothing parameters.

Model output:

- Concentration of the pollutants in the regular grid.
- Derived characteristics required by legislation (moving means, AOT40, percentiles used, instead of the number of daily or hourly exceedances).

4.2 MODELLING RESULTS

■ **Sulphur dioxide – SO_2**

Air quality model CEMOD was used to obtain spatial country wide distribution of air quality indicators for SO_2. The model requires hourly emission rates and meteorological characteristics of atmospheric boundary layer. Annual emission rates and stack parameters (co-ordinates, height and diameter, flue gas speed and temperature) were obtained from the NEIS database.

Measurements on the EMEP regional stations are used as supplementary data for the spatial air quality assessment. Concentrations measured at the remaining air quality monitoring stations (AMS) are used for the model validation.

Emissions – Since 1990-ties, SO_2 emissions have been decreasing in Slovakia. ENO (Slovenské elektrárne, Nováky) was responsible for last significant decrease in 2016. ENO is one of four dominant sources of air pollution in Slovakia, with the total emissions, representing about ¾ of all SO_2 emissions of large and medium sources in the country (ENO 29.9%; U.S. Steel Košice 28.2%; Slovnaft Bratislava 10.3%; Slovalco, a.s., Žiar nad Hronom 10.6%). Stacks and vents are represented in the model as point sources. Small sources (mainly household heating), as well as medium and large sources with low emission fluxes, are represented as area sources.

Database NEIS contains 9 324 stacks with SO_2 emissions, however, the emissions of most of them are rather low – less than 1 ton per year. That is why just the selected sources with higher emissions (259 stacks) were selected for the model simulation for year 2017. The subset of stacks used for simulation, represents 99.2% of the total SO_2 emissions. Emissions from small sources (domestic heating) are less significant than that ones, of industrial sources. In the model calculations, small sources, as well as medium and large sources, with small emission fluxes, were represented by 35 area sources.

Model results – A slight inter-annual increase of SO_2 concentrations was confirmed, as a result of slightly worsened dispersion conditions and effect of cold January.

The complexity of problems of air quality modelling, using a dispersion model, such as CEMOD is, that it is not easy to capture vertical profile of wind speed, particularly important for SO_2, where the dominant sources are large energy production and industrial sources with high stacks.

The highest values of measured hourly concentrations occurred in the localities, influenced by major emission sources, however SO_2 did not exceed the low limit for the assessment, given by the legislation.

No exceedance of limit value for mean 24-hour SO_2 concentration occurred at any of the stations in NMSKO, in 2017.

However, hourly mean concentration value of 350 $\mu g.m^{-3}$ was exceeded in Bratislava, Mamateyova monitoring station (1 out of 24 of exceedances per year is allowed by legislation).

The underestimation of hourly concentrations in CEMOD outputs close to the ENO power plant and sources in Vranov nad Topľou, is due to different nature of upper-air and surface winds. Due to the effective height of stacks, the smoke plume of these sources is influenced by the upper-air, rather than the surface wind, entering the model calculations as one of the input parameters.

From **Fig. 4.1**, **Fig. 4.2** and **Fig. 4.3** is evident, that the territory affected by higher SO_2 concentrations is related to the locations of most important SO_2 emission sources. The location of dominant sources (ENO, U.S. Steel and Slovnaft) is evident from these three maps. Air quality modelling confirmed, that the limit value for SO_2 was not exceeded in 2017. Last exceedance appeared in 2004 at Bystričany monitoring station.

Fig. 4.1 *Annual mean of SO_2 concentration [$\mu g.m^{-3}$] – 2017.*

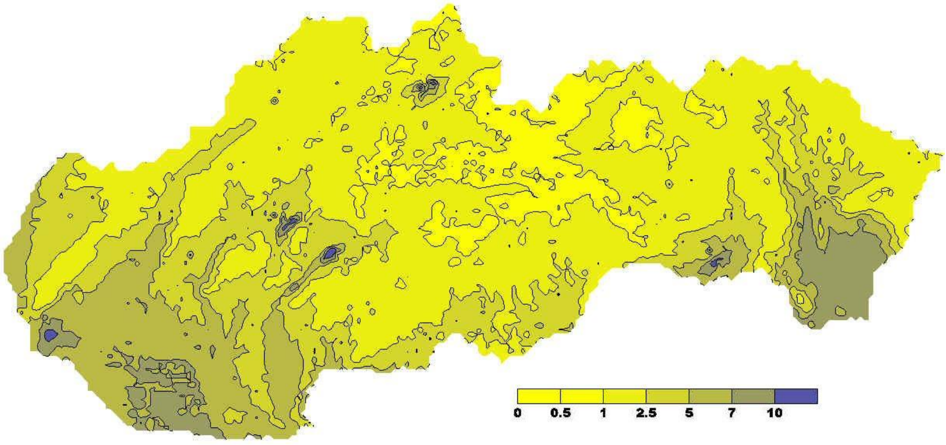


Fig. 4.2 *99.2 percentile of daily mean of SO_2 concentration [$\mu g.m^{-3}$] – 2017.*

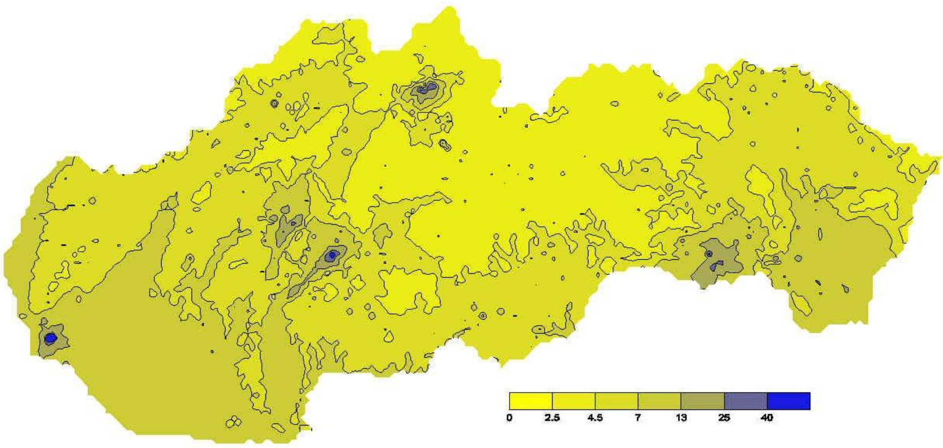
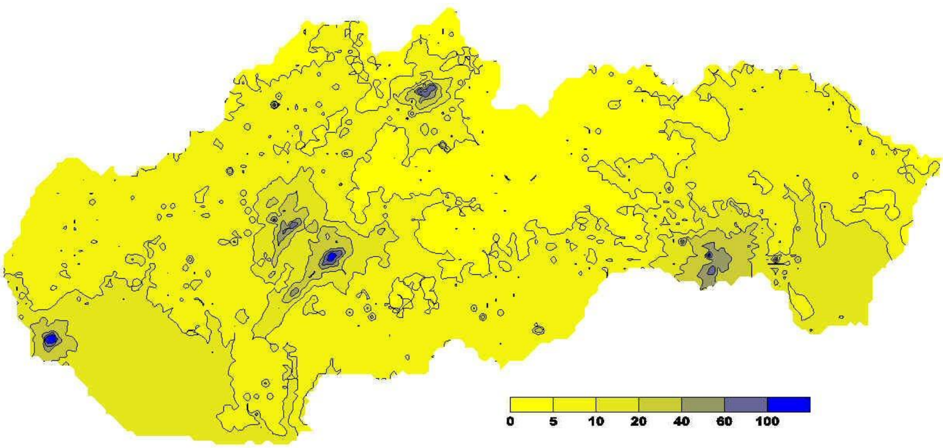


Fig. 4.3 *99.7 percentile of hourly mean of SO_2 concentration [$\mu g.m^{-3}$] – 2017.*



Tab. 4.1 Measured (AMS) and modelled (CEMOD) air quality indicators for sulphur dioxide (SO_2) – 2017.

AGGLOMERATION Zone	Monitoring station	(SO_2) – annual mean concentration [μg.m^{-3}]			99.2-percentile from 24-hour concentrations of sulphur dioxide			99.7-percentile from hourly concentrations of sulphur dioxide		
		AMS	CEMOD	Diff	AMS	CEMOD	Diff	AMS	CEMOD	Diff
BRATISLAVA	Bratislava, Mamateyova	7.5	7.1	-5%	15	14	-7%	38	34	-11%
KOŠICE	Košice, Štefánikova*	13.3	5.0	-62%	20	11	-45%	41	25	-39%
Banská Bystrica region	Banská Bystrica, Štefánikovo nábr.	4.2	3.8	-10%	11	9	-18%	27	15	-44%
Bratislava region	Malacky, Mierové nám.	5.2	5.5	6%	13	9	-31%	20	13	-35%
Košice region	Krompachy, SNP	5.9	6.4	8%	11	14	27%	18	27	50%
Nitra region	Nitra, Štúrova**	8.0	7.5	-6%	13	11	-15%	21	14	-33%
Prešov region	Vranov n/Topľou, M. R. Štefánika	8.0	8.1	1%	19	14	-26%	36	20	-44%
Trenčín region	Prievidza, Malonecpalská*	4.8	6.0	25%	17	15	-12%	41	31	-24%
	Bystričany, Rozvodňa SSE	6.3	8.5	35%	30	23	-23%	77	63	-18%
	Handlová, Morovianska cesta	5.4	6.9	28%	40	17	-58%	64	36	-44%
	Trenčín, Hasičská	7.1	6.9	-3%	16	11	-31%	20	19	-5%
Trnava region	Senica, Hviezdoslavova	4.2	5.7	36%	20	9	-55%	26	14	-46%
Žilina region	Ružomberok, Riadok	4.6	5.2	13%	12	12	0%	24	23	-4%

** Percentage of valid data less than 50%* *** Percentage of valid data less than 85%* *Diff – difference*

Tab. 4.1 contains the calculated and measured indicators for air quality assessment (99.2 percentile corresponds to limit value for 24-hour means and 99.7 percentile corresponds to limit value for hourly means). It is obvious, that the smaller is the measured value, the more difficult is to achieve the required accuracy in calculations. This is particularly the case for the mean annual concentrations, where the absolute difference of 1 μg.m^{-3} represents a percentage of up to 15% (which is a common measurement uncertainty of air quality monitoring instruments), while required model accuracy is 30%. For mean daily and hourly values, the absolute value of the differences between measured and modelled concentrations is relatively small.

Comparison of calculated results with measured values in Tab. 4.1 points in part to the problem of small, unrecorded air pollution sources (residential heating systems) at the site. Until 2016, ENO power plant as the only point source, had a dominant influence on SO_2 concentrations, measured at the monitoring stations in its vicinity (i.e. Prievidza, Bystričany and Handlová). At present, however, the residential heating by coal influences the air quality in Nováky.

Annual mean of background concentrations, measured at the EMEP monitoring stations, was less than 1.65 μg.m^{-3}. Those values are smaller than 8.3% of limit value for protection of vegetation. An increase of this value compared to 2016 was observed only at the EMEP station with a lower altitude. This fact, also taking into account the slight decrease in emissions (by almost 5%) confirms, that in 2017, the conditions for dispersion of pollutants worsened, as compared to 2016. At the same time, it points to the unchanged situation in the interannual transboundary transmission of this pollutant.

Nitrogen dioxide, oxides of nitrogen – NO_2, NO_X

Air quality model CEMOD was used to obtain spatial country-wide distribution of the air quality indicators for NO_2. The data for pre-processing procedure is similar to SO_2. However, the model takes into account the oxidation of NO_X to NO_2 and is more input intensive. Concentrations measured at EMEP stations were used as supplementary data for the spatial distribution of background concentrations. The model calibration is based on the measured values (receptor points - AMS - Tab. 4.2).

Emissions – Road transport is significant source of oxides of nitrogen, representing about 40% of total NO_X emissions from all sectors. The input data of mobile sources, including the structure of road network and transport intensities, are particularly important for this reason.

In the process of input data preparation, the main road network with a total length of 10 634 km was divided into 3 258 road sections and the corresponding emissions of passenger cars and trucks were calculated. For calculation in receptor points (**Tab. 4.2**), local communications were included to complete the main road network. In addition to information from the traffic census in 2015, the growth coefficients according to the projected traffic intensity, provided by the Slovak Road Administration, were applied. In model calculations, fugitive emissions, parking places, fuel filling stations and other known local impacts, were represented by area sources.

Annual emissions for large and medium point sources were obtained from the NEIS data base, appropriate time profiles according to the source types were applied. Database NEIS contains nearly 9 870 stacks with NO_2 emissions, however, the emissions are mostly rather low – only 902 of them had annual emissions of higher than 1 t and only 61 stacks of more than 100 t. That is why just the sources with higher emissions (457 stacks) were selected for the model simulation for year 2017. The subset of stacks, used for simulation, represents more than 98.6% (21 946 t) of the total NO_2 emissions from large and medium NO_2 emission sources (22 261 t). Of this total, only four major sources (ENO, U.S. Steel, Mondi SCP and Slovnaft) emit 35% of the total emissions from medium and large sources.

In contrast to sulphur dioxide, emissions of oxides of nitrogen are not a matter of several dominant large air pollution sources. The higher number of chimneys (vents) were included in model input as compared to modelling of CO or benzene. Local heating systems – heating plants – account for larger part of the remaining share of emissions of medium and large air pollution sources. Small sources of air pollution (mainly domestic heating systems) emitted about 5%, as compared to emissions from medium and large sources.

Small sources (residential heating) and industrial point sources with low emission fluxes from the NEIS database, parking places and road segments with incomplete information on traffic intensities, were represented by area sources. The results of calculations at these points are mainly used to determine the influence of indirect effects (fugitive emissions, short-term economic activities, etc.).

Tab. 4.2 *Measured (AMS) and modelled (CEMOD) air quality indicators for nitrogen dioxide (NO_2) – 2017.*

AGGLOMERATION Zone	Monitoring station	(NO_2) – annual mean concentration [μg.m^{-3}]			99.8th-percentile from hourly concentrations of nitrogen dioxide		
		AMS	CEMOD	Difference	AMS	CEMOD	Difference
BRATISLAVA	Bratislava, Trnavské mýto	39	36	-8%	132	145	10%
	Bratislava, Jeséniova	14	21	50%	77	66	-14%
	Bratislava, Mamateyova	24	26	8%	116	102	-12%
KOŠICE	Košice, Štefánikova	31	33	6%	119	131	10%
Banská Bystrica region	Banská Bystrica, Štefánikovo nábr.	38	33	-13%	132	146	11%
	Banská Bystrica, Zelená	13	13	0%	77	50	-35%
	Jelšava, Jesenského	10	10	0%	50	41	-18%
Bratislava region	Malacky, Mierové nám.	29	25	-14%	97	103	6%
Košice region	Krompachy, SNP	18	19	6%	73	71	-3%
Nitria region	Nitra, Janíkovce	14	17	21%	87	81	-7%
	Nitra, Štúrova	35	31	-11%	116	161	39%
Prešov region	Humenné, nám. slobody	11	13	18%	82	47	-43%
	Prešov, Arm. gen. L. Svobodu	38	37	-3%	107	144	35%
Trenčín region	Prievidza, Malonecpalská	19	21	11%	94	70	-26%
	Trenčín, Hasičská	31	34	10%	108	123	14%
Trnava region	Trnava, Kollárova	37	35	-5%	118	155	31%
Žilina region	Martin, Jesenského	26	23	-12%	85	74	-13%
	Ružomberok, Riadok	21	21	0%	89	98	10%
	Žilina, Obežná	25	19	-24%	103	132	28%

Model results – At the stations Bratislava, Trnavské Mýto, Banská Bystrica, Štefánikovo nábr., Prešov and Trnava, the average annual concentrations were slightly below the limit value (37 to 39 μg.m^{-3}). Annual mean concentrations of nitrogen dioxide exceeded the upper limit for the assessment of air pollution only at five monitoring stations (Bratislava, Trnavské Mýto, Banská Bystrica, Štefánikovo nábr.; Nitra, Štúrova; Prešov, Arm. gen. Ľ. Svobodu and Trnava, Kollárova). All of these AMS are located close to the roads with high traffic intensity. The highest hourly mean concentration was measured at Bratislava, Trnavské mýto and Banská Bystrica, Štefánikovo nábr. (identical values 132 μg.m^{-3}). However, the hourly upper limit for the assessment (140 μg.m^{-3}) was not exceeded.

In terms of annual amount of solar radiation, year 2017 was one of the years with increased rate of photochemical reactions. Photochemical activity in air is a function of global radiation and supports the rate of chemical transformation of NO_X to NO_2. The measured values of nitrogen dioxide at the station Bratislava, Trnavské mýto, are proof of that. Despite the temporary diversion of road traffic, we did not observe such a drop in concentration as in the case of carbon monoxide (CO) and benzene. The decrease in concentrations due to the increased distance was compensated by a gradual chemical transformation.

In the legislative is given the mean annual critical level for NO_X for protection of vegetation. No limit value of NO_X is set for protection of human health. Model calculations of NO_X are only informative and serve to verify the functionality of the CEMOD model. The measured data for NO_X are not given, because the continuous measuring instruments in the NMSKO are not intended for vegetation protection purposes.

Fig. 4.4 shows the spatial distribution of average annual concentrations of oxides of nitrogen (NO_x), **Fig. 4.5** is the spatial distribution of average annual concentrations of nitrogen dioxide, and **Fig. 4.6** presents 99.8 percentile of the hourly NO_2 concentration, (99.8 percentile corresponds to the 18th highest hourly concentration. The 1-hour NO_2 limit value of 200 μg.m^{-3} must not be exceeded more than 18 times per calendar year).

In case of nitrogen dioxide (**Fig. 4.5, Fig. 4.6**), the impact of mobile sources (i.e. the road network) is generally less pronounced due to the gradual transformation of emitted oxides of nitrogen into nitrogen dioxide (this transformation is a function of time), respectively, due to dispersion and advection as a function of distance. The result is a combination of the effects of road transport, stationary sources and background concentrations. In case of CO, the share of automobile transport is more significant – this is due to the fact, that only a few dominant stationary air pollution sources are registered, the other ones are of little importance. The same applies to the mean hourly concentrations of nitrogen dioxide. In the case of NO_X in **Fig. 4.4** (immediate chemical transformation of NO_x to NO_2) we can already see the lines of highways (similarly as it is possible to see in the case of CO)

The annual mean background concentration measured in 2017 at EMEP stations is 5.5 μg.m^{-3} and smaller one. The measured value is less than 18.3% of the limit value for vegetation protection. An increase in this value compared to 2016 was observed only at the EMEP station with a lower altitude. Bearing in mind the slight decrease in emissions, this fact confirms that in 2017 the conditions for the dispersion of pollutants were worsened as compared to 2016. At the same time, it points to the unchanged situation in the year-on-year transboundary transmission of this pollutant. This situation is similar to that one, of sulphur dioxide

Fig. 4.4 *Annual mean of NO_X concentration [µg.m^{-3}] – 2017.*

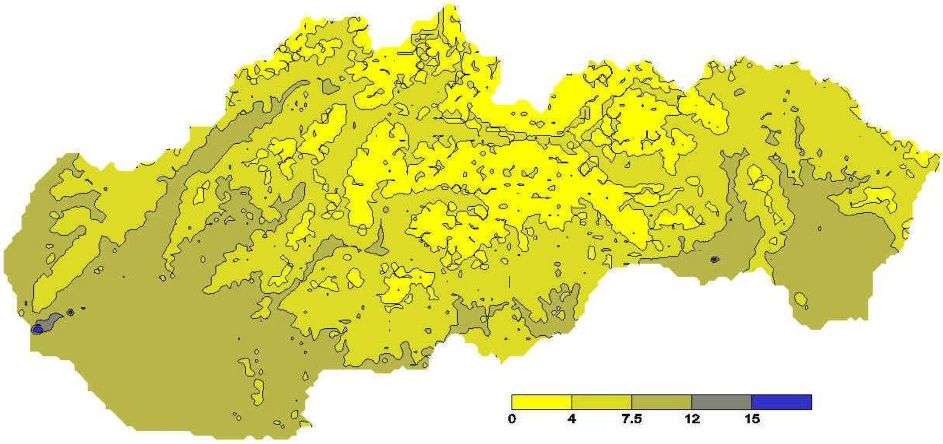


Fig. 4.5 *Annual mean of NO_2 concentration [µg.m^{-3}] – 2017.*

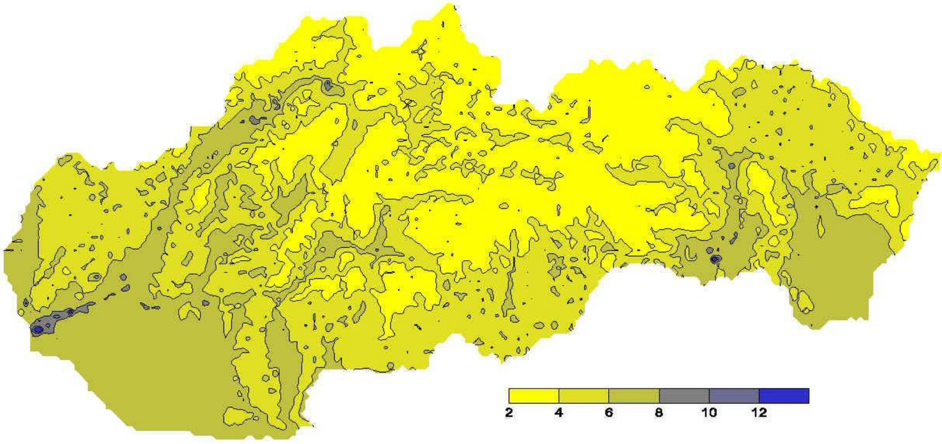
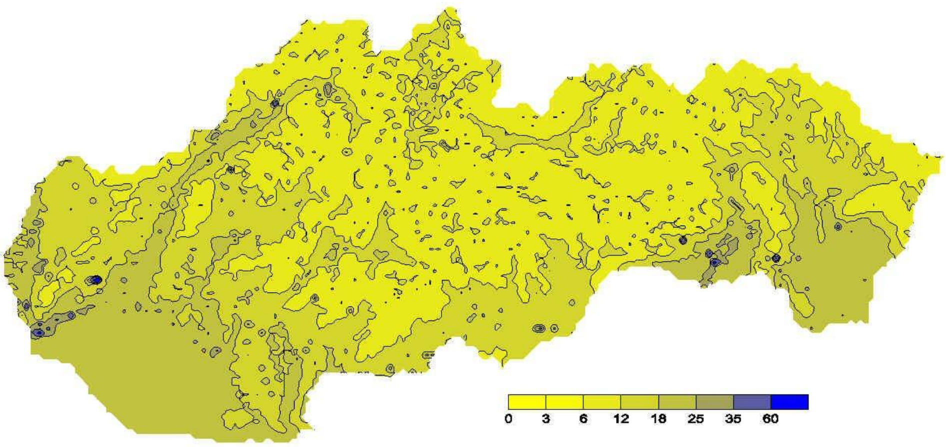


Fig. 4.6 *99.8 percentile of hourly NO_2 concentrations [µg.m^{-3}] – 2017.*



Carbon monoxide – CO

Air quality model CEMOD was used to obtain spatial country wide distribution of the air quality indicators of carbon monoxide. For the input data processing, the same procedure was used as for NO_2, but the model calculated a maximum 8 hour moving means per day.

The concentrations measured in monitoring network were used to calibrate the model. In 2017, carbon monoxide was monitored at 13 stations of NMSKO.

Whereas carbon monoxide is one of the basic pollutants, it is necessary to estimate its spatial country-wide distribution, although the limit values for CO are not exceeded in Slovakia.

Emissions – The emissions from road transport (mobile sources) as well as from industrial, energy and heat production (stationary sources) were used as the model input data. Mobile sources are responsible for about 10% of total carbon monoxide emissions in Slovakia, while emissions from domestic heating are estimated for over 40%. Emissions of large industrial, energy and heat production sources are higher. The carbon monoxide emissions of mobile sources are more strongly dependent on engine operating mode, than in case of nitrogen dioxide. Cold start, driving with a cold engine over short distances, increases exhaust emissions from road transport, especially in winter. Similarly to the procedure with NO_2, emissions were calculated using the traffic intensities per vehicle type and road segments. In case of trucks, slightly more pessimistic combination of emission factors was used, compared to the European standards, taking into account the technical condition of vehicles in Slovakia.

Emissions of carbon monoxide from large and medium stationary sources were obtained from NEIS emission database, and similarly to the procedure of SO_2 and NO_2, only the stacks with higher emissions were used in the model simulation. Of the total number 9 823 stacks and vents with carbon monoxide emissions, 188 of them were included into the calculations. The subset of stacks used for the simulation represents nearly 97% of the total carbon monoxide emissions. U.S. Steel Košice and Slovalco, Žiar nad Hronom together, produce about 85.2% of the above emissions of large and medium sources (U.S. Steel Košice 74.3% and Slovalco, Žiar nad Hronom 10.9%). Another major source of carbon monoxide emissions is metallurgy, cement and lime production.

In the model simulation, stationary air pollution sources with low emission rates, parking places and road segments with incomplete information on the traffic intensities, were represented by the area sources. The fugitive emissions and other local effects were then represented by 29 area sources.

Model results – In 2017, the limit value for protection of human health and low limit for the assessment of carbon monoxide were not exceeded. This pollutant has been unproblematic for several years. The results of measurements in 2017 confirm the observed trend of a country wide slight decrease in measured values in Slovakia. More significant increase in carbon monoxide concentrations was recorded at the Trenčín, Hasičská and Ružomberok, Riadok stations. Apparently, the traffic monitoring station is affected by problems with traffic flow. On the other hand, the most significant decrease in concentrations was recorded at the stations Bratislava, Trnavské mýto; Nitra, Štúrova and Trnava, Kollárova. The decrease recorded at the Bratislava, Trnavské mýto station is probably influenced by a temporary change in the organization of traffic in 2017.

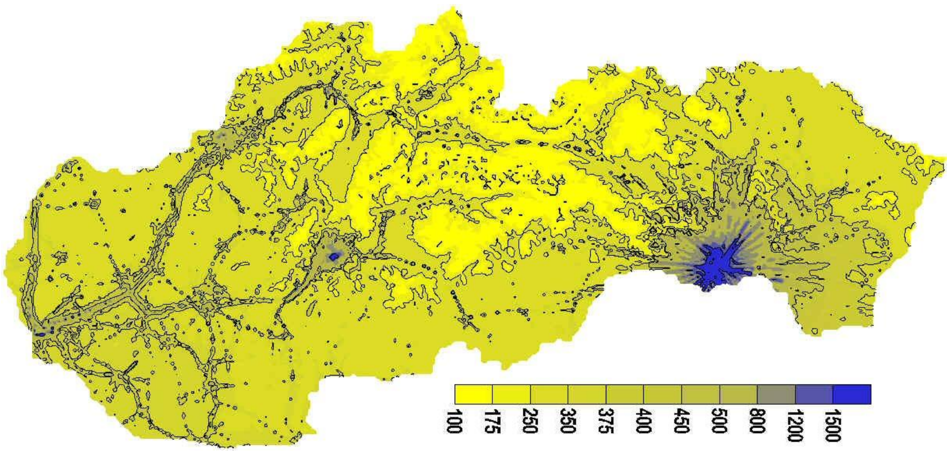
Fig. 4.7 shows the spatial distribution of maximum daily 8-hour moving means of CO, with the dominant influence of mobile sources. The increased impact of road traffic on the level of carbon monoxide occurred at most traffic monitoring stations, with the local character of road traffic, being more pronounced, including local problems with traffic flow and parking. Impact of U.S. Steel, Košice dominates near this air pollution source, and influences also the regional background over longer distances. The annual mean background concentration estimated for 2017 varied from 150 to 350 $\mu g.m^{-3}$. When interpreting the results, it is necessary to keep in mind, that a spatial resolution of 1 km was used (the model calculates the resulted concentrations in a regular grid with a node point distance of 1 km).

Tab. 4.3 *Measured (AMS) and modelled (CEMOD) air quality indicators for carbon monoxide and their difference in [%] – 2017.*

AGGLOMERATION Zone	Monitoring station	CO – 8-hour mean [µg.m^{-3}]		
		AMS	CEMOD	Difference
BRATISLAVA	Bratislava, Trnavské mýto*	1 004	1 590	58%
KOŠICE	Košice, Štefánikova	2 148	2 228	4%
Banská Bystrica region	Banská Bystrica, Štefánikovo nábr.	2 238	2 189	-2%
Bratislava region	Malacky, Mierové nám.	1 601	1 823	14%
Košice region	Veľká Ida, Letná	2 470	2 426	-2%
	Krompachy, SNP	2 033	1 848	-9%
Nitra region	Nitra, Štúrova	1 466	1 604	9%
Prešov region	Prešov, Arm. gen. L. Svobodu	2 214	2 321	5%
Trenčín region	Trenčín, Hasičská	3 686	3 421	-7%
Trnava region	Trnava, Kollárova	1 584	1 710	8%
Žilina region	Martin, Jesenského	2 136	2 193	3%
	Ružomberok, Riadok	3 091	2 906	-6%
	Žilina, Obežná	2 156	2 234	4%

** Temporary change in organization of transport*

Fig. 4.7 *Maximum daily 8-hour moving mean of CO [µg.m^{-3}] – 2017.*



Benzene

Due to the high potential risk of this substance to human health, the increased attention has to be paid to the issue of benzene. The content of benzene in fuels is known only approximately and to determine the emission factor for a representative car is problematic, resp. can be determined only with a high degree of uncertainty. Therefore, we decided at this stage of development to use knowledge from abroad (Germany, Czech Republic). It has been found, that there is a significant statistical relationship between the concentrations of benzene and carbon monoxide, measured in parallel. The close relationship between the concentrations of both pollutants reflects the similarity of the conditions in their emissions into the air. Until 2003, we used the IDW-A interpolation mode, as a modelling tool using the above findings. After the extension of the CEMOD model, only the CEMOD model has been used for this pollutant since 2004 for the nationwide assessment of air quality.

In 2017, the low limit for assessment (2 µg.m^{-3}) of benzene was exceeded at the monitoring stations Krompachy, SNP and Prešov Arm. gen. L. Svobodu, the upper limit for assessment (3.5 µg.m^{-3}) was not exceeded.

Emissions – The main source of benzene emissions is road transport and combustion processes in the industry. Slovnaft Bratislava and U.S. Steel Košice are dominant sources of benzene emissions among large and medium air pollution sources in NEIS database.

However, the amount of benzene emissions from road transport is one order of magnitude higher, as compared to emissions from industrial sources. Fugitive sources cannot be forgotten (petrol contains only about 1% of benzene by volume). The input data on emissions from mobile sources were processed by similar procedure as carbon monoxide and oxides of nitrogen. Fugitive emissions and known local activities were represented by 56 area sources in the model simulation.

Model results – Fig. 4.8 shows the spatial distribution of annual mean benzene concentration. Although the spatial resolution of the model simulation is 1 x 1 km, it is possible to recognize the road network fragments in spatial distribution of annual mean benzene concentration. Emissions of mobile sources significantly affect air quality, close to the roads, as they are emitted directly into the human breathing zone. The contribution of road transport outside the city, close to roads, represents only 0.1 $\mu g.m^{-3}$ in annual mean. In Bratislava agglomeration, the impact of dominant stationary sources (Slovnaft) is apparent, in addition to impact of roads with heavy traffics. The background concentration based on previous measurements at EMEP stations represents less than 10% of limit value for protection of human health. Annual mean concentrations on background stations decreased in recent years. This seems to be a pan-European trend.

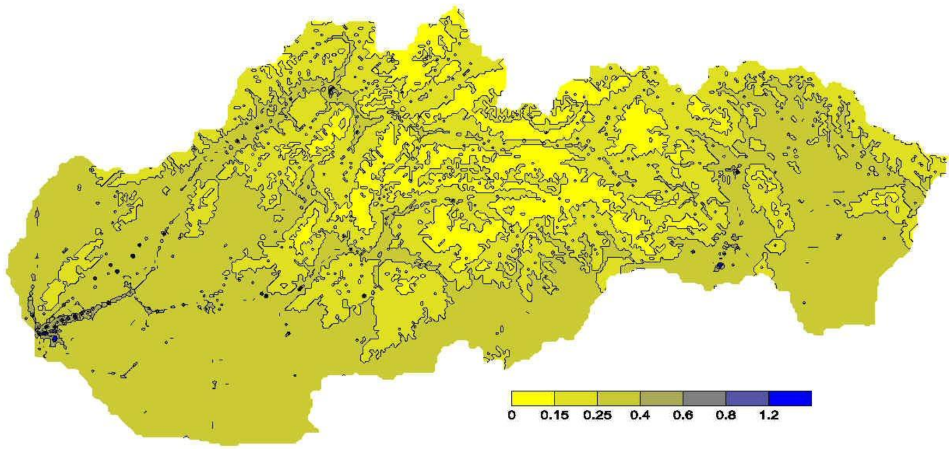
According to the results of mathematical modelling, the limit value for benzene was not exceeded in Slovakia in 2017. According to measurements in NMSKO, in 2017, the highest average annual benzene concentration was observed in Krompachy (2.6 $\mu g.m^{-3}$). This relatively high value is probably a response to the parking of vehicles with a higher age average between residential buildings near the metering station, where also the effect of nearby petrol station (about 200 m from the monitoring station) appeals. Similarly, at monitoring station in Prešov, the increased average annual benzene concentration (in 2017 - 2.5 $\mu g.m^{-3}$) shows a significant impact of nearby fuel filling station. At monitoring station Martin, Jesenského, a return of average annual benzene concentration to 1.5 $\mu g.m^{-3}$ was observed after two-year decrease. The presumed cause of the increase in concentrations, observed at this station, may be also in increased number of parked vehicles close to monitoring station. At monitoring station Nitra, Štúrova, declining trend can be observed. The values measured at station Bratislava, Trnavské mýto, probably reflect a temporary change in organization of the road traffic in 2017. The level of air pollution by benzene throughout (in Slovakia) has a slight declining trend in recent years, which continues in 2017 and that can be concluded (despite the reduced statistical significance of the measured data), that reconstruction of the NMSKO was in progress in 2015 and 2016.

Tab. 4.4 *Measured (AMS) and modelled (CEMOD) air quality indicators for benzene and their difference in % in 2017.*

AGLOMERATION Zone	Monitoring station	Benzene – annual mean concentration [$\mu g.m^{-3}$]		
		AMS	CEMOD	Difference
BRATISLAVA	Bratislava, Trnavské mýto*	0.5	0.7	40%
KOŠICE	Košice, Štefánikova	1.6	2.1	31%
Banská Bystrica region	Banská Bystrica, Štefánikovo nábr.	1.4	1.4	0%
Bratislava region	Malacky, Mierové nám.	1.2	1.3	8%
Košice region	Krompachy, SNP	2.6	2.7	4%
Nitra region	Nitra, Štúrova	0.5	0.5	0%
Prešov region	Prešov, Arm. gen. L. Svobodu	2.5	2.7	8%
Trenčín region	Trenčín, Hasičská	1.1	1.2	9%
Trnava region	Trnava, Kollárova	1.1	1.2	9%
Žilina region	Martin, Jesenského	1.5	1.7	13%
	Ružomberok, Riadok	0.8	0.9	13%

** Temporary change in organization of transport*

Fig. 4.8 *Annual mean concentration of benzene [µg.m^{-3}] – 2017.*



- **Ground level ozone – O_3**

Ground level ozone is one of secondary pollutants, created as a product of photochemical reactions from ozone precursors such are NO_X, VOC and CO. The transport of ozone from the upper levels of atmosphere (stratosphere) plays an important role, mainly in mountains (Tab. 3.10). Annual mean ozone concentrations generally increase with altitude. The maximum values are measured at sites in the higher mountains, while the smaller values are measured at monitoring stations in city centres.

In 2017, the inter annual increase of annual mean ozone concentrations was 10%, as compared to the previous year, In 2016, this value inter annually decreased by 7%. The biggest increases in annual mean of O_3 concentrations in 2017 were measured in stations Bratislava, Jeséniova and Banská Bystrica, Zelená.

The interpolation model IDW-A was used to obtain spatial country wide distribution of air quality indicators for O_3. The measurements from air quality monitoring network and parameters, required by IDW-A methodology, were used as model input data. Fig. 4.9 shows the annual mean ozone concentrations in 2017. Fig. 4.10 illustrates the number of days, in which average eight-hour concentration of O_3 exceeded 120 µg.m^{-3} (target value for protection of human health). Fig. 4.11 shows AOT40 values for the protection of vegetation, corrected for the missing values (according to Decree of the Ministry of Environment SR 244/2016 Coll. of Acts on air quality).

The target values of tropospheric ozone for protection of human health are exceeded in Slovakia. In 2017, the exceedances of limit value were recorded at higher number of stations than in 2016. In period 2015 – 2017, target value for protection of human health (more than 25 days) was exceeded at three out of sixteen monitoring stations. Two of them are located in urban areas – Bratislava, Jeséniova and Nitra, Janíkovce and the the third one Chopok, EMEP, in high altitudes (2008 m a.s.l).

The exceedances of AOT40 target values for vegetation protection in May – July (average for 2013 – 2017) occurred at four monitoring stations, out of 16 (Bratislava, Jeséniova; Nitra, Janíkovce; Banská Bystrica, Zelená and Chopok). A similar situation was in 2012 – 2016, however, average of AOT40 measured in the whole monitoring network in 2013 – 2017 is higher than in 2012 – 2016. The difference is nearly 7%. Interestingly, exceedances of the AOT40 target value were recorded at the same monitoring stations, where the highest average annual concentrations were measured, respectively, at the same stations, that have measured exceedances for protection of human health. This only underlines the apparent role of ozone precursors, as well as continental transfer of tropospheric ozone.

Based on measurements of solar radiation at meteorological stations in Bratislava, Hurbanovo, Banská Bystrica, Milhostov and Gánovce, it can be stated, that the values of global radiation in Slovakia in 2017 showed an increase of 3%, as compared to 2016. The inter-annual change in global radiation and emissions of precursors are probably the basic factors that affect air pollution by ozone in Slovakia.

Fig. 4.9 *Annual mean ozone concentrations [µg.m^{-3}] – 2017.*

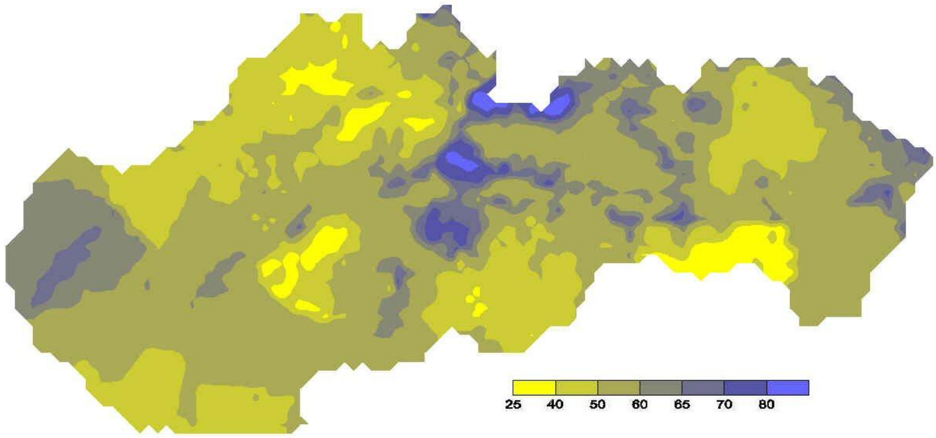


Fig. 4.10 *Number of days with target value for human health protection (120 µg.m^{-3}) exceedances in years 2015 – 2017.*

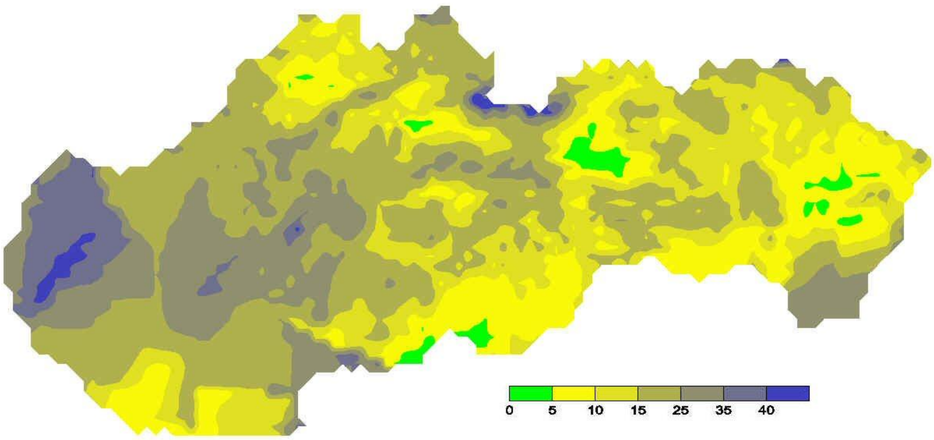
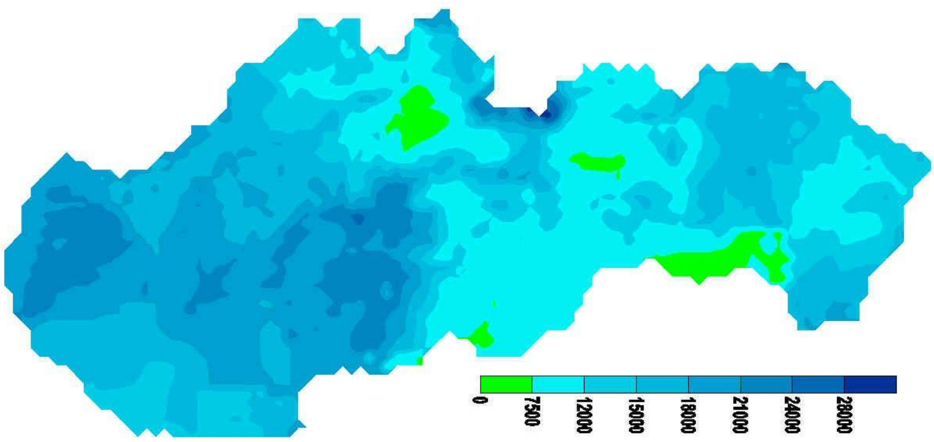


Fig. 4.11 *Mean AOT40 [µg.m^{-3}.h] for a period of five years (2013 – 2017) for protection of vegetation, corrected for missing values.*



Particulate matter – PM_{10} and $PM_{2.5}$

High concentration of PM_{10} in ambient air is a persistent problem in Slovakia. Exceedances of daily limit value occur every year. The situation is similar in other European countries. PM_{10} limit exceedances occur mainly in winter, due to households heating with solid fuels and frequent occurrence of adverse dispersion conditions.

In 2017, PM_{10} was continuously measured at 33 air quality monitoring stations, including 11 traffic, 18 urban/suburban background, 3 regional (rural) background and 1 industrial station. The number of exceedances of daily limit was above the permitted limit (35 exceedances of daily mean value 50 $\mu g.m^{-3}$) at 12 monitoring stations, of which 3 were traffic related. The highest number of daily limit exceedances (over 60) was measured at monitoring stations Jelšava, Jesenského (82), Banská Bystrica, Štefánikovo nábr. (67)and Veľká Ida, Letná (62). Veľká Ida is influenced by large metallurgical complex, Banská Bystrica, Štefánikovo nábr. by road transport, while main source in Jelšava is household heating, and to lesser extend, the local industry (magnesite production),

In 2017, $PM_{2.5}$ was continuously monitored at 32 monitoring stations, including two EMEP background stations. (Measurement of $PM_{2.5}$ concentration started in 2005 at three monitoring stations).

Annual limit value for PM_{10} was not exceeded in 2017, while annual limit value for $PM_{2.5}$ was exceeded on monitoring station Jelšava, Jeséniova.

Interpolation model IDW-A was used for spatial assessment of PM_{10} and $PM_{2.5}$. The concentrations measured at monitoring stations in monitoring network and parameters, required by IDW-A methodology, were used as model input data. PM measurements (direct or derived from TSP) from EMEP stations were used, as additional information in spatial assessment of the area.

Emissions – Residential heating is responsible for the most significant part of total PM_{10} and $PM_{2.5}$ emissions in Slovakia. In case of PM_{10}, the proportion emissions from household heating is 65% and for $PM_{2.5}$ almost 80%, from the total emissions.

Road transport is also important sector. Although the total annual emissions from road transport are lower than those ones from large and medium air pollution sources, the local impact in breathing zone is dominant, close to the roads with high traffic intensity.

The summary of PM_{10} ($PM_{2.5}$) emissions from large industrial and energy sources represents approximately 30% (15%) of total emissions. While the impact of large sources due to high stacks influences mainly the background concentrations, emissions from the household heating and road transport have significant impact close to the locations, where they enter the ambient air. Small and medium local industrial, energy and heat production sources without proper air pollution abatement technology can influence air quality significantly in their vicinity.

Agricultural works and wind erosion from the unpaved soils are responsible mainly for the coarse size fraction of PM, similarly to construction and demolition.

Significant is the role of secondary fine particles, formed in the atmosphere by chemical reactions (e.g. oxides of nitrogen from road transport and ammonia from agriculture). The share of secondary PM_{10} may be 30% and $PM_{2.5}$ even more.

Model results **(**PM_{10}**)** – The spatial distribution of PM_{10} is shown in **Fig. 4.12** and **Fig. 4.13**. Based on the measured data, the annual mean concentration in the territory of Slovakia slightly increased in 2017, as compared to 2016. The increase in daily limit value exceedances is significant. One of reasons may be the cold season in 2017, with more intensive heating than in 2016. (January 2017 was extremely cold).

The statistical analysis, which was prepared, reveals a high statistical significance of dependence between the measured values from EMEP background stations (located far from air pollution sources) and concentrations, measured at the other monitoring stations. According to the results of air quality modelling in previous studies, the background PM_{10} concentration in Slovakia is about 20%. It implies, that the problem with PM_{10} needs to be addressed in local scale and regional scale.

Fig. 4.12 *Annual mean concentration of PM_{10} [µg.m^{-3}] – 2017.*

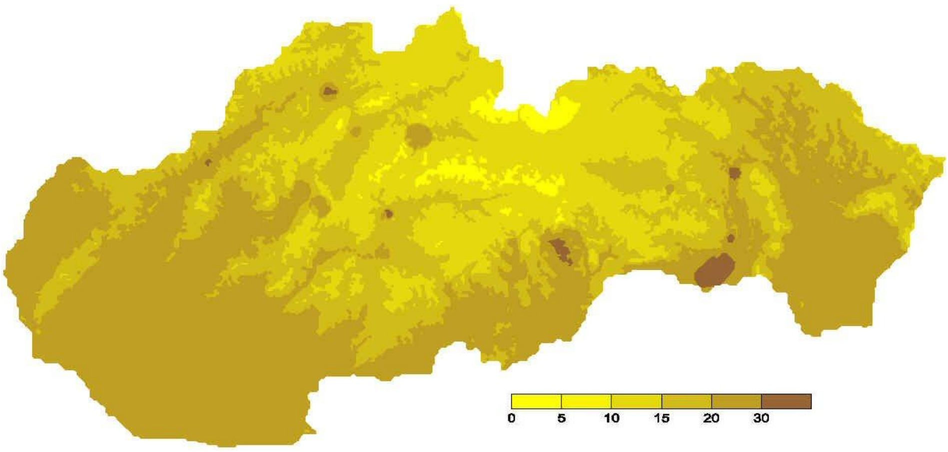
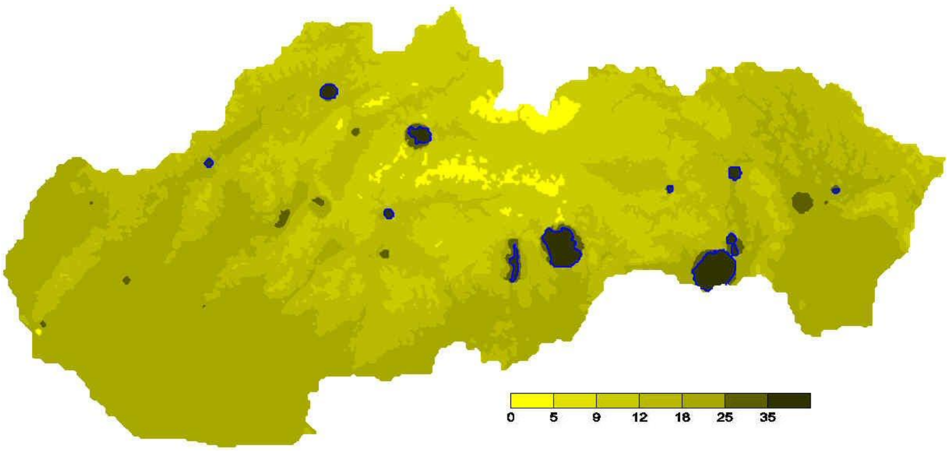


Fig. 4.13 *Number of daily exceedances for PM_{10} – 2017*
*(Blue line delimits an area with a limit value exceeded)***.**



Source apportionment - Using model calculations, the contribution of individual types of sources of air pollution in the total concentration of $PM_{10,}$ was determined. It was found, that the contribution of large and medium sources in the measured average annual concentrations in the NMSKO is less than 2%, with the exception of the US Steel area, Košice (Veľká Ida around 30%). In case of mobile sources, this contribution in agglomerations Bratislava and Košice represents from 10 to 20%, in other cities from 5 to 15%. Contributions from mobile sources were also included into calculations and represent the contribution, related to fine particles from exhaust as well as from wear of brakes, tires and road surface (asphalt) and resuspension of dust, deposited on roads. Measured data from rural background stations of NMSKO with the EMEP program were included as a contribution from regional background. Model calculations pointed to large contribution of household heating.

Main sources of PM_{10} in Slovakia:
- Local household heating with solid fuels.
- Road transport (abrasion of road surfaces, tires and brake wear).
- Small and medium local industrial resources without proper separation technology.
- Wind erosion from unpaved surfaces (source mainly of coarse size fraction).
- Construction and demolition work (spatially limited source, especially of coarse size fraction).
- Agricultural work (time-limited source, especially of coarse size fraction).
- Secondary dust - fine particles that are formed in air by chemical reaction (e.g. oxides of nitrogen from road transport and ammonia from agriculture).

These sources should be targeted on local measures to reduce the level of PM_{10} (reduction of consumption of solid fuels in local heating, changes in organization of transport, pedestrian zones, expansion of greenery, strengthening of surfaces, inspection of technical condition and pollution of vehicle tires, cleaning of streets and sidewalks of cities, anti-erosion measures on construction sites, dumping of bulk materials, dumping of waste, strict control of local industrial resources). Often the concentration of 50 $\mu g.m^{-3}$ is exceeded already in the up-wind sites of cities, when flowing from the south and east (episodically) or during some agricultural works, e.g. dry ploughing, harvesting or beet campaigns. In recent years, the contribution of air pollution from wood burning in domestic heating has increased significantly.

Designing local measures to reduce PM_{10} levels is very challenging, regarding the high background concentrations. While for other pollutants assessed, the background concentration level is less than 30% of the limit value, for PM_{10} it is up to 75% and for $PM_{2.5}$ even higher percentage, which means exceeding the upper limit for air quality assessment by background itself. The urban background of PM_{10} of larger cities in Slovakia (over 50 000 inhabitants) is probably 20 – 30 $\mu g.m^{-3}$. In recent years, the probability of exceeding the limit value for the average annual concentration (40 $\mu g.m^{-3}$) decreased. Due to relatively short duration of the measurement program in case of $PM_{2.5}$ compared to PM_{10}, for the time being, not enough information is available to assess the long-term trend.

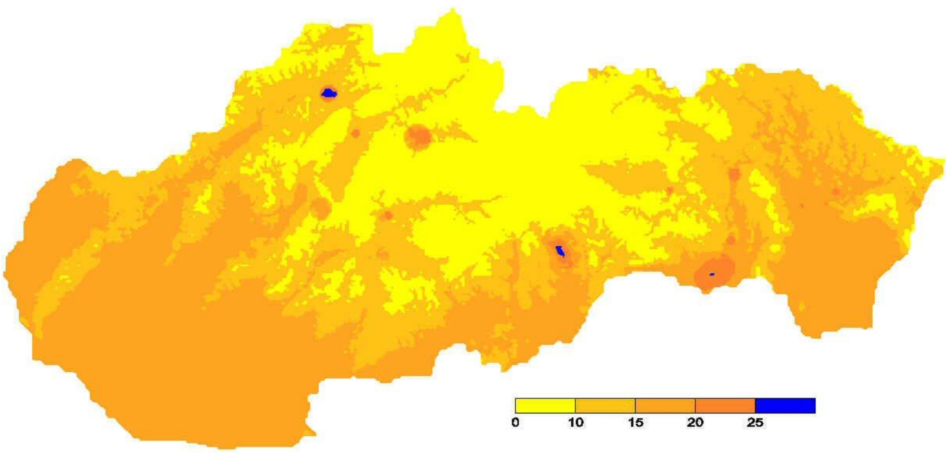
Model results **(**$PM_{2.5}$**)** – In 2015, the limit value for $PM_{2.5}$ came into force. In 2015 and 2016, no exceedance of annual limit value was measured at any of monitoring station in Slovakia.

Due to smaller aerodynamic diameter, local conditions for dispersion and extreme conditions for resuspension (drought, wind) are more significantly applied, when polluting air with $PM_{2.5}$ particles. PM_{10} and $PM_{2.5}$ are measured in parallel at almost all monitoring stations. While in case of PM_{10}, the limit value of average annual concentration was not exceeded, in 2017, the $PM_{2.5}$ limit value was exceeded at two stations (Jelšava, Jesenského and Žilina, Obežná). The value measured at the station Veľká Ida, Letná is exactly equal to target value.

According to the results of interpolation model IDW-A, the limit value for $PM_{2.5}$ was exceeded in nearly 75% of the territory of Slovakia.

$PM_{2.5}$ needs more energy to resuspension than PM_{10}, due to smaller aerodynamic diameter. Consequently, the resuspension of winter sanding/salting and various episodes relevant to resuspension from the uncovered soils or other various fugitive sources are significantly less important for $PM_{2.5}$ than for PM_{10}.

Fig. 4.14 *Annual mean concentration of $PM_{2.5}$ [$\mu g.m^{-3}$] – 2017.*



4.3 CONCLUSION

Air quality in 2017 was affected by cold January, which caused the increased demands on household heating.

The limit values of PM_{10}, $PM_{2.5}$ as well as the target value for benzo(a)pyrene were exceeded.

PM_{10} and $PM_{2.5}$ remain the most significant pollutants at locations, where residential heating by solid fuels plays an important role. The worst situation is in mountain, where is a good access to firewood, while orographic features allow frequent occurrence of adverse dispersion conditions, especially during the heating season.

Road transport presents significant impact on PM_{10} limit value exceedances, close to roads with high traffic intensities. Again, the situation is worse in winter, and associated with higher emissions during cold starts of motors, combined with worsen dispersion conditions.

The high impact of small air pollution sources (residential heating) and road traffic on the air quality as compared to the impact of large and medium industrial sources is due to the fact, that emissions are emitted close to the breathing zone, while stack emissions from large industrial sources are emitted from high stacks and are usually efficiently dispersed before reaching the breathing zone.

Financial conditions often do not allow the local population to use natural gas for heating to purchase modern low-emission boilers. However, some improvement can be achieved even by such basic measures, as educating people on good practice in operating solid fuel boilers and fireplaces or efficient driving habits.

5 AIR QUALITY ASSESSMENT – CONCLUSION

5.1 AIR QUALITY MANAGEMENT AREAS, PROPOSED FOR YEAR 2018

The air quality management areas for year 2018 were proposed by the Slovak Hydrometeorological Institute on basis of the air quality assessment in zones and agglomerations in 2015 – 2017 (According to § 8 section 3 of Act No. 137/2010 Coll. of Acts). The pollutant will be removed from air quality management only when it had been below the limit value for 3 consecutive years.

Tab. 5.1 *The air quality management areas for year 2018, declared on the basis of measurements in 2015 – 2017 (taking into account the measurements in previous years, in case of low percentage of valid measurements).*

AGGLOMERATION Zone	Air quality management area	Pollutant
BRATISLAVA	Territory of capital of SR, Bratislava	PM_{10}, NO_2, BaP
KOŠICE, Košice region	Territories of Košice city and municipalities Veľká Ida, Sokoľany, Bočiar and Haniská	PM_{10}, BaP
Banská Bystrica region	Territory of Banská Bystrica city	PM_{10}, BaP
	Territory of Jelšava city and municipalities Lubeník, Chyžné, Magnezitovce, Mokrá Lúka, Revúcka Lehota	PM_{10}, $PM_{2.5}$
	Territory of Hnúšťa city and its parts Brádno, Hačava, Likier, Polom, municipality Rimavské Brezovo, Tisovec city and its part Rimavská Píla	PM_{10}
Košice region	Territory of Krompachy city	PM_{10}, BaP
Prešov region	Territory of Prešov city and Ľubotice municipality	NO_2, PM_{10}
Trenčín region	Territory of Prievidza city	BaP
	Territory of municipalities Bystričany, Zemianske Kostoľany, Kamenec pod Vtáčnikom, Čereňany and Nováky city	PM_{10}
	Territory of Trenčín city	PM_{10}
Trnava region	Territory of Trnava city	NO_2
Nitra region	Territory of Nitra city	BaP
Žilina region	Territory of Ružomberok city and Likavka municipality	PM_{10}
	Territory of Žilina city	PM_{10}, $PM_{2.5}$

Note: On monitoring station Bystričany, Rozvodňa SSE, the limit value for average 24-hour PM_{10} concentration was exceeded in years 2012 and 2013. However, in years 2014 – 2017, the limit value for average 24-hour PM_{10} concentration was not exceeded on this monitoring station. In years 2014 – 2016, the valid number of measurements was not reached. Therefore the station Bystričany was proposed to let it be as the Area of air quality management and to enhance it for Nováky, Zemianske Kostoľany, Kamenec pod Vtáčnikom and Čereňany, due to the similar emission sources (influence of heat power plant and household heating,) as well as similar dispersion conditions.

In contrary to it, although on monitoring station Humenné, Nám. slobody in year 2017, the limit PM_{10} value was exceeded (36 exceedances of average 24-hour concentration 50 $\mu g.m^{-3}$ were measured, however the legislation permits 35 exceedances). The territory of Humenné city is proposed not to be included among the Areas of air quality management, because the limit value exceedance was caused by building activity, which is for the time being finished.

5.2 AIR QUALITY ASSESSMENT BY ZONES AND AGLOMERATIONS, ACCORDING TO THE REQUIREMENTS OF DIRECTIVE 2008/50/EC

EU legislation[2] implies an obligation to assess the air quality in each zone and agglomeration. **Tab. 5.2** shows agglomerations and zones, where the limit value for PM_{10}, $PM_{2.5}$ and NO_2 was exceeded in years under the review.

Tab. 5.2 *Zones and agglomerations with exceedances of limit values of PM_{10}, $PM_{2.5}$ and NO_2 based on measurements in 2015 – 2017 (taking into account data in previous years, in case of low percentage of valid measurements).*

AGGLOMERATION Zone	Pollutant	AMS/year of limit exceedance		
		PM_{10}	$PM_{2.5}$	NO_2
BRATISLAVA	PM_{10}, NO_2	Bratislava, Trnavské mýto/2012 – 2015		Bratislava, Trnavské mýto/2015
KOŠICE	PM_{10}	Košice, Štefánikova/2017; Košice, Amurská/2017		
Banská Bystrica region	PM_{10}, $PM_{2.5}$	Banská Bystrica Štefánikovo nábr./2017; Jelšava/2017; Hnúšťa/2017	Jelšava/2017	
Košice region	PM_{10}	Veľká Ida/2016 – 2017; Krompachy/2017		
Prešov region	NO_2, PM_{10}	Prešov/2017		Prešov/2014 – 2015
Trenčín region	PM_{10}	Trenčín, Hasičská/2017		
Žilina region	PM_{10}, $PM_{2.5}$	Ružomberok, Riadok/2017; Žilina, Obežná/2017	Žilina, Obežná/2017	

In the evaluated years 2015 – 2017, the target value for BaP and the target value for protection of human health for O_3 were exceeded in Bratislava agglomeration, as well as in Slovakia zone (**Tab. 3.6**, **Tab. 3.11**).

[2] *Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe and http://ec.europa.eu/environment/air/pdf/guidanceunderairquality.pdf*

6 EMISSIONS

INTRODUCTION TO EMISSIONS

What are the emissions?

Air polluting substance (the emission) is a material present in the air that may have adverse effects on human health and the environment. These substances can be of natural origin, e.g. volcanic activities or can be caused by human activities. The emissions associated with human activities, so-called *anthropogenic emissions*, are important in terms of air protection. The concept of emissions is defined in the legislation of the Slovak Republic.

> *Emission is every direct or indirect discharge of polluting substance into the atmosphere.*[1]
> *Emission means the release of a substance from a point source into the atmosphere.*[2]
> *Emission means the direct or indirect release of substances, vibrations, heat or noise from individual or diffuse sources in the installation into air, water or land.*[3]

What relationship is between released emissions and air quality?

Air pollutants can be divided into primary and secondary emissions. Emissions of air pollutants released into the atmosphere from human activities represent primary pollution. Primary air pollutants arise principally from the combustion processes, for instance transport, industry and energy production. However, substances occurring in the air have also a natural origin, do not arise by human activities. The atmosphere allows their transport, dispersion and deposition from the source to the receptor. The receptors can be other components of the environment (for instance water, soil, living organisms). Secondary air pollutants are not emitted directly. They are created by the chemical or photochemical processes and mutual interactions of primary emissions after their release and occurring in the atmosphere. A suitable example of secondary air pollution represents the ground ozone. Certain air pollutants can be of primary as well as the secondary origin, which means that they are emitted directly but also can be created from other primary air pollutants. The pollution of atmosphere, respectively the air quality, is detected by measuring of air polluting substances concentration in the atmosphere or through the usage of mathematical models.

What are the consequences of excessive emission discharge?

The emissions emitted into the air, as a result of human activities, have a negative impact on human health and the environment. They cause a decrease of air quality, for instance the acidification of atmospheric precipitation, which influences the fauna and flora, the destruction of buildings and constructions and the damage of the ozone layer in the atmosphere. As indirect precursors, they contribute to global warming and climate change. Various health risks and life quality decline are being associated with the deteriorating of air quality, for instance the occurrence and worsening of asthma and other respiratory problems.

According to recently published data by the European Environment Agency (EEA) the air pollution caused in the year 2014 in the Slovak Republic 5 416[4] premature deaths. The contribution of individual air pollutants ($PM_{2.5}$ – fine particulate matters with an aerodynamic diameter equal or less than 2.5 µm;

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[1] *Act on air protection No 137/2010 Coll.*
[2] *Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC*
[3] *Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)*
[4] *https://www.eea.europa.eu//publications/air-quality-in-europe-2017*

NO_2 – nitrogen dioxide and O_3 – ozone) to the overall number of premature deaths is provided in the ***Tab.* 6.1**. The EEA defines premature deaths as deaths that occur before a person reaches an expected age. This expected age is typically the life expectancy for a country stratified by sex. The most common causes of premature deaths are cardiovascular diseases, stroke, lung and respiratory diseases. In addition, air pollution influences other areas of our lives. Work incapacity and high healthcare costs are also attributed to the impacts of air pollution and the environment.

Tab. 6.1 *The number of estimated premature deaths in SR. The share of individual contributions of air pollutants: fine particulate matters $PM_{2.5}$, nitrogen dioxide NO_2 and ozone O_3.*

Year	Number of deaths	$PM_{2.5}$ b)		NO_2 b)		O_3 b)
		$C_0 = 0$ a)	$C_0 = 2.5$ a)	$C_0 = 20$ a)	$C_0 = 10$ a)	
2014	5 416	5 160	4 520	100	1 330	160

a) The EEA has performed the sensitivity study for health impacts of emissions $PM_{2.5}$ a NO_2. The lowest concentration used to calculate the health impacts of a pollutant in a baseline scenario is referred to as the counterfactual concentration C_0. C_0 represents for instance the pollutant concentration that could be achieved by changes in the environment or the concentration below which the concentration-health response function may not be appropriate, due to the lack of epidemiological data. The value for $PM_{2.5}$ used in previous reports of EEA was $C_0 = 0\ \mu g.m^{-3}$. Taking into account the background pollution concentration in Europe, the availability of risk estimates and sensitivity analysis in 2008, an alternative $C_0 = 2.5\ \mu g.m^{-3}$ has also been considered. The calculation of NO_2 has been made by two alternatives: $C_0 = 10$ and $C_0 = 20\ \mu g.m^{-3}$.

b) The uncertainties in the estimates of premature deaths (expressed as 95% confidence interval) represent the relative risk factors: ±35% ($PM_{2.5}$), ±45% (NO_2) and ±50% (O_3). There might be a bias in the NO_2 estimates due to the correlation with $PM_{2.5}$.

For what purposes is information on released emissions of air pollutants used?

The calculation, control and assessment of emissions are important activities due to the consequential possibility to regulate their discharge into the air. Quantitative information on the emission and their sources is inevitable condition of:

- decision making of responsible bodies,
- providing the information to the professional audience and public,
- definition of environmental priorities and identification of problem causes,
- various plans and strategies estimation of environmental effects,
- environmental costs and benefits assessment of different approaches,
- monitoring of impact respectively the effectiveness of implemented measurements,
- achievement of compliance with national and international commitments.

■ BALANCING OF AIR POLLUTANT EMISSIONS RELEASED INTO THE AIR

The Slovak Hydrometeorological Institute, Department of Emissions and Biofuels is responsible for the preparation of national emission inventory of discharged air pollutant. This balancing of emission amounts is required on the national, European and international levels. At the national level, emissions from medium and large sources of air pollution are collected and recorded in the **National Emission Information System (NEIS)** (Chapter **6.4** National Emission Information System). At the European and international level is required regular **annual reporting of emission inventories** of certain air pollutants for the time period since the year 1990 (Chapter **6.2** Emission Inventories of air pollutants). The scope of required data in the submission reports for implementation of European directives and international conventions is broader than the coverage of resources and activities in the NEIS database. The summary of emissions from air pollution sources in the NEIS is therefore smaller than the national summary reported under European and international conventions.

6.1 THE OVERVIEW OF REPORTING OBLIGATIONS OF THE SLOVAK REPUBLIC UNDER THE INTERNATIONAL COMMITMENTS AND INTERNATIONAL AND EUROPEAN LEGISLATION

Air protection is one of the important pillars of the European and international environmental legislation, which is currently being a subject of regular tracking, controlling and monitoring. In recent two decades, there has been a visible progress in the regulation of anthropogenic emissions. This advance is a result of various legislation changes at the European level. The main goals of these changes have been the assurance of clean air without harming effects on human health and the ecosystems.

European legislation focused on the achievement of targets and the monitoring of development uses different legislative tools, for instance: the national emission ceilings to limit the released amounts of air pollutants into the air from stationary sources of air pollution[5], from diffuse (fugitive) sources[6] as well as from mobile sources[7], the commitments of Member States on reduction of annually released national emissions, tightening of emission limits and technical requirements on sources of air pollution, obligation of introduction the best available techniques (BAT)[8] and others. All legislative measures set the duties of regular and detail reporting on emissions.

Recent changes in the field of air protection in Europe represent following legislation:

- Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC,
- Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control),
- Directive (EU) 2015/2193 of the European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants,
- Regulation (EC) No 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EC,
- Regulation (EU) No 538/2014 of the European Parliament and of the Council of 16 April 2014 amending Regulation (EU) No 691/2011 on European environmental economic accounts,
- the others.

6.1.1 The UNECE Convention on Long-Range Transboundary Air Pollution (Convention LRTAP)

The Slovak Republic, the Member States of European Union (EU) and other states outside of EU are the signatories of the United Nations Economic Commission for Europe (UNECE) Convention On Long-Range Transboundary Air Pollution in 1979 (Convention LRTAP) and its several protocols including the Protocol on acidification, eutrophication and ground ozone from the year 1999, which was revised in year 2012 (revised Gothenburg protocol).

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[5] *Point sources*

[6] *Diffuse (fugitive) sources or emissions are non-managed, surface leakages of emissions into the external atmosphere, for instance: sorting or crushing of stones without abatement technique, animal farming, steaming and burning landfills, surface dustiness, conveyor belts outside of closed buildings, areas of open storages and tanks with a fixed roof if not abated, open composting areas, sewage sludge tanks of wastewater treatment plants, etc.*

[7] *Transport*

[8] *BAT „Best Available Technique"- (definition of Directive IED) means the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and where that is not practicable, to reduce emissions and the impact on the environment as a whole.*

The overview of Convention LRTAP Protocols:

- Geneva Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP),
- Helsinki Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent (1985),
- Sofia Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes (1988),
- Geneva Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes (1991),
- Oslo Protocol on Further Reduction of Sulphur Emissions (1994),
- Aarhus Protocol on Heavy Metals (1998),
- Aarhus Protocol on Persistent Organic Pollutants (POPs) (1998),
- Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (1999), revised (2012).

6.1.2 Directive (EU) 2016/2284 of the European Parliament and of the Council on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC

New Directive 2016/2284 (further "new NECD") repealed the Directive on national emission ceilings 2001/81/EC, and brought about the harmonisation with revised Gothenburg Protocol. Previous Directive on national emission ceilings (2001/81/EC, NECD) had determined the ceilings for the year 2010 – the amounts of four air pollutant in absolute values for each member state, which were not allowed to be exceeded. Monitored emissions of air pollutants were nitrogen oxides (NO_X), non-methane volatile organic compounds (NMVOC), sulphur oxides (SO_X) and ammonia (NH_3). Determined ceilings are currently still valid for maintaining the continuity with historical emissions until to the year 2020 when emissions and the achievement of commitments will be assessed for the first time in accordance to rules of new NECD. The Slovak Republic meets all current requirements and ceilings. The overview of obligations related to Directive 2001/81/EC is shown in **Tab. 6.2**.

Tab. 6.2 *Emission ceilings determined by Directive 2001/81/EC for year 2010 valid until 2020.*

	Emission ceilings 2010 [kt]			
	NO_X	SO_X	VOC	NH_3
SR	130	110	140	39
EÚ 28	8 297	9 003	8 848	4 294

New NECD has set for the Slovak Republic and the Member States new reduction commitments for certain air pollutants. Compliance is divided into two phases. The first phase relates to the time period from the year 2020 to the year 2029. The second phase will enter into force from the year 2030. The reduction commitment of overall emissions released into the air is expressed as percentage decline compares to the emission of the base year of 2005. In addition, the list of monitored pollutants has been extended of one other substance – fine particulate matters $PM_{2.5}$. **Tab. 6.3** provides the overview of reduction commitments values for particular air pollutants in both phases.

Tab. 6.3 *The overview of new NECD commitments for air pollutants SO_2, NO_X, NMVOC, NH_3, $PM_{2.5}$.*

Member state		Reduction compared with 2005 for any year from 2020 to 2029	Reduction compared with 2005 for any year from 2030		Reduction compared with 2005 for any year from 2020 to 2029	Reduction compared with 2005 for any year from 2030
SR	**SO_2**	57%	***82%***	**NO_X**	36%	***50%***
EÚ 28		59%	***79%***		42%	***63%***
SR	**NMVOC**	18%	***32%***	**NH_3**	36%	***50%***
EÚ 28		28%	***40%***		42%	***63%***
SR	**$PM_{2.5}$**	36%	***49%***			
EÚ 28		22%	***49%***			

6.1.3 Regulation (EU) No 691/2011 on European environmental economic accounts

Since 2013 the European environmental economic accounts (EEEA) and their reporting have become mandatory for the Member States. The EEEA constitute the tool for the impact assessment of industry, households and environment mutual interactions (emission intensity). On the principle of common statistical classification of economic activities of economy units ("KAU" kind-of-activity unit) is determined the final emission intensity of individual categories for air pollutants. This integrated statistical system links economic and environmental information into certain outputs in order to provide the base for policy and strategic decision making. The EEEA are delineated into several modules.

The European Economic Environmental Accounts (EEEA) and their reporting became mandatory for EU Member States in 2013. As a satellite component of the European System of Accounts (ESU / ESA), fully in line with the National Accounts System (SNU / SNA), the interaction and impact of the economy and households on the environment (emission intensity). This integrated statistical system combines economic and environmental information into concrete outputs to serve policy making and strategic decision making. EEEAs are defined in several modules.

Fulfilment of reporting obligations requires the cooperation with the Statistical Office of the Slovak Republic which is in charge of the EEEA and their reporting to the European Commission (EUROSTAT). The Slovak Hydrometeorological Institute ensures the preparation of the Module I: **Air Emission Accounts (AEA)**. Reporting of the AEA is concerned to 15 pollutants and greenhouse gases (CO_2, biomass CO_2, N_2O, CH_4, PFC, HFC, SF_6 and NF_3, NO_X, SO_2, NMVOC, CO, PM_{10}, $PM_{2.5}$ and NH_3). The AEA are closely intertwined to the emission inventories under the Convention LRTAP and the UN Framework Convention on Climate Change (UNFCCC).

On the principle of classification of economic activities of economic units (so-called "KAU" kind-of-activity unit) in accordance with the ŠÚ SR, the resulting emission intensity of individual categories is determined for all pollutants. The breakdown of individual reported emissions is required by NACE Rev. 2. 2. (A * 64), according to the statistical classification of economic activities in the European Community. This European industry classification system is standardized into the 6-digit numerical codes characteristic of the economic activity. The breakdown requested by the Commission is aggregated into 64 individual categories (by 2-digit code).The Slovak Republic uses for the preparation of AEA two methods. In the case of air pollutants, the **inventory-first approach** is used. Reported data is based on the official Air Pollutants Emission Inventory Submission under the Convention LRTAP. However, division of emissions is not coherent and thus adjusted methods with use of input data of the National Emission Information System (NEIS) is needed, but other statistical and auxiliary data. The **energy-first approach** is applied for greenhouse gases (GHG). This approach is based on energy statistics used in the GHG emission inventory under the United Nations Framework Convention on Climate Change (UNFCCC). The EEEA apply the residence principle and have the same system boundaries as the European System of Accounts (ESA). The required categorization also includes households in the areas of transport, heating and others.

6.2 EMISSION INVENTORIES OF AIR POLLUTANTS

The compliance with the objectives of the Convention LRTAP and the new NECD has to be proved by required reporting of emission inventory for the following pollutants:

- nitrogen oxides (NO_X),
- non-methane volatile organic compounds (NMVOC),
- sulphur oxides (SO_X),
- ammonia (NH_3),
- carbon oxide (CO),
- total suspended particles (TSP):
  - particulate matter PM_{10} (with aerodynamic diameter equal or less than 10 µm),
  - fine particulate matter $PM_{2.5}$ (with aerodynamic diameter equal or less than 2.5 µm),
- black carbon (BC),
- heavy metals (Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn),
- certain persistent organic pollutants (POPs).

Principles of emission inventories to be followed:

- transparency,
- consistency,
- comparability,
- completeness,
- accuracy of reported data.

Emission inventory is an annual report of air pollutants emission amounts that were released to the atmosphere from all stationary, fugitive and mobile sources at the territory of the Slovak Republic. Emission data is provided in weight units for the period since 1990, the last reported data is two years older than current year – that means submission of inventory reported in 2017 includes the period of years 1990 – 2016. The structure of provided data is in accordance with the internationally standardized format – Nomenclature for Reporting (NFR). Currently, it constitutes from 127 different categories in which emissions are reported. Data covers anthropogenic activities divided into particulate groups.

To fill in a standardized sample file that is used for reporting, it is also necessary to use the abbreviations of the so-called notation keys in the following cases:

- IE (included elsewhere) - the data is included in another item; IE is reported when emissions are transferred to another heading
- NA (not applicable) - data not available; An NA is indicated if the activity exists in the national territory but does not give rise to emissions of a specific substance
- NO (not estimated) - not estimated; NO is given if there is activity in the national territory, emissions of a particular substance arise, but no input data, methodology or emission factor are available
- NO (not occured) - not present; NO is indicated if the activity does not exist in the territory of the country

The **Tab. 6.6** is provided with complete tree structure of nomenclature NFR14. It contains also the activities that do not occur in the Slovak Republic. The nomenclature has a multilevel structure and allows the aggregation of individual categories to the bigger groups, for instance: aggregation to the sectors for the purposes of evaluation, comparability and overview statistics.

The overview of selected sectors of nomenclature NFR14:

ENERGY AND STATIONARY FUEL COMBUSTION ACTIVITIES

- Fuel combustion
- Fugitive emissions

INDUSTRY

- Mineral production
- Chemical industry
- Metal production
- Solvents
- Other product use
- Other production industry

AGRICULTURE

- Manure management
- Agricultural soils
- Field burning of agricultural residues
- Agriculture other

WASTE

- Solid waste disposal on land
- Biological treatment of waste
- Incineration and open burning of waste
- Waste water handling
- Other waste

One of the most important data sources in the preparation process of final inventory is the database of **National Emission Information System (NEIS)**[9] (more detail in Chapter **6.4** National Emission Information System). This system provides detailed data from the operator of air pollutants sources. Direct emission data (national methodology) are processed in line with the reporting requirements. The second main data source is the statistical data from the Statistical Office of the Slovak Republic. Input statistical data are annually updated and revised in the timeline since 1990, if necessary in compliance with the principles of emission inventories. The calculations are performed by methodologies of international guidelines EMEP/EEA Air pollutant emission inventory guidebook[10] or national methodologies.

6.2.1 Evaluation of emission trends

■ 90's of 20th century and the period before Slovakia joined the EU

Social and political changes in the 1990s, the establishment of an independent state of the Slovak Republic and efforts to join the European Union (accession during the enlargement in 2004) enabled significant legislative changes to be made in the area of the environment. But strict air protection was introduced already in 1991 (Act No. 309/1991 Coll. on the environment, as amended[11]). The base for the legislation was inspired by for example German legislation and tried to prevent uncontrolled growth of the industry. The development of all monitored emissions in the 1990s reflected the socio-political changes that occurred in Slovakia and resulted in remarkable decrease of emissions. The Register of Emissions and Air Pollution Sources (REZZO) was the first database used to record emissions in the Slovak Republic during the period 1990 – 1999. Later, database NEIS has been developed. It records emissions from 2000 to the present. **Tab. 6.4** shows the overview of important changes that have influenced the emission trends in the Slovak Republic.

9 NEIS (National Emission Information System), 2016 http://www.air.sk/neis.php

10 EMEP/EEA Air pollutant emission inventory guidebook – 2016 (on-line: http://www.eea.europa.eu/publications/emep-eea-guidebook-2016

11 https://www.slov-lex.sk/pravne-predpisy/SK/ZZ/1991/309/vyhlasene_znenie.html

Development since 2005

The year 2005 is fundamental because it is considered as a baseline for comparison with the achievement of current commitments. The emissions of air pollutants have a downward trend in the most of the sectors due to the legislative measures, application of new environmental technologies as well as the economic reasons. However, the decline in recent years is weak. Selected factors that contribute to emission reduction are presented in the **Tab. 6.5**. In this period the sector of fuel combustion in households has recorded more fluctuation or increasing trend for the particular emissions. It is connected to the use of solid fuels and production of fine particulate matter $PM_{2.5}$ originated in combustion.

The European Environment Agency (EEA) annually process and publish data provided by member states. The comparison of amounts of the Slovak air pollutant emissions with other member states of EU is available at the websites of EEA[12], the websites of the EMEP Centre on Emission Inventories and Projections (CEIP)[13] and others[14].

Tab. 6.4 *The overview of the significant activities and factors, which has contributed to emission reduction during the years 1990 – 2004.*

	TSP	SO_X	NO_X	CO	HM	POPs
Change of composition in fuel base in favour of NG	X				X	
Reduction in consumption of HC, BC, HFO (replacement with low-sulphur fuel oils)		X	X		X	
Introduction of separation techniques e. g. denitrification of Vojany	X		X		X	
Increasing of abatement efficiency			X			
Installation of desulphurization equipment (Power plants Zemianske Kostoľany, Vojany)		X				
Reduction of production volume (Power plants Zemianske Kostoľany, Vojany)		X	X			
Effectiveness of policies and measures to limit CO emissions from major sources 1996				X		
Decline of pig iron and sinter production				X		
Change in technology of aluminium production						X
Reconstruction of certain waste incineration facilities						X
Road transport - unleaded petrol since 1996					X	

Notes: HM – heavy metals; NG – natural gas; HC – hard coal; BC –brown coal; HFO – heavy fuel oil; POPs – persistent organic pollutants

Tab. 6.5 *The overview of the significant activities and factors, which has contributed to emission reduction during the years 2004 – 2016.*

	TSP	SO_X	NO_X	CO	HM
Reduction in consumption of HC, BC, HFO (replacement with low-sulphur fuel oils)	X	X		X	
Change in sulphur content in fuel (Decree of the MoE No. 53/2004 Coll.; Decree of the MoE No. 228/2014 Coll.)		X			
Reconstruction of separators (SE – Nováky; US Steel Košice) 2006	X				
Reduction in glass production 2007					X
Decommissioning of non-ecologized boilers (Vojany Power Plant 2007)	X	X			
Decline in pig iron and sinter production due to the 2009 crisis			X	X	X
Decrease in magnesite clinker production due to the 2009 crisis			X		
Reduction of production volume by 2007 (Zemianske Kostoľany Power Stations)			X		
Road transport 2008/09 - generation fleet renewal with new vehicles			X	X	
Reduction of gas transported by pipelines 2012 (Compressor stations Eustream, a.s)			X		
Installation of a new desulphur unit in heating plant CM European Power Slovakia 2012		X			
Extremely high average annual temperature 2014 decreased demand in the household sector		X	X		
Shutdown of Units 3 and 4 in 2016 (Power Plant Nováky that used BC)	X	X	X		

Notes: HM – heavy metals; NG – natural gas; HC – hard coal; BC –brown coal; HFO – heavy fuel oil; MoE – the Ministry of the Environment of the Slovak Republic

[12] *https://www.eea.europa.eu/data-and-maps*
[13] *http://www.ceip.at/ms/ceip_home1/ceip_home/ceip_intro/*
[14] *http://webdab1.umweltbundesamt.at/official_country_trend.html*

The long-term development of individual pollutants since 1990 is shown in the figures (**Fig. 6.1** – **Fig. 6.4**). For better transparency, a wide range of values and different scale of units, the figures are divided into four groups on air pollutants, heavy metals, polycyclic aromatic hydrocarbons and persistent organic pollutants.

Fig. 6.1 Emission trends of selected air pollutants in years 1990 – 2016.

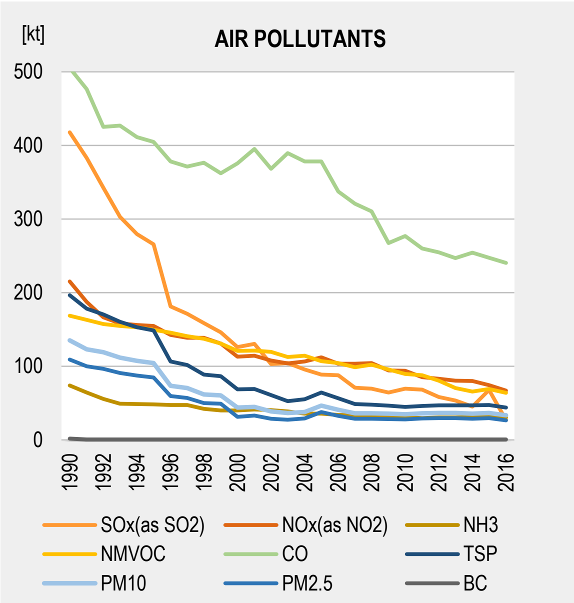


Fig. 6.2 Emission trends of selected heavy metals in years 1990 – 2016.

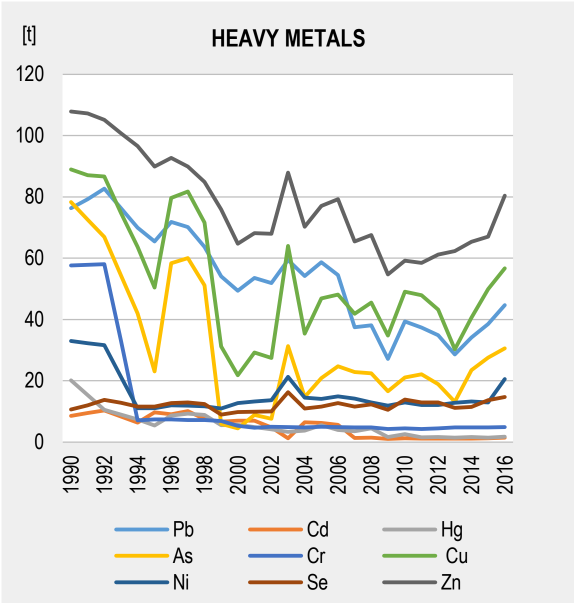


Fig. 6.3 Emission trends of polycyclic aromatic hydrocarbons (PAH) in years 1990 – 2016.

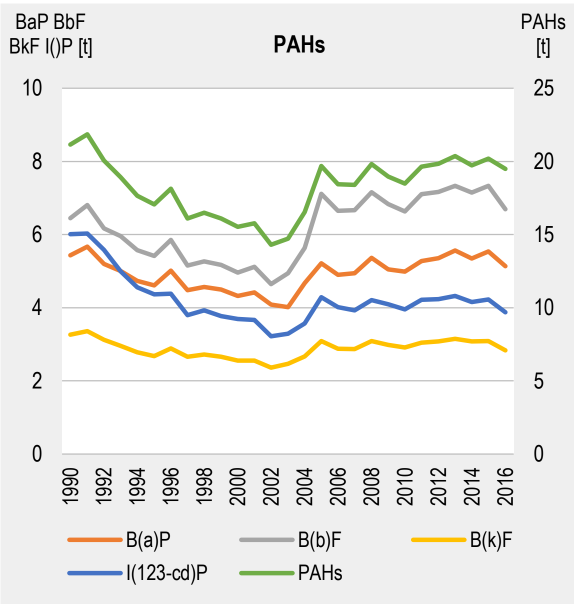
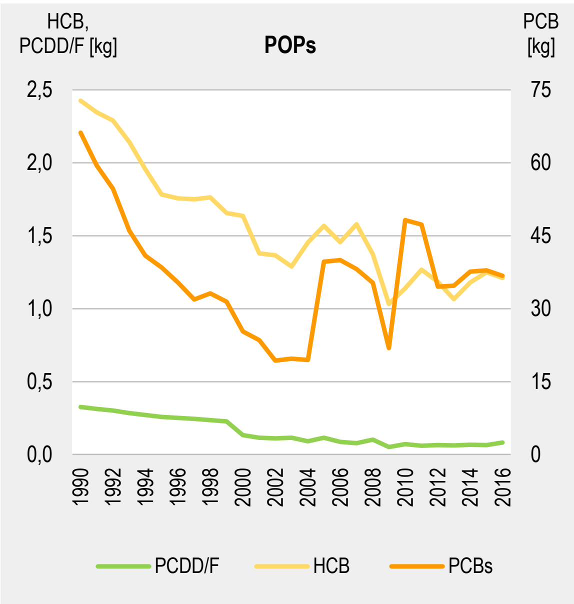


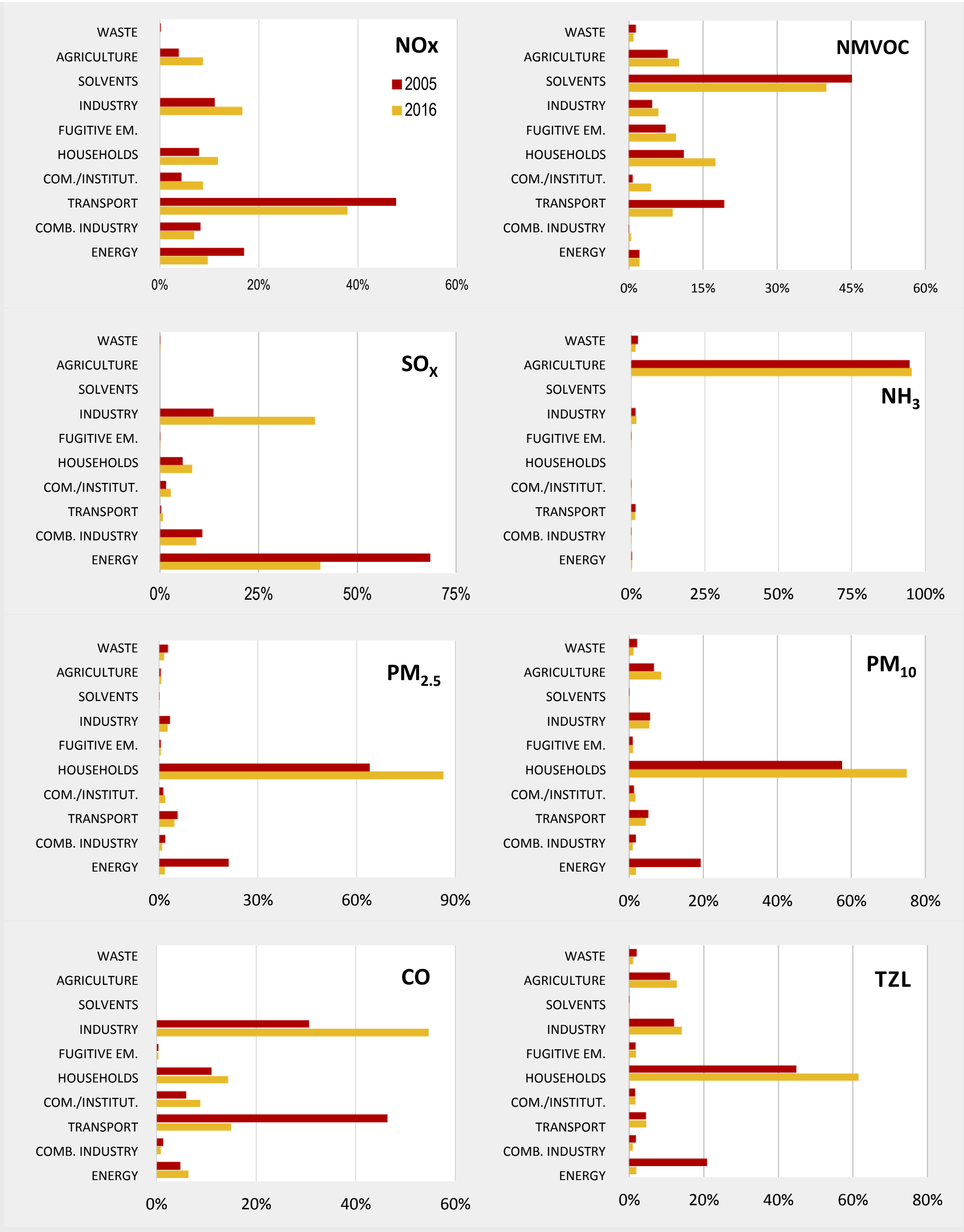
Fig. 6.4 Emission trends of persistent organic pollutants (POPs) in years 1990 – 2016.



6.3 SECTORAL OVERVIEW OF EMISSIONS

Division of emissions to sectors is a considerable indicator for policymaking and setting the direction for national strategies and programs. The overview and comparison of individual sectoral shares of the national emission totals of selected air pollutants for the year 2005 and year 2016 are presented on the **Fig. 6.5**.

Fig. 6.5 *The comparison of base year (2005) and the latest available year (2016) of selected air pollutants (NO_X, NMVOC, SO_X, NH_3, $PM_{2.5}$, PM_{10}, TSP, CO) according to their respective sectors. Figures show the percentage share of sectoral emissions in the national balance.*



6.3.1 Energy and stationary fuel combustion activities

Energy and fuel combustion activities are significant sources of emission. Households are the main contributors of particulate matters (their fractions $PM_{2.5}$ and PM_{10}) transport plays a major role in NOx pollution. The power industry forms a significant part of the SOx balance. According to the structure of the NFR14 and the type of activity we divide it into the following sectors:

ENERGY AND STATIONARY FUEL COMBUSTION ACTIVITIES

- Fuel combustion (1A)
  - *Energy industries*
  - *Manufacturing industry and construction*
  - *Transport*
  - *Households*
  - *Other sectors*
- Fugitive emissions (1B)

Emission trends in the sector of energy and stationary fuel combustion activities

The Energy and stationary fuel combustion activities sector has a declining emission trend (**Fig. 6.6**, **Fig. 6.7)**. The latest increase was recorded in year 2015. It was the last year of derogation for power plant Nováky (Slovenské elektrárne, a.s) for operation of unabated old boilers (sources ENO B - block 3 and 4). During the year 2015 this source also combusted noticeable higher amount of brown coal compare to previous years. Accordingly, a peak of released emissions of SO_X is visible in trend. The refurbishment of other combustion units ENO 1 and 2 has been conducted, which resulted to considerable drop of emissions in the following year. Categories of fugitive emissions have declining trends in recent years (**Fig. 6.7**).

Fig. 6.6 *Emission trends of air pollutants in sector energy and stationary fuel combustion activities in years 2005 – 2016.*

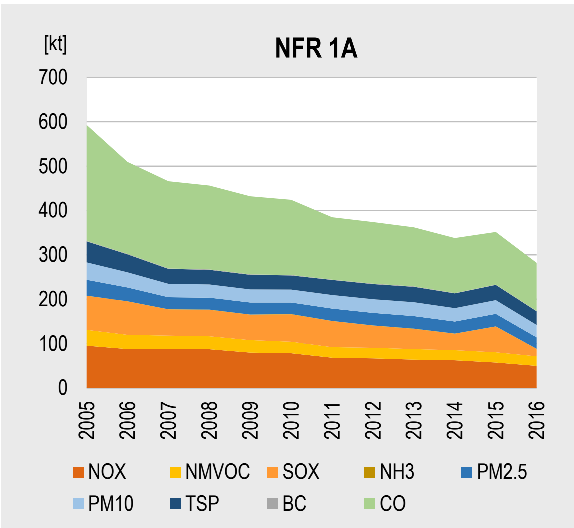
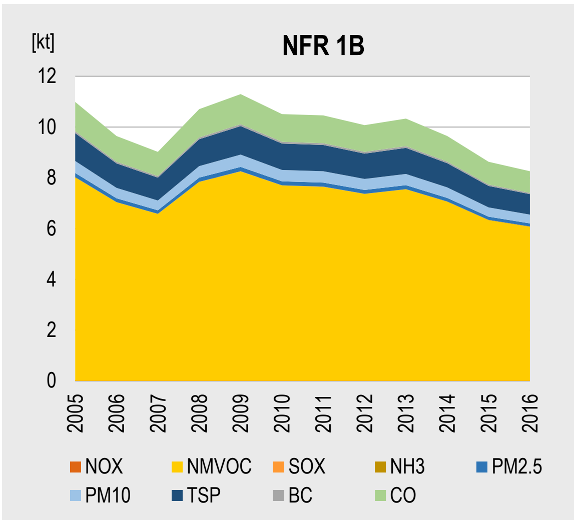


Fig. 6.7 *Emission trends of air pollutants in sector of fugitive emissions in years 2005 – 2016.*



Note: Emissions originated from included activities and processes (AP in legend) can be produces in different amounts. Hence, they might not be fully visible at the figures. However, also small amounts can be important.

Transport

Transport sector is the most important source of nitrogen oxide emissions (NO_X) and carbon monoxide emissions (CO). Main share belongs to road transport, in particular the usage of diesel heavy-duty vehicles as well as diesel passenger cars. The sectoral breakdown according to structure of NFR14 and activity kind is following:

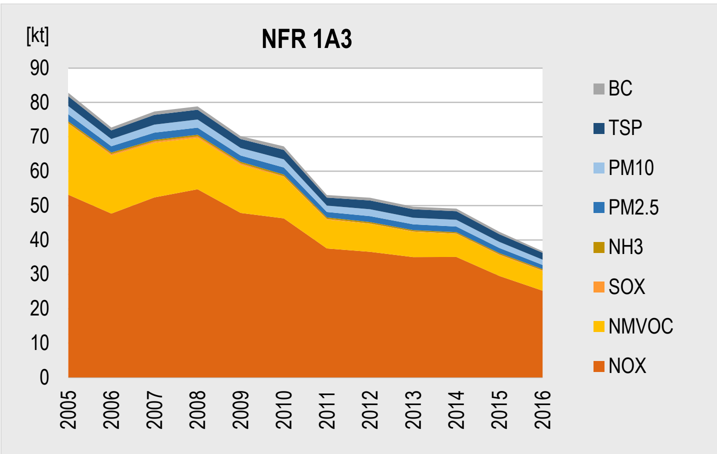
TRANSPORT (1A3)

- Civil aviation
- Road transport
    - *Passenger cars*
    - *Light duty vehicles*
    - *Heavy duty vehicles and buses*
    - *Mopeds & motorcycles*
    - *Gasoline evaporation*
    - *Automobile tyre and brake wear*
    - *Automobile road abrasion*
- Railways
- Water transport
- Pipeline transport

Emission trends in the sector of transport

In the recent years, there has been notable change in use of public transport and shift to usage of passenger cars. In addition, the level of transit transport increased (heavy-duty vehicles - HDV). In the fuel consumption by railways is noted an increase compared to the road transport, which has had sharp increase. The total aggregated transport pollutants in 2016 decreased compared to 2005, ranging from 46.5% (heavy metals) to 93.6% (SOx).

Fig. 6.8 *Emission trends of air pollutants in transport in years* 2005 – *2016.*



Note:
Emissions originated from included activities and processes (AP in legend) can be produces in different amounts. Hence, they might not be fully visible at the figures. However, also small amounts can be important.

Households

Emissions from households (respectively emissions from local heating) are a serious issue in many countries including the Slovak Republic. Large part of households use for heating the individual combustion appliances. In the process of solid fuel combustion in households, besides desired heat, air pollutants are produced in gaseous and solid forms and released into the atmosphere. Total suspended particles can be divided according to their size into PM_{10} and $PM_{2.5}$. Both emission types signify a health risk for humans. Larger particles can cause upper respiratory tract irritation, smaller particles settle deep into the lungs and cause diseases that are more serious. Emissions from domestic heating contribute significantly to the deterioration of local air quality.

Obsolete, worn and unsuitable combustion appliances, as well as improper heating methods, contribute to increased emission production. Emissions depend on fuel type (with what we heat), type of appliance (which equipment we use: e. g. boilers, ovens, fireplaces) and of course the manner of heating (how we heat and maintain the appliance).

Despite the legal ban of waste burning in households, it is still a current topic without a suitable regulation. Harmful substances are produced if the municipal waste or plastic bottles are combusted in local heating appliances. The composition of emissions depends on the combusted materials. This negligent behaviour leads to emission production of persistent organic pollutants (POPs) and heavy metals, which are often carcinogenic. During winter inversions and poor dispersion conditions, these emissions are concentrated in mountain basins.

Emission trends in households

Since 2005, all monitored emissions from households are rising as a result of the price increase of natural gas. Natural gas was widely used for household until 2005. Currently, the trend of emissions is relatively steady with slight decrease in 2014 and 2016 due to the weather conditions during winters.

Enhanced quality of produced data on households

The statistical survey focused on households´ heating was carried out in cooperation with the Statistical Office of the Slovak Republic. The survey was conducted in the frame of the grant project of SHMÚ funded by Eurostat: *Quality improvements of the air emission accounts and extension of provided time-series*. The sample of households was focused especially on family houses with solid fuels as primary heating fuel. On the basis of this newly gathered information on appliances structure and types used in the households, types of fuels used, thermal and insulation properties of family houses and their age structure was processed the update of the methodology for households' heating. The improvement of the methodology brought about more precise emissions estimation in households. Emissions were recalculated in the entire time-series since 1990. New emission values for $PM_{2.5}$ slightly declined compared to previous emission data. However, they still form the majority of the national total (81%). The project resulted also into the development of methodologies for historical years to create Air Emission Accounts for years 1990 – 2007.

Fig. 6.9 *Emission trends of air pollutants in households sector in years 2005 – 2016.*

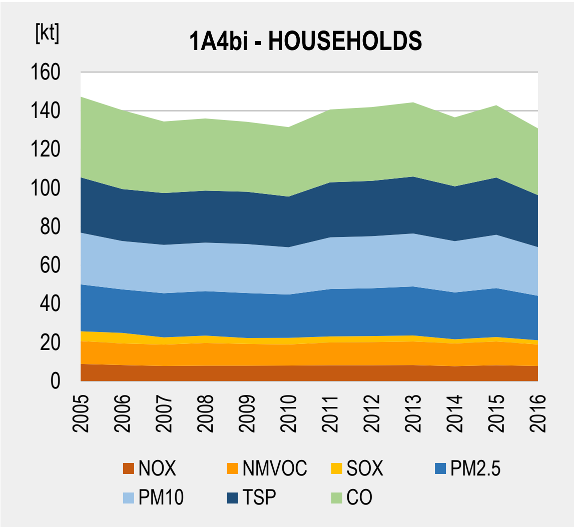
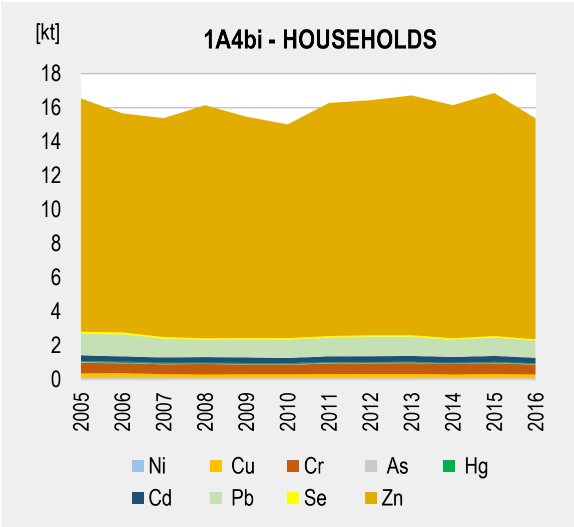


Fig. 6.10 *Emission trends of heavy metals in households sector in years 2005 – 2016.*



Note: Emissions originated from included activities and processes (AP in legend) can be produces in different amounts. Hence, they might not be fully visible at the figures. However, also small amounts can be important.

6.3.2 Industry

Among the member states of EU, the Slovak Republic belongs to the states with the fastest growing economy for recent years. In spite of grow the emissions have a decreasing trend. The share of industrial production on the national GDP of 2016[15] was at the level of 24%. In Slovakia, there are traditionally represented industries such as metallurgical production, production of iron and steel, production of coke and refinery products, chemical production, construction industry and others.

[15] *Analýza vývoja priemyselnej výroby https://www.mhsr.sk/uploads/files/w5xfaTOG.pdf*

The sectoral breakdown according to the structure of NFR14 and activity kind is reported in the following structure:

INDUSTRIAL PROCESSES

- Mineral production (2A)
- Chemical industry (2B)
- Metal production (2C)
- Solvents (2D)
- Other product use (2G)
- Other production industry (2H-2L)

The **Fig. 6.11** to **Fig. 6.14** show downward trends of emissions due to the implementation of strict legislative measures in the field of the air protection and technological progress in environmental abatement techniques which reduce the levels of discharged emissions.

Fig. 6.11 *Emission trends of air pollutants in sector of mineral production in years 2005 – 2016.*

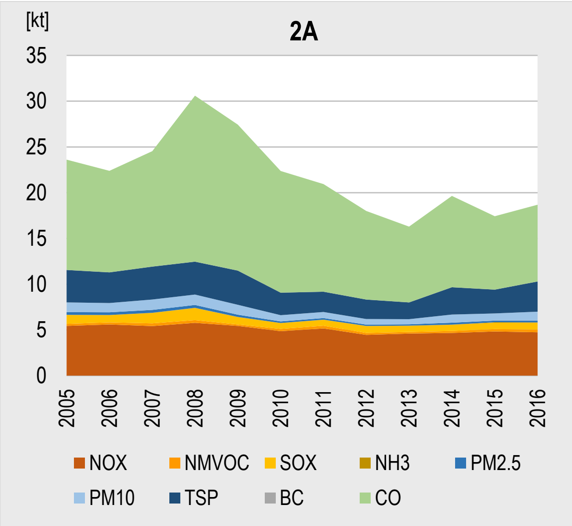


Fig. 6.12 *Emission trends of air pollutants in sector of chemical industry in years 2005 – 2016.*

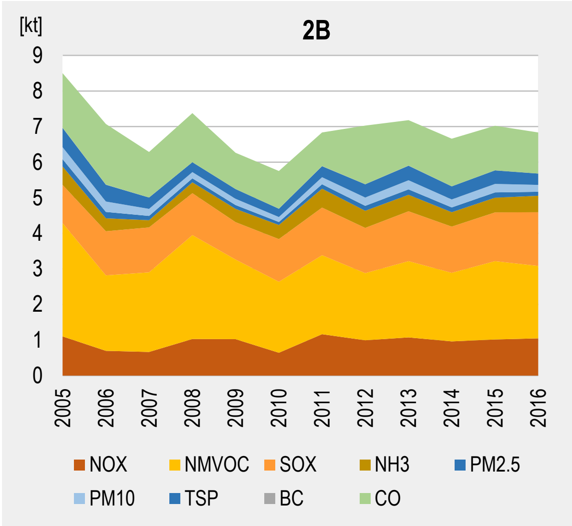


Fig. 6.13 *Emission trends of air pollutants in sector of metal production in years 2005 – 2016.*

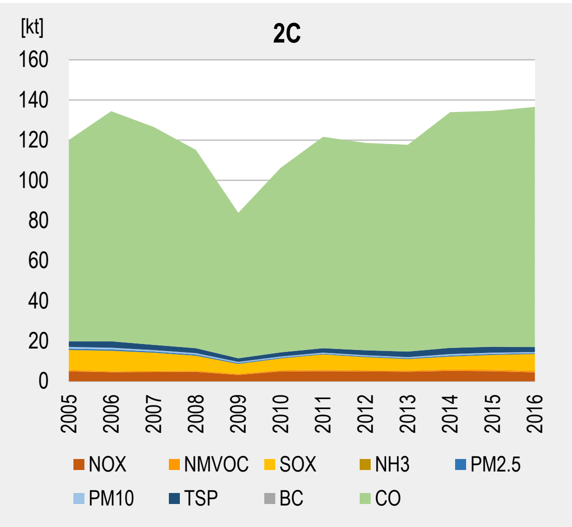
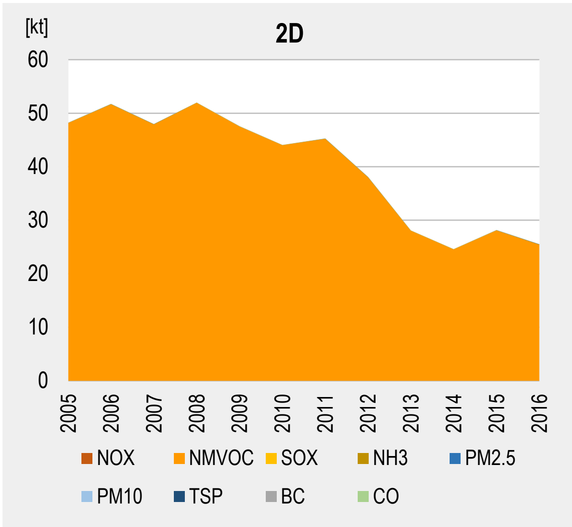


Fig. 6.14 *Emission trends of air pollutants in sector of solvents in years 2005 – 2016.*



Note: Emissions originated from included activities and processes (AP in legend) can be produces in different amounts. Hence, they might not be fully visible at the figures. However, also small amounts can be important.

6.3.3 Agriculture

Anthropogenic activities significantly contribute to the concentration changes of several gases in the atmosphere. The most important and prevailing gas emitted from agriculture regarding the effect to the environment is considered the ammonia. Ammonia reacts with other chemical substances presented in the atmosphere and forms the compounds of the solid phase (NH_4NO_3). Hence, ammonia contributes to the forming of secondary atmospheric aerosols.[16]

Wide emission scale of different gases is originated in agriculture, especially nitric oxide (NO), emissions of particulate matters (PM_{10} and $PM_{2.5}$) and emissions of non-methane volatile organic compounds (NMVOC).

Emissions of nitrogen (NH_3 a NO) one can define as a loss of nitrogen in the form of the oxides (so-called *volatilisation*). Nitrogen oxides are creating during the entire life cycle, starting by the creating of organic waste (nitrogen excretion in the form of urea and manure of livestock) until its usage at the fertilization of agricultural soils.

Nitrogen is elementary compound essential for animal and crops growing. The substance is presented in feed doses and inorganic fertilizers. Nitrogen is built into plant tissues, muscles and bones of live-stock. Unconsumed nitrogen in form of excretion (urea and dung) has to be stored before further use. During this period, the emissions are generated. Manure is used as fertilizer for agricultural soil or input of biogas stations. In the process of crops growing it is necessary to supply the elementary nitrogen in to the agricultural soil in order to better growth of plants also in the form of organic fertilizers. In certain circumstances, the applied nitrogen can be washed out from the agricultural soil. Nitrogen is undergone through chemical reactions with the production of emissions within all mentioned active-ties. These emissions have an adverse effect on environments, mainly for the air and water quality.

Emission balance has the following structure NFR 14:

AGRICULTURE

- Manure management (3B)
- Agricultural soils (3D)
- Field burning of agricultural residues (3F)
- Agriculture other (3I)

Percentage determination of individual categories of ammonia emissions are listed below:
- surface application of organic and inorganic waste to agricultural soil: approximately 66%,
- livestock housing and storage of organic waste: approximately 32%,
- grazing: approximately 2%.

The share of the agricultural sector in the national total of NMVOC is approximately 10%. NMVOC are forming in the digestive tract of herbivores as a by-product of enteric (intestinal) fermentation. In this process, the microorganisms cleave the saccharides to simple molecules. The amount of released emission of NMVOC depends on the digestive tract, age and weight of the animal as well as the quality and amount of consumed feed. Another source of emissions is the feed storage, above all the storage of silage.

The agriculture is producing the emissions of particulate matters PM_{10} a $PM_{2.5}$. The share of PM_{10} emissions at the national total of PM_{10} is approximately 2%, whilst the share of $PM_{2.5}$ emissions at the national total is only 0,15%. The emissions are creating in agriculture especially during the handling with animal feed, manipulation and drying of agricultural crops, manipulation with bedding animals in stables and in soil cultivation. At the same time, pollutants are produced when the animals are active during their stabling.

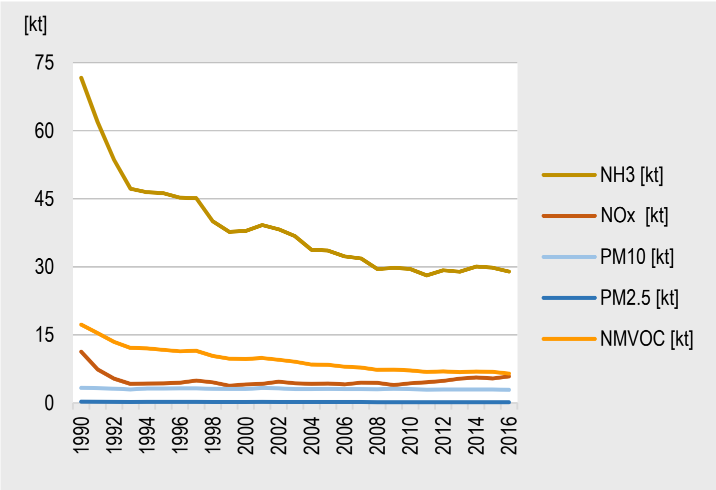
[16] *https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/urban-pm25-atlas-air-quality-european-cities*

Emission trends in the sector of agriculture

During the period 1990 – 2016, livestock numbers in the Slovak Republic has dropped dramatically in the most of the monitored species except goats and poultry. Number of cattle has decreased by 71%, swine by 77% and sheep by 39% over the period. This trend was related to the adverse economic situation in the entire sector. The decline in the number of livestock has had a major impact on the decrease of calculated emissions (**Fig. 6.15**).

In 2010 – 2016, there was a slight increase in NH_3 and NO_X emissions. It was caused by increased consumption of inorganic nitrogen fertilizers and their application to agricultural land.

Fig. 6.15 *Emission trends in agriculture.*



6.3.4 Waste managements

From the sectoral point of view, the emission inventory has the following breakdown according to the structure of NFR14:

WASTE MANAGEMENT

- Solid waste disposal on land (5A)
- Biological treatment of waste (5B)
- Incineration of waste (5C)
- Wastewater handling (5D)
- Other waste (5E)

Tab. 6.6 *The complete tree structure of Nomenclature For Reporting (NFR14) – part 1.*

1. ENERGY

- **1.A STATIONARY FUEL COMBUSTION ACTIVITIES**
  - 1.A.1 ENERGY INDUSTRIES
    - 1.A.1.a Public electricity and heat production
    - 1.A.1.b Petroleum refining
    - 1.A.1.c Manufacture of solid fuels and other energy industries
  - 1.A.2 MANUFACTURING INDUSTRY AND CONSTRUCTION
    - 1.A.2.a Iron and steel
    - 1.A.2.b Non-ferrous metals
    - 1.A.2.c Chemicals
    - 1.A.2.d Pulp, Paper and Print
    - 1.A.2.e Food processing, beverages and tobacco
    - 1.A.2.f Non-metallic minerals
    - 1.A.2.g Other manufacturing industries and construction
      - 1.A.2.g.vii Mobile Combustion in manufacturing industries and construction
      - 1.A.2.g.viii Other stationary combustion in manufacturing industries and construction
  - 1.A.3 TRANSPORT
    - 1.A.3.a Civil aviation
      - 1.A.3.a.i(i) International aviation LTO (civil)
      - 1.A.3.a.ii(i) Domestic aviation LTO (civil)
    - 1.A.3.b Road transport
      - 1.A.3.b.i Passenger cars
      - 1.A.3.b.ii Light duty vehicles
      - 1.A.3.b.iii Heavy duty vehicles and buses
      - 1.A.3.b.iv Mopeds & motorcycles
      - 1.A.3.b.v Gasoline evaporation
      - 1.A.3.b.vi Automobile tyre and brake wear
      - 1.A.3.b.vii Automobile road abrasion
    - 1.A.3.c Railways
    - 1.A.3.d Water transport
      - 1.A.3.d.i(ii) International inland waterways
      - 1.A.3.d.ii National navigation (shipping)
    - 1.A.3.e Other transport
      - 1.A.3.e.i Pipeline transport
      - 1.A.3.e.ii Other
  - 1.A.4 OTHER SECTORS
    - 1.A.4.a Commercial/Institutional
      - 1.A.4.a.i Commercial/Institutional: Stationary
      - 1.A.4.a.ii Commercial/Institutional: Mobile
    - 1.A.4.b Residential
      - 1.A.4.b.i Residential: Stationary
      - 1.A.4.b.ii Residential: Household and gardening (mobile)
    - 1.A.4.c Agriculture/Forestry/Fishing
      - 1.A.4.c.i Stationary
      - 1.A.4.c.ii Off-road vehicles and other machinery
      - 1.A.4.c.iii National fishing
  - 1.A.5 OTHER COMBUSTION
    - 1.A.5.a Other stationary (including military)
    - 1.A.5.b Other, Mobile (including military, land based and recreational boats)
- **1.B FUGITIVE EMISSIONS**
  - 1.B.1 FUGITIVE EMISSIONS FROM SOLID FUELS
    - 1.B.1.a Coal mining and handling
    - 1.B.1.b Solid fuel transformation
    - 1.B.1.c Other fugitive emissions from solid fuels
  - 1.B.2 FUGITIVE EMISSIONS FROM OIL AND NATURAL GAS
    - 1.B.2.a Fugitive emissions oil
      - 1.B.2.a.i Exploration, production, transport
      - 1.B.2.a.iv Refining / storage
      - 1.B.2.a.v Distribution of oil products
    - 1.B.2.b Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution, other)
    - 1.B.2.c Venting and flaring (oil, gas, combined oil and gas)
    - 1.B.2.d Other fugitive emissions from energy production

Tab. 6.6 *The complete tree structure of Nomenclature For Reporting (NFR14) – part 2.*

2. INDUSTRY

- **2.A MINERAL PRODUCTION**
  - 2.A.1 CEMENT PRODUCTION
  - 2.A.2 LIME PRODUCTION
  - 2.A.3 GLASS PRODUCTION
  - 2.A.5 MINERALS OTHER THAN COAL
    - 2.A.5.a Quarrying and mining of minerals other than coal
    - 2.A.5.b Construction and demolition
    - 2.A.5.c Storage, handling and transport of mineral products
  - 2.A.6 OTHER MINERAL PRODUCTS
- **2.B CHEMICAL INDUSTRY**
  - 2.B.1 AMMONIA PRODUCTION
  - 2.B.2 NITRIC ACID PRODUCTION
  - 2.B.3 ADIPIC ACID PRODUCTION
  - 2.B.5 CARBIDE PRODUCTION
  - 2.B.6 TITANIUM DIOXIDE PRODUCTION
  - 2.B.7 SODA ASH PRODUCTION
  - 2.B.10 OTHER CHEMICAL INDUSTRY
    - 2.B.10.a Chemical industry: Other
    - 2.B.10.b Storage, handling and transport of chemical products
- **2.C METAL PRODUCTION**
  - 2.C.1 IRON AND STEEL PRODUCTION
  - 2.C.2 FERROALLOYS PRODUCTION
  - 2.C.3 ALUMINIUM PRODUCTION
  - 2.C.4 MAGNESIUM PRODUCTION
  - 2.C.5 LEAD PRODUCTION
  - 2.C.6 ZINC PRODUCTION
  - 2.C.7 OTHER METAL PRODUCTION AND HANDLING
    - 2.C.7.a Copper production
    - 2.C.7.b Nickel production
    - 2.C.7.c Other metal production
    - 2.C.7.d Storage, handling and transport of metal products
- **2.D SOLVENTS**
  - 2.D.3 SOLVENTS USE
    - 2.D.3.a Domestic solvent use including fungicides
    - 2.D.3.b Road paving with asphalt
    - 2.D.3.c Asphalt roofing
    - 2.D.3.d Coating applications
    - 2.D.3.e Degreasing
    - 2.D.3.f Dry cleaning
    - 2.D.3.g Chemical products
    - 2.D.3.h Printing
    - 2.D.3.i Other solvent use
- **2.G OTHER PRODUCT USE**
- **2.H OTHER PRODUCTION INDUSTRY**
  - 2.H.1 PULP AND PAPER INDUSTRY
  - 2.H.2 FOOD AND BEVERAGES INDUSTRY
  - 2.H.3 OTHER INDUSTRIAL PROCESSES
- **2.I WOOD PROCESSING**
- **2.J PRODUCTION OF POPs**
- **2.K CONSUMPTION OF POPS AND HEAVY METALS**
- **2.L OTHER PRODUCTION, CONSUMPTION, STORAGE, TRANSPORTATION OR HANDLING OF BULK PRODUCTS**

Tab. 6.6 The complete tree struct ure of Nomenclature For Reporting (NFR14) – part 3.

3 AGRICULTURE

- **3.B MANURE MANAGEMENT**
  - 3.B.1 CATTLE
    - 3.B.1.a Dairy cattle
    - 3.B.1.b Non-dairy cattle
  - 3.B.2 SHEEP
  - 3.B.2 SWINE
  - 3.B.4 OTHER
    - 3.B.4.a Buffalo
    - 3.B.4.d Goats
    - 3.B.4.e Horses
    - 3.B.4.f Mules and asses
    - 3.B.4.g Poultry
      - 3.B.4.g.i Laying hens
      - 3.B.4.g.ii Broilers
      - 3.B.4.g.iii Turkeys
      - 3.B.4.g.iv Other poultry
    - 3.B.4.h Other animals
- **3.D AGRICULTURAL SOILS**
  - 3.D.a FERTILIZERS
    - 3.D.a.1 Inorganic N-fertilizers (includes also urea application)
    - 3.D.a.2 Application to soils
      - 3.D.a.2.a Animal manure applied to soils
      - 3.D.a.2.b Sewage sludge applied to soils
      - 3.D.a.2.c Other organic fertilisers applied to soils (including compost)
    - 3.D.a.3 Urine and dung deposited by grazing animals
    - 3.D.a.4 Crop residues applied to soils
  - 3.D.b INDIRECT EMISSIONS FROM MANAGED SOILS
  - 3.D.c FARM-LEVEL AGRICULTURAL OPERATIONS INCLUDING STORAGE, HANDLING AND TRANSPORT OF AGRICULTURAL PRODUCTS
  - 3.D.d OFF-FARM STORAGE, HANDLING AND TRANSPORT OF BULK AGRICULTURAL PRODUCTS
  - 3.D.e CULTIVATED CROPS
  - 3.D.f USE OF PESTICIDES
- **3.F FIELD BURNING OF AGRICULTURAL RESIDUES**
- **3.I AGRICULTURE OTHER**

5. WASTE

- **5.A SOLID WASTE DISPOSAL ON LAND**
- **5.B BIOLOGICAL TREATMENT OF WASTE**
  - 5.B.1 COMPOSTING
  - 5.B.2 ANAEROBIC DIGESTION AT BIOGAS FACILITIES
- **5.C INCINERATION AND OPEN BURNING OF WASTE**
  - 5.C.1 INCINERATION
    - 5.C.1.a Municipal waste incineration
    - 5.C.1.b Industrial waste incineration in total
      - 5.C.1.b.i Industrial waste incineration
      - 5.C.1.b.ii Hazardous waste incineration
      - 5.C.1.b.iii Clinical waste incineration
      - 5.C.1.b.iv Sewage sludge incineration
      - 5.C.1.b.v Cremation
      - 5.C.1.b.vi Other waste incineration
  - 5.C.2 OPEN BURNING OF WASTE
- **5.D WASTE WATER HANDLING**
  - 5.D.1 DOMESTIC WASTEWATER HANDLING
  - 5.D.2 INDUSTRIAL WASTEWATER HANDLING
  - 5.D.3 OTHER WASTEWATER HANDLING
- **5.E OTHER WASTE**

6. OTHER

- 6. A OTHER

NATIONAL TOTAL

6.4 NATIONAL EMISSION INFORMATION SYSTEM

The basic data from the stationary air pollution sources (hereinafter sources) in SR has began to collect already in 80s of the 20th century. Data were stored in relative simply database of Emission and Air Pollution Source Registry (EAPSR). Radical changes in 90s induced creating a new broader information system for the registering of air pollution sources. Since 2001, the National Emission Information System (NEIS) is used for this purpose. The NEIS was during years regularly extended and updated. The primary scope of the NEIS was mainly the computations of the emissions amounts and air pollution fees for release. At present, this system is used as important (in some cases the only) source of broad-spectrum data (amounts of released air pollutants, amounts of combusted fuels, combustion plant and technology parameters etc.). The Slovak Hydrometeorological Institue is delegated by the Ministry of Environment of the Slovak Republic to manage and administrate the NEIS.

Nowadays, system includes module for district offices, portal NEIS PZ WEB for the air pollution source operators (*https://neispz.shmu.sk/*) and central reporting and output module for SHMÚ. Selected data are available on the site *http://neisrep.shmu.sk*, where the user after creating a free account can prepare and dowload customed reports.

Data stored in the NEIS are collected on the base of two main reporting obligations of air pollution source operators:

- obligation as provided in § 4 Act No. 401/1998 on air emission fees, as amended,
- obligation as provided in § 15 section 1 letter e) Act No. 137/2010 on air protection, as amended.

Operators annually report required data thought the portal NEIS PZ WEB. Initial data processing is executed by the district officers at the respective district offices. Summary yearly data evaluation of all large and medium stationary source operators in respective district is submitted by district offices electronically to SHMÚ by 31st May. SHMÚ is processing, analyzing and reviewing data, and also correcting them in collaboration with district officers, if necessary. This centralised review process is running over every year to the end of October. After this internal review process follows the processing of many output reports.

Outputs of the NEIS are used in the preparation process of multiple reports in line with the reporting requirements of the SR (more details in Chapter **6.1**). Also overviews of the most significant stationary air pollution source operators in SR in Chapter **6.4.2** and **6.4.3** were prepared on the base of the NEIS data.

6.4.1 Number of stationary sources listed in NEIS

The term 'stationary air pollution source' is defined in the Act No. 137/2010 on the air[17], as amended, § 3 section 1 letter a). “Source” means a stationary technical unit, stock or fuel storage, landfill, quarry or other area with possibility of steaming up, burning or transferring of pollutants. Source is also other building, object and activity, which could have an effect on emissions and air pollution. Source is allocated as a complex of all parts, components and activities within the functional unit and spatial unit. Section 2 of § 3 states that stationary sources are divided as large, medium or small sources, according to the ratio of their effect on emissions and air pollution. In terms of section 4, the stationary sources are categorized on the base of technology character. The categories and the projected capacity thresholds are listed in the Annex 1 to the Regulation No. 410/2012, as amended[18].

[17] *https://www.slov-lex.sk/pravne-predpisy/SK/ZZ/2010/137/20171201*
[18] *https://www.slov-lex.sk/pravne-predpisy/SK/ZZ/2012/410/20171219*

Number of stationary sources recorded in the NEIS during the year 2016 at regional level is presented in the tables from **Tab. 6.7** to **Tab. 6.9**. Total number of sources means the number of large and medium stationary sources. The tables from **Tab. 6.8** to **Tab. 6.9** present more detailed numbers in division of scale and operational status. Status out of operation means that sources were not running the whole year, i.e. no emissions were released from these sources. The reasons can be various: temporary suspension of production during a longer reconstruction, termination without liquidation of the installations (e.g. unused or abandoned factories), or other.

Tab. 6.7 *Number of stationary air pollution sources listed in NEIS for the year 2016 at regional level.*

Region	Total number of sources	From this:	
		large sources	medium sources
Bratislava	1 901	90	1 811
Trnava	1 682	119	1 563
Trenčín	1 573	105	1 468
Nitra	1 873	148	1 725
Žilina	1 604	90	1 514
Banská Bystrica	1 893	120	1 773
Prešov	1 664	67	1 597
Košice	1 478	139	1 339
SR	**13 668**	**878**	**12 790**

Tab. 6.8 *Number of large stationary air pollution sources listed in NEIS for the year 2016 at regional level.*

Region	Number of large sources	From this:	
		in operation	out of operation
Bratislava	90	84	6
Trnava	119	105	14
Trenčín	105	93	12
Nitra	148	116	32
Žilina	90	77	13
Banská Bystrica	120	97	23
Prešov	67	53	14
Košice	139	109	30
SR	**878**	**734**	**144**

Tab. 6.9 *Number of medium stationary air pollution sources listed in NEIS for the year 2016 at regional level.*

Region	Number of medium sources	From this:	
		in operation	out of operation
Bratislava	1 811	1 545	266
Trnava	1 563	1 234	329
Trenčín	1 468	1 290	178
Nitra	1 725	1 321	404
Žilina	1 514	1 312	202
Banská Bystrica	1 773	1 391	382
Prešov	1 597	1 363	234
Košice	1 339	1 074	265
SR	**12 790**	**10 530**	**2 260**

6.4.2 Overview of the most significant stationary air pollution source operators in SR listed in database NEIS

Tables from **Tab. 6.10** to **Tab. 6.13** include the list of most significant operators of stationary air pollution sources (thereinafter “sources“) in SR during the year 2016. The emission values are presented in tonnes per year. These total yearly emissions were released from stationary air pollution sources, which are located at the territory of given district and operated by presented operator. The percentual value of Share on total emissions - SR presents the share on total emissions released in given year from large and medium stationary sources in SR listed in NEIS.

Tab. 6.10 *Total suspended particles (TSP) released from the most important sources of operators – 2016.*

	Operator	Sources in district	Emissions [t]	Share on total emissions [%]
1.	U. S. Steel Košice, s.r.o.	Košice II	2 702.63	49.89
2.	Považská cementáreň, a.s.	Ilava	183.28	3.38
3.	Slovenské elektrárne, a.s. závod Nováky	Prievidza	153.94	2.84
4.	Duslo, a.s.	Šaľa	147.17	2.72
5.	FORTISCHEM a. s.	Prievidza	135.34	2.50
6.	Slovalco, a.s.	Žiar nad Hronom	101.84	1.88
7.	Mondi SCP, a.s.	Ružomberok	76.24	1.41
8.	DOLVAP, s.r.o.	Žilina	70.56	1.30
9.	CRH (Slovensko) a.s.	Malacky	58.54	1.08
10.	CM European Power Slovakia, s. r. o.	Bratislava II	46.62	0.86
11.	Zvolenská teplárenská, a.s.	Zvolen	43.79	0.81
12.	BUKOCEL, a.s.	Vranov nad Topľou	39.19	0.72
13.	OFZ, a.s.	Dolný Kubín	33.76	0.62
14.	SLOVNAFT, a.s.	Bratislava II	33.40	0.62
15.	Carmeuse Slovakia, s.r.o.	Košice II	30.82	0.57
16.	Johns Manville Slovakia, a.s.	Trnava	29.94	0.55
17.	VOLKSWAGEN SLOVAKIA, a.s.	Bratislava IV	25.05	0.46
18.	Tate & Lyle Boleraz, s.r.o.	Trnava	23.46	0.43
19.	CRH (Slovensko) a.s.	Košice – okolie	21.68	0.40
20.	SYRÁREŇ BEL SLOVENSKO a.s.	Michalovce	20.56	0.38
	TOTAL		**3 977.84**	**73.43**

Tab. 6.11 *Sulphur oxides expressed as SO_2 released from the most important sources of operators – 2016.*

	Operator	Sources in district	Emissions [t]	Share on total emissions [%]
1.	U. S. Steel Košice, s.r.o.	Košice II	6 615.05	26.73
2.	Slovenské elektrárne, a.s. závod Nováky	Prievidza	6 134.13	24.78
3.	Slovalco, a.s.	Bratislava II	2 844.85	11.49
4.	SLOVNAFT, a.s.	Bratislava II	2 055.93	8.31
5.	BUKÓZA ENERGO, a. s.	Vranov nad Topľou	1 117.58	4.52
6.	OFZ, a.s.	Dolný Kubín	738.42	2.98
7.	CM European Power Slovakia, s. r. o.	Bratislava II	737.92	2.98
8.	Zvolenská teplárenská, a.s.	Zvolen	662.50	2.68
9.	Martinská teplárenská, a.s.	Martin	445.40	1.80
10.	Knauf Insulation, s.r.o.	Žarnovica	402.11	1.62
11.	Slovenské elektrárne, a.s. závod Vojany	Michalovce	259.18	1.05
12.	Žilinská teplárenská, a.s.	Žilina	254.44	1.03
13.	TEKO, a. s.	Košice IV	213.86	0.86
14.	Duslo, a.s.	Šaľa	175.50	0.71
15.	SLOVENSKÉ CUKROVARY, s.r.o.	Galanta	171.20	0.69
16.	BUKOCEL, a.s.	Vranov nad Topľou	120.49	0.49
17.	Johns Manville Slovakia, a.s.	Trnava	108.63	0.44
18.	Veolia Utilities Žiar nad Hronom, a.s.	Žiar nad Hronom	98.61	0.40
19.	Mondi SCP, a.s.	Ružomberok	96.88	0.39
20.	KOVOHUTY, a.s.	Spišská Nová Ves	93.81	0.38
	TOTAL		**23 346.48**	**94.33**

***Tab. 6.12** Nitrogen oxides expressed as NO_2 released from the most important sources of operators – 2016.*

	Operator	Sources in district	Emissions [t]	Share on total emissions [%]
1.	U. S. Steel Košice, s.r.o.	Košice II	5 862.98	22.54
2.	Slovenské elektrárne, a.s. závod Nováky	Prievidza	1 792.30	6.89
3.	CRH (Slovensko) a.s.	Malacky	1 432.68	5.51
4.	Mondi SCP, a.s.	Ružomberok	1 135.39	4.36
5.	CM European Power Slovakia, s. r. o.	Bratislava II	1 079.42	4.15
6.	SLOVNAFT, a.s.	Bratislava II	982.36	3.78
7.	CRH (Slovensko) a.s.	Košice - okolie	735.48	2.83
8.	Považská cementáreň, a.s.	Ilava	627.37	2.41
9.	Duslo, a.s.	Šaľa	596.06	2.29
10.	CEMMAC a.s.	Trenčín	518.58	1.99
11.	Slovalco, a.s.	Žiar nad Hronom	442.82	1.70
12.	OFZ, a.s.	Dolný Kubín	435.11	1.67
13.	Slovenské magnezitové závody, a.s. Jelšava	Revúca	433.95	1.67
14.	Zvolenská teplárenská, a.s.	Zvolen	414.48	1.59
15.	Carmeuse Slovakia, s.r.o.	Košice II	357.33	1.37
16.	BUKÓZA ENERGO, a. s.	Vranov nad Topľou	349.93	1.35
17.	eustream, a. s.	Michalovce	285.66	1.10
18.	RONA, a.s.	Púchov	272.20	1.05
19.	Martinská teplárenská, a.s.	Martin	261.49	1.01
20.	TEKO, a. s.	Košice IV	241.47	0.93
	TOTAL		**18 257.06**	**70.18**

***Tab. 6.13** Carbon monoxide (CO) released from the most important sources of operators – 2016.*

	Operator	Sources in district	Emissions [t]	Share on total emissions [%]
1.	U. S. Steel Košice, s.r.o.	Košice II	110 147.07	72.57
2.	Slovalco, a.s.	Žiar nad Hronom	18 005.01	11.86
3.	CEMMAC a.s.	Trenčín	2 503.14	1.65
4.	Považská cementáreň, a.s.	Ilava	2 155.93	1.42
5.	Mondi SCP, a.s.	Ružomberok	1 983.29	1.31
6.	KOVOHUTY, a.s.	Spišská Nová Ves	1 588.46	1.05
7.	Calmit, spol. s r.o.	Nitra	1 507.16	0.99
8.	CRH (Slovensko) a.s.	Malacky	1 321.62	0.87
9.	Slovenské magnezitové závody, a.s. Jelšava	Revúca	1 260.40	0.83
10.	OFZ, a.s.	Dolný Kubín	1 125.79	0.74
11.	Slovenské elektrárne, a.s. závod Nováky	Prievidza	800.25	0.53
12.	SLOVNAFT, a.s.	Bratislava II	452.85	0.30
13.	Leier Baustoffe SK s.r.o.	Prešov	388.59	0.26
14.	Slovenské elektrárne, a.s. závod Vojany	Michalovce	343.23	0.23
15.	FORTISCHEM a. s.	Prievidza	339.24	0.22
16.	SLOVINTEGRA ENERGY, a.s.	Levice	289.02	0.19
17.	SLOVMAG a.s. Lubeník	Revúca	283.28	0.19
18.	Železiarne Podbrezová a.s. skrátene ŽP a.s.	Brezno	186.12	0.12
19.	Veolia Utilities Žiar nad Hronom, a.s.	Žiar nad Hronom	177.44	0.12
20.	Službyt, spol. s r.o. Senica	Senica	177.24	0.12
	TOTAL		**145 035.12**	**95.55**

6.4.3 Overview of the most significant stationary air pollution source operators in SR at regional level

Tables from **Tab. 6.14** to **Tab. 6.21** present the most significant operators of large and medium stationary sources listed in NEIS in 2016 at regional level. The emission values are presented in tonnes per year. These total yearly emissions were released from stationary air pollution sources, which are located at the territory of given district and specific region and which are operated by presented operator. The percentual value Share on total emission - region presents the share on total emissions released from large and medium stationary sources in the given region and year. The percentual value Share on total emissions - SR presents the share on total emissions released in given year from large and medium stationary sources in SR listed in NEIS.

Tab. 6.14 *Total suspended particles, Sulphur oxides, Nitrogen oxides and Carbon monoxide released from stationary sources of most significant operators in 2016 at regional level –* ***Bratislava region.***

		Operator	Sources in district	Emissions [t]	Share on total emissions	
					region [%]	SR [%]
Total suspended particles	1.	CM European Power Slovakia, s. r. o.	Bratislava II	46.62	0.86	21.94
	2.	SLOVNAFT, a.s.	Bratislava II	33.40	0.62	15.72
	3.	VOLKSWAGEN SLOVAKIA, a.s.	Bratislava IV	25.05	0.46	11.79
	4.	CRH (Slovensko) a.s.	Malacky	21.68	0.40	10.20
	5.	Bratislavská teplárenská, a.s.	Bratislava III	6.60	0.12	3.11
	6.	ALAS SLOVAKIA, s.r.o.	Malacky	6.01	0.11	2.83
	7.	Ministerstvo obrany Slovenskej republiky	Pezinok	5.02	0.09	2.36
	8.	TERMMING, a.s.	Bratislava II	4.50	0.08	2.12
	9.	IKEA Industry Slovakia s. r. o.	Malacky	4.09	0.08	1.93
	10.	Obec Rohožník	Malacky	3.98	0.07	1.87
		TOTAL		**156.95**	**73.86**	**2.90**
Sulphur oxides *as SO_2*	1.	SLOVNAFT, a.s.	Bratislava II	2 055.93	67.22	8.31
	2.	CM European Power Slovakia, s. r. o.	Bratislava II	737.92	24.13	2.98
	3.	Duslo, a.s.	Bratislava III	175.50	5.74	0.71
	4.	CRH (Slovensko) a.s.	Malacky	39.89	1.30	0.16
	5.	Bratislavská teplárenská, a.s.	Bratislava II	12.94	0.42	0.05
	6.	Ministerstvo obrany Slovenskej republiky	Pezinok	8.16	0.27	0.03
	7.	Bratislavská teplárenská, a.s.	Bratislava III	6.10	0.20	0.02
	8.	Odvoz a likvidácia odpadu, a.s.	Bratislava II	5.59	0.18	0.02
	9.	BPS Senec, s. r. o.	Senec	4.91	0.16	0.02
	10.	BIONERGY, a. s.	Bratislava II	2.42	0.08	0.01
		TOTAL		**3 049.36**	**99.70**	**12.32**
Nitrogen oxides *as NO_2*	1.	CRH (Slovensko) a.s.	Malacky	1 432.68	32.53	5.51
	2.	CM European Power Slovakia, s. r. o.	Bratislava II	1 079.42	24.51	4.15
	3.	SLOVNAFT, a.s.	Bratislava II	982.36	22.30	3.78
	4.	Bratislavská teplárenská, a.s.	Bratislava III	120.26	2.73	0.46
	5.	VOLKSWAGEN SLOVAKIA, a.s.	Bratislava IV	98.47	2.24	0.38
	6.	Odvoz a likvidácia odpadu, a.s.	Bratislava II	89.34	2.03	0.34
	7.	Veolia Energia Slovensko, a. s.	Bratislava V	79.53	1.81	0.31
	8.	TERMMING, a.s.	Bratislava II	51.95	1.18	0.20
	9.	Bratislavská teplárenská, a.s.	Bratislava IV	48.81	1.11	0.19
	10.	NAFTA a.s.	Malacky	33.98	0.77	0.13
		TOTAL		**4 016.81**	**91.19**	**15.44**
Carbon monoxide	1.	CRH (Slovensko) a.s.	Malacky	1 321.62	56.74	0.87
	2.	SLOVNAFT, a.s.	Bratislava II	452.85	19.44	0.30
	3.	TERMMING, a.s.	Malacky	130.70	5.61	0.09
	4.	Bratislavská teplárenská, a.s.	Bratislava III	39.32	1.69	0.03
	5.	VOLKSWAGEN SLOVAKIA, a.s.	Bratislava IV	32.02	1.37	0.02
	6.	Ministerstvo obrany Slovenskej republiky	Pezinok	30.73	1.32	0.02
	7.	Veolia Energia Slovensko, a. s.	Bratislava V	29.52	1.27	0.02
	8.	Obec Rohožník	Malacky	28.28	1.21	0.02
	9.	IKEA Industry Slovakia s. r. o.	Malacky	25.02	1.07	0.02
	10.	PPC Energy, a.s.	Bratislava III	20.54	0.88	0.01
		TOTAL		**2 110.60**	**90.61**	**1.39**

Tab. 6.15 *Total suspended particles, Sulphur oxides, Nitrogen oxides and Carbon monoxide released from stationary sources of most significant operators in 2016 at regional level –* ***Trnava region.***

		Operator	Sources in district	Emissions [t]	Share on total emissions	
					region [%]	SR [%]
Total suspended particles	1.	Johns Manville Slovakia, a.s.	Trnava	29.94	14.66	0.55
	2.	Tate & Lyle Boleraz, s.r.o.	Trnava	23.46	11.48	0.43
	3.	SLOVENSKÉ CUKROVARY, s.r.o.	Galanta	19.03	9.31	0.35
	4.	Agropodnik a.s. Trnava	Dunajská Streda	11.77	5.76	0.22
	5.	Agro Boleráz, s.r.o.	Trnava	5.75	2.81	0.11
	6.	PCA Slovakia, s.r.o.	Trnava	5.64	2.76	0.10
	7.	Bekaert Slovakia, s.r.o.	Galanta	5.59	2.74	0.10
	8.	JK Gabčíkovo s.r.o.	Dunajská Streda	4.26	2.08	0.08
	9.	ENVIRAL, a.s.	Hlohovec	4.09	2.00	0.08
	10.	Agropodnik a.s. Trnava	Senica	3.89	1.90	0.07
		TOTAL		**113.42**	**55.51**	**2.09**
Sulphur oxides as SO_2	1.	SLOVENSKÉ CUKROVARY, s.r.o.	Galanta	171.20	40.50	0.69
	2.	Johns Manville Slovakia, a.s.	Trnava	108.63	25.70	0.44
	3.	MACH TRADE, spol. s r.o.	Galanta	29.95	7.08	0.12
	4.	Hornonitrianske bane Prievidza, a.s.	Senica	21.42	5.07	0.09
	5.	ZLIEVÁREŇ T R N A V A s.r.o.	Trnava	18.39	4.35	0.07
	6.	ECO PWR, s. r. o.	Dunajská Streda	11.04	2.61	0.04
	7.	RUPOS, s.r.o.	Trnava	9.05	2.14	0.04
	8.	ZF Slovakia, a.s.	Trnava	4.99	1.18	0.02
	9.	BPS Hubice, s. r. o.	Dunajská Streda	4.97	1.17	0.02
	10.	Ing. Peter Horváth - SHR	Galanta	4.65	1.10	0.02
		TOTAL		**384.28**	**90.90**	**1.55**
Nitrogen oxides as NO_2	1.	SLOVENSKÉ CUKROVARY, s.r.o.	Galanta	130.88	14.93	0.50
	2.	Johns Manville Slovakia, a.s.	Trnava	116.37	13.27	0.45
	3.	ENVIRAL, a.s.	Hlohovec	62.01	7.07	0.24
	4.	Tate & Lyle Boleraz, s.r.o.	Trnava	50.61	5.77	0.19
	5.	Službyt, spol. s r.o.	Senica	36.35	4.15	0.14
	6.	IKEA Industry Slovakia s. r. o.	Trnava	26.68	3.04	0.10
	7.	TEPLÁREŇ Považská Bystrica, s.r.o.	Dunajská Streda	25.12	2.87	0.10
	8.	Bekaert Hlohovec, a.s.	Hlohovec	20.92	2.39	0.08
	9.	STAKOTRA MANUFACTURING, s.r.o.	Piešťany	15.97	1.82	0.06
	10.	ELBIOGAS s. r. o.	Dunajská Streda	12.78	1.46	0.05
		TOTAL		**497.69**	**56.77**	**1.91**
Carbon monoxide	1.	Službyt, spol. s r.o.	Senica	177.24	33.98	0.12
	2.	IKEA Industry Slovakia s. r. o.	Trnava	27.34	5.24	0.02
	3.	ENVIRAL, a.s.	Hlohovec	20.99	4.02	0.01
	4.	Tate & Lyle Boleraz, s.r.o.	Trnava	17.36	3.33	0.01
	5.	SLOVENSKÉ CUKROVARY, s.r.o.	Galanta	16.80	3.22	0.01
	6.	ZLIEVÁREŇ T R N A V A s.r.o.	Trnava	12.39	2.38	0.01
	7.	Johns Manville Slovakia, a.s.	Trnava	11.55	2.21	0.01
	8.	I.D.C. Holding, a.s.	Galanta	11.22	2.15	0.01
	9.	ASTOM ND, s. r. o.	Dunajská Streda	9.78	1.88	0.01
	10.	Wienerberger slovenské tehelne, spol. s r.o.	Trnava	9.70	1.86	0.01
		TOTAL		**314.36**	**60.26**	**0.21**

Tab. 6.16 *Total suspended particles, Sulphur oxides, Nitrogen oxides and Carbon monoxide released from stationary sources of most significant operators in 2016 at regional level –* ***Trenčín region.***

		Operator	Sources in district	Emissions [t]	Share on total emissions	
					region [%]	**SR** [%]
Total suspended particles	1.	Považská cementáreň, a.s.	Ilava	183.28	28.72	3.38
	2.	Slovenské elektrárne, a.s.	Prievidza	153.94	24.12	2.84
	3.	FORTISCHEM a. s.	Prievidza	135.34	21.21	2.50
	4.	Hornonitrianske bane Prievidza,	Prievidza	20.33	3.19	0.38
	5.	Považský cukor a.s.	Trenčín	15.39	2.41	0.28
	6.	TERMONOVA, a.s.	Ilava	15.38	2.41	0.28
	7.	CEMMAC a.s.	Trenčín	11.49	1.80	0.21
	8.	Continental Matador Rubber, s.r.o.	Púchov	6.07	0.95	0.11
	9.	KVARTET,a.s.	Partizánske	5.86	0.92	0.11
	10.	Kameňolomy, s.r.o.	Trenčín	5.46	0.86	0.10
		TOTAL		**552.54**	**86.58**	**10.20**
Sulphur oxides *as SO_2*	1.	Slovenské elektrárne, a.s.	Prievidza	6 134.13	96.62	24.78
	2.	VETROPACK NEMŠOVÁ, s.r.o.	Trenčín	86.90	1.37	0.35
	3.	Hornonitrianske bane Prievidza, a.s.	Prievidza	26.55	0.42	0.11
	4.	Považská cementáreň, a.s.	Ilava	12.44	0.20	0.05
	5.	BIOPLYN HOROVCE 2 s. r. o.	Púchov	9.58	0.15	0.04
	6.	FORTISCHEM a. s.	Prievidza	8.42	0.13	0.03
	7.	BIOPLYN HOROVCE 3, s. r. o.	Púchov	6.75	0.11	0.03
	8.	Bioplyn Horovce, s. r. o.	Púchov	5.83	0.09	0.02
	9.	CEMMAC a.s.	Trenčín	5.28	0.08	0.02
	10.	AGROSERVIS-SLUŽBY, spol. s r.o.	Partizánske	4.84	0.08	0.02
		TOTAL		**6 300.72**	**99.24**	**25.46**
Nitrogen oxides *as NO_2*	1.	Slovenské elektrárne, a.s.	Prievidza	1 792.30	43.95	6.89
	2.	Považská cementáreň, a.s.	Ilava	627.37	15.38	2.41
	3.	CEMMAC a.s.	Trenčín	518.58	12.72	1.99
	4.	RONA, a.s.	Púchov	272.20	6.67	1.05
	5.	VETROPACK NEMŠOVÁ, s.r.o.	Trenčín	203.65	4.99	0.78
	6.	FORTISCHEM a. s.	Prievidza	76.99	1.89	0.30
	7.	TEPLÁREŇ Považská Bystrica, s.r.o.	Považská Bystrica	70.47	1.73	0.27
	8.	TERMONOVA, a.s.	Ilava	43.20	1.06	0.17
	9.	Continental Matador Rubber, s.r.o.	Púchov	33.16	0.81	0.13
	10.	Výroba tepla, s. r. o.	Trenčín	29.45	0.72	0.11
		TOTAL		**3 667.37**	**89.93**	**14.10**
Carbon monoxide	1.	CEMMAC a.s.	Trenčín	2 503.14	37.04	1.65
	2.	Považská cementáreň, a.s.	Ilava	2 155.93	31.90	1.42
	3.	Slovenské elektrárne, a.s.	Prievidza	800.25	11.84	0.53
	4.	FORTISCHEM a. s.	Prievidza	339.24	5.02	0.22
	5.	Považský cukor a.s.	Trenčín	168.59	2.49	0.11
	6.	TEPLÁREŇ Považská Bystrica, s.r.o.	Považská Bystrica	144.35	2.14	0.10
	7.	Technické služby mesta Partizánske, spol. s r. o.	Partizánske	110.47	1.63	0.07
	8.	ENGIE Services a.s.	Myjava	86.62	1.28	0.06
	9.	KVARTET,a.s.	Partizánske	33.02	0.49	0.02
	10.	Výroba tepla, s. r. o.	Trenčín	26.40	0.39	0.02
		TOTAL		**6 368.02**	**94.22**	**4.20**

Tab. 6.17 *Total suspended particles, Sulphur oxides, Nitrogen oxides and Carbon monoxide released from stationary sources of most significant operators in 2016 at regional level –* ***Nitra region.***

		Operator	Sources in district	Emissions [t]	Share on total emissions	
					region [%]	SR [%]
Total suspended particles	1.	Duslo, a.s.	Šaľa	147.17	40.12	2.72
	2.	SLOVINCOM, spol. s r.o.	Komárno	13.44	3.66	0.25
	3.	DECODOM, spol. s r. o.	Topoľčany	10.72	2.92	0.20
	4.	P.G.TRADE, spol. s r.o.	Nové Zámky	9.11	2.48	0.17
	5.	SLOVENSKÉ ENERGETICKÉ STROJÁRNE a.s.	Levice	8.87	2.42	0.16
	6.	SLOVINTEGRA ENERGY, a.s.	Levice	8.82	2.40	0.16
	7.	MENERT – THERM, s.r.o.	Šaľa	7.53	2.05	0.14
	8.	Prvá energetická a teplárenská spoločnosť, s.r.o.	Zlaté Moravce	7.49	2.04	0.14
	9.	LENCOS spol. s r.o.	Levice	6.48	1.77	0.12
	10.	Kameňolomy a štrkopieskovne, a.s.,	Nitra	6.08	1.66	0.11
		TOTAL		**225.70**	**61.53**	**4.17**
Sulphur oxides as SO_2	1.	BIONOVES, s.r.o.	Nitra	23.25	17.91	0.09
	2.	P.G.TRADE, spol. s r.o.	Nové Zámky	15.47	11.92	0.06
	3.	GAS PROGRES I., spol. s r.o.	Nitra	10.08	7.76	0.04
	4.	AT GEMER, spol. s r.o.	Nové Zámky	9.95	7.66	0.04
	5.	BIOGAS, s.r.o.	Nitra	9.24	7.12	0.04
	6.	Bioplyn Cetín, s. r. o.	Nitra	8.54	6.58	0.03
	7.	Liaharenský podnik Nitra, a.s.	Levice	7.85	6.04	0.03
	8.	BPS Lipová 1 s.r.o.	Nové Zámky	5.98	4.61	0.02
	9.	Calmit, spol. s r.o.	Nitra	4.88	3.76	0.02
	10.	Icopal a.s.	Nové Zámky	3.82	2.94	0.02
		TOTAL		**99.05**	**76.32**	**0.40**
Nitrogen oxides as NO_2	1.	Duslo, a.s.	Šaľa	596.06	40.26	2.29
	2.	BIOENERGY TOPOĽČANY s.r.o.	Topoľčany	129.03	8.71	0.50
	3.	SLOVINTEGRA ENERGY, a.s.	Levice	125.21	8.46	0.48
	4.	Bytkomfort, s.r.o.	Nové Zámky	46.42	3.14	0.18
	5.	VICENTE TORNS SLOVAKIA, a.s.	Komárno	34.17	2.31	0.13
	6.	TOP PELET, s.r.o.	Topoľčany	26.45	1.79	0.10
	7.	P.G.TRADE, spol. s r.o.	Nové Zámky	23.61	1.59	0.09
	8.	DECODOM, spol. s r. o.	Topoľčany	20.00	1.35	0.08
	9.	Wienerberger slovenské tehelne, spol. s r.o.	Zlaté Moravce	19.62	1.33	0.08
	10.	Nitrianska teplárenská spoločnosť, a.s.	Nitra	18.59	1.26	0.07
		TOTAL		**1 039.17**	**70.18**	**3.99**
Carbon monoxide	1.	Calmit, spol. s r.o.	Nitra	1 507.16	59.09	0.99
	2.	SLOVINTEGRA ENERGY, a.s.	Levice	289.02	11.33	0.19
	3.	Bytkomfort, s.r.o.	Nové Zámky	164.09	6.43	0.11
	4.	Duslo, a.s.	Šaľa	91.34	3.58	0.06
	5.	Secop s.r.o.	Zlaté Moravce	57.26	2.25	0.04
	6.	Wienerberger slovenské tehelne, spol. s r.o.	Zlaté Moravce	38.41	1.51	0.03
	7.	SLOVINCOM, spol. s r.o.	Komárno	23.00	0.90	0.02
	8.	Bioplyn Cetín, s. r. o.	Nitra	21.49	0.84	0.01
	9.	VICENTE TORNS SLOVAKIA, a.s.	Komárno	20.78	0.81	0.01
	10.	K.T. spol. s r.o.	Komárno	18.82	0.74	0.01
		TOTAL		**2 231.36**	**87.49**	**1.47**

***Tab. 6.18** Total suspended particles, Sulphur oxides, Nitrogen oxides and Carbon monoxide released from stationary sources of most significant operators in 2016 at regional level – **Žilina region**.*

		Operator	Sources in district	Emissions [t]	Share on total emissions	
					region [%]	SR [%]
Total suspended particles	1.	Mondi SCP, a.s.	Ružomberok	76.24	19.19	1.41
	2.	DOLVAP, s.r.o.	Žilina	70.56	17.76	1.30
	3.	OFZ, a.s.	Dolný Kubín	33.76	8.50	0.62
	4.	Žilinská teplárenská, a.s.	Žilina	14.41	3.63	0.27
	5.	TEHOS, s.r.o.	Dolný Kubín	12.34	3.11	0.23
	6.	Martinská teplárenská, a.s.	Martin	10.64	2.68	0.20
	7.	Bekam, s.r.o.	Žilina	10.59	2.67	0.20
	8.	D O L K A M Šuja, a.s.	Žilina	10.43	2.63	0.19
	9.	Kia Motors Slovakia s.r.o.	Žilina	9.57	2.41	0.18
	10.	KYSUCA s.r.o.	Kysucké Nové Mesto	7.59	1.91	0.14
		TOTAL		256.13	64.47	4.73
Sulphur oxides as SO_2	1.	OFZ, a.s.	Dolný Kubín	738.42	41.52	2.98
	2.	Martinská teplárenská, a.s.	Martin	445.40	25.04	1.80
	3.	Žilinská teplárenská, a.s.	Žilina	254.44	14.31	1.03
	4.	Mondi SCP, a.s.	Ružomberok	96.88	5.45	0.39
	5.	SOTE s.r.o.	Čadca	85.85	4.83	0.35
	6.	ŽOS Vrútky a.s.	Martin	68.22	3.84	0.28
	7.	AFG s.r.o.	Turčianske Teplice	12.68	0.71	0.05
	8.	DOLVAP, s.r.o.	Žilina	11.41	0.64	0.05
	9.	BPS BORCOVA, s.r.o.	Turčianske Teplice	8.69	0.49	0.04
	10.	ZDROJ MT, spol. s r.o.	Martin	7.33	0.41	0.03
		TOTAL		1 729.30	97.23	6.99
Nitrogen oxides as NO_2	1.	Mondi SCP, a.s.	Ružomberok	1 135.39	41.11	4.36
	2.	OFZ, a.s.	Dolný Kubín	435.11	15.75	1.67
	3.	Martinská teplárenská, a.s.	Martin	261.49	9.47	1.01
	4.	Žilinská teplárenská, a.s.	Žilina	186.59	6.76	0.72
	5.	Rettenmeier Tatra Timber, s.r.o.	Liptovský Mikuláš	153.54	5.56	0.59
	6.	SPECIALTY MINERALS SLOVAKIA, spol. s r.o.	Ružomberok	65.91	2.39	0.25
	7.	Kia Motors Slovakia s.r.o.	Žilina	44.10	1.60	0.17
	8.	LMT, a. s.	Liptovský Mikuláš	38.29	1.39	0.15
	9.	KYSUCA s.r.o.	Kysucké Nové Mesto	28.28	1.02	0.11
	10.	SOTE s.r.o.	Čadca	26.70	0.97	0.10
		TOTAL		2 375.41	86.01	9.13
Carbon monoxide	1.	Mondi SCP, a.s.	Ružomberok	1 983.29	47.59	1.31
	2.	OFZ, a.s.	Dolný Kubín	1 125.79	27.02	0.74
	3.	LMT, a. s.	Liptovský Mikuláš	169.26	4.06	0.11
	4.	SOTE s.r.o.	Čadca	107.35	2.58	0.07
	5.	Rettenmeier Tatra Timber, s.r.o.	Liptovský Mikuláš	66.23	1.59	0.04
	6.	ŽOS Vrútky a.s.	Martin	54.08	1.30	0.04
	7.	TURZOVSKÁ DREVÁRSKA FABRIKA s.r.o.	Čadca	43.72	1.05	0.03
	8.	LEHOTSKY CAPITAL s.r.o.	Liptovský Mikuláš	39.24	0.94	0.03
	9.	Žilinská teplárenská, a.s.	Žilina	38.53	0.92	0.03
	10.	KYSUCA s.r.o.	Kysucké Nové Mesto	28.11	0.67	0.02
		TOTAL		3 655.60	87.73	2.41

***Tab. 6.19** Total suspended particles, Sulphur oxides, Nitrogen oxides and Carbon monoxide released from stationary sources of most significant operators in 2016 at regional level – **Banská Bystrica region**.*

		Operator	Sources in district	Emissions [t]	Share on total emissions region [%]	Share on total emissions SR [%]
Total suspended particles	1.	Slovalco, a.s.	Žiar nad Hronom	101.84	21.84	1.88
	2.	Zvolenská teplárenská, a.s.	Zvolen	43.79	9.39	0.81
	3.	Energy Edge ZC s. r. o.	Žarnovica	17.96	3.85	0.33
	4.	Veolia Utilities Žiar nad Hronom, a.s.	Žiar nad Hronom	14.69	3.15	0.27
	5.	Nemak Slovakia s.r.o.	Žiar nad Hronom	12.71	2.73	0.23
	6.	SLOVMAG a.s. Lubeník	Revúca	12.07	2.59	0.22
	7.	Hontianska energetická, s. r. o.	Veľký Krtíš	10.03	2.15	0.19
	8.	Bytes, spol. s r.o.	Detva	8.56	1.84	0.16
	9.	Bučina DDD, spol. s r.o.	Zvolen	8.49	1.82	0.16
	10.	STEFE ECB, s.r.o.	Žiar nad Hronom	8.43	1.81	0.16
		TOTAL		**238.57**	**51.16**	**4.40**
Sulphur oxides as SO_2	1.	Slovalco, a.s.	Žiar nad Hronom	2 844.85	65.23	11.49
	2.	Zvolenská teplárenská, a.s.	Zvolen	662.50	15.19	2.68
	3.	Knauf Insulation, s.r.o.	Žarnovica	402.11	9.22	1.62
	4.	Veolia Utilities Žiar nad Hronom, a.s.	Žiar nad Hronom	98.61	2.26	0.40
	5.	SLOVMAG a.s. Lubeník	Revúca	93.80	2.15	0.38
	6.	KOMPALA a.s.	Banská Bystrica	76.95	1.76	0.31
	7.	VUM, a.s.	Žiar nad Hronom	21.91	0.50	0.09
	8.	Slovenské magnezitové závody, a.s., Jelšava	Revúca	15.76	0.36	0.06
	9.	Ministerstvo obrany Slovenskej republiky	Brezno	13.50	0.31	0.05
	10.	Calmit, spol. s r.o.	Rimavská Sobota	12.49	0.29	0.05
		TOTAL		**4 242.49**	**97.27**	**17.14**
Nitrogen oxides as NO_2	1.	Slovalco, a.s.	Žiar nad Hronom	442.82	14.54	1.70
	2.	Slovenské magnezitové závody, a.s., Jelšava	Revúca	433.95	14.25	1.67
	3.	Zvolenská teplárenská, a.s.	Zvolen	414.48	13.61	1.59
	4.	Veolia Utilities Žiar nad Hronom, a.s.	Žiar nad Hronom	208.77	6.86	0.80
	5.	Železiarne Podbrezová a.s. skrátene ŽP a.s.	Brezno	146.23	4.80	0.56
	6.	Bučina DDD, spol. s r.o.	Zvolen	135.63	4.45	0.52
	7.	Energy Edge ZC s. r. o.	Žarnovica	134.61	4.42	0.52
	8.	KOMPALA a.s.	Banská Bystrica	112.95	3.71	0.43
	9.	Calmit, spol. s r.o.	Rimavská Sobota	103.91	3.41	0.40
	10.	BUČINA ZVOLEN, a.s.	Zvolen	75.87	2.49	0.29
		TOTAL		**2 209.21**	**72.55**	**8.49**
Carbon monoxide	1.	Slovalco, a.s.	Žiar nad Hronom	18 005.01	84.63	11.86
	2.	Slovenské magnezitové závody, a.s., Jelšava	Revúca	1 260.40	5.92	0.83
	3.	SLOVMAG a.s. Lubeník	Revúca	283.28	1.33	0.19
	4.	Železiarne Podbrezová a.s. skrátene ŽP a.s.	Brezno	186.12	0.87	0.12
	5.	Veolia Utilities Žiar nad Hronom, a.s.	Žiar nad Hronom	177.44	0.83	0.12
	6.	VUM, a.s.	Žiar nad Hronom	176.19	0.83	0.12
	7.	Calmit, spol. s r.o.	Rimavská Sobota	127.11	0.60	0.08
	8.	Energy Edge ZC s. r. o.	Žarnovica	71.08	0.33	0.05
	9.	STEFE ECB, s.r.o.	Rimavská Sobota	70.24	0.33	0.05
	10.	Bučina DDD, spol. s r.o.	Zvolen	70.08	0.33	0.05
		TOTAL		**20 426.96**	**96.02**	**13.46**

Tab. 6.20 *Total suspended particles, Sulphur oxides, Nitrogen oxides and Carbon monoxide released from stationary sources of most significant operators in 2016 at regional level –* ***Prešov region.***

		Operator	Sources in district	Emissions [t]	Share on total emissions	
					region [%]	SR [%]
Total suspended particles	1.	BUKOCEL, a.s.	Vranov nad Topľou	39.19	23.60	0.72
	2.	BUKÓZA ENERGO, a. s.	Vranov nad Topľou	16.01	9.64	0.30
	3.	BIOENERGY BARDEJOV, s.r.o.	Bardejov	9.06	5.45	0.17
	4.	TATRAVAGÓNKA a.s.	Poprad	5.39	3.24	0.10
	5.	BYTENERG spol. s r.o.	Medzilaborce	5.15	3.10	0.10
	6.	IS-LOM s.r.o., Maglovec	Prešov	4.27	2.57	0.08
	7.	LOMY, s. r. o.	Prešov	3.81	2.29	0.07
	8.	SPRAVBYTKOMFORT a.s. Prešov	Prešov	3.49	2.10	0.06
	9.	JAKOR s. r. o.	Vranov nad Topľou	3.40	2.05	0.06
	10.	VSK MINERAL s.r.o.	Vranov nad Topľou	3.09	1.86	0.06
		TOTAL		**92.86**	**55.92**	**1.71**
Sulphur oxides *as SO_2*	1.	BUKÓZA ENERGO, a. s.	Vranov nad Topľou	1 117.58	85.75	4.52
	2.	BUKOCEL, a.s.	Vranov nad Topľou	120.49	9.24	0.49
	3.	CHEMES, a.s. Humenné	Humenné	20.26	1.55	0.08
	4.	Roľnícke družstvo v Plavnici	Stará Ľubovňa	9.03	0.69	0.04
	5.	BPS Ladomirová, s. r. o.	Svidník	4.84	0.37	0.02
	6.	AGROKOMPLEX, spol. s r.o. Humenné	Humenné	4.81	0.37	0.02
	7.	ZEOCEM, a.s.	Vranov nad Topľou	4.65	0.36	0.02
	8.	Leier Baustoffe SK s.r.o.	Prešov	3.38	0.26	0.01
	9.	Centrum sociálnych služieb Spišský Štvrtok, n.o.	Levoča	3.11	0.24	0.01
	10.	BPS Huncovce, s.r.o.	Kežmarok	2.67	0.21	0.01
		TOTAL		**1 290.81**	**99.04**	**5.22**
Nitrogen oxides *as NO_2*	1.	BUKÓZA ENERGO, a. s.	Vranov nad Topľou	349.93	30.98	1.35
	2.	BUKOCEL, a.s.	Vranov nad Topľou	208.87	18.49	0.80
	3.	BIOENERGY BARDEJOV, s.r.o.	Bardejov	103.79	9.19	0.40
	4.	SPRAVBYTKOMFORT a.s. Prešov	Prešov	88.15	7.80	0.34
	5.	Leier Baustoffe SK s.r.o.	Prešov	27.42	2.43	0.11
	6.	CHEMOSVIT ENERGOCHEM, a.s.	Poprad	26.87	2.38	0.10
	7.	CHEMES, a.s. Humenné	Humenné	25.86	2.29	0.10
	8.	Veolia Energia Poprad a.s.	Poprad	18.28	1.62	0.07
	9.	AGROKOMPLEX, spol. s r.o. Humenné	Humenné	11.48	1.02	0.04
	10.	Snina Energy, s. r. o.	Snina	10.64	0.94	0.04
		TOTAL		**871.30**	**77.14**	**3.35**
Carbon monoxide	1.	Leier Baustoffe SK s.r.o.	Prešov	388.59	37.25	0.26
	2.	BUKÓZA ENERGO, a. s.	Vranov nad Topľou	138.82	13.31	0.09
	3.	BUKOCEL, a.s.	Vranov nad Topľou	81.11	7.78	0.05
	4.	Schüle Slovakia, s.r.o.	Poprad	48.98	4.70	0.03
	5.	Teplo GGE s. r. o.	Snina	34.39	3.30	0.02
	6.	SPRAVBYTKOMFORT a.s. Prešov	Prešov	30.87	2.96	0.02
	7.	BYTENERG spol. s r.o.	Medzilaborce	23.64	2.27	0.02
	8.	BIOENERGY BARDEJOV, s.r.o.	Bardejov	21.20	2.03	0.01
	9.	Spravbytherm s.r.o.	Kežmarok	20.67	1.98	0.01
	10.	Veolia Energia Poprad a.s.	Poprad	11.29	1.08	0.01
		TOTAL		**799.55**	**76.65**	**0.53**

Tab. 6.21 *Total suspended particles, Sulphur oxides, Nitrogen oxides and Carbon monoxide released from stationary sources of most significant operators in 2016 at regional level –* ***Košice region.***

		Operator	Sources in district	Emissions [t]	Share on total emissions	
					region [%]	SR [%]
Total suspended particles	1.	U. S. Steel Košice, s.r.o.	Košice II	2 702.63	91.13	49.89
	2.	CRH (Slovensko) a.s.	Košice - okolie	58.54	1.97	1.08
	3.	Carmeuse Slovakia, s.r.o.	Košice - okolie	30.82	1.04	0.57
	4.	SYRÁREŇ BEL SLOVENSKO a.s.	Michalovce	20.56	0.69	0.38
	5.	Slovenské elektrárne, a.s.	Michalovce	14.80	0.50	0.27
	6.	KOVOHUTY, a.s.	Spišská Nová Ves	11.03	0.37	0.20
	7.	Mesto Sobrance	Sobrance	10.85	0.37	0.20
	8.	Tepelné hospodárstvo Moldava, a.s.	Košice - okolie	9.65	0.33	0.18
	9.	Carmeuse Slovakia, s.r.o.	Košice II	8.92	0.30	0.16
	10.	AMETYS s.r.o. Košice	Košice - okolie	7.14	0.24	0.13
		TOTAL		**2 874.96**	**96.94**	**53.07**
Sulphur oxides *as SO_2*	1.	U. S. Steel Košice, s.r.o.	Košice II	6 615.05	90.04	26.73
	2.	Slovenské elektrárne, a.s.	Michalovce	259.18	3.53	1.05
	3.	Tepláreň Košice, a. s. v skratke TEKO, a. s.	Košice IV	213.86	2.91	0.86
	4.	KOVOHUTY, a.s.	Spišská Nová Ves	93.81	1.28	0.38
	5.	TP 2, s.r.o.	Michalovce	49.20	0.67	0.20
	6.	Slovenské magnezitové závody, a.s. Jelšava	Košice II	22.90	0.31	0.09
	7.	Bioplyn Rozhanovce, s.r.o.	Košice - okolie	18.77	0.26	0.08
	8.	RMS, a.s. Košice	Košice II	12.63	0.17	0.05
	9.	Carmeuse Slovakia, s.r.o.	Košice II	8.40	0.11	0.03
	10.	Danubian Biogas s.r.o.	Košice - okolie	7.61	0.10	0.03
		TOTAL		**7 301.41**	**99.39**	**29.50**
Nitrogen oxides *as NO_2*	1.	U. S. Steel Košice, s.r.o.	Košice II	5 862.98	71.16	22.54
	2.	CRH (Slovensko) a.s.	Košice - okolie	735.48	8.93	2.83
	3.	Carmeuse Slovakia, s.r.o.	Košice II	357.33	4.34	1.37
	4.	eustream, a. s.	Michalovce	285.66	3.47	1.10
	5.	Tepláreň Košice, a. s. v skratke TEKO, a. s.	Košice IV	241.47	2.93	0.93
	6.	Slovenské elektrárne, a.s.	Michalovce	92.85	1.13	0.36
	7.	Košická energetická spoločnosť, a.s.	Košice IV	60.94	0.74	0.23
	8.	KOSIT a.s.	Košice IV	53.41	0.65	0.21
	9.	TMS International Košice s.r.o.	Košice II	47.84	0.58	0.18
	10.	Duslo, a.s.	Michalovce	43.87	0.53	0.17
		TOTAL		**7 781.83**	**94.45**	**29.91**
Carbon monoxide	1.	U. S. Steel Košice, s.r.o.	Košice II	110 147.07	97.36	72.57
	2.	KOVOHUTY, a.s.	Spišská Nová Ves	1 588.46	1.40	1.05
	3.	Slovenské elektrárne, a.s.	Michalovce	343.23	0.30	0.23
	4.	Duslo, a.s.	Michalovce	160.42	0.14	0.11
	5.	Tepelné hospodárstvo Moldava, a.s.	Košice - okolie	102.90	0.09	0.07
	6.	Carmeuse Slovakia, s.r.o.	Košice II	97.78	0.09	0.06
	7.	Slovenské magnezitové závody, a.s. Jelšava	Košice II	93.13	0.08	0.06
	8.	Embraco Slovakia s.r.o.	Spišská Nová Ves	72.68	0.06	0.05
	9.	CRH (Slovensko) a.s.	Košice - okolie	60.02	0.05	0.04
	10.	eustream, a. s.	Michalovce	54.35	0.05	0.04
		TOTAL		**112 720.02**	**99.63**	**74.26**

6.4.5 Emissions form stationary sources in SR

Tab. 6.22 includes emissions of basic air pollutants in tonnes, which were released from large and medium stationary sources (except small sources and households) in SR in given year. Specific territorial emissions in given year (**Tab. 6.22**) are representing the amount of emissions in tonnes, which were released from large and medium stationary sources and falls on one square km of given district.

Tab. 6.22 *Emissions [t] and Specific territorial emissions [t.km^{-2}] of basic pollutants released from large and medium stationary sources in 2016 at district level - part 1.*

District	Emissions [t]				Specific territorial emissions [t.km^{-2}]			
	TSP	SO_2	NO_2	CO	TSP	SO_2	NO_2	CO
Bratislava	152.088	3 001.110	2 814.729	719.290	0.41	8.16	7.66	1.96
Malacky	47.864	40.485	1 534.261	1 536.751	0.05	0.04	1.62	1.62
Pezinok	7.262	10.519	18.436	48.637	0.02	0.03	0.05	0.13
Senec	5.293	6.462	37.285	24.766	0.01	0.02	0.10	0.07
Dunajská Streda	31.193	18.226	111.015	47.459	0.03	0.02	0.10	0.04
Galanta	40.623	223.110	241.352	81.048	0.06	0.35	0.38	0.13
Hlohovec	11.233	4.021	113.402	40.627	0.04	0.02	0.42	0.15
Piešťany	7.617	7.643	61.366	26.908	0.02	0.02	0.16	0.07
Senica	13.469	25.174	53.456	195.166	0.02	0.04	0.08	0.29
Skalica	7.945	0.188	25.239	12.114	0.02	0.00	0.07	0.03
Trnava	92.230	144.371	270.842	118.330	0.12	0.19	0.37	0.16
Bánovce nad Bebravou	5.346	0.469	16.699	14.428	0.01	0.00	0.04	0.03
Ilava	204.365	15.321	705.751	2 205.484	0.57	0.04	1.97	6.15
Myjava	4.110	5.274	34.920	93.302	0.01	0.02	0.11	0.28
Nové Mesto nad Váhom	6.731	0.299	34.844	21.436	0.01	0.00	0.06	0.04
Partizánske	10.143	9.070	67.584	165.143	0.03	0.03	0.22	0.55
Považská Bystrica	9.694	2.377	78.361	156.511	0.02	0.01	0.17	0.34
Prievidza	341.540	6 176.456	1 932.787	1 248.580	0.36	6.44	2.01	1.30
Púchov	12.941	36.703	355.015	66.850	0.03	0.10	0.95	0.18
Trenčín	43.288	102.909	852.020	2 786.692	0.06	0.15	1.26	4.13
Komárno	31.780	0.416	111.141	101.171	0.03	0.00	0.10	0.09
Levice	62.560	13.578	215.455	370.468	0.04	0.01	0.14	0.24
Nitra	42.237	66.202	158.051	1 628.592	0.05	0.08	0.18	1.87
Nové Zámky	21.495	38.671	132.125	204.589	0.02	0.03	0.10	0.15
Šaľa	166.162	4.077	630.199	107.151	0.47	0.01	1.77	0.30
Topoľčany	28.323	5.191	194.375	29.379	0.05	0.01	0.33	0.05
Zlaté Moravce	14.234	1.651	39.354	109.071	0.03	0.00	0.08	0.21
Bytča	5.244	1.584	8.020	5.215	0.02	0.01	0.03	0.02
Čadca	6.404	89.358	49.491	170.071	0.01	0.12	0.07	0.22
Dolný Kubín	57.957	739.188	473.084	1 185.542	0.12	1.50	0.96	2.41
Kysucké Nové Mesto	13.183	0.637	41.196	33.744	0.08	0.00	0.24	0.19
Liptovský Mikuláš	31.386	3.101	250.615	327.215	0.02	0.00	0.19	0.24
Martin	27.402	523.891	302.286	118.850	0.04	0.71	0.41	0.16
Námestovo	17.676	17.925	22.239	74.814	0.03	0.03	0.03	0.11
Ružomberok	87.765	100.856	1 234.671	2 055.863	0.14	0.16	1.91	3.18
Turčianske Teplice	4.110	23.870	37.893	25.943	0.01	0.06	0.10	0.07
Tvrdošín	7.807	2.672	30.136	12.956	0.02	0.01	0.06	0.03
Žilina	138.349	275.495	312.115	156.870	0.17	0.34	0.38	0.19

Tab. 6.22 Emissions [t] and Specific territorial emissions [$t.km^{-2}$] of basic pollutants released from large and medium stationary sources in 2016 at district level - part 2.

	Emissions [t]				Specific territorial emissions [$t.km^{-2}$]			
District	**TSP**	**SO_2**	**NO_2**	**CO**	**TSP**	**SO_2**	**NO_2**	**CO**
Banská Bystrica	30.336	86.362	260.962	121.296	0.04	0.11	0.32	0.15
Banská Štiavnica	5.006	2.626	5.669	10.132	0.02	0.01	0.02	0.03
Brezno	34.764	27.032	185.237	294.764	0.03	0.02	0.15	0.23
Detva	26.171	0.579	83.918	70.462	0.06	0.00	0.19	0.16
Krupina	6.638	20.886	32.013	28.575	0.01	0.04	0.05	0.05
Lučenec	14.615	12.191	40.372	31.538	0.02	0.01	0.05	0.04
Poltár	3.964	5.023	18.476	30.907	0.01	0.01	0.04	0.06
Revúca	29.449	117.963	557.871	1 604.974	0.04	0.16	0.76	2.20
Rimavská Sobota	20.834	15.838	198.750	239.069	0.01	0.01	0.14	0.16
Veľký Krtíš	20.725	23.339	67.297	53.555	0.02	0.03	0.08	0.06
Zvolen	67.216	672.078	665.849	217.180	0.09	0.89	0.88	0.29
Žarnovica	29.968	403.543	223.375	134.279	0.07	0.95	0.53	0.32
Žiar nad Hronom	176.645	2 973.985	705.164	18 437.417	0.34	5.75	1.36	35.62
Bardejov	10.958	2.504	109.293	25.121	0.01	0.00	0.12	0.03
Humenné	6.904	27.187	53.169	34.256	0.01	0.04	0.07	0.05
Kežmarok	6.168	4.133	31.401	34.737	0.01	0.01	0.05	0.06
Levoča	3.214	3.281	8.080	17.372	0.01	0.01	0.02	0.04
Medzilaborce	5.409	0.015	10.140	25.099	0.01	0.00	0.02	0.06
Poprad	18.106	1.367	96.343	110.987	0.02	0.00	0.09	0.10
Prešov	25.086	5.634	151.490	445.461	0.03	0.01	0.16	0.48
Sabinov	3.694	0.132	15.394	11.004	0.01	0.00	0.03	0.02
Snina	13.824	0.216	35.779	76.940	0.02	0.00	0.04	0.10
Stará Ľubovňa	2.097	9.597	23.221	7.129	0.00	0.01	0.03	0.01
Stropkov	0.384	0.223	3.794	1.469	0.00	0.00	0.01	0.00
Svidník	3.991	5.811	13.892	13.454	0.01	0.01	0.03	0.02
Vranov nad Topľou	66.217	1 243.211	577.504	240.020	0.09	1.62	0.75	0.31
Gelnica	5.025	1.017	6.971	15.645	0.01	0.00	0.01	0.03
Košice	2 736.328	6 878.642	6 691.789	110 442.102	11.23	28.22	27.45	453.11
Košice-okolie	116.286	33.672	814.848	221.847	0.08	0.02	0.53	0.14
Michalovce	44.799	308.932	501.507	600.953	0.04	0.30	0.49	0.59
Rožňava	21.014	4.844	47.960	86.167	0.02	0.00	0.04	0.07
Sobrance	11.792	14.477	27.643	36.143	0.02	0.03	0.05	0.07
Spišská Nová Ves	22.203	97.350	72.614	1 691.371	0.04	0.17	0.12	2.88
Trebišov	8.191	7.514	75.706	44.495	0.01	0.01	0.07	0.04
SLOVAKIA	**5 417.070**	**24 749.757**	**26 015.302**	**151 782.945**	**0.11**	**0.50**	**0.53**	**3.10**

LIST OF ANNEXES