Slovak
Hydrometeorological Institute

Ministry of Environment
of the Slovak Republic

AIR POLLUTION

IN THE SLOVAK REPUBLIC

2012

Bratislava 2014

Report was elaborated by

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AMBIENT AIR

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AMBIENT AIR

1

REGIONAL AIR POLLUTION AND QUALITY OF PRECIPITATION

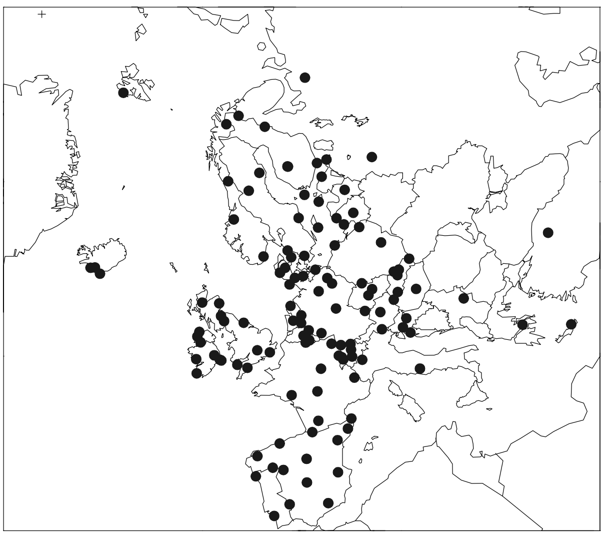
1.1 REGIONAL AIR POLLUTION AND QUALITY OF PRECIPITATION

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 a 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 in cities.

The UN ECE Convention on Long Range Transboundary Air Pollution (CLRTAP) was signed in 1979. Since its entry into force in 1983 the Convention has been extended by eight protocols: Protocol on Long-term Financing of the Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) (Geneva, 1984); Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 Per Cent (Helsinky, 1985); Protocol Concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes (Sofia 1988); Protocol Concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes (Geneva 1991); Protocol on Further Reduction of Sulphur Emissions (Oslo, 1994); Protocol on Heavy Metals (Aarhus, 1998); Protocol on Persistent Organic Pollutants (Aarhus, 1998); The 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg, 1999). The commitment to the first sulphur Protocol represented a 30% reduction of European sulphur dioxide emissions by 1993 as compared to 1980. The Slovak Republic has fulfilled this commitment. Reduction of European emissions has already been manifested in a decrease of acidity in precipitation over the territory of Slovakia. In compliance with the second sulphur Protocol, the European sulphur dioxide emissions had to be reduced 60% by 2000, 65% by 2005 and 72% by 2010, as compared to 1980. According to the last Protocol (Gothenburg, 1999) the Slovak Republic had to reduce sulphur dioxide emissions 80% by 2010 as compared to 1980, those oxides of nitrogen 42%, ammonia 37% and volatile organic compounds 6% as compared to 1990. For the time being three last protocols of CLRTAP undergo revision. As an addendum to the POP Protocol seven substances shall be revised and evaluate for the new or revised protocol. Concerning heavy metal Protocol the priority remains on three main metals, cadmium, lead and mercury. The Gothenburg Protocol (1999) to abate acidification, eutrophization a ground level ozone undergoes revision and particulate matter might be addressed either via the HM Protocol, or revised Gotheburg Protocol.

Implementation of the Co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe - EMEP is a part of the Convention. In accordance to the Convention, the EMEP is mandatory to all European countries. Its goal is to monitor, model and evaluate the long-range transport of air pollutants in Europe and elaborate foundations for the strategy to reduce European emissions. The EMEP monitoring network (Fig. 1.1) comprises more than 100 regional stations and four stations in the territory of Slovakia belonging to the national monitoring network of the Slovak Hydrometeorological Institute are at the same time also a part of EMEP network. The EMEP monitoring programme has been gradually extended.

Fig. 1.1 **Network of EMEP monitoring stations**



The monitoring of sulphur compounds and precipitation has been enhanced for oxides of nitrogen, ammonium in ambient air, particulate matter and ozone. In 1994, the measurements of volatile organic compounds (VOCs) have begun 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. In 2003 the new monitoring strategy has been adopted classifying stations into three levels (more details on www.emep.int).

1.2 EMEP STATIONS OF NATIONAL AIR QUALITY MONITORING NETWORK

In 2012, there were 4 EMEP stations of National Air Quality Monitoring Network in operation in the Slovak Republic to monitor regional air and precipitation quality. At the Bratislava-Koliba station the same precipitation monitoring programme is in operation as on regional stations, serving for comparison to regional stations. Locations and elevations of the individual stations are indicated in Figure 1.2.

Chopok

Meteorological observatory of the Slovak Hydrometeorological Institute, located on the crest of the Low Tatras mountains, 2 008 m above sea level, 19°35'32" longitude, 48°56'38" latitude. Measurements started in 1977. Since 1978 the station has become a part of the EMEP network and GAW/WMO network.

Stará Lesná

Station is situated in the area of the Astronomic Institute of the Slovak Academy of Sciences on the south-eastern edge of TANAP (National Park of the Tatras), 2 km north from the Stará Lesná village, 808 m above sea level, 20°17'28" longitude, 49°09'10" latitude. The station started measurements in 1988. Since 1992 the station has become a part of the EMEP network.

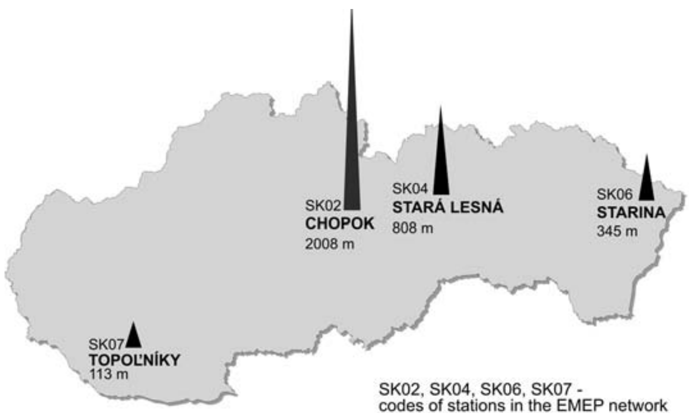
Topoľníky

The Aszód pump station on the small Danube river, 7 km south-east of the Topoľníky village, in plain terrain of the Danube lowlands, 113 m above sea level, 17°51'38" longitude, 47°57'36" latitude. Only family houses for employees of the pump station are situated nearby. Measurements have been carried out since 1983. Since 2000 the station has become a part of the EMEP network.

Starina

Station is situated in the region of the Starina water reservoir, 345 m above sea level, 22°15'35" longitude, 49°02'32" latitude. Nearby are located only the buildings of the Bodrog river and Hornád river watershed. The station started to be operated in 1994. The same year the station has become a part of the EMEP network.

Fig. 1.2 **EMEP stations in the Slovak Republic – 2012**



Measurement programme

AMBIENT AIR		Ozone (O_3)	Sulphur dioxide (SO_2)	Oxides of nitrogen (NOx)	Sulphates (SO_4^{2-})	Nitrates (NO_3^-)	Nitric acid (HNO_3)	Chlorides (Cl^-)	Ammonia, ammon. 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)	Copper (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 in ambient air*

PRECIPITATION		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

Methods of determination

		Collection	Determination
AMBIENT AIR	**SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, K^+, Na^+, Mg^{2+}, Ca^{2+}**	cellulose filter W40	IC - Dionex
	NOx	after oxidation into NaOH absorption solution with guajacol	spectrophotometry, modified Salzman method
	SO_2, HNO_3	cellulose filter W40 impregnated by KOH solution	IC - Dionex
	O_3	registration by analyzer	principle - UV absorption
	VOCs C_2 - C_6	stainless steel canister	GC and FID
	PM weight mass	nitrocellulose filter Sartorius	Gravimetrically
	Heavy metals - Pb, Cd, Cu, Cr, Ni, Zn, As	nitrocellulose filter Sartorius	after digestion in MW-oven by ICP-MS
PRECIPITATION	**pH**	"wet only" - rain gauges WADOS "bulk" - NILU sampling PE vessel	pH meter
	Conductivity		conductometer
	SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, K^+, Na^+, Mg^{2+}, Ca^{2+}		IC - Dionex
	Zn, Cu, Cr, Ni, Pb, Cd, As		AAS - in flame or graphite atomizer and MHS

1.3 ASSESSMENT OF RESULTS FROM MEASUREMENTS IN 2012

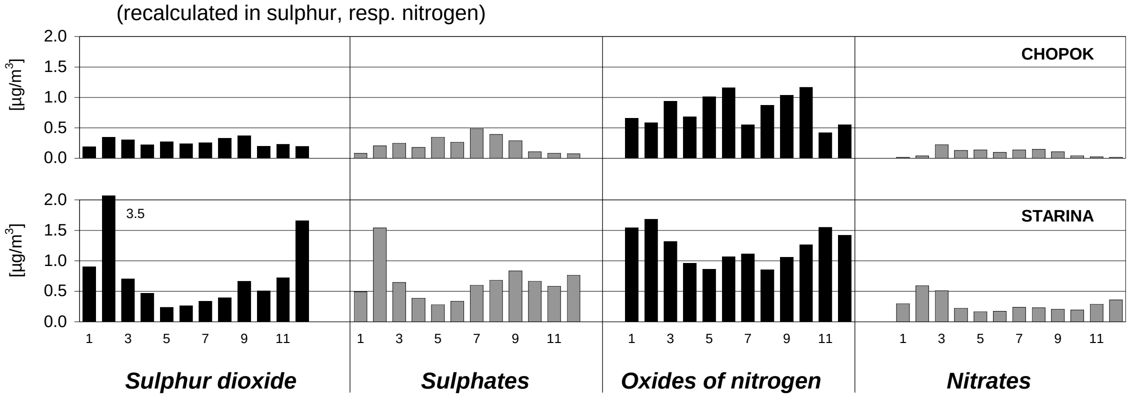
SO_2, sulphates

Background concentrations of sulphur dioxide recalculated in sulphur (Tab. 1.1.) was 0.26 µg.m^{-3} on the Chopok station and 0.86 µg.m^{-3} on the Starina station, in 2012. ***In coincidence with the Annex 13 to the Decree of the Ministry of Environment of the Slovak Republic No 360/2010 on air quality, the critical value for protection of vegetation is 20 µg SO_2.m^{-3} in calendar year and winter season. This value has been exceeded neither at the calendar year (Chopok 0.52 µg $S0_2$.m^{-3} and Starina 1.72 µg $S0_2$.m^{-3}), nor in winter season (Chopok 0.4 µg $S0_2$.m^{-3} and Starina 2.6 µg $S0_2$.m^{-3}).*** Sulphates contributed to the total weight mass of particulate matter 12.1% on the Chopok station and 13.7% on the Starina station. Concentration ratio of sulphates to sulphur dioxide, recalculated in sulphur represented 0.9 on the Chopok station and 0.76 on the Starina station.

NO_x, nitrates

Background level of concentrations of oxides of nitrogen, recalculated in nitrogen (Tab. 1.1) presented 0.81 µg.m^{-3}on the Chopok station and 1.24 µg.m^{-3} on the Starina station, in 2012. ***In coincidence with the Annex 13 to the Decree of the Ministry of Environment of the Slovak Republic No 360/2010 on air quality, the critical value for protection of vegetation is 30 µg NO_x.m^{-3} in calendar year. This value was not exceeded in calendar year (Chopok 2.67 µg NO_x.m^{-3} a Starina 4.09 µg NO_x.m^3).*** Nitrates in ambient air on the Chopok and Starina stations occurred predominantly in the form of particles in 2012, as compared to gaseous nitrates, the difference on the Starina station is more distinctive than on the Chopok station. Both these forms of nitrogen are collected on filters separately and also measured separately and their phase division is dependent upon the ambient air temperature and humidity. Nitrates contributed to the total mass of particulate matter 6.9% on the Chopok station and 9% on the Starina station. Concentration ratio of total nitrates ($HNO_3 + NO_3$) to NO_x-NO_2 recalculated in nitrogen represented the value of 0.15 at the Chopok station and 0.27 at the Starina station.

Fig. 1.3 **Monthly mean concentrations of sulpur and nitrogen compounds in ambient air – 2012** (recalculated in sulphur, resp. nitrogen)



Ammonia, ammonium ions and alkali ions

In coincidence with the requests of the EMEP monitoring strategy for the EMEP stations "level one" the measurements of ammonia, ammonium ions, 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 listed components (NH3 and NH4 recalculated in nitrogen) from the Starina station in 2012 are listed in Table 1. Ammonium ions in annual average 0.58 µgN.m^{-3} share 9.1% of PM. Annual concentration of ammonia represents 0.41 µgN.m^{-3}. Concentration ratio of ammonium ions and ammonia expressed in nitrogen is 1.4.

Tab. 1.1 **Annual averages of gaseous and particulate components in ambient air – 2012**

	SO_2 (S) µg/m³	SO_4^{2-} (S) µg/m³	NO_x (N) µg/m³	NO_3^- (N) µg/m³	HNO_3 (N) µg/m³	Cl^- µg/m³	NH_3 (N) µg/m³	NH_4^+ (N) µg/m³	Na^+ µg/m³	K^+ µg/m³	Mg^{2+} µg/m³	Ca^{2+} µg/m³
Chopok	0.26	0.23	0.81	0.09	0.09	0.05	-	-	-	-	-	-
Starina	0.86	0.65	1.24	0.29	0.29	0.12	0.41	0.58	0.06	0.10	0.01	0.07

	O_3 µg/m³	PM_{10} µg/m³	Pb ng/m³	Cu ng/m³	Cd ng/m³	Ni ng/m³	Cr ng/m³	Zn ng/m³	As ng/m³
Chopok	93	*5.7	1.28	1.35	0.04	0.38	0.72	5.44	0.20
Topoľníky	59	20.6	8.56	3.26	0.25	0.71	1.17	20.53	1.05
Starina	60	14.2	6.08	1.77	0.20	-	-	12.97	0.64
Stará Lesná	63	15.2	5.83	2.16	0.18	0.72	1.19	14.13	0.62

SO_2, SO_4^{2-} – recalculated in sulphur, *NOx, NO_3^-, HNO_3 – recalculated in nitrogen*
* *TSP (total suspended particles)*

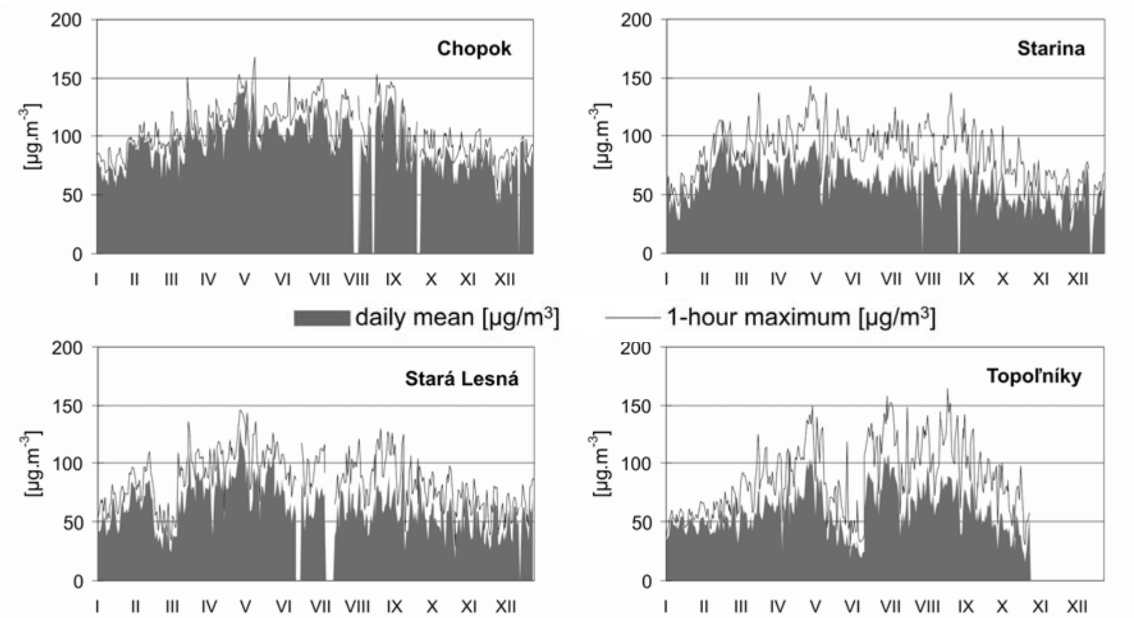
Particulate matter PM_{10}, TSP and heavy metals

In Tab. 1.1 are presented the concentrations of PM_{10} (Stará Lesná, Starina, Topoľníky), resp. TSP (Chopok) and concentrations of heavy metals in PM_{10}, resp. TSP. Share of sum of all measured metals expressed in percentage from $PM_{10,}$ resp. TSP at the regional stations of Slovakia oscillates in range 0,15 – 0,16%.

Ozone

In Figure 1.4 the annual course of ground level ozone concentrations at the Chopok, Stará Lesná, Starina and Topoľníky regional stations are depicted. The longest time series of ozone measurements has been at the Stará Lesná station, since 1992. The measurements of ozone in Topoľníky, Starina and Chopok began to be carried out later, in 1994. In 2012, the annual average of ozone concentration at the Chopok station reached 93 µg.m^{-3}, at Starina 60 µg.m^{-3}, at Topoľniky 59 µg.m^{-3} and Stará Lesná 63 µg.m^{-3}. Measurements of ozone and exceedances of critical levels are completely assessed in Chapter 3 Atmospheric ozone.

Fig. 1.4 **Ground level ozone [µg.m^{-3}] – 2012**



Volatile organic compounds, VOCs C_2–C_6

VOCs (Volatile Organic Compounds) C_2–C_6, or 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 tenth of ppb up to several ppb. However since October 2008 up to the half of September 2011 the VOC measurements are not available due to long-term lasting problems with the operation of new GC in Tested laboratory. Measurements started again 15 September 2011. For the time being the VOC analyses are available for 2012 (Tab. 1.2)

Tab. 1.2 **Annual averages of VOC [ppb] in ambient air, Starina, 2012**

	etane	etene	propane	propene	i-butane	n-butane	acetylene	i-pentane	n-pentane	izoprene	n-hexane	benzene
2012	2.125	0.840	0.813	0.351	0.479	0.383	0.266	0.171	0.087	0.134	0.081	0.133

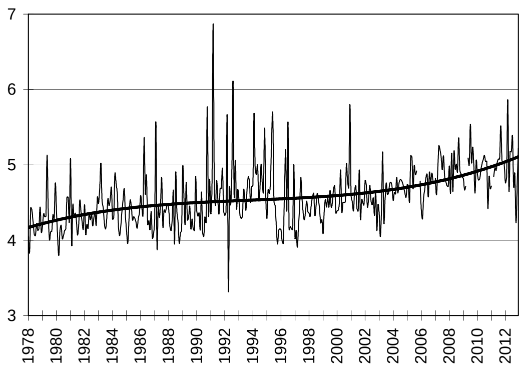
Atmospheric precipitation

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 2012 the amount of precipitation recorded at background stations ranged between 432 and 993 mm. The upper level of amount of precipitation does belong to the highest situated station Chopok and the lower one to Topoľníky with the lowest elevation. Acidity of atmospheric precipitation dominated at the Stará Lesná station with the low level of pH range 4.69 – 4.89 (Tab. 1.3, Fig. 1.6). Time series and trend of pH values within a long-time period indicate clearly the decrease in acidity (Tab. 1.3). Values of pH are in a good coincidence with the pH values according to the EMEP maps.

Fig. 1.5 **pH in daily precipitation – Chopok**



Concentrations of dominant sulphates in precipitation recalculated in sulphur varied within the range 0.41 – 0.55 mg.l^{-1}. Concentrations of sulphates at the Topoľníky station represent the low value of the pH range while the Starina the upper value of the pH range. The annual mean at the Chopok, Topoľníky and Stará Lesná stations show minimum difference in annual mean. Total decrease of sulphates in long-term time series has corresponded to the SO_2 emission reduction since 1980.

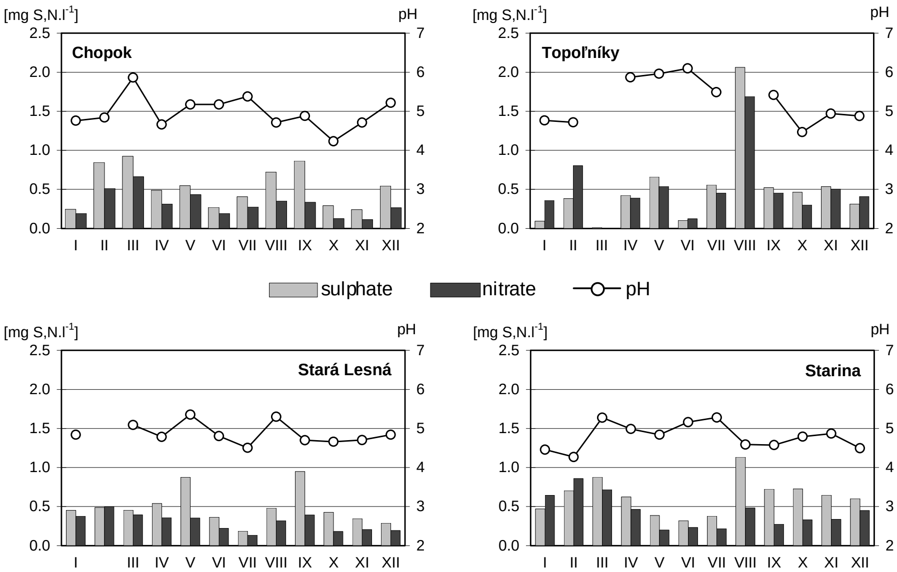
Tab.1.3 Annual averages of main components in daily precipitation – 2012

	Precip. mm	pH	Cond. µS/cm	SO_4^{2-}(S) mg/l	NO_3^- (N) mg/l	NH_4^+(N) mg/l	Cl^- mg/l	Na^+ mg/l	K^+ mg/l	Mg^{2+} Mg/l	Ca^{2+} mg/l
Chopok	993	4.74	10.59	0.43	0.26	0.40	0.16	0.13	0.04	0.03	0.19
Topoľníky	432	4.89	13.19	0.41	0.39	0.48	0.15	0.12	0.04	0.04	0.35
Starina	676	4.83	14.58	0.55	0.38	0.38	0.19	0.14	0.08	0.03	0.24
Stará Lesná	606	4.69	17.19	0.42	0.25	0.30	0.14	0.17	0.04	0.02	0.22
Bratislava-Koliba	608	5.01	16.82	0.57	0.52	0.62	0.19	0.17	0.08	0.04	0.38

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

The share of nitrate (recalculated in nitrogen) in acidity of precipitation was substantially smaller than those of sulphates and varied within the concentration range 0.25 – 0.39 mg.l^{-1}. The low level of concentration range is represented by the Stará Lesná station, while upper level of this range does belong to the station Topoľníky. Ammonium ions also do belong to the major ions and their concentration range was 0.30 – 0.48 mg.l^{-1}.

Fig. 1.6 **Daily precipitation – 2012**



Heavy metals

Since 2000 the measurement programme of heavy metals in precipitation has been gradually modified to meet the requirements of the CCC EMEP monitoring strategy. In Bratislava-Koliba the measurement of the same set of heavy metals in precipitation was implemented as in background stations of Slovakia (Table 1.3). This station serves for comparison and is not considered as the background station. The results of annual weighted means of heavy metals concentrations in monthly precipitation in 2012 are presented in Table 1.4. The decrease of heavy metals within the monitored period is most distinctive at lead.

Tab. 1.4 Annual averages of heavy metals in monthly precipitation – 2012

	precip. mm	**Pb** µg/l	**Cd** µg/l	**Cr** µg/l	**As** µg/l	**Cu** µg/l	**Zn** µg/l	**Ni** µg/l
Chopok	776	2. 13	0. 08	0. 27	0. 29	1. 18	33. 82	0. 55
Topoľníky	429	1. 10	0. 04	0. 23	0. 12	1. 18	8. 18	0. 30
Starina	616	1. 40	0. 07	0. 27	0. 17	1. 56	9. 70	1. 26
Stará Lesná	633	1. 08	0. 06	0. 08	0. 13	0. 84	7. 50	0. 57
Bratislava-Koliba	734	1. 49	0. 06	0. 18	0. 20	3. 28	16. 41	0. 44

AMBIENT AIR

LOCAL AIR POLLUTION

2

2.1 LOCAL AIR POLLUTION

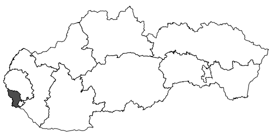
Air quality assessment is claimed by Air Protection Act No. 137/2010 Coll. Criterions for air quality assessment (upper and lower assessment thresholds, margin of tolerance, limit and target values) are given in Decree No. 360/2010 Coll. about Air Quality. Fundamental air quality assessment is performed on the basis of measured data. Slovak Hydrometeorological Institute (SHMÚ) carried out measurements at monitoring stations of National air quality monitoring network (NAQMN).

The SHMÚ has monitored the level of air pollution since 1971, when the first manual stations in Bratislava and Košice were put into operation. In the course of the following years the measurements were gradually extended into the most polluted cities and industrial areas.

In 1991 modernization of the air quality monitoring network began. The manual stations were gradually replaced by automatic ones, which enable the continuous monitoring of pollution and made it possible to evaluate time changes and the extremes of the short-term concentrations. In the course of the last ten years the air quality monitoring network has kept developing. In 2012, 30 stations (without EMEP, rural and ozone stations) were located on the territory of the SR. Most of them monitored the level of pollution caused by the basic pollutants (SO_2, NO_2, NO_x, and PM_{10}, $PM_{2,5}$). In the year 2012 measurements of benzene were carried out at 10. The air pollution monitoring by heavy metals (Pb, Cd, As and Ni) were performed at 5 urban (suburban) and at 4 rural EMEP stations. Concentrations of benzo(a)pyrene were analysed at 7 sites totally.

In accordance to the Air Protection Act the territory of the Slovak Republic was divided into 8 zones and 2 agglomerations for the following pollutants: SO_2, NO_2, NO_x, PM_{10}, $PM_{2.5}$, benzene and CO. The delimitation of zones is identical with the higher administrative units – the regions. From Bratislava and Košice regions were excluded administrative units of cities Bratislava and Košice and these are assessed separately as agglomerations. According to the Decree No. 360/2010 Coll. about Air Quality for pollutants: Pb, As, Cd, Ni, BaP, Hg and O_3 was territory of Slovakia divided only into agglomeration Bratislava and rest of territory represents zone Slovakia.

2.2 CHARACTERISATION OF ZONES AND AGGLOMERATIONS, WHERE MONITORING IS CARRIED OUT



AGGLOMERATION - BRATISLAVA

AREA: 368 km^2 POPULATION: 415 589

Characterization of area

Bratislava

Bratislava spreads out over an area of 368 km^2 along both banks of the Danube at the boundary-line of the Danube plain and the Little Carpathians and the Bor lowlands at an elevation of 130 – 514 meters. Wind patterns in this area are affected by the slopes of the Little Carpathians, which do interfere into the northern part of the city. Geographical effects enhance the wind speed from prevailing directions. The ventilation of the city is favourably affected by high wind speeds. In regard to prevailing north-west wind, the city is properly situated to major air pollution sources, which from which significant part is located in area from the south to north-eastern periphery of Bratislava. The main share in air pollution is from the chemical industry, power generation and car transport. Secondary suspended particles, the level of which depends upon meteorological factors, land use and agricultural activities and characteristics of surface, are significant source of air pollution by particular matter.

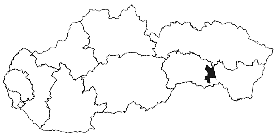
Location of stations

Bratislava - Jeséniova
The station is located in the ground of the SHMÚ, 287 m above sea. It is situated apart from the major city sources of air pollution, in a locality with middle built-up area, where family houses prevail.

Bratislava - Kamenné námestie
The station is situated in the city centre, close to the TESCO supermarket, in an area of middle frequency of transport. Its position represents the central part of the city.

Bratislava - Trnavské mýto
The station is situated near to a busy crossroad formed by Šancová and Trnavská street - Krížna and Vajnorská street. It represents location with extreme high emissions from road transport.

Bratislava - Mamateyova
The station is located at open playing area in sufficient distant from housing estate built-up area. Among the major sources of air pollution belong traffic, power sources and the petrochemical complex, Slovnaft a.s., Bratislava. The last mentioned contributes to the air pollution mainly under the east wind direction.



AGGLOMERATION - KOŠICE

AREA: 244 km^2 POPULATION: 240 164

Characterization of area

Košice

The city of Košice spreads out in the valley of the Hornád river and its surroundings. According to geographical classification it belongs to the zone of the inner Carpathians. From the south-west, the Slovenský kras intervenes into this area, in the north the Slovenské rudohorie and in the east the Slánske hills spread out. Among these mountain ranges, Košice's basin is situated. The mountain range configuration affects the climate conditions in this area. The prevailing wind from the north is typical by the relatively higher wind speeds, on average 5.7 m.s^{-1}. The annual average wind speed from all directions is 3.6 m.s^{-1}. The major share in air pollution of this area is caused by heavy industry, mainly engineering, non-ferrous and ferrous metallurgy as well as processing of limestone. Energy sources, including the city heating plants and local boiler rooms emit lesser amounts of pollutants.

Location of stations

Košice - Štefánikova
Station is located in urban area predominantly surrounded by family houses separated by green alley from near road.

Košice - Amurská
Station is located in open area 100 m far from housing estate built-up area, which surrounded station from south, west and north directions. Easterly in distance of approximately 120 m is situated a small lake. It is typical urban background station.

ZONE - BANSKÁ BYSTRICA REGION

AREA: 9 454 km^2 POPULATION: 658 490

Characterization of area

Banská Bystrica

The town is located in the Bystrica valley, which is by the northern part of the Zvolen basin surrounded by the Staré Hory hills to the north, by the Horehron valley to the north-east and by the Kremnica hills to the south-east. The annual average temperature is 8 °C. Prevailing wind is from the north and north-east, an average speed 2.1 m.s^{-1} with high occurrence of temperature inversion in valley positions. Air pollution is affected by wood processing industries releasing emissions of suspended particles, but also by a large number of local heating sources. Traffic does contribute to the high level of air pollution in the town centre, as well.

Zvolen

The city is located in the south-western part of Zvolen basin. It is situated in the middle pohronie up to Banská Bystrica and it extends into Slatina, Detva and Sliač basin. Volcanic mountains Štiavnica a Kremnica hills lined the Zvolen basin from west, Javorie south and Poľana from east. The meteorological conditions for dispersion and transportation of pollutants in Zvolen are better in spring and summer periods. In autumn and winter periods the adverse meteorological conditions for dispersion of emission pollutants prevail. In these periods often occur calm and inversion of temperature. Generally lowered ability of pollution transport indicates low wind speeds, which are lower than 1 m.s^{-1} in 45% of days within the year.

Žiar nad Hronom

The area of the Žiar basin is closed from more sides, bordered by the Pohronský Inovec in the south-west, by the Vtáčnik and the Kremnica hills in the west up to the north, and by the Štiavnica hills in the east to the south-east. The area is characterised by the very unfavourable meteorological conditions in regard to the level of air pollution by industrial emissions at a ground level layer. The annual average wind speed in all directions is 1.8 $m.s^{-1}$. The east and north-west wind directions occur there most frequently within a year.

Hnúšťa

The area is situated in the valley of the Rimava river. Along the quite narrow valley, the individual mountain ranges of relatively great elevation are extended. Short-term measurements confirm the expected low wind speeds of about 1.5 $m.s^{-1}$ on average and a considerable high occurrence of calm.

Jelšava

Jelšava is situated in the area, which lies in the southern part of the Jelšava's mountains, bordered in the north-east by the massive Hrádok, in the south-west by the Železnické foothills and in the south by the Jelšava's kras. The terrain is relatively broken along the central Muráň stream, oriented in a north-west – south-east. Air circulation is indicated by the direction of the Muráň river valley. The annual average wind speed is relatively low 2.5 $m.s^{-1}$. The frequent occurrence of surface inversions during the night is due to the mountain terrain. Two massifs, Skalka and Slovenská skala, bordering the valley, also contribute to the occurrence of inversions. The major share in air pollution is from the Slovak magnesite plants Jelšava and Lubeník, situated to the north-west of the town and the small predominantly local gas heating system.

Location of stations

Banská Bystrica - Štefánikovo nábrežie

Monitoring station is located closely to the frequented route providing transport into the eastern region of Slovakia. In the vicinity of about 100 m are situated housing estate buildings and hotel Lux. From the larger size scale the monitoring station is located in a valley part of city at the river Hron. This unfavourable location implicates adverse dispersion conditions of pollutants.

Banská Bystrica - Zelená

The station is located in the ground of the SHMÚ, 427 m above sea. In close vicinity the combination of housing estate buildings and family houses is presented. It is located apart from major pollution sources.

Zvolen - J. Alexyho

The station is located in the area of elementary school which is segment of the large housing estate Sekier in the south-eastern part of the city. In the vicinity of about 300 m is situated a frequented route into the Metropolis of Eastern Slovakia Košice. Besides of traffic the main contribution to air pollution represents emissions from wood processing industry.

Hnúšťa - Hlavná

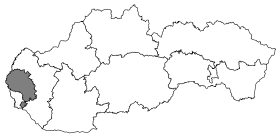
The station is situated in open middle building area on the north edge of the town, approximately 50 m far from state road No. 531.

Jelšava - Jesenského

The station is situated in the peripheral part of the city, in kindergarten, on a hill which is open to the major polluter (SZM Jelšava) from one side. From distance of about 100 m of the other side the building estate is located.

Žiar nad Hronom - Jilemnického

The station is placed at the suburban part of the city in the vicinity of 4-storey buildings. Approximately in the distance of 100 m is located main route towards Prievidza. Close to the station is high voltage electricity line under which is the ground covered with low vegetation.



ZONE - BRATISLAVA REGION

AREA: 1 685 km^2 POPULATION: 197 093

Characterization of area

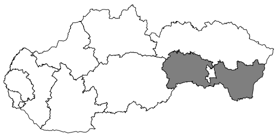
Malacky

Region Malacky spreads out northerly from the capital of the Slovak Republic, Bratislava. It is located in the southern part of Zahorie lowland, on western side borders it Morava river, which is as well bordering line with Austria and on the east are situated Low Carphatian mountains. Administrative centre as well the largest town of the region is Malacky. The east-west and north-west wind directions occur there most frequently within a year. Annual average wind speed is about 2.7 m.s^{-1}.

Location of stations

Malacky - Sasinkova

Monitoring station is located close to city centre. In the vicinity are located supermarkets and family houses. Stations is located 5 m from the kerbside of relative frequented road leading from the town towards the highway D2.



ZONE - KOŠICE REGION

AREA: 6 511 km^2 POPULATION: 553 861

Characterization of area

Krompachy

Krompachy is located in the valley system with good local circulation of air. Southern part of the city is situated in valley of the Slovinský potok surrounded by hills of about 350 m above sea level high. The northern part is placed in the valley of Hornád, which is oriented to east-west direction. The average wind speed is low, approximately 1.4 m.s^{-1}. The main polluter is ferrous metal plant Kovohuty in Krompachy. To the air pollution contributes also the local heating systems.

Strážske

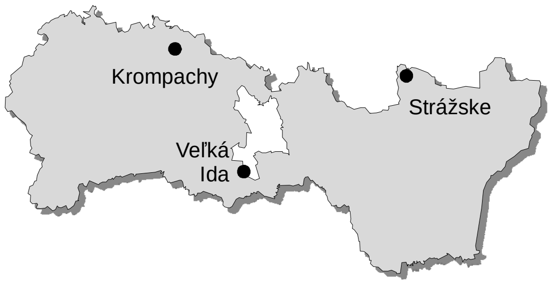
Strážske is located easterly from Vihorlat in northern part of the Eastslovak lowland in area called Brekovská brána, which strengths wind speed from north directions. Annual average of the wind speed is 3.4 m.s^{-1}. The daily course of wind speed is significantly emphasized with minimum during night hours. The main source of air pollution is local chemical industry.

Veľká Ida

The station is located at the border line of Košice's basin and Moldava lowland. The area is surrounded from south by Abov hills, from western by Slovenský kras and from northern by Slovenské rudohorie. The prevailing winds are from north-east and south-west directions. The annual average of wind speed is about 2.5 m.s^{-1}. The main air pollution source is the ferrous metallurgy complex and surrounding large dumps from extracted ores.

Location of stations

Krompachy - SNP
Monitoring station is located close to the main route Košice - Spišská Nová Ves. The surrounding built-up area comprises multi-storey houses.



Strážske - Mierová
Monitoring station is situated in the centre of town. It is placed in an open area among buildings, gardens and green areas approximately 1.5 km east-south-east out from the Chemko Strážske plant. In the vicinity is a middle frequented first class road Michalovce-Prešov, which is separated from stations by tree alley.

Veľká Ida - Letná
The station is located in the south-eastern part of the Veľká Ida municipality, near the US Steel Košice ferrous metallurgy complex, in a relatively open area. In the vicinity of station are located family houses, gardens, railway stations and waste dumps of slag, which is not fully covered by grass.

ZONE - NITRA REGION

AREA: 6 344 km^2 POPULATION: 688 400

Characterization of area

Nitra

Major part of the region interferes into Danube plain and the differences of high are very small in the whole area, higher altitudes in the north-east part are caused only by Danube upland. Prevailing winds are from north-east and south-west directions with a small occurrence of calm situations.

Location of stations

Nitra - Štúrova
Monitoring station is located on the right site in distance of 100 m of traffic circle towards to the centre of the town Nitra. In the vicinity are 4-storey buildings and green places.

Nitra - Janíkovce
Monitoring station is located in the area of elementary school Veľké Janíkovce. It is situated at cascade slope. Opposite is open area with airport Nitra.

ZONE - PREŠOV REGION

AREA: 8 974 km^2 POPULATION: 817 382

Characterization of area

Prešov

Prešov lies in the northern promontory of Košice's basin. The surrounding mountains of the Šariš's highland and the Slánske mountain range reach an altitude of 300 – 400 m above sea level. The highest hill Stráža, which is located in the north of the town, protects the town from the invasion of cool Arctic air. In the course of a year the northern air circulation prevails which is also the strongest among all of directions. The next most frequently occurred wind directions are from south. Good ventilation of the town is provided by the widening of the valley itself at the confluence of the Sečkov and Torysa. The main air pollution sources in town constitute from municipal boilers, partly lacking separation techniques, traffic, wood industry as well as secondary suspended particles.

Humenné

Humenné lies in the valley of the river Laborec, which is protected in the north by a wide zone of the Carphatians and in the south by the Vihorlat mountain range. The valley is north-east oriented. Because of the complexity in geography, the prevailing wind direction is not so uniquely determined. The occurrence of calm is relatively high. The local chemical industry is the main air pollution source in this area. The main polluter is the heating plant Chemes a.s., Humenné.

Vranov

Vranov lies in the valley of the river Topľa, which passes into the East Slovakian lowlands. The location is bordered in the west by the Slánske hills and in the north by the wide zone of the Carpathians. Air circulation is influenced by the north-west orientation of the Topľa river valley. The main air pollution sources in the area are the local wood processing industry and local heating systems.

Location of stations

Humenné - Nám. slobody

The station is located in the southern part of the town centre in open area at the edge of a pedestrian zone with minimum car transport. The surrounding buildings are connected to the central heating system of Chemes a.s., Humenné plant which is located approximately 2 km west from monitoring station.

Prešov - Arm. gen. L. Svobodu

Monitoring station is located in south-east part of the city in an open area close to the Arm. gen. L. Svobodu road, with high frequency of transport. Station is located 2 m from kerbside.

Vranov nad Topľou - M. R. Štefánika

The station is situated in the town centre which is built up with a mixture of family houses and 2–3 storey residential houses approximately 2 km north-west out from the Bukocel a.s., Hencovce plant. It is distant from the main road, of about 30 m.

ZONE - TRENČÍN REGION

AREA: 4 502 km^2 POPULATION: 593 159

Characterization of area

Horná Nitra

This area includes a part of the Horná Nitra basin from Prievidza to Bystričany. The direction of wind is affected considerably by the geography and orientation of the basin. The most frequent winds occur there from the north and north-east directions. A low value of annual wind speed 2.3 m.s^{-1} indicates the unfavourable conditions for emission dispersion and transport. The dominant cause of air pollution in this area is power generation. To a lesser extent emissions from sources of chemical industry and local heating contribute as well. The low quality of fuel for power generation sources contributes to air pollution in this area significantly. The coal in use contains apart from sulphur also arsenic.

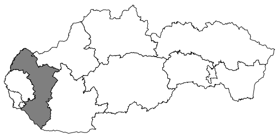
Location of stations

Prievidza - Malonecpalská
The station is located at the edge of town inside elementary school in open area. In the vicinity is situated local road No. 64 towards Žilina.

Handlová - Morovianska cesta
The station is located in a predominantly family house built-up area in territory of elementary school close to the municipal road. The major polluters are power generators and industrial sources.

Bystričany - Rozvodňa SSE
The station is directly placed in object of control room of SSE which is situated at agricultural area among fruit trees. The Nováky power plant (ENO) is in distance of 8 km northerly from the monitoring station.

Trenčín - Hasičská
Station is located between stadium and commercial buildings at the main street leading from Trenčín to Trenčianska Teplá.



ZONE - TRNAVA REGION

AREA: 4 147 km^2 POPULATION: 556 577

Characterization of area

Senica

The town itself is located on the southern slopes of Myjava hills in the altitude of 208 m. From western and partly northern side as well, the territory is bordered by the Little Carpathians. It is open only alongside Myjava river from east side, where the promontory of Záhorie lowlands intervenes. From the standpoint of emission transport and dispersion the wind conditions are favourable under the prevailing north-west wind, as this is associated with the relatively higher wind speeds.

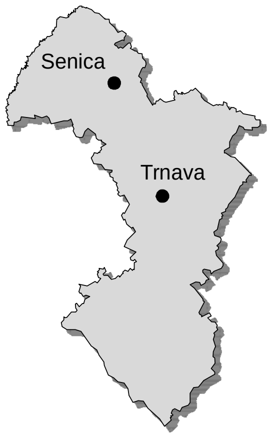
Trnava

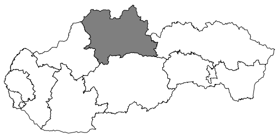
Trnava is located in the centre of the Trnava downs, at an altitude of 146 m, 45 km from the capital of the Slovak Republic, Bratislava. The prevailing wind is from the north-west, the second highest wind frequency is from south-east. The location is well ventilated with small occurrence of calm situations.

Location of stations

Senica - Hviezdoslavova
Station is placed 5 m from kerbside of main route to Kúty with a relative high heavy-duty fraction of traffic. In distance of 40 m in south direction are located multi-storey buildings.

Trnava - Kollárova
Station is located at open area close to the crossroad with high frequency of traffic. It is located in the immediate vicinity of large parking area near a railway station.





ZONE - ŽILINA REGION

AREA: 6 809 km^2 POPULATION: 690 121

Characterization of area

Ružomberok

The location of the city comprises the area of the western part of the Liptov basin, on the confluence of rivers Váh, Revúca and Likavka. The Veľká Fatra mountains constitute the border in the west, the Choč mountains in the north and the Low Tatras in the south. The most frequently occur winds from west sector, at an average speed 1.6 m.s^{-1}.

Žilina

The town itself is spread in the central valley of the Váh river, in the basin of central Považie. Žilina basin is classified as a moderately high basin. From the east the Little Fatra mountains intervene into the area, from the south the White Carpathians and from the north-west the Javorníky mountains. In a basin area, the relative humidity of air is higher and also the number of foggy days is the highest throughout the year. Slight windiness of average wind speed 1.3 m.s^{-1} and the up to 60% occurrences of calm characterise this area. From the standpoint of potential air pollution, the wind conditions in the Žilina basin are very unfavourable and thus relatively smaller sources of emissions caused to the high level of air pollution at the ground level layer.

Martin

The town of Martin is situated in the Turčianska basin at the confluence of the rivers Turiec and Váh, and surrounded by the Veľká and Malá Fatra mountain ranges. The basin area is located between high mountains and has unfavourable climatic conditions from the standpoint of pollutant emission dispersion. The frequent occurrence of temperature inversions, low average wind speed 2.8 m.s^{-1} and high relative humidity contribute to higher level of pollution.

Location of stations

Žilina - Obežná

The station is situated in the north-eastern part of the town at the edge of housing estate in relative open area close to the local roads with small traffic frequency. The position is open in all directions and representative for wind speeds and wind directions measurements.

Ružomberok - Riadok

The station is located in the kindergarten close to a low traffic route way. In the surrounding built-up area low family housing prevails.

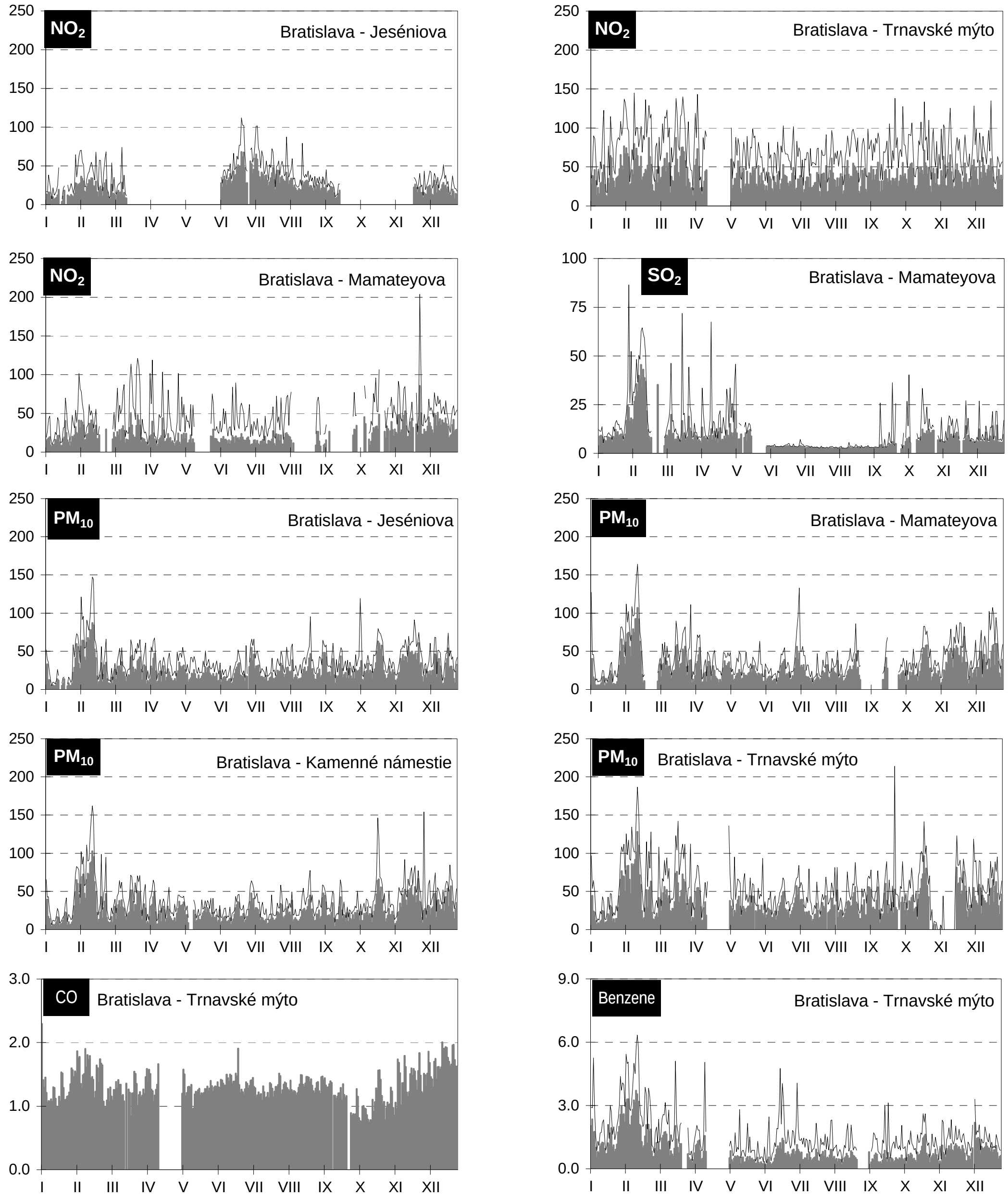
Martin - Jesenského

The station is located 5 m from the kerbside of the main street. Station is located in the southern part of the city in area mainly build up by family houses.

Tab. 2.1 **Geographical co-ordinates of monitoring stations and list of pollutants monitored in – 2012**

AGGLOMERATION/ zone		Longitude	Latitude	Altitude [m]	PM_{10}	$PM_{2.5}$	NO_2	SO_2	CO	C_6H_6	Pb	Cd	Ni	As	BaP
BRATISLAVA	Bratislava, Kamenné nám	17°06'48"	48°08'41"	139	*										
	Bratislava, Trnavské mýto	17°07'43"	48°09'30"	136	*		*		*	*					*
	Bratislava, Jeséniova	17°06'22"	48°10'05"	287	*		*								*
	Bratislava, Mamateyova	17°07'32"	48°07'30"	138	*		*	*							
KOŠICE	Košice, Amurská	21°17'11"	48°41'28"	201	*	*									
	Košice, Štefánikova	21°15'33"	48°43'34"	209	*	*	*			*					
Banská Bystrica region	Banská Bystrica, Štefánikovo nábr.	19°09'16"	48°44'07"	346	*		*	*	*	*	*	*	*	*	
	Banská Bystrica, Zelená	19°06'55"	48°44'00"	425		*	*								
	Jelšava, Jesenského	20°14'26"	48°37'52"	289	*	*									
	Hnúšťa, Hlavná	19°57'06"	48°35'02"	320	*	*									
	Zvolen, J. Alexyho	19°09'24"	48°33'29"	321	*	*									
	Žiar nad Hronom, Jilemnického	18°50'32"	48°35'58"	296	*	*									
Bratislava region	Malacky, Sasinkova	17°01'11"	48°26'15"	198	*		*	*	*	*					
Košice region	Veľká Ida, Letná	21°10'30"	48°35'32"	209	*	*			*		*	*	*	*	*
	Strážske, Mierová	21°50'15"	48°52'26"	133	*	*									
	Krompachy, SNP	20°52'26"	48°54'57"	372	*	*	*	*	*	*	*	*	*	*	*
Nitra region	Nitra, Štúrova	18°04'10"	48°18'00"	143	*		*	*	*	*					*
	Nitra, Janíkovce	18°08'27"	48°17'00"	149	*	*	*								
Prešov region	Humenné, Nám. slobody	21°54'50"	48°55'51"	160	*	*									
	Prešov, Arm. gen. L.Svobodu	21°16'03"	48°59'36"	252	*	*	*		*	*					
	Vranov nad Topľou, M. R. Štefánika	21°41'15"	48°53'11"	133	*	*		*							
Trenčín region	Bystričany, Rozvodňa SSE	18°30'51"	48°40'01"	261	*	*		*							
	Handlová, Morovianska cesta	18°45'23"	48°43'59"	448	*	*		*							
	Prievidza, Malonecpalská	18°37'40"	48°46'58"	276	*	*		*			*	*	*	*	*
	Trenčín, Hasičská	18°02'28"	48°53'47"	214	*	*	*	*	*	*					
Trnava region	Senica, Hviezdoslavova	17°21'48"	48°40'50"	212	*	*		*							
	Trnava, Kollárova	17°35'06"	48°22'16"	152	*	*	*		*	*					*
Žilina region	Martin, Jesenského	18°55'17"	49°03'35"	383	*	*	*		*	*					
	Ružomberok, Riadok	19°18'10"	49°04'44"	475	*	*		*			*	*	*	*	
	Žilina, Obežná	18°46'15"	49°12'41"	356	*	*	*								

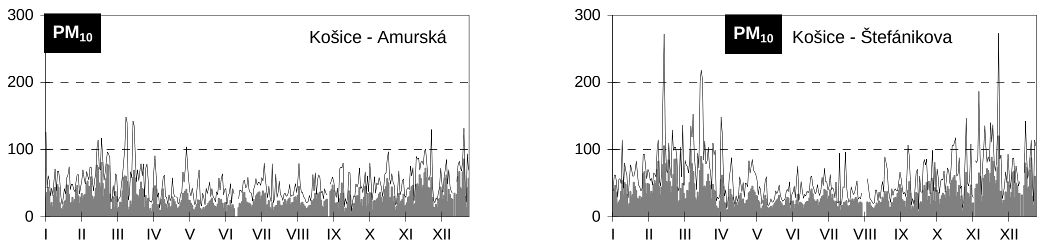
Fig. 2.1 **Concentrations of NO_2, SO_2, PM_{10}, benzene and CO – agglomeration Bratislava – 2012**



█ concentrations: NO_2, SO_2, PM_{10}, benzene - daily average [$\mu g.m^{-3}$] CO - daily maximum of 8 h means [$mg.m^{-3}$]

— 1 h maximum concentrations: NO_2, SO_2, PM_{10}, benzene [$\mu g.m^{-3}$]

Fig. 2.2 **Concentrations of PM_{10}, $PM_{2.5}$ and benzene – agglomeration Košice – 2012**



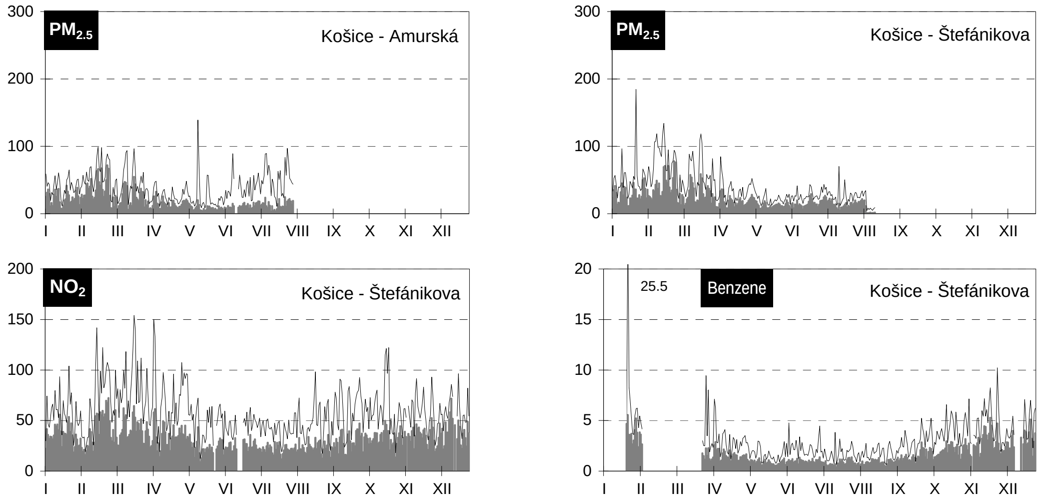
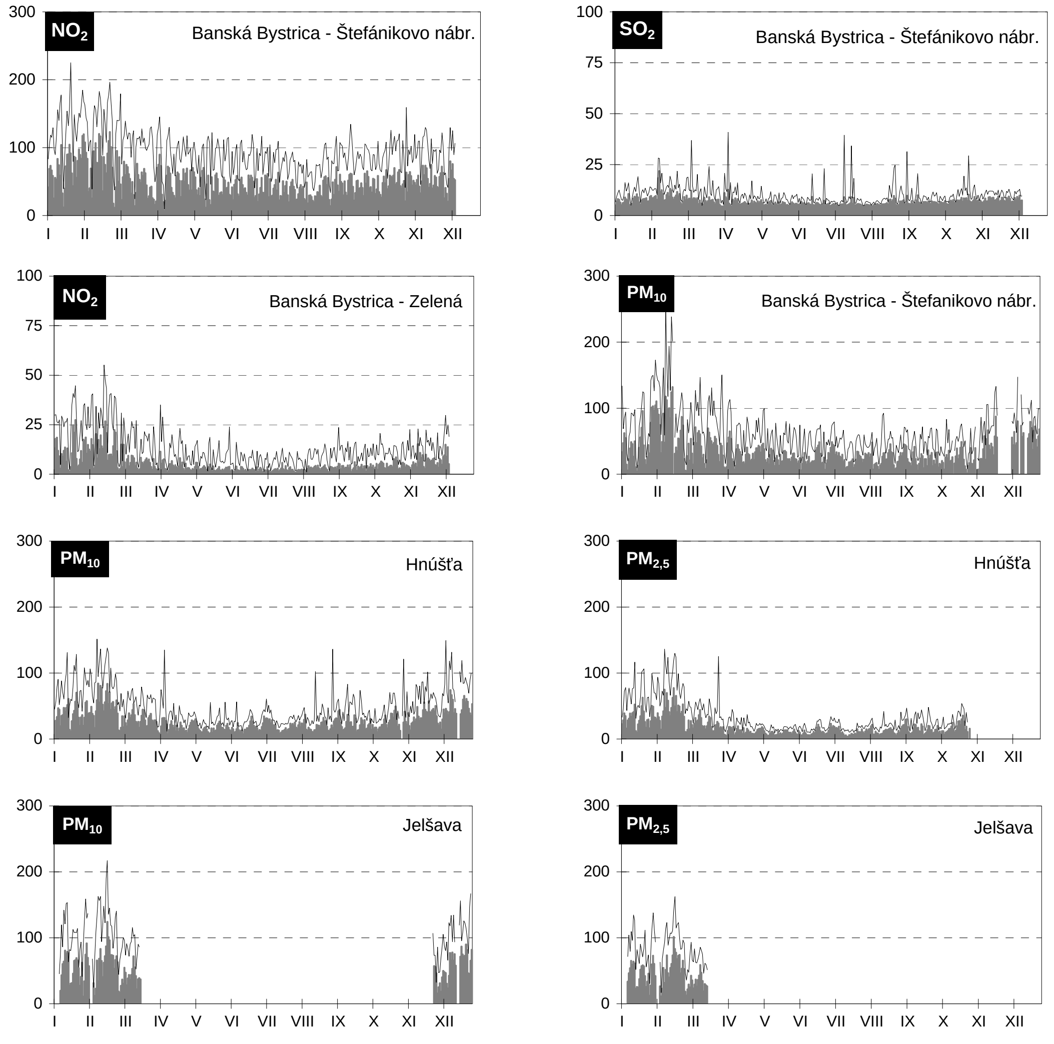


Fig. 2.3 **Concentrations of NO_2, SO_2, PM_{10}, $PM_{2,5}$, CO and benzene – zone Banská Bystrica region – 2012**



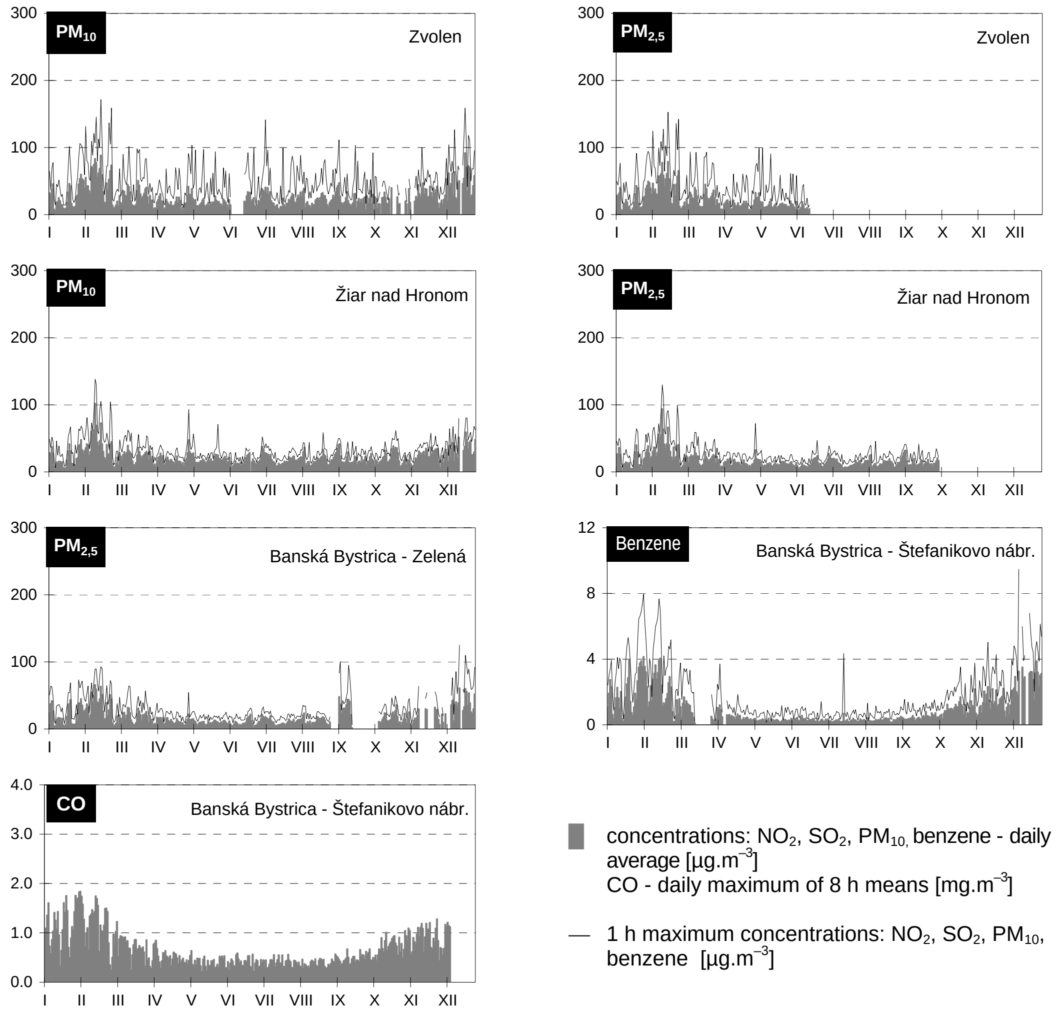
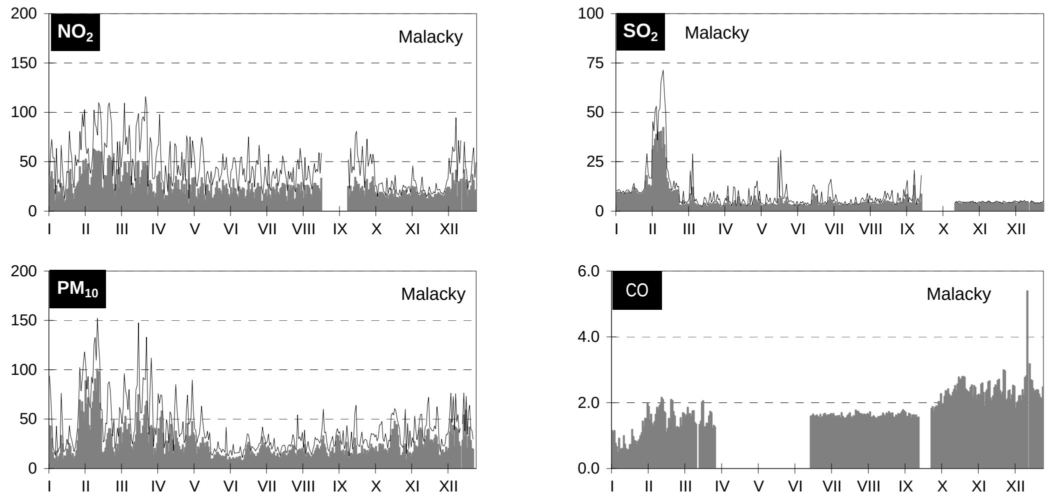
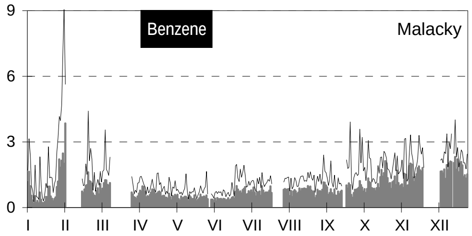


Fig. 2.4 **Concentrations of NO_2, SO_2, PM_{10}, CO and benzene – zone Bratislava region – 2012**

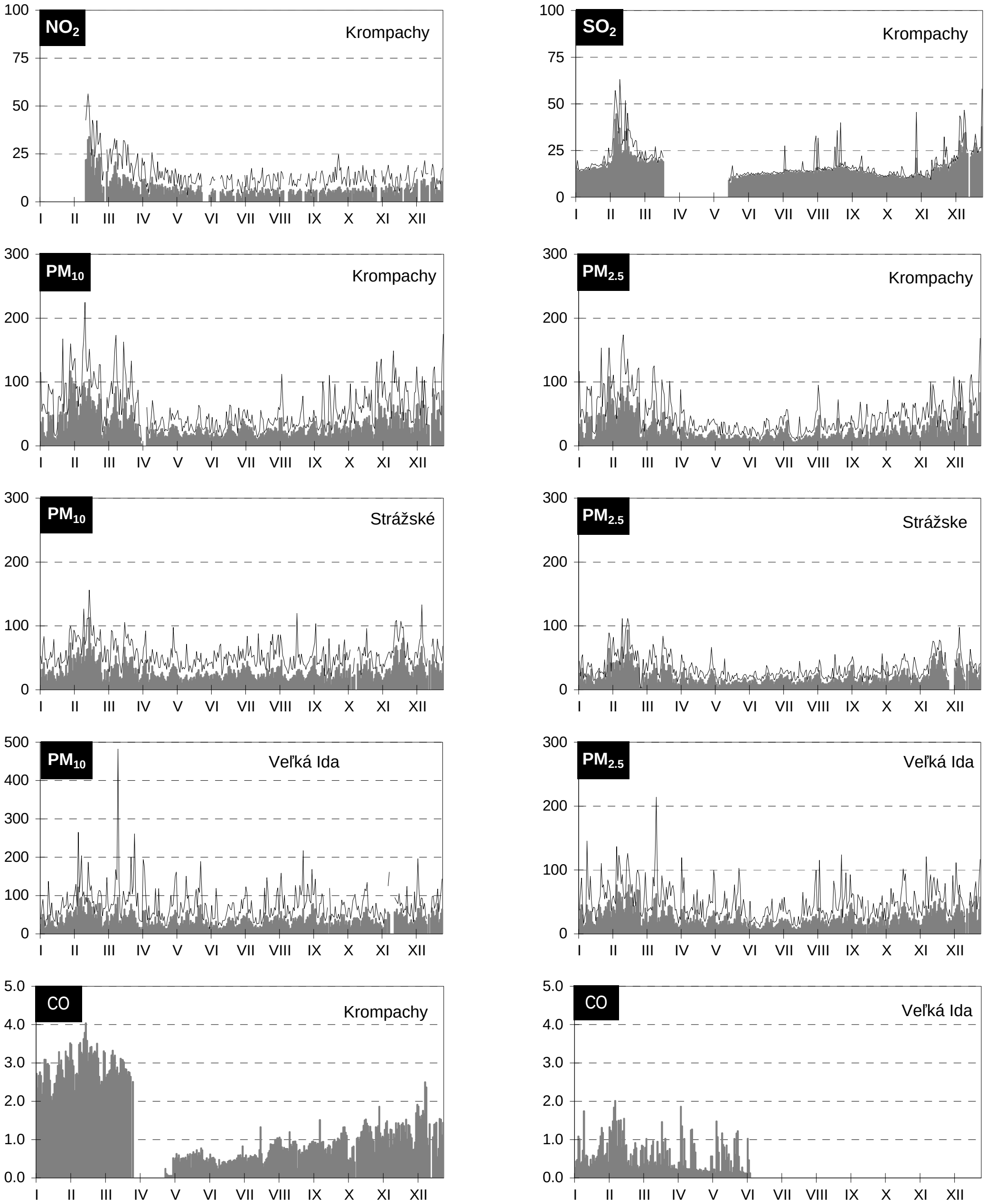


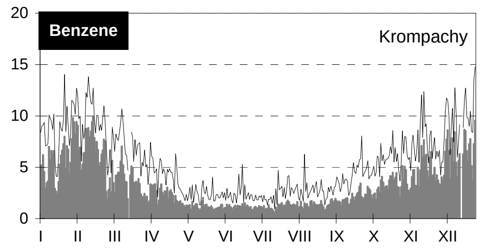


concentrations: NO_2, SO_2, PM_{10}, benzene - daily average [µg.m^{-3}]
CO - daily maximum of 8 h means [mg.m^{-3}]

— 1 h maximum concentrations: NO_2, SO_2, PM_{10}, benzene [µg.m^{-3}]

Fig. 2.5 **Concentrations of NO_2, SO_2, PM_{10}, $PM_{2,5}$, CO and benzene – zone Košice region – 2012**

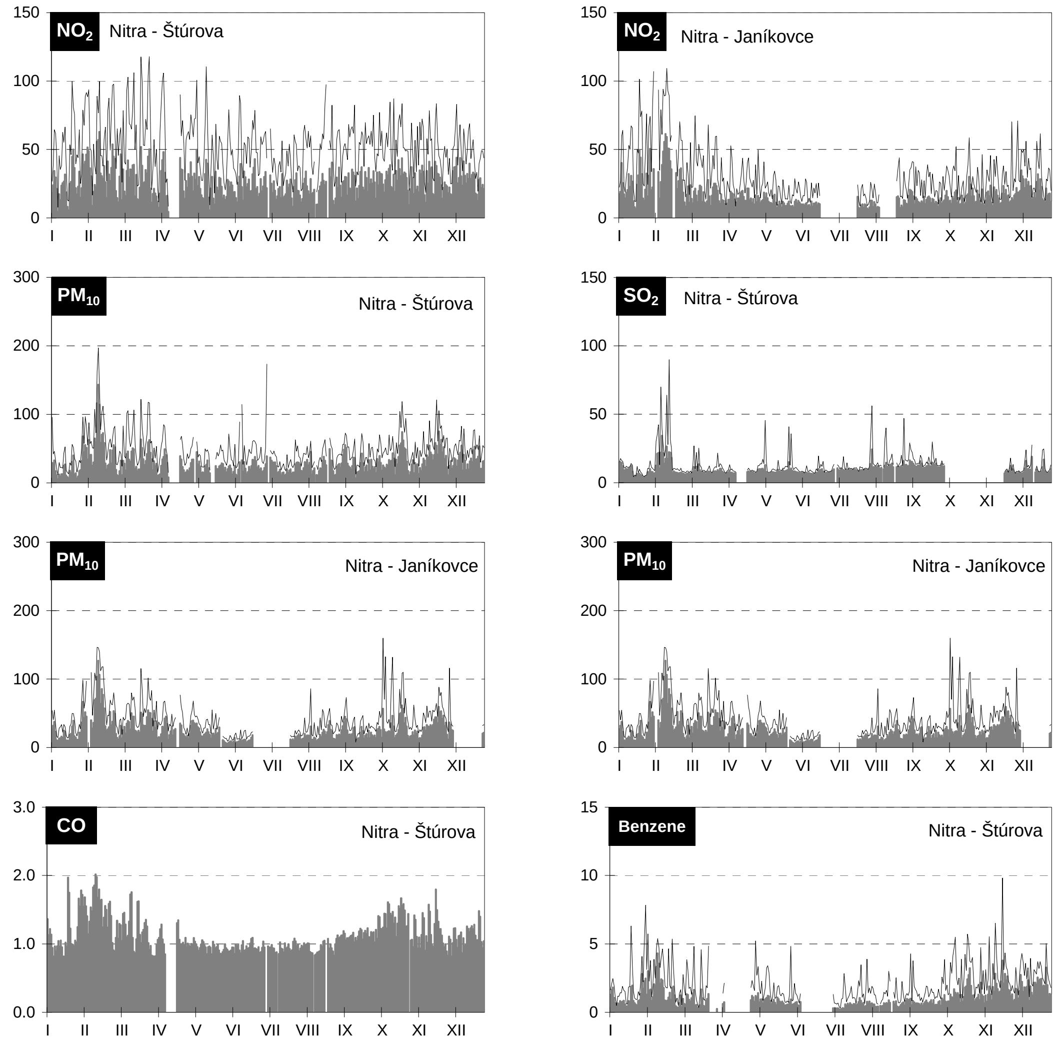




▮ concentrations: NO_2, SO_2, PM_{10}, $PM_{2.5}$, benzene - daily average [µg.m^{-3}]
CO - daily maximum of 8 h means [mg.m^{-3}]

— 1 h maximum concentrations: NO_2, SO_2, PM_{10}, $PM_{2,5}$, benzene [µg.m^{-3}]

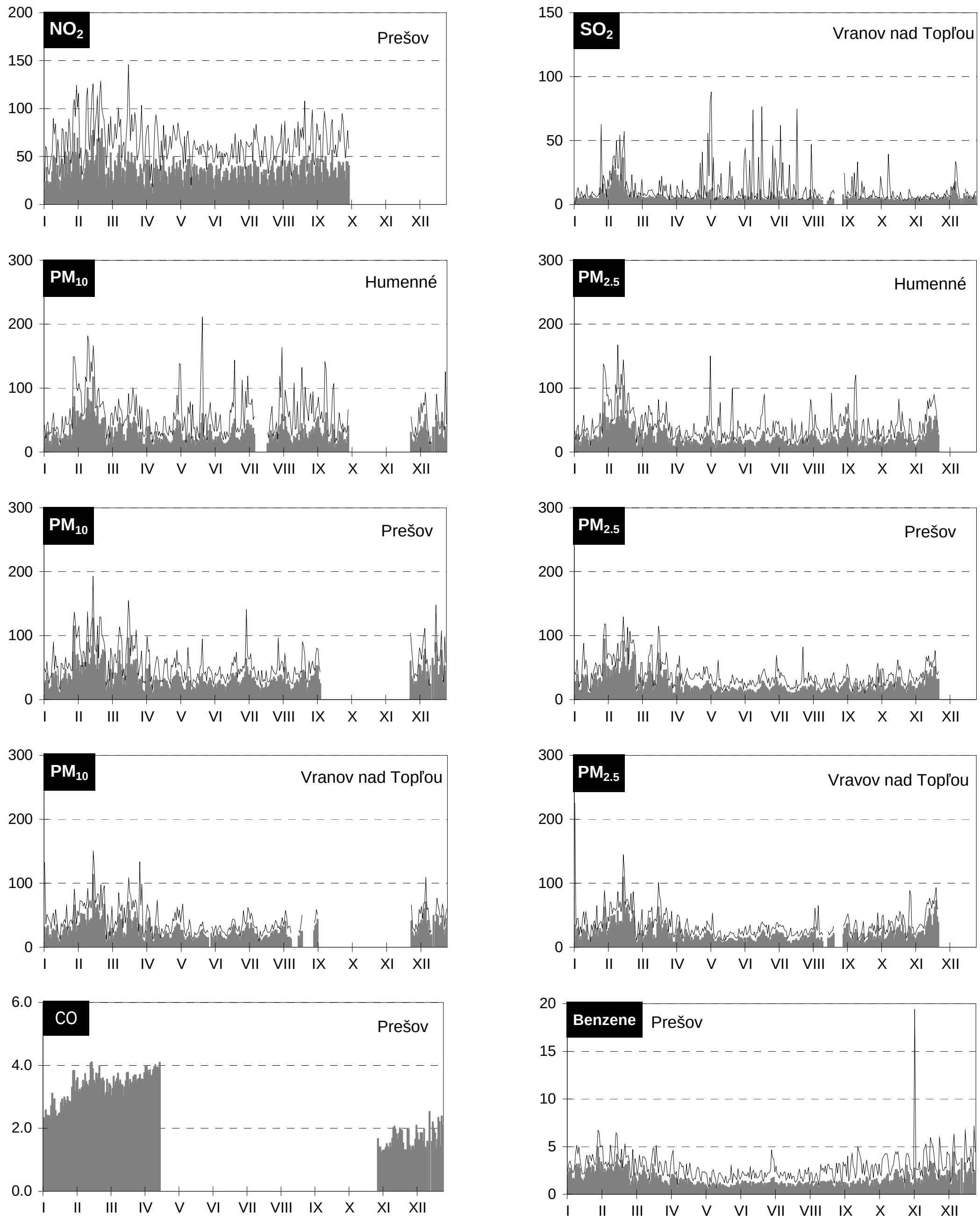
Fig. 2.6 **Concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$, CO and benzene – zone Nitra region – 2012**



▮ concentrations: NO_2, SO_2, PM_{10}, $PM_{2.5}$, benzene - daily average [µg.m^{-3}]
CO - daily maximum of 8 h means [mg.m^{-3}]

— 1 h maximum concentrations: NO_2, SO_2, PM_{10}, benzene [µg.m^{-3}]

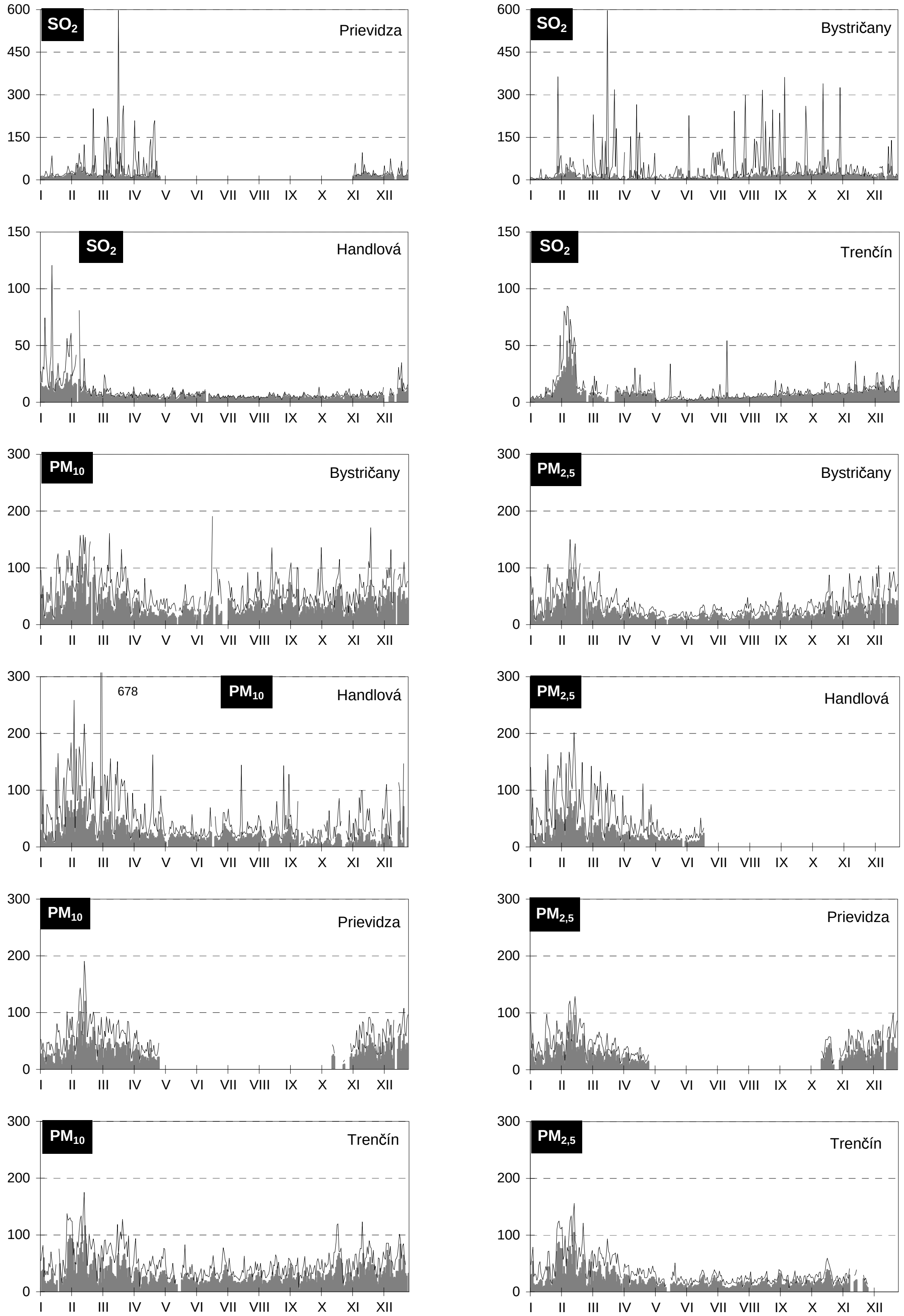
Fig. 2.7 **Concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$, CO and benzene – zone Prešov region – 2012**

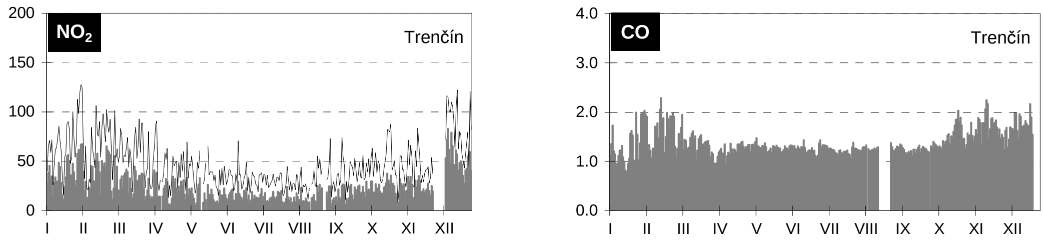


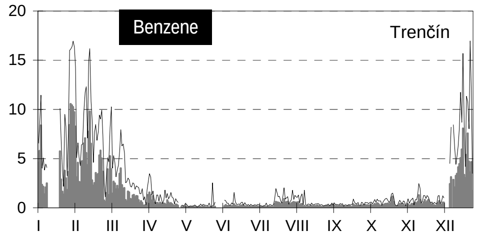
concentrations: NO_2, SO_2, PM_{10}, $PM_{2.5}$, benzene - daily average [$\mu g.m^{-3}$]
CO - daily maximum of 8 h means [$mg.m^{-3}$]

— 1 h maximum concentrations: NO_2, SO_2, PM_{10}, benzene [$\mu g.m^{-3}$]

Fig. 2.8 **Concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$, CO and benzene – zone Trenčín region – 2012**







concentrations: NO_2, SO_2, PM_{10}, $PM_{2.5}$, benzene - daily average [µg.m^{-3}]
CO - daily maximum of 8 h means [mg.m^{-3}]

— 1 h maximum concentrations: NO_2, SO_2, PM_{10}, $PM_{2.5}$, benzene [µg.m^{-3}]

Fig. 2.9 **Concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$, CO and benzene – zone Trnava region – 2012**

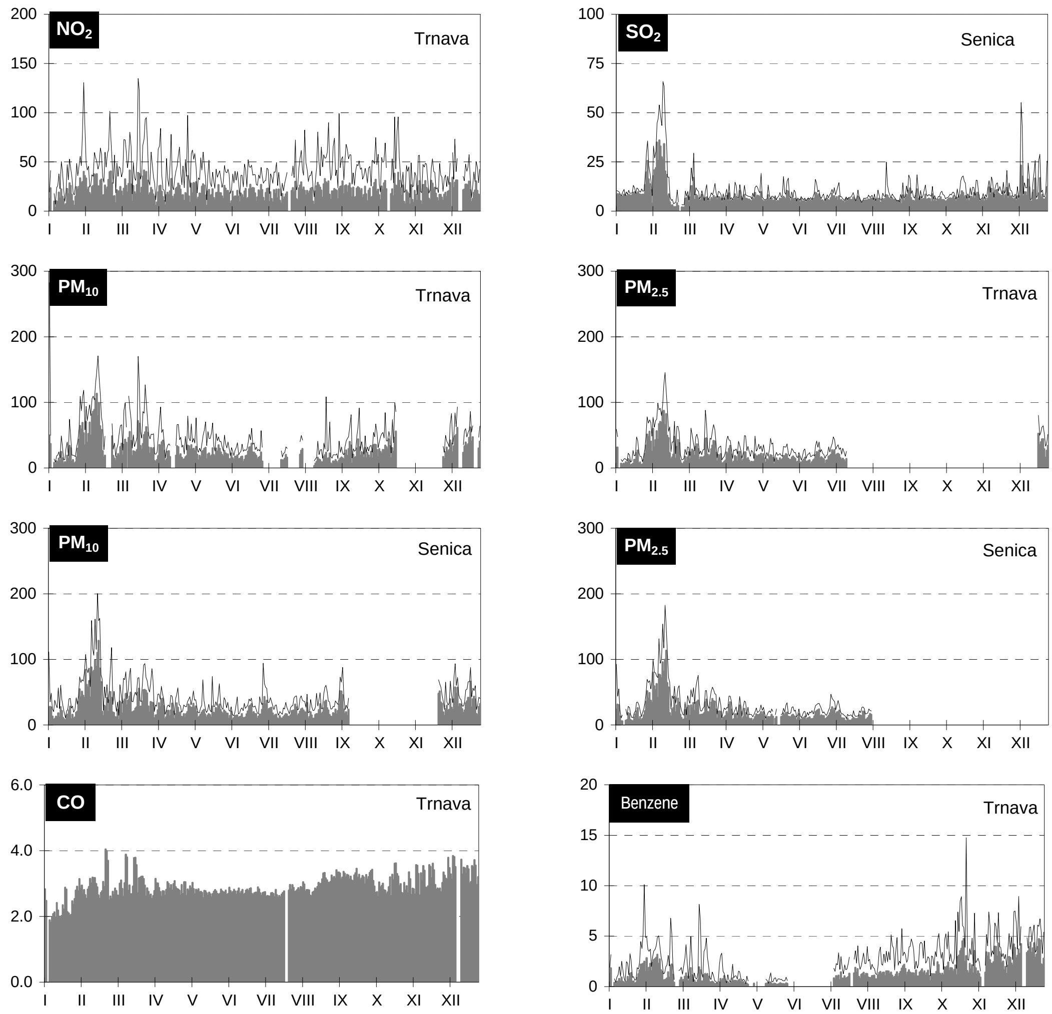


Fig. 2.10 **Concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$, CO and benzene – zone Žilina region – 2012**

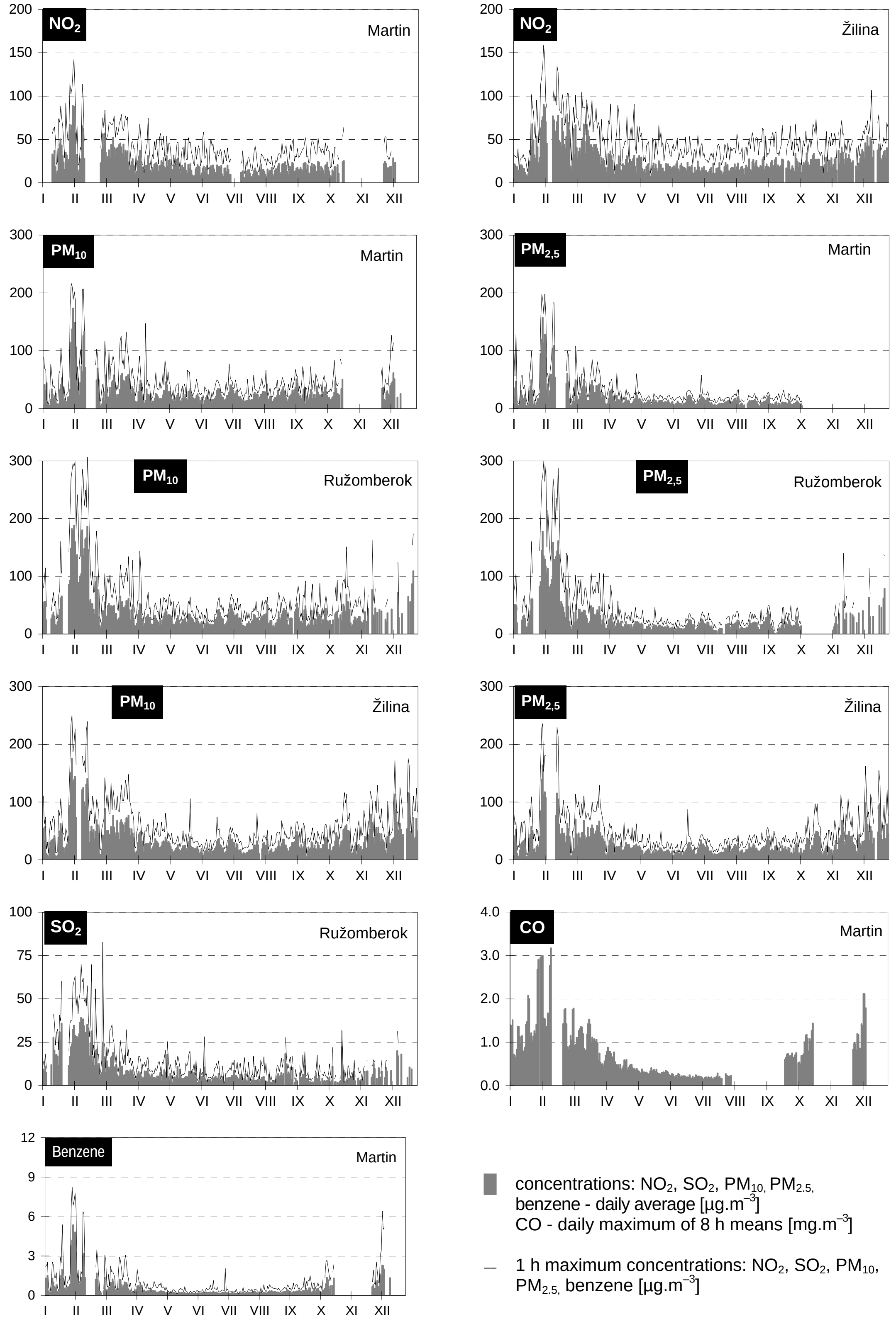
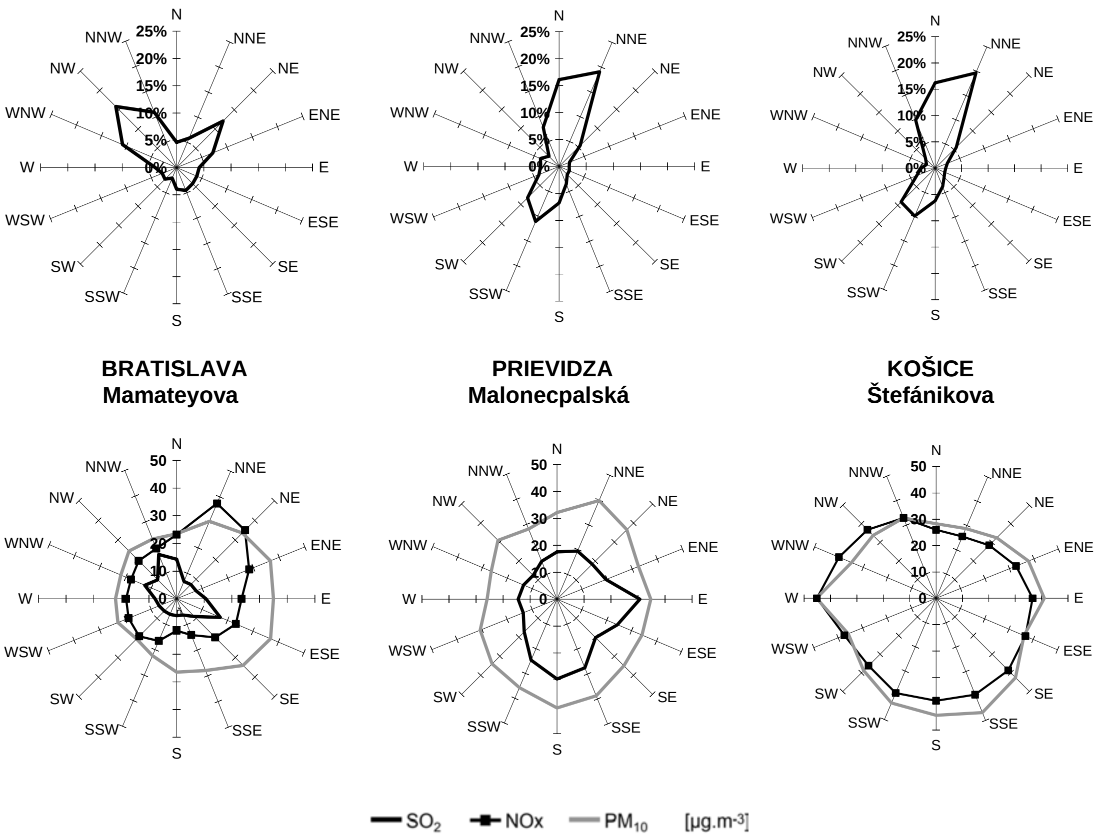


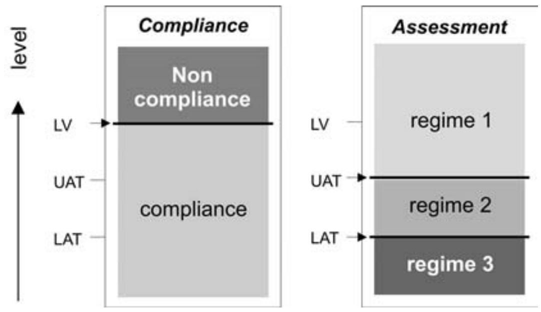
Fig. 2.11 **Wind and concentration roses – 2012**



2.3 PROCESSING OF MEASUREMENT RESULTS ACCORDING TO LIMIT VALUES

The Air Protection Act 137/2010 Coll. the air quality assessment is carried out at whole territory of the Slovak Republic in each zone and agglomerations. On the basis of air quality assessment each zone/agglomeration the monitoring regimes are defined. This assessment performed for the period of the last five years distinguishes three particular monitoring regimes. These are schematically illustrated on Figure 2.12 and in Table 2.2 are specified requirements for air quality assessment for specific regimes.

Fig. 2.12 **Regimes of air quality assessment in relation to LV[1], UAT[2] a LAT[3]**



Tab. 2.2 **Requirements for assessment in three different regimes**

Maximum level of pollution in agglomerations and zones	Requirements for assessment
REGIME 1 **Above upper assessment threshold**	High quality of measurements is obligatory. Measured data can be supplemented by further information, model computations including.
REGIME 2 **Below upper assessment threshold, but above lower assessment threshold**	Measurements are obligatory, however to a lesser extent, or to a lesser intensity, under the premise that the data are supplemented by other reliable sources of information.
REGIME 3 **Below lower assessment threshold**	
In agglomerations, only for pollutants, for which an alert threshold has been set	At least one measurement station is required in each agglomeration combined with the model computations, expert estimate and indicative measurements. Those are measurements based on simple methods, or operated in limited time. These are less accurate than continuous measurements, but may be used to control relatively low level of pollution and as supplementary measurements in other areas.

For some pollutants margin of tolerance were set up. Limit values, upper and lower assessment thresholds defined in Decree No. 360/2010 Coll. about Air Quality are presented in tables 2.3 and 2.4. Alert thresholds values were set up for:

SO_2 – 500 µg.m^{-3} and NO_2 – 400 µg.m^{-3}.

Alert thresholds values are exceeded if each of 3 consecutive 1 hour concentration exceeds the particular level given above.

But these limit values are assumed to be exceeded only in case, if the polluted area is larger than 100 km^2 or represent the whole zone. The stringer criteria is taken into account.

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[1] *Limit value as defined in Decree No. 360/2010 Coll.*
[2] *Upper assessment threshold as defined in Decree No. 360/2010 Coll.*
[3] *Lower assessment threshold, as defined in Decree No. 360/2010 Coll.*

Results from continuous measurements are presented in graphical and tabular form. For illustration the concentrations and wind roses were evaluated for one station from west, middle and east part of Slovakia (Fig. 2.11).

Statistical characteristics were processed for all monitoring stations in Slovakia. The stations, where the limit values and limit values plus margin of tolerance were exceeded, are highlighted in tables in bold (Tab. 2.5 – 2.7).

Sulphur dioxide In the year 2012 in none of agglomeration or zone the hourly or daily limit values were exceeded in more cases than it is allowed. Also none alert concentration has not been exceeded as well.

Nitrogen dioxide Annual limit value was exceeded at stations Banská Bystrica-Štefánikovo 50.4 $\mu g.m^{-3}$. The higher level was partly caused by reconstruction works of traffic circle which will result to improvement of local air quality. Hourly limit value has not been exceeded at any station. The maximal level was below the alert threshold.

PM_{10} The major air pollution problem in Slovakia similarly to the whole Europe is pollution by particulate matter. In the year 2012 daily limit value was exceeded at 14 stations. At 2 AMS annual limit value was exceeded as well.

$PM_{2,5}$ For $PM_{2,5}$ is given only annual limit 25 $\mu g.m^{-3}$, which come in force in 1. 1. 2015. For the year 2012 is put in force limit value and margin of tolerance 27 $\mu g.m^{-3}$ (Commission implementing Decision 2011/850/EU, ANNEX 1, bod 5). In 2012 was this value exceeded at 4 stations and target limit at 25 $\mu g.m^{-3}$ at 6 stations, what represent significant decrease in comparison to the year 2011.

Carbon monoxide The level of pollution by carbon monoxide is considerably low and the limit value was not exceeded at any of the monitoring stations.

Benzene The highest annual concentration 3.3 $\mu g.m^{-3}$ in Krompachy is deeply bellow the limit value 5 $\mu g.m^{-3}$.

Pb, As, Ni, Cd Annual average concentration 6,9 $ng.m^{-3}$ exceeded target value for As at station Prievidza-Malonecpalská and at more s stations the level is above Upper assessment threshold. Others heavy metals are below targets and limit values.

BaP The target value was exceeded at stations Veľká Ida-Letná, Krompachy-SNP and Prievidza-Malonecpalská.

Tab. 2.3 **Limit values plus limits of tolerance for respective years**

	Interval of averaging	Limit value* [µg.m⁻³]	To be met by	Margin of tolerance	Limit value + margin of tolerance [µg.m⁻³]												
					Since 31/12/00	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
SO_2	1h	350 (24)	1.1.2005	150 µg/m³	500	470	440	410	380	350	350	350	350	350	350	350	350
SO_2	24h	125 (3)	1.1.2005	-													
SO_2^V	1y, W[1]	20 (-)	1.1.2003	-													
NO_2	1h	200 (18)	1.1.2010	50%	300	290	280	270	260	250	240	230	220	210	200	200	200
NO_2	1y	40 (-)	1.1.2010	50%	60	58	56	54	52	50	48	46	44	42	40	40	40
NO_x^V	1y	30 (-)	1.1.2003	-													
PM_{10}	24h	50 (35)	1.1.2005	50%	75	70	65	60	55	50	50	50	50	50	50	50	50
PM_{10}	1y	40 (-)	1.1.2005	20%	48	46	45	43	42	40	40	40	40	40	40	40	40
Pb	1y	0.5 (-)	1.1.2005	100%	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
CO	max. 8 hour daily value	10000 (-)	1.1.2003 (1.1.2005)	6000 µg/m³	16000	16000	16000	14000	12000	10000	10000	10000	10000	10000	10000	10000	10000
Ben-zene	1y	5 (-)	1.1.2006 (1.1.2010)	100%	10	10	10	10	10	10	9	8	7	6	5	5	5
$PM_{2.5}$	1y	25	1. 1. 2008	5 µg/m³									30	29	29	28	27
$PM_{2.5}$**	1y	25	1. 1. 2015	-													

[1] *winter period (October 1 - March 31)* *V critical level for protection of vegetation*
** allowed exceedances per year are in brackets ** target value*

	Interval of averaging	Target value [ng/m³]	To be met by
As	1y	6	31. 12. 2012
Cd	1y	5	31. 12. 2012
Ni	1y	20	31. 12. 2012
BaP	1y	1	31. 12. 2012

Tab. 2.4 **Limit values, upper and lower assessment threshold**

	Receptor	Interval of averaging	Limit value [µg.m⁻³]	Assessment threshold [µg.m⁻³]	
				upper*	lower*
SO_2	Human health	1h	350 (24)		
SO_2	Human health	24h	125 (3)	75 (3)	50 (3)
SO_2	Vegetation	1y. 1/2y	20 (-)	12 (-)	8 (-)
NO_2	Human health	1h	200 (18)	140 (18)	100 (18)
NO_2	Human health	1y	40 (-)	32 (-)	26 (-)
NO_x	Vegetation	1y	30 (-)	24 (-)	19.5 (-)
PM_{10}	Human health	24h	50 (35)	35 (35)	25 (35)
PM_{10}	Human health	1y	40 (-)	28 (-)	20 (-)
Pb	Human health	1y	0.5 (-)	0.35 (-)	0.25 (-)
CO	Human health	8h (maximum)	10 000 (-)	7 000 (-)	5 000 (-)
Benzene	Human health	1y	5 (-)	3.5 (-)	2 (-)
$PM_{2,5}$	Human health	1y	25**	17	12

** allowed exceedances per year are in brackets **valid since 1st January 2015*

Tab. 2.5 **Assessment of air quality according to limit values for protection of human health – 2012**

AGLOMERATION / Zone		Human protection									VP 2)	
	Pollutant	SO_2		NO_2		PM_{10}		$PM_{2.5}$ +MT	CO	Benzén	SO_2	NO_2
	Time of averaging	1 hour	24 hour	1 hour	1 year	24 hour	1 year	1 year	8 hour 1)	1 year	3 subsequent hour	3 subsequent hour
	Limit value [µg.m⁻³] *(počet prekročení)*	350 *(24)*	125 *(3)*	200 *(18)*	40	50 *(35)*	40	27	10000	5	500	400
BRATISLAVA	Bratislava, Kamenné nám.					28	25.8	c <u>13.7</u>				
	Bratislava, Trnavské mýto			0	38.8	a 65	a 35.9		2479	0.9		0
	Bratislava, Jeséniova			b 0	b 24.7	22	25.1					0
	Bratislava, Mamateyova	a 0	a 0	a 1	a 22.9	a 36	a 27.4				0	0
KOŠICE	Košice, Štefánikova			0	32.3	58	34.9	b 22.1		a 1.7		0
	Košice, Amurská					31	28.7	b 19.3				
Banská Bystrica region	Banská Bystrica, Štefánik.nábr.	0	0	1	50.4	62	35.4		1841	1.0	0	0
	Banská Bystrica, Zelená			0	5.5			a 18.2				0
	Jelšava, Jesenského					c 55	c 54.9	c 44.8				
	Hnúšťa, Hlavná					34	28.4	a 18.4				
	Zvolen, J. Alexyho					30	27.1	c 22.3				
	Žiar n/H, Jilemnického					9	22.4	a 16.8				
Bratislava region	Malacky, Sasinkova	0	0	0	24.8	25	25.6		a 5552	a 0.9	0	0
Košice region	Veľká Ida, Letná					77	38.6	26.3	c 2013			
	Strážske, Mierová					38	30.2	21.1				
	Krompachy, SNP	a 0	a 0	a 0	a 7.4	63	33.9	26.4	4037	3.3	0	0
Nitra region	Nitra, Janíkovce			a 0	a 17.0	a 22	a 26.4	b 19.3				0
	Nitra, Štúrova	a 0	a 0	0	26.6	37	30.0		2017	a 1.1	0	0
Prešov region	Humenné, Nám. slobody					a 33	a 30.5	22.7				
	Prešov, Arm. gen. L. Svobodu			a 0	a 36.7	a 51	a 35.6	23.7	c 4109	1.6		0
	Vranov n/T, M. R. Štefánika	0	0			b 22	b 27.3	a 21.5			0	
	Stará Lesná, AÚ SAV, EMEP 3)					2	19.3	11.6				
	Kolonické sedlo, Hvezdáreň 3)					c 7	c 23.1	c 18.2				
Trenčín region	Prievidza, Malonecpalská	c 1	c 0			c 26	c 34.4	b 28.8			0	
	Bystričany, Rozvodňa SSE	3	0			60	35.2	21.7			0	
	Handlová, Morovianska cesta	0	0			32	23.2	c 24.4			0	
	Trenčín, Hasičská	0	0	0	24.5	47	31.8	a 21.4	2288	1.3	0	0
Trnava region	Senica, Hviezdoslavova	0	0			a 26	a 27.1	b 20.8			0	
	Trnava, Kollárova			0	20.8	a 28	a 27.9	b 22.0	4190	a 1.5		0
	Topoľníky, Aszód, EMEP 3)					a 15	a 24.5	c 20.7				
Žilina region	Martin, Jesenského			a 0	a 21.9	a 25	a 29.1	a 18.3	b 3169	a 0.6		0
	Ružomberok, Riadok	a 0	a 0			72	40.1	a 29.0			0	
	Žilina, Obežná			0	26.5	64	34.9	28.3				0

1) maximal 8 hour value of moving average
2) alert threshold limit values
3) stations located in rural background areas
<u>gravimetry</u>

Pollutants which exceeded limit values are in bold

Data coverage: [green] > 90%, a 75 – 90%, b 50 – 75%, c < 50% of valid values

Tab. 2.6 **Assessment of air quality according to target and limit values for As, Cd and Ni for the protection of human health in 2012**

AGLOMERATION/ zone	Pollutant	As	Cd	Ni	Pb
	Target value [ng.m^{-3}]	6.0	5	20	
	Limit value [ng.m^{-3}]				500
	Upper assessment threshold [ng.m^{-3}]	3.6	3	14	350
	Lower assessment threshold [ng.m^{-3}]	2.4	2	10	250
Slovakia	Banská Bystrica, Štefánikovo nábr.	2.7	0.9	2.3	35.2
	Veľká Ida, Letná	2.2	0.8	1.7	31.1
	Krompachy, SNP	2.9	2.1	1.4	135.9
	Prievidza, Malonecpalská	6.9	0.3	0.9	8.9
	Ružomberok, Riadok	3.3	0.5	1.3	14.9

Tab. 2.7 **Assessment of air quality according to target values for BaP for the protection of human health in 2012**

AGLOMERATION / zone	Pollutant	BaP
	Target value [ng.m^{-3}]	1.0
	Upper assessment threshold [ng.m^{-3}]	0.6
	Lower assessment threshold [ng.m^{-3}]	0.4
BRATISLAVA	Bratislava, Trnavské mýto	0,8
	Bratislava, Jeséniova	0.9
Slovakia	Veľká Ida, Letná	3.3
	Krompachy, SNP	2.9
	Nitra, Štúrova	0.7
	Prievidza, Malonecpalská	1.7
	Trnava, Kollárova	0.9

AMBIENT AIR

ATMOSPHERIC OZONE

3

3.1 ATMOSPHERIC OZONE

Most of the atmospheric ozone (approximately 90%) is in the stratosphere (11 – 50 km), the rest in the troposphere. Stratospheric ozone protects our biosphere against lethal ultra-violet UV-C radiation and to a considerable degree weakens UV-B radiation, which may cause the whole range of unfavourable biological effects such as skin cancer, cataracts, etc. The depletion of stratospheric ozone and thus total ozone as well, observed since the end of the 1970s, is associated with the increase in intensity and doses of UV-B radiation in the troposphere and on the Earth's surface. The main share in stratospheric ozone depletion is due to the emissions of freons and halons, which are the source of active chlorine and bromine in the stratosphere. The concentration of active chlorine in troposphere culminated in the mid-1990s. At present the culmination in stratosphere is supposed. A slow recovery of ozone layer to the pre-industrial level is expected in the middle of this century.

The growth of ozone concentrations in the troposphere approximately 1 $\mu g.m^{-3}$ annually was observed over the industrial continents of the Northern Hemisphere by the end of 1980s. It is associated with the increasing emission of ozone precursors (NOx, VOCs, CO) from car transport, power generation and industry. Since the early 1990s no trend of the average concentration level of ground level ozone in Slovakia, like as in many European countries, has been observed. In spite of considerable decrease of ozone precursor emission reduction in Slovakia and in surrounding countries during nineties the effect was not adequate. Only ozone peaks decreased significantly. It was shown the average level of ozone concentration is more controlled by large scale processes (downward mixing from the free troposphere, long-range transport and global warming). The extremely warm and dry year 2003 represented the absolute exception from these trends. Most of the ozone level indicators reached the highest values at all Slovak suburban, rural and mountain stations in the period 1993 – 2003. The alert thresholds 240 $\mu g.m^{-3}$ (the first time since 1995) was overstepped in six cases in south-west Slovakia. The level of concentrations in 2012 was lower as in 2003. The high ground level ozone concentrations, mainly during photochemical smog episodes in summer, impact unfavourably on human health (mainly on the respiratory system of human beings), vegetation (mainly on agricultural crops and forests) and various materials.

3.2 GROUND LEVEL OZONE IN THE SLOVAK REPUBLIC DURING 2007 – 2012

Target and thresholds values for ground level ozone

In Table 3.1 the target values for ground level ozone are listed according to the Act 137/2010 Coll. on Air, information and alert thresholds. If ground level ozone concentration exceeds some of the threshold values the population has to be informed or warned.

Tab. 3.1 **Target values for ground level ozone, information and alert thresholds**

Target resp. threshold values	Concentration O_3 [$\mu g.m^{-3}$]	Averaging/accumulation time
Target value for the protection of human health	120*	8 hour
Target value for the protection of vegetation AOT40**	18 000 [$\mu g.m^{-3}.h$]	1 May–31 July
Information threshold	180	1 hour
Alert threshold	240	1 hour

* *Maximum daily 8-hour average 120 $\mu g.m^{-3}$ not to be exceeded on more than 25 days per calendar year averaged over three years.*

** *AOT40, expressed in $\mu g.m^{-3}$.hours, means the sum of the difference between hourly concentrations greater that 80 $\mu g.m^{-3}$ (= 40 ppb) and 80 $\mu g.m^{-3}$ over a given period using only the 1 hour values measured between 8:00 and 20:00 of Central European Time each day, averaged over five years.*

Assessment of ground level ozone in Slovakia during 2007–2012

The measurement of ground level ozone concentrations in Slovakia started in 1992, within the operation of monitoring network under the Slovak Hydrometeorological Institute. The number of monitoring stations has been gradually extended. The stations at Stará Lesná, Starina (in operation since 1994) Topoľníky and Chopok (in operation since 1995) are part of the EMEP monitoring network. For monitoring of ground level ozone concentrations, the ozone analysers have been used. All these analysers operate on the principle of UV absorption. In 1994, the secondary national ozone standard was installed in the Slovak Hydrometeorological Institute and regular audits by portable calibrator started to be carried out in the stations. A secondary standard of the Slovak Hydrometeorological Institute is regularly compared with the primary ozone standard in the Czech Hydrometeorological Institute in Prague. In 2012 the number of missing data did not exceed 5% almost at all stations (Tab. 3.2). Large gaps were only at the Jelšava, Nitra Janíkovce and Topoľníky.

Tab. 3.2 **Number of missing daily averages of ground level ozone concentrations [%]**

Station	2007	2008	2009	2010	2011	2012
Banská Bystrica, Zelená			*42.5	0.03	0.1	0.6
Bratislava, Jeséniova	0.6	1.6	0.1	0.2	1.3	1.6
Bratislava, Mamateyova	0.8	1.1	7.2	6.2	4.9	3.9
Humenné, Nám. Slobody	9.5	0.5	0.1	3.8	7.5	0.7
Jelšava, Jesenského	5.0	0.1	3.0	2.8	61.6	73.1
Košice, Ďumbierska	1.1	0.1	2.1	0.4	0.1	3.3
Nitra, Janíkovce			*13.7	22.5	63.5	11.8
Prievidza, Malonecpalská	1.9	0.4	3.4	0.5	4.6	1.9
Žilina, Obežná	1.0	0.05	1.5	0.1	0.4	3.1
Gánovce, Meteo. st.	0.01	1.7	0.1	0.4	0.2	2.4
Chopok, EMEP	1.0	1.7	0.3	2.6	2.2	3.4
Kojšovská hoľa	0.7	1.9	0.1	14.2	2.5	4.2
Stará Lesná, AÚ SAV, EMEP	0.2	0.3	0.6	0.4	2.2	3.2
Starina, Vodná nádrž, EMEP	6.6	2.6	0.8	0.1	0.2	1.6
Topoľníky, Aszód, EMEP	1.4	0.6	0.6	2.9	-	18.9

** ozone measurement introduced in 2009 - long-term failure*

Tab. 3.3 **Annual averages of ground level ozone concentration [μg.m^{-3}]**

Station	2007	2008	2009	2010	2011	2012
Banská Bystrica, Zelená			**53	56	60	66
Bratislava, Jeséniova	59	59	60	61	63	65
Bratislava, Mamateyova	49	48	48	46	51	53
Humenné, Nám. slobody	56	55	59	53	53	55
Jelšava, Jesenského	56	51	49	44	-	-
Košice, Ďumbierska	57	56	81	63	73	62
Nitra, Janíkovce			*74	53	-	*62
Prievidza, Malonecpalská	48	53	50	49	51	52
Žilina, Obežná	44	46	48	47	48	49
Gánovce, Meteo. st.	60	65	62	63	64	66
Chopok, EMEP	91	92	90	87	96	93
Kojšovská hoľa	79	76	85	90	87	82
Stará Lesná, AÚ SAV, EMEP	68	74	61	67	65	63
Starina, Vodná nádrž, EMEP	62	59	58	51	59	60
Topoľníky, Aszód, EMEP	58	60	59	55	-	*59

**75 – 90%, ** 50–75% of valid measurements - long-term failure*

In 2012, the annual average concentrations of ground level ozone in urban and industrial locations of Slovakia ranged within the interval 49 – 66 μg.m^{-3} (Tab. 3.3). The concentrations in the rest of the territory ranged between 59 and 93 μg.m^{-3}, mainly depending on the altitude. The highest annual average of ground level ozone concentrations was reached at the summit station Chopok (93 μg.m^{-3}). The effect of ozone from the accumulation zone (800 – 1500 m over the ground) over the Europe is evident. The year 2012, according to vegetation period averages, belongs to the photochemically less active years. Annual averages of ground level ozone concentration in 2012 were lower than in record year 2003.

In Figure 3.1, the seasonal cycle of daily ozone concentrations in Stará Lesná during 1992 – 2012 is depicted. The seasonal course is typical for lowlands and valley (not summit) positions of industrial continents. Original spring maximums of ozone concentrations, associated with the transport of ozone from upper atmospheric layers, is extended for the whole summer period, as a consequence of photochemical ozone formation in a atmospheric boundary layer.

The daily average course of ground level ozone concentration in August in Stará Lesná is depicted in Figure 3.2 (higher values for this month are mostly of anthropogenic origin). The figure documents the increase in daily maximum values of ozone concentrations about 30 – 40 µg.m^{-3} in photochemically active years (1992, 1994, 1995, 1999, 2000, 2002, 2003 and 2007) as compared to those in less favourable years.

The number of exceedances of ozone threshold values in Slovakia during 2007 – 2012 is summarised in Tables 3.4 – 3.6. The alert threshold when the public must be warned (240 µg.m^{-3}) was not exceeded in 2012 (Table 3.4). Also the information threshold to the public (180 µg.m^{-3}) was in 2012 not exceeded.

Fig. 3.1 **Seasonal variability of ground level ozone concentration in Stará Lesná during 1992 – 2012**

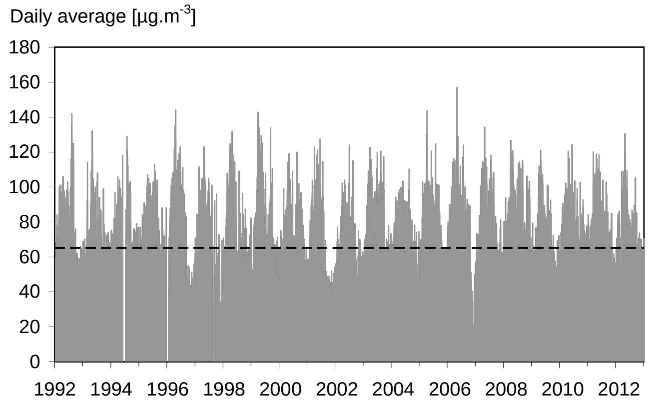
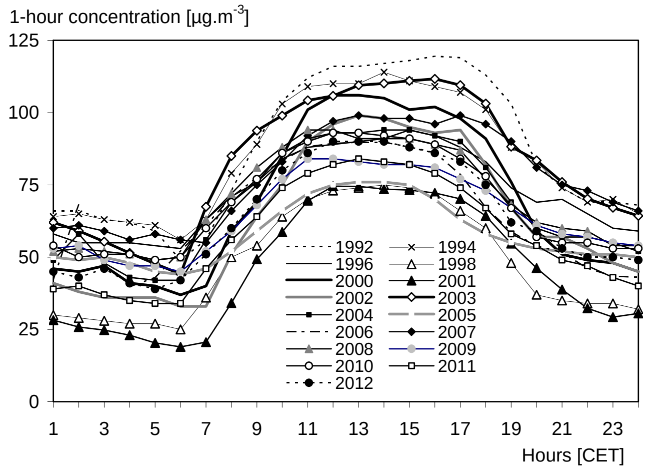


Fig. 3.2 **Average daily cycles of ground level ozone concentration in Stará Lesná, in August 1992 – 2012**



Tab. 3.4 **Number of exceedances of ozone information threshold (IT) and alert threshold (AT) to the public during 2007 – 2012**

Station	AT = 240 µg.m^{-3}						IT = 180 µg.m^{-3}					
	2007	2008	2009	2010	2011	2012	2006	2007	2008	2009	2010	2012
Banská Bystrica, Zelená			0	0	0	0			0	0	0	0
Bratislava, Jeséniova	0	0	0	12	0	0	10	0	0	39	3	0
Bratislava, Mamateyova	1	0	0	0	0	0	17	1	2	3	0	0
Humenné, Nám. Slobody	0	0	0	0	0	0	0	0	0	0	0	0
Jelšava, Jesenského	0	0	0	0	0	0	6	0	0	0	0	0
Košice, Ďumbierska	0	0	0	0	0	0	0	0	0	0	0	0
Nitra, Janíkovce			0	0	0	0			1	0	0	0
Prievidza, Malonecpalská	0	0	0	0	0	0	1	0	0	0	0	0
Žilina, Obežná	0	0	0	0	0	0	0	0	0	0	0	0
Gánovce, Meteo. st.	0	0	0	0	0	0	0	0	0	0	0	0
Chopok, EMEP	0	0	0	0	0	0	0	0	0	0	0	0
Kojšovská hoľa	0	0	0	0	0	0	2	2	0	0	0	0
Stará Lesná, AÚ SAV, EMEP	0	0	0	0	0	0	0	0	0	0	0	0
Starina, Vodná nádrž, EMEP	0	0	0	0	0	0	0	0	0	0	0	0
Topoľníky, Aszód, EMEP	0	0	0	0	-	0	4	0	0	0	-	0

In Table 3.5 is presented the number of exceedances of ozone target value for protection of human health (8 h mean 120 μg.m^{-3}) averaged over 2010 – 2012. The target value not to be exceeded on more than 25 days per calendar year averaged over three years. In 2010 – 2012 was the number of 25 days overstepped at nine monitoring stations. The highest exceedance was observed at Chopok (59 days) and Kojšovská hoľa (50 days) stations.

Tab. 3.5 **Number of exceedances of ozone target value for protection of human health (8 h average 120 μg.m^{-3}) during 2010 – 2012**

Station	2010	2011	2012	Average 2010 – 2012
Banská Bystrica, Zelená	17	32	53	**34**
Bratislava, Jeséniova	24	24	48	**32**
Bratislava, Mamateyova	21	27	35	**28**
Humenné, Nám. slobody	8	10	10	9
Jelšava, Jesenského	4	13	-	-
Košice, Ďumbierska	14	70	25	**36**
Nitra, Janíkovce	16	11	43	**30**
Prievidza, Malonecpalská	9	14	12	12
Žilina, Obežná	20	34	34	**29**
Gánovce, Meteo. st.	7	25	12	15
Chopok, EMEP	36	68	74	**59**
Kojšovská hoľa	55	58	37	**50**
Stará Lesná, AÚ SAV, EMEP	15	17	14	15
Starina, Vodná nádrž, EMEP	2	7	7	5
Topoľníky, Aszód, EMEP	23	-	31	**27**

Table 3.6 shows AOT40 values corrected on the missing data (ANNEX III, Directive 2002/3/EC). The target AOT40 value for the protection of vegetation is 18 000 μg.m^{-3}.h averaged over five years. If five year average cannot be determined the valid data for at least three years can be used. From the table one can see, that AOT40 target value averaged over five years was overstepped at all urban background and regional background stations (with the exception of seven stations).

Tab. 3.6 **AOT40 [μg.m^{-3}.h] (target value for the protection of vegetation is 18 000 μg.m^{-3}.h averaged over five years)**

Station	2010	2011	2012	Average 2008 – 2012
Banská Bystrica, Zelená	15110	19748	27387	**20748**
Bratislava, Jeséniova	21253	17584	24255	**20300**
Bratislava, Mamateyova	14712	16534	19200	16764
Humenné, Nám. slobody	9606	17635	13214	15866
Jelšava, Jesenského	8542	24358	–	13896
Košice, Ďumbierska	12496	29975	18487	**22399**
Nitra, Janíkovce	12991	–	25206	**23436**
Prievidza, Malonecpalská	11874	13961	16014	14289
Žilina, Obežná	16248	17661	20120	17922
Gánovce, Meteo. st.	12786	19025	11819	15438
Chopok, EMEP	20815	29298	30666	**28169**
Kojšovská hoľa	23077	25597	20181	**22788**
Stará Lesná, AÚ SAV, EMEP	12894	15314	12607	14439
Starina, Vodná nádrž, EMEP	5107	10153	9320	10289
Topoľníky, Aszód, EMEP	16764	–	14871	**19390**

- long-term failure

It may be stated in conclusion, that in the extremely warm, dry and photochemical active year 2003 the highest values of the most ground level ozone indicators in Slovakia were observed from the beginning of observations (since 1992). This reality is to some extend surprising taking into account a massive decrease of anthropogenic precursor emissions (NOx, VOC and CO) in Slovakia (already below Gothenburg ceilings) and in Europe as well during the last 10 – 15 years. It documents the large share of “uncontrollable” ozone at the territory of Slovakia. Downward mixing, long-range transport (including intercontinental transport), formation of ozone from biogenic precursors and climate change apparently play much more significant role as was previously assumed. The ground level ozone over Slovakia is mostly of advective origin. This conclusion demonstrates the limitations of national ozone mitigation strategy. One of the conclusions the European TOR2 project (ended in 2003) is proposal to shift the ground level ozone problem among global issues, for example into Kyoto Protocol. The level of surface ozone concentrations indicators in Slovakia in 2012 was in average below the 2003 level.

3.3 TOTAL ATMOSPHERIC OZONE OVER THE TERRITORY OF THE SLOVAK REPUBLIC IN 2012

Since August 1993 total atmospheric ozone over the territory of Slovakia has been measured with the Brewer ozone spectrophotometer MKIV #097 in the Aerological and Radiation Centre (ARC) of the Slovak Hydrometeorological Institute (SHMI) at Gánovce near Poprad (49º02’N, 20º19’E, 706 m a.s.l.). As well the solar UV spectra is regularly scanned through the range 290 – 325 nm at 0.5 nm increments. Poprad-Gánovce station is a part of the Global Ozone Observing System (GOOS). The results are submitted to the World Ozone Data Centre (WOUDC) in Canada and to the WMO Ozone Mapping Centre in Greece. Poprad-Gánovce station is included to Global Atmosphere Watch (GAW) network for total ozone and solar UV spectral radiation.

Information about the ozone layer state and intensity of harmful solar UV radiation is provided daily to the public by TV, radio, the press and mobile phone services. Since April 2000 the SHMÚ Aerological and Radiation Centre has been providing 24 hour UV Index forecast for the public. Predicted UV Index for selected altitudes and its daily course for Poprad-Gánovce coordinates is presented for clear sky, half covered sky and overcast condition on the SHMI internet site: (www.shmu.sk/ozon/) from March 15 to September 30.

The annual mean of the total atmospheric ozone was 320.0 Dobson Units in 2012. This is 5.4% below the long-term average (calculated upon the Hradec Kralove measurements in the period 1962 – 1990).

Since 1994 annual means measured at Poprad-Gánovce station have been available. The 1994 – 2012 long-term average is 326.5 Dobson units. In mentioned period the annual mean in the year 2012 was the sixth lowest with the deviation of –2.0%. Significant negative deviation occurred in two successive years.

Total ozone statistics for the year 2012 (daily means, relative deviations from long term average, monthly means, standard deviations and extremes) are in Table 3.8. Positive difference from the long-term average was in November – December only. The negative deviations of total ozone from long-term average of 8 – 9% were in the March – July period.

Total ozone weekly averages are shown in Figure 3.3. The graph illustrates the total ozone amount in the year 2012 with respect to long-term mean values and shows significant short-term variations in total column ozone in our geographical region. Continues negative weekly averages lasted from 8 to 43 calendar week. Also out of that period negative weekly averages prevailed.

Solar ultraviolet (UV) radiation has many biological effects. If UV dose exceeds critical limits for some biological processes it can be very harmful. An active band of wavelengths in range of 290 – 325 nm which is significantly influenced by the total ozone amount in the atmosphere is indicated as UV-B radiation. The wavelength-depending weighting factor is applied on the spectral irradiance to calculate the effective UV-B irradiance causing a particular biological effect. The CIE Erythemal action spectrum is most frequently used to express a detrimental effect on human health. McKinlay and Diffey derived the erythemal action spectrum in 1987. It is internationally accepted and indicated as the CIE (Commission Internationale de l´Eclairage). All values of solar ultraviolet radiation shown in this text and graphs are modified by the CIE erythemal action spectrum.

Fig. 3.3 **Total atmospheric ozone over the territory of Slovakia in 2012**

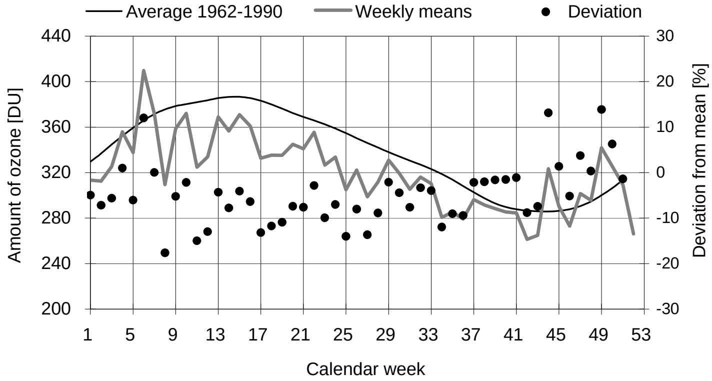


Fig. 3.4 **Annual course of CIE effective irradiance and UV index noon values – Gánovce 2012**

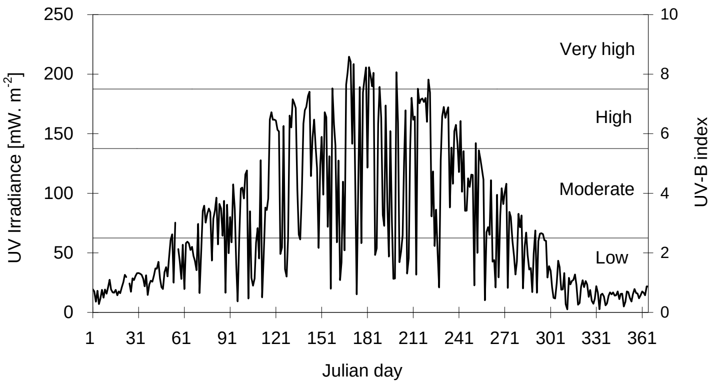


Figure 3.4. shows the biologically effective irradiance (in units of $mW.m^{-2}$). Values have been measured at local noon (about 10:39 UTC) when the daily maximal solar elevation is achieved. Daily UV-B maximum on clear sky days should be measured around local noon. A significant variability of values demonstrates the weather condition (especially cloudiness) influence. As the UV irradiance depends on the solar elevation it has a distinctive daily and annual course. Noon UV-B irradiances are more than 10-times lower in winter as compared to summer. Comparable attenuation is also caused by cloudiness and precipitation in summer. The annual course is not symmetrical by solstices after filtering of cloud and aerosol influence. Decreasing phase in annual course of total ozone causes shift in occurrence of the highest UV irradiances toward period after the summer solstice to the last decade of June and early July. Solar UV irradiances observed before summer solstice are lower than those ones measured after the summer solstice by the same solar elevation, cloud and aerosol attenuation due to typical annual course of the total ozone.

The UV Index is also shown in Figure 3.4. It is a unit to simplify expression of the UV irradiance level relevant to the erythemal effect on human skin and has been standardised by relationship: 1 UV Index = 25 $mW.m^{-2}$ of UV irradiance modified by CIE erythemal action spectrum. Its values are used to express a recommended sunburn time. Individual sunburn time has to be modified depending on skin type and skin adaptation by producing melanin. Values over 5 attained in spring and summer months are classified as high. The sun exposure without protection should be limited to several minutes. Values below 3 attained from October to March are classified as low. Sunburn time over one hour is not dangerous even if the ozone layer is attenuated. The only protective tool should be glasses. However considerably high UV-B radiation doses are relevant in snowy high mountain positions at the beginning of spring. Practical unit to describe a quantity of the erythemal ultraviolet radiation is Minimal Erythemal Dose (MED). 1 MED is defined as the minimal UV dose that causes a reddening of previously unexposed human skin. However, because the sensitivity of human individuals depends on skin type, the relationship between MED and physical units has been defined for the most sensitive skin type. Irradiance 1 $MED.hour^{-1}$ corresponds to 0.0583 $W.m^{-2}$ for the dose 1 MED = 210 $J.m^{-2}$. More information about total ozone, solar UV radiation and the protection against a harmful solar radiation are available on the SHMI internet site.

Tab. 3.7 **Total atmospheric ozone in Dobson units [DU] and its deviations [%] from long-term average at Poprad-Gánovce in 2012**

Day	I		II		III		IV		V		VI		VII		VIII		IX		X		XI		XII	
	O_3	Dev	O_3	Dev	O_3	Dev	O_3	Dev	O_3	Dev	O_3	Dev	O_3	Dev	O_3	Dev	O_3	Dev	O_3	Dev	O_3	Dev	O_3	Dev
1	264	-19	324	-10	335	-12	426	10	324	-15	354	-3	293	-16	310	-6	276	-12	297	2	326	14	307	4
2	257	-21	349	-3	346	-9	356	-8	321	-16	348	-5	291	-16	310	-6	275	-12	288	-1	335	17	323	9
3	294	-10	364	1	351	-8	347	-10	329	-13	337	-8	299	-14	302	-8	278	-11	278	-4	327	14	330	11
4	257	-22	346	-4	360	-5	359	-7	345	-9	330	-9	300	-13	304	-8	278	-10	278	-4	319	12	311	4
5	331	0	348	-4	379	0	348	-10	350	-8	367	1	300	-13	297	-10	276	-11	281	-3	294	3	338	13
6	369	11	429	18	381	0	358	-8	362	-4	333	-8	302	-13	288	-12	288	-7	276	-4	340	19	356	18
7	312	-6	408	12	411	8	367	-5	373	-1	336	-7	308	-11	291	-11	280	-9	300	4	304	6	375	24
8	372	12	414	13	381	0	362	-7	365	-3	302	-16	291	-15	302	-8	278	-9	284	-2	279	-3	354	17
9	340	2	445	21	364	-4	399	3	341	-9	306	-16	309	-10	320	-2	278	-9	271	-6	290	1	330	9
10	289	-14	419	14	321	-16	356	-8	340	-10	312	-14	308	-10	314	-4	287	-6	285	-1	268	-6	332	9
11	251	-25	371	1	367	-4	365	-6	306	-19	341	-5	313	-9	351	8	290	-5	309	7	257	-10	328	8
12	264	-22	383	4	350	-8	398	3	300	-20	337	-6	322	-6	347	7	287	-5	280	-3	252	-12	357	17
13	329	-3	343	-7	314	-18	354	-9	322	-14	345	-4	314	-8	348	7	312	3	281	-2	288	0	343	12
14	364	7	386	4	311	-19	363	-6	345	-8	352	-2	314	-8	333	3	315	4	283	-1	268	-7	348	13
15	353	4	423	14	344	-10	361	-7	337	-10	345	-4	300	-12	316	-2	300	0	278	-3	275	-5	277	-10
16	354	4	408	10	323	-15	355	-8	353	-5	315	-12	333	-2	304	-6	283	-6	290	1	273	-5	296	-4
17	355	4	335	-10	315	-18	363	-6	336	-10	302	-16	333	-2	294	-9	290	-3	279	-3	280	-3	301	
18	320	-7	363	-3	316	-17	360	-7	353	-5	299	-16	323	-5	292	-9	289	-3	250	-13	274	-5	302	-3
19	278	-19	343	-8	329	-14	348	-10	349	-6	302	-15	323	-4	286	-11	287	-4	244	-15	311	7	337	8
20	326	-6	315	-16	365	-5	377	-2	340	-8	295	-17	321	-5	278	-13	309	4	244	-15	306	5	308	-2
21	340	-2	296	-21	344	-10	366	-5	335	-10	290	-18	338	0	282	-12	302	2	246	-14	301	4	295	-6
22	305	-12	293	-22	319	-17	357	-7	331	-10	305	-14	345	3	284	-11	288	-3	249	-13	303	4	322	2
23	316	-10	298	-21	303	-21	349	-9	321	-13	316	-10	328	-2	286	-10	276	-6	260	-9	311	7	301	-5
24	363	4	269	-28	316	-18	361	-6	314	-15	327	-7	314	-6	281	-12	265	-10	256	-10	307	5	270	-15
25	398	13	308	-18	361	-6	362	-6	350	-5	349	-1	344	3	277	-13	279	-5	254	-11	274	-6	250	-22
26	417	18	388	3	356	-7	320	-17	354	-4	359	2	332	-1	277	-13	286	-3	259	-9	285	-3	243	-24
27	329	-7	390	3	338	-12	308	-20	382	4	334	-5	315	-6	302	-5	281	-4	287	0	257	-12	271	-15
28	347	-2	387	3	322	-16	315	-18	381	4	325	-7	300	-10	277	-12	310	6	291	2	291	-1	298	-7
29	321	-10	342	-10	373	-3	315	-18	359	-2	302	-14	304	-9	284	-10	301	3	307	7	302	2	264	-18
30	311	-13			396	3	317	-17	352	-4	293	-16	306	-8	300	-5	296	2	324	13	306	4	267	-18
31	322	-10			371	-4			358	-2			309	-7	284	-9			327	14			311	-4
Ø	324	-5	362	-2	347	-9	356	-8	343	-8	325	-9	314	-8	301	-7	288	-4	278	-3	293	2	311	1
Std	41	11	45	13	27	7	25	6	20	6	22	6	15	5	21	6	12	5	22	7	23	8	33	13
Max	417	18	445	21	411	8	426	10	382	4	367	2	345	3	351	8	315	6	327	14	340	19	375	24
Min	251	-25	269	-28	303	-21	308	-20	300	-20	290	-18	291	-16	277	-13	265	-12	244	-15	252	-12	243	-24

O_3 - *total ozone* Dev - *relative deviation from long-term mean (Hradec Králové 1962 – 1990)*
Std - *standard deviation [DU]*

Continuous measurements of the UV radiation have been performed with the broadband UV-Biometers in parallel with discrete spectral Brewer spectrophotometer measurements. Spectral response function of the UV-Biometer is close to CIE-erythemal action spectrum. Stability of the operational UV-Biometers has been checked by regular comparison with the reference UV-Biometer calibrated towards the Brewer spectrophotometer. That procedure ensures compatibility of UV-Biometers and the Brewer spectrophotometer UV radiation measurements. UV-Biometers enable to register the UV irradiances more densely (every 10 s) than with the Brewer spectrophotometer. The 1 min averages of the integral CIE-erythemal UV irradiance have been stored. More frequent recording of the UV radiation enables to determine more realistic daily maxima and daily doses, especially during cloudy days. All UV radiation characteristics below are obtained from UV-Biometer measurements.

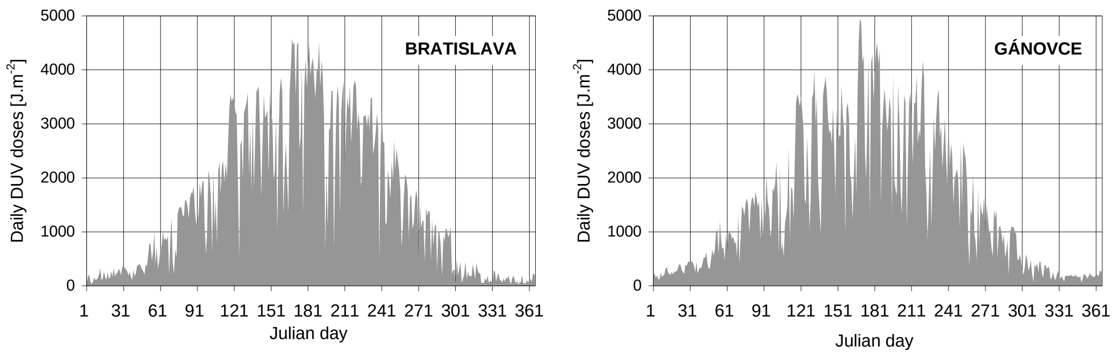
The biggest 1 min average of the CIE-erythemal UV irradiance of 216.3 $mW.m^{-2}$ (3.71 $MED.h^{-1}$) was registered in Bratislava (48º10'N, 17º06'E, 304 m a.s.l.) on June 8. The biggest 1 min average of the CIE-erythemal UV irradiance of 215.7 $mW.m^{-2}$ (3.7 $MED.h^{-1}$) was registered at Poprad-Ganovce on the same day. Deviation of the daily total column ozone from the long-term average was -16% on that day.

The biggest hourly average of the CIE-erythemal UV irradiance of 192.8 $mW.m^{-2}$ (3.31 $MED.h^{-1}$) was registered in Bratislava on June 21. Deviation of the daily total column ozone from the long-term average was –18% on that day. The biggest hourly average of the CIE-erythemal UV irradiance of 200.3 $mW.m^{-2}$ (3.43 $MED.h^{-1}$) was registered at Poprad-Ganovce on June 17. Deviation of the daily total column ozone from the long-term average was –16% on that day.

Daily doses of the CIE-erythemal UV radiation are presented in Figure 3.5. Maximum daily dose of 4573 $J.m^{-2}$ (which correspondents to 21.8 MED) was measured in Bratislava on June 16. Maximum daily dose of 4937 $J.m^{-2}$ (23.5 MED) was measured at poprad-Ganovce on June 17.

In the period April-September 2012 total CIE-erythemal UV radiation dose in Bratislava was 479 411 $J.m^{-2}$. This value is 3% lower than the dose in 2011. Total CIE-erythemal dose at Poprad-Ganovce was 450 644 $J.m^{-2}$ for the same period. This value is 4% lower than the dose in 2011.

Fig. 3.5 **Annual Course of CIE effective UV radiation Daily Doses in 2012**



4

EMISSION AND AIR POLLUTION SOURCE INVENTORY

4.1 EMISSION AND AIR POLLUTION SOURCE INVENTORY

Anthropogenic emissions of pollutants in the atmosphere cause many present and potential problems, such as acidification, ambient air quality deterioration, global warming/climate change, destruction of buildings and constructions, disruption of ozonosphere.

Quantitative information on these emissions and their sources are necessary requirements for:

- Decision making process of the responsible bodies.
- Information service for experts and public.
- Definition of environmental priorities and identification of causes of problems.
- Assessment of environmental impact on different plans and strategies.
- Assessment of environmental costs and benefits on different approaches.
- Monitoring of effects, respective effectiveness of adopted measures.
- Support by agreement with adopted national and international commitments.

STATIONARY SOURCES

In the period 1985 – 1999 information related to stationary sources of air pollution was compiled according to the Act 35/1967 Coll. on air in the EAPSI (Emission and Air Pollution Source Inventory) system. This system was divided by the heating output into 3 subsystems:

EAPSI 1.............. Stationary sources of the heating output over 5 MW and selected technologies (updated annually)

EAPSI 2................ Stationary sources of the heating output 0.2 – 5 MW and selected technologies

EAPSI 3............... Stationary (local) sources of the output below 0.2 MW (consumption of fuels for inhabitants)

The changes in the air protection legislations in the 90's raised requirements to create entirely new tool for the evidence of stationary sources of air pollution. Development of the new system, so-called NEIS – National Emission Inventory System, started in year 1997 in the frame of project of the Ministry of Environment in coordination with Slovak Hydrometeorological Institute (SHMÚ) and close cooperation with the regional offices, district offices and selected operators. The NEIS, a multi-modular system, follows requirements of current air protecting legislation and it is based on annual update cycle. Module NEIS BU enables complex data collection and data processing in respective of district offices, as well as the logical verification of emission calculation from the operator's input data. It also serves as a base tool in decision making for determination of pollution charge value. Data acquisition is carried out by a set of printed questionnaires or by the software module NEIS PZ. This module was created for the operators. It enables besides processing of the input data electronically also the emission calculation. Operator's databases are sent to the corresponding district office, where they are imported to the local district NEIS BU database. Subsequently, data from the district databases is fed into the NEIS CU central database at SHMÚ, where the following control is carried out. The NEIS uses the support of standard database products MS ACCESS and MS SQL server.

The function of the system was attested during preliminary testing in the selected regions within all area of the Slovak Republic and the system was accepted by cross-sectoral operative committee.

The NEIS system underwent extensive changes within 2004 – 2005 as a result of implementation of the Decree of Ministry of Environment of the SR No. 61/2004 Coll. In this context, the system has been renamed to National Emission Information System (NEIS). Archiving of the documents issued by district offices has started within the system. Data acquisition was extended also in terms of transposing EU policies and measures into national legislation (VOC sources, waste incineration, service stations and terminals a. o.)

Positive contribution of database NEIS

- Homogeneous system of data processing about sources and their emissions at local, regional and national level.
- Provision of an actual and effective tool to all primary data processors providing uniform level of acquisition, processing, control and verification of data about the sources and their emissions.
- Enhance the transparency of procedure to concede the quantity of emissions by operators of the sources and thus pay taxes for air pollution owing to the built-in control system as well as necessity to provide the input data into the NEIS database exclusively in coincidence with the legislative regulations.
- Establishment of a Slovak national database that enables optimal task fulfilment throughout all levels of the top state administration bodies and provides the input data for international emission inventories, respectively compilation of special emission inventories.
- Availability of information on the Internet website www.air.sk.
- Establishment of the air pollution operators and sources documents archive.

The comparison of the EAPSI and NEIS systems

Changes in the air protection legislation carried out within 1990 – 2000 (e.g. identification/delimitation and definition of sources, change in categorization of sources and their division according to the output or capacity) caused that the EAPSI system is currently comparable with the NEIS module only at the national level. Comparison of the individual parts of EAPSI (1 and 2) with the NEIS module (large, medium-size sources), respectively comparison of individual sources in both systems is difficult.

According to the Act 137/2010 Coll. (§ 15, section 1, chapter e) as amended, the district offices are (according to the § 26, section 3, chapter g,m) obliged to elaborate yearly reports about the operational characteristics of the air pollution sources in their district and provide them electronically by 31st May of the current year at the latest in order to additional processing by SHMÚ, the organization accredited by the Ministry of Environment to manage the central database NEIS CU and provide the data processing at the national level.

The NEIS system includes the sources of air pollution, which are assigned according to the category and input (Decree No. 356/2010):

Large sources	Stationary sources containing stationary combustion units having cumulative heating input over 50 MW and other technological units with a production capacity above the defined limit.
Middle sources	Stationary sources containing stationary combustion units having cumulative heating input 0.3 – 50 MW and other technological units with a production capacity under the defined limit for the large sources and above the defined limit.
Small sources	Stationary equipment – domestic heating equipment for combustion of solid fuels and natural gas with heating input less than 0.3 MW.

Results (1990 – 2012) – evaluation

Large sources

EAPSI 1 The EAPSI 1 database has been represented by a coherent set of data since 1990 – 1999. In the year 1999, the 967 air pollution sources, i.e. technological units owned by an operator, defined by the code of the area-administrative unit and the serial number. For each of these units, the data about quantity, type and quality of fuel consumed, technical and technological parameters of combustion and separation technique are updated annually. Using these data, the emissions of CO, NO_x, SO_2 and particulate matter for the individual sources are calculated by using the emission factors. Since 1996, these values for selected sources have been substituted by the data provided by the operators using the recalculations from the results of measurements. Emission data from technologies are provided by the individual sources based on their own findings. Emissions from combustion processes and technologies of individual sources are further summarised at the level of area administrative units. Sources registered in EAPSI 1 are provided by the geographical co-ordinates, which enable the projection of them in a geographical information system.

NEIS Since 2000 the gathering of the selected data on sources and their emissions has been provided in the NEIS. The system contained 885 (721 of it in operation) large point sources in 2012. As the sources of 5 MW and above were included to the evidence of large point sources in the EAPSI system, the comparison of numbers of sources in both systems is not possible.

Middle sources

EAPSI 2 Updating of EAPSI 2 data is carried out in several-year cycle. Inventory and acquisition of data from individual sources were carried out continuously. Summarising was carried out in 1985 and 1989. However, the number of sources registered in EAPSI 2, was growing to such an extent, that the data are not comparable. The third updating was carried out in cooperation with the Offices of Environment within the period 1993 – 1996 and ended in December 1996.

NEIS Since 2000 the data updating in the NEIS system has been provided each year. In 2012, NEIS registered 13111 (10995 it in operation) medium sources. System EAPSI 2 registered only sources of heating output 0.2 – 5 MW and therefore to compare the number of sources in the individual systems is not possible.

Small sources

EAPSI 3 NEIS The emission balance is being processed in the system NEIS CU and is based on the data about the selling of solid fuels for households and retail users (years 2001 – 2003 according to the Decree No. 144/2000, since 2004 according to the Decree No. 53/2004, since 2010 according to the Decree No. 362/2010), consumption of natural gas for the inhabitants (register of SPP, a.s.) and specified emission factors. Local furnaces are assessed as the areal sources on the level of district. In 2004, the emission balance has been revised[1] following the emission recalculation since 1990. Within the revision the emission factors were updated (in coincidence with the valid legislation of air protection) as well the qualitative features of solid fuels (in sense of OTN ZP 2008) and the wood combustion emissions were additionally recalculated as its consumption have not been included in the balance before 2004. In the past the balance has not been carried out regularly (EAPSI 3 system had been updated annually only until 1997), in the missing years the data have been additionally calculated. In such a way the consistent data time series since 1990 have been obtained.

[1] *Balance of the air pollution small sources in the Slovak Republic, Profing 2003*

MOBILE SOURCES

Emissions estimates from mobile sources have been annually calculated since 1990. Software program COPERT 4[2] has been used for balance calculation of road transport emissions. Since 2008 COPERT 4[2] is approved and recommended by Executive Committee the UNECE Convention on Long-Range Transboundary Air Pollution[3]. The calculation of emissions from the road transport sector in Slovakia for the year 2011 has been provided in the newest version COPERT 4 version 9.0. Applied input data was activity data such as numbers of vehicles for each category defined in program COPERT 4 and average annual mileage in each category of vehicles. Emissions were calculated according to fuel type as well as vehicle type. Additional input data was levels of pollutants in fuels (gasoline, diesel, LPG, CNG) and fuel consumption including the share of biofuels. Model COPERT v.9.0 takes into account the share of biofuels in the energy consumption of different types of vehicles. However, model COPERT does not count Total Suspended Particulates (TSP) from abrasion of tires and brakes neither it does not provide any solid particles from road abrasion. Therefore these missing emissions were calculated separately from the traffic performance in fleet mileage (detected from the COPERT from numbers of vehicles and annual mileage) and emission factors Tier 1 set out in EMEP/EEA air pollutant emission inventory guidebook to complete emission balance. Fuel and energy consumption values show a slight decrease for the year 2011 compared to 2010, particularly gasoline (petrol stayed about the same), which had an impact on the enhanced production of mostly lower emissions of TSP. Update of input data in 2011 led to recalculation of emissions of TSP, NO_x and CO for other transport too.

The evaluation of pollution sources and emissions is carried out also for rail, air and water transport. The methodology for emission calculation from railway transport operations is an accordance with the methodology EMEP/CORINAIR[4] for non-road sources and used emission factors are in comply with the methodological manual Emission Inventory Guidebook. Pollution production for the water transport in SR is applied only to the transect of the river Dunaj (Danube) related to Slovak territory where the shipping activity is taken place. The methodology used for determination of annual emission production from operating activities of shipping vessels is simplified method of EMEP/CORINAIR for non-road sources based on compilation using average emission factors recommended by working group CORINAIR. In the aviation, the flight altitude is an important factor in emission assessment due to different pollution impacts of aircrafts during the flight at heights compare to the landing or take-off manoeuvres. The methodology for objective impact assessment of air pollutants in larger altitude from aircraft engines has not been clearly developed yet. Therefore emission inventory is based on local pollution produced at major airports in Slovakia. Input is based on operational-statistical data of realized flight (LTO) cycle, fuel consumption and an overview of fuel sold. Innovative methodology is also based on knowledge of emission factors of individual aircraft types.

[2] *http://www.emisia.com/copert/*
[3] *http://www.unece.org/env/lrtap/*
[4] *http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009*

4.2 DEVELOPMENT OF TRENDS IN BASIC POLLUTANTS

EMISSIONS OF BASIC POLLUTANTS

Trends in basic pollutants compiled in systems EAPSI and NEIS are listed in Tables 4.1a and 4.1b and Figures 4.1 and 4.2.

Particulate matter

Emissions of particulate matter (PM) have been decreasing continuously since 1990. This was caused by the change of the fuel base in favour of high-grade fuels, as well as the improvement of fuel quality characters used and a further spreading of separation techniques used, respectively advancing of its effectiveness. Increase of PM emissions in 2004 and 2005 was caused by the extended wood consumption in the sector small sources (heating households) as a result of growing retail price of natural gas and coal. The decrease of PM emissions in 2006 was achieved mainly by reconstruction of separators in some sources in energy and industry (power plant Slovenské elektrárne, a.s. prevádzka Nováky, U.S. Steel s.r.o. Košice). Another decrease of the PM emissions in 2007 was mostly caused by the power plant Slovenské elektrárne, a.s. in Vojany, of which some combustion units was out of operation. Since 2008, the trend of PM emissions is stable. A slight increase in PM emissions in 2011 occurred in the sector of small sources - households, where the consumption of firewood increased at the expense of natural gas.

SO_2

The downward trend of SO_2 emissions up to year 2000 was caused by the decreasing consumption of brown coal, hard coal, heavy fuel oil (Slovnaft a.s., Bratislava replaced it with low-sulphur fuel oil). On the decreased emission was significantly contributing the installation of desulphurisation systems in large power sources (power plants in Zemianske Kostoľany and Vojany). The fluctuations of SO_2 emissions within 2001 and 2003 were caused either by their partial or total operation, orby the quality of combusted fuel and volume of production of energetic sources. In 2004 till 2006 another decrease of SO_2 emissions was recorded. This decrease was caused mainly by the combustion of low-sulphur-content fuel oils and coal (Slovnaft a.s. Bratislava; TEKO a.s. Košice) and by the reduction of production volume (power plants in Zemianske Kostoľany and Vojany). Considerable decrease of SO_2 emission of about 77% was observed in road transport category in 2005. This decrease, contrary to the increase in consumption of fuel substances was caused by the implementation of measures referring to the content of sulphur in fuel substances (Decree No. 53/2004). Another decrease of SO_2 emissions in 2007 was mostly caused by the power plant in Vojany, of which some combustion units was out of operation. Since 2008, the trend of SO_2 emissions is stable. Minor increase of SO_2 emissions from the large sources in 2010 of 8% was caused by the increase of brown coal consumption in power plant Slovenské elektrárne Nováky, and by the slightly increase of sulphur-content in this fuel. The reduction of SO_2 emissions in 2012 was due to installation of a new desulphurisation unit in the heating plant CM European power Slovakia, s.r.o. Bratislava. On the reduction was also contributing Slovenské elektrárne, a.s., plant Nováky, where was operated only one boiler.

Oxides of nitrogen

Emissions of nitrogen oxides have showed a smooth decrease since 1990, although in the years 1994 – 1995 they increased slightly in order to the increase in consumption of natural gas. A decrease of emissions of NO_x since 1996 was caused by the change of emission factor, taking into consideration the resent condition of technique and technology in combustion processes. Since 1997, the decrease in solid fuel consumption has led to a further decrease in NO_x emissions. In the further emissions decrease in years 2002 and 2003 participated the denitrification process (power plant Vojany). This decline is related to the reduction of production (power plants in Zemianske Kostoľany and Vojany) and consumption of natural gas (Slovenský plynárenský priemysel – preprava a.s., compressor stations Nitra and Veľké Zlievce). Significant decline of NO_x emissions was achieved in mobile sources, mainly in the road transport. This decrease is connected to the renovation of rolling stock in case of both passenger and good vehicles, and to the use of more accurate emission factor. Significant decrease of emissions in 2009 was mainly due to decrease in iron, steel and magnesite sinter production as a result of economic recession (U. S. Steel Košice, s.r.o., Slovenské magnezitové závody a.s.). Another decrease was occurred in 2012 by the significant reduction in the amount of transported natural gas in pipeline compressor stations operated by eustream, a.s.

CO

The downward trend in CO emissions since 1990 has been caused mainly by the decrease in consumption and by the change of composition of fuel combusted by retail consumers. Carbon monoxide emissions from the large sources have been slightly decreasing as well. The iron and steel industry participate most significantly in the total CO emissions, therefore the emission trend is following the iron and steel production volume. The decrease in CO emissions since 1996 was due to the effects of policy and measures (determined on the results of measurements) to reduce CO emissions from the most significantly sources. The emission trend changes of CO within 1997 and 2002 is also affected by the quantity of pig iron production as well as the fuel consumption. In 2003 the CO emissions slightly increased mainly at large sources (the CO emissions specified by continuous measurement in U.S. Steel s.r.o., Košice), since then the emissions have had only moderately decreasing trend. In 2005 the decrease of CO emissions was announced at large sources too, mainly as a consequence of agglomerate production cutting down in U.S. Steel s.r.o., Košice and by the implementation of a new technology with effective combustion at lime production (Dolvap s.r.o., Varín). Significant decrease in CO emissions of major sources in 2009 was mainly due to decrease in iron and steel production as a result of economic recession. Increase of CO emissions was achieved only in the sector of small sources (residential heating) and it is related to the increase of wood consumption caused by the increasing price of natural gas and coal. The emission decrease in the sector road transport is associated with onward renovation of rolling stock by the generationally new vehicles equipped by the three-way catalysts. Emissions in year 2010 and 2011 increased (about to the level of year 2002) due to increased production of iron and steel in facility U.S. Steel s.r.o., Košice. In 2012 emissions slightly decreased because of lower emissions mainly from installations U.S. Steel s.r.o. Košice and Dolvap s.r.o. Varín.

EMISSIONS OF OTHER POLLUTANTS

The Slovak Republic is bound by the Convention on Long Range Transboundary Air Pollution (1979) to provide inventory of the selected pollutants. The emission inventories of non-methane volatile organic compounds (NMVOC), heavy metals (HMs), persistent organic pollutants (POPs) and particulate matter with aerodynamic diameter less than 10 or 2.5 µm (PM_{10} and $PM_{2.5}$) are processed in accordance with the international methodology using the NFR09 nomenclature and recommendations of TFEIP working groups. Emissions at national level are estimated in cooperation with the external experts and balanced on the base of activity data multiplied by the emission factors. Estimated emissions of pollutants mentioned above as well as the other basic pollutants are transformed into the international NFR system according to the requirements for reporting and annually reported to the UNECE secretariat and EEA by the Ministry of Environment of the SR.

NMVOC

Emission inventory of NMVOC is elaborated according to EMEP/EEA (Air Pollutant Emission Inventory Guidebook). In 2001 a new subsector road paving with asphalt was included in the national emission inventory and as a result of this the emissions increased adequately in individual years. In 2004 the emission factor from the mentioned sector was revalued and changed. The previous emission factor was based on the highest emission production. New emission factor respects the fact that asphalt mixture contains 5.5% of asphalt. The rest consists of aggregate. The combustion of wood was for the first time included in the residential sector in 2004. Emissions increased slightly in the mentioned sector. In the sector of fuel distribution, LPG distribution has been included since 2001.

The NMVOC emissions have decreased since 1990 according to the balance. This development was caused by the decreased consumption of solvent based paints and the gradual introduction of low solvent paint, broad introduction of measures in the crude oil processing and fuel distribution sectors as well as a change of fuels in the energy sector and alteration of the cars in favour of cars equipped with catalysts. The NMVOC emissions have increased in the sector of paints and glues by about 54% since 2000 because the paints and glues are used as part of a large spectrum of industrial activities and various technological operations. Continually the consumption and import of print's ink and solvent paints has increased, too. In years 2004 and 2005 occurred expansion in automotive industry in Slovakia, many of paint-shops was opened and so the consumption of paints has increased. Since 2007, entered into force Council Directive 1999/13/EC of 11 March 1999 with which operators had to adjust to emission limits. In 2007 was recalculated time series from sector dry cleaning and degreasing as a result of refinements counting solvent consumption in the use of paints and glues. In 2008, time series of land-filled and incinerated waste were recalculated on the basis of updated input data. Finally, emissions from road transport were recalculated in order to use an updated version of the model COPERT IV. In 2009 there was a decrease in NMVOC emissions associated with the decrease in industrial production. Emissions from road transport were recalculated until 2000, because of the use of a new version of the model COPERT IV in inventory. Due to updating of activity data, were emissions from waste sector for years 2008, 2005, 2004 and 2002 recalculated. Decreasing trend of NMVOC emissions is continuing to the year 2010. The most significant decline was in solvents consumption in sector degreasing of metal surfaces and road transport. In 2011 the increment of NMVOC emissions occurred particularly due to higher consumption of solvents in sector of chemical/dry cleaning and degreasing and in household heating sector. Changes and updates in waste incineration sector led in to recalculations of emissions within 2000 – 2010.

POPs

Emission inventory of persistent organic pollutants (POPs) is processed according to the methodology, elaborated in the frame of the project Initial Assistance to the Slovak Republic in Meeting Its Obligations Under the Stockholm Convention on Persistent Organic Pollutants, and updated according to the UNEP[5] and methodologies used in the Czech Republic and Poland. Emissions of polychlorinated dioxins and furans (PCDD/F) and polycyclic aromatic hydrocarbons (PAH) from road transport were recalculated by model COPERT IV.

Emissions of POPs from waste incineration was recalculated in 2012. Downward trend of POPs emissions to the air proved to be most remarkable in the area of PAH emissions in the 90-ties, when it was caused also by the change of aluminium production technology (use of pre-baked anodes) (Tab. 4.8, Fig. 4.5). Increased emissions of polychlorinated biphenyls (PCB) were influenced by the increase of consumption in

[5] *Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases, UNEP Chemicals, February 2005*

crude oil in the road transport, by increased production of iron and steel and using wood in the residential sector. Increased consumption of wood in this sector and metallurgy influenced also total emission of PAHs. Emissions of PCDD/F have declined since 2000 because of reconstruction of some technologies (for example municipal and industrial waste incinerators). Total emissions PCDD/F depend on waste incineration, iron ore agglomeration and domestic heating, increase in the year 2012 was caused by increased amount of iron ore agglomeration and industrial waste combusted. HCB emissions are influenced by waste incineration.

HMs

Emission inventory of heavy metals (HMs) is estimated according to the EMEP/EEA (Air Pollutant Emission Inventory Guidebook). In 2004 wood burning was included in the residential sector and emissions since 1990 were revised. Heavy metals emissions markedly decreased compared to the emission value from year 1990. Except the ceasing of several obsolete ineffective metallurgy plants this trend has been effected by a broad reconstruction of electrostatic precipitators and other dust control equipment, by a change of raw materials used, and in particular by the elimination of leaded petrol since 1996. The Pb emissions increased since 2004 as a result of the increase of production in sector of ore agglomeration and copper production. In recent years slight variations in value have been typical for emission trends of HMs. In year 2007 emissions of Pb and Hg decreased in comparison to 2006 due to decrease in sector of ore agglomeration and glass production. At this stage we noticed increase of Cd emissions due to copper production increase. In 2008 increased emissions of lead, cadmium, mercury, copper, zinc and selenium due to increase of amount of incinerated industrial waste and due to increase of emissions in public electricity and heat production, combustion in manufacturing industry. In 2008 were recalculated time series in sector land-filling and incineration of waste based on updated input data. Road transport emissions were recalculated because of update version of the COPERT IV was used in inventory. In 2009 there was a decrease of emissions of heavy metals associated with the decrease in industrial production. Emissions from road transport were recalculated until 2000, because the new version of the model COPERT IV was used in inventory. Due to updating of activity data, were emissions from waste sector recalculated for years 2008, 2005, 2004 and 2002. Furthermore were recalculated emissions of cadmium from glass production. Recalculation was done for years 2007 and 2008 because of revision of emission factor for coloured glass. In 2010 there was an increase of emissions of heavy metals compared to year 2009 due to increase of metal and glass production. Changes and updates in the waste incineration sector led into recalculations of emissions within 2000 – 2010. In 2011 the slight abatement in HM`s emissions was noticed compare to recalculated year 2010 as well as in waste incineration sector. In the other of sectors, the increase was identified

PM_{10}, $PM_{2,5}$

Emissions of PM_{10} and $PM_{2.5}$ have been processed annually on the base of requirements of EMEP/EEA (Air Pollutant Emission Inventory Guidebook), starting from the base year 2000. Emissions of PM_{10} and $PM_{2.5}$ are estimated based on the amount of TSP from database NEIS and they are calculated according to the IIASA methodology. Emissions from the road transport are calculated by the COPERT IV[2] model. The most important contribution to emissions of PM_{10} and $PM_{2.5}$ in the sector of road transport is from diesel engines; the contribution of abrasion to emission of PM_{10} and $PM_{2.5}$ is less important than in total PM (Tab. 4.2 a, b). The most important contribution to total emissions of PM_{10} and $PM_{2.5}$ can be found in the residential sector, increased emissions in this sector are caused by the increased consumption in wood as a consequence of increased price of natural gas and coal. (Tab. 4.9, Fig. 4.6).

Calculation of emissions PM_{10} and $PM_{2.5}$ was elaborated using default indicators. Considering the fact that on the EU level are studies to determine the emission ceilings in Member States in accordance with GAINS[6] model (IIASA), the SR has decided to establish new methodology of emission estimation for PM_{10} and $PM_{2.5}$ in accordance with the GAINS model (input data, emission factors). GAINS model uses the data aggregated from energy balance of the SR from Slovak Statistical Office; whereas country specific methodology uses the input data from NEIS database. The estimated emissions of PM_{10} and $PM_{2.5}$ by country specific methodology are fully consistent with TSP emissions. This is a basic requirement for estimation of emission projections. The whole calculation is already programmed in NEIS database.

Share of individual sectors in total emissions of the Slovak Republic in 2012

Figure 4.2 represents the contribution of stationary and mobile sources to air pollution. The graphs show that the share of transport in air pollution by oxides of nitrogen and carbon monoxide is significant. On the other hand, combustion processes and industry contribute to air pollution mainly by sulphur oxides and particulate matters. Table 4.3 shows the total emissions in individual agglomerations and zones (in sense of the Annex 17 to the Decree No. 360/2010 Coll.).

Most important sources of air pollution in the Slovak Republic in 2012

Table 4.4 introduces twenty the most important air pollution sources in the SR. The share of these sources in the total air emissions of the SR varies from 72.35% to 97.48%. Table 4.5 lists top ten sources in administrative regions according to the amount of emissions of basic pollutants.

Specific territorial emissions in 2012

Table 4.6 and Figure 4.3 provide information that gives some idea about the territorial distribution of the emitted pollutants. However, it is necessary to distinguish between the amount of pollutants emitted from the respective territory and the ambient air concentrations, because the pollutants emitted may impact more distant areas, depending on the stack height and meteorological conditions.

4.3 VERIFICATION OF THE RESULTS

Verification of the data gathered during the emission inventory was carried out in comparison with:

- Updated data from previous years and by the verification of reasons for their changes (e.g. change in fuel base, respectively fuel quality characters, technology, separation technique, etc.).
- Data listed in the EAPSI 1 questionnaires compared to the data provided by operators to the district offices for identification of a tax height. Differences appeared mostly in fuel quality characters and this may significantly affect the quantity of the emission calculated in dependence on the quantity of fuel consumed. Further differences arose as a consequence of the fact that district offices enabled sources to report the emission quantity calculated on their own measurements. In some cases the differences between the levels found out in the balance calculation and the recalculation from the results of measurements were significant. In the 1996 and 1999 EAPSI balance, for the selected sources such measurement results were taken into account, where the level of results measured as well as the procedure of recalculation were satisfactory.
- Module NEIS BU enables the control of emissions estimated on the district level and its implementation decreased the uncertainty of national emission estimates.

Note: The inventory results of the basic pollutants emitted in year N are completed to the 30th October (N+1) and the inventory results of the other pollutants emitted in year N are completed to the 15th February (N+2).

[6] *Emission estimation of PM_{10} and $PM_{2.5}$ was performed with RAINS model, which has been replaced by GAINS model*

Tab. 4.1a **Emissions of basic pollutants [thous. t] in the SR within 1990 – 1999**

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
PM	EAPSI 1	208.075	153.590	110.545	79.925	52.335	55.770	38.461	36.646	31.168	34.813
	EAPSI 2	36.425	[1] 36.425	[1] 36.425	[1] 36.425	[1] 17.097	[1] 17.097	9.478	[2] 9.478	[2] 9.478	[2] 9.478
	EAPSI 3	34.795	35.710	31.968	29.386	26.077	24.582	24.539	20.170	21.039	20.234
	EAPSI 4	4.103	3.358	2.943	2.674	2.798	2.945	2.891	2.823	2.956	2.710
	Total	283.398	229.083	181.881	148.410	98.307	100.394	75.369	69.117	64.641	67.235
SO_2	EAPSI 1	421.983	347.084	296.036	246.413	182.747	188.590	197.308	176.564	153.723	147.111
	EAPSI 2	37.509	[1] 37.509	[1] 37.509	[1] 37.509	[1] 27.091	[1] 27.091	10.577	[2] 10.577	[2] 10.577	[2] 10.577
	EAPSI 3	63.197	58.173	53.697	42.124	33.069	28.117	20.173	14.994	17.088	14.489
	EAPSI 4	2.968	2.402	2.135	1.978	2.101	2.254	2.293	2.326	2.498	1.088
	Total	525.657	445.168	389.377	328.024	245.008	246.052	230.351	204.461	183.886	173.265
NO_x	EAPSI 1	146.474	135.389	127.454	122.169	111.616	118.040	76.853	70.583	74.322	65.436
	EAPSI 2	4.961	[1] 4.961	[1] 4.961	[1] 4.961	[1] 5.193	[1] 5.193	3.960	[2] 3.960	[2] 3.960	[2] 3.960
	EAPSI 3	13.331	13.077	12.243	10.583	9.456	9.023	8.845	7.784	8.355	8.201
	EAPSI 4	61.479	50.718	45.652	43.586	44.843	46.585	45.618	44.841	45.889	42.718
	Total	226.245	204.145	190.310	181.299	171.108	178.841	135.276	127.168	132.526	120.315
CO	EAPSI 1	162.047	160.591	132.874	160.112	168.561	165.715	129.388	141.636	118.581	122.149
	EAPSI 2	27.307	[1] 27.307	[1] 27.307	[1] 27.307	[1] 11.409	[1] 11.409	12.037	[2] 12.037	[2] 12.037	[2] 12.037
	EAPSI 3	161.905	152.335	139.809	113.629	92.663	81.778	66.759	51.933	56.990	51.171
	EAPSI 4	164.003	151.872	151.295	161.360	165.921	163.931	153.841	153.968	155.118	144.215
	Total	515.262	492.105	451.285	462.408	438.554	422.833	362.025	359.574	342.726	329.572

EAPSI 1–3 – stationary sources *EAPSI 4 – mobile sources (road and other transport)*
[1] *data based on expert estimate* [2] *the 1996 data*

Tab. 4.1b **Emissions of basic pollutants [thous. t] in the SR within 2000 – 2008**

			2000	2001	2002	2003	2004	2005	2006	2007	2008
PM	Stationary sources – NEIS	LS [1]	29.923	29.722	25.037	20.166	17.670	18.719	13.992	6.020	5.406
		MS [1]	4.958	4.405	3.767	3.259	2.748	2.392	2.281	1.979	1.764
		SS [2]	19.877	20.550	17.217	18.300	21.504	28.709	26.980	26.821	26.921
	Mobile sources	RT	1.834	2.036	2.212	2.225	2.375	2.849	2.610	3.074	2.791
		OT	0.399	0.404	0.366	0.329	0.343	0.359	0.336	0.353	0.325
	Total		56.991	57.117	48.599	44.279	44.640	53.028	46.199	38.247	37.207
SO_2	Stationary sources – NEIS	LS [1]	101.956	109.822	91.461	95.283	87.932	81.592	80.104	64.974	64.059
		MS [1]	8.083	6.655	3.964	3.620	2.652	2.107	1.902	1.598	1.246
		SS [2]	16.055	13.764	7.127	6.384	5.381	5.073	5.524	3.735	3.844
	Mobile sources	RT	0.670	0.675	0.730	0.150	0.159	0.189	0.177	0.204	0.210
		OT	0.189	0.194	0.064	0.059	0.063	0.047	0.044	0.047	0.045
	Total		126.953	131.110	103.346	105.496	96.187	89.008	87.751	70.558	69.404
NO_x	Stationary sources – NEIS	LS [1]	54.484	51.653	46.412	44.605	44.244	42.424	39.038	35.762	34.488
		MS [1]	8.052	7.751	6.356	6.620	4.926	4.377	4.992	3.542	3.575
		SS [2]	7.993	8.391	7.137	7.356	7.582	8.866	8.336	7.819	7.979
	Mobile sources	RT	32.027	35.072	35.495	34.914	37.794	41.473	39.561	43.838	43.249
		OT	4.860	4.899	4.808	4.305	4.506	4.723	4.427	4.654	4.568
	Total		107.416	107.766	100.208	97.800	99.052	101.863	96.354	95.615	93.859
CO	Stationary sources – NEIS	LS [1]	120.609	115.177	122.225	141.047	147.317	133.787	147.318	141.062	136.530
		MS [1]	10.779	10.280	9.150	9.394	7.531	5.853	5.350	5.330	4.518
		SS [2]	53.792	50.178	33.815	33.811	34.753	41.766	40.882	37.018	37.367
	Mobile sources	RT	113.171	127.348	123.273	106.268	101.161	89.077	77.516	59.244	65.068
		OT	1.719	1.626	1.591	1.463	1.509	1.566	1.452	1.533	1.446
	Total		300.070	304.609	290.054	291.983	292.271	272.049	272.518	244.187	244.929

LS - large sources, MS - middle sources, SS - small sources, RT - road transport, OT - other transport

[1] *According to the Decree of MPŽPaRR SR No. 356/2010 Coll.*
[2] *According to the Decree of MPŽPaRR SR No.144/2000 Coll. (2001 – 2003), according to the Decree of MŽP SR No. 53/2004 Z. z. (2004 – 2009), according to the Decree of MPŽPaRR No. 362/2010 Z. z.(since 2010)*

Emissions from road transport estimated to December 31st 2013, emissions from other sectors to November 25th 2013.

Tab. 4.1c **Emissions of basic pollutants [thous. t] in the SR within 2009 – 2012**

			2009	2010	2011	2012
PM	Stationary sources – NEIS	LS [1]	4.966	4.936	5.139	5.283
		MS [1]	1.554	1.474	1.404	1.348
		SS [2]	27.083	26.214	28.507	28.745
	Mobile sources	RT	2.470	2.745	2.682	2.737
		OT	0.295	0.384	0.329	0.320
	Total		36.368	35.753	38.061	38.433
SO_2	Stationary sources – NEIS	LS [1]	59.739	64.798	64.321	54.235
		MS [1]	0.991	0.906	0.839	0.894
		SS [2]	3.116	3.424	3.102	3.169
	Mobile sources	RT	0.194	0.211	0.204	0.2092
		OT	0.041	0.054	0.017	0.0161
	Total		64.081	69.393	68.483	58.523
NO_x	Stationary sources – NEIS	LS [1]	31.333	31.466	31.199	27.465
		MS [1]	3.389	3.485	3.716	3.978
		SS [2]	7.990	8.076	8.215	8.241
	Mobile sources	RT	37.638	40.510	37.773	37.087
		OT	3.854	5.058	4.327	4.219
	Total		84.204	88.595	85.230	80.990
CO	Stationary sources – NEIS	LS [1]	106.635	125.475	136.615	131.712
		MS [1]	4.104	4.446	4.680	4.913
		SS [2]	36.181	35.953	37.710	38.172
	Mobile sources	RT	59.568	53.489	46.880	45.079
		OT	1.360	1.542	1.339	1.342
	Total		207.848	220.905	227.224	221.218

LS - large sources, MS - middle sources, SS - small sources, RT - road transport, OT - other transport

[1] *According to the Decree of MPŽPaRR SR No. 356/2010 Coll.*
[2] *According to the Decree of MPŽPaRR SR No.144/2000 Coll. (2001 – 2003), according to the Decree of MŽP SR No. 53/2004 Z. z. (2004 – 2009), according to the Decree of MPŽPaRR No. 362/2010 Z. z.(since 2010)*

Emissions from road transport estimated to December 31st 2013, emissions from other sectors to November 25th 2013.

Tab. 4.2a **Emissions of PM [t] from road transport in the SR within 1990 – 2012**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Emissions from diesel engine	2221	1826	1571	1417	1452	1501	1413	1338	1362	1228	955
Emissions from diesel engine	116	107	91	94	99	96	90	73	75	50	42
Emissions from LPG engine	0	0	0	0	0	0	0	0	0	0	1
Emissions from CNG engine	0	0	0	0	0	0	0	0	0	0	0
Total emissions from exhaust	2337	1932	1662	1511	1551	1597	1503	1411	1437	1278	998
Abrasion emissions	1031	848	778	764	833	900	929	979	1013	987	836
Total	3368	2780	2440	2276	2385	2497	2432	2389	2451	2265	1834

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Emissions from diesel engine	1025	1182	1150	1253	1488	1305	1606	1261	1060	1223	1197	1202
Emissions from diesel engine	51	48	44	40	44	37	36	36	28	24	23	22
Emissions from LPG engine	1	1	1	1	1	1	1	1	1	1	1	1
Emissions from CNG engine	0	0	0	0	0	0	0	0	0	0	0	0
Total emissions from exhaust	1077	1231	1196	1294	1533	1343	1643	1299	1089	1248	1221	1224
Abrasion emissions	959	982	1029	1081	1315	1267	1431	1493	1381	1497	1461	1513
Total	2036	2212	2225	2375	2849	2610	3074	2791	2470	2745	2682	2737

Tab. 4.2b **Emissions of PM_{10} and $PM_{2,5}$ [t] from road transport in the SR within 2001 – 2012**

	PM_{10}	$PM_{2,5}$	PM_{10}	PM_{10}	PM_{10}	$PM_{2,5}$	PM_{10}	$PM_{2,5}$	PM_{10}	$PM_{2,5}$	PM_{10}	$PM_{2,5}$
Emissions from diesel engines	1025	1025	1182	1182	1150	1150	1253	1253	1488	1488	1305	1305
Emissions from petrol engines	51	51	48	48	44	44	40	40	44	44	37	37
Total emissions from exhaust	1076	1076	1229	1229	1194	1194	1292	1292	1532	1532	1342	1342
Abrasion emissions	637	340	655	349	676	361	711	379	866	462	821	437
Total	1713	1416	1884	1578	1870	1555	2003	1672	2398	1994	2163	1779

	2007		2009		2009		2010		2011		2012	
	PM_{10}	$PM_{2,5}$	PM_{10}	$PM_{2,5}$	PM_{10}	$PM_{2,5}$	PM_{10}	$PM_{2,5}$	PM_{10}	$PM_{2,5}$	PM_{10}	$PM_{2,5}$
Emissions from diesel engines	1606	1606	1261	1261	1060	1060	1223	1223	1197	1197	1202	1202
Emissions from petrol engines	36	36	36	36	28	28	24	24	23	23	22	22
Total emissions from exhaust	1642	1642	1297	1297	1088	1088	1247	1247	1220	1220	1223	1223
Abrasion emissions	909	485	976	521	876	470	948	506	928	496	964	516
Total	2551	2127	2273	1818	1965	1558	2195	1753	2148	1716	2187	1739

Emissions estimated to December 15th, 2013

Fig. 4.1 **Development trends in basic pollutant emissions within 1990 – 2012**

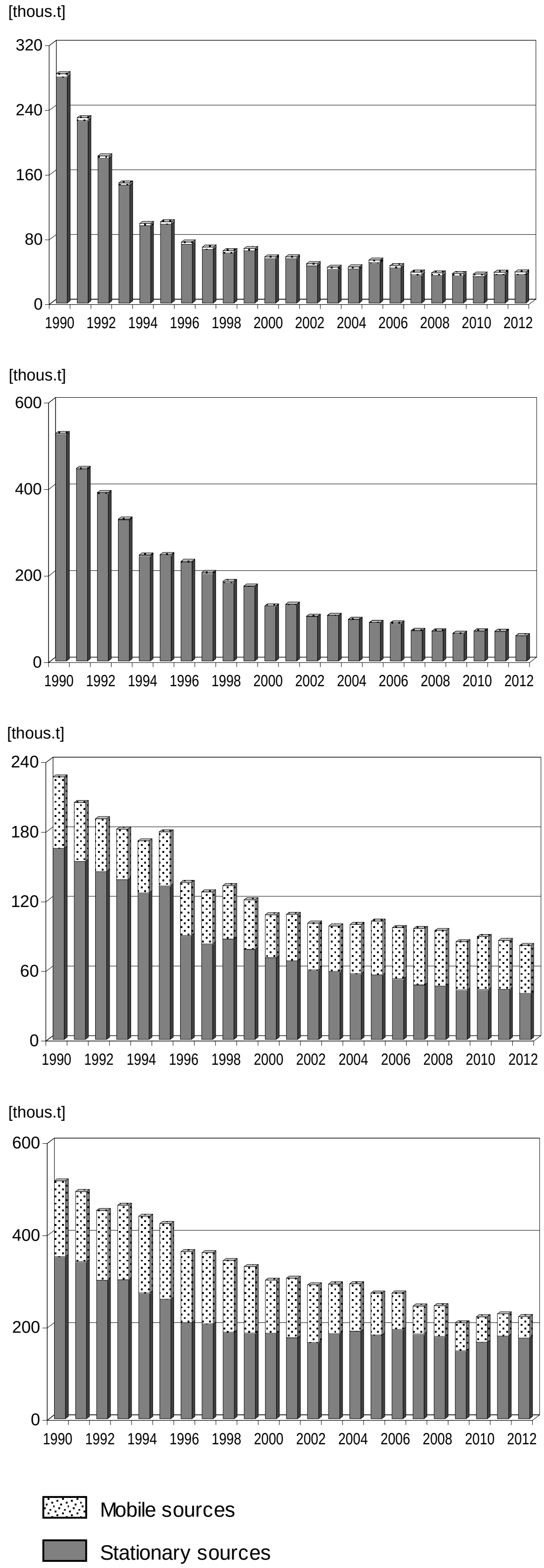
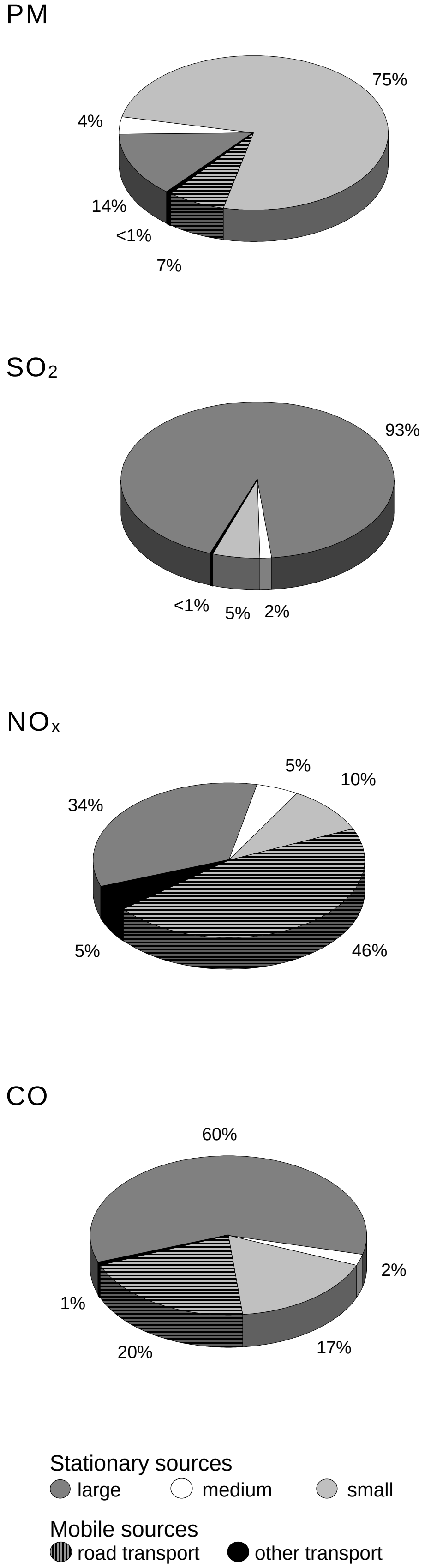


Fig. 4.2 **Emissions of basic pollutants in 2012**



Tab. 4.3 **Stationary source emissions of basic pollutants [t] in agglomerations and zones* within 2000 – 2012**

PM		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Agglo-meration	Bratislava	942	477	444	484	470	472	430	353	339	332	327	309	281
	Košice	15758	17173	14601	9890	6807	4362	4107	3418	3056	3009	3245	3268	3443
Zone	Bratislava region	501	546	493	466	457	506	452	469	477	469	447	482	485
	Trnava region	1518	1518	1284	1325	1522	1935	1825	1752	1770	1755	1742	1902	1886
	Trenčín region	4607	4820	4199	4331	4804	5280	4712	4464	4312	4145	3843	4197	4171
	Nitra region	3057	2921	2476	2474	2740	3414	3144	3074	3053	2991	2896	3194	3176
	Žilina region	6585	6271	5298	5344	5852	7076	6540	6443	6459	6447	6238	6831	6875
	Banská Bystrica reg.	6320	6355	5334	5346	5820	7378	6710	6579	6566	6497	6328	6772	6854
	Prešov region	4207	4266	3491	3667	4588	5556	5158	4606	4514	4608	4345	4671	4800
	Košice region	11262	10331	8400	8398	8862	13842	10176	3663	3545	3349	3213	3422	3404
Total		54758	54677	46022	41725	41922	49820	43254	34820	34090	33603	32625	35050	35376

SO_2		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Agglo-meration	Bratislava	13240	13594	11348	12263	9869	9285	11764	8648	8302	9265	10276	7422	3239
	Košice	18307	12607	10500	10781	13113	12526	11417	10307	9910	9087	9671	9247	9920
Zone	Bratislava region	384	380	208	150	290	377	207	176	169	178	160	191	246
	Trnava region	2160	2051	1166	1077	1141	1037	1039	566	566	423	472	494	498
	Trenčín region	28625	45187	38305	46051	44108	40937	39659	33450	36114	33251	37232	40144	33947
	Nitra region	4752	4749	3799	3648	2485	2336	2367	1158	1134	1066	532	382	400
	Žilina region	10775	10237	7140	7647	6147	5035	4444	3751	3693	3384	2949	2606	2598
	Banská Bystrica reg.	10654	10043	8814	7983	6300	6197	6791	5022	4724	4119	4157	4978	4212
	Prešov region	8372	8082	6320	6719	4864	4856	4204	3407	1811	1945	2474	1487	1988
	Košice region	28825	23310	14952	8969	7649	6185	5639	3823	2727	1128	1203	1310	1250
Total		126094	130242	102552	105287	95966	88772	87530	70307	69149	63847	69127	68262	58298

NO_x		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Agglo-meration	Bratislava	6393	5151	5313	5462	5318	4791	4521	4110	4112	4142	4126	3710	3252
	Košice	12382	12172	12140	12355	11107	10929	12222	9975	8665	8167	9323	7883	8286
Zone	Bratislava region	1792	1900	1972	1602	1670	1742	1700	1882	1874	1739	1437	1712	1527
	Trnava region	2012	1966	1684	1675	1644	1667	1608	1470	1563	1381	1487	1774	1630
	Trenčín region	9083	10489	9616	10167	9677	7822	7835	7219	7588	7328	6892	7639	6960
	Nitra region	3905	3974	3843	3921	4356	3989	3653	2979	3465	3220	2603	3003	2444
	Žilina region	5433	5170	4599	4491	4709	4674	4479	4550	4397	4256	4757	4964	4857
	Banská Bystrica reg.	6541	6666	6316	5840	6160	6281	5522	5550	5699	4465	5399	5840	5203
	Prešov region	3279	3443	3212	3244	3168	3459	3284	2849	2490	2781	2785	2500	2621
	Košice region	19710	16864	11209	9825	8943	10314	7543	6538	6189	5233	4217	4105	2904
Total		70530	67794	59905	58581	56752	55666	52366	47122	46042	42712	43027	43130	39684

CO		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Agglo-meration	Bratislava	1528	1319	1264	1224	1277	1120	1065	879	821	837	824	868	778
	Košice	84544	78619	83700	104605	107218	93197	109060	102663	94378	68477	88292	101053	99454
Zone	Bratislava region	1951	1638	1488	2794	1775	1576	1901	2020	2661	3520	3250	3037	1769
	Trnava region	4746	4682	3591	3399	3493	3865	3563	3459	3306	2627	2728	2967	2963
	Trenčín region	11684	10334	7815	7789	8036	9331	10854	9430	10043	10481	11476	11151	10918
	Nitra region	7964	7379	5470	5586	5672	6627	6459	5690	6849	6385	6185	6283	5532
	Žilina region	19357	19287	16520	16462	17257	15924	14990	14686	14210	11573	12059	12370	10976
	Banská Bystrica reg.	26309	26301	24299	25727	27840	29375	26835	27382	29303	27604	25728	26445	27266
	Prešov region	12170	11838	9075	8804	8800	9282	8714	7522	7080	7042	6795	7010	7128
	Košice region	14927	14237	11969	7862	8232	11109	10108	9680	9764	8374	8536	7820	8012
Total		185180	175636	165191	184252	189601	181407	193550	183410	178415	146920	165874	179005	174796

** According to the Decree of MŽP SR No. 360/2010 Coll., Annex 17*

Tab. 4.4 **The most important air pollution sources in the SR and their share in the emissions of pollutants (NEIS – large and middle sources*) in 2012**

	PM		SO_2		NO_x		CO	
	Operator	[%]	Operator	[%]	Operator	[%]	Operator	[%]
1	U.S. Steel, s.r.o., Košice	47.21	SE, a.s., Bratislava, o.z., ENO Zem. Kostoľany	60.49	U.S. Steel, s.r.o., Košice	20.10	U.S. Steel, s.r.o., Košice	72.18
2	SE, a.s., Bratislava, o.z., ENO Zem. Kostoľany	4.47	U.S. Steel, s.r.o., Košice	15.44	SE, a.s., Bratislava, o.z., ENO Zem. Kostoľany	11.21	Slovalco, a.s., Žiar nad Hronom	9.76
3	Fortischem a.s., Nováky	2.82	CM European power Slovakia, s.r.o., Bratislava	2.92	Tepláreň a.s., Košice	4.22	Považská cementáreň, a.s., Ladce	2.06
4	Duslo a.s., Šaľa	2.20	SLOVNAFT a.s., Bratislava	2.57	CM European power Slovakia, s.r.o. Bratislava	3.56	CEMMAC, a.s., Horné Srnie	1.45
5	Carmeuse Slovakia s.r.o., závod Košice	2.06	Slovalco, a.s., Žiar nad Hronom	2.52	Holcim (Slovensko) , a.s. Rohožník	3.23	Slovenské magnezitové závody a.s., Jelšava	1.43
6	Mondi scp, a.s., Ružomberok	1.86	Tepláreň a.s., Košice	2.20	Považská cementáreň, a.s. Ladce	2.81	KOVOHUTY, a.s., Krompachy	1.30
7	Považská cementáreň, a.s., Ladce	1.69	BUKÓZA ENERGO, a.s., Vranov nad Topľou	2.19	Slovenské magnezitové závody a.s. Jelšava	2.72	Calmit, s.r.o., prev. Tisovec	1.06
8	Obaly SOLO, s.r.o., Ružomberok	1.50	Zvolenská teplárenská a.s., Zvolen	1.78	Mondi scp, a.s., Ružomberok	2.63	OFZ, a.s., Istebné	0.88
9	BUKÓZA ENERGO, a.s., Vranov nad Topľou	1.50	Martinská teplárenská, a.s., Martin	1.44	OFZ, a.s., Istebné	2.30	Holcim (Slovensko) , a.s., Rohožník	0.50
10	Tepláreň a.s., Košice	1.45	SE, a.s., Bratislava, Elektráreň Vojany I a II	1.14	BUKÓZA ENERGO, a.s., Vranov nad Topľou	2.12	CALMIT spol. s r.o., Bratislava, prev. Žirany	0.50
11	Slovalco, a.s., Žiar nad Hronom	1.29	Žilinská teplárenská, a.s., Žilina	0.91	Duslo a.s., Šaľa	2.06	HNOJIVÁ DUSLO, s.r.o., STRÁŽSKE	0.49
12	Carmeuse Slovakia s.r.o., závod Včeláre	1.03	Dalkia Industry Žiar nad Hronom, a.s.	0.86	SE, a.s., Bratislava, Elektráreň Vojany I a II	1.97	Slovmag a.s., Lubeník	0.36
13	CM European power Slovakia, s.r.o., Bratislava	0.82	Knauf Insulation, s.r.o., Nová Baňa	0.55	SLOVNAFT a.s., Bratislava	1.96	Slovenské magnezitové závody a.s., závod Bočiar	0.34
14	BUKOCEL a.s., Hencovce	0.78	OFZ, a.s., Istebné	0.37	CEMMAC, a.s., Horné Srnie	1.89	SLOVAKIA STEEL MILLS, a.s., Strážske	0.32
15	DOLVAP, s.r.o., Varín	0.77	Holcim (Slovensko) , a.s., Rohožník	0.34	HOLCIM (Slovensko) a.s., Geča	1.65	SE, a.s., Bratislava, Elektráreň Vojany I a II	0.30
16	Knauf Insulation, s.r.o., Nová Baňa	0.70	Slovenské cukrovary, a.s., Sereď	0.32	Slovalco, a.s., Žiar nad Hronom	1.64	SE, a.s., Bratislava, o.z., ENO Zem. Kostoľany	0.26
17	Zvolenská teplárenská a.s., Zvolen	0.66	Duslo, a.s., odštepný závod ISTROCHEM	0.31	Zvolenská teplárenská a.s., Zvolen	1.62	BUKOCEL a.s., Hencovce	0.26
18	SE, a.s., Bratislava, Elektráreň Vojany I a II	0.66	Mondi scp, a.s., Ružomberok	0.25	Carmeuse Slovakia s.r.o., závod Košice	1.51	SLOVNAFT a.s., Bratislava	0.25
19	Smrečina Hofatex a.s., Banská Bystrica	0.56	TP 2, s.r.o., STRÁŽSKE	0.24	PPC POWER, a.s., Bratislava	1.42	Mondi scp, a.s., Ružomberok	0.25
20	SLOVNAFT a.s., Bratislava	0.55	Energy Snina, a.s.	0.22	Žilinská teplárenská, a.s., Žilina	1.31	Fortischem a.s., Nováky	0.23
Total		74.58		97.07		71.92		94.19

** According to the Decree of MŽP SR No. 356/2010 Coll.*

Tab. 4.5 **Sequence of the sources within the region according to the emissions in 2012 (NEIS – large and middle sources*)**

BRATISLAVA REGION

	PM		SO_2	
	Source	District	Source	District
1.	CM European power Slovakia, s.r.o. Bratislava	Bratislava II	CM European power Slovakia, s.r.o. Bratislava	Bratislava II
2.	SLOVNAFT a.s. Bratislava	Bratislava II	SLOVNAFT a.s. Bratislava	Bratislava II
3.	VOLKSWAGEN SLOVAKIA, a.s., Bratislava	Bratislava IV	Holcim (Slovensko) , a.s. Rohožník	Malacky
4.	Holcim (Slovensko) , a.s. Rohožník	Malacky	Duslo, a.s. odštepný závod ISTROCHEM Bratislava	Bratislava III
5.	Swedspan Slovakia s.r.o., Malacky	Malacky	Bratislavská teplárenská, a.s., Bratislava, Výhr. Juh	Bratislava II
6.	PPC POWER, a.s. Bratislava	Bratislava III	MO SR, PSB Bratislava, kotolne Viničné a Sl. Grob	Pezinok
7.	Slovnaft Petrochemicals, s.r.o. Bratislava	Bratislava II	Bratislavská teplárenská a.s. Bratislava, Tepláreň II	Bratislava III
8.	Termming, a.s. Bratislava	Bratislava II	Univolt-Remat s.r.o. Pezinok	Pezinok
9.	Obec Rohožník	Malacky	Odvoz a likvidácia odpadu, a.s. Bratislava	Bratislava II
10.	MO SR, PSB Bratislava, kotolne Viničné a Sl. Grob	Pezinok	Slovnaft Petrochemicals, s.r.o. Bratislava	Bratislava II
	NO_x		CO	
	Source	District	Source	District
1.	CM European power Slovakia, s.r.o. Bratislava	Bratislava II	Holcim (Slovensko) , a.s. Rohožník	Malacky
2.	Holcim (Slovensko) , a.s. Rohožník	Malacky	SLOVNAFT a.s. Bratislava	Bratislava II
3.	SLOVNAFT a.s. Bratislava	Bratislava II	Swedspan Slovakia s.r.o., Malacky	Malacky
4.	PPC POWER, a.s. Bratislava	Bratislava III	Termming, a.s. Bratislava, Malacky	Malacky
5.	Slovnaft Petrochemicals, s.r.o. Bratislava	Bratislava II	VOLKSWAGEN SLOVAKIA, a.s., Bratislava	Bratislava IV
6.	Swedspan Slovakia s.r.o., Malacky	Malacky	NAFTA a.s., Gbely	Malacky
7.	VOLKSWAGEN SLOVAKIA, a.s., Bratislava	Bratislava IV	Obec Rohožník	Malacky
8.	Odvoz a likvidácia odpadu, a.s. Bratislava	Bratislava II	MO SR, PSB Bratislava, kotolne Viničné a Sl. Grob	Pezinok
9.	Bratislavská teplárenská, a.s., Bratislava, Tepl. západ	Bratislava IV	Slovnaft Petrochemicals, s.r.o. Bratislava	Bratislava II
10.	Dalkia a.s. Bratislava, zdroje v okrese BA 5	Bratislava V	Dalkia a.s. Bratislava, zdroje v okrese BA 5	Bratislava V

TRNAVA REGION

	PM		SO_2	
	Source	District	Source	District
1.	Amylum Slovakia spol. s r.o. Boleráz	Trnava	Slovenské cukrovary, a.s., Sereď	Galanta
2.	Agropodnik a.s. Trnava Lehnice	Dunajská Streda	Johns Manville Slovakia a.s. Trnava	Trnava
3.	Slovenské cukrovary, a.s., Sereď	Galanta	Zlieváreň Trnava s.r. o	Trnava
4.	Johns Manville Slovakia a.s. Trnava	Trnava	Mach-Trade s.r.o., Sereď	Galanta
5.	E.ON Elektrárne s.r.o. Trakovice	Hlohovec	RUPOS s.r.o. Ružindol	Trnava
6.	Zlieváreň Trnava s.r. o	Trnava	Baňa Záhorie, a.s. Čáry	Senica
7.	PENAM, a.s., Nitra, prev. Trnava	Trnava	Trnavská ekologická spoločnosť s.r.o. Zeleneč	Trnava
8.	RaVOD Pata, roľnícke a výrobnoobchodné družstvo	Galanta	PLYNEX s.r.o. Dolná Streda	Galanta
9.	ENVIRAL a.s., Leopoldov	Hlohovec	Obec Lakšárska Nová Ves, ZŠ Lakšárska Nová Ves	Senica
10.	Agropodnik a.s., Trnava, prev. Senica	Senica	ASTOM ND, s.r.o., Veľký Meder	Dunajská Streda
	NO_x		CO	
	Source	District	Source	District
1.	E.ON Elektrárne s.r.o. Trakovice	Hlohovec	Službyt s.r.o, Senica	Senica
2.	Johns Manville Slovakia a.s. Trnava	Trnava	E.ON Elektrárne s.r.o. Trakovice	Hlohovec
3.	Slovenské cukrovary, a.s., Sereď	Galanta	Swedwood Slovakia s.r.o.OZ Malacky prev. Trnava	Trnava
4.	ENVIRAL a.s., Leopoldov	Hlohovec	Zlieváreň Trnava s.r. o	Trnava
5.	Amylum Slovakia spol. s r.o. Boleráz	Trnava	BEKAERT SLOVAKIA s.r.o. Sládkovičovo	Galanta
6.	Službyt s.r.o, Senica	Senica	ENVIRAL a.s., Leopoldov	Hlohovec
7.	Swedwood Slovakia s.r.o. OZ Malacky prev. Trnava	Trnava	Amylum Slovakia spol. s r.o. Boleráz	Trnava
8.	Zlieváreň Trnava s.r. o	Trnava	Slovenské cukrovary, a.s., Sereď	Galanta
9.	BEKAERT Hlohovec, a.s.	Hlohovec	I.D.C. Holding, a.s., Pečivárne Sereď	Galanta
10.	Mach-Trade s.r.o., Sereď	Galanta	ASTOM ND, s.r.o., Veľký Meder	Dunajská Streda

NITRA REGION

	PM		SO$_2$	
	Source	District	Source	District
1.	Duslo a.s., Šaľa	Šaľa	CALMIT spol. s r.o. Bratislava, prev. Žirany	Nitra
2.	Prvá energetická a teplárenská spoločnosť, s.r.o.	Zlaté Moravce	Icopal a.s., Štúrovo	Nové Zámky
3.	PPC ČAB akciová spoločnosť Nové Sady	Nitra	Bioplyn Cetín s.r.o., Malý Cetín	Nitra
4.	SES a.s. Tlmače	Levice	Liaharenský podnik Nitra, a.s., Veľký Ďur	Levice
5.	Tlmačská energetická, s.r.o. Tlmače	Levice	Tlmačská energetická, s.r.o. Tlmače	Levice
6.	BIOENERGY TOPOĽČANY s.r.o.	Topoľčany	BYTREAL Tlmače s.r.o. Tlmače	Levice
7.	Slovintegra Energy, s.r.o. Levice	Levice	MO SR, Posádková správa budov Nitra	Nitra
8.	DECODOM s.r.o. Topoľčany	Topoľčany	Duslo a.s., Šaľa	Šaľa
9.	P.G.TRADE spol. s r.o. Komárno, zdroje v okrese	Nové Zámky	ELEKTROKARBON a.s. Topoľčany	Topoľčany
10.	BYTREAL Tlmače s.r.o. Tlmače	Levice	BMC s.r.o. Nitra	Nitra
	NO$_x$		CO	
	Source	District	Source	District
1.	Duslo a.s., Šaľa	Šaľa	CALMIT spol. s r.o. Bratislava, prev. Žirany	Nitra
2.	BIOENERGY TOPOĽČANY s.r.o.	Topoľčany	Slovintegra Energy, s.r.o. Levice	Levice
3.	Slovintegra Energy, s.r.o. Levice	Levice	Bytkomfort s.r.o., Nové Zámky	Nové Zámky
4.	Bytkomfort s.r.o., Nové Zámky	Nové Zámky	Duslo a.s., Šaľa	Šaľa
5.	SES a.s. Tlmače	Levice	Wienerberger Slov. tehelne spol. s r.o. Zl. Moravce	Zlaté Moravce
6.	eustream, a.s. , prev. Ivanka pri Nitre	Nitra	Secop s.r.o. Zlaté Moravce	Zlaté Moravce
7.	Dalkia Vráble, a.s.	Nitra	BIOENERGY TOPOĽČANY s.r.o.	Topoľčany
8.	DECODOM s.r.o. Topoľčany	Topoľčany	Liaharenský podnik Nitra, a.s., Veľký Ďur	Levice
9.	Nitrianska teplárenská spoločnosť a.s., Nitra	Nitra	Bioplyn Cetín s.r.o., Malý Cetín	Nitra
10.	COM-therm s.r.o., Komárno	Komárno	Dalkia Vráble, a.s.	Nitra

TRENČÍN REGION

	PM		SO$_2$	
	Source	District	Source	District
1.	SE, a.s., Bratislava, o.z. ENO Zem. Kostoľany	Prievidza	SE, a.s., Bratislava, o.z. ENO Zem. Kostoľany	Prievidza
2.	Považská cementáreň, a.s. Ladce	Ilava	VETROPACK NEMŠOVÁ, s.r.o.	Trenčín
3.	Fortischem a.s. Nováky	Prievidza	Hornonitrianske bane Prievidza, a.s., zdroje v okrese	Prievidza
4.	Hornonitrianske bane Prievidza, a.s., zdroje v okrese	Prievidza	Považská cementáreň, a.s. Ladce	Ilava
5.	KRONOTIMBER SK, s.r.o. Lehota pod Vtáčnikom	Prievidza	Služby pre bývanie s.r.o., Trenčín	Trenčín
6.	TERMONOVA a.s., Nová Dubnica	Ilava	Fortischem a.s. Nováky	Prievidza
7.	Považský cukor a.s., Trenčianska Teplá	Trenčín	SLOVZINK a.s., Košeca	Ilava
8.	KVARTET, a.s. Partizánske	Partizánske	Bioplyn Horovce, s.r.o.	Púchov
9.	Radsworth, a.s.-organizačná zložka Nováky	Prievidza	CEMMAC, a.s. Horné Srnie	Trenčín
10.	TEPLÁREŇ, a.s. Považská Bystrica	Považská Bystrica	Geotim, s.r.o Bojnice	Prievidza
	NO$_x$		CO	
	Source	District	Source	District
1.	SE, a.s., Bratislava, o.z. ENO Zem. Kostoľany	Prievidza	Považská cementáreň, a.s. Ladce	Ilava
2.	Považská cementáreň, a.s. Ladce	Ilava	CEMMAC, a.s. Horné Srnie	Trenčín
3.	CEMMAC, a.s. Horné Srnie	Trenčín	SE, a.s., Bratislava, o.z. ENO Zem. Kostoľany	Prievidza
4.	RONA a.s. Lednické Rovne	Púchov	Fortischem a.s. Nováky	Prievidza
5.	VETROPACK NEMŠOVÁ, s.r.o.	Trenčín	Považský cukor a.s., Trenčianska Teplá	Trenčín
6.	Fortischem a.s. Nováky	Prievidza	TSM Partizánske s.r.o.	Partizánske
7.	TEPLÁREŇ, a.s. Považská Bystrica	Považská Bystrica	COFELY Brezová pod Bradlom	Myjava
8.	Continental Matador Rubber, s.r.o. Púchov	Púchov	TEPLÁREŇ, a.s. Považská Bystrica	Považská Bystrica
9.	TERMONOVA a.s., Nová Dubnica	Ilava	PSL, a.s. Považská Bystrica	Považská Bystrica
10.	Handlovská energetika, s.r.o. Handlová	Prievidza	Služby pre bývanie s.r.o., Trenčín	Trenčín

BANSKÁ BYSTRICA REGION

	PM		SO_2	
	Source	District	Source	District
1.	Slovalco, a.s. Žiar nad Hronom	Žiar nad Hronom	Slovalco, a.s. Žiar nad Hronom	Žiar nad Hronom
2.	Knauf Insulation, s.r.o. Nová Baňa	Žarnovica	Zvolenská teplárenská a.s. Zvolen	Zvolen
3.	Zvolenská teplárenská a.s. Zvolen	Zvolen	Dalkia Industry Žiar nad Hronom, a.s.	Žiar nad Hronom
4.	Smrečina Hofatex a.s. Banská Bystrica	Banská Bystrica	Knauf Insulation, s.r.o. Nová Baňa	Žarnovica
5.	BUČINA DDD, spol. s r.o. Zvolen	Zvolen	Slovmag a.s. Lubeník	Revúca
6.	Harmanec-Kuvert s.r.o., Brezno	Brezno	KOMPALA Badín	Banská Bystrica
7.	Slovmag a.s. Lubeník	Revúca	VUM, a.s. Žiar nad Hronom	Žiar nad Hronom
8.	Calmit, s.r.o., prev. Tisovec	Rimavská Sobota	Slovenské magnezitové závody a.s. Jelšava	Revúca
9.	MO SR, PS budov Banská Bystrica	Brezno	Železiarne Podbrezová a.s.	Brezno
10.	Dalkia Industry Žiar nad Hronom, a.s.	Žiar nad Hronom	Družstvo Agrospol, Lučenec	Lučenec
	NO_x		CO	
	Source	District	Source	District
1.	Slovenské magnezitové závody a.s. Jelšava	Revúca	Slovalco, a.s. Žiar nad Hronom	Žiar nad Hronom
2.	Slovalco, a.s. Žiar nad Hronom	Žiar nad Hronom	Slovenské magnezitové závody a.s. Jelšava	Revúca
3.	Zvolenská teplárenská a.s. Zvolen	Zvolen	Calmit, s.r.o., prev. Tisovec	Rimavská Sobota
4.	Dalkia Industry Žiar nad Hronom, a.s.	Žiar nad Hronom	Slovmag a.s. Lubeník	Revúca
5.	eustream, a.s., prev. Veľké Zlievce	Veľký Krtíš	Železiarne Podbrezová a.s.	Brezno
6.	Železiarne Podbrezová a.s.	Brezno	VUM, a.s. Žiar nad Hronom	Žiar nad Hronom
7.	KOMPALA Badín	Banská Bystrica	STEFE ECB, s.r.o. Rimavská Sobota	Rimavská Sobota
8.	Bučina Zvolen a.s.	Zvolen	Zvolenská teplárenská a.s. Zvolen	Zvolen
9.	Calmit, s.r.o., prev. Tisovec	Rimavská Sobota	Smrečina Hofatex a.s. Banská Bystrica	Banská Bystrica
10.	Knauf Insulation, s.r.o. Nová Baňa	Žarnovica	Kremnické tepelné hospodárstvo, s.r.o. Kremnica	Žiar nad Hronom

ŽILINA REGION

	PM		SO_2	
	Source	District	Source	District
1.	Mondi scp, a.s. Ružomberok	Ružomberok	Martinská teplárenská, a.s. Martin	Martin
2.	Obaly SOLO, s.r.o. Ružomberok	Ružomberok	Žilinská teplárenská, a.s. Žilina	Žilina
3.	DOLVAP, s.r.o. Varín	Žilina	OFZ, a.s., Istebné	Dolný Kubín
4.	OFZ, a.s., Istebné	Dolný Kubín	Mondi scp, a.s. Ružomberok	Ružomberok
5.	Žilinská teplárenská, a.s. Žilina	Žilina	SOTE s.r.o., Čadca	Čadca
6.	SOTE s.r.o., Čadca	Čadca	ŽOS Vrútky a.s.	Martin
7.	TEHOS, s.r.o., Dolný Kubín	Dolný Kubín	ZDROJ MT s.r.o. Martin - Priekopa	Martin
8.	DOLKAM Šuja ,a.s. Rajec	Žilina	AFG Turčianske Teplice	Turčianske
9.	KIA Motors Slovakia s.r.o. Žilina	Žilina	RABČAN, s.r.o. Rabča	Námestovo
10	Martinská teplárenská, a.s. Martin	Martin	AVEX electronics, s.r.o., prev. Oravská Lesná	Námestovo
	NO_x		CO	
	Source	District	Source	District
1.	Mondi scp, a.s. Ružomberok	Ružomberok	OFZ, a.s., Istebné	Dolný Kubín
2.	OFZ, a.s., Istebné	Dolný Kubín	Mondi scp, a.s. Ružomberok	Ružomberok
3.	Žilinská teplárenská, a.s. Žilina	Žilina	LMT a.s., Liptovský Mikuláš	Liptovský Mikuláš
4.	Martinská teplárenská, a.s. Martin	Martin	Obaly SOLO, s.r.o. Ružomberok	Ružomberok
5.	Obaly SOLO, s.r.o. Ružomberok	Ružomberok	SOTE s.r.o., Čadca	Čadca
6.	Rettenmeier Tatra Timber s.r.o. Liptovský Hrádok	Liptovský Mikuláš	Rettenmeier Tatra Timber s.r.o. Liptovský Hrádok	Liptovský Mikuláš
7.	Speciality Minerals Slovakia s.r.o., Ružomberok	Ružomberok	Žilinská teplárenská, a.s. Žilina	Žilina
8.	KIA Motors Slovakia s.r.o. Žilina	Žilina	Turzovská drevárska fabrika Turzovka	Čadca
9.	LMT a.s., Liptovský Mikuláš	Liptovský Mikuláš	ŽOS Vrútky a.s.	Martin
10	TEHOS, s.r.o., Dolný Kubín	Dolný Kubín	DONGHEE SLOVAKIA, s.r.o. Žilina	Žilina

PREŠOV REGION

	PM		SO_2	
	Source	District	Source	District
1.	BUKÓZA ENERGO, a.s. Vranov nad Topľou	Vranov n/Topľou	BUKÓZA ENERGO, a.s. Vranov nad Topľou	Vranov n/Topľou
2.	BUKOCEL a.s. Hencovce	Vranov n/Topľou	Energy Snina, a.s.	Snina
3.	CHEMES, a.s., HUMENNÉ	Humenné	BUKOCEL a.s. Hencovce	Vranov n/Topľou
4.	Bytenerg MEDZILABORCE	Medzilaborce	CHEMES, a.s., HUMENNÉ	Humenné
5.	BIOENERGY BARDEJOV, s.r.o. Bardejov	Bardejov	Zeocem Bystré a.s.	Vranov n/Topľou
6.	Zeocem Bystré a.s.	Vranov n/Topľou	Roľnícke družstvo Plavnica	Stará Ľubovňa
7.	Lesy Slovenskej republiky o.z. Vranov nad Topľou	Vranov n/Topľou	BPS Huncovce s.r.o.	Kežmarok
8.	TATRAVAGÓNKA a.s. POPRAD	Poprad	MO SR, kot. Kamenica n. Cir.	Humenné
9.	SPRAVBYTKOMFORT a.s. Prešov	Prešov	ZŠ Malcov	Bardejov
10	SCHULE SLOVAKIA, s.r.o.Poprad	Poprad	MO SR, Stredisko prevádzky objektov Prešov	Prešov
	NO_x		CO	
	Source	District	Source	District
1.	BUKÓZA ENERGO, a.s. Vranov nad Topľou	Vranov n/Topľou	BUKOCEL a.s. Hencovce	Vranov n/Topľou
2.	BUKOCEL a.s. Hencovce	Vranov n/Topľou	Leier Baustoffe SK s.r.o. Petrovany	Prešov
3.	BIOENERGY BARDEJOV, s.r.o. Bardejov	Bardejov	BUKÓZA ENERGO, a.s. Vranov nad Topľou	Vranov n/Topľou
4.	Energy Snina, a.s.	Snina	BIOENERGY BARDEJOV, s.r.o. Bardejov	Bardejov
5.	SPRAVBYTKOMFORT a.s. Prešov	Prešov	SPRAVBYTKOMFORT a.s. Prešov	Prešov
6.	CHEMES, a.s., HUMENNÉ	Humenné	SCHULE SLOVAKIA, s.r.o. Poprad	Poprad
7.	CHEMOSVIT ENERGOCHEM, a.s., SVIT	Poprad	CHEMOSVIT FOLIE, a.s. Svit	Poprad
8.	DALKIA POPRAD a.s.	Poprad	Teplo GGE s.r.o. Snina	Snina
9.	TATRAVAGÓNKA a.s. POPRAD	Poprad	CHEMES, a.s., HUMENNÉ	Humenné
10	Zeocem Bystré a.s.	Vranov n/Topľou	Energy Snina, a.s.	Snina

KOŠICE REGION

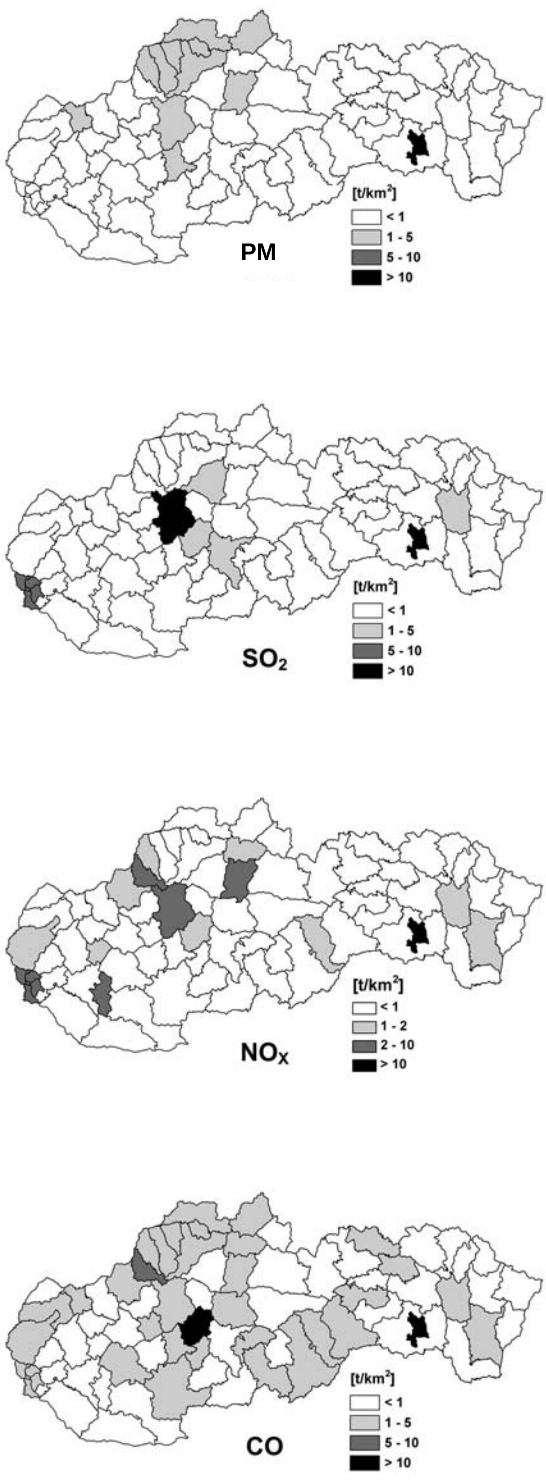
	PM		SO_2	
	Source	District	Source	District
1.	U.S. Steel, s.r.o. Košice	Košice II	U.S. Steel, s.r.o. Košice	Košice II
2.	Carmeuse Slovakia s.r.o., závod Košice	Košice II	Tepláreň a.s. Košice	Košice IV
3.	Tepláreň a.s. Košice	Košice IV	SE, a.s., Bratislava, Elektráreň Vojany I a II	Michalovce
4.	Carmeuse Slovakia s.r.o., závod Včeláre	Košice - okolie	TP 2, s.r.o. STRÁŽSKE	Michalovce
5.	SE, a.s., Bratislava, Elektráreň Vojany I a II	Michalovce	Slovenské magnezitové závody a.s. závod Bočiar	Košice II
6.	Mesto Sobrance	Sobrance	KOVOHUTY, a.s. Krompachy	Spišská Nová Ves
7.	HOLCIM (Slovensko) a.s. Geča	Košice - okolie	Carmeuse Slovakia s.r.o., závod Košice	Košice II
8.	KOVOHUTY, a.s. Krompachy	Spišská Nová Ves	Bioplyn Rozhanovce, s.r.o.	Košice - okolie
9.	Tepelné hosp. Moldava a.s. Moldava nad Bodvou	Košice - okolie	RMS, a.s. Košice	Košice II
10	Harsco Metals Slovensko, s.r.o. Košice	Košice II	Refrako, s.r.o. Košice	Košice II
	NO_x		CO	
	Source	District	Source	District
1.	U.S. Steel, s.r.o. Košice	Košice II	U.S. Steel, s.r.o. Košice	Košice II
2.	Tepláreň a.s. Košice	Košice IV	KOVOHUTY, a.s. Krompachy	Spišská Nová Ves
3.	SE, a.s., Bratislava, Elektráreň Vojany I a II	Michalovce	HNOJIVÁ DUSLO, s.r.o. STRÁŽSKE	Michalovce
4.	HOLCIM (Slovensko) a.s. Geča	Košice - okolie	Slovenské magnezitové závody a.s. závod Bočiar	Košice II
5.	Carmeuse Slovakia s.r.o., závod Košice	Košice II	SLOVAKIA STEEL MILLS, a.s. Strážske	Michalovce
6.	eustream , a.s., prev. Veľké Kapušany	Michalovce	SE, a.s., Bratislava, Elektráreň Vojany I a II	Michalovce
7.	SLOVAKIA STEEL MILLS, a.s. Strážske	Michalovce	Carmeuse Slovakia s.r.o., závod Košice	Košice II
8.	TP 2, s.r.o. STRÁŽSKE	Michalovce	Tepelné hosp. Moldava a.s. Moldava nad Bodvou	Košice - okolie
9.	eustream, a.s. , prev. Jablonov nad Turňou	Rožňava	Tepláreň a.s. Košice	Košice IV
10	HNOJIVÁ DUSLO, s.r.o. STRÁŽSKE	Michalovce	eustream , a.s., prev. Veľké Kapušany	Michalovce

**According to the Decree of MPŽPaRR SR No. 356/2010 Coll.*

Tab. 4.6 **Stationary source emissions by districts in 2012**

District	Emissions [t.year⁻¹]				Specific territorial emis. [t.year⁻¹.km⁻²]			
	PM	SO_2	NO_x	CO	PM	SO_2	NO_x	CO
1. Bratislava	281	3239	3252	778	0.76	8.80	8.84	2.11
2. Malacky	270	211	1336	1404	0.28	0.22	1.41	1.48
3. Pezinok	115	23	88	193	0.30	0.06	0.23	0.51
4. Senec	100	12	102	173	0.28	0.03	0.28	0.48
5. Dunajská Streda	409	46	220	558	0.38	0.04	0.20	0.52
6. Galanta	271	221	318	422	0.42	0.34	0.50	0.66
7. Hlohovec	134	15	303	253	0.50	0.06	1.13	0.95
8. Piešťany	231	26	122	326	0.61	0.07	0.32	0.86
9. Senica	345	50	166	693	0.50	0.07	0.24	1.01
10. Skalica	220	23	93	297	0.62	0.07	0.26	0.83
11. Trnava	277	115	408	414	0.37	0.16	0.55	0.56
12. Bánovce n/B	241	27	80	324	0.52	0.06	0.17	0.70
13. Ilava	356	47	1023	3152	0.99	0.13	2.86	8.81
14. Myjava	352	39	111	562	1.08	0.12	0.34	1.72
15. Nové Mesto n/V	329	36	136	449	0.57	0.06	0.23	0.77
16. Partizánske	162	27	114	370	0.54	0.09	0.38	1.23
17. Považská Bystrica	606	68	212	932	1.31	0.15	0.46	2.01
18. Prievidza	1232	33470	3865	1701	1.28	34.86	4.03	1.77
19. Púchov	523	72	447	704	1.39	0.19	1.19	1.88
20. Trenčín	372	162	971	2725	0.55	0.24	1.44	4.04
21. Komárno	416	45	219	589	0.38	0.04	0.20	0.54
22. Levice	1078	135	496	1713	0.70	0.09	0.32	1.10
23. Nitra	336	71	308	1183	0.39	0.08	0.35	1.36
24. Nové Zámky	607	84	310	1017	0.45	0.06	0.23	0.75
25. Šaľa	279	15	732	283	0.78	0.04	2.06	0.79
26. Topoľčany	209	23	272	310	0.35	0.04	0.45	0.52
27. Zlaté Moravce	252	28	106	437	0.48	0.05	0.20	0.84
28. Bytča	411	46	116	550	1.46	0.16	0.41	1.95
29. Čadca	1228	252	330	1718	1.61	0.33	0.43	2.26
30. Dolný Kubín	374	239	839	1649	0.76	0.49	1.70	3.35
31. Kysucké Nové Mesto	265	28	102	352	1.52	0.16	0.58	2.02
32. Liptovský Mikuláš	631	74	370	1121	0.47	0.05	0.28	0.84
33. Martin	479	924	458	727	0.65	1.26	0.62	0.99
34. Námestovo	1200	156	274	1603	1.74	0.23	0.40	2.32
35. Ružomberok	920	222	1414	1398	1.42	0.34	2.19	2.16
36. Turčianske Teplice	221	36	80	304	0.56	0.09	0.20	0.77
37. Tvrdošín	185	20	72	247	0.39	0.04	0.15	0.52
38. Žilina	961	601	802	1307	1.18	0.74	0.98	1.60
39. Banská Bystrica	591	131	440	875	0.73	0.16	0.54	1.08
40. Banská Štiavnica	261	35	66	348	0.89	0.12	0.23	1.19
41. Brezno	684	113	288	1255	0.54	0.09	0.23	0.99
42. Detva	436	49	154	615	0.97	0.11	0.34	1.37
43. Krupina	374	49	102	506	0.64	0.08	0.18	0.87
44. Lučenec	650	82	198	874	0.79	0.10	0.24	1.06
45. Poltár	214	25	65	301	0.45	0.05	0.14	0.63
46. Revúca	531	200	1067	3162	0.73	0.27	1.46	4.33
47. Rimavská Sobota	1163	131	444	3075	0.79	0.09	0.30	2.09
48. Veľký Krtíš	531	76	458	740	0.63	0.09	0.54	0.87
49. Zvolen	408	1018	757	595	0.54	1.34	1.00	0.78
50. Žarnovica	505	354	182	646	1.19	0.83	0.43	1.52
51. Žiar n/H	506	1950	982	14275	0.98	3.76	1.90	27.56
52. Bardejov	434	50	219	648	0.46	0.05	0.23	0.69
53. Humenné	369	93	132	499	0.49	0.12	0.18	0.66
54. Kežmarok	441	51	141	620	0.53	0.06	0.17	0.74
55. Levoča	221	26	63	299	0.62	0.07	0.18	0.84
56. Medzilaborce	201	21	47	260	0.47	0.05	0.11	0.61
57. Poprad	297	32	193	490	0.27	0.03	0.17	0.44
58. Prešov	494	56	272	870	0.53	0.06	0.29	0.93
59. Sabinov	417	46	121	557	0.86	0.09	0.25	1.15
60. Snina	438	168	200	650	0.54	0.21	0.25	0.81
61. Stará Ľubovňa	539	70	155	719	0.86	0.11	0.25	1.15
62. Stropkov	148	16	42	199	0.38	0.04	0.11	0.51
63. Svidník	279	31	75	367	0.51	0.06	0.14	0.67
64. Vranov n/T	521	1331	960	951	0.68	1.73	1.25	1.24
65. Gelnica	414	46	102	559	0.71	0.08	0.18	0.96
66. Košice	3443	9920	8286	99454	14.17	40.82	34.10	409.28
67. Košice - okolie	894	117	777	1222	0.58	0.08	0.51	0.80
68. Michalovce	202	792	1298	1843	0.20	0.78	1.27	1.81
69. Rožňava	921	104	332	1245	0.79	0.09	0.28	1.06
70. Sobrance	190	29	61	254	0.35	0.05	0.11	0.47
71. Spišská Nová Ves	391	115	180	2354	0.67	0.20	0.31	4.01
72. Trebišov	391	46	153	535	0.36	0.04	0.14	0.50
Slovakia	35376	58298	39684	174796	0.72	1.19	0.81	3.56

Fig. 4.3 **Specific territorial emission in 2012**

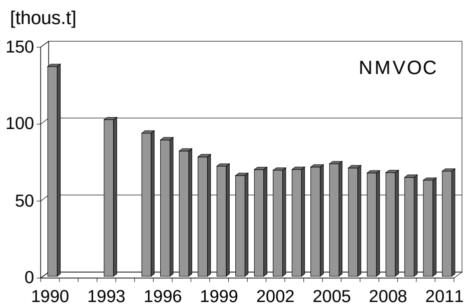


Tab. 4.7 **NMVOC emissions [t] in the SR in 1990, 1995, 2000, 2002 – 2011**

Sector / Subsector	1990	1995	2000	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Combustion processes I	335	258	201	214	214	203	185	174	158	172	157	159	158
Public power	223	187	139	147	161	156	139	131	121	130	119	121	126
District heating plants	112	71	62	67	53	47	46	43	37	42	38	39	32
Combustion processes II	12641	9618	7913	7070	7505	8931	11934	11162	11113	11173	11273	10957	11904
Commercial and institutional plants	226	150	26	23	24	25	28	27	29	32	49	67	80
Agriculture	IE	IE	6	7	7	7	9	8	6	6	6	5	6
Residential plants	12415	9468	7881	7040	7474	8899	11897	11127	11078	11135	11218	10885	11819
Combustion processes in industry	981	805	584	646	703	751	806	897	881	883	662	940	997
Comb. in boilers, gas turb. and stat. eng.	206	150	158	146	168	120	121	117	94	94	90	87	84
Iron production	32	29	28	32	35	34	33	37	36	32	27	33	30
Ore agglomeration	438	358	396	383	409	402	384	390	367	338	213	273	321
Copper production	305	268	2	85	91	195	268	353	384	419	332	548	562
Production processes	27029	11129	8717	7728	7152	7104	6434	5821	5474	4903	4338	4841	4841
Processes in petroleum industries	17188	7474	6627	5571	4672	4617	4058	3469	3166	2804	2623	2693	2636
Coke production	1053	834	719	765	801	800	783	787	783	720	450	900	684
Steel production	43	36	34	40	43	41	41	47	47	42	36	45	39
Rolling mills	233	297	300	304	336	329	341	361	372	347	295	318	304
Aluminium production	0,101	0,049	0,165	0,165	0,167	0,235	0,2	0,2	0,3	0,2	0,2	0,2	0,2
Proc. in organic chemical industries	6437	1369	651	690	941	970	870	845	793	667	609	584	881
Food production	2073	1118	385	357	358	346	340	311	312	322	324	301	296
Road paving with asphalt	2,4	1	0,5	0,5	0,6	0,5	0,7	0,5	0,7	0,8	0,8	0,7	0,8
Exploitation&distrib. of natural resour.	8822	8535	5929	6024	7431	7696	7104	6276	6170	6363	6207	5864	6039
Exploitation&distribution of crude oil	5198	4298	3750	3801	3999	4149	4280	4472	4266	4272	4324	4037	3975
Distribution of fuel	3624	4237	2179	2223	3432	3547	2824	1804	1904	2091	1883	1827	2064
Solvent and other products use	52875	37065	26978	31020	32272	32760	33561	34634	33579	33964	33330	31860	36897
Use of paints and glues	32811	20687	13214	15110	16369	18457	18918	19522	20003	20385	20365	20279	20251
Dry cleaning and degreasing	11500	7695	5092	7332	7408	5822	6101	6600	5057	5052	4412	3005	8101
Processing of fat and oil	332	363	299	240	156	134	189	152	147	138	144	152	169
Products	8232	8320	8374	8338	8339	8347	8353	8360	8372	8389	8409	8425	8377
Road transport	27334	24129	14041	15136	13121	12465	11974	10362	8710	8834	7325	6596	6420
Other transport	953	599	528	500	460	469	488	449	484	455	417	594	422
Waste incineration	4631	388	190	130	139	154	150	182	138	121	134	152	168
Municipal waste	71	107	147	111	115	130	130	135	128	112	126	101	130
Industrial waste	281	281	43	19	23	21	17	44	8	7	5	48	34
Hospital waste	IE	IE	0,1	0,1	2	2	3	4	3	3	3	3	3
Agricultural waste*	4279												
Agriculture	651	436	436	436	436	436	436	436	437	438	439	440	438
Total	136252	92962	65517	68904	69433	70969	73072	70394	67144	67307	64282	62405	68286

Emissions from transport estimated to December 31th, 2013, emissions from the other sectors estimated to December 15th, 2013.
IE = included in other source category
** Agricultural waste combustion is prohibited since 1994*
Because of changeover from EAPSI to NEIS in year 2000 some changes of source appointment have to be done in the framework of subsectors combustion in boilers, gas turbines and stationary engines; commercial and institutional plants and new sector agriculture (sector non-industrial combustion plants) was established.

Fig. 4.4 **Development trends in NMVOC emissions in 1990 – 2011**

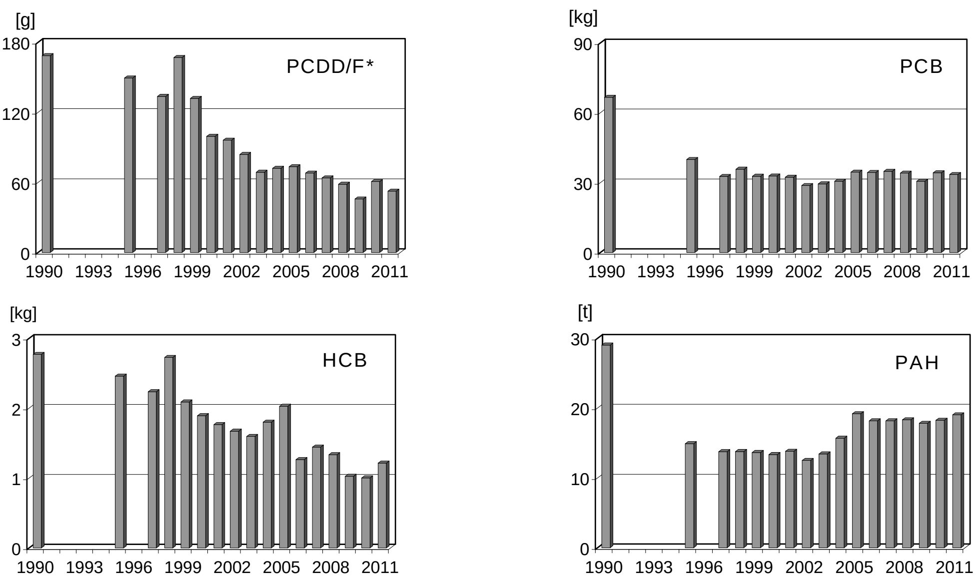


Tab. 4.8 **Emissions of persistent organic pollutants in the SR in 2011**

Sector / Subsector	PCDD/F*	PCB	HCB	PAH				
				sum PAH	B(a)P	B(k)F	B(b)F	I(1,2,3-cd)P
	[g]	[kg]	[kg]	[kg]	[kg]	[kg]	[kg]	[kg]
Combustion processes I	6.582	0.536	0.195	1389.616	151.782	390.761	390.893	456.180
Public power	1.785	0.506	0.179	10.114	0.073	4.890	5.023	0.127
District heating plants	0.238	0.029	0.016	11.824	0.029	5.871	5.871	0.053
Coke production	4.560			1 367.679	151.679	380.000	380.000	456.000
Combustion processes II	3.343	9.035	0.176	16050.126	4598.227	2002.961	6036.611	3412.327
Commercial and institutional plants	0.036	0.006	0.002	1.274	0.006	0.624	0.634	0.010
Residential plants	3.303	9.028	0.173	16048.693	4598.216	2002.273	6035.896	3412.308
Agriculture	0.004	0.001	0.000	0.159	0.005	0.065	0.081	0.008
Combustion processes in industry	21.787	3.927	0.195	108.830	61.714	17.647	22.163	7.307
Comb. in boilers, gas turb. and stat. eng.	0.486	0.573	0.093	17.455	1.279	4.860	9.243	2.072
Iron production	0.335	0.021		56.889	56.889			
Ore agglomeration	20.441	3.212	0.093	34.078	3.504	12.703	12.703	5.169
Cast iron production	0.108	0.021		0.017	0.003	0.006	0.006	0.003
Others	0.418	0.100	0.009	0.392	0.039	0.079	0.211	0.063
Production processes	6.115	1.781	0.583	1175.983	428.055	347.848	354.758	45.322
Aluminium production	0.340	0.057		597.798	195.409	188.900	188.900	24.589
Steel production	4.534	1.660		73.699	73.699			
Carbon mineral production				504.486	158.947	158.947	165.858	20.732
Wood impregnation								
Others	1.241	0.063	0.583					
Road transport	0.398	14.830	0.012	143.688	21.564	48.352	49.310	24.463
Other transport	0.007	0.741	0.001	8.897	2.224	1.335	3.114	2.224
Waste incineration	14.329	2.670	0.054	160.538	45.049	31.950	66.303	17.235
Municipal waste	0.074	0.983	0.019	7.210	0.130	3.524	3.524	0.032
Industrial waste	1.711	0.034	0.000	0.133	0.002	0.065	0.065	0.001
Hospital waste	11.722	1.563	0.022	6.075	0.109	2.970	2.970	0.027
Others	0.822	0.090	0.013	147.119	44.808	25.391	59.744	17.176
Total	52.564	33.519	1.215	19037.679	5308.616	2840.854	6923.152	3965.057

B(a)P - Benzo(a)pyrene, B(k)F - Benzo(k)fluorantene, B(b)F - Benzo(b)fluorantene, I(1,2,3-cd)P - Indeno(1,2,3-cd)pyrene
**Expressed as I-TEQ; I-TEQ is calculated from the values for 2,3,7,8 - substituted co-geners of PCDD and PCDF under using of I-TEF according NATO/CCMS (1988).*
Emissions estimated to February 15th, 2013.

Fig. 4.5 **Development trends in POPs emissions in 1990 – 2011**

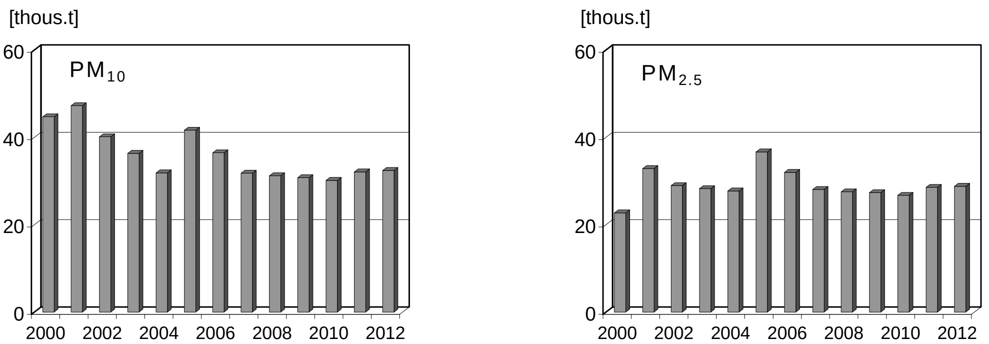


Tab. 4.9 **PM_{10} and $PM_{2.5}$ emissions [thous. t] in the SR in 2007 – 2012**

Sector / Subsector	2007		2008		2009		2010		2011		2012	
	PM_{10} [Gg]	$PM_{2,5}$ [Gg]	PM_{10} [Gg]	$PM_{2,5}$ [Gg]	PM_{10} [Gg]	$PM_{2,5}$ [Gg]	PM_{10} [Gg]	$PM_{2,5}$ [Gg]	PM_{10} [Gg]	$PM_{2,5}$ [Gg]	PM_{10} [Gg]	$PM_{2,5}$ [Gg]
Combustion processes I	1.438	1.048	1.307	0.939	1.227	0.878	1.200	0.877	1.253	0.936	1.193	0.869
Public Electricity and Heat Production	0.743	0.612	0.696	0.561	0.649	0.518	0.619	0.522	0.703	0.600	0.635	0.528
Petroleum refining	0.112	0.089	0.076	0.061	0.083	0.066	0.049	0.039	0.047	0.037	0.047	0.037
Coke production	0.583	0.346	0.535	0.317	0.495	0.294	0.532	0.316	0.503	0.299	0.511	0.303
Combustion processes II	25.296	23.048	25.431	23.145	25.589	23.460	24.773	22.594	26.993	24.739	27.193	24.907
Commercial and institutional plants	0.136	0.094	0.173	0.124	0.137	0.102	0.147	0.114	0.147	0.117	0.156	0.128
Residential plants	25.044	22.903	25.137	22.967	25.353	23.311	24.508	22.431	26.722	24.573	26.931	24.734
Agriculture	0.067	0.031	0.077	0.035	0.068	0.031	0.081	0.034	0.088	0.035	0.069	0.030
Other combustion processes	0.048	0.019	0.044	0.020	0.032	0.016	0.036	0.016	0.036	0.014	0.037	0.015
Combustion processes in industry	2.041	1.485	1.762	1.295	1.603	1.158	1.506	1.092	1.383	0.946	1.436	0.948
Production of iron and steel	0.556	0.395	0.470	0.324	0.395	0.287	0.515	0.376	0.484	0.330	0.487	0.304
Production of non-ferrous metals	0.136	0.117	0.193	0.166	0.178	0.155	0.169	0.146	0.097	0.081	0.099	0.085
Chemical industry	0.225	0.179	0.226	0.187	0.243	0.193	0.218	0.183	0.194	0.164	0.201	0.149
Production of paper and cellulose	0.086	0.056	0.082	0.049	0.149	0.102	0.094	0.040	0.141	0.057	0.208	0.111
Food production	0.048	0.028	0.042	0.022	0.036	0.019	0.036	0.019	0.037	0.018	0.034	0.016
Other combustion processes in industry	0.991	0.710	0.748	0.546	0.601	0.404	0.475	0.329	0.429	0.296	0.407	0.283
Transport	2.889	2.447	2.583	2.113	2.247	1.826	2.562	2.102	2.460	2.013	2.492	2.030
Civil aviation	0.010	0.010	0.012	0.012	0.009	0.009	0.008	0.008	0.008	0.008	0.007	0.007
Road transport	1.643	1.643	1.299	1.299	1.089	1.089	1.248	1.248	1.221	1.221	1.225	1.225
Road transport - abrasion	0.909	0.485	0.976	0.521	0.876	0.470	0.948	0.506	0.928	0.496	0.964	0.516
Railways	0.141	0.133	0.128	0.122	0.111	0.105	0.113	0.107	0.109	0.104	0.092	0.088
Navigation	0.185	0.176	0.169	0.160	0.161	0.153	0.244	0.231	0.195	0.185	0.204	0.194
Industrial technologies	0.151	0.063	0.148	0.058	0.124	0.052	0.120	0.051	0.156	0.075	0.136	0.067
Mineral products	0.041	0.003	0.043	0.004	0.033	0.003	0.033	0.003	0.029	0.002	0.023	0.002
Chemical industry	0.069	0.042	0.063	0.039	0.058	0.036	0.057	0.035	0.098	0.060	0.088	0.053
Paper and pulp	0.001	0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001
Other industrial processes	0.040	0.016	0.041	0.015	0.032	0.013	0.029	0.012	0.028	0.012	0.025	0.011
Total	31.814	28.091	31.230	27.551	30.790	27.374	30.161	26.715	32.245	28.709	32.449	28.820

Emissions estimated to January 24th, 2014.

Fig. 4.6 **Development trends in PM_{10} and $PM_{2.5}$ emissions in 2000 – 2012**



Tab. 4.10 **Emissions of heavy metals [t] in the SR in 2011**

Sector / Subsector	Pb	As	Cd	Cr	Cu	Hg	Ni	Se	Zn
Combustion processes I	2.123	0.398	0.091	0.062	0.074	0.064	0.184	0.008	3.066
Public power	0.026	0.239	0.001	0.059	0.041	0.004	0.182	0.008	0.069
District heating plants	2.096	0.159	0.090	0.003	0.033	0.060	0.002	0.000	2.997
Combustion processes II	1.259	0.491	0.037	0.241	0.371	0.035	0.237	0.039	3.567
Commercial and institutional plants	0.232	0.046	0.010	0.010	0.012	0.007	0.009	0.001	0.338
Residential plants	1.010	0.441	0.026	0.231	0.357	0.027	0.227	0.038	3.205
Agriculture	0.016	0.004	0.001	0.001	0.001	0.000	0.001	0.000	0.024
Combustion processes in industry	41.635	21.840	0.511	1.872	41.353	0.471	9.231	10.514	28.541
Comb. in boilers, gas turb. and stat. engines	1.462	0.266	0.069	0.348	0.177	0.091	5.389	0.139	1.875
Iron production	0.114	0.010	0.181	0.860	0.067	0.288	0.499	0.037	7.165
Glass production	4.222	0.300	0.041	0.580	0.145	0.012	0.459	4.352	2.660
Ore agglomeration	19.813	0.029	0.012	0.064	6.512	0.047	2.865	0.920	10.366
Copper production	15.865	21.224	0.208		34.451	0.001		5.066	6.433
Cement production	0.159	0.002	0.0005	0.017		0.033	0.018	0.0003	0.041
Aluminium oxide production									
Magnesite production	0.0004	0.0082	0.0006	0.0018	0.0012	0.00003	0.0004		0.0022
Production processes	1.499	0.077	0.035	0.784	2.633	0.186	7.249	0.013	14.212
Steel production	1.197	0.065	0.013	0.152	2.363	0.013	2.389	0.013	4.986
Aluminium production			0.0163				1.6284		1.6284
Ferro alloys production	0.096	0.007	0.003	0.002	0.004		0.001		0.466
Pig iron production	0.1302	0.0054	0.0027	0.0217	0.0000		0.0109		0.0923
Galvanizing	0.0700			0.6090	0.2100		3.2200		6.0900
Alloys (Cu-Zn) production	0.006				0.057				0.950
Inorganic chemical industry						0.1732			
Road transport	2.977		0.024	0.410	10.213		0.191	0.027	4.516
Other transport			0.0007	0.0037	0.1260		0.0052	0.0007	0.0741
Waste incineration	9.668	0.011	0.577	0.853	1.263	0.451	0.505	0.005	3.946
Municipal waste	8.347	0.009	0.464	0.835	1.150	0.334	0.501	0.002	3.153
Industrial waste	1.200	0.002	0.103	0.016	0.103	0.103	0.003	0.002	0.720
Hospital waste	0.120	0.0002	0.010	0.002	0.010	0.010	0.0003	0.0002	0.072
Cremation						0.004			
Total	59.161	22.817	1.276	4.226	56.033	1.207	17.602	10.607	57.922

Emissions estimated to December 15th, 2013

Fig. 4.7 **Development trends in heavy metals emissions in 1990 – 2011**