Slovak
Hydrometeorological Institute

Ministry of Environment
of the Slovak Republic

AIR POLLUTION

IN THE SLOVAK REPUBLIC

2008

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Report was elaborated by

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C O N T E N T

AMBIENT AIR

EMISSIONS

AMBIENT AIR

1

REGIONAL AIR POLLUTION AND QUALITY OF PRECIPITATION

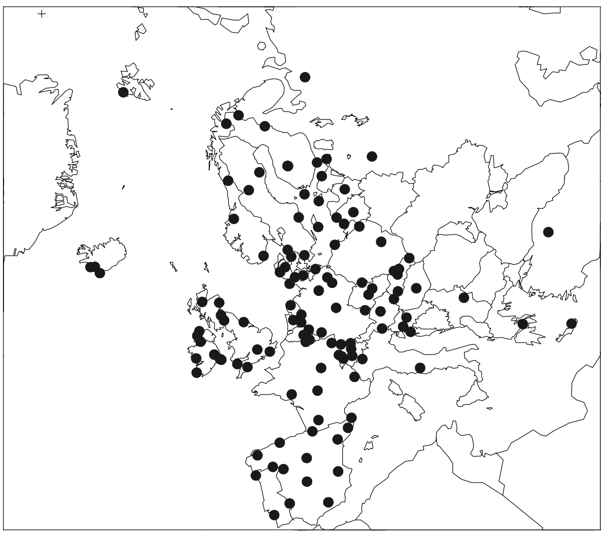
1.1 REGIONAL AIR POLLUTION AND QUALITY OF PRECIPITATION

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 have to be reduced 72% by 2010, as compared to 1980. According to the last Protocol (Gothenburg, 1999) the Slovak Republic shall 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 HM Protocol the priority remains on three main metals, cadmium, lead and mercury. PM 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 approximately 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.

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



The EMEP monitoring programme has been gradually extended. 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 CCC - NILU. 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). Since 2003 the monitoring strategy has been revised more times and its actual version is also on www.emep.int.

1.2 EMEP STATIONS OF NATIONAL AIR QUALITY MONITORING NETWORK

In 2008, there were 4 EMEP stations of National Monitoring Network in operation in the Slovak Republic to monitor regional air pollution and chemical composition of precipitation. Locations and elevations of the individual stations are indicated in Figure 1.2. All these stations are part of the European EMEP network.

EMEP stations

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 been a part of the EMEP network and GAW/BAPMoN 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.

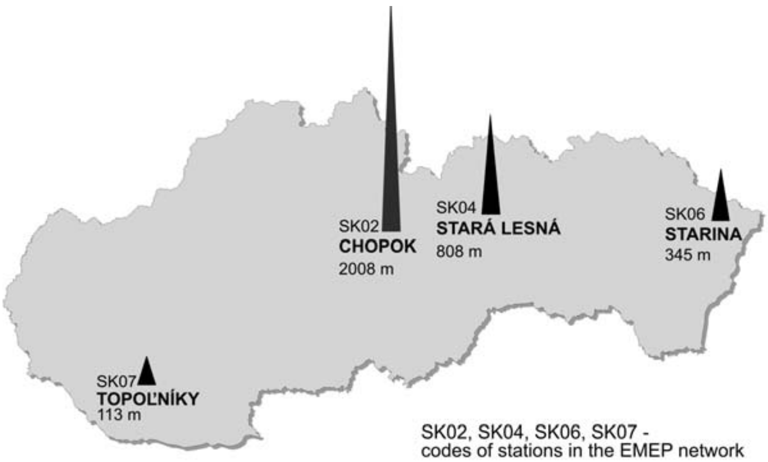
Topoľníky

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 – 2008**



Measurement programme

AMBIENT AIR

Station	Ozone (O_3)	Sulphur dioxide (SO_2)	Oxides of nitrogen (NO_x)	Sulphates (SO_4^{2-})	Nitrates (NO_3^-)	Nitric acid (HNO_3)	Ammonia, ammon. ions (NH_3, NH_4^+)	Alkali ions (K^+, Na^+, Ca^{2+}, Mg^{2+})	VOC	PM_{10} [1]	TSP* [1]	Lead (Pb)	Arsenic (As)	Cadmium (Cd)	Nickel (Ni)	Chromium (Cr)	Copper (Cu)	Zinc (Zn)	Polyaromatic hydrocarbons (BaP)
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
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* [1] *weekly sampling*

ATMOSPHERIC PRECIPITATION

Station	pH	Conductivity	Sulphates (SO_4^{2-})	Nitrates (NO_3^-)	Ammonium ions (NH_4^+)	Alkali ions (K^+, Na^+, Ca^{2+}, Mg^{2+})	Chlorides (Cl^-)	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

1.3 ASSESSMENT OF RESULTS FROM MEASUREMENTS IN 2008

Sulphur dioxide, sulphates

Background concentrations of sulphur dioxide recalculated in sulphur (Tab. 1.1, Fig. 1.3) reached 0.15 μg.m^{-3} on the Chopok station and 0.66 μg.m^{-3} on the Starina station, in 2008. ***In coincidence with the Annex 1 to the Decree of the Ministry of Environment of the Slovak Republic No 705/2002 on air quality, the limit value for protection of ecosystems is 20 μg SO_2.m^{-3} in calendar year and winter season. This value has been exceeded neither at the calendar year (Chopok 0.3 μg $S0_2$.m^{-3} and Starina 1.3 μg $S0_2$.m^{-3}), nor in winter season (Chopok 0.2 μg $S0_2$.m^{-3} and Starina 2.2 μg $S0_2$.m^{-3}).*** Sulphates contributed to the total weight mass of particulate matter (Fig. 1.4) 19.6% on the Chopok station and 17.1% on the Starina station. Concentration ratio of sulphates to sulphur dioxide, recalculated in sulphur represents interval 1.5 on the Chopok station and 1.2 on the Starina station.

Oxides of nitrogen, nitrates

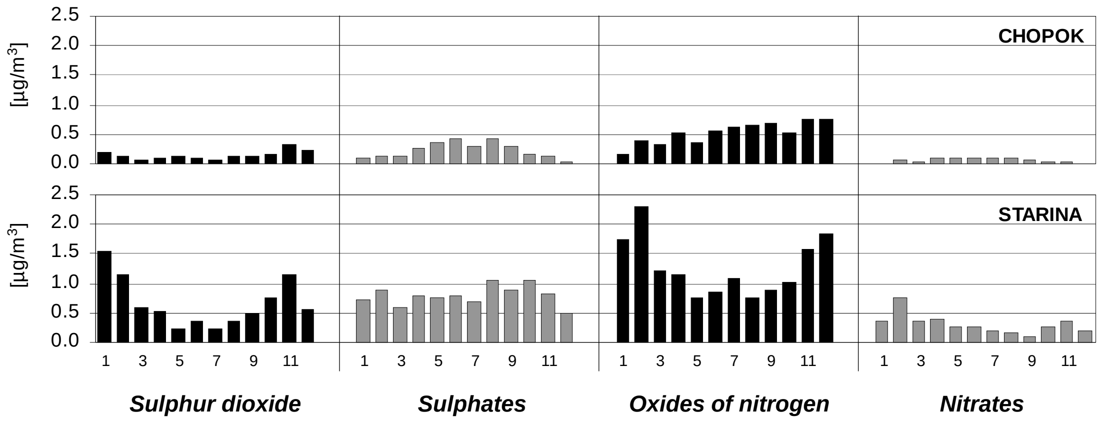
Background level of concentrations of oxides of nitrogen, recalculated in nitrogen (Tab. 1.1, Fig. 1.3) presented 0.54 μg.m^{-3} on the Chopok station and 1.27 on the Starina station, in 2008. ***In coincidence with the Annex 1 to the Decree of the Ministry of Environment of the Slovak Republic No 705/2002 on air quality, the limit value for protection of vegetation is 30 μg NO_x.m^{-3} in calendar year. This limit value was not exceeded in calendar year. (Chopok 1.78 μg NO_x.m^{-3} and Starina 4.19 μg NO_x.m^{-3}).*** Nitrates in ambient air on the Chopok and Starina stations occurred predominantly in the form of particles in 2008. Concentrations of nitric acid were substantially lower in 2008 as compared to particulate nitrates on the Chopok and Starina stations. 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 8.1% on the Chopok station and 9.6% 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 0.12 at the Chopok station and 0.25 at the Starina station.

Tab. 1.1 **Annual averages of gaseous and particulate components in ambient air, 2006 – 2008**

		SO_2 (S) µg.m⁻³	SO_4^{2-} (S) µg.m⁻³	NO_x (N) µg.m⁻³	NO_3^- (N) µg.m⁻³	HNO_3 (N) µg.m⁻³	O_3 µg.m⁻³	PM_{10} µg.m⁻³	Pb ng.m⁻³	Cu ng.m⁻³	Cd ng.m⁻³	Ni ng.m⁻³	Cr ng.m⁻³	Zn ng.m⁻³	As ng.m⁻³
Chopok	2006	0.27	0.33	0.59	0.09	0.02	**96	*7.0	2.67	1.24	0.08	0.60	0.97	6.40	0.22
	2007	0.18	0.27	0.72	0.08	0.01	92	*5.1	1.59	0.84	0.05	0.44	0.60	4.14	0.13
	2008	0.15	0.23	0.54	0.06	0.01	92	*3.5	1.31	0.64	0.04	0.28	0.51	4.36	0.11
Topoľníky	2006	1.34	1.37	2.80	0.97	0.04	60	*24.5	13.10	3.59	0.31	2.83	2.94	20.84	1.26
	2007	-	-	-	-	-	58	23.2	11.09	4.11	0.28	1.15	1.01	19.44	0.83
	2008	-	-	-	-	-	60	18.0	8.82	3.02	0.24	0.63	0.81	18.00	0.84
Starina	2006	1.36	1.23	1.24	0.38	0.05	**62	19.2	11.18	1.99	0.31	0.69	0.72	16.32	0.76
	2007	0.80	0.86	1.24	0.32	0.02	63	17.7	8.46	2.10	0.29	0.58	0.59	12.61	0.45
	2008	0. 66	0.79	1.27	0.3	0.02	59	13.9	6.58	1.56	0.22	0.51	0.61	11.81	0.49
St. Lesná	2006	0.77	1.01	1.52	0.34	0.05	73	14.9	9.36	2.21	0.23	0.51	0.64	16.32	0.67
	2007	-	-	-	-	-	68	12.6	5.92	2.39	0.20	0.44	0.48	13.03	0.52
	2008	-	-	-	-	-	74	11.6	5.80	1.75	0.16	0.35	0.36	13.34	0.58

SO_2, SO_4^{2-} – recalculated in sulphur *NO_x, NO_3^-, HNO_3 – recalculated in nitrogen*
** TSP (total suspended particles)* *** 50 – 75% of measurements*

Fig. 1.3 **Monthly mean concentrations of sulphur and nitrogen compounds in ambient air – 2008**
(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. Averaged concentrations of these components (NH_3 and NH_4^+ recalculated in nitrogen) for years 2007 and 2008 are listed in Table. In the Stará Lesná station these ions have been measured until the beginning of September 2007 and since July 2007 the measurements started to be measured at the Starina station. In 2008 these measurements were running only at the Starina station.

Station	Year	NH_3 (N) [µg.m⁻³]	NH_4^+ (N) [µg.m⁻³]	Na^+ [µg.m⁻³]	K^+ [µg µg.m⁻³]	Mg^{2+}[µg.m⁻³]	Ca^{2+} [µg.m⁻³]
Stará Lesná	2006	0.36	1.05	0.19	0.18	0.02	0.15
	2007*	0.40	0.77	0.09	0.15	0.03	0.14
Starina	2007**	0.18	0.80	0.08	0.14	0.02	0.08
	2008	0.20	0.78	0.08	0.12	0.02	0.10

** until September 2007* *** since July 2007*

PM_{10}, resp. TSP, heavy metals and benzo(a)pyrene (BaP)

In Tab. 1.1 are presented the concentrations of PM_{10} (Stará Lesná, Starina, Topoľníky), variating within range of 11.6 – 18 $\mu g.m^{-3}$ and TSP 3.5 $\mu g.m^{-3}$ (Chopok) in 2008. Concentrations of heavy metals from PM_{10}, resp. TSP are listed in Table 1.1 and Figure 1.4. The share of the sum of all measured metals in mass weight of suspended particles (PM_{10}, resp. TSP) varied at regional stations within 0.16 – 0.21%. BaP has been measured at the Starina (annual average 0.20 $ng.m^{-3}$) and Topoľníky stations (annual average 0.50 $ng.m^{-3}$).

Fig. 1.4 **Heavy metals in ambient air – 2008**

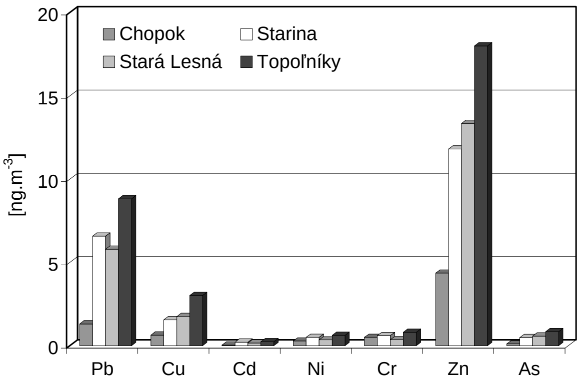
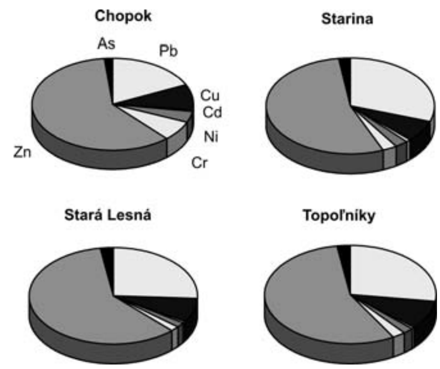


Fig. 1.5 **Proportional share of heavy metals – 2008**

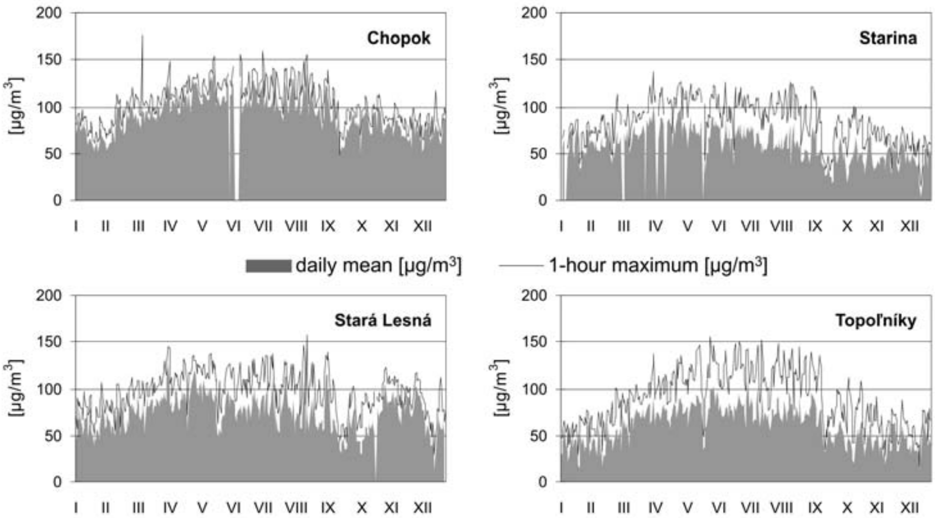


Ozone

In Figures 1.6 the annual course of ground level ozone concentrations at the regional stations Chopok, Stará Lesná, Starina and Topoľníky 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 2008, the annual average of ozone concentration at the Chopok station reached 92 $\mu g.m^{-3}$, at Starina 59 $\mu g.m^{-3}$, Stará Lesná 74 $\mu g.m^{-3}$, and Topoľníky 60 $\mu g.m^{-3}$. Measurements of ozone and exceedances of critical levels are completely assessed in Chapter 3 Atmospheric Ozone.

An increase in ozone concentrations was observed within 1970 – 1990, on average 1 $\mu g.m^{-3}$ annually. After 1990 the increase slowed down or stopped in compliance with the other European observations. This trend does correspond to the European development of ozone precursors.

Fig. 1.6 **Ground level ozone [μg.m^{-3}] – 2008**



VOCs $C_2 – C_6$

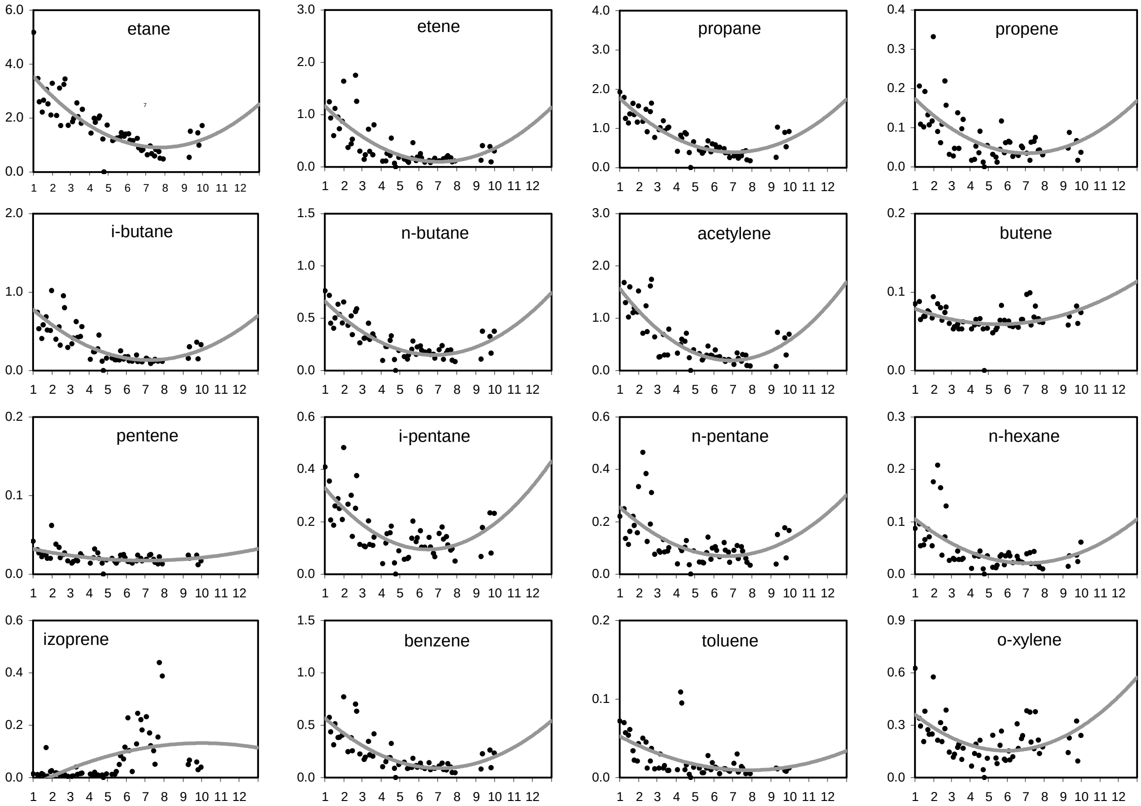
VOCs (Volatile Organic Compounds) $C_2 – C_6$, or the so-called light hydrocarbons, started to be sampled in autumn 1994 at the Starina station. Starina is one of the few European stations, included into the EMEP network with regular sampling of volatile organic compounds. They are measured and assessed 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 (Tab. 1.2, Fig. 1.7). Etane is the most abundant, then propane, acetylene and etene. Remarkable is presence of isoprene releasing from the near leafy forest.

Tab. 1.2 **Annual averages of VOCs [ppb] in ambient air, Starina, 2006 – 2008**

	etane	etene	propane	propene	i-butane	n-butane	acetylene	butene	pentene	i-pentane	n-pentane	izoprene	n-hexane	benzene	toluene	o-xylene
2006	2.034	0.746	0.915	0.119	0.284	0.350	0.879	0.048	0.035	0.270	0.160	0.107	0.085	0.334	0.043	0.247
2007	1.804	0.648	0.797	0.117	0.343	0.314	0.534	0.067	0.024	0.241	0.132	0.150	0.053	0.240	0.023	0.262
2008*	1.708	0.390	0.786	0.073	0.311	0.294	0.564	0.065	0.022	0.160	0.121	0.069	0.045	0.220	0.023	0.214

** average for nine month (I-IX), due to long-term failure of GC*

Fig. 1.7 **VOCs [ppb] – Starina – 2008**



Atmospheric precipitation

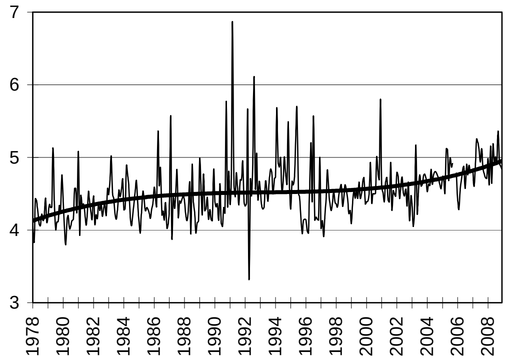
Major ions, pH, hydrogen ions, conductivity

In 2008 the amount of precipitation recorded at background stations ranged between 528 and 1353 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 ranged from 4.75 to 5.30 (Tab. 1.3, Fig. 1.9). Figure 1.9 illustrates the annual courses of pH, sulphates and nitrates at the Chopok station based upon the daily sampling. Time series and trend of pH values within a long-time period indicate clearly the decrease in acidity (Fig. 1.8).

Concentrations of dominant sulphates in precipitation recalculated in sulphur varied within the range 0.37 – 0.52 mg.l^{-1}. Concentrations of sulphates on the three higher situated stations are very similar in annual mean and slightly lower at the lowlands Topoľníky station. Total decrease of sulphates in long-term time series has corresponded to the SO_2 emission reduction since 1980.

The share of nitrate in acidity of precipitation was substantially smaller than those of sulphates and varied within the concentration range, recalculated in nitrogen 0.27 – 0.32 mg.l^{-1}. Ammonium ions also do belong to the major ions and their concentration range was 0.27–0.48 mg.l^{-1}.

Fig. 1.8 **pH in daily precipitation – Chopok**

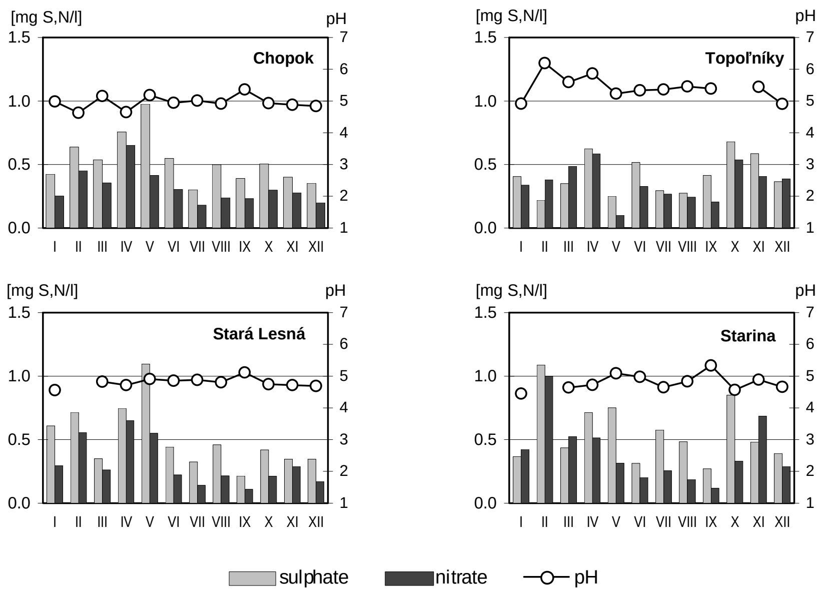


Tab.1.3 **Annual averages of main components in daily precipitation - 2006 – 2008**

		Precip. mm	pH	Cond. µS.cm^{-1}	SO_4^{2-}(S) mg. l^{-1}	NO_3^- (N) mg. l^{-1}	NH_4^+(N) mg. l^{-1}	Cl^- mg. l^{-1}	Na^+ mg. l^{-1}	K^+ mg. l^{-1}	Mg^{2+} mg. l^{-1}	Ca^{2+} mg. l^{-1}
Chopok	2006	908	4.75	12.9	0.48	0.31	0.48	0.14	0.08	0.06	0.02	0.09
	2007	1087	4.93	13.3	0.54	0.30	0.43	0.19	0.23	0.07	0.04	0.15
	2008	1353	4.93	13.3	0.49	0.29	0.43	0.23	0.18	0.08	0.04	0.16
Topoľníky	2006	456	5.08	14.2	0.47	0.40	0.54	0.19	0.13	0.07	0.06	0.25
	2007	551	5.07	13.3	0.49	0.34	0.49	0.18	0.14	0.10	0.06	0.31
	2008	528	5.30	11.7	0.37	0.32	0.48	0.22	0.16	0.08	0.08	0.37
Starina	2006	788	4.52	17.3	0.49	0.40	0.39	0.17	0.14	0.12	0.05	0.20
	2007	738	4.54	18.4	0.54	0.38	0.32	0.19	0.19	0.08	0.03	0.18
	2008	858	4.75	16.1	0.52	0.32	0.32	0.21	0.16	0.08	0.04	0.23
Stará Lesná	2006	609	4.63	15.3	0.52	0.35	0.42	0.31	0.24	0.07	0.04	0.21
	2007	790	4.80	16.4	0.54	0.28	0.58	0.28	0.25	0.18	0.04	0.26
	2008	747	4.82	15.6	0.48	0.27	0.27	0.29	0.28	0.09	0.04	0.24

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

Fig. 1.9 **Daily precipitation – 2008**



Heavy metals

Since 2000 the measurement programme of heavy metals in precipitation has been gradually modified to meet the present requirements of the CCC EMEP monitoring strategy. In Bratislava-Jeséniova the measurement of the same set of heavy metals in precipitation was implemented as in background stations of Slovakia (Table 1.4). This station serves however only for comparison and is not assessed as the background station. The results of annual weighted means of heavy metals concentrations in monthly precipitation within 2004 – 2006 are presented in Table 1.4.

Tab. 1.4 **Annual averages of heavy metals in monthly precipitation, 2006 – 2008**

		Precip. mm	Pb $\mu g.l^{-1}$	Cd $\mu g.l^{-1}$	Cr $\mu g.l^{-1}$	As $\mu g.l^{-1}$	Cu $\mu g.l^{-1}$	Zn $\mu g.l^{-1}$	Ni $\mu g.l^{-1}$
Chopok	2006	687	3.60	0.16	0.33	0.60	2.37	33.5	0.61
	2007	941	1.94	0.06	0.13	0.15	0.70	20.36	0.48
	2008	1159	3.39	0.09	0.22	0.17	1.41	20.92	0.64
Topoľníky	2006	502	2.39	0.09	*0.11	*0.30	*1.39	*7.1	*0.77
	2007	571	0.92	0.04	0.07	0.10	1.28	9.21	0.44
	2008	560	1.30	0.05	0.11	0.11	3.03	11.92	0.84
Starina	2006	749	2.28	0.09	*0.07	*0.19	*1.19	*8.4	*0.34
	2007	625	1.72	0.06	0.07	0.13	1.93	9.76	0.40
	2008	708	2.12	0.06	0.12	0.16	1.67	10.17	0.60
Stará Lesná	2006	603	2.24	0.22	*0.09	*0.25	*1.36	*10.8	*0.39
	2007	673	1.18	0.09	0.08	0.13	0.99	10.74	0.28
	2008	616	2.05	0.14	0.10	0.17	3.40	13.74	0.62
Bratislava	2006	711	2.50	0.09	*0.19	*0.28	*2.84	*16.4	*0.77
	2007	554	2.01	0.07	0.21	0.22	2.31	15.8	1.07
	2008	625	1.45	0.05	0.20	0.16	2.89	14.55	0.57

* *weighted mean within the period of January to May 2006*

Conclusion

In coincidence with the EMEP measurements the Slovak Republic is situated on the south-east boundary of a territory with the highest regional air pollution and acidity of precipitation in Europe. Development of regional air pollution and chemical composition of precipitation corresponds to the development of European emissions.

AMBIENT AIR

2

LOCAL AIR POLLUTION

2.1 LOCAL AIR POLLUTION

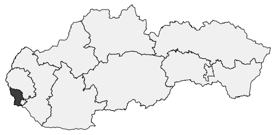
Air quality assessment is claimed by Air Protection Act No 478/2002 Coll. as amended. Criterions for air quality assessment (upper and lower assessment thresholds, margin of tolerance, limit and target values) are given in Decree No 705/2002 Coll. about Air Quality amended by Decree No 351/ 2008 Coll. 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 disseminated into the most polluted towns and industrial areas.

In 1991 modernization of the air quality monitoring network began. The manual stations were gradually substituted 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 2008, 29 stations (without EMEP 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}). In the year 2008 measurements of benzene were carried out at 10 and $PM_{2,5}$ at 3 automatic stations. The air pollution monitoring by heavy metals (Pb, Cd, As and Ni) were performed at 6 localities and benzo(a)pyrene on 6 sites.

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, NOx, Pb, PM_{10}, $PM_{2.5}$, benzene and CO. The delimitation of zones is identical with the higher administrative units – regions. From Bratislava and Košice regions geographical extension of cities Bratislava and Košice were selected and these cities are assessed separately as agglomerations. According to the Decree No 705/2002 Coll. about Air Quality amended by Decree No 351/ 2007 Coll. for pollutants: As, Cd, Ni, BaP, Hg and O_3 was territory of Slovakia divided only into agglomeration Bratislava and rest represents zone Slovakia.

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



AGGLOMERATION - BRATISLAVA

AREA: 368 km^2 POPULATION: 428 791

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 are concentrated in a relatively small area between the south and 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 secondary source of air pollution in the city.

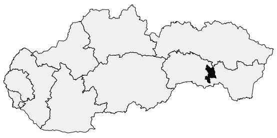
Location of stations

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 scarce built-up area, where family houses prevail.

Bratislava - Mamateyova
The station is located in open are at 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 an east wind direction.

Bratislava - Trnavské mýto
The station is situated near to a busy crossroad formed by Šancová and Trnavská street – Krížna and Vajnorská street. As far as traffic emissions are concerned, this location is an extremely polluted one. It represents location with extreme high emissions from road transport.

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 old part of the city. Besides of transport this location is polluted by major sources, mainly Slovnaft, Ltd., from a south-east wind directions.



AGGLOMERATION - KOŠICE

AREA: 245 km^2 POPULATION: 233 659

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. Energy sources, including the city heating plants and local boiler rooms emit lesser amounts of pollutants.

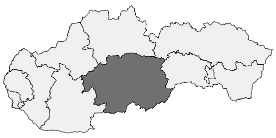
Location of stations

Košice - Štúrova

This is a city centre station. It is placed in an open area, at the edge of large parking area and small park. The station is located at a distance of about 10 m north from the inner circle roads and 50 m south from the second route of this circle.

Košice – Strojárska

Station is situated in open area 10 m far from 2-storey buildings, separated by green alley from near road which is in distance of about 15 m.



ZONE - BANSKÁ BYSTRICA REGION

AREA: 9 455 km^2 POPULATION: 653 697

Characterization of area

Banská Bystrica

The town is located in the Bystrica valley, which is by the northern part of the Zvolenská 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 of about 33%. 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 situations. 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. The major share in air pollution is due to aluminium production and power generation.

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. The major part of air pollution is caused by emissions from transport and wood processing industry.

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

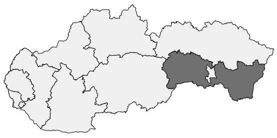
The station is situated in open area on the north edge of the town, approximately 50 m far from state road No 531.

Žiar nad Hronom - Dukelských hrdinov

The station is placed on a boundary-line between 4-storey housing and an open space, passing down, out of the station

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.



ZONE - BRATISLAVA REGION

AREA: 1 685km^2 POPULATION: 187 787

Characterization of area

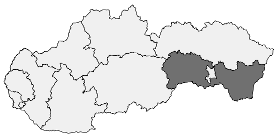
Malacky

Region Malacky spreads out northerly from the capital of the Slovak Republic, Bratislava. It is located in the southern part of Zahorska 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: 6 508 km^2 POPULATION: 541 850

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 Abovské 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 of extracting ores.

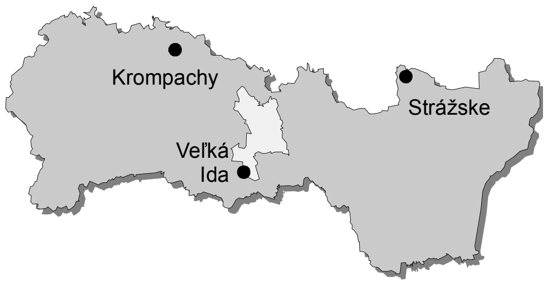
Location of stations

Krompachy - Lorenzova

The station is located in the valley of the Slovinský potok, on the western edge of the town 2 km south-west of the ferrous metal plant Kovohuty Krompachy. The surrounding built-up area comprises multi-storey houses. It is a valley position with an increased occurrence of inversions.

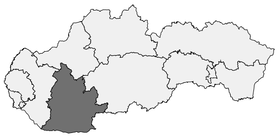
Veľká Ida - Letná

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.



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.



ZONE - NITRA REGION

AREA: 6 343 km^2 POPULATION: 706 375

Characterization of area

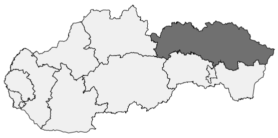
Nitra

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 - Janka Kráľa
Station is situated in the build up area of the town. It is placed at the courtyard of KÚ ŽP Nitra surrounded by 2 storey houses and threes. This location is temporally and it will be placed back on the former place.

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: 8 993 km^2 POPULATION: 803 955

Characterization of area

Prešov

Prešov lies in the northern promontory of Košice's basin. The surrounding mountains of the Šariš's highland and the Slánské 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, 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

Prešov - Solivarská

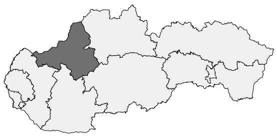
The station is located in the south-eastern part of the town in an open zone of low density buildings in the vicinity of the Solivarská and Arm. gen. L. Svobodu cross-road with high frequency of transport. Station is located 10 m from kerbside.

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.

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.



ZONE - TRENČÍN REGION

AREA: 4 502 km^2 POPULATION: 599 859

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.

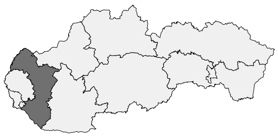
Location of stations

Prievidza - Malonecpalská
The station is located at the edge of town inside elementary school in open area. In the vicinity is situated local road N. 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 and industry sources.

Bystričany - Rozvodňa SSE
The station is directly placed in object of control room 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: 4 148 km^2 POPULATION: 559 934

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 Záhorska 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. Main share in air pollution of the town is due to chemical industry (Slovenský hodváb a.s., Senica), power generation and car transport.

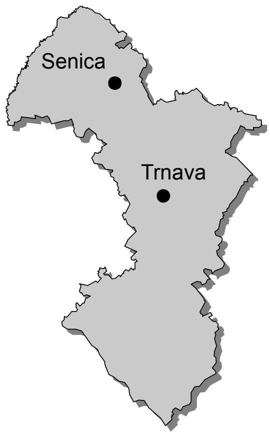
Trnava

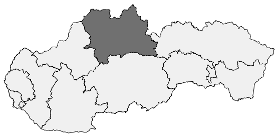
Trnava – one of the most important cities in the Slovak Republic is located in the centre of the Trnava downs, at an altitude of 146 m, 45 km from the capital of the Slovak Republic, Bratislava. The prevailing wind is from the north-west, the second highest wind frequency is from south-east. The location 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

ROZLOHA: 6 788 km^2 POPULÁCIA: 696 347

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}. The North Slovakian pulp and paper processing plants (Mondi scp a.s., Ružomberok) are the largest industrial source of air pollution. A considerable share in this pollution is caused by small local sources, as well. Specific air pollution represents a mixture of predominantly organic-sulphur compounds.

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. According to the climate characteristics the area belongs to a moderately warm region. 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 small sources of emissions lead to the high level of air pollution at the ground level layer. Air pollution by classical pollutants is due to the local heating plant of the Slovak Power Plants, but local chemical industry and mainly heavy traffic in the town centre contribute as well.

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, average wind speed 2,8 m.s^{-1} and high relative humidity contribute to higher level of pollution. Heavy engineering, central and local heating plants and car transport are the largest emitters of pollutants.

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. A major pollution source pulp and paper processing plant - Mondi scp a.s., Ružomberok is situated north-east of the monitoring station.

Martin - Jesenského

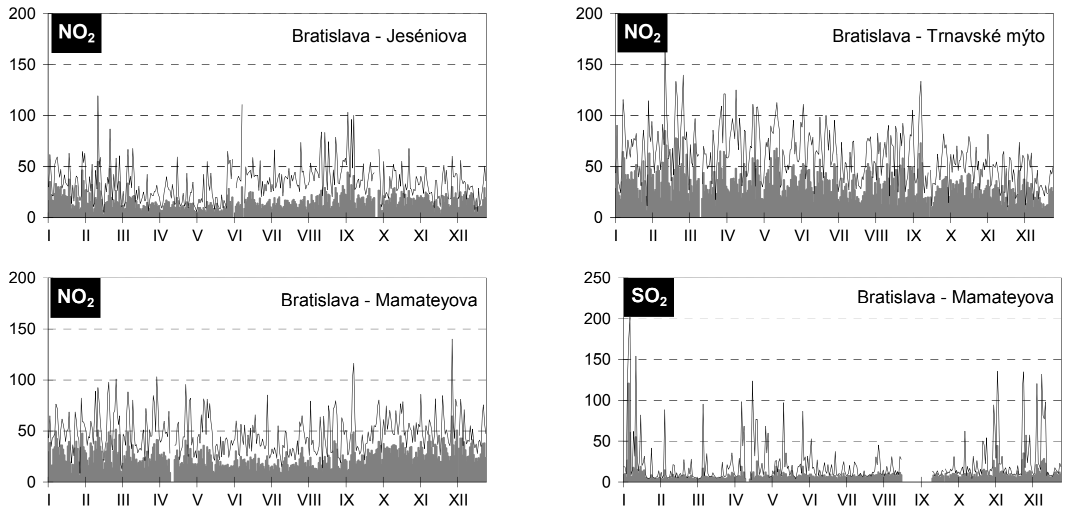
The station is located 5 m from the kerbside of the main street. Station is located in the southern part of the city in area mainly build up by family houses.

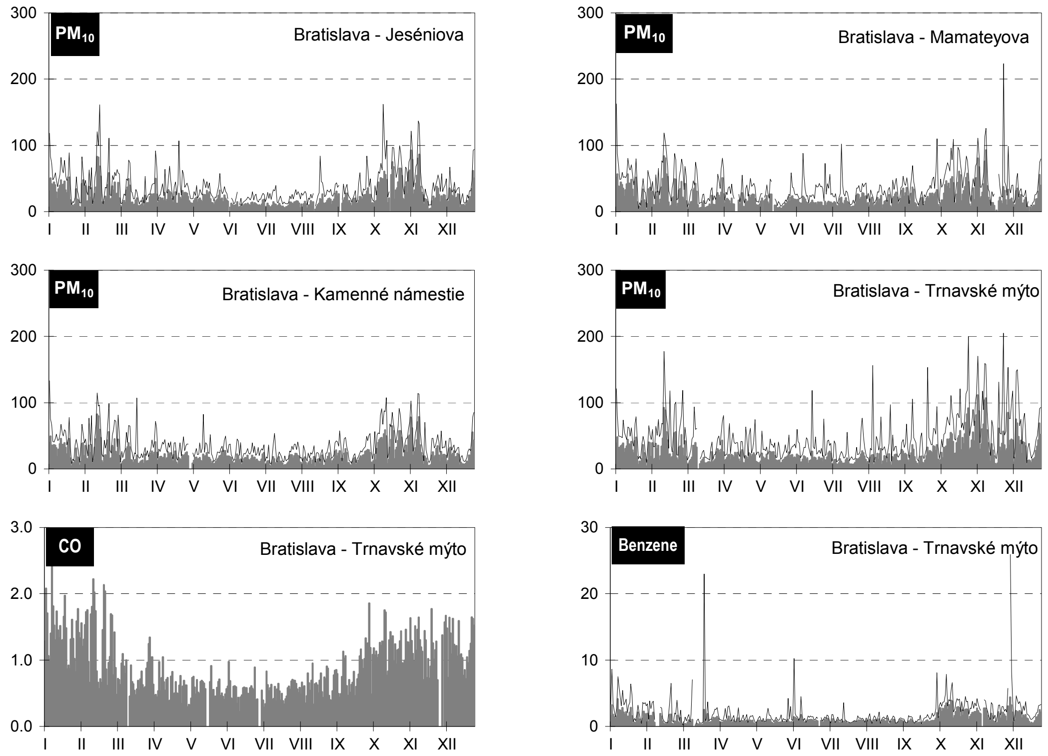
Tab. 2.1 **Geographical co-ordinates of monitoring stations and list of pollutants monitored in 2008**

AGGLOMERATION/ zone		Longitude	Latitude	Altitude [m]	SO_2	NO_2	PM_{10}	$PM_{2,5}$	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, Štúrova	21°15'39"	48°43'02"	199		*	*		*	*					
	Košice, Strojárska	21°15'07"	48°43'36"	202			*								
Banská Bystrica region	Banská Bystrica, Štefánikovo nábr.	19°09'16"	48°44'07"	346	*	*	*		*	*	*	*	*	*	
	Zvolen, J. Alexyho	19°09'24"	48°33'29"	321			*								
	Jelšava, Jesenského	20°14'26"	48°37'52"	289			*								
	Hnúšťa, Hlavná	19°57'06"	48°35'02"	320			*								
	Žiar nad Hronom, Dukelských hrdinov	18°51'01"	48°35'09"	285			*								
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, Lorenzova	20°52'23"	48°54'45"	387	*	*	*		*	*	*	*	*	*	*
Nitra region	Nitra, Janka Kráľa	18°04'29"	48°18'38"	142	*	*	*		*	*					
	Nitra, Janíkovce 1)	18°08'27"	48°17'00"	149		*	*								
Prešov region	Humenné, Nám. slobody	21°54'50"	48°55'51"	180		*	*								
	Prešov, Solivarská	21°15'52"	48°58'40"	258		*	*		*	*					
	Vranov nad Topľou, M. R. Štefánika	21°41'15"	48°53'11"	133	*		*								
Trenčín region	Prievidza, Malonecpalská	18°37'40"	48°46'58"	276	*		*	*			*	*	*	*	*
	Bystričany, Rozvodňa SSE	18°30'51"	48°40'01"	261	*		*								
	Handlová, Morovianska cesta	18°45'23"	48°43'59"	448	*		*								
	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		*	*	*							

[1)] *station was put in operation at the end of year*

Fig. 2.1 **Concentrations of NO_2, SO_2, PM_{10}, benzene and CO – agglomeration Bratislava – 2008**

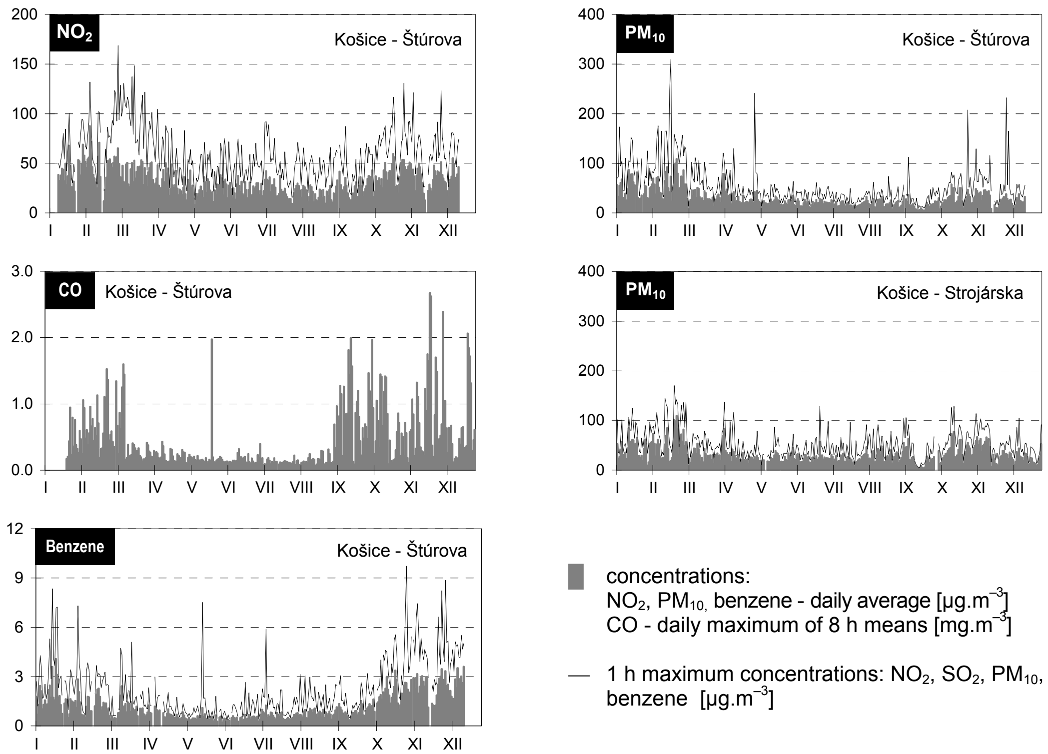




▮ concentrations: NO_2, SO_2, PM_{10}, benzene - daily average [µg.m^{-3}] CO - daily maximum of 8 h means [mg.m^{-3}]

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

Fig. 2.2 **Concentrations of NO_2, PM_{10}, CO and benzene – agglomeration Košice – 2008**



▮ concentrations:
NO_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. 2.3 **Concentrations of NO_2, SO_2, PM_{10}, CO and benzene – zone Banská Bystrica region – 2008**

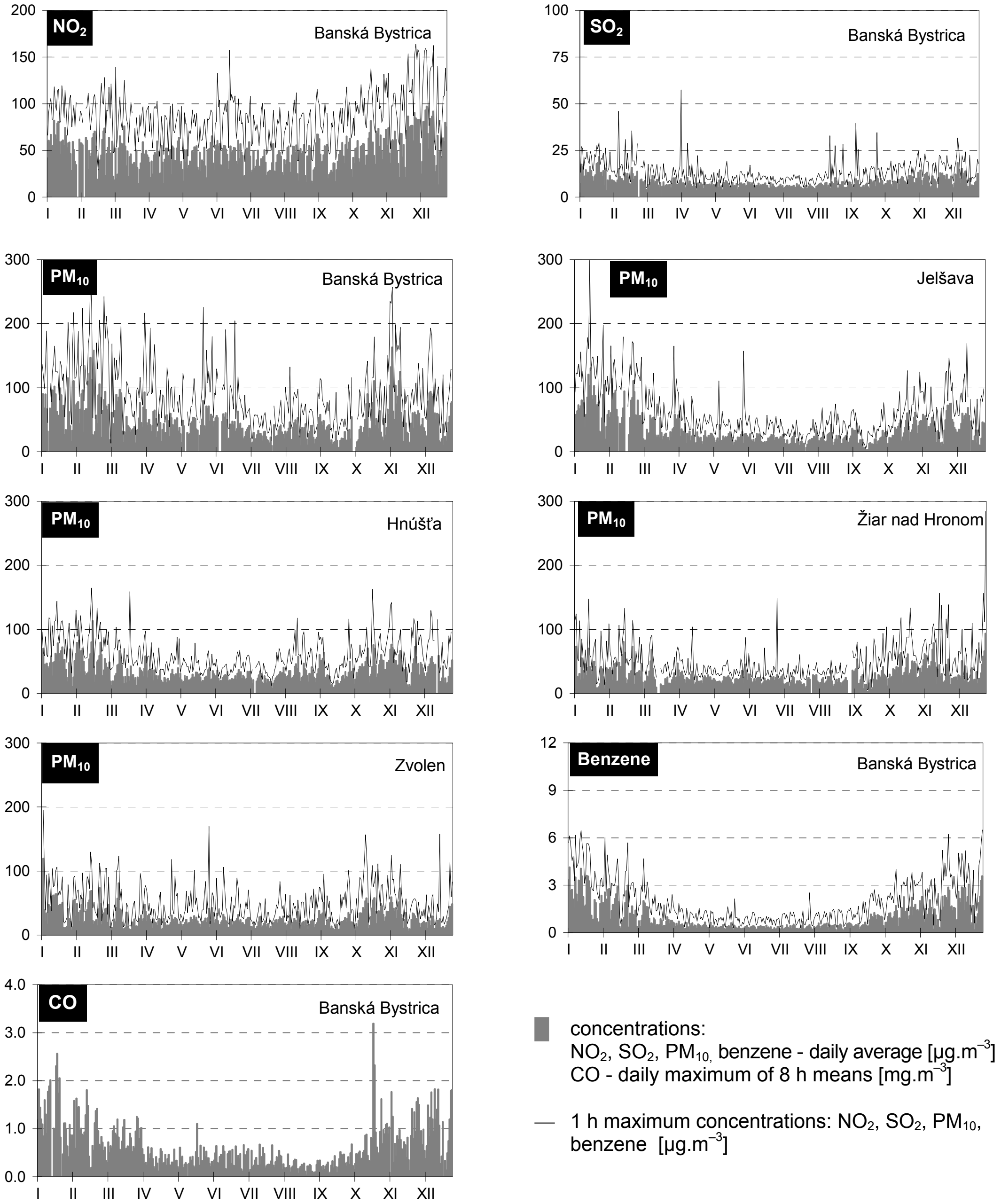
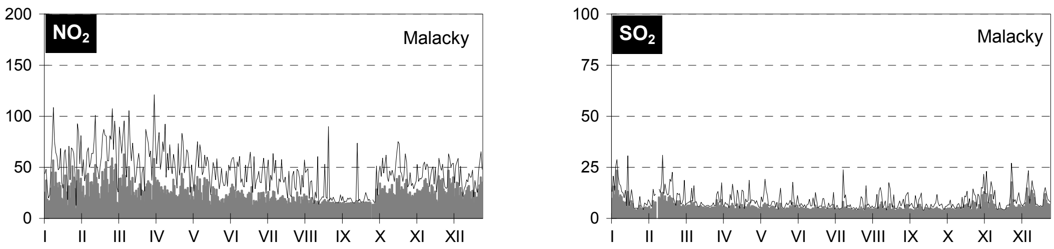


Fig. 2.4 **Concentrations of NO_2, SO_2, PM_{10} , CO and benzene – zone Bratislava region – 2008**



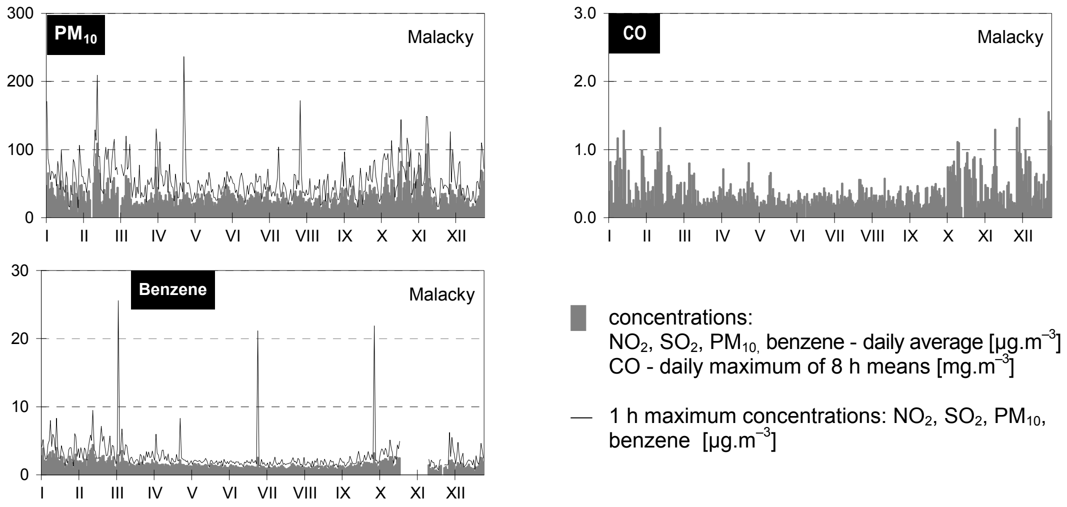


Fig. 2.5 **Concentrations of NO_2, SO_2, PM_{10}, CO and benzene – zone Košice region – 2008**

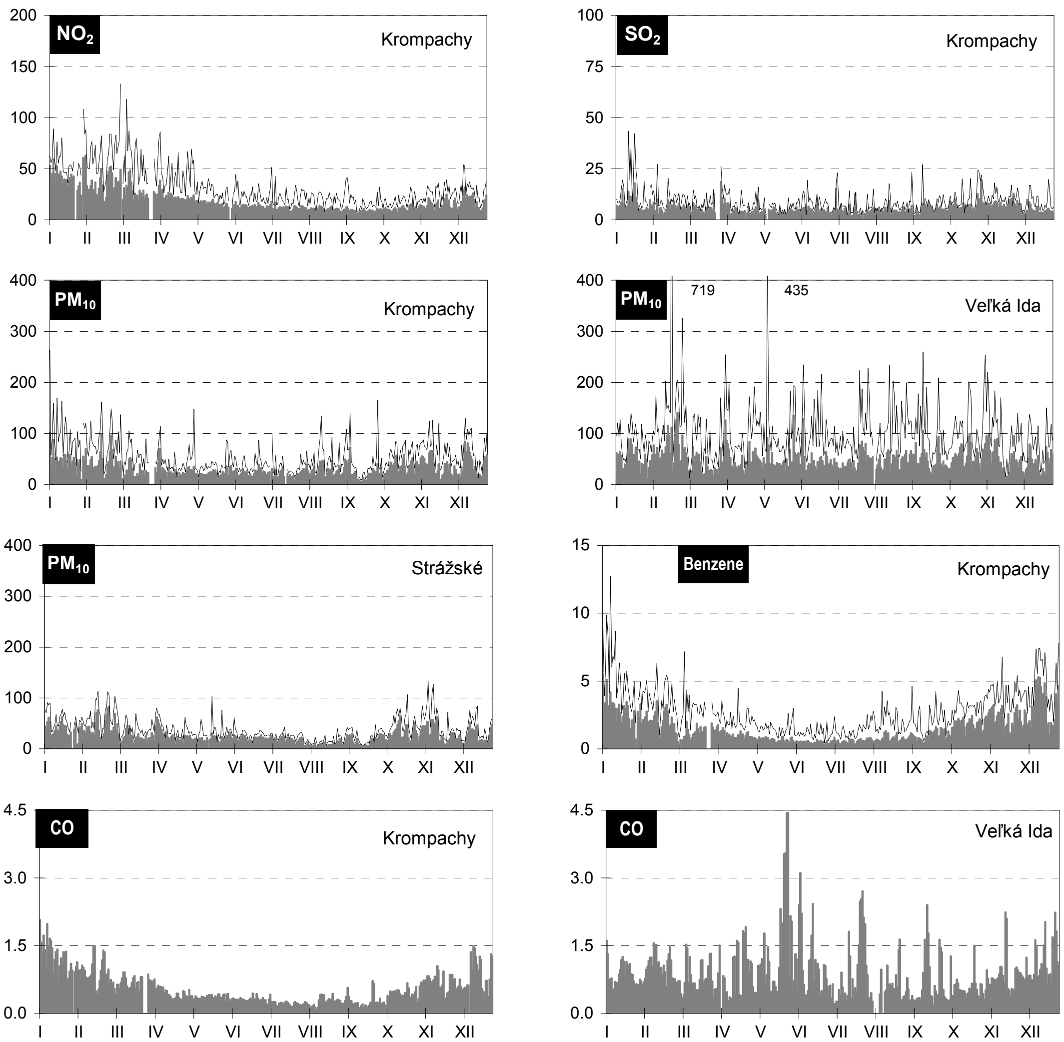


Fig. 2.6 **Concentrations of NO_2, SO_2, PM_{10}, CO and benzene – zone Nitra region – 2008**

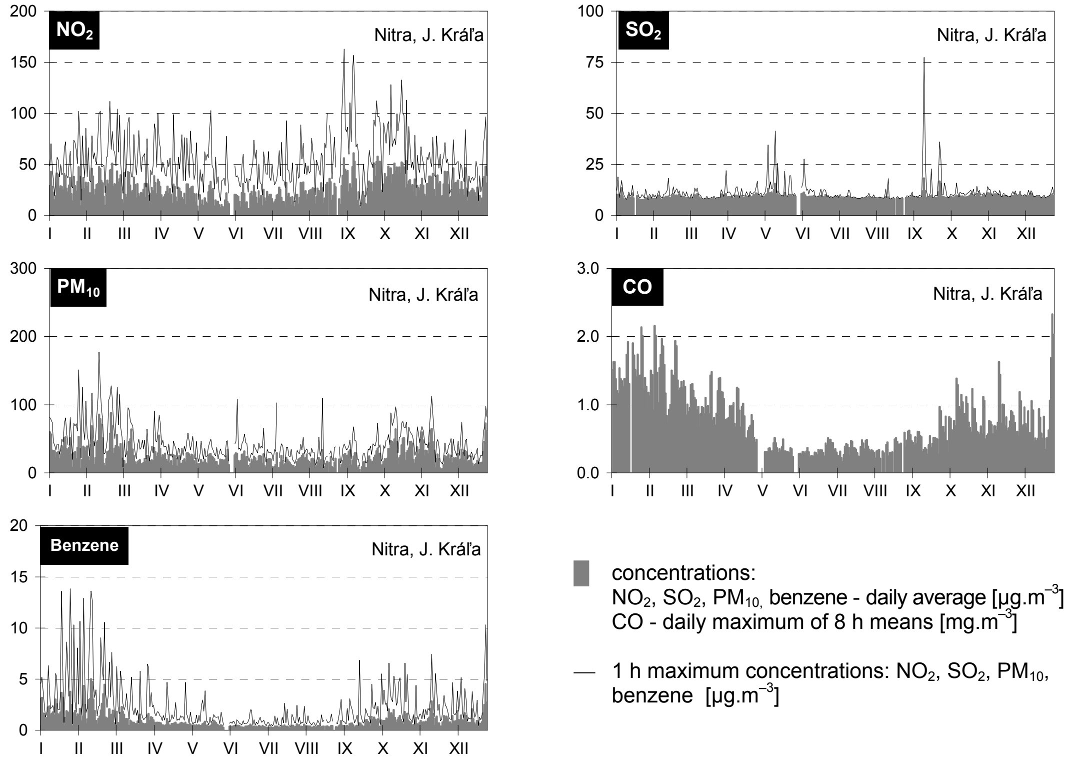
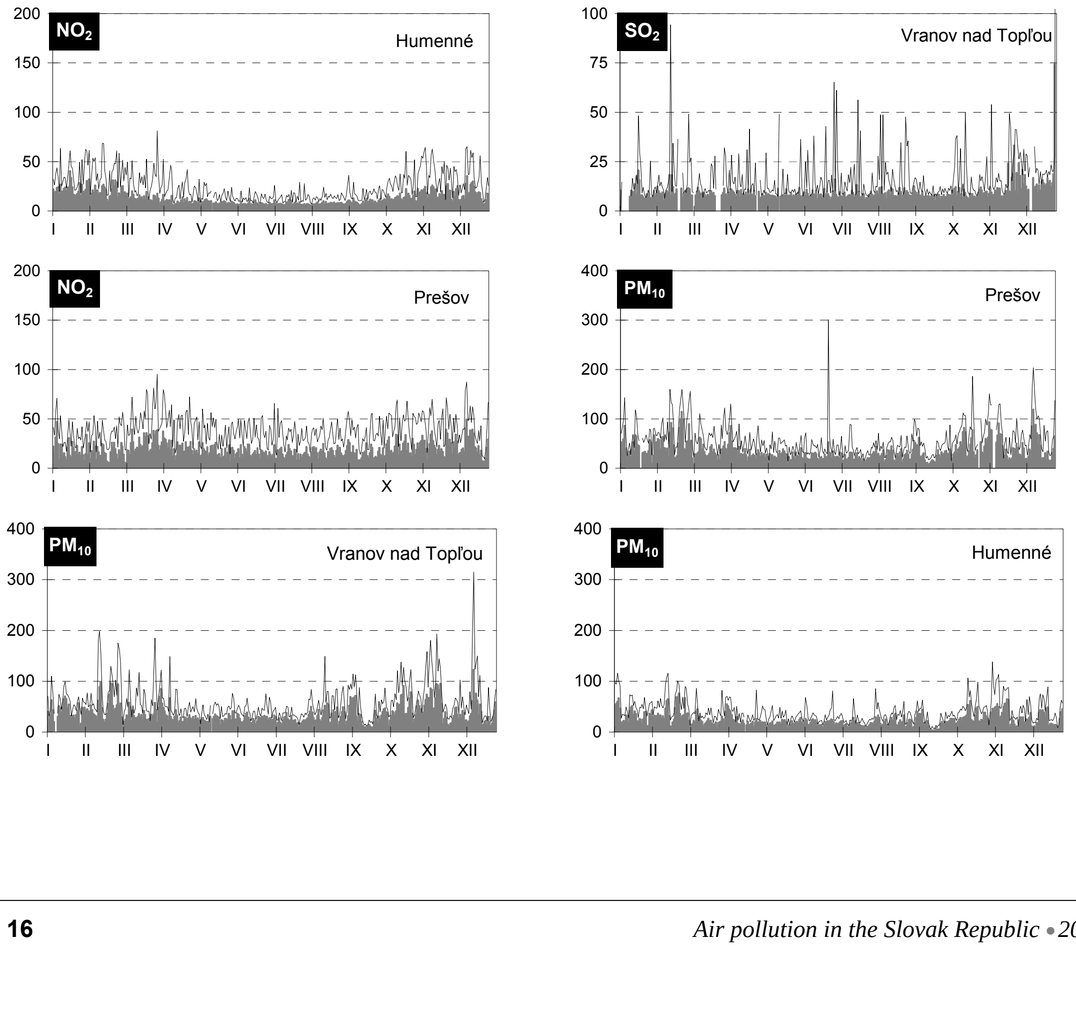
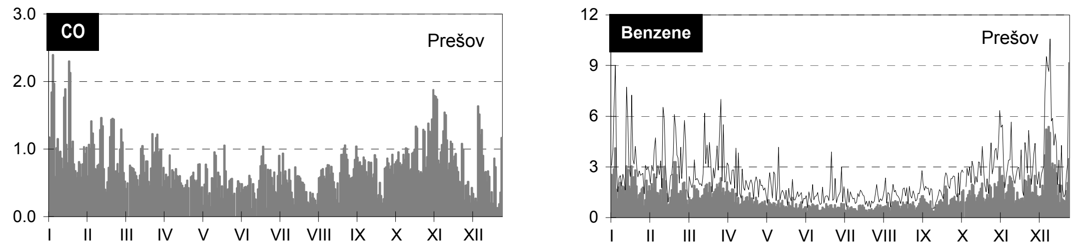


Fig. 2.7 **Concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$, CO and benzene – zone Prešov region – 2008**

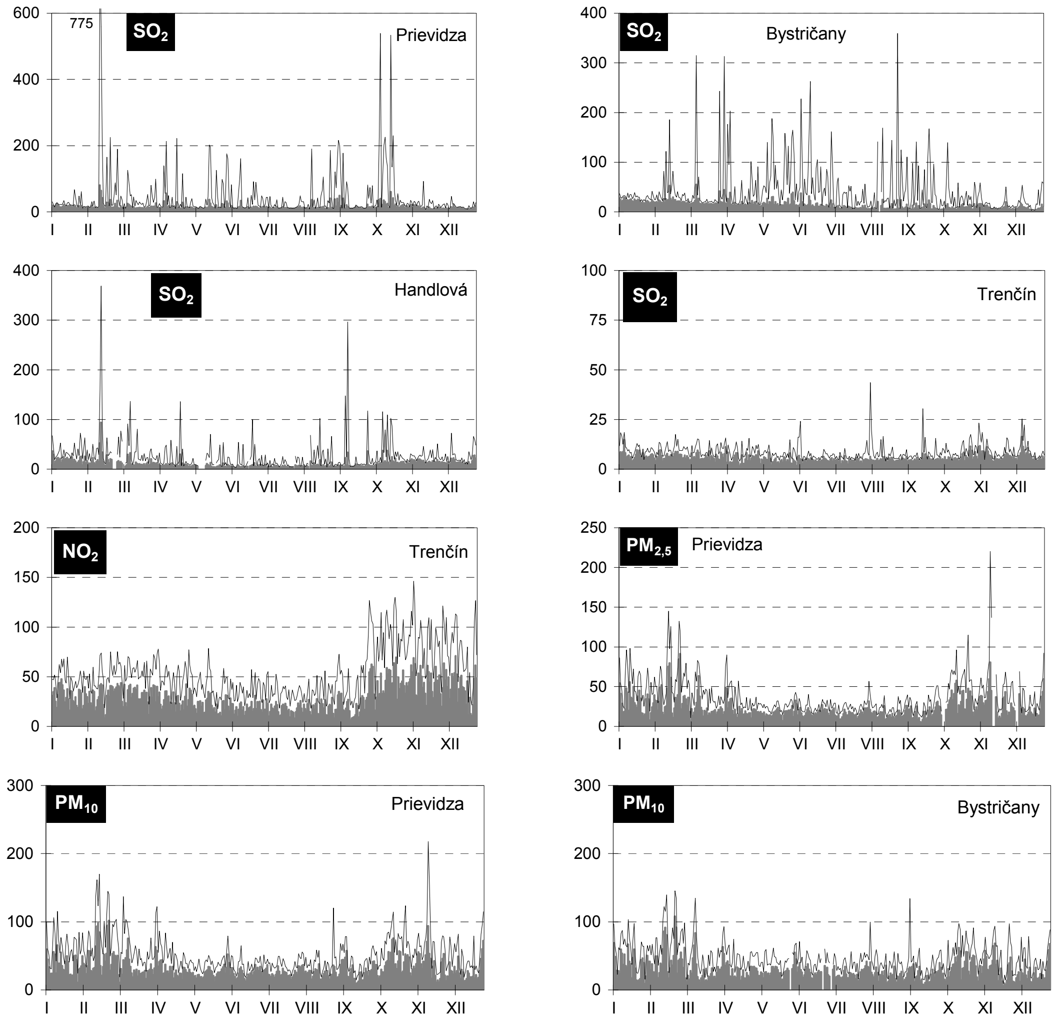


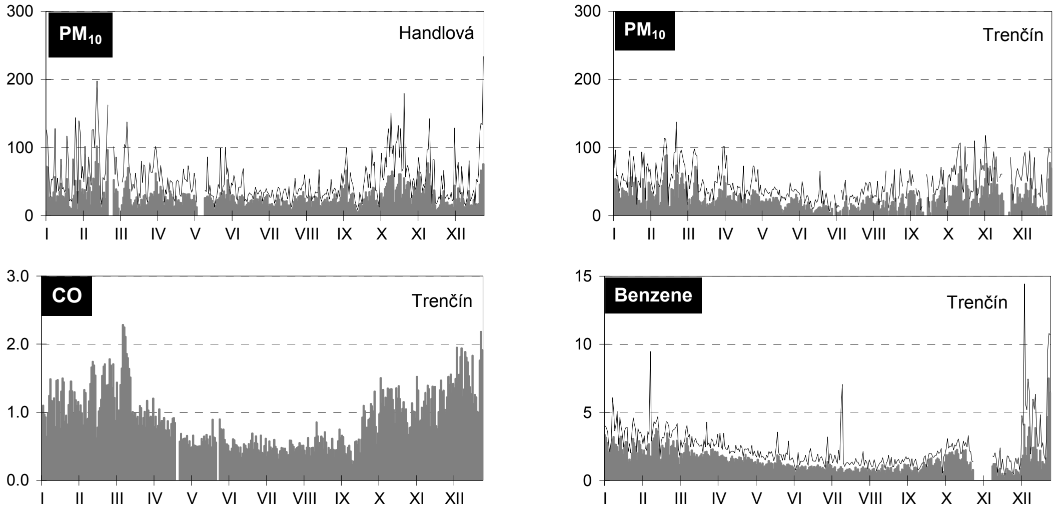


concentrations: NO_2, SO_2, PM_{10}, benzene - daily average [μg.m^{-3}] CO - daily maximum of 8 h means [mg.m^{-3}]

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

Fig. 2.8 **Concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$, CO and benzene – zone Trenčín region – 2008**

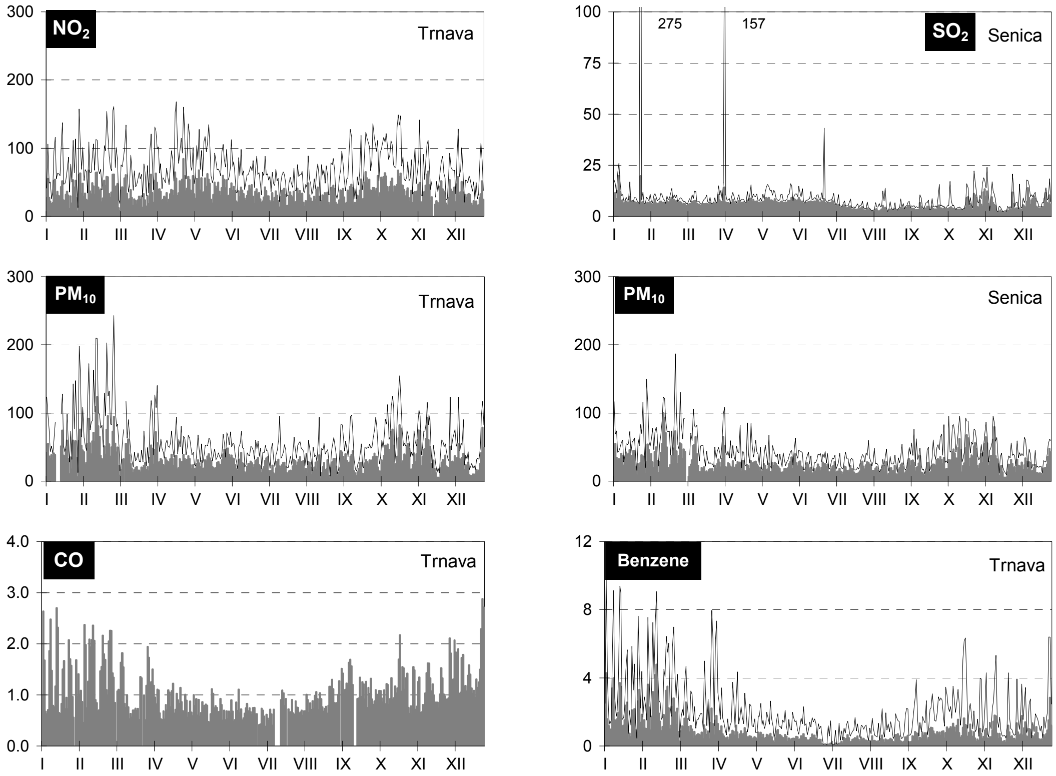




concentrations: NO_2, SO_2, PM_{10}, benzene - daily average [µg.m^{-3}] CO - daily maximum of 8 h means [mg.m^{-3}]

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

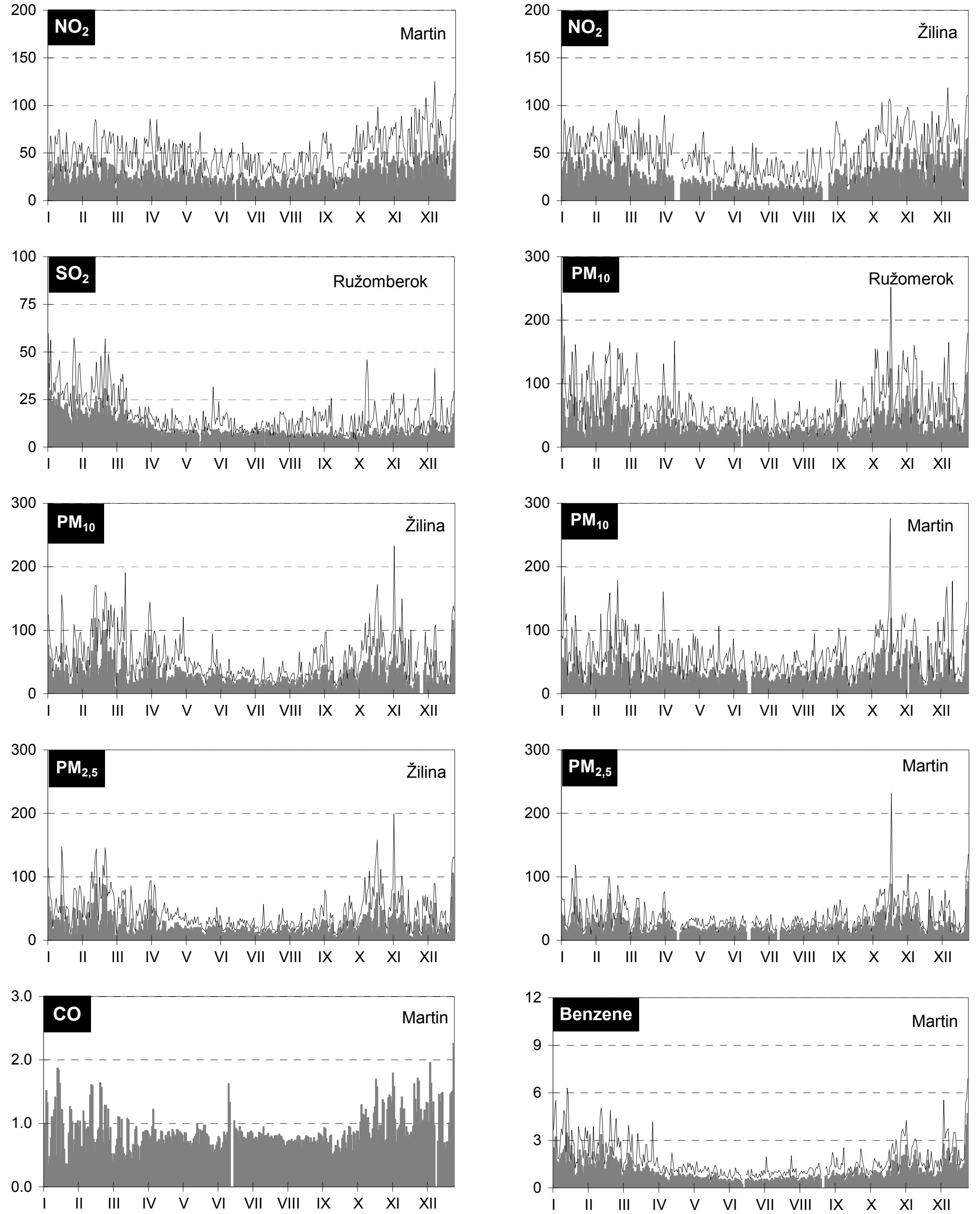
Fig. 2.9 **Concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$, CO and benzene – zone Trnava region – 2008**



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}]

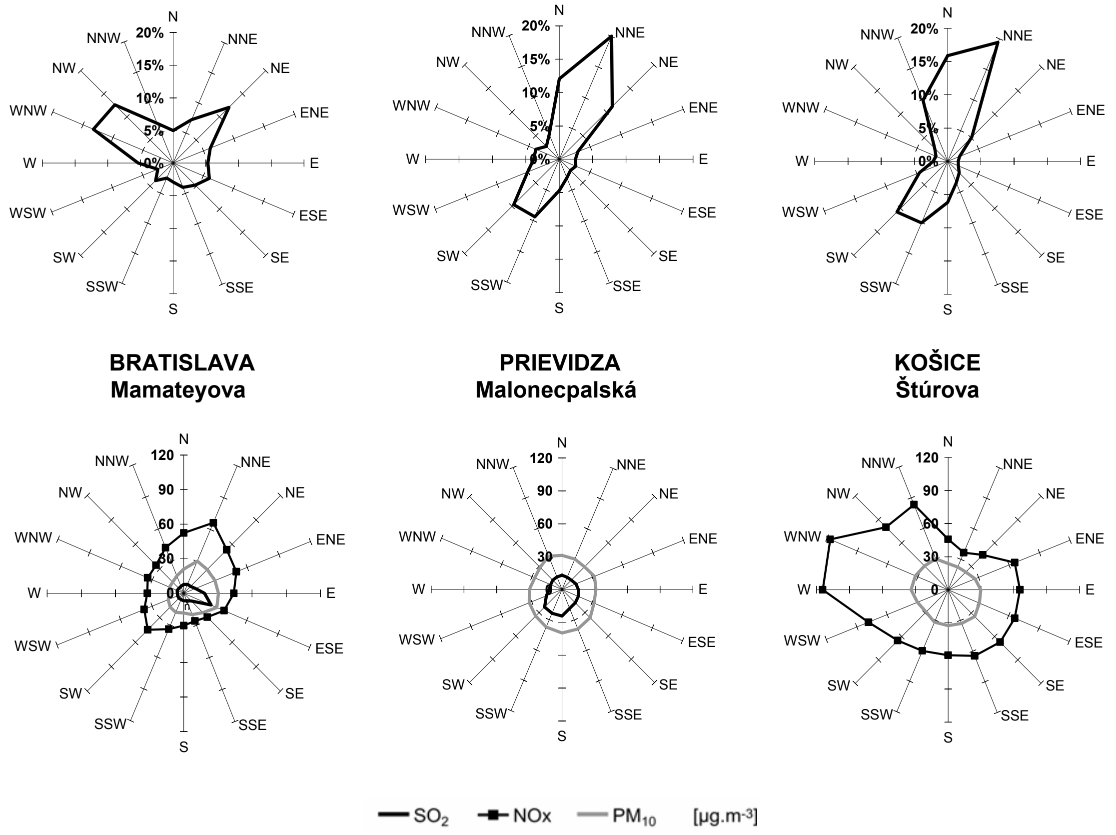
Fig. 2.10 **Concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$, CO and benzene – zone Žilina region – 2008**



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 [$\mu g.m^{-3}$]

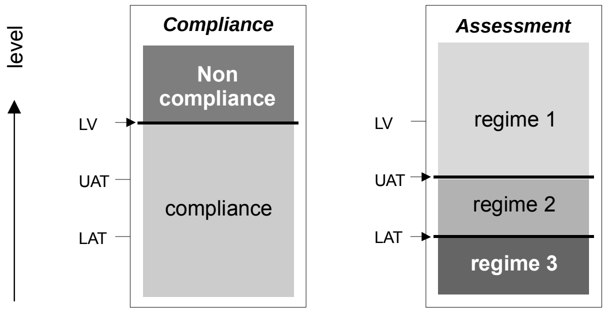
Fig. 2.11 **Wind and concentration roses – 2008**



2.3 PROCESSING OF MEASUREMENT RESULTS ACCORDING TO LIMIT VALUES

The Air Protection Act 478/2002 harmonized the principles of air quality assessment with the EU AQ legislation. The whole territory of the Slovak Republic was divided into zones and agglomerations and on the basis of air quality assessment in each zone/agglomeration the monitoring regimes were defined. This assessment performed for the period of the last five years distinguishes three particular monitoring regimes. These are schematically illustrated on the 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.
In all types of zones, apart from agglomeration zones, for all pollutants for which an alert threshold has been set	Model computations, expert estimates and indicative measurements are sufficient.

For several pollutants the margins of tolerance (MoT) were set up, table 2.3. The margins of tolerance are gradually decreasing since, they will meet the zero value at the date when limit values will come into force. In the year 2006 margin of tolerance was given only for annual limit values of NO_2 and benzene. Limit values, upper and lower assessment thresholds defined in Decree No 705/ 2002 Coll. about Air Quality are presented in tables 2.3 and 2.4. Alert thresholds and limit values for signals “INFORMATION” and “REGULATION” were set up for:

[1] *Limit value as defined in Decree No 705/2002 Coll. about Air Quality amended by Decree No 351/2008 Coll.*
[2] *Upper assessment threshold as defined in Decree No 705/2002 Coll. about Air Quality amended by Decree No 351/2007Coll.*
[3] *Lower assessment threshold, as defined in Decree No 705/2002 Coll. about Air Quality amended by Decree No 351/2007Coll.*

Signal **Information**: If the values of moving average concentrations during 3 hours are above:

- SO_2 - 400 µg.m^{-3} NO_2 - 250 µg.m^{-3}

Signal **Regulation**: If the values of concentrations during 3 hours are above:

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

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

Results from continuous measurements are presented in graphical and tabular form. For illustration purposes 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 (Tables 2.5–2.7).

Sulphur dioxide In the year 2008 in none of agglomeration or zone the hourly or daily limit values were exceeded in more cases than it is allowed. Limit value for signal regulation was exceeded one time at 1 station at zone Trenčín region. But signal regulation was not put on the alert, because pollution area was smaller than 100 km^2.

Nitrogen dioxide Annual limit value for protection of human health was exceeded only at station Banská Bystrica-Štefánikovo nábrežie. This value was above limit values plus margin of tolerance as well. It supposed that this high level was caused mainly by local reconstruction works. Close to the station construction-site trucks, diesel engine generator and another machines operated and contributed to the air pollution significantly.

PM_{10} In 2008 PM_{10} was monitored at 28 urban and suburban stations. Station Nitra-Janíkovce was put in operation at the end of the year 2008 and therefore these results were not included in the assessment. Parallel measurements of $PM_{2.5}$ fraction were carried out at 3 stations. Air pollution by particulates PM_{10} is presently the major problem not only in Slovakia but also in most European countries. In the year 2008 the general decrease of PM_{10} air pollution level in comparison to the year 2007 was observed at agglomeration Bratislava and in zones Trenčín and Žilina region. The opposite tendency was recorded in zones Prešov and Trnava region. On the whole territory the daily limit value was exceeded at 16 stations and at 2 from them also annual limit value as well.

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

Benzene The highest concentrations occurred at stations Malacky-Sasinkova, Krompachy-Lorenzova and Trenčín-Hasičská, but the annual average concentration 1.5 µg.m^{-3} is far below the limit value 5 µg.m^{-3} set up for the year 2010.

Pb The highest level is observed in Krompachy-Lorenzova, where metallurgy industry is major air pollution source. Despite of this the air pollution level at the whole territory is low even below the lower assessment threshold.

As, Ni, Cd In the year 2008 none of these pollutants exceeded the target value at any station.

BaP The target value which has to be attained on 31st December 2012 was exceeded at stations Veľká Ida-Letná, Prievidza-Malonecpalská and Krompachy-Lorenzova.

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
SO_2	1h	350 (24)	1/1/05	150 µg.m⁻³	500	470	440	410	380	350					
SO_2	24h	125 (3)	1/1/05	-											
SO_2[e]	1r, W[1]	20 (-)	19/07/01	-											
NO_2	1h	200 (18)	1/01/10	50 %	300	290	280	270	260	250	240	230	220	210	200
NO_2	1r	40 (-)	1/01/10	50 %	60	58	56	54	52	50	48	46	44	42	40
NOx[e]	1r	30 (-)	19/07/01	-											
PM_{10}	24h	50 (35)	1/01/05	50 %	75	70	65	60	55	50					
PM_{10}	1r	40 (-)	1/01/05	20 %	48	46	45	43	42	40					
Pb	1r	0.5 (-)	1/01/05	100 %	1.0	0.9	0.8	0.7	0.6	0.5					
Pb[2]	1r	0.5 (1.0) (-)	1/1/10 (1/1/05)	100 %	1.0	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5
CO	max. 8 hour daily value	10 000 (-)	1/1/2003 (1/1/2005)		16 000	16 000	16 000	14 000	12 000	10 000					
Benzene	1r	5 (-)	1/1/2006 (1/1/2010)	100 %	10	10	10	10	10	10	9	8	7	6	5

[1] *winter period (October 1 - March 31)*
[e] *for protection of vegetation*
[2] *only for specific point sources*
* *allowed exceedances per year are in brackets*

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 (-)
NOx	Vegetation	1y	30 (-)	24 (-)	19,5 (-)
PM_{10}	Human health	24h	50 (35)	30 (7)	20 (7)
PM_{10}	Human health	1y	40 (-)	14 (-)	10 (-)
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 (-)

* *allowed exceedances per year are in brackets*

	Interval of averaging	Target value [ng.m⁻³]	To be met by
As	1r	6	31.12.2012
Cd	1r	5	31.12.2012
Ni	1r	20	31.12.2012
BaP	1r	1	31.12.2012

Tab. 2.5 **Assessment of air quality according to limit values and limit values plus margin of tolerance (MoT) in 2008**

		Protection of health												VHP [2]	
	Pollutant	**SO_2**		**NO_2**		**NO_2+MT**		**PM_{10}**		**Pb**	**CO**	**Ben-zene**	**Ben. +MT**	**SO_2**	**NO_2**
	Time of averaging	1 hour	24 hour	1 hour	1 year	1 hour	1 year	24 hour	1 year	1 year	8 hour [1]	1 year	1 year	3 subsequent hour	3 subsequent hour
	Limit value [μg.m⁻³] *(number of exceedances)*	350 *(24)*	125 *(3)*	200 *(18)*	40	220 *(18)*	44	50 *(35)*	40	500 [ng.m⁻³]	10000	5	7	500	400
BRATISLAVA	Bratislava, Kamenné nám.							16	21.4						
	Bratislava, Trnavské mýto			0	33.1	0	33.1	30	25.4		2419	1.1	1.1		0
	Bratislava, Jeséniova			0	16.4	0	16.4	24	23.1						0
	Bratislava, Mamateyova	0	0	0	25.3	0	25.3	20	21.6	9				0	0
KOŠICE	Košice, Štúrova			0	31.7	0	31.7	**38**	29.5		3078	1.2	1.2		0
	Košice, Strojárska							**55**	31.6						
Banská Bystrica region	Banská Bystrica, Štef. nábr.	0	0	0	**47.6**	0	**47.6**	**126**	**46.5**	36	3194	1.0	1.0	0	0
	Jelšava, Jesenského							**75**	33.7						
	Hnúšťa, Hlavná							**61**	34.6						
	Zvolen, J. Alexyho							27	25.9						
	Žiar n. H., Dukelských hrdinov							24	27.8						
Bratislava region	Malacky, Sasinkova	0	0	0	26.0	0	26.0	**40**	32.6		1553	1.5	1.5	0	0
Košice region	Veľká Ida, Letná							**157**	**50.0**	39	4445				
	Strážske, Mierová							25	24.7						
	Krompachy, Lorenzova	0	0	0	18.8	0	18.8	**46**	31.1	190	2317	1.5	1.5	0	0
Nitra region	Nitra, J. Kráľa	0	0	0	26.4	0	26.4	25	25.3		2330	0.9	0.9	0	0
	Nitra, Janíkovce					c	c	c	c						
Prešov region	Humenné, Nám. slobody			0	13.1	0	13.1	21	24.5						0
	Prešov, Solivarská			0	19.1	0	19.1	**64**	35.3		2532	1.3	1.3		0
	Vranov nad Topľou, M. R. Štefánika	1	0					**67**	35.9					0	
	Stará Lesná [3]							14	22.6						
	Kolonické sedlo, Hvezdáreň [3]							c5	c21.6						
Trenčín region	Prievidza, Malonecpalská	5	0					**44**	32.2	9				1	
	Bystričany, Rozvodňa SSE	1	0					31	29.8					0	
	Handlová, Morovianska cesta	1	0					**36**	29.2					0	
	Trenčín, Hasičská	0	0	0	29.6	0	29.6	32	26.4		2284	1.5	1.5	0	0
Trnava region	Senica, Hviezdoslavova	0	0					24	26.3					0	
	Trnava, Kollárova			0	36.0	0	36.0	**53**	32.4		2879	0.9	0.9		0
	Topoľníky [3]							13	21.0						
Žilina region	Martin, Jesenského			0	27.6	0	27.6	**55**	35.8		2366	1.1	1.1		0
	Ružomberok, Riadok	0	0					**70**	37.2	13				0	
	Žilina, Obežná			0	26.5	0	26.5	**55**	32.7						

[1] *maximal 8 hour value of moving average* [2] *alert threshold limit values*
[3] *stations located in rural background areas*

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 limit values, limit values plus margin of tolerance (MoT) and target values**

	Pollutant	**As**					**Cd**					**Ni**				
	Year	**2004**	**2005**	**2006**	**2007**	**2008**	**2004**	**2005**	**2006**	**2007**	**2008**	**2004**	**2005**	**2006**	**2007**	**2008**
	Target value [ng.m^{-3}]	6.0	6.0	6.0	6.0	6.0	5	5	5	5	5		20	20	20	20
	Upper assessment threshold [ng.m^{-3}]	3.6	3.6	3.6	3.6	3.6	3	3	3	3	3		14	14	14	14
	Lower assessment threshold [ng.m^{-3}]	2.4	2.4	2.4	2.4	2.4	2	2	2	2	2		10	10	10	10
BRATISLAVA	Bratislava, Mamateyova	0.9	1.7	1.1	0.7	1.0	0.3	0.4	0.3	0.2	0.2	2.1	2.9	1.9	1.3	1.3
Slovakia	Banská Bystrica, Štefánikovo nábr [1]	4.5	5.1	3.6	2.4	3.0	1.4	1.3	1.2	1.0	0.9	2.0	4.4	5.6	1.7	2.0
	Veľká Ida, Letná	2.2	2.6	1.7	1.8	1.9	3.1	1.9	1.1	1.1	0.8	1.9	2.3	1.6	1.8	2.1
	Krompachy, Lorenzova	**13.0**	**6.4**	4.7	4.3	3.6	2.9	2.7	2.6	1.3	1.6	1.8	2.8	3.6	1.6	1.5
	Prievidza, Malonecpalská [2]	**8.3**	5.6	**7.9**	5.3	5.7	0.4	0.5	0.4	0.3	0.3	1.6	1.4	1.0	1.3	1.0
	Ružomberok, Riadok	5.5	4.0	5.0	2.6	2.4	0.4	0.5	0.5	0.4	0.4	3.4	1.5	1.5	1.3	1.2

[1] *till the year 2007 Nám. slobody* [2] *till the year 2006 J. Hollého*

Tab. 2.7 **Assessment of air quality according target value for BaP in 2008**

	Pollutant	**BaP**
	Limit 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	0.7
	Bratislava, Jeséniova	0.4
Slovakia	Veľká Ida, Letná	**2.4**
	Krompachy, Lorenzova	**1.7**
	Prievidza, Malonecpalská	**1.4**
	Trnava, Kollárova	0.7

3 ATMOSPHERIC OZONE

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 (NO_x, 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 2008 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 2003 – 2008

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 478/2002 Coll. on air protection, that in accordance with EU legislation have to be fulfilled to 2010, and 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 2003 – 2008

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 2008 the number of missing data did not exceed 3% at all stations (Tab. 3.2). Large gaps were only at the Starina and Kojšovská hoľa stations.

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

Station	2003	2004	2005	2006	2007	2008
Bratislava, Jeséniova	2.5	2.2	5.8	16.8	0.6	1.6
Bratislava, Mamateyova	3.6	2.7	6.3	2.3	0.8	1.1
Humenné, Nám. slobody	1.9	0.3	0.3	10.3	9.5	0.5
Jelšava, Jesenského	4.1	0	0.3	8.2	5.0	0.1
Košice, Ďumbierska	1.4	0.5	8.6	44.4	1.1	0.1
Prievidza, Malonecpalská					1.9	0.4
Žilina, Obežná	2.7	0.3	0.5	0.5	1.0	0.05
Gánovce, Meteo. st.	1.4	24.9	15.9	7.8	0.01	1.7
Chopok, EMEP	45.5	9.6	1.9	29.0	1.0	1.7
Kojšovská hoľa	9.9	1.1	9.9	6.3	0.7	1.9
Stará Lesná, AÚ SAV, EMEP	4.7	0.5	0.3	10.9	0.2	0.3
Starina, Vodná nádrž, EMEP	2.2	17.3	7.1	24.8	6.6	2.6
Topoľníky, Aszód, EMEP	1.4	3.6	6.6	1.7	1.4	0.6

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

Station	2003	2004	2005	2006	2007	2008
Bratislava, Jeséniova	71	64	68	66	59	59
Bratislava, Mamateyova	53	48	53	50	49	48
Humenné, Nám. slobody	66	58	60	62	56	55
Jelšava, Jesenského	55	51	52	55	56	51
Košice, Ďumbierska	68	60	67	*49	57	56
Prievidza, Malonecpalská					48	53
Žilina, Obežná	48	42	41	44	44	46
Gánovce, Meteo. st.	68	66	67	68	60	65
Chopok, EMEP	*109	91	95	*96	91	92
Kojšovská hoľa	91	86	86	84	79	76
Stará Lesná, AÚ SAV, EMEP	67	62	70	73	68	74
Starina, Vodná nádrž, EMEP	73	66	66	*62	62	59
Topoľníky, Aszód, EMEP	67	59	60	60	58	60

** 50 – 75% of valid measurements*

In 2008, the annual average concentrations of ground level ozone in urban and industrial locations of Slovakia ranged within the interval 46 – 59 μg.m^{-3} (Tab. 3.3). The concentrations in the rest of the territory ranged between 59 and 92 μg.m^{-3}, mainly depending on the altitude. The highest annual average of ground level ozone concentrations was reached at the summit station Chopok (92 μg.m^{-3}). The effect of ozone from the accumulation zone (800 – 1500 m over the ground) over the Europe is evident. The year 2008, according to vegetation period averages, belongs to the photochemically less active years. Annual averages of ground level ozone concentration in 2008 were lower than in record year 2003.

In Figure 3.1, the seasonal cycle of daily ozone concentrations in Stará Lesná during 1992 – 2008 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 2003 – 2008 is summarised in Tables 3.4 – 3.6. The alert threshold when the public must be warned (240 µg.m^{-3}) was not exceed in 2008 (Tables 3.4). The information threshold to the public (180 µg.m^{-3}) in 2008 was exceeded at two stations (Bratislava Mamateyova and Kojšovská hoľa).

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 2006 – 2008. The target value not to be exceeded on more than 25 days per calendar year averaged over three years. In 2006 – 2008 was the number of 25 days overstepped at nine monitoring stations. The highest exceedance was observed at Chopok station (62 days) and Kojšovská hoľa (59 days).

Fig. 3.1 **Seasonal variability of ground level ozone concentration in Stará Lesná during 1992 – 2008**

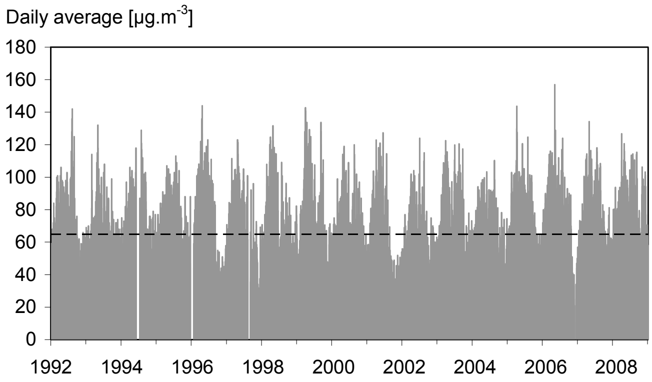
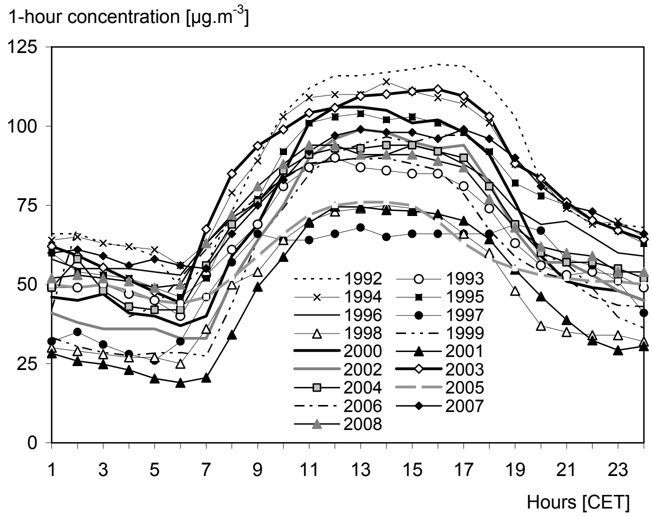


Fig. 3.2 **Average daily cycles of ground level ozone concentration in Stará Lesná, in August 1992 – 2008**



Tab. 3.4 **Number of exceedances of ozone information threshold (IT) and alert threshold (AT) to the public during 2002 – 2007**

Station	AT = 240 µg.m^{-3}						IT = 180 µg.m^{-3}					
	2003	2004	2005	2006	2007	2008	2003	2004	2005	2006	2007	2008
Bratislava, Jeséniova	3	0	0	0	0	0	42	0	6	19	10	0
Bratislava, Mamateyova	3	0	0	0	1	0	32	0	8	11	17	2
Humenné, Nám. slobody	0	0	0	0	0	0	0	0	0	1	0	0
Jelšava, Jesenského	0	0	0	0	0	0	5	0	0	3	6	0
Košice, Ďumbierska	0	0	0	0	0	0	0	2	0	0	0	0
Prievidza, Malonecpalská	0	0	0	0	0	0	0	0	0	0	1	0
Žilina, Obežná	0	0	0	0	0	0	0	0	0	8	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	3	1	0	1	0	0
Kojšovská hoľa	0	0	1	0	0	0	0	0	2	1	2	1
Stará Lesná, AÚ SAV, EMEP	0	0	0	0	0	0	0	0	0	1	0	0
Starina, Vodná nádrž, EMEP	0	0	0	0	0	0	0	0	0	3	0	0
Topoľníky, Aszód, EMEP	0	0	0	0	0	0	18	0	0	0	4	0

Tab. 3.5 **Number of exceedances of ozone target value for protection of human health (8 h average 120 μg.m^{-3}) during 2006 – 2008**

Station	2006	2007	2008	Average 2006 – 2008
Bratislava, Jeséniova	50	31	32	**38**
Bratislava, Mamateyova	34	37	24	**32**
Humenné, Nám. slobody	35	31	10	25
Jelšava, Jesenského	31	50	22	**34**
Košice, Ďumbierska	*0	20	6	9
Prievidza, Malonecpalská	-	21	13	7
Žilina, Obežná	30	40	21	**30**
Gánovce, Meteo. st.	39	25	14	**26**
Chopok, EMEP	*53	66	66	**62**
Kojšovská hoľa	63	74	39	**59**
Stará Lesná, AÚ SAV, EMEP	44	36	32	**37**
Starina, Vodná nádrž, EMEP	*27	18	5	17
Topoľníky, Aszód, EMEP	41	46	39	**42**

** 50 – 75% of valid measurements*
– station did not measure in monitored interval

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 Košice, Prievidza, Žilina and Starina).

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	2006	2007	2008	Average 2004 – 2008
Bratislava, Jeséniova	32180	20654	20644	**23033**
Bratislava, Mamateyova	23968	22900	19894	**20554**
Humenné, Nám. slobody	26739	21608	14998	**19946**
Jelšava, Jesenského	22732	25987	18677	**19753**
Košice, Ďumbierska	–	18397	12229	*16621
Prievidza, Malonecpalská	–	17466	16853	*17160
Žilina, Obežná	26498	21891	16816	17942
Gánovce, Meteo. st.	25550	19028	19572	**21179**
Chopok, EMEP	33118	26477	32240	**29925**
Kojšovská hoľa	31802	29146	19811	**25167**
Stará Lesná, AÚ SAV, EMEP	25258	20505	19844	**19377**
Starina, Vodná nádrž, EMEP	–	19320	11648	*15692
Topoľníky, Aszód, EMEP	27430	26102	25159	**23851**

* *data from 2006 are not included in the average, because of the station's missing valid measurements in the summer time interval*
– station did not measure in monitored interval

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 (NO_x, 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 2008 was in average close below the 2003 level.

3.3 TOTAL ATMOSFERIC OZONE OVER THE TERRITORY OF THE SLOVAK REPUBLIC IN 2008

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 of the Slovak Hydrometeorological Institute (SHMÚ) at Gánovce near Poprad. 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 regularly 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 via the SR Press Agency and by mobile phone service. Since April 2000 the SHMI Aerological and Radiation Centre has been providing 24 hour UV Index forecast for the public. During the period March 15 – September 30 predicted UV Index daily course for clear day, half covered sky and overcast is presented on the SHMI Web site: (www.shmu.sk/ozon/).

The annual mean of the total atmospheric ozone was 319.5 Dobson Units in 2008. This is 5.5% below the long-term average (calculated upon the Hradec Králove measurements in the period 1962 – 1990). Since 1994 annual means measured at Poprad-Gánovce station have been available. The 1994 – 2008 long-term average is 325.9 Dobson units. In mentioned period the year 2008 has belonged to 3 years with the lowest ozone. In comparison with the year 2007 the annual mean was lower by 2.4%.

Total ozone statistics for the year 2008 (daily means, relative deviations from long term averages, monthly means, standard deviations and extremes) are in Table 3.7. The monthly mean below an average was observed during whole year. The most significant negative monthly deficiencies were in February (–12%), August (–10%) and June (–8%). The lowest deficiencies of –1% were in November and December.

Total ozone weekly averages are in Figure 3.3. The graph illustrates a behaviour of the ozone layer in the year 2008 and shows significant short-term variations in total ozone amount in our geographical region. Only 11 weekly averages were equal or higher than long term average.

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

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. During a day of clear sky daily UV-B maximum should be measured. A significant scattering of values demonstrates the weather condition influence. Clouds depending on their optical depth can significantly reduce the UV irradiance. As the UV irradiance depends on the solar elevation it has a distinctive daily and annual course. UV-B values in winter are more than 10-times lower as compared to summer. Comparable attenuation is also caused by cloudiness and precipitation in summer. After filtering of cloud, precipitation and aerosol influence the annual course is not symmetrical by solstices. Decreased annual course of total ozone causes the highest UV irradiance after solstice in last decade of June and early July.

The UV Index is also shown in Figure 3.4. It is a unit to simply express the UV irradiance level relevant to the erythemal effect on human skin and has been standardised by relationship 1 UV Index = 25 $mW.m^{-2}$. 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 7 attained in spring and summer months are classified as high. The sun exposure without protection should be limited to several minutes. Values below 4 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 Erythema 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. 1 $MED.hour^{-1}$ corresponds to 0.0583 $W.m^{-2}$ for 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 SHMÚ web site.

Fig. 3.3 **Total atmospheric ozone over the territory of Slovakia in 2008**

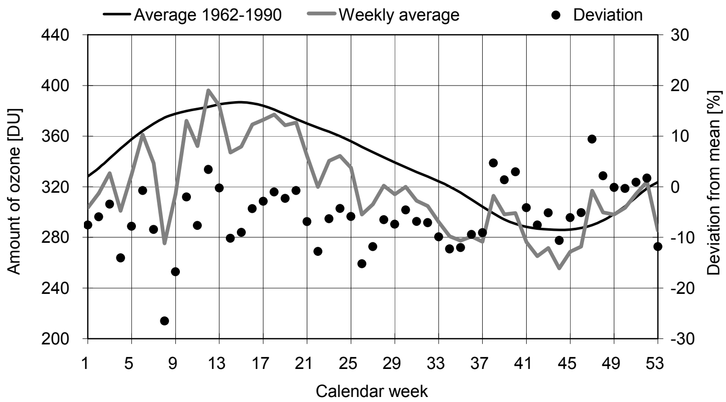


Fig. 3.4 **Annual course of CIE effective irradiance noon values – Gánovce 2008**

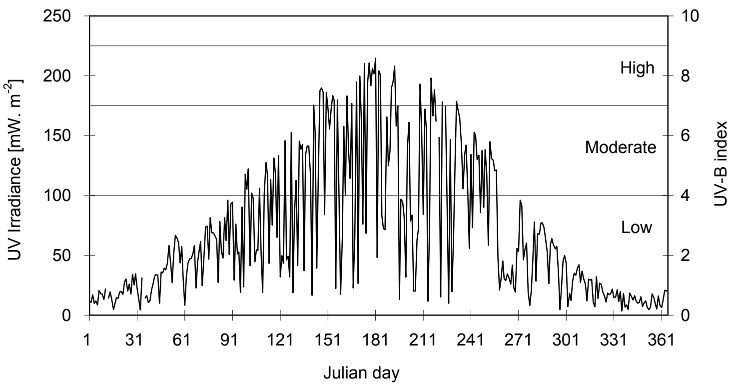
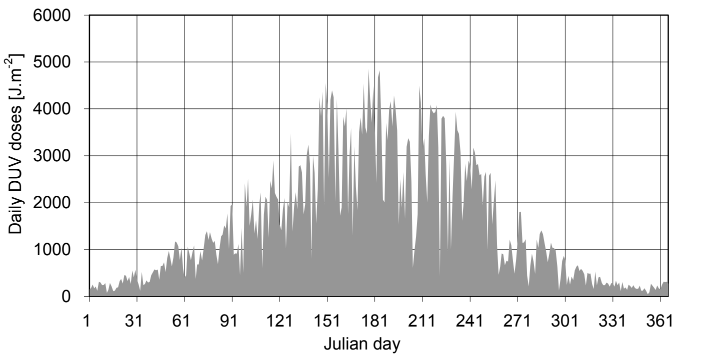


Fig. 3.5 **Annual course of CIE daily doses – Gánovce 2008**



The maximal noon value of CIE-weighted irradiance 214.7 $mW.m^{-2}$ (which correspondents to 3.68 $MED.hour^{-1}$) was measured at noon on June 29. In that day a deficiency in total ozone of 14% was measured. In 2008 the 200 $mW.m^{-2}$ value was overcome in eight days which is the same number than in 2007. First day was June 22, the last one was July 11. High irradiance was connected with sunny weather and low total column ozone down to 18% below an average. In the period June 22 – July 4 average ozone deficiency of 15% was recorded.

UV-B radiation has been currently monitored every day at regular 1-hour or half an hour increments. The observing schedule was only temporarily stopped during thunderstorms. The Brewer ozone spectrophotometer MKIV is primarily designed for total ozone measurements and must be calibrated with internal lamps very often if ambient temperature significantly changes. Calibrating and measuring procedures cannot run simultaneously that is why the less number of values is sometimes available to calculate the daily integral. The UV measuring procedure lasts several minutes because the light intensity is gradually measured at 70 wavelengths. All those reasons cause some hardly quantified uncertainty in daily sum calculation. Daily CIE-erythemal doses are presented in Figure 3.5. A maximum daily dose of 4854 J.m^{-2} (which correspondents to 23.1 MED) was measured on June 25.

Total CIE-erythemal dose for the period April-September 2008 was 458 027 J.m^{-2}. This value is 4.6% lower than in 2007. However it has ranked among 5 highest values recorded at Poprad-Gánovce station since 1994.

Tab. 3.7 **Total atmospheric ozone [DU] in 2008 and the deviations from long-term average**

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	360	11	345	-4	382	1	319	-17	369	-3	337	-8	302	-13	311	-6	278	-11	284	-2	264	-8	303	2
2	352	8	391	9	355	-6	326	-16	386	1	336	-8	299	-14	299	-10	287	-8	284	-2	246	-14	275	-7
3	349	7	324	-10	303	-20	367	-5	376	-1	338	-7	293	-16	300	-9	282	-9	290	0	271	-5	323	8
4	396	21	332	-8	330	-13	344	-11	376	-1	339	-7	300	-14	292	-12	284	-8	339	17	258	-10	277	-7
5	363	10	368	2	402	6	365	-6	362	-4	347	-4	340	-2	304	-8	289	-7	346	20	244	-15	283	-6
6			308	-15	409	8	361	-7	354	-6	346	-5	325	-6	296	-10	276	-10	319	10	251	-12	299	0
7	314	-5	357	-2	368	-3	391	1	353	-7	340	-6	314	-9	288	-12	268	-13	289	0	262	-9	328	9
8	292	-12	408	12	426	12	340	-12	368	-2	338	-7	328	-5	292	-11	285	-7	296	3	272	-5	328	9
9	311	-7	384	5	367	-4	348	-10	375	-1	337	-7	349	2	355	9	264	-14	269	-7	323	13	293	-3
10	314	-6	371	1	373	-2	353	-9	384	2	336	-7	332	-3	307	-6	264	-14	260	-10	292	2	301	-1
11	306	-9	347	-6	372	-2	345	-11	384	2	340	-6	307	-10	291	-11	273	-10	253	-12	287	0	315	3
12	329	-2	336	-9	344	-10	344	-11	387	3	358	-1	311	-9	300	-8	277	-9	248	-14	272	-5	304	0
13	337	0	327	-12	349	-9	342	-12	380	2	333	-7	306	-10	284	-13	281	-7	253	-12	282	-2	302	-2
14	313	-8	299	-19	353	-7	345	-11	382	2	351	-2	317	-7	297	-8	292	-3	268	-7	287	0	281	-9
15	380	12	331	-11	349	-9	353	-9	369	-1	356	-1	335	-2	284	-12	304	1	268	-7	243	-16	282	-9
16	312	-9	373	1	326	-15	374	-3	372	0	339	-5	311	-8	292	-10	317	5	261	-9	247	-14	329	6
17	384	12	358	-4	346	-9	408	6	358	-4	349	-2	299	-12	298	-8	324	8	285	-1	279	-3	313	1
18	328	-5	297	-20	405	6	361	-6	346	-7	366	3	312	-8	302	-6	323	8	257	-10	273	-5	308	-1
19	306	-11	271	-28	413	8	380	-1	342	-8	331	-7	322	-5	274	-15	310	4	264	-8	291	0	340	9
20	293	-15	245	-35	425	11	355	-8	356	-4	335	-6	303	-10	276	-14	296	0	256	-10	289	0	294	-6
21	279	-20	295	-21	406	6	353	-8	354	-4	321	-9	318	-6	279	-13	317	7	261	-9	314	8	334	6
22	343	-1	243	-35	386	1	385	0	341	-8	304	-14	308	-8	273	-14	300	1	275	-4	376	29	306	-3
23	271	-22	321	-15	393	2	385	0	359	-3	294	-17	347	3	263	-17	297	1	292	2	397	36	361	14
24	257	-26	256	-32	398	4	390	1	334	-9	293	-17	343	2	299	-6	319	8	288	1	321	10	342	8
25	310	-12	276	-27	437	14	353	-8	325	-12	294	-17	308	-8	281	-12	324	10	266	-7	284	-3	358	12
26	315	-11	284	-25	427	11	360	-6	309	-16	290	-18	312	-7	283	-11	305	4	263	-8	319	9	345	8
27	331	-6	304	-19	354	-8	385	1	305	-17	300	-15	303	-9	275	-13	276	-6	258	-10	304	4	276	-14
28	296	-17	310	-18	362	-6	382	0	308	-16	315	-10	306	-8	277	-12	267	-9	249	-13	284	-4	280	-13
29	317	-11	347	-8	349	-9	378	-1	310	-16	301	-14	313	-6	274	-13	266	-9	243	-15	298	1	267	-17
30	286	-20			361	-6	372	-2	330	-10	286	-18	311	-7	278	-11	285	-2	239	-16	289	-2	278	-14
31	349	-2			349	-10			339	-7			322	-3	275	-12			290	2			312	-4
Ø	323	-5	324	-12	375	-2	362	-6	355	-5	328	-8	316	-7	290	-10	291	-3	275	-4	287	-1	308	-1
Std	33	11	43	12	33	9	20	5	25	6	22	5	15	5	17	4	19	7	25	8	35	12	26	8
Max	396	21	408	12	437	14	408	6	387	3	366	3	349	3	355	9	324	10	346	20	397	36	361	14
Min	257	-26	243	-35	303	-20	319	-17	305	-17	286	-18	293	-16	263	-17	264	-14	239	-16	243	-16	267	-17

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

4

EMISSION AND AIR POLLUTION SOURCE INVENTORY

4.1 EMISSION AND AIR POLLUTION SOURCE INVENTORY

Anthropogenic emissions of pollutants into 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 effect, 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 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 is a multi-modular system with a yearly update following requirements of actual air protecting legislation. Module NEIS BU enables complex data collection and data processing in respective district offices, as well as the logical verification of emission calculation from the operator’s input data. Also serves to issue the decisions on the tax height. 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 and enables besides electronically processing of the input data 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. Data from the district databases are then fed into the NEIS CU central database at SHMÚ, where they are controlled. The NEIS employs the support of standard database products MS ACCESS and MS SQL server.

The function of 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 also the system has been renamed to National Emission Information System (NEIS). Within the system it was started archiving of the documents issued by district offices. Data acquisition was expanded 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.
- Better 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 the top state administration bodies to fulfill the tasks optimally at all levels and provides the input data for international emission inventories, respectively compilation of special emission inventories.
- Information available on the Internet website www.air.sk.
- Establishment of 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 may be compared with the NEIS module only on 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 478/2002 Coll. (§33, section 3, chapter g, m) as amended, the district offices are obliged to elaborate yearly reports about the operational characteristics of air pollution sources in their district and provide them electronically at the latest till 31st May of the current year for the next processing to 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. 706/2002):

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 – 2008) – 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 844 (745 of it in operation) large point sources in 2008. 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 2008, NEIS registered 12 642 (10 923 of 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), 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

The emissions from subsector transport include the road transport, civil aviation, navigation and railways sources of air pollution in the Slovak Republic. The emissions from road and non-road transport were calculated by using models and default methods and the consistent data series from 1990 – 2008.

Emissions from mobile sources are defined annually since 1990. To balance emissions from the road transport COPERT IV[2] model has been used since the 2008 approved and recommended by the Executive Committee of the UNECE Convention on Long-Range Transboundary Air Pollution[3]. Road transport, has been recalculated from year 2000 with COPERT IV (2000 – 2007). Before 2000 the changes are negligible. Model COPERT version IV contains the available technical data on various categories of vehicles in the combination with more specific parameters for that country. Parameters can be changed according to user features and updated. Calculation of emissions is based on five main types of input parameters: the total fuel consumption, vehicle fleet, driving mode, emission factors and other parameters such as average annual driving performance.

In addition to the road transport, the emissions for non-road transport (railways, navigation and aviation transport) were estimated since 1990 – 2008. EMEP/CORINAIR Guidebook[4] for the non-road sources methodology was used for the railways transport emission estimation with application of average emissions factors.

The emission inventory for aviation transport was estimated according to the local pollution from the important airports in the Slovak Republic. The operation information and statistical data can be used for estimation. The movements of aircrafts, LTO cycles, fuel consumption or fuel sold were used for the estimation every year. Given the fact that there has not yet been developed a clear methodology, nor known the experience which would allow air pollutants objectively assess the impact of aircraft engines in larger amounts of air transport is an inventory of emissions of pollutants in air pollution and processed according to the local major airports. The basic input operational and statistics data are the number of aircraft movements made, the flight (LTO) cycle, fuel consumption and an overview of fuel sold. Innovated methodology is also based on knowledge of emission factors of various types of aircraft.

The emission balance of PM_{10} and $PM_{2.5}$ from road transport was completed for the first time in 2004 back to the base year 1990. According to the requirements of the updated method EMEP/CORINAIR[5] and to the requirement for reporting of these emissions for UNECE (NFR[6]) the emissions from exhausts of gasoline engines and abrasive emissions (abrasion of road surface, tires and brake facing) were evaluated. The method and emission factors were recommended by the TNO-MEP agency (The Environmental Agency of Netherlands). The results of PM_{10} and $PM_{2.5}$ emissions from road transport are summarized in Tables 4.2a and 4.2b.

[2] *http://lat.eng.auth.gr/copert*
[3] *http://www.unece.org/env/lrtap/*
[4] *Emission Inventory Guidebook – 3rd edition*
[5] *http://reports.eea.europa.eu/EMEPCORINAIR5/*
[6] *New format for reporting*

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 and SO_2

Emissions of particulate matter and SO_2 have been decreasing continuously since 1990. Apart from the decrease in energy production and consumption, 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. A further spreading of separation techniques used, respectively advancing of its effectiveness shared in the particulate matter emission reduction. 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, use of low-sulphur fuel oil (Slovnaft Ltd., Bratislava) and installation of the desulphurisation systems for the 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, or by the quality of combustion fuel and volume of production. In 2004, 2005 and 2006 the decrease of SO_2 emissions was recorded mainly at large sources. This decrease was caused mainly by the combustion of low-sulphur-content fuel oils and coal (Slovnaft Ltd., Bratislava, TEKO Ltd., Košice) and by the reduction of production volume (power plants in Zemianske Kostoľany and Vojany). 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 price for natural gas and coal. 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). In 2006 the decrease of particulate matter emissions was achieved mainly by reconstruction of separators in some sources in energy and industry (Power plants in Zemianske Kostoľany, U.S. Steel Ltd., Košice). The decrease of the particulate matter and SO_2 emissions in 2007 and 2008 for the large stationary sources was mostly caused by the power plant in Vojany, of which some combustion units was out of operation.

Oxides of nitrogen

Emissions of nitrogen oxides have showed a smooth decrease since 1990. A slight emission increase in 1995 was associated with the increase in consumption of natural gas. A decrease of emissions of NO_x in 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. The further emissions decrease in years 2002 and 2003 was caused by denitrification process (power plant Vojany). In 2006 NO_x emissions decreased mainly at large and middle stationary sources. This decline is related to the reduction of production (power plants in Zemianske Kostoľany and Vojany) and consumption of solid fuel and natural gas (power plants in Zemianske Kostoľany, Slovak Gas Industry Ltd. Nitra). In years 2007 – 2008 the consumption of anthracite and Polish hard coal decreased. Significant decline of NO_x emissions was achieved in mobile sources, mainly in the road transport. This decrease is connected to the reduction of consumption liquid hydrocarbons fuels in comparison to 2006, and to the renovation of rolling stock in case of both passenger and good vehicles.

CO A downward trend in CO emissions since 1990 has been caused mainly by the decrease in consumption and by the change of fuel composition in the sphere of retail consumers. Carbon monoxide emissions originating from combustion processes of the major sources have been slightly decreasing as well. The iron and steel industry participate most significantly in the total CO emissions from major sources. Carbon monoxide emission's decrease in 1992 was due to a decrease in iron and steel production volume. In 1993, when the iron and steel production increased again reaching the 1990 level, the CO emissions increased proportionally. A decrease in CO emissions in 1996 was due to the effects of measures (determined on the results of measurements) being taken to limit CO_2 emissions in the most important source in this sector. The fluctuation of CO emissions within 1997 and 2003 also is affected by the quantity of pig iron production as well as the fuel consumption. In 2004 the CO emissions slightly increased mainly at large sources (the amount of CO emissions specified upon the continuous measurement in U.S. Steel Ltd., Košice), since then the emissions have had only moderately decreasing trend. The emission decrease in the sector road transport within 2004 – 2005 is associated with onward renovation of rolling stock by the generationally new vehicles equipped by the three-way catalysts. 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 Ltd., Košice and by the implementation of a new technology with effective combustion at lime production (Dolvap Ltd., Varín). In 2005 the CO emission increase was achieved only in the sector of small sources (residential) and it is related to the increase of wood consumption caused by the increase of price for natural gas and coal. In 2006 – 2008 the trend of total CO emissions decrease continued mainly in the sector of mobile sources; in the road transport the consumption of liquid hydrocarbon fuels decreased in comparison to 2005 and the rolling stock was renovated. The emission decrease in large stationary sources was influenced significantly by the decrease of fuel consumption in iron and steel production.

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} or $PM_{2.5}$) are processed in accordance with the international methodology using the SNAP 97 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 Joint EMEP/CORINAIR Atmospheric 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 (Table 4.7, Figure 4.4). The NMVOC emissions have increased in the sector of paints and glues by about 51 % 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. Since 2006 and 2007 was noticed a moderate decrease of emissions due to decrease of emissions in sectors of exploitation and distribution of crude oil, transport, ore agglomeration and combustion in manufacturing industry.

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 Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases, UNEP Chemicals, February 2005 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. 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 mostly by the change of aluminium production technology (use of pre-baked anodes) (Table 4.8, Figure 4.5). Increased emissions of polychlorinated biphenyls (PCB) were influenced by the increase of consumption in crude oil in the road transport and using wood in the residential sector. Increased consumption of wood in this sector influenced also total emission of PAHs. Emissions of PCDD/F have declined since 2000 because of reconstruction of some technologies (for example municipal waste incinerators). In 2005 emissions of PCDD/F increased because of increased amount of incinerated medical waste. In 2006, amount of incinerated medical waste slightly decreased and agglomeration of iron ore slightly increased. In comparison with 2005, the share of different fuels in residential sector remained nearly without changes. As a result of all these factors, total emissions PCDD/F decreased, hexachlorbenzene (HCB) slightly increased and PCB and PAH slightly decreased. In 2007 emissions of PCDD/F slightly decreased as a result of decrease in the sector of combustion in manufacturing industry (agglomeration of iron ore) and waste incineration. Moderate increase of PCB and PAH emissions were caused by increased fuel consumption in road transport sector, emissions of HCB slightly increased as a consequence of increased amount of secondary copper and cement produced, besides mentioned increase in the road transport.

HMs

Emission inventory of heavy metals (HMs) is estimated according to the Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook. In 2004 combustion of wood 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. Beside 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, a change of raw materials used, and in particular by the elimination of leaded petrol (Table 4.10, Figure 4.7) 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.

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

Emissions of PM_{10} and $PM_{2.5}$ have been processed annually on the base of requirements of Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook[5], 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 (Tables 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. (Table 4.9, Figure 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[7] 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.[8]

Share of individual sectors in total emissions of the Slovak Republic in 2008

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 8 to the Decree no. 705/2002 Coll.).

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

[8] *Proposal for the estimation of total suspended particulars with aerodynamics diameter that is smaller than 10 and 2.5 μm, SHMÚ, 2008.*

Most important sources of air pollution in the Slovak Republic in 2008

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 69.75% to 95.97%. Table 4.5 lists top ten sources in administrative regions according to the amount of emissions of basic pollutants.

Specific territorial emissions in 2008

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).

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	10.764	8.852	7.980	7.641	8.544	8.755	8.940	9.142	9.509	8.766
	Total	290.059	234.577	186.918	153.377	104.053	106.204	81.418	75.436	71.194	73.291
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	3.423	2.733	2.389	2.175	2.313	2.490	2.536	2.554	2.724	1.088
	Total	526.112	445.499	389.631	328.221	245.220	246.288	230.594	204.689	184.112	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	56.850	47.509	43.738	42.362	43.535	45.453	45.038	44.915	46.210	43.225
	Total	221.616	200.936	188.396	180.075	169.800	177.709	134.696	127.242	132.847	120.822
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	154.199	142.872	140.621	150.676	154.804	156.743	151.133	153.216	153.946	144.655
	Total	505.458	483.105	440.611	451.724	427.437	415.645	359.317	358.822	341.554	330.012

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**	Large sources [1]	29.923	29.722	25.037	20.166	17.670	18.719	13.992	6.020	5.406
		Middle sources [1]	4.958	4.405	3.767	3.259	2.748	2.392	2.281	1.972	1.764
		Small sources [2]	19.877	20.550	17.217	18.300	21.504	28.708	26.980	26.821	26.921
	Mobile sources	Road transport	3.376	3.688	4.280	5.763	4.849	5.786	6.211	6.186	4.693
		Other transport	0.399	0.404	0.366	0.329	0.343	0.359	0.336	0.353	0.325
	Total		58.533	58.769	50.667	47.817	47.114	55.964	49.800	41.352	39.109
SO_2	**Stationary sources – NEIS**	Large sources [1]	101.955	109.823	91.461	95.283	87.932	81.592	80.104	64.974	64.059
		Middle sources [1]	8.083	6.655	3.964	3.620	2.652	2.107	1.902	1.598	1.246
		Small sources [2]	16.055	13.764	7.127	6.384	5.382	5.073	5.524	3.735	3.844
	Mobile sources	Road transport	0.669	0.670	0.733	0.150	0.157	0.189	0.195	0.204	0.209
		Other transport	0.189	0.194	0.064	0.059	0.063	0.047	0.044	0.047	0.045
	Total		126.951	131.106	103.349	105.496	96.186	89.008	87.769	70.558	69.403
NO_x	**Stationary sources – NEIS**	Large sources [1]	54.485	51.653	46.412	44.605	44.244	42.424	39.038	35.762	34.488
		Middle sources [1]	8.052	7.751	6.356	6.620	4.926	4.377	4.992	3.542	3.575
		Small sources [2]	7.993	8.391	7.137	7.356	7.582	8.866	8.336	7.819	7.979
	Mobile sources	Road transport	31.687	34.817	35.324	33.006	37.663	43.121	39.297	44.299	44.049
		Other transport	4.860	4.899	4.808	4.305	4.506	4.722	4.427	4.654	4.568
	Total		107.077	107.511	100.037	95.892	98.921	103.510	96.090	96.076	94.659
CO	**Stationary sources – NEIS**	Large sources [1]	120.609	115.177	122.225	141.047	147.317	133.787	147.318	141.062	136.530
		Middle sources [1]	10.779	10.280	9.150	9.394	7.531	5.853	5.350	5.330	4.518
		Small sources [2]	53.792	50.178	33.815	33.811	34.753	41.766	40.882	37.018	37.367
	Mobile sources	Road transport	115.409	131.467	123.183	108.986	104.770	97.114	82.433	63.484	62.023
		Other transport	1.719	1.626	1.591	1.463	1.509	1.566	1.452	1.533	1.446
	Total		302.308	308.728	289.964	294.701	295.880	280.086	277.435	248.427	241.884

[1] *According to the Decree of MŽP SR no. 706/2002 Coll.*
[2] *According to the Decree of MŽP SR no.144/2000 Coll. (2001 – 2003), according to the Decree of MŽP SR no. 53/2004 Coll. (2004 – 2007).*
Emissions estimated to October 31st, 2009

Tab. 4.2a **Emissions of PM [t] from road transport in the SR within 1990 – 2008**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Emissions from diesel engine	2916	2339	2040	1889	2020	2200	2263	2292	2397	2260
Emissions from petrol engine	376	348	335	354	346	346	321	302	283	238
Total emissions from exhaust	3292	2687	2375	2243	2366	2546	2584	2594	2680	2498
Abrasion emissions	6737	5587	5102	5000	5765	5761	5897	6114	6324	5823
Total	10029	8274	7477	7243	8131	8307	8481	8708	9004	8321

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emissions from diesel engine	2125	2302	2761	3721	3166	3767	3897	4076	3067
Emissions from petrol engine	256	274	226	245	231	266	242	234	262
Total emissions from exhaust	2968	3247	3872	5362	4404	5230	5448	5607	4069
Abrasion emissions	1715	1965	2306	2110	2243	2699	3351	2842	3036
Total	7064	7788	9166	11437	10044	11961	12938	12760	10434

Tab. 4.2b **Emissions of PM_{10} and $PM_{2.5}$ [t] from road transport in the SR within 2000 – 2008**

	2000		2001		2002		2003		2004		2005		2006		2007		2008	
	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}	$PM_{2,5}$	PM_{10}	$PM_{2,5}$	PM_{10}	$PM_{2,5}$	PM_{10}	$PM_{2,5}$
Emissions from diesel engines	1169	1056	1261	1154	1509	1385	2006	1885	1698	1560	2057	1891	2417	2235	2238	2046	1748	1543
Emissions from petrol engines	193	120	232	145	196	121	210	130	200	123	233	141	209	129	203	125	225	139
Total emissions from exhaust	989	989	1082	1082	1291	1291	1787	1787	1468	1468	1743	1743	1816	1816	1869	1869	1356	1356
Abrasion emissions	557	298	638	341	749	400	685	366	728	389	875	467	1085	578	922	491	985	525
Total	2908	2463	3213	2722	3745	3197	4688	4168	4094	3540	4908	4242	5527	4758	5232	4531	4274	3523

Emissions estimated to October 31st, 2009

Fig. 4.1 **Development trends in basic pollutant emissions within 1990 – 2008**

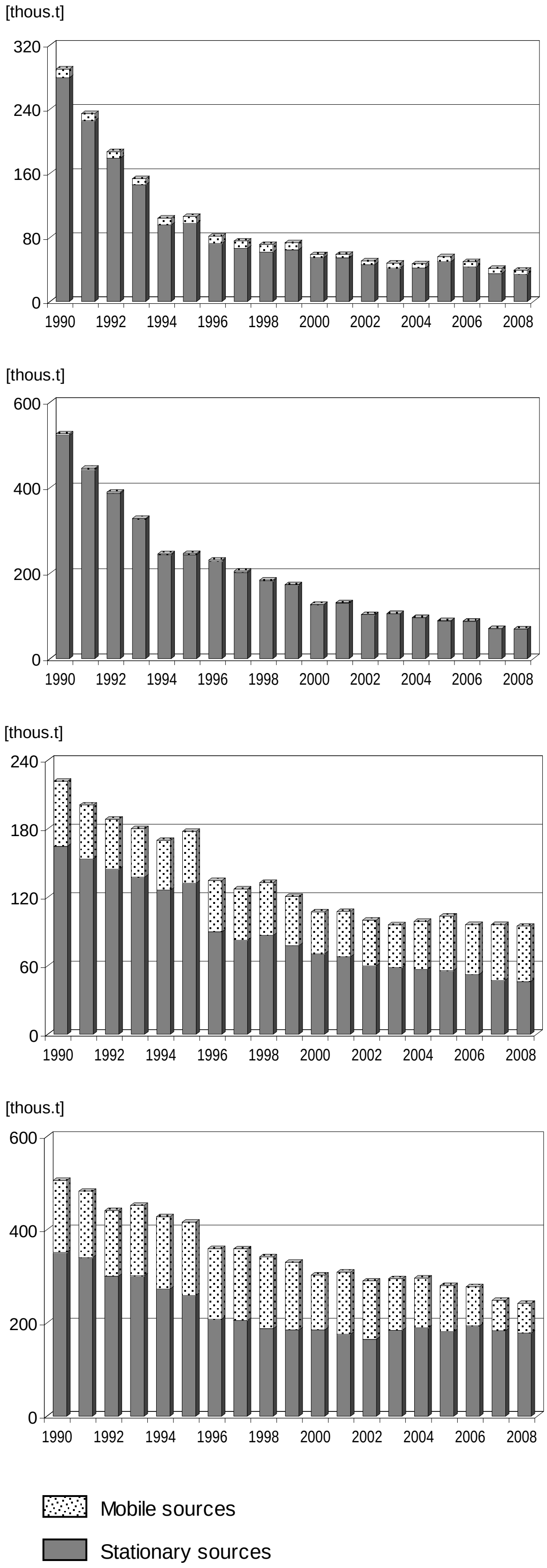
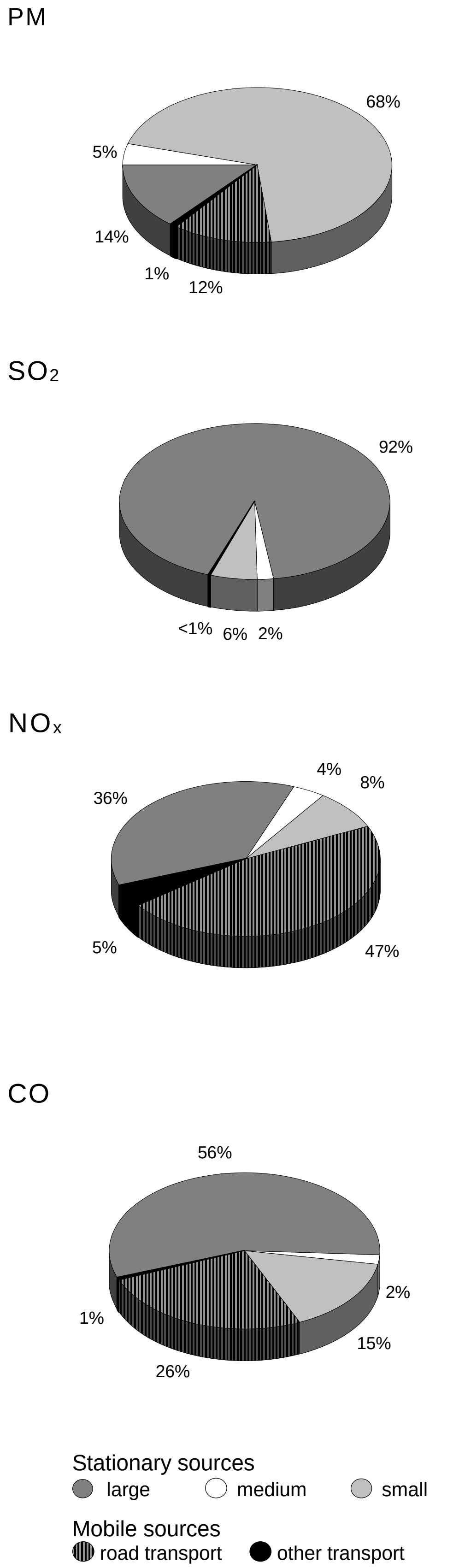


Fig. 4.2 **Emissions of basic pollutants in 2008**



Tab. 4.3 **Stationary source emissions of basic pollutants [t] in agglomerations and zones* within 2000 – 2008**

PM		2000	2001	2002	2003	2004	2005	2006	2007	2008
Agglomeration	Bratislava	942	477	444	482	467	472	430	353	339
	Košice	15758	17173	14601	9890	6806	4362	4107	3418	3056
Zone	Bratislava region	501	546	493	465	456	506	452	469	477
	Trnava region	1518	1518	1284	1325	1522	1935	1825	1752	1770
	Trenčín region	4607	4820	4199	4332	4804	5280	4712	4464	4312
	Nitra region	3057	2921	2476	2478	2744	3414	3144	3074	3053
	Žilina region	6585	6271	5298	5343	5852	7076	6540	6443	6459
	Banská Bystrica region	6320	6355	5334	5346	5819	7378	6710	6579	6566
	Prešov region	4207	4266	3491	3666	4588	5556	5158	4606	4514
	Košice region	11262	10331	8400	8397	8864	13842	10176	3663	3545
Total		54758	54677	46022	41725	41922	49820	43253	34820	34090

SO_2		2000	2001	2002	2003	2004	2005	2006	2007	2008
Agglomeration	Bratislava	13240	13594	11348	12263	9869	9285	11764	8648	8302
	Košice	18307	12608	10500	10781	13113	12526	11417	10307	9910
Zone	Bratislava region	384	380	208	150	289	377	207	176	169
	Trnava region	2160	2051	1166	1077	1141	1037	1039	566	566
	Trenčín region	28625	45187	38305	46051	44108	40937	39659	33450	36114
	Nitra region	4752	4749	3799	3648	2485	2336	2367	1158	1134
	Žilina region	10775	10237	7140	7647	6147	5035	4444	3751	3693
	Banská Bystrica region	10654	10043	8814	7983	6300	6197	6791	5022	4724
	Prešov region	8372	8082	6320	6719	4864	4856	4204	3407	1811
	Košice region	28825	23310	14952	8969	7650	6185	5639	3823	2727
Total		126094	130242	102552	105287	95966	88772	87530	70307	69149

NO_x		2000	2001	2002	2003	2004	2005	2006	2007	2008
Agglomeration	Bratislava	6393	5151	5313	5414	5260	4791	4521	4110	4112
	Košice	12382	12172	12140	12343	11092	10929	12222	9975	8665
Zone	Bratislava region	1792	1900	1972	1590	1650	1742	1700	1882	1874
	Trnava region	2012	1966	1684	1670	1652	1667	1608	1470	1563
	Trenčín region	9083	10489	9616	10198	9687	7822	7835	7219	7588
	Nitra region	3905	3974	3843	3993	4424	3989	3653	2979	3465
	Žilina region	5433	5170	4599	4483	4700	4674	4479	4550	4397
	Banská Bystrica region	6541	6666	6316	5843	6146	6281	5522	5550	5699
	Prešov region	3279	3443	3212	3224	3173	3459	3284	2849	2490
	Košice region	19710	16864	11209	9824	8967	10314	7543	6538	6189
Total		70530	67794	59905	58581	56752	55667	52366	47122	46042

CO		2000	2001	2002	2003	2004	2005	2006	2007	2008
Agglomeration	Bratislava	1528	1319	1264	1204	1254	1120	1065	879	821
	Košice	84544	78619	83700	104600	107212	93197	109060	102663	94378
Zone	Bratislava region	1951	1638	1488	2789	1767	1576	1901	2020	2661
	Trnava region	4746	4682	3591	3397	3496	3865	3563	3459	3306
	Trenčín region	11684	10334	7815	7801	8040	9331	10854	9430	10043
	Nitra region	7964	7379	5470	5615	5700	6627	6459	5690	6849
	Žilina region	19357	19287	16520	16459	17253	15924	14990	14686	14210
	Banská Bystrica region	26309	26301	24299	25729	27834	29375	26835	27382	29303
	Prešov region	12170	11838	9075	8796	8802	9282	8714	7522	7080
	Košice region	14927	14237	11969	7861	8242	11109	10108	9680	9764
Total		185180	175635	165191	184252	189601	181406	193550	183410	178415

** According to the Decree of MŽP SR no. 705/2002 Coll., Annex 8*

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 2008**

	TZL		SO_2		NO_x		CO	
	Prevádzkovateľ	[%]	Prevádzkovateľ	[%]	Prevádzkovateľ	[%]	Prevádzkovateľ	[%]
1	U.S. Steel, s.r.o., Košice	39.43	SE, a.s., Bratislava, o.z., ENO Zem. Kostoľany	53.66	U.S. Steel, s.r.o., Košice	17.29	U.S. Steel, s.r.o., Košice	64.69
2	SE, a.s., Bratislava, o.z., ENO Zem. Kostoľany	7.09	U.S. Steel, s.r.o., Košice	12.91	SE, a.s., Bratislava, o.z., ENO Zem. Kostoľany	10.04	SLOVALCO, a.s., Žiar nad Hronom	9.64
3	Považská cementáreň, a.s., Ladce	2.39	SLOVNAFT a.s., Bratislava	12.40	SLOVNAFT a.s., Bratislava	6.71	Calmit, s.r.o., Bratislava, prev. Tisovec	2.43
4	SLOVNAFT a.s., Bratislava	2.23	SLOVALCO, a.s., Žiar nad Hronom	2.09	SE, a.s., Bratislava, Elektráreň Vojany I a II	4.90	Carmeuse Slovakia s.r.o., závod Košice	2.01
5	SLOVALCO, a.s., Žiar nad Hronom	2.15	Žilinská teplárenská, a.s., Žilina	1.95	TEKO a.s., Košice	3.94	KOVOHUTY, a.s., Krompachy	1.86
6	Carmeuse Slovakia s.r.o., závod Včeláre	1.78	SIDERIT s.r.o., Nižná Slaná	1.95	Holcim (Slovensko), a.s., Rohožník	3.44	CALMIT spol. s.r.o., Bratislava, prev. Žírany	1.47
7	Novácke chemické závody, a.s., Nováky	1.67	TEKO a.s., Košice	1.53	Mondi scp, a.s., Ružomberok	2.79	Považská cementáreň, a.s., Ladce	1.40
8	SE, a.s., Bratislava, Elektráreň Vojany I a II	1.65	Zvolenská teplárenská a.s., Zvolen	1.44	Považská cementáreň, a.s., Ladce	2.75	CEMMAC, a.s., Horné Srnie	1.32
9	Duslo a.s., Šaľa	1.55	SE, a.s., Bratislava, Elektráreň Vojany I a II	1.35	eustream, a.s., prev. Veľké Kapušany	2.71	DOLVAP, s.r.o., Varín	1.28
10	SIDERIT Nižná Slaná	1.25	BUKOCEL a.s., Hencovce	1.25	V.S.H., a.s., Turňa nad Bodvou	2.66	Slovenské magnezitové závody a.s., Jelšava	1.23
11	Mondi scp, a.s., Ružomberok	1.13	Martinská teplárenská, a.s., Martin	1.25	eustream, a.s., prev. Jablonov nad Turňou	2.62	Mondi scp, a.s., Ružomberok	1.14
12	TEKO a.s., Košice	1.05	Smurfit Kappa Štúrovo, a.s.	1.01	Slovenské magnezitové závody a.s., Jelšava	2.40	Holcim (Slovensko), a.s., Rohožník	1.11
13	Knauf Insulation, s.r.o., Nová Baňa	0.94	Slovenské magnezitové závody a.s., Jelšava	0.84	eustream, a.s., prev. Veľké Zlievce	2.16	OFZ, a.s., Istebné	1.00
14	SES a.s., Tlmače	0.89	Carmeuse Slovakia s.r.o., závod Košice	0.47	eustream, a.s., prev. Ivánka pri Nitre	1.75	SE, a.s., Bratislava, Elektráreň Vojany I a II	0.59
15	DOLVAP, s.r.o., Varín	0.89	Knauf Insulation, s.r.o., Nová Bana	0.42	SLOVALCO, a.s., Žiar nad Hronom	1.56	Calmit, s.r.o., Bratislava, prev. Margecany	0.50
16	Žilinská teplárenská, a.s., Žilina	0.86	Wienerberger Slovenské tehelne spol. s.r.o.	0.34	Duslo a.s., Šaľa	1.49	BUKOCEL a.s., Hencovce	0.48
17	Carmeuse Slovakia s.r.o., závod Košice	0.80	CHEMES, a.s., HUMENNÉ	0.31	CEMMAC, a.s., Horné Srnie	1.42	Wienerberger Slov. Tehelne s.r.o., závod Boleráz	0.40
18	KVARTET, a.s., Partizánske	0.75	Dalkia Industry Žiar nad Hronom, a.s., Žiar n/H	0.28	Smurfit Kappa Štúrovo, a.s.	1.34	Slovmag a.s., Lubeník	0.40
19	BUKOCEL a.s., Hencovce	0.66	ZSNP, a.s., Žiar nad Hronom	0.27	PPC POWER, a.s., Bratislava	1.24	SIDERIT sro., Nižná Slaná	0.30
20	Kronospan SK, s.r.o., Prešov	0.61	Slovenské cukrovary, a.s., Sereď	0.24	BUKOCEL a.s., Hencovce	1.24	SLOVNAFT a.s., Bratislava	0.30
Spolu		69.75		95.97		74.47		93.53

** According to the Decree of MŽP SR no. 706/2002 Coll.*

Tab. 4.5 **Sequence of the sources within the region according to the emissions in 2008 (NEIS – large and middle sources*)**

BRATISLAVA REGION

	PM		SO_2	
	Source	District	Source	District
1.	SLOVNAFT a.s., Bratislava	Bratislava II	SLOVNAFT a.s., Bratislava	Bratislava II
2.	Holcim (Slovensko), a.s., Rohožník	Malacky	Duslo, a.s., odštepný závod ISTROCHEM Bratislava	Bratislava III
3.	Swedwood Slovakia s.r.o., OZ Malacky	Malacky	Holcim (Slovensko), a.s., Rohožník	Malacky
4.	VOLKSWAGEN SLOVAKIA,a.s., Bratislava	Bratislava IV	Slovnaft Petrochemicals, s.r.o., Bratislava	Bratislava II
5.	PPC POWER, a.s., Bratislava	Bratislava III	Bratislavská vodárenská spoloč., a.s., Bratislava	Bratislava II
6.	Slovnaft Petrochemicals, s.r.o., Bratislava	Bratislava II	MO SR, PSB Bratislava, kotolne Viničné a Sl. Grob	Pezinok
7.	ALAS Slovakia, s.r.o., kameňolom Sološnica	Malacky	Univolt-Remat s.r.o., Pezinok	Pezinok
8.	Swietelsky Slovakia Bratislava	Pezinok	NAFTA Gbely	Malacky
9.	Dalkia a.s., Bratislava, zdroje v okrese	Bratislava V	Technické služby - čistenie, s.r.o., Bratislava	Bratislava II
10.	MO SR, PSB Bratislava, kotolne Viničné a Sl. Grob	Pezinok	Bratislavská vodárenská spoloč., a.s., Bratislava	Bratislava V
	NO_x		CO	
	Source	District	Source	District
1.	SLOVNAFT a.s., Bratislava	Bratislava II	Holcim (Slovensko), a.s., Rohožník	Malacky
2.	Holcim (Slovensko), a.s., Rohožník	Malacky	SLOVNAFT a.s., Bratislava	Bratislava II
3.	PPC POWER, a.s., Bratislava	Bratislava III	Swedwood Slovakia s.r.o., OZ Malacky	Malacky
4.	Slovnaft Petrochemicals, s.r.o., Bratislava	Bratislava II	Termming, a.s., Bratislava, Malacky	Malacky
5.	Swedwood Slovakia s.r.o., OZ Malacky	Malacky	Slovnaft Petrochemicals, s.r.o., Bratislava	Bratislava II
6.	Dalkia a.s., Bratislava, zdroje v okrese	Bratislava V	Dalkia a.s., Bratislava, zdroje v okrese	Bratislava V
7.	Odvoz a likvidácia odpadu, a.s., Bratislava	Bratislava II	Bratislavská teplárenská, a.s., Bratislava, Tepl. západ	Bratislava IV
8.	Bratislavská teplárenská, a.s., Bratislava, Tepl. západ	Bratislava IV	MO SR, PSB Bratislava, kotolne Viničné a Sl. Grob	Pezinok
9.	VOLKSWAGEN SLOVAKIA, a.s., Bratislava	Bratislava IV	DOPRASTAV a.s., Senec	Senec
10.	Bratislavská teplárenská a.s., Bratislava, Tepláreň II	Bratislava III	NAFTA Gbely	Malacky

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.	Johns Manville Slovakia a.s., Trnava	Trnava	Johns Manville Slovakia a.s., Trnava	Trnava
3.	Slovenské cukrovary, a.s., Sereď	Galanta	Wienerberger Slov.tehelne s.r.o., závod Boleráz	Trnava
4.	Corn Corporation, s.r.o., Dunajská Streda	Dunajská Streda	Mach-Trade s.r.o., Sereď	Galanta
5.	RaVOD Pata roľnícke a výrobnoobchodné družs.	Galanta	Zlieváreň Trnava s.r.o.	Trnava
6.	PENAM, a.s., Nitra, prev. Trnava	Trnava	Baňa Záhorie, a.s., Čáry	Senica
7.	AGROPODNIK, a.s., Trnava	Trnava	Slovasfalt s.r.o., obaľovňa Moravský Sv. Ján	Senica
8.	BELAR a.s., Dunajská Streda	Dunajská Streda	Obec Lakšárska Nová Ves, ZŠ Lakšárska N.V.	Senica
9.	Výroba kameňa a pieskov, spol. s.r.o., Buková	Trnava	PD Siladice	Hlohovec
10	ENVIRAL a.s., Leopoldov	Hlohovec	Tehelňa Gbely s.r.o.	Skalica
	NO_x		CO	
	Source	District	Source	District
1.	Johns Manville Slovakia a.s., Trnava	Trnava	Wienerberger Slov.tehelne s.r.o., závod Boleráz	Trnava
2.	Slovenské cukrovary, a.s., Sereď	Galanta	Johns Manville Slovakia a.s., Trnava	Trnava
3.	Amylum Slovakia spol. s.r.o., Boleráz	Trnava	I.D.C. Holding, a.s., Pečivárne Sereď	Galanta
4.	ENVIRAL a.s., Leopoldov	Hlohovec	Swedwood Slovakia s.r.o., OZ Malacky, prev.Trnava	Trnava
5.	Eissmann Automotive Slovensko spol s.r.o., Holíč	Skalica	Amylum Slovakia spol. s.r.o., Boleráz	Trnava
6.	Swedwood Slovakia s.r.o., OZ Malacky,	Trnava	BEKAERT Hlohovec, a.s.	Hlohovec
7.	Wienerberger Slov.tehelne s.r.o., závod Boleráz	Trnava	ENVIRAL a.s., Leopoldov	Hlohovec
8.	Mach-Trade s.r.o., Sereď	Galanta	Zlieváreň Trnava s.r.o.	Trnava
9.	BEKAERT Hlohovec, a.s.	Hlohovec	Slovenské cukrovary, a.s., Sereď	Galanta
10	PCA Slovakia s.r.o., Trnava	Trnava	Medea-S, s.r.o., Sládkovičovo	Galanta

NITRA REGION

	PM		SO_2	
	Source	District	Source	District
1.	Duslo a.s., Šaľa	Šaľa	Smurfit Kappa Štúrovo, a.s.	Nové Zámky
2.	SES a.s., Tlmače	Levice	Icopal a.s., Štúrovo	Nové Zámky
3.	Smurfit Kappa Štúrovo, a.s.	Nové Zámky	BYTREAL Tlmače s.r.o., Tlmače	Levice
4.	Lencos s.r.o., Levice	Levice	Wienerberger Slov. tehelne s.r.o., Zl. Moravce	Zlaté Moravce
5.	BYTREAL Tlmače s.r.o., Tlmače	Levice	Duslo a.s., Šaľa	Šaľa
6.	CALMIT spol. s.r.o., Bratislava, prev. Žírany	Nitra	M Agrokom s.r.o., Marcelová	Levice
7.	Slovintegra Energy, s.r.o., Levice	Levice	EMGO Slovakia s.r.o., Nové Zámky	Nové Zámky
8.	PPC ČAB akciová spoločnosť Nové Sady	Nitra	MO SR, Posádková správa budov Nitra	Nitra
9.	P.G.TRADE spol. s.r.o., Komárno, zdroje v okrese	Nové Zámky	CESTY NITRA a.s., NITRA, prev. Práznovce	Topoľčany
10.	Kameňolomy a štrkopieskovne a.s., lom Pohranice	Nitra	N-ADOVA, spol. s.r.o., Nitra	Nitra

	NO_x		CO	
	Source	District	Source	District
1.	eustream, a.s., prev. Ivánka pri Nitre	Nitra	CALMIT spol. s.r.o., Bratislava, prev. Žírany	Nitra
2.	Duslo a.s., Šaľa	Šaľa	Wienerberger Slov. tehelne s.r.o., Zl. Moravce	Zlaté Moravce
3.	Smurfit Kappa Štúrovo, a.s.	Nové Zámky	Slovintegra Energy, s.r.o., Levice	Levice
4.	Slovintegra Energy, s.r.o., Levice	Levice	Duslo a.s., Šaľa	Šaľa
5.	SES a.s., Tlmače	Levice	DANFOSS COMPRESSORS, s.r.o., Zlaté Moravce	Zlaté Moravce
6.	Bytkomfort s.r.o., Nové Zámky	Nové Zámky	Smurfit Kappa Štúrovo, a.s.	Nové Zámky
7.	Nitrianska teplárenská spoločnosť a.s., Nitra	Nitra	eustream, a.s., prev. Ivánka pri Nitre	Nitra
8.	OPM2SR s.r.o., Nitra	Nitra	Komárňanské tlačiarne spol. s.r.o., Komárno	Komárno
9.	COM-therm s.r.o., Komárno	Komárno	SES a.s., Tlmače	Levice
10.	DECODOM s.r.o., Topoľčany	Topoľčany	MO SR, Posádková správa budov Nitra	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	TEPLÁREŇ, a.s., Považská Bystrica	Považská
3.	Novácke chemické závody, a.s., Nováky	Prievidza	KVARTET, a.s., Partizánske	Partizánske
4.	KVARTET, a.s., Partizánske	Partizánske	VETROPACK NEMŠOVÁ, s.r.o.	Trenčín
5.	VETROPACK NEMŠOVÁ, s.r.o.	Trenčín	TSM Partizánske s.r.o.	Partizánske
6.	HBP, a.s., Banská mech. a elektrifikácia Nováky	Prievidza	HBP, a.s., Banská mech. a elektrifikácia Nováky	Prievidza
7.	LESS&TIMBER SK, s.r.o., Lehota pod Vtáčnikom	Prievidza	Prefabetón Koš, a.s., Nováky	Prievidza
8.	Holcim (Slovensko), a.s., Rohožník, kameňolom	Prievidza	MO SR, zdroje v okrese Trenčín	Trenčín
9.	CEMMAC, a.s., Horné Srnie	Trenčín	Služby pre bývanie s.r.o.,Trenčín	Trenčín
10.	TSM Partizánske s.r.o.	Partizánske	Považská cementáreň, a.s., Ladce	Ilava

	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	Novácke chemické závody, a.s., Nováky	Prievidza
5.	VETROPACK NEMŠOVÁ, s.r.o.,	Trenčín	Považský cukor a.s., Trenčianska Teplá	Trenčín
6.	Novácke chemické závody, a.s., Nováky	Prievidza	TEPLÁREŇ, a.s., Považská Bystrica	Považská
7.	TEPLÁREŇ, a.s., Považská Bystrica	Považská	KVARTET, a.s., Partizánske	Partizánske
8.	KVARTET, a.s., Partizánske	Partizánske	TSM Partizánske s.r.o.	Partizánske
9.	TERMONOVA a.s., Nová Dubnica	Ilava	MO SR, zdroje v okrese Trenčín	Trenčín
10.	Continental Matador Rubber, s.r.o., Púchov	Púchov	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.	Slovmag a.s., Lubeník	Revúca	Slovenské magnezitové závody a.s., Jelšava	Revúca
4.	Slovenské magnezitové závody a.s., Jelšava	Revúca	Knauf Insulation, s.r.o., Nová Baňa	Žarnovica
5.	Smrečina HOLD a.s., Banská Bystrica	Banská Bystrica	Dalkia Industry Žiar nad Hronom, a.s., Žiar n/H	Žiar nad Hronom
6.	Zvolenská teplárenská a.s., Zvolen	Zvolen	ZSNP, a.s., Žiar nad Hronom	Žiar nad Hronom
7.	NOVOKER a.s., Lučenec	Lučenec	Slovmag a.s., Lubeník	Revúca
8.	Calmit, s.r.o., Bratislava, prev. Tisovec	Rimavská Sobota	Baňa Dolina a.s., Veľký Krtíš	Veľký Krtíš
9.	MO SR, PS budov Banská Bystrica	Brezno	VUM, a.s., Žiar nad Hronom	Žiar nad Hronom
10.	Harmanec-Kuvert s.r.o., Brezno	Brezno	Ipeľské tehelne a.s., Lučenec, záv. Poltár	Poltár
	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.	eustream, a.s., prev. Veľké Zlievce	Veľký Krtíš	Calmit, s.r.o., Bratislava, prev. Tisovec	Rimavská Sobota
3.	SLOVALCO, a.s., Žiar nad Hronom	Žiar nad Hronom	Slovenské magnezitové závody a.s., Jelšava	Revúca
4.	Zvolenská teplárenská a.s., Zvolen	Zvolen	Slovmag a.s., Lubeník	Revúca
5.	Slovmag a.s., Lubeník	Revúca	VUM, a.s., Žiar nad Hronom	Žiar nad Hronom
6.	SLOVGLASS, a.s., Poltár	Poltár	Železiarne Podbrezová a.s.	Brezno
7.	Železiarne Podbrezová a.s.	Brezno	Ipeľské tehelne a.s., Lučenec, záv. Poltár	Poltár
8.	Bučina Zvolen a.s.	Zvolen	SLOVAL, s.r.o., Žiar nad Hronom	Žiar nad Hronom
9.	ZSNP, a.s., Žiar nad Hronom	Žiar nad Hronom	eustream, a.s., prev. Veľké Zlievce	Veľký Krtíš
10.	Knauf Insulation, s.r.o., Nová Baňa	Žarnovica	Knauf Insulation, s.r.o., Nová Baňa	Žarnovica

ŽILINA REGION

	PM		SO_2	
	Source	District	Source	District
1.	Mondi scp, a.s., Ružomberok	Ružomberok	Žilinská teplárenská, a.s., Žilina	Žilina
2.	DOLVAP, s.r.o., Varín	Žilina	Martinská teplárenská, a.s., Martin	Martin
3.	Žilinská teplárenská, a.s., Žilina	Žilina	Wienerberger-Slov. tehelne spol. s.r.o.	Ružomberok
4.	SOTE s.r.o., Čadca	Čadca	SOTE s.r.o., Čadca	Čadca
5.	OFZ, a.s., Istebné	Dolný Kubín	Mondi scp, a.s., Ružomberok	Ružomberok
6.	Martinská teplárenská, a.s., Martin	Martin	OFZ, a.s., Istebné	Dolný Kubín
7.	DOLKAM Šuja,a.s., Rajec	Žilina	ŽOS Vrútky a.s.	Martin
8.	BEKAM, s.r.o., Žilina	Žilina	OZETA NEO, a.s., Trenčín	Liptovský Mikuláš
9.	KIA Motors Slovakia s.r.o., Žilina	Žilina	ZDROJ MT s.r.o., Martin - Priekopa	Martin
10	KYSUCA s.r.o., Kysucké Nové Mesto	Kysucké Nové	Spojená škola internátna Námestovo	Námestovo
	NO_x		CO	
	Source	District	Source	District
1.	Mondi scp, a.s., Ružomberok	Ružomberok	DOLVAP, s.r.o., Varín	Žilina
2.	Žilinská teplárenská, a.s., Žilina	Žilina	Mondi scp, a.s., Ružomberok	Ružomberok
3.	OFZ, a.s., Istebné	Dolný Kubín	OFZ, a.s., Istebné	Dolný Kubín
4.	Martinská teplárenská, a.s., Martin	Martin	Wienerberger-Slov. tehelne spol. s.r.o., Ružomberok	Ružomberok
5.	Rettenmeier Tatra Timber s.r.o., Liptovský Hrádok	Liptovský Mikuláš	SOTE s.r.o., Čadca	Čadca
6.	SPECIALITY MINERALS SLOV. s.r.o., Ružomberok	Ružomberok	Rettenmeier Tatra Timber s.r.o., Liptovský Hrádok	Liptovský Mikuláš
7.	KIA Motors Slovakia s.r.o., Žilina	Žilina	ŽOS Vrútky a.s.	Martin
8.	SOTE s.r.o., Čadca	Čadca	Žilinská teplárenská, a.s., Žilina	Žilina
9.	KYSUCA s.r.o., Kysucké Nové Mesto	Kysucké Nové	Turzovská drevárska fabrika s.r.o., Turzovka	Čadca
10	ŽOS Vrútky a.s.	Martin	DREVOMAX, s.r.o., prev. Rajecké Teplice	Žilina

PREŠOV REGION

	PM		SO_2	
	Source	District	Source	District
1.	BUKOCEL a.s., Hencovce	Vranov n/Topľou	BUKOCEL a.s., Hencovce	Vranov n/Topľou
2.	Kronospan SK, s.r.o., Prešov	Prešov	CHEMES, a.s., HUMENNÉ	Humenné
3.	CHEMES, a.s., HUMENNÉ	Humenné	Energy Snina,a.s.	Snina
4.	Bukóza Progres s.r.o., Hencovce	Vranov n/Topľou	Zeocem Bystré a.s.	Vranov n/Topľou
5.	IS - Lom Maglovec s.r.o., Vyšná Šebastová	Prešov	Zastrova a.s., Spišská Stará Ves	Kežmarok
6.	VSK MINERAL s.r.o., Vechec	Vranov n/Topľou	Tehelne Vranov s.r.o., Vranov n. Topľou	Vranov n/Topľou
7.	Legno Export spol. s.r.o., Beňadikovce	Svidník	DSS Spišský Št. Spišský Štvrtok	Levoča
8.	Zeocem Bystré a.s.	Vranov n/Topľou	ZŠ Malcov	Bardejov
9.	TATRY-TEPLO, s.r.o., Tatranská Lomnica	Poprad	ZŠ s MŠ Nižný Slavkov	Sabinov
10	TATRAVAGÓNKA a.s., POPRAD	Poprad	SAD Poprad a.s., prevádzkáreň Levoča	Levoča
	NO_x		CO	
	Source	District	Source	District
1.	BUKOCEL a.s., Hencovce	Vranov n/Topľou	BUKOCEL a.s., Hencovce	Vranov n/Topľou
2.	CHEMES, a.s., HUMENNÉ	Humenné	CHEMES, a.s., HUMENNÉ	Humenné
3.	Energy Snina, a.s.	Snina	TENERGO BRNO a.s., prev. Snina	Snina
4.	SPRAVBYT a.s., Prešov	Prešov	Kronospan SK, s.r.o., Prešov	Prešov
5.	DALKIA POPRAD a.s.	Poprad	ZLIEVAREŇ SVIT, a.s.	Poprad
6.	Kronospan SK, s.r.o., Prešov	Prešov	Energy Snina, a.s.	Snina
7.	Zeocem Bystré a.s.	Vranov n/Topľou	Zeocem Bystré a.s.	Vranov n/Topľou
8.	BARDTERM s.r.o., Bardejov	Bardejov	SPRAVBYT a.s., Prešov	Prešov
9.	CHEMOSVIT ENERGOCHEM, a.s., SVIT	Poprad	Inžinierske stavby, a.s., Obaľovačka Veľká	Kežmarok
10	TATRAVAGÓNKA a.s., POPRAD	Poprad	ENERGOBYT s.r.o., Humenné, zdroje v okrese	Snina

KOŠICE REGION

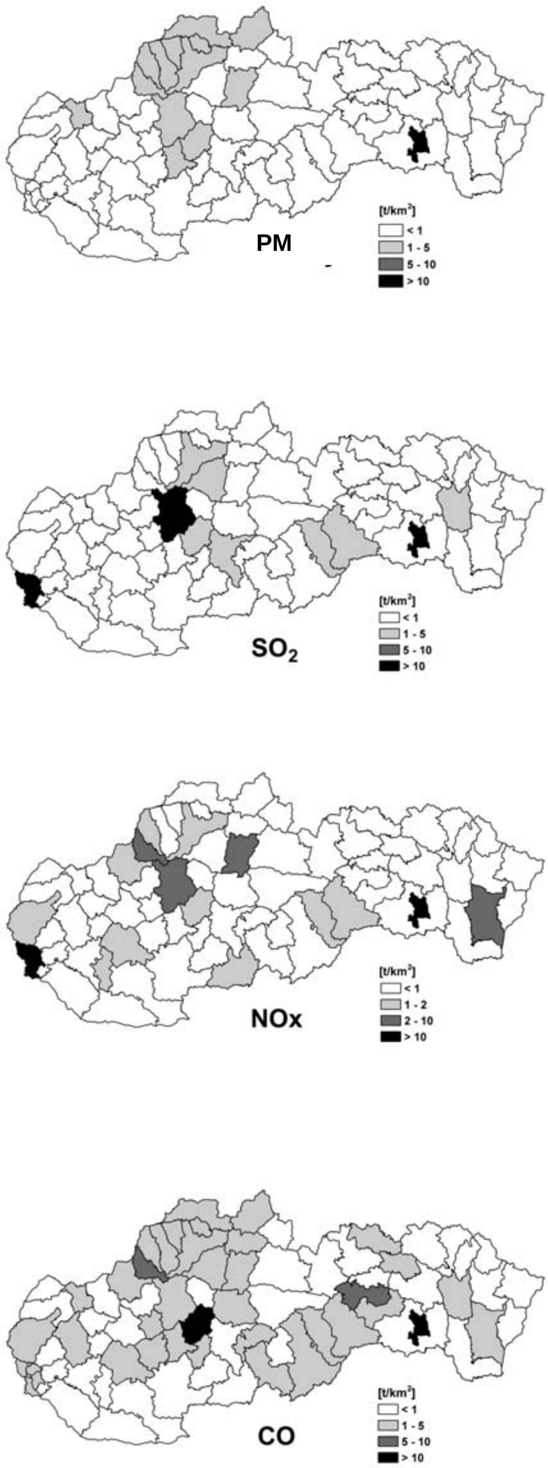
	PM		SO_2	
	Source	District	Source	District
1.	U.S. Steel, s.r.o., Košice	Košice II	U.S. Steel, s.r.o., Košice	Košice II
2.	Carmeuse Slovakia s.r.o., závod Včeláre	Košice - okolie	SIDERIT s.r.o., Nižná Slaná	Rožňava
3.	SE, a.s., Bratislava, Elektráreň Vojany I a II	Michalovce	TEKO a.s., Košice	Košice IV
4.	SIDERIT s.r.o., Nižná Slaná	Rožňava	SE, a.s., Bratislava, Elektráreň Vojany I a II	Michalovce
5.	TEKO a.s., Košice	Košice IV	Carmeuse Slovakia s.r.o., závod Košice	Košice II
6.	Carmeuse Slovakia s.r.o., závod Košice	Košice II	Slovenské magnezitové závody a.s., závod Bočiar	Košice II
7.	KOVOHUTY, a.s., Krompachy	Spišská Nová Ves	KOVOHUTY, a.s., Krompachy	Spišská Nová Ves
8.	Carmeuse Slovakia s.r.o., závod Slavec	Rožňava	Refrako, s.r.o., Košice	Košice II
9.	KERKO a.s., Michalovce	Michalovce	V.S.H., a.s., Turňa nad Bodvou	Košice - okolie
10	VSK MINERAL s.r.o., Košice, lom Spišská N. Ves	Spišská Nová Ves	Reliningserv 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.	SE, a.s., Bratislava, Elektráreň Vojany I a II	Michalovce	Carmeuse Slovakia s.r.o., závod Košice	Košice II
3.	TEKO a.s., Košice	Košice IV	KOVOHUTY, a.s., Krompachy	Spišská Nová
4.	eustream, a.s., prev. Veľké Kapušany	Michalovce	SE, a.s., Bratislava, Elektráreň Vojany I a II	Michalovce
5.	V.S.H., a.s., Turňa nad Bodvou	Košice - okolie	Calmit, s.r.o., Bratislava, prev. Margecany	Gelnica
6.	eustream, a.s., prev. Jablonov nad Turňou	Rožňava	SIDERIT s.r.o., Nižná Slaná	Rožňava
7.	Carmeuse Slovakia s.r.o., závod Košice	Košice II	HNOJIVÁ DUSLO, s.r.o., STRÁŽSKE	Michalovce
8.	Slovenské magnezitové závody a.s., závod Bočiar	Košice II	V.S.H., a.s., Turňa nad Bodvou	Košice - okolie
9.	Refrako, s.r.o., Košice	Košice II	Slovenské magnezitové závody a.s., závod Bočiar	Košice II
10	SIDERIT s.r.o., Nižná Slaná	Rožňava	eustream, a.s., prev. Jablonov nad Turňou	Rožňava

**According to the Decree of MŽP SR no. 706/2002 Coll.*

Tab. 4.6 **Stationary source emissions by districts in 2008**

District	Emissions [t.year^{-1}]				Specific territorial emis. [t.year^{-1}.km^{-2}]			
	TZL	SO_2	NO_x	CO	TZL	SO_2	NO_x	CO
1. Bratislava	339	8302	4112	821	0.92	22.56	11.17	2.23
2. Malacky	270	132	1689	2301	0.28	0.14	1.78	2.42
3. Pezinok	112	23	95	183	0.30	0.06	0.25	0.49
4. Senec	95	13	90	176	0.26	0.04	0.25	0.49
5. Dunajská Streda	376	52	203	532	0.35	0.05	0.19	0.49
6. Galanta	258	209	289	453	0.40	0.33	0.45	0.71
7. Hlohovec	122	19	133	203	0.46	0.07	0.50	0.76
8. Piešťany	217	31	123	316	0.57	0.08	0.32	0.83
9. Senica	321	63	137	465	0.47	0.09	0.20	0.68
10. Skalica	205	30	129	289	0.57	0.08	0.36	0.81
11. Trnava	271	162	550	1048	0.37	0.22	0.74	1.41
12. Bánovce n/B	234	34	82	326	0.51	0.07	0.18	0.70
13. Ilava	399	45	1198	2322	1.12	0.12	3.35	6.49
14. Myjava	330	47	94	461	1.01	0.14	0.29	1.41
15. Nové Mesto n/V	310	43	137	442	0.53	0.07	0.24	0.76
16. Partizánske	208	239	124	462	0.69	0.79	0.41	1.53
17. Považská Bystrica	570	225	268	1014	1.23	0.49	0.58	2.19
18. Prievidza	1356	35194	4190	1690	1.41	36.66	4.36	1.76
19. Púchov	494	77	468	684	1.32	0.20	1.25	1.82
20. Trenčín	410	210	1026	2641	0.61	0.31	1.52	3.91
21. Komárno	387	55	219	589	0.35	0.05	0.20	0.54
22. Levice	1080	162	616	1513	0.70	0.10	0.40	0.98
23. Nitra	332	52	954	2599	0.38	0.06	1.10	2.98
24. Nové Zámky	595	770	787	884	0.44	0.57	0.58	0.66
25. Šaľa	235	22	654	268	0.66	0.06	1.84	0.75
26. Topoľčany	195	32	139	292	0.33	0.05	0.23	0.49
27. Zlaté Moravce	229	40	96	704	0.44	0.08	0.18	1.35
28. Bytča	386	57	109	541	1.37	0.20	0.39	1.92
29. Čadca	1176	303	325	1760	1.54	0.40	0.43	2.31
30. Dolný Kubín	337	125	436	1849	0.69	0.25	0.89	3.76
31. Kysucké Nové Mesto	248	34	93	341	1.42	0.19	0.54	1.96
32. Liptovský Mikuláš	604	122	346	946	0.45	0.09	0.26	0.71
33. Martin	469	963	490	741	0.64	1.31	0.67	1.01
34. Námestovo	1147	202	263	1578	1.66	0.29	0.38	2.28
35. Ružomberok	742	423	1355	2804	1.15	0.65	2.09	4.33
36. Turčianske Teplice	207	33	55	289	0.53	0.08	0.14	0.74
37. Tvrdošín	177	31	66	278	0.37	0.07	0.14	0.58
38. Žilina	966	1401	860	3084	1.19	1.72	1.06	3.78
39. Banská Bystrica	539	79	364	858	0.67	0.10	0.45	1.06
40. Banská Štiavnica	246	43	62	335	0.84	0.15	0.21	1.15
41. Brezno	645	150	290	1189	0.51	0.12	0.23	0.94
42. Detva	413	65	180	627	0.92	0.14	0.40	1.40
43. Krupina	352	54	87	494	0.60	0.09	0.15	0.85
44. Lučenec	635	89	205	888	0.77	0.11	0.25	1.07
45. Poltár	212	64	244	425	0.45	0.13	0.51	0.89
46. Revúca	536	751	1332	2958	0.73	1.03	1.83	4.05
47. Rimavská Sobota	1094	166	304	4935	0.74	0.11	0.21	3.35
48. Veľký Krtíš	499	111	958	761	0.59	0.13	1.13	0.90
49. Zvolen	348	1007	647	570	0.46	1.33	0.85	0.75
50. Žarnovica	496	335	186	660	1.16	0.79	0.44	1.55
51. Žiar n/H	551	1809	841	14603	1.06	3.49	1.62	28.19
52. Bardejov	395	60	135	560	0.42	0.06	0.14	0.60
53. Humenné	368	253	447	596	0.49	0.34	0.59	0.79
54. Kežmarok	414	67	133	592	0.49	0.08	0.16	0.71
55. Levoča	210	36	65	302	0.59	0.10	0.18	0.84
56. Medzilaborce	176	26	43	241	0.41	0.06	0.10	0.57
57. Poprad	293	38	203	458	0.27	0.03	0.18	0.41
58. Prešov	516	70	266	705	0.55	0.07	0.28	0.75
59. Sabinov	392	60	125	547	0.81	0.12	0.26	1.13
60. Snina	412	163	200	630	0.51	0.20	0.25	0.78
61. Stará Ľubovňa	508	78	144	719	0.81	0.13	0.23	1.15
62. Stropkov	141	20	41	196	0.36	0.05	0.11	0.50
63. Svidník	269	39	78	368	0.49	0.07	0.14	0.67
64. Vranov n/T	420	901	610	1165	0.55	1.17	0.79	1.51
65. Gelnica	403	66	103	1256	0.69	0.11	0.18	2.15
66. Košice	3056	9910	8665	94378	12.58	40.78	35.66	388.39
67. Košice - okolie	907	126	1265	1326	0.59	0.08	0.83	0.86
68. Michalovce	287	905	3135	1464	0.28	0.89	3.08	1.44
69. Rožňava	980	1405	1283	1743	0.84	1.20	1.09	1.49
70. Sobrance	174	28	51	246	0.32	0.05	0.09	0.46
71. Spišská Nová Ves	414	136	173	3176	0.71	0.23	0.29	5.41
72. Trebišov	380	60	179	554	0.35	0.06	0.17	0.52
Slovakia	34090	69149	46042	178415	0.70	1.41	0.94	3.64

Fig. 4.3 **Specific territorial emission in 2008**

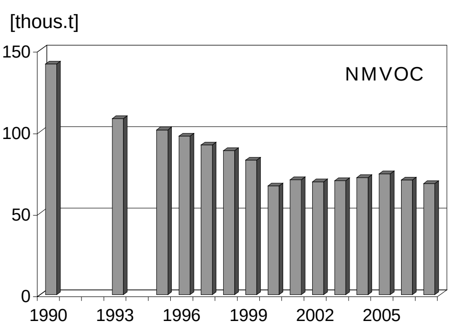


Tab. 4.7 **NMVOC emissions [t] in the SR in 1990 – 2007**

Sector / Subsector	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007
Combustion on energy and transformation industries	335	258	201	221	215	214	203	185	174	156
Public power	223	187	139	159	147	161	156	139	131	120
District heating plants	112	71	62	62	67	53	47	46	43	36
Non-industrial combustion plants	12641	9618	7913	8305	7070	7505	8931	11934	11162	11090
Commercial and institutional plants	226	150	26	27	23	24	25	28	27	28
Agriculture	IE	IE	6	7	7,5	7	7	9	8	6
Residential plants	12415	9468	7881	8271	7040	7474	8899	11897	11127	11056
Combustion in manufacturing industry	981	805	585	772	647	704	753	806	898	879
Comb. in boilers, gas turb. and stat. engines	206	150	159	231	146	169	121	121	117	93
Iron production	32	29	28	29	32	35	34	33	37	36
Ore agglomeration	438	358	396	403	383	409	403	384	390	366
Copper production	305	268	2	109	85	91	195	268	353	384
Production processes	27029	11129	8717	8343	7727	7149	7103	6434	5823	5472
Processes in petroleum industries	17188	7474	6627	6306	5571	4671	4617	4058	3469	3165
Coke production	1053	834	719	719	765	801	800	783	787	783
Steel production	43	36	34	37	40	42	41	41	47	46
Rolling mills	233	297	300	267	304	336	329	341	361	372
Aluminium production	0,101	0,049	0,165	0,165	0,165	0,167	0,235	0,2	0,2	0,2
Proc. in organic chemical industries	6437	1369	651	644	690	941	970	870	845	793
Food production	2073	1118	385	370	357	358	346	340	311	312
Road paving with asphalt	2,4	1,0	0,5	0,5	0,5	0,6	0,5	0,7	1,0	0,7
Exploitation&distrib. of natural resour.	8822	8535	5929	6161	6024	7431	7696	7105	6276	6169
Exploitation&distribution of crude oil	5198	4298	3750	3848	3801	3999	4149	4281	4472	4265
Distribution of fuel	3624	4237	2179	2313	2223	3432	3547	2824	1804	1904
Solvent and other products use	52875	37065	26978	28724	31019	32272	32759	33561	34634	33577
Use of paints and glues	32811	20687	13214	14025	15110	16369	18457	18918	19522	20003
Dry cleaning and degreasing	11500	7695	5091	6171	7331	7408	5821	6101	6600	5056
Processing of fat and oil	332	363	299	191	240	156	134	189	152	147
Products	8232	8320	8374	8337	8338	8339	8347	8353	8360	8371
Road transport	32611	32373	15207	16783	15218	13484	13301	12991	10211	9643
Other transport	953	599	528	524	500	460	469	488	449	434
Waste treatment and disposal	4538	259	208	180	320	192	204	231	226	212
Incineration of municipal waste	102	102	133	93	75	115	130	128	134	127
Incineration of industrial waste	157	157	66	81	204	43	53	66	72	58
Incineration of hospital waste	IE	IE	9	6	42	34	21	37	20	25
Agricultural waste*	4279									
Agriculture	651	436	436	436	436	436	436	436	436	437
Total	141438	101078	66703	70450	69177	69847	71856	74172	70290	68070

Emissions from road and other transport estimated to November 11th, 2009, emissions from the other sectors estimated to February 15th, 2009.
IE = included in other source category
* *Agricultural waste combustion is prohibited from the year 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 – 2007**



Tab. 4.8 **Emissions of persistent organic pollutants in the SR in 2007**

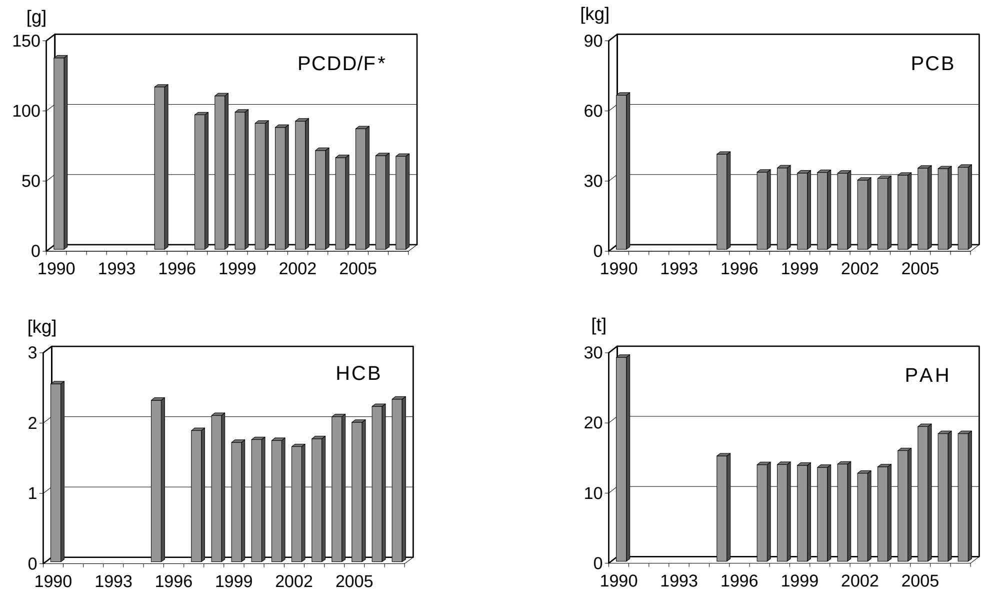
Sector / Subsector	PCDD/F*	PCB	HCB	PAH				
				sum PAH	B(a)P	B(k)F	B(b)F	I(1,2,3-cd)P
	[g]	[kg]	[kg]	[kg]	[kg]	[kg]	[kg]	[kg]
Combustion on energy and transformation industries	6.863	0.933	0.199	1453.005	57.451	436.694	436.781	522.080
Public power	1.564	0.927	0.194	1.196	0.039	0.502	0.587	0.068
District heating plants	0.079	0.006	0.005	2.404	0.007	1.191	1.194	0.012
Coke production	5.220	0.000	0.000	1449.405	57.405	435.000	435.000	522.000
Non-industrial combustion plants	3.292	8.87	0.167	15038.750	4299.841	1877.730	5645.352	3215.827
Commercial and institutional plants	0.028	0.01	0.002	0.552	0.005	0.265	0.275	0.008
Residential plants	3.259	8.86	0.164	15038.048	4299.835	1877.396	5645.001	3215.816
Agriculture	0.004	0.00	0.000	0.150	0.002	0.070	0.075	0.003
Combustion in manufacturing industry	25.883	6.69	0.444	147.167	74.133	28.778	35.225	9.031
Comb. in boilers, gas turb. and stat. eng.	0.798	0.82	0.133	35.458	1.533	13.154	18.280	2.491
Iron production	0.401	0.03	0.000	68.205	68.205	0.000	0.000	0.000
Ore agglomeration	23.343	3.67	0.107	38.895	3.999	14.498	14.498	5.899
Cast iron production	0.114	0.02	0.000	0.018	0.003	0.006	0.006	0.003
Others	1.227	2.16	0.204	4.590	0.392	1.120	2.441	0.638
Production processes	6.600	2.088	0.764	1282.077	471.150	376.772	385.060	49.095
Aluminium production	0.162	0.027	0.000	589.069	192.557	186.141	186.141	24.230
Steel production	4.851	1.98	0.000	87.962	87.962	0.000	0.000	0.000
Carbon mineral production	0.000	0.000	0.000	605.046	190.631	190.631	198.919	24.865
Wood impregnation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Others	1.587	0.0798	0.764	0.000	0.000	0.000	0.000	0.000
Road transport	0.129	11.438	0.009	105.995	14.050	36.758	37.377	17.809
Other transport	0.008	0.753	0.001	9.033	2.258	1.355	3.162	2.258
Waste treatment and disposal	23.479	1.88	0.728	134.312	37.960	26.433	55.394	14.525
Incineration of municipal waste	5.436	0.95	0.540	6.997	0.126	3.420	3.420	0.031
Incineration of industrial waste	12.927	0.26	0.001	1.005	0.018	0.491	0.491	0.004
Incineration of hospital waste	4.405	0.59	0.176	2.283	0.041	1.116	1.116	0.010
Others	0.711	0.08	0.011	124.027	37.775	21.406	50.366	14.480
Total	66.254	32.652	2.312	18170.339	4956.843	2784.52	6598.351	3830.625

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 from road and other transport estimated to November 11th, 2009, emissions from other sectors estimated to February 15th, 2009.

Fig. 4.5 **Development trends in POPs emissions in 1990 – 2007**

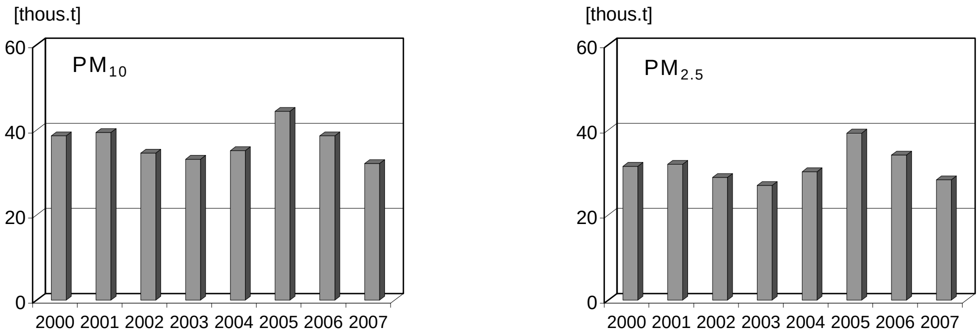


Tab. 4.9 **PM_{10} and $PM_{2.5}$ emissions [thous. t] in the SR in 2002 – 2007**

Sector / Subsector	2002		2003		2004		2005		2006		2007	
	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	7.015	6.380	6.145	4.367	7.054	6.432	10.728	10.047	7.064	6.605	1.512	1.107
Public Electricity and Heat Production	6.128	5.836	5.053	3.691	5.994	5.781	9.671	9.399	6.361	6.168	0.821	0.672
Petroleum refining	0.078	0.062	0.118	0.094	0.101	0.080	0.095	0.075	0.099	0.078	0.112	0.089
Coke production	0.809	0.482	0.974	0.582	0.959	0.571	0.962	0.573	0.604	0.359	0.579	0.346
Combustion processes II	16.282	13.725	17.125	14.703	20.346	17.983	27.191	24.530	25.389	22.727	25.119	22.998
Commercial and institutional plants	0.358	0.204	0.293	0.171	0.235	0.142	0.201	0.133	0.163	0.110	0.134	0.091
Residential plants	15.522	13.218	16.563	14.321	19.836	17.644	26.742	24.230	25.016	22.485	24.885	22.855
Agriculture	0.114	0.056	0.078	0.043	0.100	0.049	0.098	0.046	0.084	0.039	0.064	0.036
Other combustion processes	0.288	0.247	0.191	0.168	0.175	0.148	0.150	0.121	0.126	0.094	0.036	0.016
Combustion processes in industry	8.640	6.674	7.095	5.464	5.034	3.524	2.961	2.109	2.774	2.037	1.988	1.458
Production of iron and steel	5.776	4.563	4.842	3.855	2.311	1.723	0.787	0.587	0.806	0.612	0.518	0.339
Production of non-ferrous metals	0.208	0.175	0.133	0.115	0.141	0.120	0.188	0.162	0.144	0.123	0.126	0.108
Chemical industry	0.659	0.470	0.522	0.399	0.882	0.604	0.531	0.418	0.416	0.320	0.226	0.181
Production of paper and cellulose	0.211	0.104	0.221	0.118	0.388	0.153	0.296	0.128	0.227	0.097	0.085	0.056
Food production	0.081	0.060	0.074	0.061	0.089	0.071	0.094	0.081	0.093	0.079	0.039	0.028
Other combustion processes in industry	1.705	1.302	1.303	0.916	1.223	0.853	1.065	0.733	1.088	0.806	0.994	0.746
Transport	2.388	2.020	2.784	2.45	2.521	2.166	2.959	2.534	3.218	2.697	3.127	2.671
Civil aviation	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.010	0.010	0.010	0.010
Road transport	1.290	1.290	1.787	1.787	1.468	1.468	1.743	1.743	1.816	1.816	1.869	1.869
Road transport - abrasion	0.749	0.400	0.685	0.366	0.727	0.388	0.875	0.467	1.084	0.577	0.921	0.491
Railways	0.184	0.174	0.147	0.140	0.141	0.134	0.137	0.13	0.145	0.139	0.144	0.130
Navigation	0.159	0.15	0.158	0.15	0.177	0.168	0.195	0.185	0.163	0.155	0.183	0.171
Industrial technologies	0.254	0.099	0.008	0.005	0.221	0.094	0.560	0.063	0.176	0.072	0.391	0.086
Mineral products	0.018	0.002	0.001	0.000	0.041	0.004	0.430	0.004	0.047	0.004	0.300	0.003
Chemical industry	0.079	0.049	0.004	0.003	0.098	0.060	0.058	0.036	0.083	0.052	0.049	0.042
Paper and pulp	0.000	0.000	0.000	0.000	0.0003	0.0002	0.0004	0.0003	0.001	0.001	0.001	0.001
Other industrial processes	0.157	0.048	0.003	0.002	0.082	0.030	0.072	0.023	0.045	0.015	0.041	0.040
Total	34.579	28.899	33.157	26.989	35.176	30.199	44.399	39.283	38.621	34.138	32.137	28.320

Emissions from road and other transport estimated to November 11th, 2009, emissions from other sectors estimated to February 15th, 2009.

Fig. 4.6 **Development trends in PM_{10} and $PM_{2.5}$ emissions in 2000 – 2007**

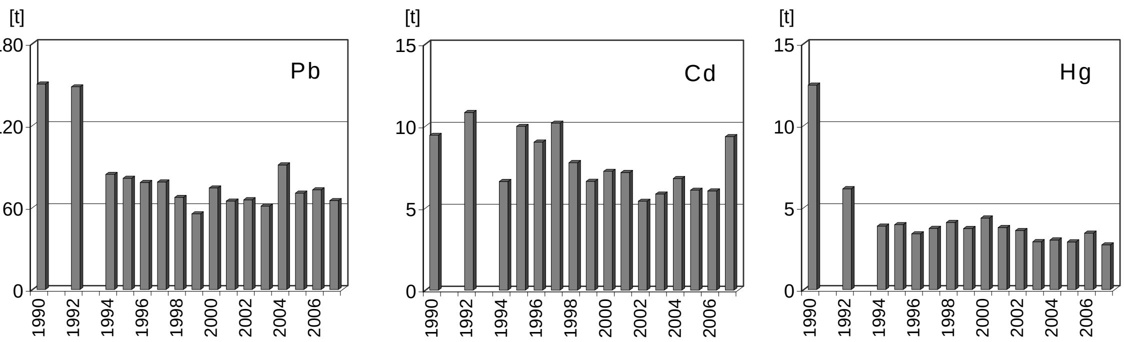


Tab. 4.10 **Emissions of heavy metals [t] in the SR in 2007**

Sector / Subsector	Pb	As	Cd	Cr	Cu	Hg	Ni	Se	Zn
Combustion on energy and transformation industries	0.206	0.368	0.009	0.085	0.064	0.009	0.160	0.011	0.347
Public power	0.035	0.341	0.001	0.081	0.058	0.005	0.156	0.010	0.100
District heating plants	0.171	0.027	0.007	0.005	0.007	0.005	0.004	0.0001	0.247
Non-industrial combustion plants	1.08	0.58	0.031	0.266	0.382	0.030	0.253	0.038	3.208
Commercial and institutional plants	0.098	0.063	0.004	0.018	0.018	0.003	0.015	0.001	0.151
Residential plants	0.956	0.509	0.025	0.246	0.361	0.026	0.237	0.037	3.018
Agriculture	0.026	0.008	0.001	0.002	0.002	0.001	0.002		0.039
Combustion in manufacturing industry	48.787	22.759	8.478	2.843	35.311	1.911	11.059	9.357	39.803
Comb. in boilers, gas turb. and stat. engines	4.595	0.548	0.204	0.419	0.260	0.189	6.309	0.163	6.322
Iron production	0.136	0.012	0.217	1.031	0.080	0.345	3.434	0.044	8.590
Glass production	6.071	0.493	7.765	0.771	0.193	0.016	0.61	5.779	3.532
Ore agglomeration	26.905	0.503	0.016	0.592	8.843	1.313	0.678	1.249	14.077
Copper production	10.853	21.177	0.274		25.932	0.001		2.121	7.221
Cement production	0.226	0.003	0.001	0.025		0.046	0.026	0.0003	0.058
Aluminium oxide production									
Magnesite production	0.001	0.023	0.002	0.005	0.003	0.0001	0.001		0.006
Production processes	1.864	0.097	0.04	0.956	3.233	0.19	8.425	0.016	18.553
Steel production	1.428	0.078	0.016	0.181	2.82	0.016	2.851	0.016	5.95
Aluminium production			0.016				1.605		1.605
Ferro alloys production	0.198	0.014	0.006	0.004	0.008		0.002		0.958
Pig iron production	0.137	0.006	0.003	0.023			0.011		0.097
Galvanizing	0.086			0.748	0.258		3.956		7.482
Alloys (Cu-Zn) production	0.015				0.148				2.461
Inorganic chemical industry						0.174			
Road transport	2.101		0.090	0.138	4.242		0.151	0.022	2.860
Other transport			0.007	0.003	0.134		0.005	0.0007	0.079
Waste treatment and disposal	11.060	0.013	0.704	0.851	1.369	0.582	0.494	0.007	4.836
Incineration of municipal waste	8.100	0.009	0.450	0.810	1.116	0.324	0.486	0.002	3.060
Incineration of industrial waste	2.056	0.003	0.176	0.028	0.176	0.176	0.006	0.004	1.233
Incineration of hospital waste	0.905	0.001	0.078	0.012	0.078	0.078	0.003	0.002	0.543
Cremation						0.004			
Total	65.098	23.817	9.359	5.142	44.735	2.722	20.547	9.452	69.686

Emissions from road and other transport estimated to November 11th, 2009, emissions from other sectors estimated to February 15th, 2009.

Fig. 4.7 **Development trends in heavy metals emissions in 1990 – 2007**



GREENHOUSE GAS EMISSIONS 5

5.1 GREENHOUSE GAS EMISSIONS

Framework Convention on Climate Change (UN FCCC)

Global climate change due to the anthropogenic emission of greenhouse gases is the most important environmental problem in the history of mankind. The framework Convention on Climate Change (UN FCCC)[1] - the basic international legal instrument to protect global climate was adopted at the UN conference on the environment and sustainable development (Rio de Janeiro 1992). The final goal of the Convention is to achieve stabilisation of greenhouse gas concentrations in the atmosphere at a level that has not yet developed any dangerous interference in the climate system.

In the Slovak Republic, the UN Convention came into force on March 21, 1994. The Slovak Republic accepted all the commitments of the Convention. The Framework Convention ratified 183 countries including the European Union until present. Most members of the Organization for Economic Cooperation and Development (OECD) as well as the Slovak Republic – known collectively as Annex I countries – committed themselves to adopting policies and measures to reduce their greenhouse gas (GHG) emissions under the Convention.

Kyoto protocol

The Kyoto Protocol, adopted by consensus at the third session of the Conference of the Parties (COP-3) in Kyoto, December 1997, enforced the international responsibility for the climate change. The all Annex I countries which ratified the Kyoto Protocol (KP), formally defined their reduction targets in articles of the KP. The Kyoto Protocol came into force on February 16, 2005 after compliance of requirement determined in Article 25, paragraph 1; it means after signing of more than one-half of Annex I countries, that representing of minimum 55% of total CO_2 emissions of Annex I countries in 1990 (the signature of the Russian Federation ensured the majority). The Slovak Republic and the most countries of Central and East Europe agreed to reduce base year level of all six GHG emissions by 8% during period 2008 – 2012. Up to date, 183 countries and one regional integration organisation (the European Community) had ratified, accepted, approved or acceded to the Kyoto Protocol. A meeting of the commitments gains high priority in the EU.

The KP targets for the "old" EU-15 member states represent the 8% reduction of all GHGs against base year for the 2008 – 2012 period. The different emission or reduction targets were agreed for each member state with the EU-15 approval as "burden-sharing agreement" (Article 4, KP).[2]

The new member states joined the European Community after 2004 have individual targets under the Kyoto Protocol. The Czech Republic, Estonia, Bulgaria, Latvia, Lithuania, Romania, Slovakia and Slovenia have reduction targets of 8% from the base year, while Hungary and Poland have reduction targets of 6%. Cyprus and Malta have no Kyoto target, while Croatia has a reduction target of 5%. The additional EEA member countries Norway and Iceland are allowed to increase emissions under the Kyoto Protocol, by 1% and 10% respectively, from their base year emissions. The candidate country Turkey has ratified the UNFCCC, but not the Kyoto Protocol. Lichtenstein and Switzerland have a reduction target of 8%.

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[1] *http://www.unfccc.de*

[2] *In the Council decision (2002/358/EC) on the approval by the EU of the Kyoto Protocol the various commitments of the Member States are expressed as percentage changes from the base-year. In 2006 the respective emission levels were expressed in terms of tonnes of CO_2-equivalent in the Commission Decision 2006/944/EC. In connection with Council decision 2002/358/EC, the Council of Environment Ministers and the Commission have, in a joint statement all community and MS initial reports which have been reviewed under the Kyoto Protocol.*

In the context of joining of the Slovak Republic the European Union (May 1, 2004), raised the new requirements for legislative implementation in the field of air protection. The European Union considers the area of climate change for the one of the four environmental priorities.[3] The Slovak Republic submit the data about GHG emissions in the relevant extend to the January 15, annually according to the Decision 280/2004/EC of the European Parliament and of the Council concerning a Mechanism for Monitoring Community GHG emissions and for implementing the Kyoto Protocol.[4] The ground for the implementing of the decision were the following criteria:

- Monitoring of the all anthropogenic emissions of GHGs in the EU member states.
- Ensure the progress in the fulfilling the reduction targets UNFCCC and the Kyoto Protocol.
- Implement Convention and Kyoto Protocol in the view of the national programs, GHGs inventory, national system and register EU and the member states.
- Ensure completeness, transparency, consistency, accuracy, comparability and the timing in the EC reporting.

In spring 2007, the European Council adopted the unilateral commitment to reduce EU GHG emissions by at least 20% by 2020 compared to 1990 levels. Furthermore, the EU would increase this reduction to 30%, provided that other developed countries commit themselves to comparable emission reductions and economically more advanced developing countries to contributing adequately according to their responsibilities and respective capabilities.

The integrated Climate and Energy Package (CEP)[5] introduced officially by European Community on January 23, 2008 is principled, complex and ambitious plan for GHGs emission reduction, increasing of energy efficiency, decreasing of fossil fuels consumption and supporting of innovative, low-carbon technologies.

A comprehensive set of fundamental legal standards for the Climate and Energy Package was published in the Official Journal of the European Union of June 5, 2009:

- Regulation (EC) 443/2009 of the European Parliament and of the Council of April 23, 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO2 emissions from light-duty vehicles.
- Directive 2009/28/EC of the European Parliament and of the Council of April 23, 2009 on the promotion of the use of energy from renewable resources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.
- Directive 2009/29/EC of the European Parliament and of the Council of April 23, 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission trading scheme of the Community.
- Directive 2009/30/EC of the European Parliament and of the Council of April 23, 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland navigation and repealing Directive 93/12/EEC.
- Directive 2009/31/EC of the European Parliament and of the Council of April 23, 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) 1013/2006.
- Decision 406/2009/EC of the European Parliament and of the Council of April 23, 2009 on the effort sharing of Member States to reduce their greenhouse gas emissions to meet the Community’s greenhouse gas emission reduction commitments up to 2020.

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[3] *New environmental action program: Environment 2010 Our Future, Our Choice*
[4] *OJ L 49, 19.2.2004, p. 1.*
[5] *Communication from the Commission: Progress Towards Achieving the Kyoto Objectives, Brussels, August 7, 2008*

Greenhouse effect of the atmosphere

The greenhouse effect of the atmosphere is a similar effect to that which may be observed in greenhouses, however the function of glass in the atmosphere is taken over by the "greenhouse gases" (international abbreviation GHGs). Short wave solar radiation is transmitted freely through the greenhouse gases, falling to the earth's surface and heating it. Long wave (infrared) radiation, emitted by the earth's surface, is caught by these gases in a major way and partly reemitted towards the earth's surface. As a consequence of this effect, the average temperature of the surface atmosphere is 30 °C warmer than it would be without the greenhouse gases. Finally, this enables the life on our planet.

Greenhouse gases

The most important greenhouse gas in the atmosphere is water vapour (H_2O), which is responsible for approximately two thirds of the total greenhouse effect. Its content in the atmosphere is not directly affected by human activity, in principle it is determined by the natural water cycle, expressed in a very simple way, as the difference between evaporation and precipitation. Carbon dioxide (CO_2) contributes to the greenhouse effect more than 30%, methane (CH_4), nitrous oxide (N_2O) and ozone (O_3), all three together 3%. The group of man-made (artificial) substances - chlorofluorocarbons (CFCs), their substitutes, hydrofluorocarbons (HCFCs, HFCs) and others such as perfluorocarbons (PFCs) and SF_6, also belong to the greenhouse gases, but their presence in atmosphere is caused by anthropogenic activity. There are other photochemical active gases as well, such as carbon monoxide (CO), oxides of nitrogen (NO_x) and non-methane organic compounds (NMVOCs), which do not belong to the greenhouse gases, but contribute indirectly to the greenhouse effect of the atmosphere. They are registered together as the precursors of ozone in the atmosphere, as they influence the formation and disintegration of ozone in the atmosphere.

The UNFCC defines an obligation to register and inventory the emission of greenhouse gases (CO_2, CH_4, N_2O and F-gases, included HFCs, PFCs and SF_6) according to the adopted IPCC methodology.[6] The growth in concentrations of greenhouse gases in the atmosphere (caused by anthropogenic emission) leads to the strengthening of the greenhouse gas effect and thus to the additional warming of the atmosphere. The present climate models estimate that global average temperature will rise by about 1.4 – 5.8 °C by the year 2100.

Concentrations of greenhouse gases in the atmosphere are formed by the difference between their emission (release into the atmosphere) and sink. It follows then that the increase of their content in the atmosphere operates by two mechanisms:

- emissions into the atmosphere,
- weakening of natural sink mechanisms.

Stabilizing atmospheric concentrations of greenhouse gases will demand a major effort. Without emissions – control policies motivated by concerns about climate change, atmospheric concentrations of carbon dioxide are expected to rise from today's 367 ppm to 490 – 1 260 ppm by the year 2100. This would represent a 75 – 350% increase since the year 1750. Stabilizing concentrations at, for example, 450 ppm would require world-wide emissions to fall below 1990 levels within the next few decades. Carbon dioxide is currently responsible for over 60% of the "enhanced" greenhouse effect. This gas occurs naturally in the atmosphere, but burning coal, oil and natural gas is releasing the carbon stored in these "fossil fuels" at an unprecedented rate. Likewise, deforestation releases carbon stored in trees. Current annual emissions amount to over 23 billion m^3 of CO_2, or almost 1% of the total mass of carbon dioxide in the atmosphere.

[6] *Intergovernmental panel (IPCC - Intergovernmental panel on Climate Change http://www.ipcc.ch) was established in 1988 commonly by ECE (UNEP) and World Meteorological Organisation (WMO). Its task is to reach the authoritative international consensus in the scientific opinions on climate change. The working groups of IPCC (under the participation of the scientists from the whole world) prepare regular updated information for COP (Conference of Parties), where the latest knowledge in association with the global warming is included.*

A second important human influence on climate is aerosols. These clouds of microscopic particles are not a greenhouse gas, but in addition to various natural sources, they are produced from sulphur dioxide emitted mainly by power stations. Aerosols settle out of the air after only a few days, but they have a substantial impact on climate.

Methane levels have already increased by a factor of two and a half during the industrial era and currently contribute 20% of the enhanced greenhouse effect. The rapid rise in methane started more recently due to intensive agriculture (mainly rice fields), animal husbandry, coal mining, natural gas mining, its transport and use as well as the biomass burning are all anthropogenic activities. As distinct from CO_2, the disintegration of methane in the atmosphere is via chemical reactions (by OH radical). Residence time of methane in the atmosphere is 10 – 12 years. At present, the annual total anthropogenic methane emission is said to be approximately 0.4 billion tons, but the global growth rate of methane budget seemed to have been at steady-state.

Nitrous oxide (with an “adjustment-time” of 114 years), a number of industrial gases and ozone contribute the remaining 20% of the enhanced greenhouse effect. Nitrous oxide levels have risen by 16%, mainly due to intensive agriculture, overusing of fertilizers and inconvenient agriculture-technical procedures. Fuel combustion, some industrial technologies, large-scale livestock breeding and sewage are the sources of N_2O emissions. Global anthropogenic emission is estimated to be 3 – 7 million tons of nitrogen per year. Natural sources are approximately twice as large as anthropogenic ones. While chlorofluorocarbons (CFCs) are stabilizing due to emission controls introduced under Montreal Protocol to protect the stratospheric ozone layer, levels of long-lived gases such as HFCs, PFCs and sulphur hexafluoride are increasing. They are used as carrier gases for sprays, fillings in cooling and extinguishing systems, as insulating substances, as solvents at the production of semiconductors, etc. Apart from the fact that they attack atmospheric ozone, they are very inert gases so that even minor emissions have a great negative effect.

5.2 GREENHOUSE GAS EMISSIONS IN THE SLOVAK REPUBLIC

Total EU-27 greenhouse gas emissions were equal to 5 045 Mt CO_2-equivealents in 2007, this represent a slight decrease (–1.2%) compared to 2006, bringing emissions 9.3% below the 1990 level without emissions and removals from land use, land use change and forestry (LULUCF) and international bunkers. The projected decrease in EU-27, compared to 1990, can reaches 14% in 2020 if additional domestic policies and measures are taken into account. Based on these data can be assumed, that the share of EU-27 GHG emissions on world emission is 12.4%.

Between 1990 and 2007, EU-27 per capita emissions declined to 10.2% tonnes CO_2 equivalents. The main decrease occurred particularly in the early 1990s. Comparable with other world are higher (7 t CO_2 equivalents per capita). Emissions per capita differ among EU countries and correspond with energy intensity (primary energy consumption per capita) and energy mix (emission per produced energy unit). All new member states, except Cyprus, Malta and Slovenia have decreased their per capita emissions substantially since 1990.

Total aggregated GHG emissions decreased in new member states by 25% in 2007 comparable to the base year 1990, mainly due to introduction of market economies and the consequent restructuring or closure of heavily polluting and energy-intensive industries. Introducing more efficient low-carbon technologies and increasing share of services on total Gross Domestic Product (GDP) grow. The transport sector, especially road transport is most growing sector in all EU member states, where additional policies and measures are required.

The emissions of greenhouse gases in the Slovak Republic are estimated in accordance with the requirements of the UN FCCC[1] and the Kyoto Protocol. The values listed in Tables are updated annually if information provided in the Statistical Yearbook of the Slovak Republic is revised and/or if methodology is changed. Emissions were estimated in compliance with the methods provided in the IPCC Guidelines,[7] Good Practice Guidance (GPG)[8] and in the SHMÚ's reports. The Fourth National Communication of the SR on the Climate Change was submitted on December 31, 2005 to the secretariat of the UNFCCC, completed with the Report on Demonstrable Progress to the Kyoto Protocol. The Communication is accessible on the web page www.enviro.gov.sk and was revised by expert review team. In preparation is Fifth National Communication of the Slovak Republic on Climate Change and will be submit on December 31, 2009 to the UNFCCC secretariat. In September 2009, the National Inventory System of the Slovak Republic[9] was revised under the in-depth review for the inventory submission 2009 of the SR by expert review team under responsibility of the secretariat of UNFCCC. The list of potential problems was published into the outcome report from the review for the information for Ministry of Environment of the SR and SHMÚ.[10] The in-depth revision was a tool for the analysis of current status in the parties of the KP and to get eligibility for participation of the Kyoto flexible mechanisms after 2008.

Total GHG emission represented 46 950.67 Gg in 2007 (without sinks from land use, land use change and forestry (LULUCF)). This represents a reduction by more than 36% in comparison with the base year 1990. In comparison with 2006, the emissions decreased by 4.1% and are the lowest from base year. The emissions signified in the literature as net emissions with the sinks from LULUCF in 2007 were 43 754.23 Gg and decreased against previous year by 4.7% caused by higher sinks in LULUCF and removing the consequences from the storm calamity in the High Tatra mountains. According to the decision of the Convention body the strictly recommended reporting software is CRFReporter, which generate automatically the required CRF Tables. The new reporting program was used also for recalculation the time series in the consistency way. The base year was agreed by national authority (the Ministry of Environment). Total GHG emissions in the Slovak Republic are stable or slightly increasing due to recovery of economic activities, increase in transport, and expected increase in actual emissions of F-gases (mainly HFCs and SF_6). The first results of preliminary GHG inventory for 2008 show the moderate increase of emissions and decrease of sinks caused by increasing of wood harvesting (Table 5.1).

Tab. 5.1 **Aggregate[11] anthropogenic emissions of GHG [Tg] in the Slovak Republic within 1990 – 2007**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Net CO_2	59.56	52.14	47.91	43.53	42.25	41.34	40.07	40.01	40.16	39.72	37.92	36.52	34.80	36.59	36.86	39.86	36.93	34.92
CO_2*	61.96	55.65	52.06	47.82	45.56	44.04	42.50	41.42	42.10	41.35	40.32	41.74	40.05	41.42	41.11	40.74	39.98	38.14
CH_4	4.79	4.64	4.38	4.09	4.07	4.25	4.21	4.24	4.50	4.70	4.42	4.47	5.08	4.84	4.82	4.58	4.63	4.53
N_2O	6.23	5.04	4.22	3.58	3.92	4.16	4.29	4.18	3.78	3.32	3.58	3.77	3.73	3.76	3.86	3.85	4.07	4.01
HFCs, PFCs, SF_6	0.27	0.27	0.25	0.16	0.14	0.14	0.08	0.10	0.08	0.09	0.10	0.11	0.12	0.17	0.19	0.21	0.26	0.27
Spolu (s net CO_2)	70.87	62.10	56.77	51.37	50.39	49.91	48.66	48.55	48.53	47.85	46.04	44.88	43.76	45.38	45.75	48.53	45.91	43.75
Spolu*	73.26	65.60	60.91	55.64	53.70	52.59	51.07	49.94	50.46	49.47	48.42	50.09	48.99	50.19	49.98	49.37	48.94	46.95

Emissions, as submitted in April 15, 2009
** GHG emissions without sinks from LULUCF*

[7] *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventory, Volume 1-3*
[8] *Good Practice Guidance and Uncertainty Management in National GHGs Inventories, IPCC 2000*
[9] *Vestnik MZP SR, 2007, 3, pages 19-45*
[10] *http://unfccc.int/documentation/documents/advanced_search/items/3594.php?rec=j&priref=600005634#beg*
[11] *According to the currently valid convention the emission reduction expressed in CO_2 equivalent should be reported, Climate Change 1995, The Science of Climate Change GWP100: CO_2=1, CH_4=21, N_2O=310, F-gases =140-23 900*

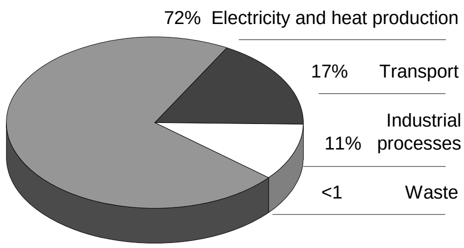
CO_2 – carbon dioxide

A most important anthropogenic source of CO_2 emissions in the atmosphere is combustion and transformation of fossil fuels, which account for about 90% of the total CO_2 emissions in the SR. In addition, carbon dioxide arises during technological processes during the production of cement, lime, magnesite and using of limestone. The balance includes also the production of coke, iron and steel, as well as CO_2 emissions arising during aluminium and ammonia production. Emission factors, estimated on the carbon content in fuels, were used. Carbon dioxide enters the atmosphere via the conversion of grasslands and forest areas into agricultural land, and forest fires (Figure 5.1).

Total net CO_2 emissions decreased moderate in 2007 compared with the previous year, totally decreased by more than 38% compared with the reference year 1990. The most feasible explanation of the significant CO_2 reduction is gradual decrease in energy demands in certain heavy energy demanding sectors (except for metallurgy) from 1993, higher share of services in the generation of the GDP, higher share of gas fuels in the primary energy resources consumption, restructuring of industries and the impact of air protection legislative measures influencing directly or indirectly the generation of greenhouse gas emissions. In the last year important changes of energy sources in the Slovak Republic were occurred.

At the same time, the moderate increasing trend in the CO_2 emissions is observed from 2000. This year is considered for the break year in the regeneration of the economy. It is expected the long-time increasing of the CO_2 emissions, approved by national projections.[12] Among the most important reasons appears the recovery of the Slovak economy, followed by new sources of pollution, and a shift to solid fuels due to the increased prices of natural gas. Similarly, increased trend in CO_2 emissions is also at the transport sector. It is anticipated a gradual increase of CO_2 emissions in this sector not only at the regional level, but it is a European problem, too

Fig. 5.1 **CO_2 emissions in 2007**



Tab. 5.2 **Total emissions and sinks of CO_2 [Gg] in the Slovak Republic within 1990 – 2007**

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Net CO_2	59555	41345	40074	40014	40160	39718	37915	36519	34802	36587	36862	39863	36930	34922
CO_2*	61962	44041	42496	41416	42100	41354	40319	41744	40045	41420	41113	40741	39981	38141
Fossil fuel combustion	58055	40816	39261	38103	38083	37307	36751	38084	36359	38032	36926	36603	35834	33990
Electricity and heat prod.	53162	36557	34947	33623	33320	32651	32569	33329	31467	33036	31651	30389	30090	27491
Transport	4892	4259	4313	4480	4763	4656	4182	4755	4892	4996	5275	6214	5743	6499
Industrial processes	3840	3158	3168	3264	3921	3980	3501	3605	3647	3355	4161	4125	4124	4143
Mineral products	2942	2342	2250	2331	3032	3052	2522	2590	2602	2303	2983	2967	3014	3089
Chemical industry	356	380	407	405	360	360	399	407	396	350	403	422	351	327
Production of metals	542	437	512	528	528	567	580	608	649	703	775	737	760	728
LULUCF	-2407	-2696	-2422	-1402	-1939	-1636	-2403	-5225	-5243	-4833	-4251	-877	-3051	-3219
Forest land	-4454	-4399	-3968	-2717	-3130	-2800	-4318	-5551	-5641	-5156	-3995	-701	-3097	-3266
Cropland	3287	2063	2063	3226	1798	1711	4394	1002	1174	1416	-14	1	1	2
Grassland	536	256	93	-50	70	-126	-797	-880	-874	-1363	-373	-442	-439	-439
Other land	-1775	-615	-609	-1861	-677	-420	-1682	204	98	269	132	264	484	484
Waste	67	67	67	48	97	67	67	55	39	33	25	13	23	8
Waste incineration	67	67	67	48	97	67	67	55	39	33	25	13	23	8
Burning biomass**	794	1183	1477	1288	1273	1304	1426	1632	1622	1734	2183	3045	2901	2977
International bunkers**	129	103	102	76	84	52	45	69	72	79	86	91	132	150

Emissions, as submitted in April 15, 2009
* *CO_2 emissions without sinks from LULUCF*
** *CO_2 emissions are not being accounted into the total emissions*

[12] *The Biennial Report 2007 according Decision 280/2004/EC*

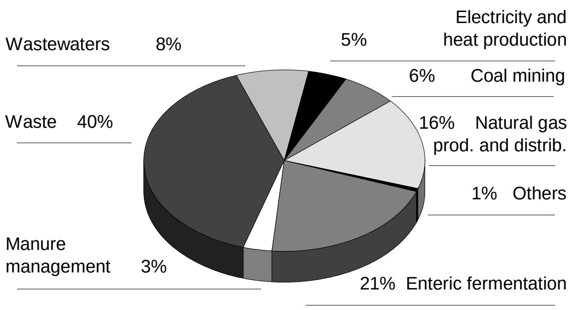
Sinks

The Slovak Republic covers a territory of 49 036 km^2, of which 41% is forest areas. Since the beginning of the century part of the agricultural land has been gradually transformed into forest. In the period from 1950, the amount of carbon fixed in the forests of the SR was increased approximately to the more than 50 Tg as a consequence of the forest area enlargement and an increase in hectare yield of wood mass. Fixation of carbon in forest ecosystems of the SR was estimated on the carbon balance in the part of the forest above the ground (trees, plant canopy, overlying humus) and that, under the ground (roots, humus in soil) including an assessment of wood exploitation and forest fires (Table 5.2). The new IPPC methodology[13] was implemented in the last inventory year for the estimation the sinks in the LULUCF sector according the good practice. Total emissions and sinks are balanced as changes in the area of the following categories: forest, cropland (arable land), grassland, wetlands, settlements and other land. The special category is biomass burning controlled and wild forest fires. All GHGs are estimated in these categories.

CH_4 – methane

Agriculture, large-scale beef cattle and pig breeding, are major sources of methane on our territory. The CH_4 does arise as the direct product of the metabolism in herbivores and as the product of organic degradation in animal excrement. Calculations of emissions for the Slovak Republic are based on the data listed in the Statistical Yearbooks and the Green Report of the Slovak Ministry of Agriculture. Leaks of natural gas in the distribution networks are a very important source of methane. Methane is also leaking into the atmosphere in brown coal mining and biomass burning. In addition, municipal waste dumps and sewage (predominantly septic tanks) are also important methane sources. Methane arises without the direct access of oxygen (Figure 5.2).

Fig. 5.2 **CH_4 emissions in 2007**



Total methane emissions reached 215.8 Gg in 2007, what is decrease comparable to the previous year. Emissions decreased by 5.34% compared to the reference year 1990. The most important changes were recorded in the sector of solid waste disposal sites (SWDS). The revision of emission factors and selection of appropriate parameters were carried out. The revision dealt with the data from 1960. The cooperation of sectoral expert with the expert for uncertainty was established. Using the Tier 2 method - First Order Decay, the total revision of methane emissions from solid waste disposal sites for time series 1960 – 2007 was performed. The uncertainty for the methane emissions from solid waste disposal site was decreased and accuracy was increased. The implementation of the kinetic model for SWDS´s emission balance was one of requirement for the acceptation of annual inventory for base year by expert review team during in-depth review.

The important methodology change in agricultural sector was performed based on Tier 2 methodology and regional input activity data in enteric fermentation of the key animal categories (cattle, sheep, swine), as well as. The methane emissions decreased in all sub-sectors except LULUCF and waste, caused by implementation of new methodologies (Table 5.3).

[13] *IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry, 2003*

Tab. 5.3 **Total emissions of CH_4 [Gg] in the Slovak Republic within 1990 – 2007**

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total CH_4 emissions	228.0	202.3	200.3	201.8	214.3	223.8	210.6	212.7	242.1	230.6	229.5	218.0	220.6	215.8
Energy	73.4	72.5	72.4	71.3	74.4	72.1	74.5	72.9	69.0	67.0	64.9	61.3	59.2	59.7
Fossil fuel combustion	21.8	13.6	12.6	10.7	11.2	10.6	11.6	11.7	9.6	10.0	10.8	13.2	12.4	10.8
Electricity and heat prod.	*20.8*	*12.5*	*11.5*	*9.5*	*9.9*	*9.3*	*10.5*	*10.4*	*8.4*	*8.7*	*9.5*	*11.8*	*11.3*	*9.7*
Transport	*1.0*	*1.1*	*1.2*	*1.2*	*1.3*	*1.3*	*1.1*	*1.3*	*1.2*	*1.2*	*1.3*	*1.3*	*1.1*	*1.1*
Fugitive emissions	51.6	58.8	59.8	60.6	63.2	61.5	62.9	61.2	59.4	57.0	54.1	48.1	46.8	49.0
Coal mining	*27.2*	*29.7*	*30.1*	*30.6*	*31.2*	*29.5*	*28.8*	*26.3*	*25.7*	*21.1*	*19.8*	*16.2*	*14.7*	*13.5*
Natural gas produc.&distrib.	*24.5*	*29.1*	*29.7*	*30.0*	*32.0*	*32.0*	*34.1*	*34.9*	*33.7*	*35.9*	*34.3*	*32.0*	*32.1*	*35.4*
Industrial processes	0.039	0.041	0.044	0.044	0.039	0.039	0.043	0.048	0.042	0.037	0.043	0.043	0.038	0.041
Chemical industry	0.039	0.041	0.044	0.044	0.039	0.039	0.043	0.048	0.042	0.037	0.043	0.043	0.038	0.041
Agriculture	112.3	80.2	75.3	67.7	63.1	60.6	59.7	61.1	59.5	56.9	52.9	53.3	52.5	51.9
Enteric fermentation	94.8	66.9	62.7	56.1	52.9	50.8	50.2	51.4	49.8	47.6	45.0	45.6	45.0	45.1
Manure management	17.6	13.3	12.6	11.6	10.2	9.9	9.5	9.6	9.7	9.3	7.8	7.7	7.5	6.8
LULUCF	0.699	0.459	0.510	0.540	0.533	0.610	0.670	0.680	0.663	0.730	0.822	1.068	0.900	0.906
Forest	0.699	0.459	0.510	0.540	0.533	0.610	0.670	0.680	0.663	0.730	0.822	1.068	0.900	0.906
Waste	42.2	49.7	52.5	62.8	76.8	91.0	76.4	78.7	113.5	106.7	111.8	103.4	108.9	104.1
Solid waste disposal sites	22.4	30.9	33.8	44.1	58.0	72.2	57.5	59.9	94.7	88.0	93.3	85.2	90.7	85.8
Wastewaters	19.7	18.7	18.6	18.5	18.6	18.6	18.8	18.6	18.6	18.5	18.3	18.1	18.0	18.0
Composting	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.1	0.2	0.3
International bunkers *	0.005	0.004	0.003	0.002	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002

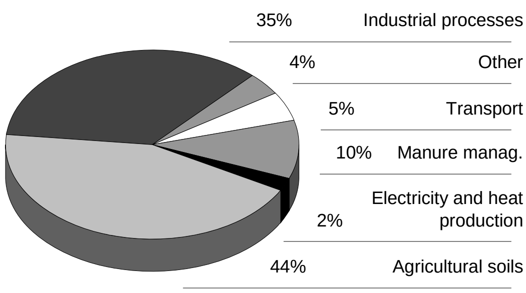
Emissions, as submitted in April 15, 2009
** CH_4 emissions are not being accounted into the total emissions*

N_2O – nitrous oxide

In comparison to the other greenhouse gases, the mechanism of nitrous oxide emissions and sinks is not explored fully. The values are charged with a relatively considerable degree of uncertainty. Surpluses of mineral nitrogen in soil (consequence of intense fertilizing) and unfavourable aerial soil conditions (heavy mechanical tillage) are the main cause of N_2O emissions. Emissions in power industry and traffic were estimated on the balance in fossil fuel consumption, by applying the default emission factors according to the IPCC methodology.[7,8] The N_2O emission arising by manipulation of sewage and sludge has been estimated also for municipal and industrial wastewater treatment plants (Figure 5.3).

In 2007, the total N_2O emissions slightly decreased compared with the year 2006 and reached 12.93 Gg. However, the drop compared to the reference year 1990 is more than 35.7%. The N_2O emissions raised from 2000, continuously. The most substantial increase was recorded in transport sector by more than 11% and industrial processes sector (chemical industry). The later regards to increase in chemical production (nitric acid). The higher increase of N_2O emissions is observed in waste sector, the emissions raised about 90% from base year. This relates to the amount of industrial wastewater treatment and detailed methodology and changes in the consideration of the waste categories. Emissions of N_2O are shown the higher level of uncertainty and the time series is slightly inconsistent comparable with other gases (Table 5.4).

Fig. 5.3 **N_2O emissions in 2007**



Tab. 5.4 **Total emissions of N_2O [Gg] in the Slovak Republic within 1990 – 2007**

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total N_2O emissions	20.11	13.42	13.83	13.48	12.18	10.73	11.56	12.15	12.02	12.12	12.46	12.41	13.13	12.93
Fossil fuel combustion	0.92	0.66	0.68	0.69	0.73	0.73	0.70	0.79	0.76	0.80	0.82	0.94	0.88	0.93
Electricity and heat prod.	0.53	0.33	0.32	0.30	0.29	0.29	0.28	0.30	0.27	0.29	0.30	0.33	0.31	0.29
Transport	0.39	0.33	0.35	0.39	0.43	0.44	0.41	0.49	0.49	0.51	0.52	0.61	0.57	0.64
Industrial processes	3.71	3.63	4.24	4.01	3.41	2.56	3.33	3.77	3.37	3.73	4.26	4.13	5.05	4.56
Chemical industry	3.71	3.63	4.24	4.01	3.41	2.56	3.33	3.77	3.37	3.73	4.26	4.13	5.05	4.56
Solvent use	0.06	0.10	0.11	0.09	0.07	0.07	0.06	0.10	0.18	0.19	0.26	0.28	0.27	0.26
Agriculture	15.09	8.73	8.50	8.40	7.68	7.08	7.21	7.25	7.41	7.15	6.88	6.82	6.70	6.95
Manure management	3.53	2.36	2.18	2.00	1.76	1.68	1.64	1.59	1.58	1.53	1.43	1.38	1.34	1.31
Agricultural soils	11.56	6.37	6.32	6.40	5.92	5.40	5.56	5.66	5.84	5.62	5.46	5.45	5.36	5.64
LULUCF	0.011	0.007	0.007	0.007	0.007	0.010	0.010	0.010	0.010	0.010	0.011	0.017	0.010	0.013
Forest	0.011	0.007	0.007	0.007	0.007	0.010	0.010	0.010	0.010	0.010	0.011	0.017	0.010	0.013
Waste	0.34	0.30	0.30	0.30	0.29	0.28	0.26	0.25	0.29	0.25	0.24	0.24	0.24	0.24
Wastewaters	0.32	0.27	0.27	0.27	0.26	0.25	0.23	0.22	0.26	0.21	0.21	0.21	0.20	0.20
Waste incineration	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02
Composting	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
International bunkers *	0.004	0.026	0.023	0.014	0.019	0.005	0.001	0.013	0.014	0.011	0.006	0.003	0.016	0.018

Emissions, as submitted April 15, 2009
* *N_2O emissions are not being accounted into the total emission*

HFCs, PFCs, SF_6

Sources and emissions of the so-called F-gases have been assessed on the territory of the Slovak Republic. The procedure was carried out in coincidence with the methodology IPCC[7,8] and the actual and potential emissions were estimated from 1990 (Table 5.5). These gases have not been produced in the SR. Sources of emissions are in their usage as coolants, extinguishing agents, foam substances, solvents, SF_6 as insulating gas in transformers and in the metallurgical industry. CF_4 and C_2F_6 arise in aluminium production. Using of HFCs, PFCs and SF_6 has risen since 1995 and this trend is expected in the future, as well.

Tab. 5.5 **Total emissions of HFCs, PFCs and SF_6 [Gg] in the Slovak Republic within 1990 – 2007**

	GWP		1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total emissions CO_2 *eq.*		[Gg]	271.40	146.38	82.85	107.16	78.60	91.41	100.49	111.86	130.88	169.00	188.68	209.20	251.87	269.31
HFCs emissions CO_2 *eq.*		[Gg]	0.00	22.15	37.58	61.20	40.96	65.12	75.59	82.43	102.35	131.96	152.88	172.34	198.90	226.99
HFC-23	11 700	[Mg]		<0.01	0.06	0.06	0.05	0.05	0.06	0.06	0.04	0.08	0.08	0.08	0.08	0.08
HFC-32	650	[Mg]			0.02	0.10	0.10	0.10	0.30	0.56	1.15	1.85	2.39	3.55	5.02	7.06
HFC-41	150															
HFC-43-10mee	1 300															
HFC-125	2 800	[Mg]		0.01	0.07	0.19	0.41	0.73	1.85	3.27	5.58	7.91	9.85	12.48	15.98	19.80
HFC-134	1 000															
HFC-134a	1 300	[Mg]		9.17	22.77	38.60	27.76	43.88	45.94	42.75	47.19	60.07	66.49	70.69	76.57	81.76
HFC-152a	140	[Mg]			<0.01	0.13	0.29	0.60	0.83	1.02	1.21	1.36	1.22	1.22	1.22	1.22
HFC-143	300															
HFC-143a	3 800	[Mg]			0.11	0.30	0.44	0.78	1.85	3.37	5.35	7.20	8.70	10.21	12.51	14.66
HFC-227ea	2 900	[Mg]		3.52	2.29	2.92	0.48	0.80	0.80	0.80	0.44	0.23	0.01	0.00	0.01	0.01
HFC-236fa	6 300								0.05	0.22	0.38	0.22	0.50	0.53	0.43	0.60
HFC-245ca	560															
PFCs emissions CO_2 *eq*		[Gg]	271.37	114.32	34.51	34.62	25.40	13.60	11.65	15.59	13.75	21.65	19.91	20.25	35.82	24.88
CF_4	6 500	[Mg]	36.60	15.44	4.68	4.70	3.45	1.88	1.57	2.18	1.90	2.93	2.69	2.73	4.83	3.35
C_2F_6	9 200	[Mg]	3.60	1.53	0.45	0.44	0.32	0.15	0.15	0.15	0.15	0.28	0.26	0.27	0.48	0.33
C_3F_8	7 000															
C_4F_{10}	7 000															
c-C_4F_8	8 700															
C_5F_{12}	7 500															
C_6F_{14}	7 400															
SF_6 emissions CO_2 *eq.*		[Gg]	0.03	9.91	10.76	11.34	12.24	12.69	13.25	13.84	14.78	15.39	15.89	16.61	17.15	17.44
SF_6	23 900	[Mg]	0.00	0.42	0.45	0.47	0.51	0.53	0.56	0.58	0.62	0.64	0.67	0.70	0.72	0.73

Emissions, as submitted in April 15, 2009

In 2007, total F-gases emissions considerable increased. This trend was expected due to a special feature of the emissions. They have a long lifespan and both actual and potential emissions are taken into account. Compared with 2006, the emissions increased by 14%. However, compared to the reference year 1990, the decease is more than 8%. The most significant increase of emissions was recorded in the case of HFCs that substituted use of the PFCs. Emissions of CF_4 a C_2F_6 together with emissions of SF_6 are released in the production of aluminium. Their concentrations increased due to an increased production capacity (Table 5.5).

5.3 ASSESSMENT

The aggregated emission of GHGs in year 2007 are approximately on the lowest level from base year 1990 (without LULUCF). There is the significant decreasing of aggregated emission against the base year (1990) about approximately 26 305 Gg it means the decreasing about almost 36% without sinks from LULUCF. A major share of aggregated emission covers the energy sector by about 76%, the industrial processes sector covers about 12%, the agriculture sector about 7% and the waste sector more than 5%. The solvent use sector covers less than 1% of the total emissions. These shares are determined as emissions in CO_2 of aggregated equivalents (Table 5.6).[11]

The GHG emission inventory should be assessed based upon its complexity due to uncertainty. These are caused and influenced by uncertainties of statistical data on fuel consumption. The applied emissions factors are another source of uncertainty. An additional error in calculation of the other GHG emissions may occur as a result of less exact methods and it can not be quantified. In spite of this, the uncertainty analysis determined by the Tier 1 method of the IPCC[8] estimated that the GHG emission inventory of 2007 is 14% (according level assessment) and 8% (according trend assessment). The calculation uncertainty by using the more sophisticated Tier 2 - Monte Carlo method is evaluated for the solid waste disposal site category. The essential result from our study is fact that total uncertainty was reduced comparable to IPCC default recommended value by Tier 1 (50%). This value is ±48% for total methane emissions from SWDS according the time series from 1960. The uncertainty assessment of the sector energy, category combustion of fossil fuels was performed by Monte Carlo method and set unsymmetrical interval of uncertainty (–2.13%; 3.18%).

In order to reduce uncertainty of emission inventory, it is necessary to determine and classify key sources and categories. The key sources were selected according to a cumulative contribution to the total emissions. They represent more than 95% of total GHG emissions. Key sources and categories were determined according to the IPCC[8] method with and without LULUCF sector. In 2007, the Slovak Republic determined 16 key sources without LULUCF and 11 key sources with LULUCF to be assessed according to the level. According to anticipated trends was assessed 11 key sources without LULUCF and 16 with LULUCF. The most important key categories are combustion of fossil fuels, road transport, and agricultural emissions, waste disposal, enteric fermentation, production of nitric acid, cement, iron and steel productions. Composition of key sources has not been changed. In the next submission the more detailed key source analyses will be prepared.

The GHG emissions reached the highest level at the end of 80-ies. In the period of 1990 – 1994 the reduction was about 25%. From 1994, the emissions have been stable. In 2000, a significant decrease was recorded. In recent years, emissions increased, mainly emissions of CO_2, due to recovery of the industrial production, transport and changes in fuels used (Figure 5.4).

A comparison of the GDP trend with the trend of aggregate emissions of greenhouse gasses shows that the SR is one of few countries where the trend of emissions is decoupled from the GDP increase. However, by international comparison, the generation of greenhouse gasses per capita still remains one of the highest in Europe. Without introduction of effective measures the Slovak Republic will contribute to further increase of GHG emissions due to anticipated growth of the GDP and recovery of economic activities. Therefore, the investment strategy to tackle GHG emissions is one of the most important objectives.

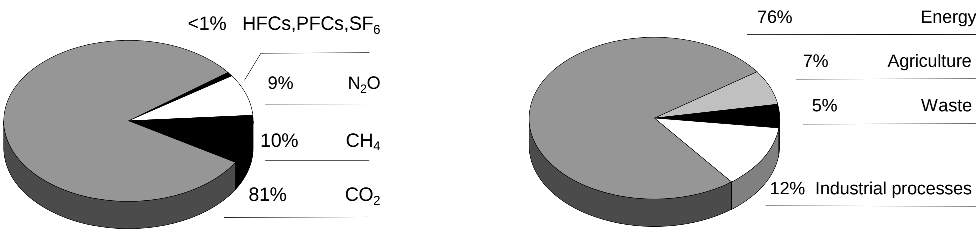
Concerning the actual and proposed dynamics of GDP growth in the Slovak Republic there exist legitimate assumption that GHG emissions will increase in line with it. Due to this scenario there is necessary to prepare investment strategies and programmes that allow us to achieve permanent distribution of GDP growth and emissions growth with the regards to the further the post-Kyoto reduction goals. The EC commitments include 20% reduction the GHG emissions after 2020 against 1990. For the Slovak Republic is the strategic target within this connection to apply low-energy effective technologies for the energy production (for the new sources), emission trading, restructuring of industry and agriculture, development of service sector and the improvement of the industry and public awareness in the environment issues.

Tab. 5.6 **Aggregated emissions of GHGs according the sectors [CO_2 eq.Gg] in the Slovak Republic within 1990 – 2007**

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Energy*	59884	42542	40992	39814	39870	39048	38532	39859	38045	39690	38541	38181	37351	35532
Industrial Processes**	5261	4431	4567	4617	5058	4867	4635	4886	4823	4681	5673	5616	5942	5825
Solvent Use	17	31	33	27	21	22	20	30	57	59	80	86	82	80
Agriculture	7036	4389	4217	4024	3707	3468	3487	3530	3547	3412	3244	3235	3178	3245
LULUCF	-2388	-2684	-2409	-1388	-1926	-1620	-2386	-5208	-5226	-4815	-4230	-850	-3029	-3196
Waste	1058	1202	1262	1458	1800	2065	1750	1785	2513	2349	2447	2256	2383	2269
Total with LULUCF	70867	49911	48663	48551	48531	47850	46038	44882	43760	45376	45755	48525	45909	43754

*Emissions, as submitted in April 15, 2009 *Including transport **Including F-gases*

Fig. 5.4 **Aggregated GHGs emissions in 2007**



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