Slovak
Hydrometeorological Institute

Ministry of Environment
of the Slovak Republic

AIR POLLUTION

IN THE SLOVAK REPUBLIC

2003

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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

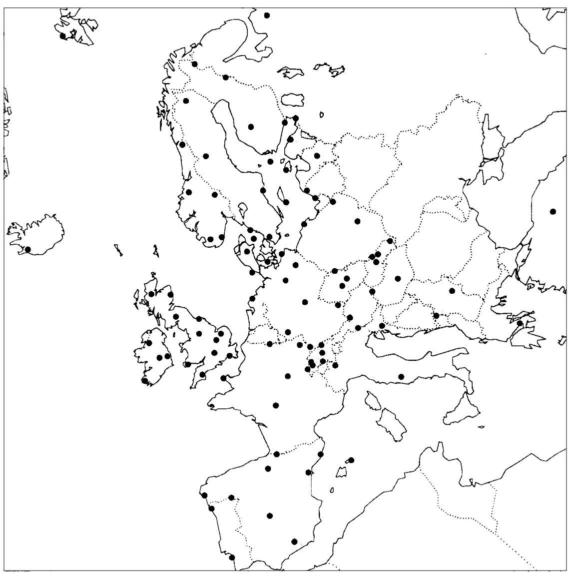
Regional air pollution is a pollution of a boundary layer of a rural country at a sufficient distance from local industrial and urban sources. The boundary layer of the atmosphere is a mixing layer extending itself from the Earth surface up to a height of about 1 000 m. In regional positions, the industrial emissions are more or less evenly vertically dispersed in the entire boundary layer and ground level concentrations are smaller than those in cities.

Pollutants coming from combustion processes such as sulphur dioxide, oxides of nitrogen, hydrocarbons or heavy metals, play an important role on a regional scale. Residence time of these pollutants in the atmosphere is several days and thus they may be transported in the atmosphere over a distance of several thousand kilometres from the source. The products of oxidation from primary gas pollutants, for instance sulphates, may reach the central troposphere by vertical transport, where they are involved in global circulation.

Since 1950, regional air pollution in Europe has been growing parallel with the emissions of pollutants from power generation, industry, heating and transport. The construction of high stacks showed to have a negative impact on the environment, as these prolonged the residence time of pollutants in the atmosphere. Acidity of precipitation, as well as the concentrations of secondary pollutants, such as ozone, hydrogen peroxide and others, has risen in the atmosphere as a result of uncontrolled emission development. At present, ozone and acid precipitation are considered to be the two main stress factors for the forest and agriculture ecosystems in Europe.

Unfavourable development along with the alarming growth of ecological damages did enhance international co-operation. 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 should be reduced 60% by 2000, 65 % by 2005 and 72 % by 2010, as compared to 1980. According to the last sulphur Protocol the Slovak Re-

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



public should reduce its emissions of sulphur dioxide 80 % by 2010 as compared to 1980, those oxides of nitrogen 42 %, ammonia 37 % and volatile organic compounds 6 % as compared to 1990.

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. By means of 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. There are two EMEP coordinating centres in Norway, MSC W - Meteorological Synthesising Centre West - Norwegian Meteorological Institute in Oslo and CCC- Chemical Coordinating Centre - NILU-Norwegian Institute for Air Research in Kjeller. The third EMEP coordinating center is in Russia, MSC E - Meteorological Synthesising Centre East - Institute for Applied Geophysics in Moscow and the fourth EMEP coordinating center is in Austria, CIAM - Centre for Integrating Assessment Modelling - IIASA - International Institute for Applied Systems Analysis in Laxenburg. The EMEP monitoring network (Fig. 1.1) comprises approximately 100 regional stations. Five stations in the territory of Slovakia belonging to the national monitoring network of the Slovak Hydrometeorological Institute are at the same time also a part of EMEP network. The basic EMEP monitoring programme has been gradually enhanced, first for sulphate, oxides of nitrogen, ammonium and ozone. In 1994, the measurements of volatile organic compounds (VOCs) have begun to be carried out under the auspices of CCC - NILU. At present the EMEP monitoring strategy includes also the monitoring of heavy metals (HMs), PM_{10} mass concentration and persistent organic compounds (POPs). At present the new monitoring strategy has been adopted and EMEP stations will be classified into the three levels according to the monitoring programmes (more details on www.emep.int).

Results of measurements from the regional network of stations in Slovakia are also used in other monitoring programmes like GAW/BAPMON (Global Atmosphere Watch/Background Air Pollution Monitoring Network) under WMO and UNEP/GEMS (United Nations Environment Programme/ Global Environment Monitoring System).

The level of regional air pollution is not assessed according to the primary ambient air quality standards, but according to the secondary ambient air quality standards and deposition limits, and thus on the long-term impact in the environment. Clean Air Act No 309/91 Coll. does include the category of secondary ambient air quality standards and deposition limits, but these have not been adopted in the Slovak Republic up to now.

The determination of secondary ambient air quality standards, or ecological limits are based on the conception of critical levels and critical loads.

Critical level (CL) is the highest concentration of pollutant which ecosystem may tolerate without being injured. Critical levels are different for individual pollutants and individual ecosystems. In the Draft Manual for Mapping Critical Levels/Loads, UN ECE, 1990, the following critical levels are suggested:

Pollutant	**Ekosystem**	**CL** [$\mu g.m^{-3}$]	**Period**
SO_2 - S	Forest Natural vegetation Agricultural crops	10 10 15	annual average
NOx - N	All categories	9	annual average
O_3	All categories	50 60 150	9-16 h average (1.4 - 30.9) 8- h average 1- h average

According to the Directive of European Community (1992), the critical ozone level for protection of vegetation was indicated 200 $\mu g.m^{-3}$ as 1-hour average and 65 $\mu g.m^{-3}$ as 24-hour average.

Executive body of Working Group on Effects within the framework of the Convention proposed the following cumulative critical levels for ozone:

- **Critical level for agricultural crops**, expressed as cumulative exposure of concentrations above 40 ppb. This index of exposure AOT40 (accumulated exposure over a threshold of 40 ppb) is calculated as the sum of the differences between 1-hour ozone concentrations in ppb for each daylight hour between 9.00 and 16.00 in which the concentration is over 40 ppb and average global radiation intensity 50 $W.m^{-2}$ or more during the period of three months May, June and July. AOT40 of 3 000 ppb h corresponds to a 5 % yield crop loss.
- **Short term critical level for agricultural crops and natural vegetation** AOT40 is 500 ppb h, cumulated within five subsequent days under low (water) vapour pressure deficit and 200 ppb h, cumulated within five subsequent days under high (water) vapour pressure deficit conditions. These values are related to daylight hours.
- **Critical level for forest ecosystems:** AOT40 is 10 ppm h. This cumulative exposure is calculated for 24 hours in a day, during a period of six months, when the trees are most sensitive to ozone.

Critical load is the deposition ecological limit and represents the maximum permissible deposition of pollutant in an ecosystem. Critical load is expressed in the mass of pollutant over the area unit per time unit (e.g. $g.m^{-2}.year^{-1}$, $kg.ha^{-1}.year^{-1}$, or $equivalent.ha^{-1}.year^{-1}$). This is a function of ecosystem sensitivity. Total deposition is composed of dry, wet and occult deposition. Dry deposition represents interception of gases and particles on the surface, mainly by vegetation. Wet deposition represents substances in rainwater and occult deposition is interception of droplets from clouds and fogs on the surface of predominantly vegetation, mainly in mountains. Dry deposition is calculated on the regional concentration of respective substances and surface behaviour, wet on annual concentration of respective substances in rainwater and annual totals of precipitation amount, occult in the differences between values from rain gauges placed under the tree canopy and those in free areas.

The territory of the Slovak Republic is ecologically mid-sensitive to sulphur deposition. The value of critical sulphur loads over the territory of Slovakia is represented by 1-3 $g S.m^{-2}.year^{-1}$, or 10-30 $kg S.ha^{-1}.year^{-1}$. However, the real sulphur deposition exceeded these values on approximately 25 % of the forest area within the last decade. Despite the fact, the European sulphur dioxide emissions have decreased, the values of total sulphur deposition are higher than the critical load. Typical values of sulphur deposition expressed in $g S m^{-2}.year^{-1}$ for the lowlands and mountain positions of Slovakia in 2003 are summarized in the following table:

Sulphur deposition	Danube lowlands	Mountain position (> 1 500 m)
Dry	0.5	0.1
Wet	0.3	0.9 (1.4)$^{+}$
Occult	0.1	0.5 (0.7)$^{++}$
Total	**0.9**	**1.5 (2.2)**

Critical load	**1.0 - 3.0**

$^{+}$ *With regard to the correction of negative error in amount of precipitation measurements in mountains*

$^{++}$ *upper level of estimate at occult deposition*

A detailed assessment of critical loads (ecological sensitivity of the territory) and determination of target loads in Slovakia for sulphur, nitrogen, actual acidity, heavy metals and some other pollutants have not been completed yet. These data are needed for Environment Impact Assessment (EIA) on long-range transmission of air pollutants as well as the EIA studies of the new large air pollution sources.

1.2 REGIONAL STATIONS IN THE SLOVAK REPUBLIC

In 2003, there were 5 stations in operation in the Slovak Republic to monitor regional air pollution and chemical composition of precipitation. Location and elevation of the individual stations are indicated in Figure 1.2. All these stations are part of the EMEP network. Apart from the above-mentioned, monthly precipitation have been sampled in the meteorological garden of the Slovak Hydrometeorological Institute in the Bratislava-Koliba station, in elevation 286 m, and analyzed on the content of heavy metals.

Regional station

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.

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.

Liesek

Meteorological observatory of the Slovak Hydrometeorological Institute on east-western side of the Roháče mountains, nearby to the Liesek village, 692 m above sea level, 19°40'46" longitude, 49°22'10"latitude. Measurements started to be carried out in 1988. Since 1992 the station has become a part of the EMEP network.

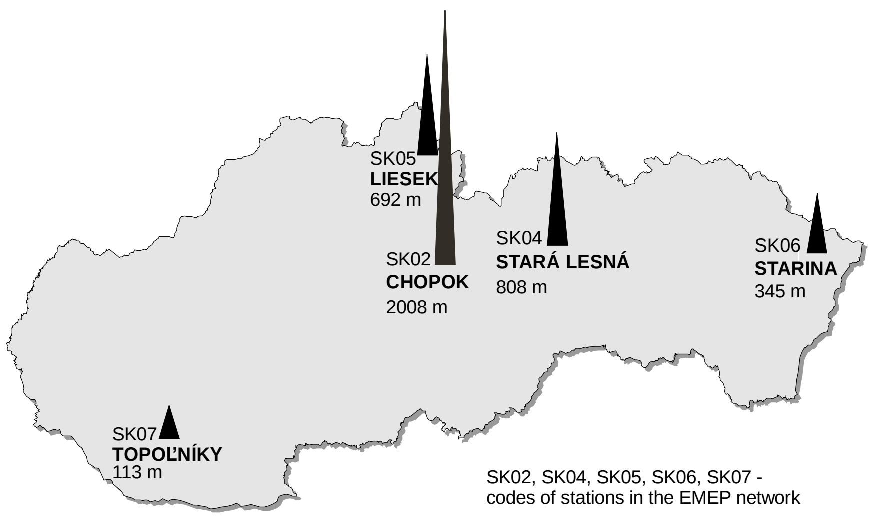
Stará Lesná

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.

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 **Regional stations in the Slovak Republic - 2003**



Measurement programme

AMBIENT AIR	**Gas components**	SO_2, NOx, HNO_3 - 24-hour sampling
		O_3 - continuous registration by analyser
		VOCs C_2 - C_6 10-15 minute sampling 2x weekly at 12.00 noon
	Particulate matter	PM mass concentration - 7 day sampling interval
		Pb, Cu, Zn, Mn, Cr, Ni, Cd, As - 7 day sampling
		SO_4^{2-}, NO_3^- - 24- hour sampling
PRECIPITATION	**Daily precipitation**	pH, conductivity, SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}
	Monthly precipitation	pH, conductivity, SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, Zn, Mn, Cu, Cr, Ni, Pb, Cd, V, As

Methods of determination

		Collection	Determination
AMBIENT AIR	**SO_2**	cellulose filter W40 impregnated by KOH solution	IC - Dionex
	NOx	after oxidation into NaOH absorption solution with guajacol	spectrophotometrically, spectrophotometer Unicam/Helios α - modified Saltzman method
	HNO_3	cellulose filter W40 impregnated by KOH solution	IC - Dionex
	O_3	registration by analyzer	principle - UV absorption
	VOCs C_2 - C_6	stainless steel canister	GC-Perkin Elmer + FID
	PM weight mass	nitrocellulose filter Sartorius	Gravimetrically, Sartorius/Mettler Toledo balances
	Heavy metals - Pb, Cu, Mn, Cr, Ni, Cd, Zn, As	nitrocellulose filter Sartorius	after digestion in MW-oven by ICP-MS and AAS Perkin Elmer in flame
	SO_4^{2-}	filter W40	ITP from water solution
	NO_3^-	filter W40	ITP from water solution
PRECIPITATION	**pH**	"wet only" - rain gauges WADOS "bulk" - PE bucket	pH meter Mettler Toledo
	Conductivity		conductometer Mettler Toledo
	SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, K^+, Na^+, Mg^{2+}, Ca^{2+}		IC - Dionex
	Zn, Mn, Cu, Cr, Ni, Pb, Cd, V, As		AAS - Perkin Elmer, in flame or graphite atomiser

1.3 ASSESSMENT OF RESULTS FROM MEASUREMENT IN 2003

SO_2, sulphate

Regional concentrations of sulphur dioxide (Tab. 1.1, Fig. 1.3) ranged between 0.61 µg S.m^{-3} (Chopok) and 2.44 µg S.m^{-3} (Topoľníky), in 2003. As compared to 2002, the values of sulphur dioxide were very similar at the individual stations, they differed only about the tenth and hundredth of µg S.m^{-3}, at the highest situated station (Chopok) and the lowest situated station (Topoľníky) the values are slightly lower, at the other stations the values are slightly higher. The upper value of the concentration range represents less than 25 % of the critical sulphur dioxide level (critical level for forest and natural vegetation is 10 µgS.m^{-3} and for agricultural crop 15 µgS.m^{-3}). ***In coincidence with the Annex 1 to the Decree of the Ministry of Environment of the Slovak Republic No 705/2002, limit value for protection of ecosystems is 20 µg SO_2.m^{-3} in calender year and winter season. This limit value did not reach even one quarter in any of the stations in calendar year and in winter season the highest value from all the stations was lower than half of the mentioned limit value only in one station (Topol'níky).*** As compared to the previous year, the concentrations of sulphates in atmospheric aerosols in 2003 were lower at all regional stations, in Chopok, Starina, Stará Lesná and Liesek the differences represented only hundredths of µg S.m^{-3}, in Topoľníky the differnce was the highest, almost 0,5 µg S.m^{-3} (Tab. 1.1, Fig. 1.3). The regional level of sulphates in Chopok was 0.39 µg S.m^{-3}, in Stará Lesná 0.92 µg S.m^{-3} and in Starina, Liesek and Topoľníky the annual averages overstepped 1 µg S.m^{-3}, in Topoľníky the value was the highest 1.26 µg S.m^{-3}. Sulphates contributed to the total mass of particulate matter 12-17 % (Fig. 1.4). Concentration ratio of sulphates to sulphur dioxide, expressed in sulphur presents interval 0.5-1.1, corresponding to the regional level of pollution.

Tab. 1.1 **Annual mean concentrations in ambient air - 2003**

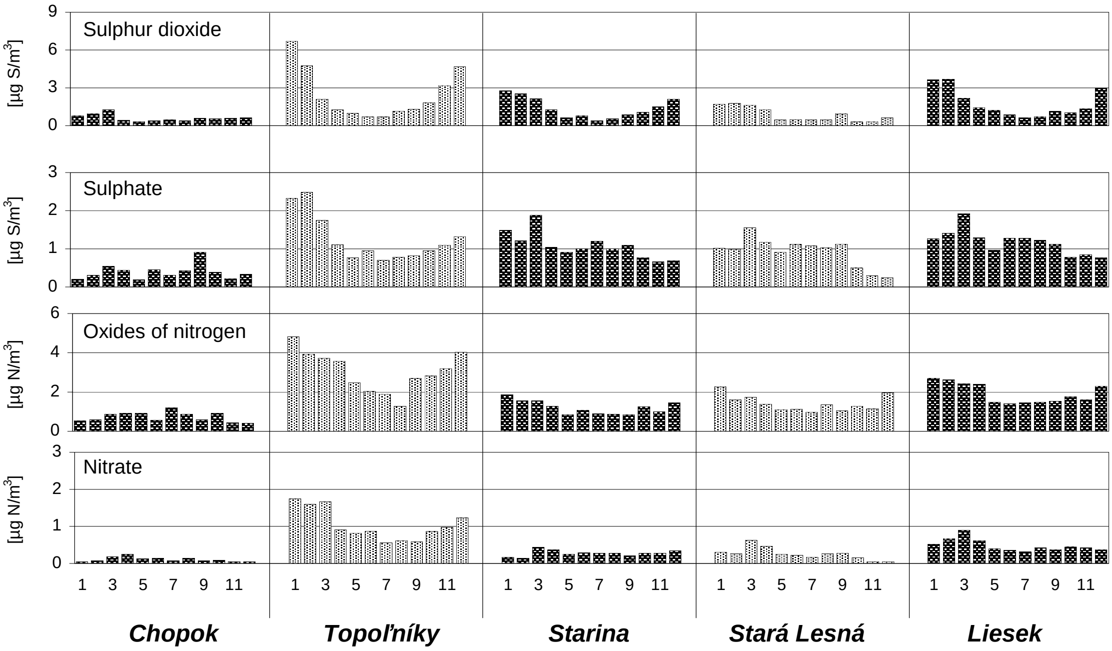
	SO_2-S µg/m^3	SO_4-S µg/m^3	NO_2-N µg/m^3	NO_3-N µg/m^3	HNO_3-N µg/m^3	O_3 µg/m^3	prach µg/m^3	Pb ng/m^3	Mn ng/m^3	Cu ng/m^3	Cd ng/m^3	Ni ng/m^3	Cr ng/m^3	Zn ng/m^3	As ng/m^3
Chopok	0.61	0.39	0.73	0.11	0.10	109	9.9	3.19	2.35	1.11	0.13	0.76	1.21	4.56	0.17
Topoľníky	2.44	1.26	3.03	1.05	0.10	65	31.7	17.66	11.01	3.87	0.49	1.86	3.50	35.58	2.07
Starina	1.39	1.08	1.21	0.27	0.16	72	20.7	14.37	4.77	1.65	0.52	0.73	0.74	18.11	0.84
Stará Lesná	0.87	0.92	1.41	0.26	0.07	66	15.8	9.91	4.50	1.59	0.31	0.66	0.93	20.29	1.08
Liesek	1.71	1.17	1.93	0.48	0.08	-	24.2	13.52	14.40	1.86	0.49	0.61	0.78	34.64	2.42

NOx, nitrates

Regional concentrations of oxides of nitrogen at regional stations, expressed in NO_2-N (Tab. 1.1, Fig. 1.3) varied within the range 0.73-3.03 µg N.m^{-3} in 2003. The smallest annual average value was recorded at Chopok 0.73 µg N.m^{-3}, the higher one at Starina 1.21 µg N.m^{-3}, Stará Lesná 1.41 µg N.m^{-3}, Liesek 1.93 µg N.m^{-3} and value 3.03 µg N.m^{-3} at the Topoľníky lowlands station. A critical level of concentrations of nitrogen oxides (9 µg N.m^{-3} for all ecosystems) was not exceeded at any of the stations in 2003. The highest concentrations of oxides of nitrogen in Topoľníky 3,03 µg N.m^{-3} represented 34 % of critical level. ***In coincidence with the Annex 1 to the Decree of the Ministry of Environment of the Slovak Republic No 705/2002, limit value for protection of ecosystems is 30 µg NO_x.m^{-3} in calendar year. This limit value was not exceeded at any of the stations. The highest value from all the stations (in Topol'níky) is on the level of one third of the limit value..*** Nitrates in ambient air occurred predominantly in the form of particulates (Tab. 1.1,

Fig. 1.3) in 2003 and at all the stations were lower comparing to 2002. Concentrations of nitric acid (Tab. 1.1) were lower at all the stations comparing to particulate nitrates, however in Topoľníky, Stará Lesná and Liesek were lower one order of magnitude while at Chopok and Starina the level of nitric acid and particulate nitrate was at the same level. Though both these forms of nitrogen are collected on filters and measured separately, CCC EMEP does require reporting of their sum, because their phase division is dependent upon ambient air temperature and humidity. Nitrates contributed to the total mass of particulate matter 5-15 % (Fig. 1.4). Concentration ratio of total nitrates (HNO_3 +NO_3) to NO_2 expressed in nitrogen represented the range 0.2-0.4.

Fig. 1.3 **Monthly mean concentrations in ambient air - 2003**



Particulate matter, heavy metals

Concentrations of particulate matter ranged from 9.9 to 31.7 µg.m^{-3} in 2003 (Tab. 1.1). As compared to 2002 TSP concentration was slightly lower in the Chopok station and slightly higher in the Topoľníky station. At the Starina station the PM_{10} value in 2003 20.7 µg .m^{-3} represented the higher value than the TSP value in 2002. The value PM_{10} 15.8 µg .m^{-3} is almost the same as the previoud year. At the Liesek station the 2002 TSP value 34.3 µg m^{-3} represented only 8-month period, but in 2003 the PM_{10} 24.2µg .m^{-3} represented annual mean. It is necessary to stress that values listed in Table 1.1 for 2003 are as TSP in case of the Chopok and Topoľníky stations and PM_{10} for the Stará Lesná, Liesek and Starina stations. In Table 1.1 and Figures 1.4 and 1.5 are introduced concentrations of heavy metals in regional stations in 2003. As far as the concentrations of the individual metals are concerned, at the Chopok station the increase of lead, manganese, copper, cadmium, nickel and chromium was recorded, but decrease of zinc and arsenic. At the Topoľníky station the slight increase of cadmium and arsenic was found, more distinctive increase of zinc and manganese, while the concentrations of lead, nickel, copper and chromium were at the same level as in 2002. At the Starina station the higher values of lead, manganese, cadmium, zinc and arsenic were measured, the copper concentrations were three times higher and vice versa the concentrations of nickel and chromium were slightly lower. At the Stará Lesná station the 2003 concentrations of lead, manganese, copper, cadmium, nickel and chromium were lower comparing to 2002, however zinc and arsenic showed higher values. At the Liesek station the values of lead, zinc and nickel recorded higher values than in 2002, cadmium and arsenic very similar as in previous year, the lower concentrations were measured at chromium, manganese and copper, at copper about the one order of magnitude. To assess the trend, the most the most outstanding decrease was at lead. This fact has been linked with the gradual lead decrease in petrol since 1982 and the production of lead-free petrol only at the present time. The share of the sum of all measured metals in mass of suspended particles varied within 0.1-0.3 % (Fig. 1.4).

Fig. 1.4 **Composition of PM mass and proportional share of heavy metals - 2003**

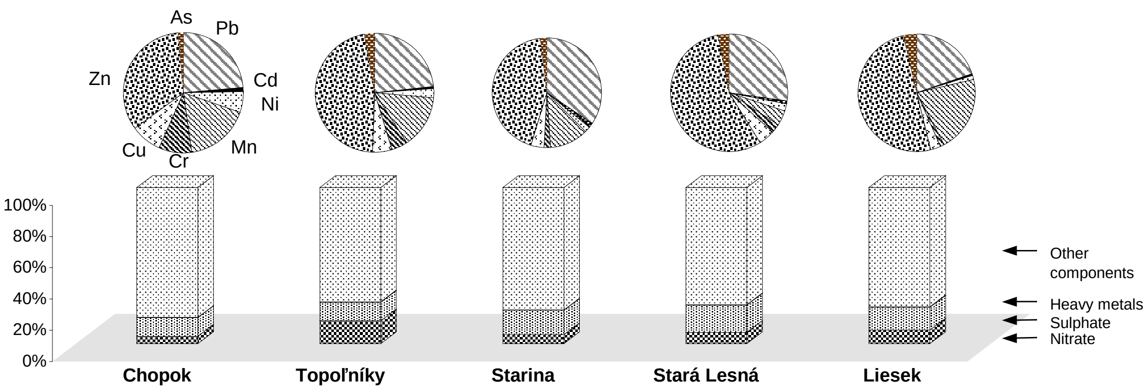
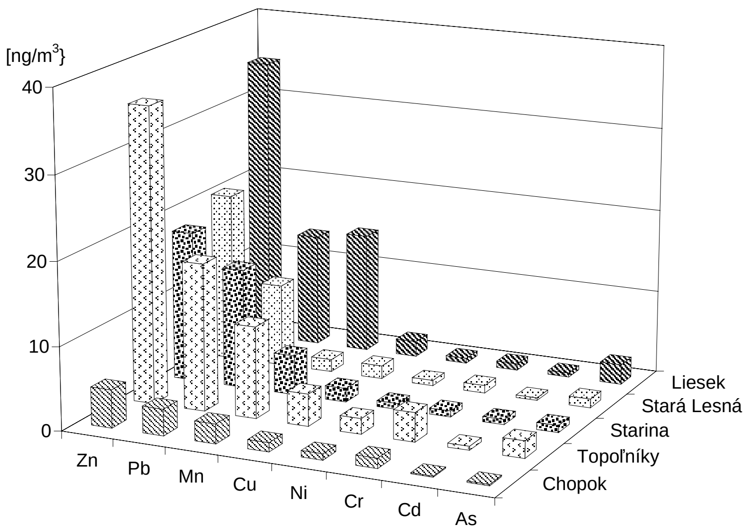


Fig. 1.5 **Heavy metals in ambient air - 2003**

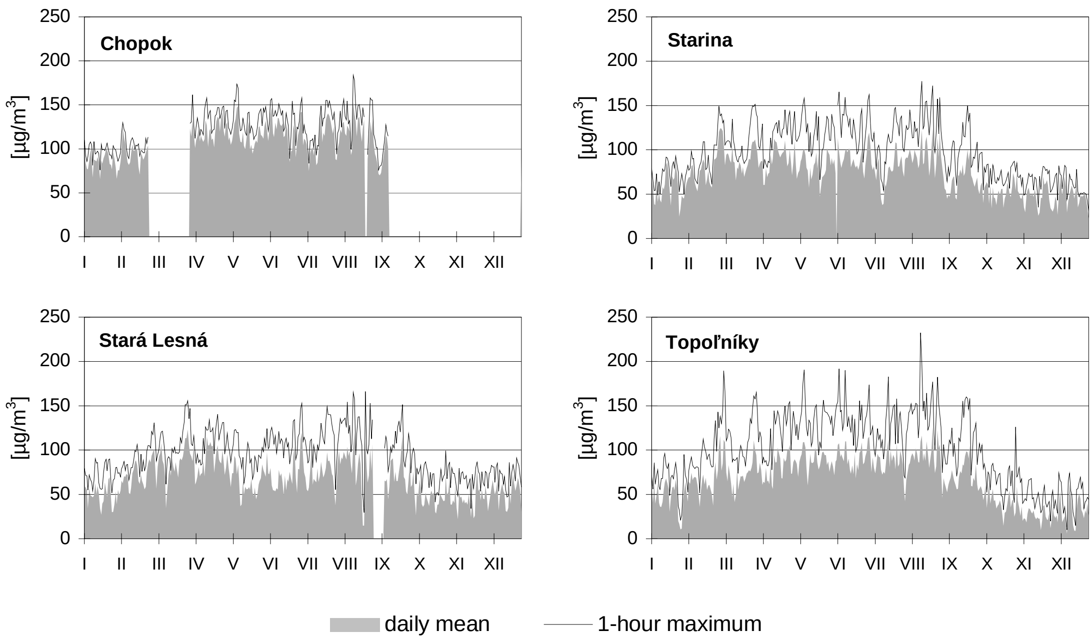


Ozone

In Figures 1.6 the annual course of ground level ozone concentrations at 4 regional stations Chopok, Stará Lesná, Starina and Topoľníky are depicted. The longest time series of ozone measurements is at the Stará Lesná station. The measurements of three other stations began to be carried out later, in 1994. In 2003, the annual average of ozone concentration at the Chopok station reached 109 μg.m^{-3}, at Starina 72 μg.m^{-3}, at Stará Lesná 66 μg.m^{-3} and at Topoľníky 65 μg.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 µg.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 - 2003**



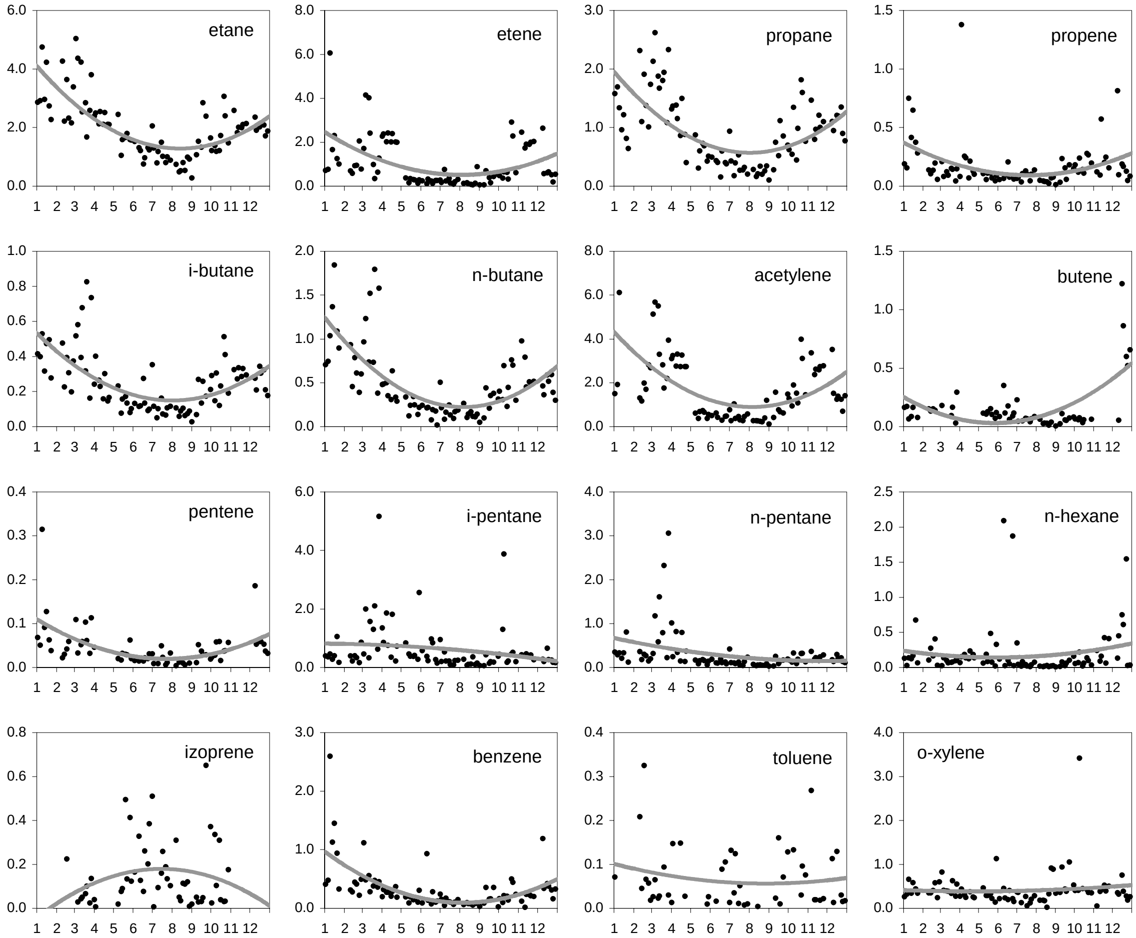
VOCs C_2-C_6

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 small number of European stations, included into the EMEP network with regular sampling of volatile organic compounds. They are then 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). In 2003 the most of the hydrocarbons showed higher values than in 2002, lower were measured at butenes, pentenes, isoprene and benzene. The presence of isoprene, releasing out of the near forest growth was remarkable. Measurements of identical samples carried out in the Slovak Hydrometeorological Institute and in EMEP CCC -NILU showed a high degree of agreement. The measurements carried out within the AMOHA (Accurate Measurements of Hydrocarbons in the Atmosphere) project, organised by NPL (National Physical Laboratory) in the United Kingdom and IFU (Fraunhofer Institute) in Germany, will be used for elaboration of European directive for optimum sampling and assessment of hydrocarbons. The VOC measurements are burdened with a considerable problems last couple of years, concerning not only the operation of a new gas chromatograph, but also the contamination of an indoor working space due to the building and other changes in the Slovak Hydrometeorological Institute.

Tab. 1.2 **Annual mean concentrations of VOC [ppb] in ambient air - Starina - 2003**

etane	etene	propane	propene	i-butane	n-butane	acetylene	butene	pentene	i-pentane	n-pentane	izoprene	n-hexane	benzene	toluene	o-xylene
1.989	1.015	0.929	0.169	0.249	0.484	1.682	0.152	0.044	0.606	0.307	0.149	0.193	0.317	0.067	0.420

Fig. 1.7 **VOCs [ppb] - Starina - 2003**



Precipitation

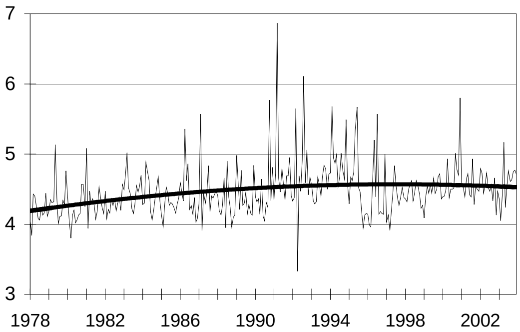
The natural acidity of precipitation in balance with atmospheric carbon dioxide is 5.65 pH. Atmospheric precipitation are considered to be acidic if the sum of anions is higher than the sum of cations and the value of pH is smaller than 5.65. Precipitation contains mainly sulphates, nitrates and chlorides as anions, but in a smaller amount also anions of weak mineral and organic acids. Sulphates contribute to the acidity of precipitation 60-70 %, while nitrates 25-30 %. Share of chlorides, weak mineral and organic acids is small. Chlorides are almost exclusively a part of neutral salts, predominantly of marine origin. Among the cations the dominant is ammonium, ions of calcium, magnesium, sodium and potassium. Ammonium is a special case because in soils it may be oxidised to nitric acid.

Major ions, pH, conductivity

Chemical analysis document a slight increase in acidity in 2003 as compared to 2002 at the most of the stations apart from the Chopok and Topoľníky stations. At the Chopok station the 2003 pH value was the same as the year ago and in Topoľníky the decrease of acidity was recorded. Figure 1.9

illustrates the amount of precipitation in 2003 varying from 368 mm up to 843 mm, depending on the location of the individual stations. Interval of pH values in monthly precipitation ranged between 4.5-5.2 (Tab. 1.3, Fig. 1.9). Annual course of sulphates, nitrates and pH based upon the daily measurements is depicted in Figure 1.10. Time series and trend of pH values within a long-time period indicate clearly the decrease in acidity (Fig. 1.8). Values of pH are in a good coincidence with the pH values according to the EMEP maps.

Fig. 1.8 **pH in precipitation - Chopok**



Stanica	Sulphur wet deposition [g $S.m^{-2}.r^{-1}$]
Chopok	0.94
Topoľníky	0.29
Starina	0.50
Stará Lesná	0.50
Liesek	0.56

Concentrations of dominant sulphates in precipitation varied within the range 0.78-1.12 mg $S.l^{-1}$, the values of sulphates were slightly higher at the most of stations as compared to the previous year with the exception of Topoľníky, where moderate decrease was recorded. However the differences in concentrations were small. Total decrease in sulphates in long-term time series has corresponded to SO_2 emission reduction since 1980. The values of sulphur wet deposition ranged between 0.29 and 0.94 g $S.m^{-2}.year^{-1}$. Critical load of wet deposition has not been indicated yet. USA and Canada indicated the value of wet sulphate deposition 0.7 g $S.m^{-2}.year^{-1}$ as the target load for forests.

The share of nitrate in acidity of precipitation was substantially lesser than those of sulphates and varied within the concentration range 0.46-0.74 mg $N.l^{-1}$. Only the Topoľníky station recorded slight decrease of nitrate concentrations, all other stations showed values slightly higher than in 2002. Concentrations of ammonium were higher at all the regional stations in 2003 as compared to 2002, the highest growth was recorded at the Topoľníky station, while chlorides and all alkali ions were similar in concentrations in 2003 and 2002. The values of conductivity were higher at the most of the stations compared to the previous year lower values were recorded at the Topoľníky and Liesek stations.

Tab. 1.3 **Annual weighted means of monthly precipitation - 2003**

	Precip. mm	pH	Cond. µS/cm	Na mg/l	K mg/l	Mg mg/l	Ca mg/l	Zn µg/l	Mn µg/l	Cd µg/l	Pb µg/l	Cr µg/l	Cu µg/l	Ni µg/l	V µg/l	As µg/l	Cl mg/l	NH_4-N mg/l	NO_3-N mg/l	SO_4-S mg/l
Chopok	843	4.5	28.1	0.26	0.23	0.06	0.34	30.4	3.8	0.62	3.41	0.23	3.03	0.53	0.63	0.32	0.41	0.63	0.74	1.12
Topoľníky	368	5.2	21.1	0.26	0.22	0.11	0.89	5.5	4.9	0.15	1.41	0.14	0.89	0.41	0.35	0.15	0.34	0.63	0.47	0.78
Starina	574	4.6	23.2	0.21	0.26	0.05	0.43	5.8	3.7	0.42	4.36	0.39	1.62	0.44	0.24	0.29	0.30	0.58	0.50	0.88
St. Lesná	532	4.7	22.8	0.24	0.35	0.06	0.44	6.9	4.9	0.51	2.11	0.09	2.08	0.45	0.23	0.21	0.38	0.73	0.46	0.94
Liesek	636	4.8	22.5	0.32	0.39	0.06	0.44	11.7	6.3	0.22	2.16	0.09	1.52	0.99	0.28	0.12	0.54	0.64	0.51	0.88

Fig. 1.9 **Monthly precipitation - 2003**

Ch - Chopok, To - Topoľníky, St - Starina, SL - Stará Lesná, Li - Liesek

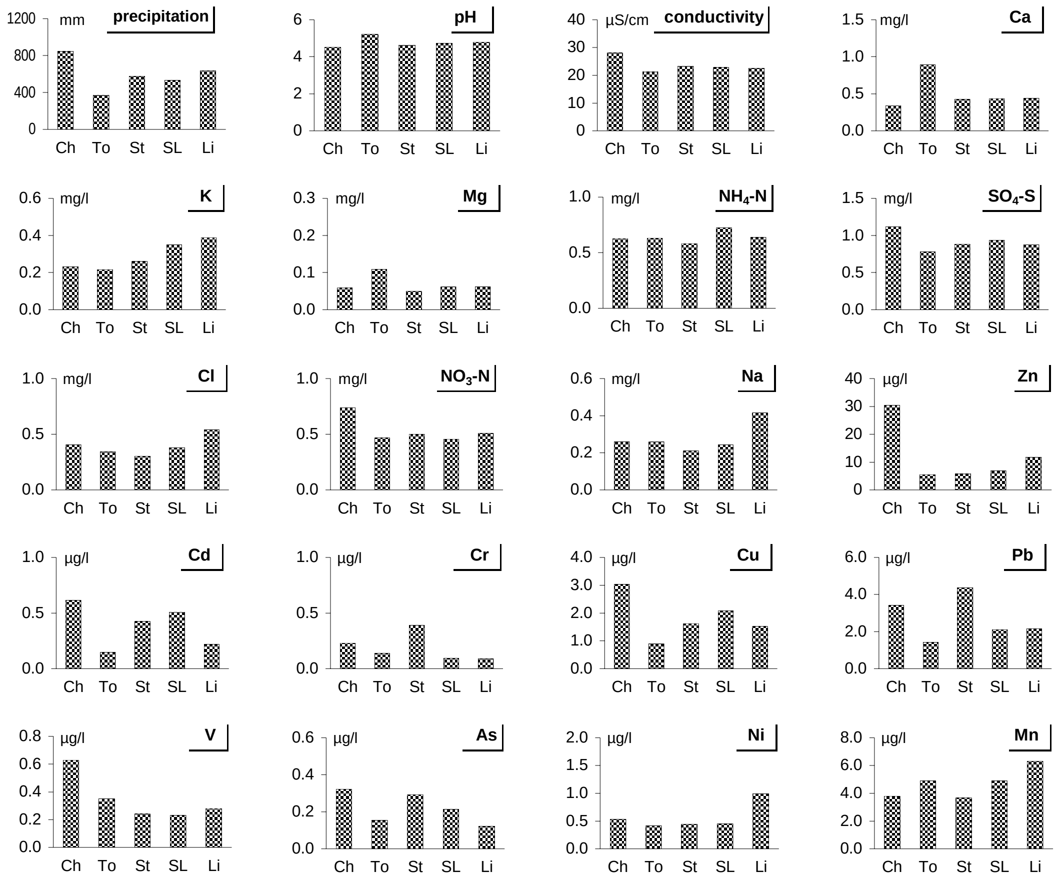
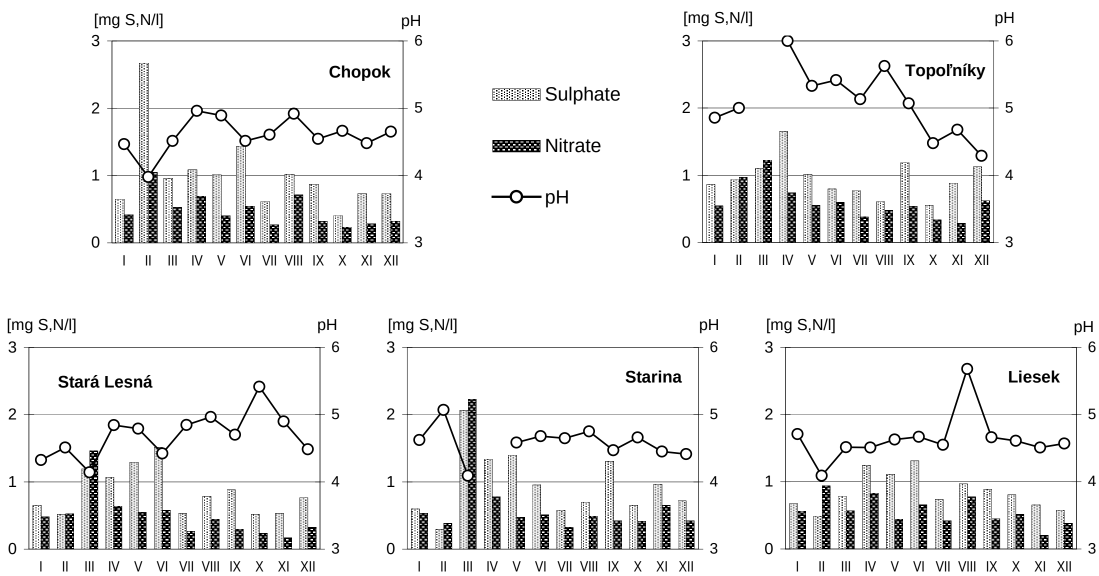


Fig. 1.10 **Daily precipitation - 2003**



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 2000, lead and cadmium started to be determined in precipitation. Since 2002 aluminium and iron were took out from the measurement programme and chromium, copper, nickel, arsenic and vanadium were implemented into the programme. Within the last year the most of the regional stations showed decrease in zinc concentrations, concentrations of manganese were similar as the year ago. Concentrations of lead were lower only at the Chopok station comparing to the previous year, at the Topoľníky station the lead concentration was almost identical in 2003 and 2002 and the three other stations recorded higher concentrations. Cadmium was higher at all the stations. For the time being, lead and cadmium as the metals of first priority is not possible to assess more complex due to the short time period, similar as the other metals introduced in the text above, measured since 2002.However it is expected that the concentrations of metals in precipitation will copy the downward trends in concentrations of metals in atmospheric aerosol.

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

LOCAL AIR POLLUTION

2

2.1 LOCAL AIR POLLUTION

Since 1st January 2003 the particular decree No 705 about Air Quality has been put into force in the Clean Air Act No 478/2002 Coll. The Clean Air Act has fully transposed the EU Air Quality legislation in the field of air quality assessment and management.

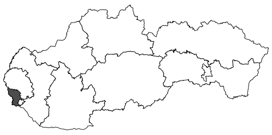
Decree No 705 defines:

- limit values and dates by which limit values are to be met, the margin of tolerance, averaging period, the number of times it can be exceeded, target values and long-term objectives for ozone, requirements for their monitoring, assessment, sampling, measurement and others technical specifications,
- upper and lower assessment thresholds for the main pollutants, requirements for the location of sampling sites, criterion for minimal numbers of sampling points for permanent measurements of air pollutants, QA/QC objectives, goals of data processing and air quality assessment, reference methods for particular pollutants, calibration of analysers, and the requirements for measurements of ozone precursors,
- agglomeration and zones (Annex 8, Decree No. 705),
- details about information and data, presented in programs for air quality improvement,
- limit values for information and alert thresholds for smog warning and regulation systems, mandatory texts for the beginning and finishing smog levels and details about information and data which has to be available for the public when thresholds are exceeded.
- limit values and dates by which limit values are to be met, margin of tolerance, averaging period, number of allowed exceedances for main pollutants (tab. 2.4),
- upper and lower assessment thresholds for main pollutants (tab.2.5),
- in cases when the air pollution level is below the upper assessment threshold combined measurements with model results are allowed,
- in cases when the air pollution level is below the lower assessment threshold, for air quality assessment it is allowed to apply model results or expertise judgment,
- requirements for the location of sampling sites for air pollution measurements (Annex No. 3, Decree No. 705),
- criterion for the specification of minimal number of sampling sites for permanent measurements (Annex No. 4, Decree No. 705),
- objectives of QA/QC data level and goals of processing data and air quality assessment (Annex 5, Decree 705),
- reference methods of measurements and analyses of pollutants, calibration of analysers (Annex 6, Decree 705),
- requirements for measurements of ozone precursors (Annex 7, Decree 705),
- details about information and data which has to be involved in programs for air quality improvement. (Annex 9, Decree 705),
- information, alert thresholds and limit values for warning purposes for signals ”Information”, “Regulation” and ”Warning” (Annex No. 10, Decree No. 705),
- mandatory texts of beginning and finishing smog levels “Information”, “Regulation” and “Warning” (Annex No. 11, Decree No. 705),
- information and data which has to be available to the public when thresholds are exceeded (Annex No. 12, Decree No. 705).

The SHMI 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 which made it possible to evaluate changes depending on time and on the extremes of the short-run concentrations. In the course of the last ten years the air quality monitoring network has kept developing. The number of the monitoring stations has changed from year to year and in the last three years the measurements of the particulate matter (PM) were gradually substituted by the measurements of the particulate matter concentrations with the aerodynamic diameter less than 10 μm (PM_{10}). In 2003, 28 stations were deployed on the territory of the SR, of these 26 had monitored the level of pollution caused by the basic pollutants (SO_2, NOx, NO_2, CO, O_3 and PM_{10}), at two others (Koliba and Podhradová) only ground level concentrations of ozone were monitored. The air pollution by ground-level ozone was monitored on 21 localities on the whole. At one station, beyond these pollutants, also the level of pollution by H_2S was monitored. In the year 2003 measurements of benzene have started at 4 stations. In accordance to the Clean Air Act the territory of the Slovak republic was divided into 8 zones and 2 agglomerations. 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.

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



AGGLOMERATION - BRATISLAVA

AREA: 368 km^2 POPULATION: 452 053

Characterization of area

Bratislava

Bratislava spreads out over an area of 370 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 situated favourably 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.

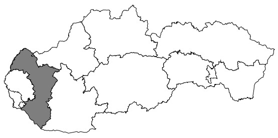
Location of stations

Bratislava - Koliba
The station is located in the grounds of the Slovak Hydrometeorological Institute, 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. From the pollutants only surface ozone is measured, because this is not a typical urban background station.

Bratislava - Mamateyova
The station is located 4 km to the south, out of the city centre, in a prefab housing estate built-up area, very close to a moderately busy road. Among the major sources of air pollution belong traffic, power sources and the petrochemical complex, Slovnaft, Ltd. The last mentioned contributes to city air pollution mainly under an east wind direction

Bratislava - Trnavské mýto
The station is situated near to a busy crossroad Šancová street - Vajnorská street. As far as traffic emissions are concerned, this location is an extremely polluted one.

Bratislava - Kamenné námestie
The station is situated in the city centre, close to the TESCO supermarket, in an area of heavy car traffic. Its position represents the old part of the city. The location is polluted by major sources, mainly Slovnaft, Ltd., with a south-east wind direction and by transport.



ZONE - TRNAVA REGION

AREA: 4 148 km^2 POPULATION: 547 173

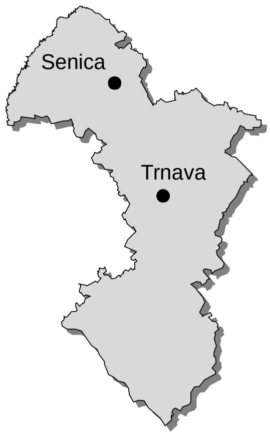
Characterization of area

Senica

The town itself is located on the southern slopes of Myjava hills in the altitude of 208 m. From its 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 does intervene. From the standpoint of emission dispersion and transport, 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 (state enterprise Slovenský hodváb - Slovak Silk), 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. Since 1996 Trnava has became a regional centre with 70 000 inhabitants. The prevailing wind is from the north-east, the second highest wind frequency is from south-east. The location is well ventilated with small occurrence of calm situations..



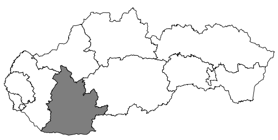
Location of stations

Senica

Station is located very close to the bus stop, near main route in the Kúty - Trnava - Hodonín direction.

Trnava

Station is located at the Dohnány and Kolárova street crossroads, approximately 2 m from the curbside in an area highly polluted by traffic emissions.



ZONE - NITRA REGION

AREA: 6 343 km^2 POPULATION: 718 358

Characterization of area

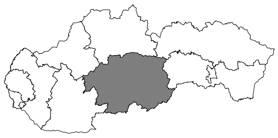
Nitra

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 downs. Prevailing wind is from north-east and south-west directions with a small occurrence of calm situations.

Location of stations

Nitra

Station is located very close to the crossroad of Štúrova street and Štefánikova trieda heavy polluted by traffic.



ZONE - BANSKÁ BYSTRICA REGION

AREA: 9 455 km^2 POPULATION: 664 072

Characterization of area

Banská Bystrica

The town is located in the Bystrické valley, which is by the northern part of the Zvolenská basin surrounded by the Starohorské hills to the north, by the Horehronské valley to the north-east and by the Kremnické hills to the south-east. According to the climate classification this location belongs within Slovakia to the moderately warm, moist region with a cool winter. The annual average temperature is 8°C. Prevailing wind is from the north and north-east, an average speed 2.1 m.s^{-1} and approximately 33% occurrence of inversion in valley positions. Air pollution is affected by the cement and wood processing industries releasing emissions of suspended particles, but also by a large number of local heating sources. Heavy traffic does contribute to the high level of air pollution in the town centre, as well.

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 Kremnické hills in the west up to the north, and by the Štiavnické 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. The area is polluted mainly by chemical production in Hnúšťa and the Magnesite plant in Hačov.

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, only 2.5 m.s^{-1}. The frequent occurrence of surface inversions during the night is due to the broken mountain terrain. Two massives, 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

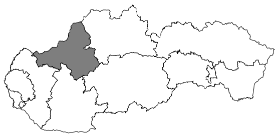
Banská Bystrica - Nám. slobody

The station is located in the city centre, 100 m from a local busy road junction, a distance of 50 m from one and two storey housing area. The station is located in the valley part of the city with poor dispersion conditions.

Žiar nad Hronom
The station is placed on a boundary-line between 4-storey housing and an open space, passing down, out of the station. Meteorological station is next of the monitoring station.

Hnúšťa
The station is situated on the north edge of the town, approximately 100 m far from state road No 531, in an open area.

Jelšava
The station is situated close to the historical town centre, approximately 50 m from the main road. It is surrounded by a low serial built up area open to the dominant pollution source of this location, the Slovakian magnesite plants. The station is situated in a valley position of slight windiness (1.9 $m.s^{-1}$) and increased inversion occurrence.



ZONE - TRENČÍN REGION

AREA: 4 502 km^2 POPULATION: 608 990

Characterization of area

Horná Nitra

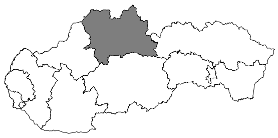
This area includes a part of the Horná Nitra basin from Prievidza to Bystričany. The direction of wind is affected considerably by the geography and orientation of the basin. The most frequent winds occur there from the north and north-east directions. A low value of annual wind speed 2.3 $m.s^{-1}$ does refer to the unfavorable 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 do contribute as well. The low quality of fuel sources for power generation contributes to air pollution in this area to a greater extent. The coal in use contains apart from sulphur also arsenic.

Location of stations

Prievidza
The station is located in the town centre, close to 4-storey residential houses and buildings of similar height. Near the station, passes slight traffic.

Handlová
The station is located in a predominantly one-family house built-up area. Among the major emission sources are power sources and industry.

Bystričany
The station is situated in the zone of the water reservoir substation, in an area planted out with the fruit-trees. The Nováky power plant (ENO) is of 8 km from the monitoring station.



ZONE - ŽILINA REGION

ROZLOHA: 6 788 km^2 POPULÁCIA: 682 983

Characterization of area

Ružomberok

The location of the city comprises the area of the western part of the Liptovská basin, on the confluence of rivers Váh, Revúca and Likavka. The Veľká Fatra mountains constitute the border in the west, the Chočské mountains in the north and the Low Tatras in the south. From a climate point of view this location is characterised as cooler, with an annual average temperature 7.1°C. The most frequent wind blows from the west, at an average speed 1.6 m.s^{-1}. Air pollution by classical pollutants is due to the operation of heating plant technology. The North Slovakian pulp and paper processing plants are the largest industrial source of air pollution. A considerable share of this pollution is caused by small local sources, as well. A mixture of predominantly organic-sulphur compounds, leaking episodically from the technology of pulp production causes specific air pollution.

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 operations 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 inversions, average wind speed 2.8 m.s^{-1} and high relative humidity contribute to higher concentrations of oxides of nitrogen, oxides of sulphur and suspended particulate matter. Heavy engineering, local heating plants of the Central Slovakian power plants and car transport are the largest emitters of pollutants.

Location of stations

Žilina - Veľká Okružná

The station is located in the town centre in a moderately dense built-up area of 1-5-storey buildings, 10 m from a busy road.

Žilina - Vlčince

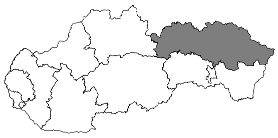
The station is situated in the north-eastern part of the town, in the Vlčince housing estate, about 0.7-1.5 km from industrial area. The position is open in all directions and representative for wind speed and wind direction measurements.

Ružomberok – Riadok

The station is located in the garden of an elementary school, close to a low traffic route way. In the surrounding built-up area low family housing prevails. A major pollution source the Ružomberok Slovak pulp and paper processing plants is situated north-east of the monitoring station.

Martin

The station is located in the area of an elementary school in the town centre, very close to the pedestrian zone and approximately 200 m from a busy road junction. It is surrounded by 2-storey buildings from one side and by school from the other sides.



ZONE - PREŠOV REGION

AREA: 8 993 km^2 POPULATION: 763 911

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, to the north out of the town, protects the town from the invasion of cool Arctic air. The town lies on the slope facing to the south and thus cool air runoff is provided, which settles under the calm at the bottom of the basin. In the course of a year the northern air circulation prevails and is also the strongest. The next highest air circulation belongs to the south direction. Good ventilation of the town is provided by the widening of the valley itself at the confluence of the Sečkov and Torysa. The main cause of air pollution in town is boiler rooms, mainly 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 varies. The occurrence of calm is relatively high. The local chemical industry presents the main air pollution source in this area.

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 valley. The main air pollution source in the area is the local wood processing industry and local heating systems.

Location of stations

Prešov - Sídlisko III

The station is situated in an open area, near a supermarket, at the boundary-line of a new housing estate and the north-western part of the historical town centre. Nearby, approximately 50 m away, is the main road to Levoča. The town boiler room using solid fuel is about 1000 m north from the station.

Prešov - Solivar

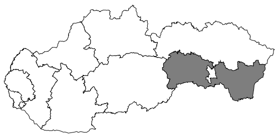
The station is located in the south-eastern part of the town in an open zone of low density buildings in the vicinity of the Solivarská and General Petrov cross-road.

Humenné

The station is located in the southern part of the town centre at the border of a pedestrian zone with minimum car transport (parking 50-100 m from AMS). The surrounding buildings are connected to the central heating. The most important air pollution source - Chemes Humenné is located approximately 2 km west from AMS.

Vranov nad Topľou

The station is situated in the town centre, in front of the Civic house, approximately 2 km north-west out from the Bukóza Vranov plant. Alongside the main road, at a distance of about 30 m from the station is the surrounding built-up area, represented by 3 and 4-storey residential houses.



ZONE - KOŠICE REGION

AREA: 6 508 km^2 POPULATION: 512 934

Characterization of area

Krompachy

The station is located in the valley of the Slovinský potok, on the western edge of the town, away from the busy roads, 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 inversion.

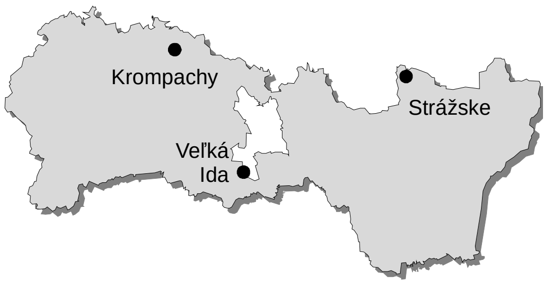
Strážske

Strážske is situated in an open area, on the western edge of town, on a housing estate with a local boiler room, approximately 1km east -south-east out from the Chemko Strážske plant. In the vicinity of the station there are no busy roads.

Košice - Veľká Ida

The station is located in the south-eastern part of the Veľká Ida municipality, near the East Slovak iron works (VSŽ), in a relatively open area. The station has been purchased by VSŽ in order to control the effect of this works on ambient air quality in the municipality.

Location of stations



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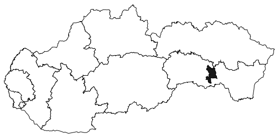


AGGLOMERATION - KOŠICE

AREA: 245 km^2 POPULATION: 240 915

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 distinguished 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, in the centre of the Osloboditeľov square, between the car park and symbolic cemetery. The inner circle roads, at a distance of about 15 m north and 50 m south from the station, go in an east-west direction. There is, in the vicinity of the station, no significant pollution source.

Košice - Strojárenská

This station is in the northern part of the historical city. It is located next to the town hall, in a densely built-up part of the city, about 50 m from the surrounding buildings. Approximately 15 m distant is the inner circle road. Under the south wind, the location is exposed to the exhaust gases coming from traffic in Moyzesova street.

Košice - Podhradová

The station is located in the grounds of the Slovak Hydrometeorological Institute, in a relatively open area, at the northern edge of the Podhradová housing estate and the city itself. From 2000, the station has monitored only surface ozone.

Tab. 2.1 **Geographical co-ordinates of monitoring stations and list of pollutants monitored in 2003**

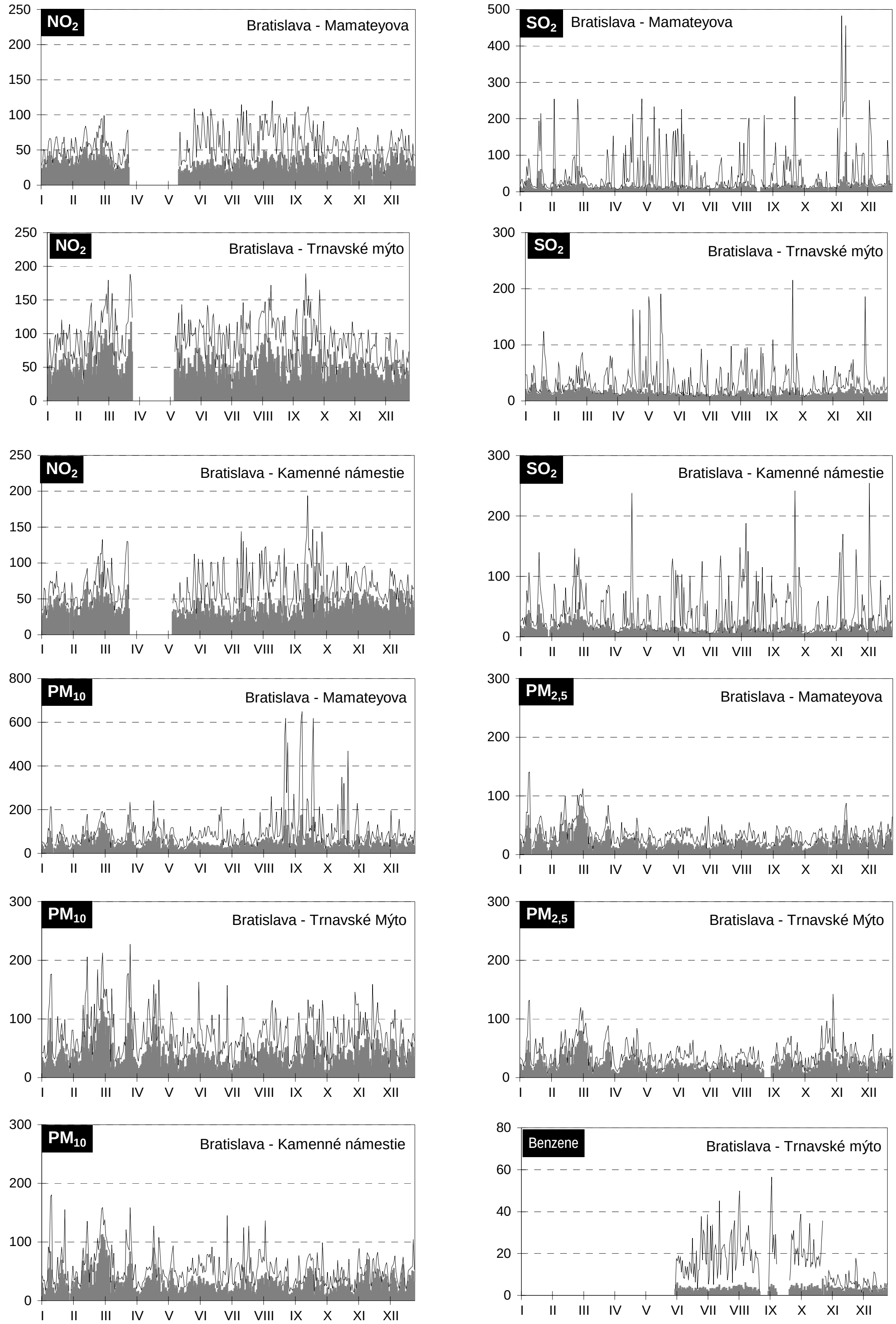
AGLOMERATION/ zone		Longitude	Latitude	Altitude [m]	SO_2	NO_2	PM_{10}	$PM_{2,5}$	O_3	CO	H_2S	Ben-zene	Pb
BRATISLAVA	Bratislava, Kamenné námestie	17°07'00"	48°08'45"	139	*	*	*						*
	Bratislava, Koliba	17°07'09"	48°10'20"	287					*				*
	Bratislava, Mamateyova	17°08'05"	48°07'43"	136	*	*	*	*	*	*			*
	Bratislava, Trnavské mýto	17°07'45"	48°09'32"	136	*	*	*	*		*		*	*
KOŠICE	Košice, Štúrova	21°15'47"	48°43'01"	199	*	*	*			*		*	
	Košice, Strojárenská	21°15'17"	48°43'37"	200	*	*	*	*		*			*
	Košice, Podhradová	21°14'45"	48°45'17"	248					*				
Trnava region	Trnava	17°35'06"	48°40'02"	251	*	*	*			*		*	*
	Senica	17°21' 48"	48°40'50"	212	*	*	*						*
Nitra region	Nitra	18°05'08"	48°18'28"	142	*	*	*			*		*	*
Trenčín region	Bystričany	18°31'00"	48°40'02"	251	*	*	*						
	Handlová	18°45'32"	48°44'00"	437	*	*	*						
	Prievidza	18°37'30"	48°45'11"	269	*	*	*	*	*				*
	Trenčín	18°02 '00"	48°53 '20"	210									*
Banská Bystrica region	Banská Bystrica, Nám.slobody	19°09'30"	48°44'12"	343	*	*	*		*	*			*
	Jelšava	20°14'18"	48°37'48"	255	*	*	*		*				*
	Hnúšťa	19°57'12"	48°35'04"	315	*	*	*		*				
	Žiar nad Hronom	18°51'07"	48°35'17"	263	*	*	*		*	*			*
Žilina region	Martin	18°55'26"	49°04'03"	396	*	*	*	*	*				*
	Ružomberok, Riadok	19°18'27"	49°04'32"	485	*	*	*		*		*		*
	Žilina, Veľká Okružná	18°44'18"	49°13'12"	390	*	*	*	*		*			*
	Žilina, Vlčince	18°46'20"	49°12'40"	368	*	*	*		*				
Košice region	Krompachy	20°52'24"	48°55'04"	385	*	*	*						*
	Strážske	21°49'48"	48°52'21"	134	*	*	*						
	Veľká Ida	21°10'34"	48°35'31"	207	*	*	*		*	*			*
Prešov region	Humenné	21°53'08"	48°54'35"	160	*	*	*		*				*
	Prešov, Sídlisko III.	21°13'54"	49°00'03"	245	*	*	*						
	Prešov, Solivar	21°15'59"	48°58'43"	255	*	*	*		*	*			*
	Vranov nad Topľou	21°41'26"	48°53'12"	128	*	*	*						*

Tab. 2.2 **Technical parameters of measuring instruments**

Pollutant measured	Principle of measurement	Range of measurement [mg/m^3]	Detection limit [µg/m^3]	Producer	Type
SO_2	UV - Fluorescence	0...2,6	2,6	TEI	Model 43C
	UV - Fluorescence	0...2,6	1,3	TELEDYNE Monitor Labs	ML 9850
	UV - Fluorescence	0...2,6	1,3	TELEDYNE API	Model 100A
H_2S	UV - Fluorescence	0...1,3	1,3	TELEDYNE Monitor Labs	ML9850 + ML 8770
NO, NO_2, NO_x	Chemiluminescence	0...1,9	0,9	TEI	Model 42C
	Chemiluminescence	0...1,9	< 0,9	TELEDYNE Monitor Labs	ML 9841
	Chemiluminescence	0...1,9	< 0,9	TELEDYNE Monitor Europe	ML 9841B
	Chemiluminescence	0...1,9	< 0,9	TELEDYNE API	Model 200A
CO	NDIR GFC	0...23,3	< 58,3	TEI	Model 48C
	NDIR GFC	0...23,3	< 11,7	TELEDYNE Monitor Labs	ML 9830
	NDIR GFC	0...23,3	< 11,7	TELEDYNE API	Model 300
Benzene	GC	0...0,162	0,3	Syntech Spectras	GC 855, GC 955
O_3	UV - Photometry	0...1	2	TEI	Model 49C
	UV - Photometry	0...1	2	TELEDYNE Monitor Labs	ML 9810,9811
	UV - Photometry	0...1	2	Horiba	APOA 360
	UV - Photometry	0...1	2	TELEDYNE API	Model 400
PM_{10} $PM_{2,5}$	Beta - absorbtion	0....1000	10	VEREWA	F 701
	Beta - absorbtion	0....1000	3	Thermo ESM Andersen	FH 62 I - R
	TEOM	0....5000	1	Rupprecht & Patashnick	1400, 1400A, 1400AB

All concentrations of measured pollutants are expressed in µg.m^{-3} at standard conditions (298°K and 101.3 kPa)

Fig. 2.1 **Concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$, CO and benzene – Agglomeration Bratislava – 2003**



concentrations:
NO_2, SO_2, PM_{10}, $PM_{2,5}$, benzene – daily average [µg/m^3], CO - daily maximum of 8 h means [mg/m^3]

— 1 h maximum concentration of NO_2, SO_2, PM_{10}, $PM_{2,5}$, benzene [µg/m^3]

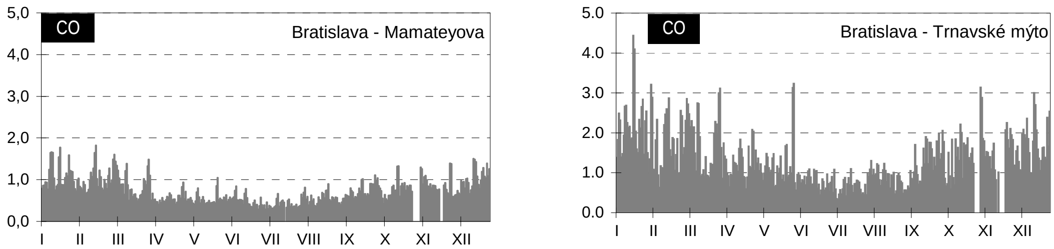


Fig. 2.2 **Concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$ and CO – Aglomeration Košice - 2003**

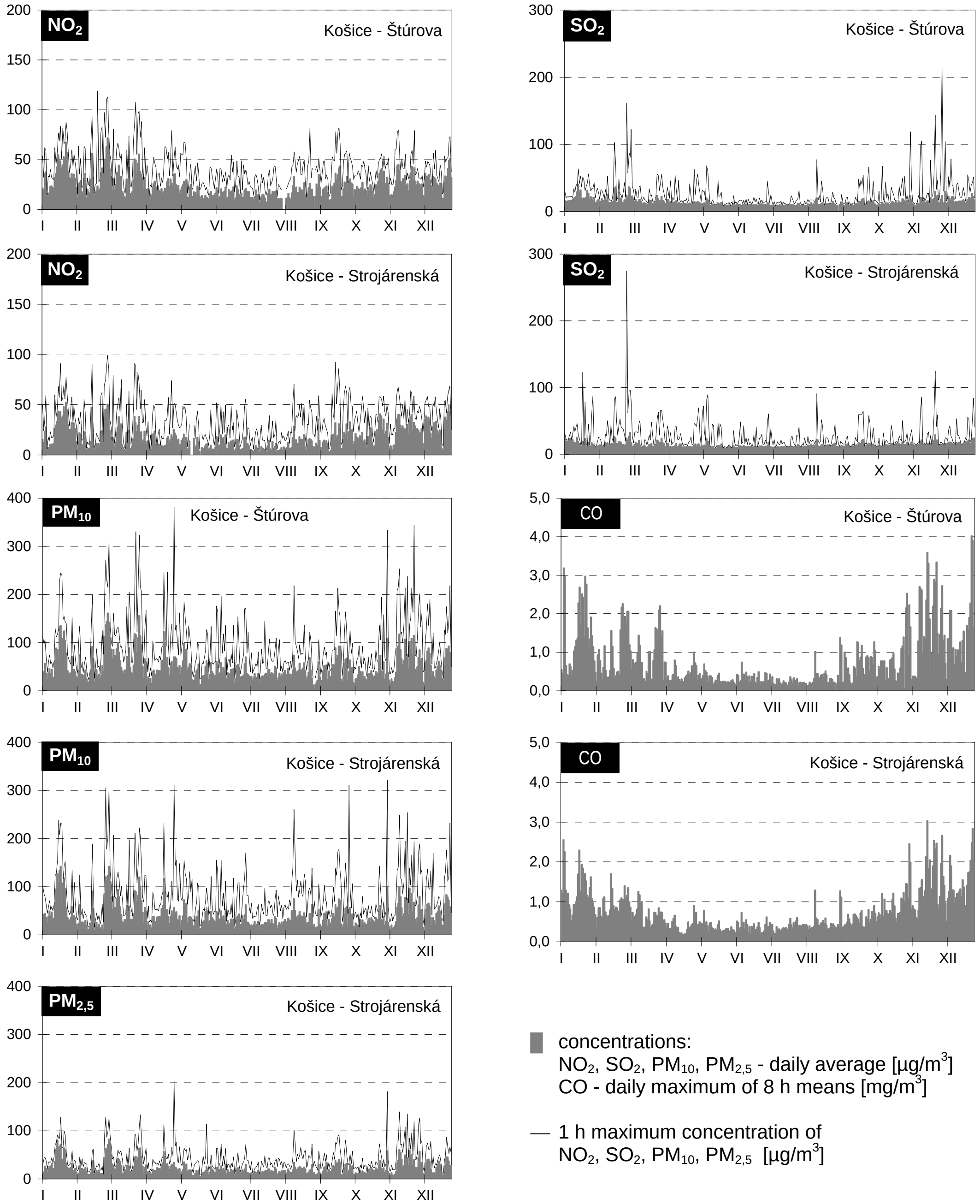


Fig. 2.3 **Concentrations of NO_2, SO_2, PM_{10}, CO and benzene – zone Trnava region - 2003**

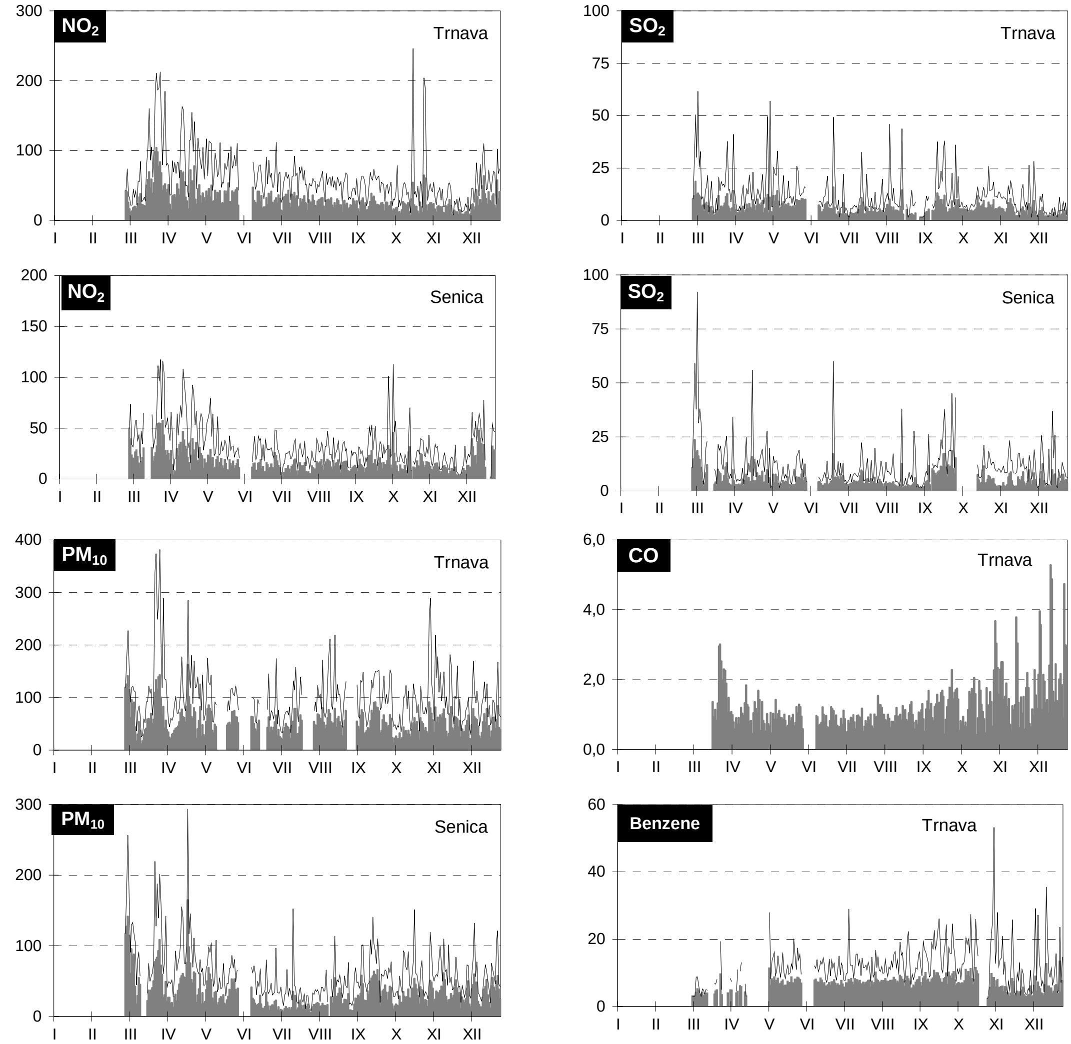
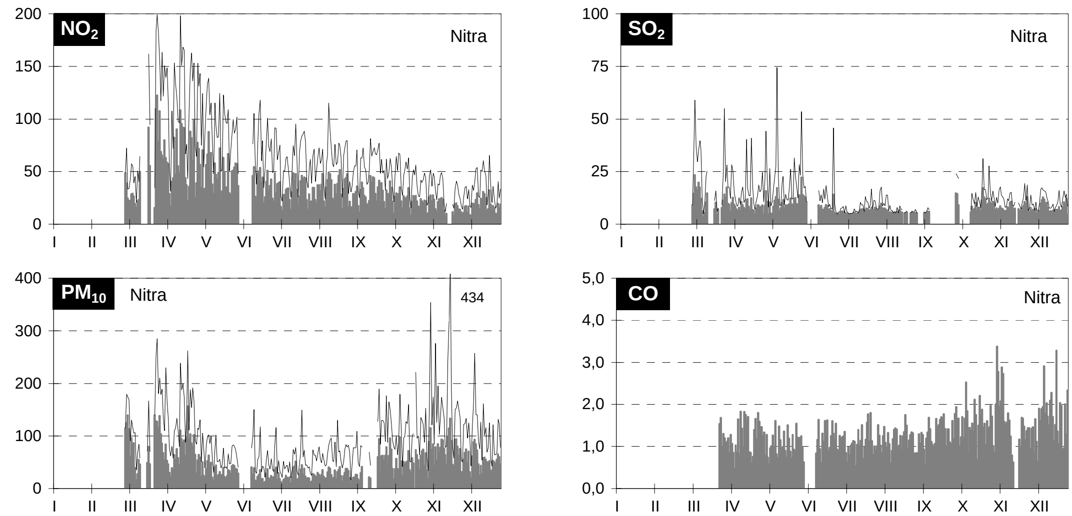
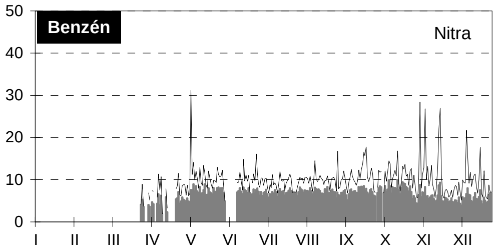


Fig. 2.4 **Concentrations of NO_2, SO_2, PM_{10}, CO and benzene – zone Nitra region - 2003**





concentrations:
NO_2, SO_2, PM_{10}, $PM_{2,5}$, benzene - daily average [µg/m^3]
CO - daily maximum of 8 h means [mg/m^3]

— 1 h maximum concentration
NO_2, SO_2, PM_{10}, $PM_{2,5}$, benzene [µg/m^3]

Fig. 2.5 **Concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$ and CO – zone Trenčín region - 2003**

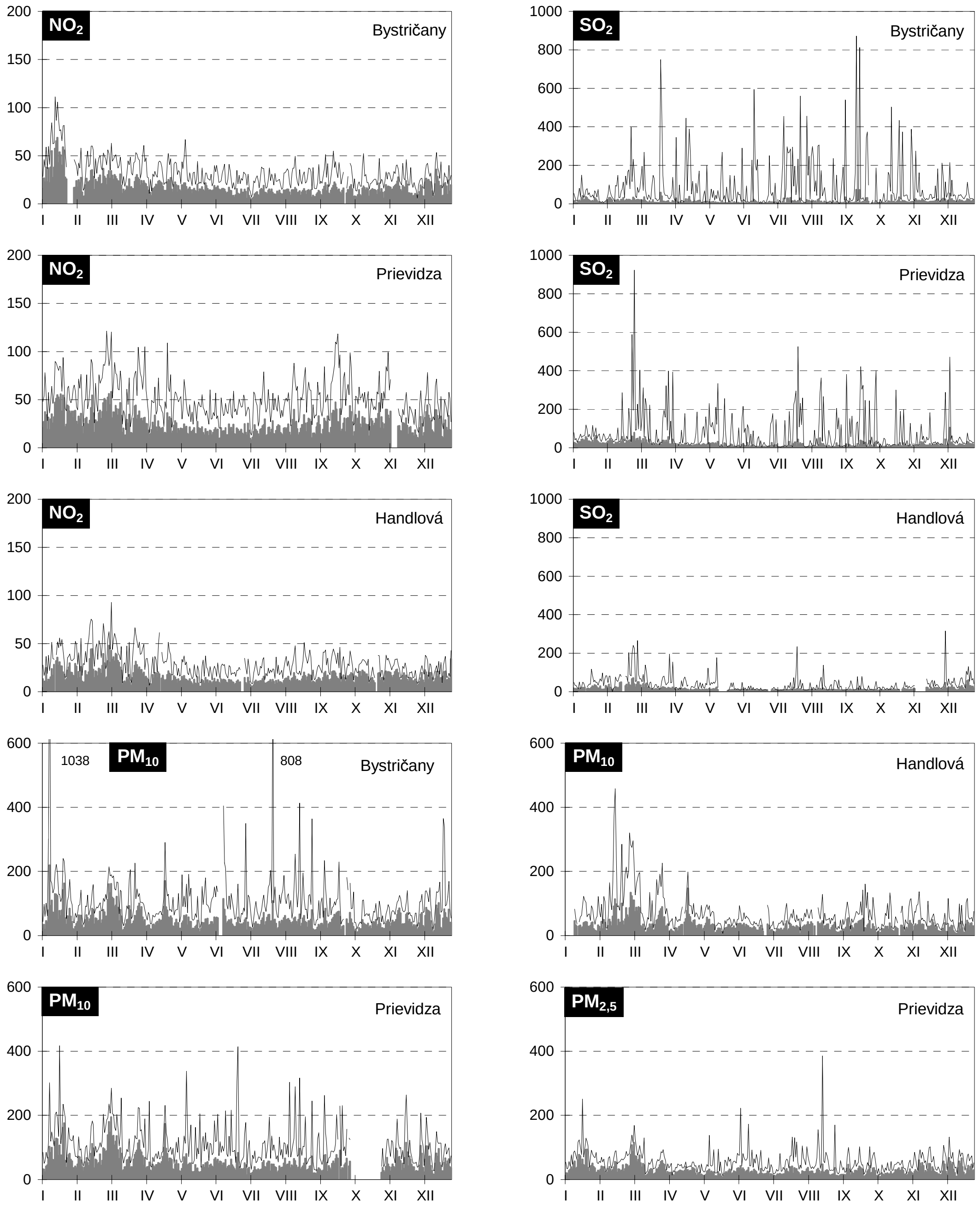
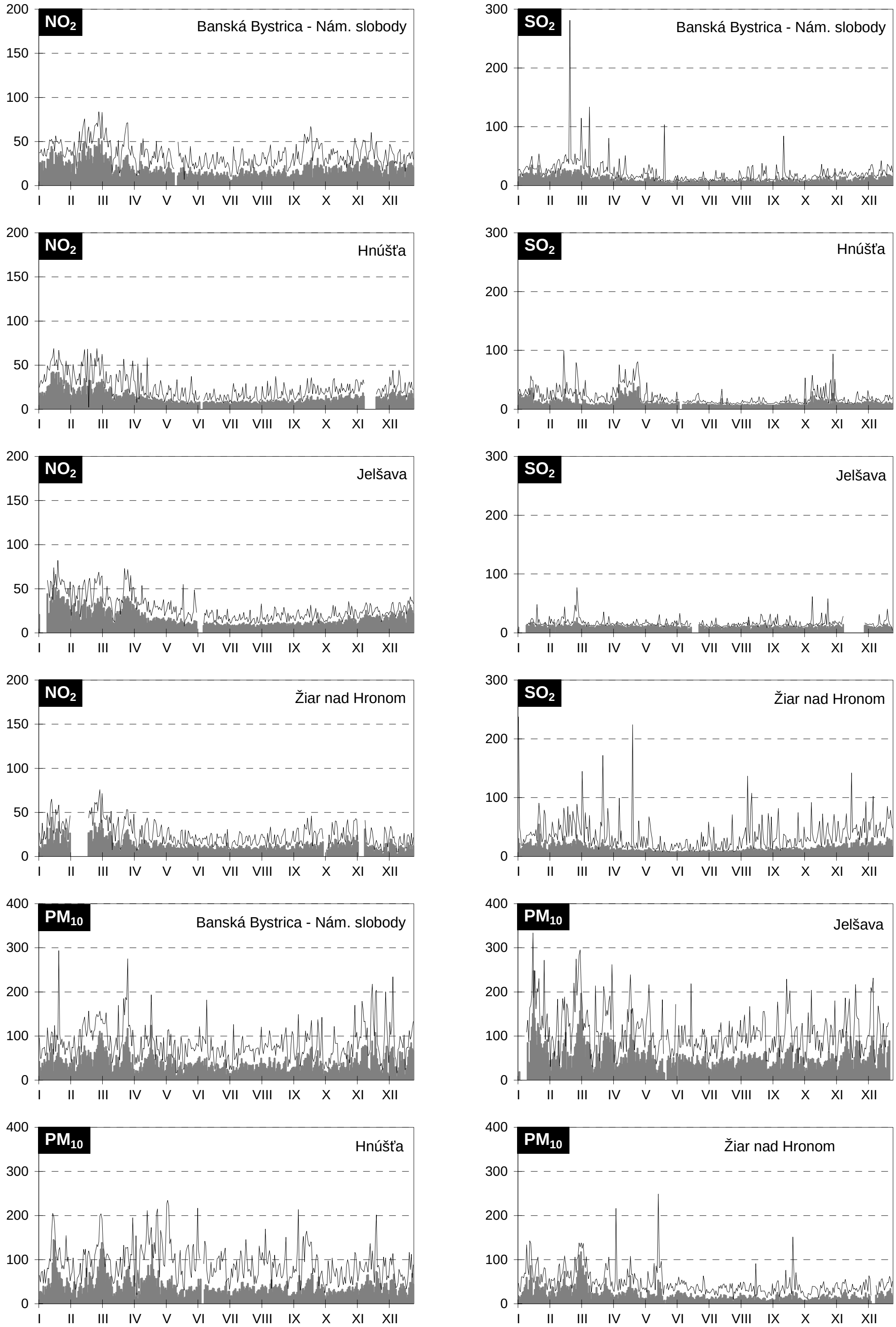
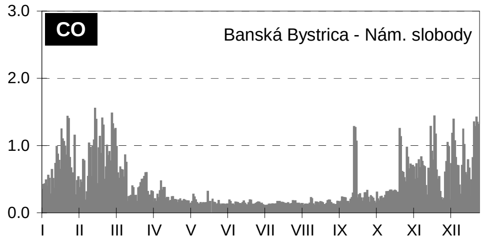


Fig. 2.6 **Concentrations of NO_2, SO_2, PM_{10} and CO – zone Banská Bystrica region – 2003**



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

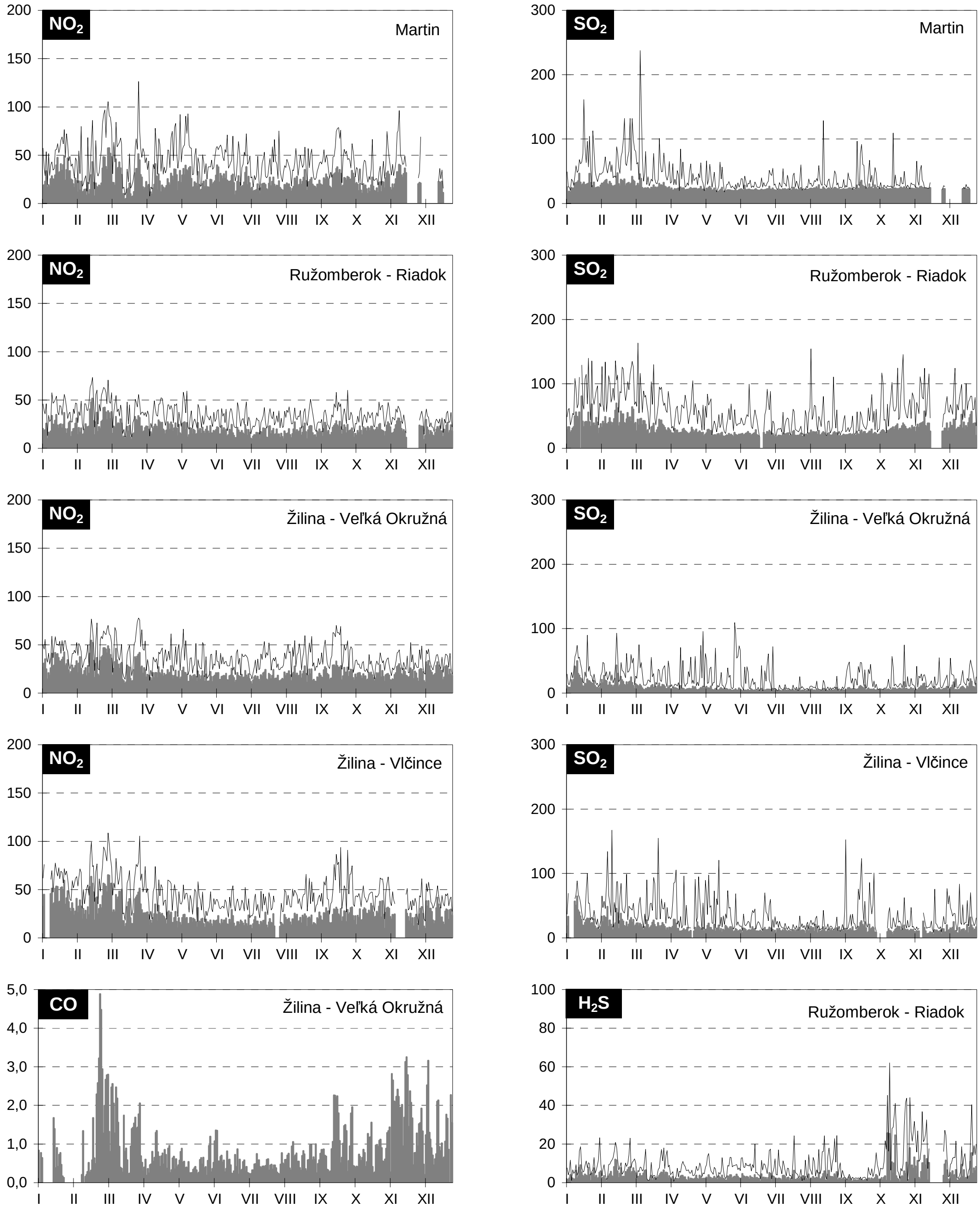
— 1 h maximum concentration of NO_2, SO_2, PM_{10}, $PM_{2,5}$ [µg/m^3]



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 concentration of
NO_2, SO_2, PM_{10}, benzene [µg/m^3]

Fig. 2.7 **Concentrations of NO_2, SO_2, PM_{10}, $PM_{2,5}$, CO and H_2S – zone Žilina region – 2003**



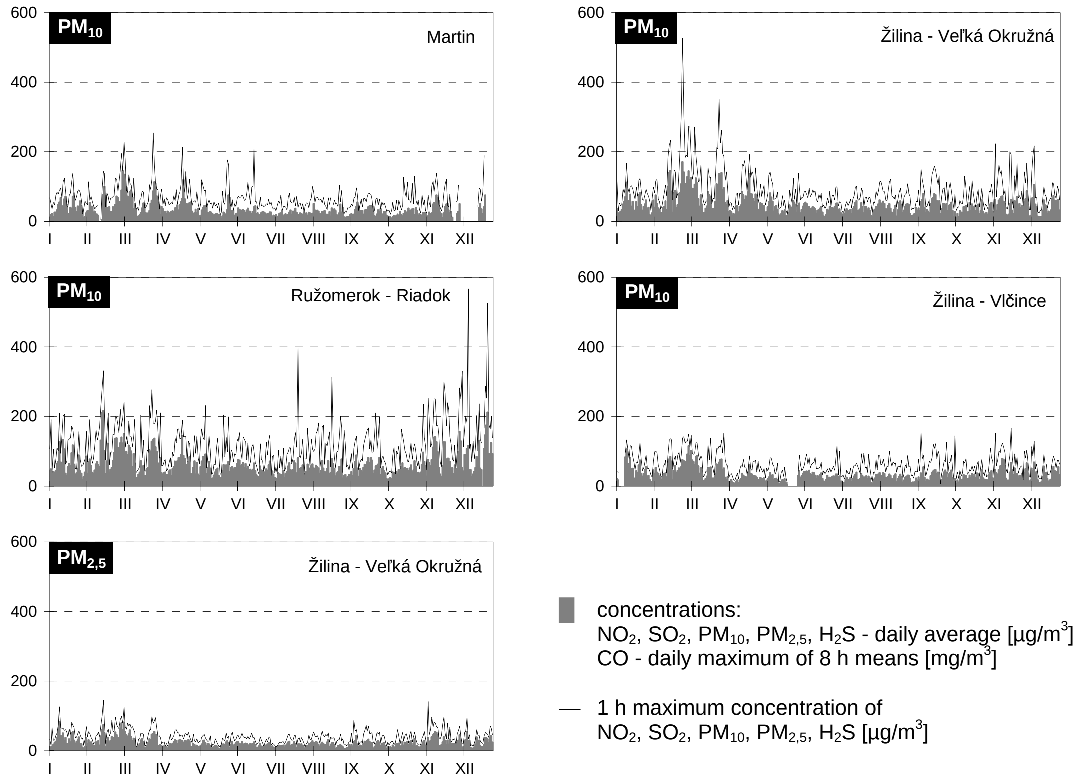
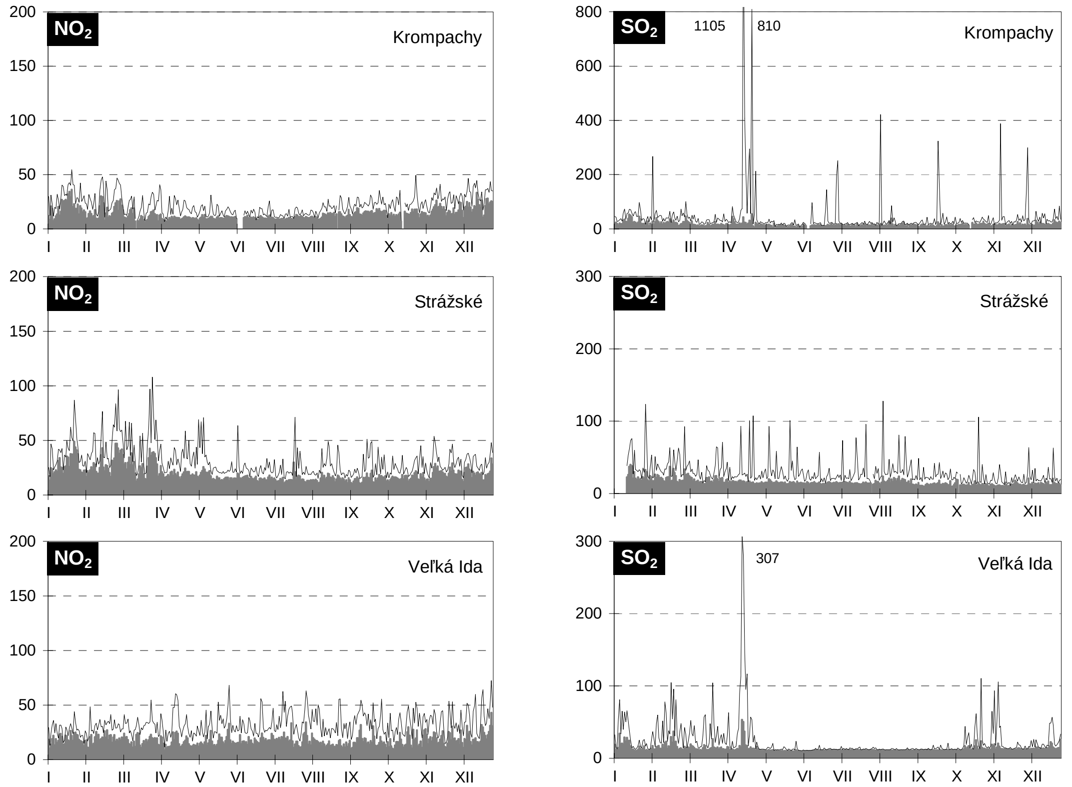


Fig. 2.8 **Concentrations of NO_2, SO_2 and PM_{10} – zone Košice region – 2003**



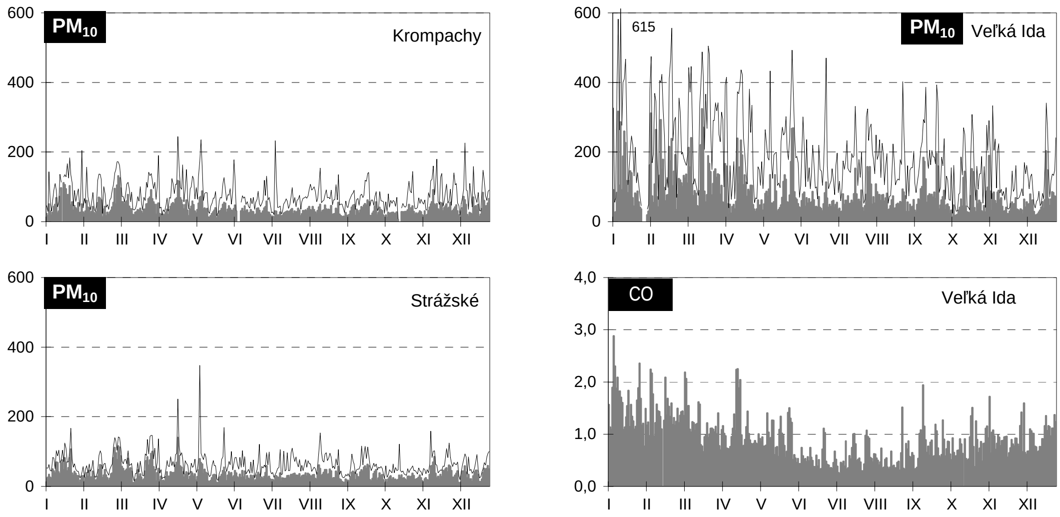
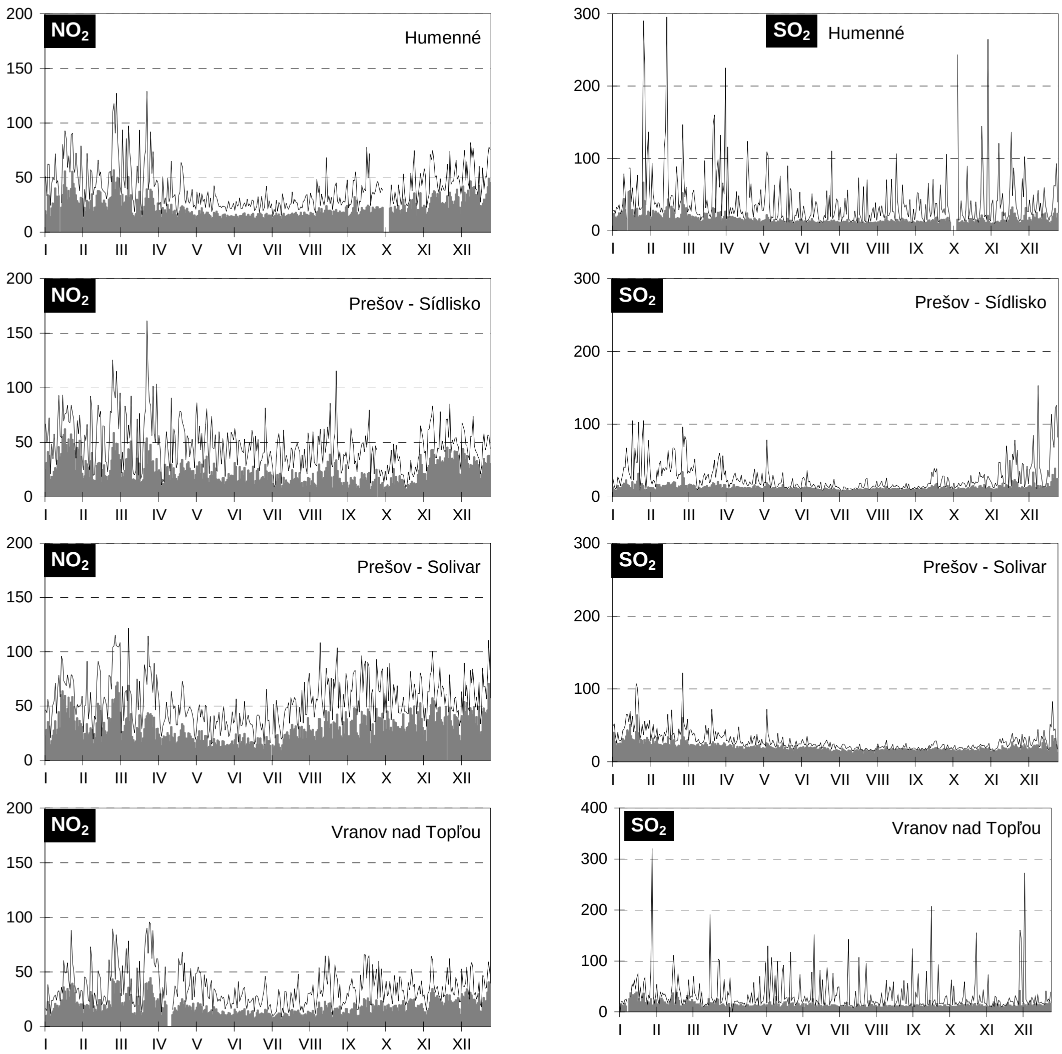


Fig. 2.9 **Concentrations of NO_2, SO_2, PM_{10} and CO – zone Prešov region – 2003**



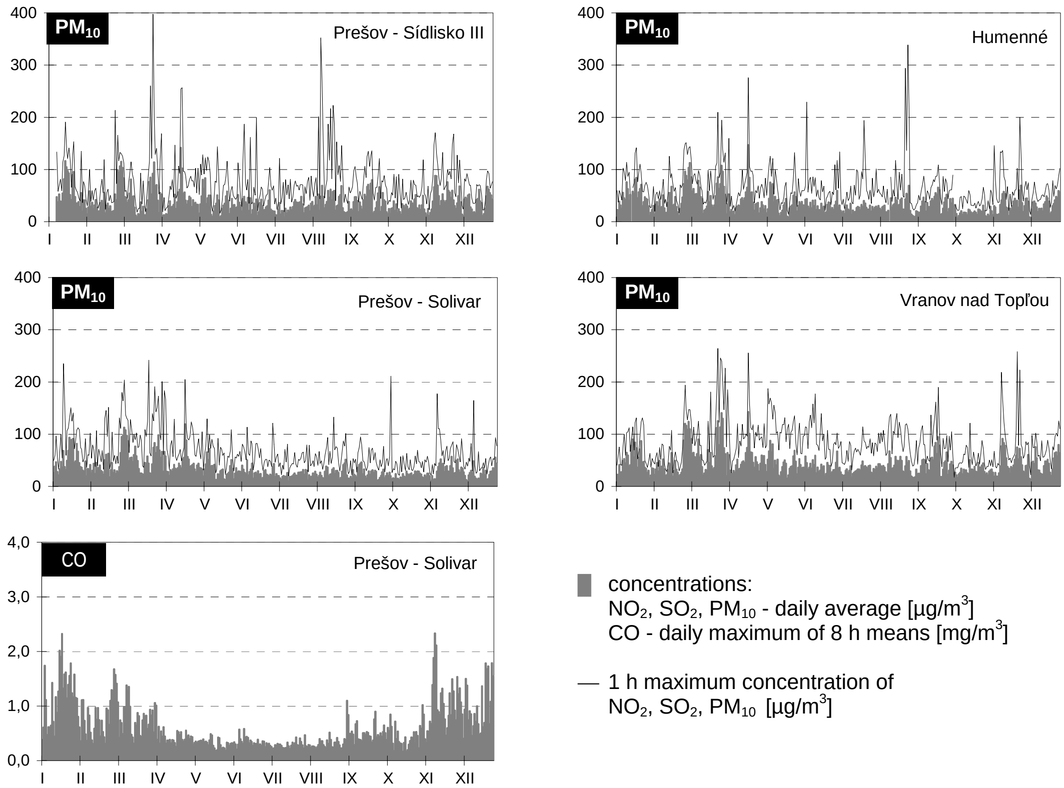
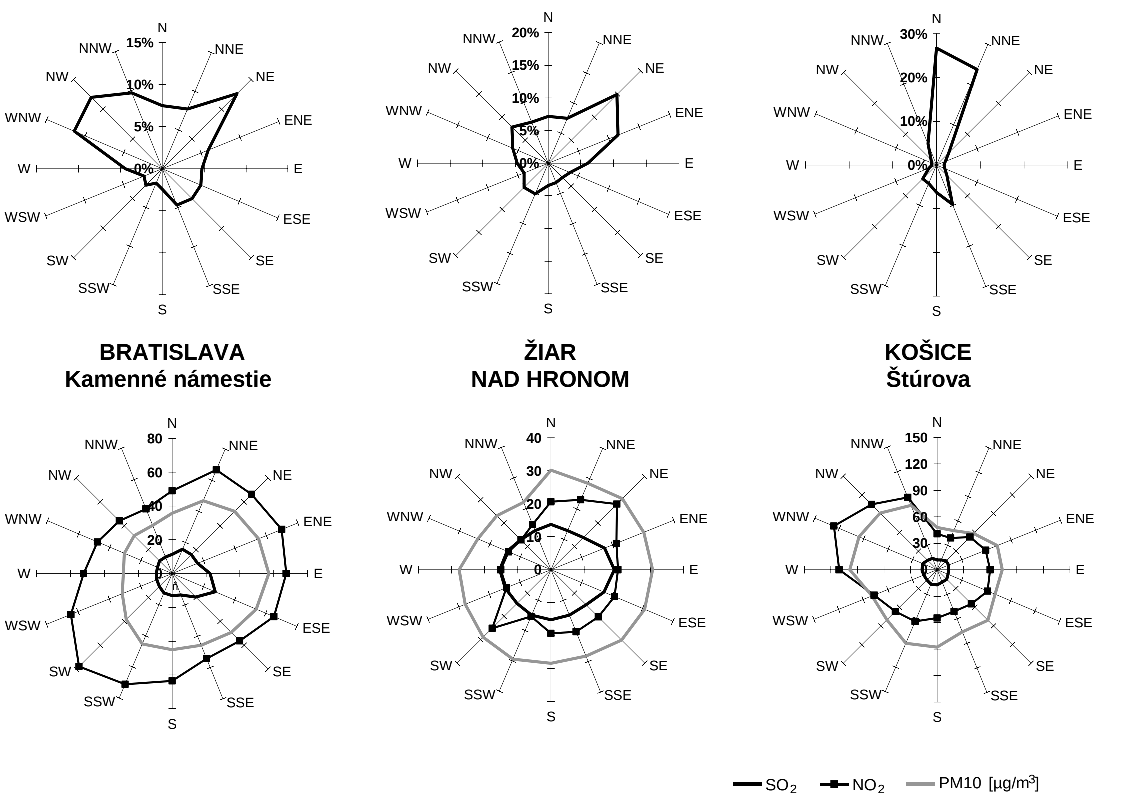


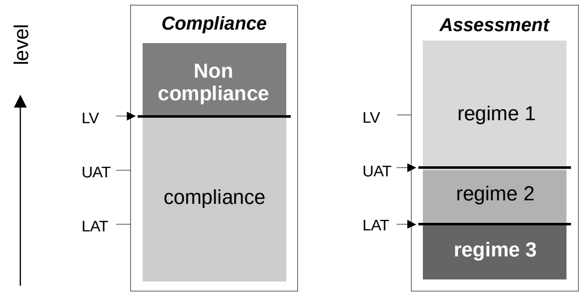
Fig. 2.10 **Wind and concentration roses – 2003**



2.3 PROCESSING OF MEASUREMENT RESULTS ACCORDING TO LIMIT VALUES

The New Clean Air Act 478/2003 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 picture 2.11, and in table 2.3 are specified requirements for air quality assessment for specific regimes.

Fig. 2.11 **Regimes of air quality assessment in relation to LV[1], UAT[2] a LAT[3]**



Tab. 2.3 **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.

[1] *Limit value as defined in Decree No 705 about Air Quality*
[2] *Upper assessment threshold as defined in Decree No 705 about Air Quality*
[3] *Lower assessment threshold, as defined in Decree No 705 about Air Quality*

Limit values, upper and lower assessment thresholds defined in Directives 1999/30/EC and 2000/69/EC are presented in tables 2.4 and 2.5. For several pollutants the margins of tolerance (MoT) were set up, table 2.5. 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 order to distinguish **limit values**, from the limit values + MoT(2003) the later are marked as **limit values 2003** in the following text**.** Alert thresholds and warning limit values were indicated for:

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

- SO_2 - 400 $\mu g.m^{-3}$
- NO_2 - 250 $\mu g.m^{-3}$

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

- SO_2 - 500 $\mu g.m^{-3}$
- NO_2 - 400 $\mu g.m^{-3}$

Statistical characteristics quoted in tables were processed for all monitoring stations in Slovakia. The stations, where the limit values and limit values 2003 were exceeded, are highlighted in tables in bold (Tables 2.6 - 2.7). The annual concentrations of heavy metals are presented in Table 2.8..

Sulphur dioxide An exceedance of limit values 2003 was not recorded at any station. The general air quality can be considered therefore as good.

Nitrogen dioxide The annual limit value 2003 for nitrogen dioxide was exceeded only at the Trnavské mýto station and just around the limit value was the annual concentration at Kamenné nám. station.

PM_{10} In 2003 PM_{10} was monitored at 26 stations. Parallel measurements of $PM_{2.5}$ fraction were carried out at 6 stations. For this fraction no limit values have been set up till now. PM_{10} concentrations are presented in tables 2.6-2.8 as values measured by automatic analyzers and as values recalculated to the reference gravimetry method (1.3*PM_{10}). For recalculation multiplying concentrations by a default factor of 1.3 is recommended. This factor was officially approved by the PM_{10} Working group and therefore all assessment was done from PM_{10} concentrations multiplying by 1.3. The limit value 2003 was exceeded at many stations Bratislava agglomeration (Trnavské mýto, Mamateyova), Trnava zone (Trnava), Nitra zone (Nitra), Banská Bystrica zone (Banská Bystrica, Hnúšťa, Jelšava), Trenčín zone (Prievidza, Bystričany) , Handlová, Žilina zone (Veľká Okružná, Ružomberok), Prešov zone (Sídlisko, Vranov nad Topľou), Košice agglomeration (Strojárenská, Štúrová), and Košice agglomeration Veľká Ida.

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.

Lead At present air pollution by lead does not represent a serious problem. in the Slovak republic.

Benzene At some location the air pollution level is slightly above limit value, which has to be met in the year 2010.

Tab. 2.4 **Limit values plus limits of tolerance for respective years**

	Interval of averaging	Limit value* [µg/m³]	To be met by	Margin of tolerance	Limit value + margin of tolerance [µg/m³]										
					Since 31/12/00	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SO_2	1h	350 (24)	1/1/05	150 µg/m³	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	10000 (-)	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)*
[2] *only for specific point sources*
[e] *for protection of vegetation*
** allowed exceedances per year are in brackets*

Tab. 2.5 **Limit values, upper and lower assessment threshold**

	Receptor	Interval of averaging	Limit value [µg/m³]	Assessment threshold [µg/m³]	
				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*

Tab. 2.6 **Assessment of pollution according to limit values in 2003**

AGLOMERATION / zone	Component	Protection of health											AT	
		SO_2		NO_2		$1.3*PM_{10}$		PM_{10}		Pb	CO	Ben-zene	SO_2	NO_2
	Time of averaging	1 hour	24 hour	1 hour	1 year	24 hour	1 year	24 hour	1 year	1 year	8 hour MA[1]	1 year	3 subsequent hour	3 subsequent hour
	Limit value [µg/m³] *(number of exceedances)*	350 *(24)*	125 *(3)*	200 *(18)*	40	50 *(35)*	40	50 (35)	40	500[2]	10 000	5	500	400
BRATISLAVA	Bratislava Kamenné nám.	0	0	0	40.0	45	32.2	18	24.8	33.9			0	0
	Bratislava Mamateyova	0	0	0	32.6	134	49.1	70	37.8	42.8	1824		0	0
	Bratislava Trnavské mýto	0	0	0	53.6	106	42.1	51	32.4	30.2	4430	3.25	0	0
Trnava region	Trnava	2	0	7	29.7	137	54.1	67	41.6	24.0	5281	6.74	0	0
	Senica	0	0	0	16.7	52	34.1	18	26.2	16.0			0	0
Nitra region	Nitra	0	0	0	34.8	109	49.1	64	37.7	21.3	3380	6.79	0	0
Banská Bystrica region	Banská Bystrica Nám. Slobody	0	0	0	20.3	100	41.0	46	31.5	50.2	1548		0	0
	Hnúšťa	0	0	0	14.1	84	40.8	34	31.4				0	0
	Jelšava	0	0	0	23.6	161	55.3	90	42.5	30.6			0	0
	Žiar nad Hronom	0	0	0	13.7	21	21.8	10	16.8	21.0	1935		0	0
Trenčín region	Bystričany	2	0	0	18.6	134	50.2	71	38.6				0	0
	Handlová	0	0	0	15.7	36	32.3	21	24.8				0	0
	Prievidza	6	0	0	25.6	146	55.0	89	42.3	18.6			0	0
Žilina region	Martin	0	0	0	23.6	51	34.5	29	26.5	21.8			0	0
	Ružomberok Riadok	0	0	0	20.2	201	61.1	120	47.0	17.2			0	0
	Žilina Veľká Okružná	0	0	0	22.1	137	47.8	66	36.8	28.3	4883		0	0
	Žilina Vlčince	0	0	0	25.7	55	33.3	26	25.6				0	0
Prešov region	Humenné	0	0	0	23.3	65	35.7	28	27.4	32.4			0	0
	Prešov Solivar	0	0	0	30.0	50	33.4	25	25.7	45.3	2333		0	0
	Prešov Sídlisko III	0	0	0	24.0	84	39.2	39	30.2				0	0
	Vranov nad Topľou	0	0	0	18.6	104	44.0	47	33.9	40.3			0	0
Košice region	Krompachy	2	0	0	14.2	80	38.7	33	29.8	145.2			0	0
	Strážske	0	0	0	19.8	60	36.4	28	28.0				0	0
	Veľká Ida	0	0	0	18.0	247	82.4	176	63.4	150.3	2866		0	0
KOŠICE	Košice Strojárenská	0	0	0	17.1	98	40.9	46	31.5	59.5	3032		0	0
	Košice Štúrova	0	0	0	23.7	132	49.2	80	37.8		4023	2.09	0	0

AT – Alert threshold (number of days)

[1] maximal 8 hour value of moving average *[2]lead in ng/m³* **50-75% measurements*

XX,X	*Value is above limit*
XXX	*Number of exceedances > allowed number of exceedances*

Tab. 2.7 **Assessment of pollution according to limit values + margin of tolerance in 2003**

AGGLOMERATION / zone	Component	Protection of health											AT	
	Component	SO_2		NO_2		$1.3*PM_{10}$		PM_{10}		Pb	CO	Benzene	SO_2	NO_2
	Time of averaging	1 hour	24 hour	1 hour	1 year	24 hour	1 year	24 hour	1 year	1 year	8 hour MA[1]	1 year	3 subsequent hour	3 subsequent hour
	Limit value + margin of tolerance [µg/m³] *(number of exceedances)*	410 *(24)*	125 *(3)*	270 *(18)*	54	60 *(35)*	43	60 (35)	43	900[2]	14000	10	500	400
BRATISLAVA	Bratislava Kamenné nám.	0	0	0	40,0	26	32.2	10	24.8	33.9			0	0
	Bratislava Mamateyova	0	0	0	32,6	**87**	49.1	**42**	37.8	42.8	1824		0	0
	Bratislava Trnavské mýto	0	0	0	53,6	**65**	42.1	26	32.4	30.2	4430	3.25	0	0
Trnava region	Trnava	1	0	0	29,7	**90**	54.1	**36**	41.6	24.0	5281	6.74	0	0
	Senica	0	0	0	16,7	27	34.1	13	26.2	16.0			0	0
Nitra region	Nitra	0	0	0	34,8	**81**	49.1	**45**	37.7	21.3	3380	6.79	0	0
Banská Bystrica region	Banská Bystrica Nám. Slobody	0	0	0	20,3	**61**	41.0	15	31.5	50.2	1548		0	0
	Hnúšťa	0	0	0	14,1	**48**	40.8	19	31.4				0	0
	Jelšava	0	0	0	23,6	**111**	55.3	**58**	42.5	30.6			0	0
	Žiar nad Hronom	0	0	0	13,7	13	21.8	6	16.8	21.0	1935		0	0
Trenčín region	Bystričany	2	0	0	18,6	**92**	50.2	**44**	38.6				**0**	0
	Handlová	0	0	0	15,7	**23**	32.3	16	24.8				0	0
	Prievidza	1	0	0	25,6	**109**	55.0	**63**	42.3	18.6			0	0
Žilina region	Martin	0	0	0	23,6	33	34.5	14	26.5	21.8			0	0
	Ružomberok Riadok	0	0	0	20,2	**141**	61.1	**78**	47.0	17.2			0	0
	Žilina Veľká Okružná	0	0	0	22,1	**81**	47.8	**42**	36.8	28.3	4883		0	0
	Žilina Vlčince	0	0	0	25,7	33	33.3	10	25.6				0	0
Prešov region	Humenné	0	0	0	23,3	35	35.7	14	27.4	32.4			0	0
	Prešov Solivar	0	0	0	30,0	30	33.4	15	25.7	45.3	2333		0	0
	Prešov Sídlisko III	0	0	0	24,0	**45**	39.2	24	30.2				0	0
	Vranov nad Topľou	0	0	0	18,6	**65**	44.0	28	33.9	40.3			0	0
Košice region	Krompachy	2	0	0	14,2	**40**	38.7	17	29.8	145.2			0	0
	Strážske	0	0	0	19,8	35	36.4	16	28.0				0	0
	Veľká Ida	0	0	0	18,0	**198**	82.4	**133**	63.4	150.3	2866		0	0
KOŠICE	Košice Strojárenská	0	0	0	17,1	**62**	40.9	33	31.5	59.5	3032		0	0
	Košice Štúrova	0	0	0	23,7	**96**	49.2	**53**	37.8		4023	2.09	0	0

AT – Alert threshold (number of days)

[1] maximal 8 hour value of moving average *[2]lead in ng/m³* **50-75% measurements*

XX,X *Value is above limit + margin of tolerance*

XXX *Number of exceedances > allowed number of exceedances*

Tab. 2.8 **Annual average concentrations of heavy metals [ng/m^3] in PM_{10} particles in 2003**

	Cd	Ni	As
Bratislava Koliba	1.21	2.03	2.03
Bratislava Petržalka	1.59	2.40	2.48
Bratislava Trnavske mýto	1.09	3.23	2.15
Bratislava Kamenné nám.	1.14	4.00	2.02
Nitra	0.61	1.68	2.49
Senica	0.47	4.35	1.32
Trenčín	0.72	1.44	3.28
Ban. Bystrica Nám. slobody	1.30	1.11	7.06
Ružomberok Riadok	0.44	1.32	5.56
Žiar nad Hronom	0.60	0.74	3.38
Prievidza	0.52	1.19	9.00
Žilina Veľká Okružná	0.70	1.21	7.40
Martin	0.60	1.07	4.78
Jelšava	0.84	1.25	4.65
Košice Strojárenská	2.02	1.59	3.76
Veľká Ida	5.15	2.29	3.07
Prešov Solivar	1.83	1.02	2.50
Krompachy	2.31	1.09	11.32
Humenné	1.45	0.95	1.49
Vranov nad Topľou	1.98	1.13	2.94

AMBIENT AIR

ATMOSPHERIC OZONE 3

3.1 ATMOSPHERIC OZONE

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

The growth of ozone concentrations in the troposphere approximately 1 $\mu g.m^{-3}$ annually was observed over the industrial continents of the Northern Hemisphere by the end of 1980s. It is associated with the increasing emission of ozone precursors (NOx, VOCs, CO) from car transport, power generation and industry. Since the early 1990s the concentration of ground level ozone in Europe has been more or less stagnant, which is also evident in the measurements in Slovakia. In spite of considerable decrease of ozone precursor emission reduction in Slovakia and in surrounding countries during nineties the effect seems to be not adequate. Only ozone peaks decreased significantly. The average level of ozone concentration is probably 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 the current 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 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 1998-2003

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 and threshold values	Concentration O_3 [$\mu g.m^{-3}$]	Averaging/accumulation time
for protection of human health	120*	8 hour
for protection of vegetation AOT40**	18 000 [$\mu g.m^{-3}.h$]	1 May - 31 July
for information of population	180	1 hour
alert thresholds for population	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.*

Measurements of ground level ozone in Slovakia during 1998-2003

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) and Chopok (in operation since 1995) are part of the EMEP monitoring network. In 2001 new ozone measurements were introduced at Štrbské Pleso station. For monitoring of ground level ozone concentrations, the ozone analysers of the US companies Thermoelectron and MLU and of Japan Horriba 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 2003 the number of missing data did not exceed 10 % at most of the stations (Tab. 3.2). Exceptional data gaps were only at the Chopok and Veľlá Ida stations.

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

Station	1998	1999	2000	2001	2002	2003
Banská Bystrica	2.4	2.5	3.0	9.3	3.8	1.1
Bratislava - Koliba	*	*	5.7	4.7	3.0	2.5
Bratislava - Petržalka	5.8	0.5	18.6	3.6	1.6	3.6
Hnúšťa	7.2	4.9	2.7	3.3	5.8	6.8
Humenné	1.7	15.1	2.7	3.0	2.5	1.9
Chopok	42.7	32.8	30.0	-	6.0	45.5
Jelšava	0.6	4.9	20.5	1.6	8.2	4.1
Košice -Podhradová	21.0	17.8	9.6	4.4	4.1	1.4
Kojšovská hoľa	*	*	24.0	7.9	1.1	9.9
Martin	0.9	6.3	1.4	90.4	46.3	9.3
Poprad (Gánovce)	*	*	25.4	6.0	4.7	1.4
Prešov	*	10.9	16.7	3.3	1.1	5.5
Prievidza	10.2	9.3	10.1	13.4	10.4	2.7
Ružomberok	–	47.4	7.1	7.7	1.9	2.2
Stará Lesná	9.2	3.8	8.7	2.4	0.8	4.7
Starina	8.4	0.8	8.2	3.6	0.5	2.2
Štrbské Pleso	*	*	*	11.2	0.8	4.1
Topoľníky	58.5	11.2	10.1	25.8	1.1	1.4
Veľká Ida	*	4.7	34.2	15.0	6.6	40.8
Žiar nad Hronom	2.3	5.7	53.0	63.0	5.5	1.1
Žilina	4.6	7.4	13.1	1.4	6.8	2.7

** station installed later* *– station closed down, respectively long-term failure of station*

Tab. 3.3 **Long-term characteristics of ground level ozone concentrations** [µg.m^{-3}]

Station	1998		1999		2000		2001		2002		2003	
	AA	AVP	AA	AVP	AA	AVP	AA	AVP	AA	AVP	AA	AVP
Banská Bystrica	42	83	42	93	41	90	44	90	39	88	46	101
Bratislava - Koliba	55	78	–	–	52	85	54	85	56	87	71	111
Bratislava - Petržalka	30	47	40	69	45	75	40	74	49	86	53	99
Hnúšťa	39	82	42	79	48	91	49	92	53	102	60	109
Humenné	57	91	46	72	48	80	48	74	56	93	66	104
Chopok	**80	84	**92	**111	**75	**83	–	–	97	112	**109	112
Jelšava	50	75	50	97	47	88	49	92	48	96	55	105
Košice - Podhradová	40	62	41	62	48	81	47	74	64	104	68	104
Kojšovská hoľa	*	*	*	*	100	120	89	98	86	101	91	110
Martin	49	91	49	83	46	81	–	–	49	91	50	90
Poprad (Gánovce)	*	*	61	93	51	82	51	77	59	96	68	103
Prešov	*	*	45	74	49	90	49	86	45	88	51	100
Prievidza	35	67	46	81	46	91	45	78	43	78	51	95
Ružomberok	–	–	**34	**62	39	77	46	79	41	80	32	64
Stará Lesná	49	73	66	105	64	97	58	91	56	87	67	97
Starina	56	76	59	83	63	90	63	86	64	93	73	105
Štrbské Pleso	*	*	*	*	*	*	75	95	78	99	86	109
Topoľníky	**43	78	52	85	52	73	**41	**75	47	77	67	113
Veľká Ida	*	*	44	73	**47	**85	40	73	43	87	**31	66
Žiar nad Hronom	47	84	40	72	**43	**72	–	–	50	88	58	105
Žilina	41	84	42	82	47	88	38	72	46	89	48	97

AA – annual average AVP – average from daily hours (9-16) during vegetation period (April-September)
** station installed later – station closed down, resp. long-term failure ** 50-75% of measurements*

In 2003, the annual average concentrations of ground level ozone in urban and industrial locations of Slovakia ranged within the interval 31-66 μg.m^{-3} (Tab. 3.3). The concentrations in the rest of the territory ranged between 67 and 109 μg.m^{-3}, mainly depending on the altitude. The highest annual average of ground level ozone concentrations was reached at the summit station Chopok (109 μg.m^{-3}). The effect of ozone from the accumulation zone (800-1500 m over the ground) over the Europe is evident. The average from daily hours (9:00-16:00), during the vegetation period (April – September) ranged at all stations (with exception of Ružomberok and Veľká Ida – industrial stations) around the level of 100 μg.m^{-3}. The year 2003, according to annual averages as well as maximum concentrations, belongs to the photochemically very active years.

In Figure 3.1, the seasonal cycle of daily ozone concentrations in Stará Lesná during 1992-2003 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. At the same time it follows from this Figure, that the ambient air quality standard for protection of vegetation 65 μg.m^{-3} (daily average, not in use at present) is exceeded in Stará Lesná during the whole vegetation period.

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 and 2003) as compared to those in less favourable years. Values in 1997, 1998 and 2001 are the smallest in the whole monitoring period.

Fig. 3.1 **Seasonal change of ground level ozone concentration in Stará Lesná during 1992-2003**

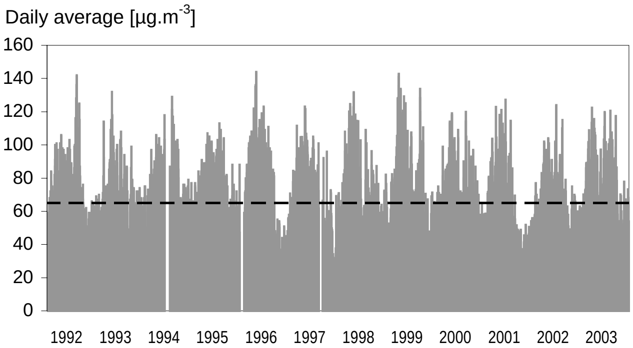
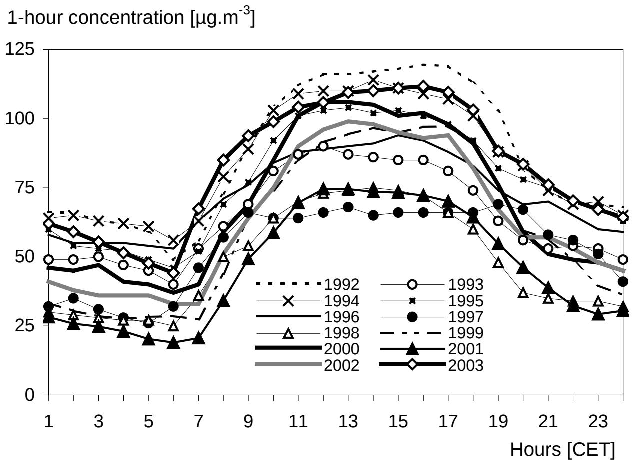


Fig. 3.2 **Average daily cycles of ground level ozone concentration in Stará Lesná, in August 1992-2003**



The number of exceedances of ozone threshold values in Slovakia during 1998-2003 is summarised in Tables 3.4-3.6. The alert threshold when the public must be warned (240 μg.m^{-3}) was in 2003 exceeded in six cases. As compared to other photochemical active years, the information threshold (180 μg.m^{-3}) was also exceeded. more frequently in 2003.

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 2001-2003. The target value not to be exceeded on more than 25 days per calendar year averaged over three years. In 2001-2003 was the number of 25 days overstepped at all monitoring stations, most at Chopok (98 days).

Tab. 3.4 **Number of exceedances in ozone information threshold (IT) and alert threshold (AT) for information and alert of the public during 1998-2003**

Station	AT_{1h} = 240 µg.m^{-3}						AT_{1h} = 180 µg.m^{-3}					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
Banská Bystrica	0	0	0	0	0	0	2	0	0	0	0	0
Bratislava - Koliba	0	0	-	0	0	3	1	-	2	6	0	42
Bratislava - Petržalka	0	0	0	0	0	3	0	5	6	3	0	32
Hnúšťa	0	0	0	0	0	0	0	0	0	0	2	0
Humenné	0	0	0	0	0	0	0	0	0	0	0	0
Chopok	0	0	0	0	0	0	2	0	0	0	2	3
Jelšava	*	0	0	0	0	0	0	0	0	0	0	5
Košice - Podhradová	0	0	0	0	0	0	0	0	2	0	0	0
Kojšovská hoľa	*	*	*	0	0	0	*	*	45	0	0	0
Martin	0	0	0	0	0	0	1	0	4	0	0	0
Poprad (Gánovce)	*	*	*	0	0	0	*	*	0	0	0	0
Prešov	*	*	0	0	0	0	*	0	23	0	0	7
Prievidza	0	0	0	0	0	0	0	0	0	0	0	0
Ružomberok	0	-	0	0	0	0	-	0	0	0	0	0
Stará Lesná	0	0	0	0	0	0	0	0	0	0	0	0
Starina	0	0	0	0	0	0	0	0	0	0	0	0
Štrbské Pleso	*	*	*	*	0	0	*	*	*	0	0	0
Topoľníky	0	0	0	0	0	0	0	0	23	0	0	18
Veľká Ida	*	*	0	0	0	0	*	0	2	0	0	0
Žiar nad Hronom	0	0	0	0	0	0	1	0	5	0	0	0
Žilina	0	0	0	0	0	0	3	30	0	0	0	0

** station installed later – station closed down, resp. long-term failure*

Tab. 3.5 **Number of exceedances of ozone target value for protection of human health (8 h average 120 µg.m^{-3}) during 2001-2003**

Station	2001	2002	2003	Average 2001-2003
Banská Bystrica	32	14	48	31
Bratislava Koliba	26	27	78	44
Bratislava Petržalka	16	24	55	32
Hnúšťa	29	38	79	49
Humenné	1	19	68	29
Chopok	-	92	103	98
Jelšava	29	37	66	44
Košice Podhradová	1	57	64	41
Kojšovská hoľa	65	65	97	76
Martin	-	14	29	22
Prešov Solivar	14	17	61	31
Prievidza	12	1	33	15
Ružomberok Riadok	8	5	6	6
Stará Lesná	30	10	39	26
Starina	6	13	67	29
Štrbské Pleso	35	34	71	47
Topoľníky	8	26	103	46
Veľká Ida	6	30	-	18
Žiar nad Hronom	-	11	66	39
Žilina Vlčince	14	27	57	33

** station installed later – station closed down, resp. long-term failure*

Table 3.6 shows AOT40 values calculated from measurements and also AOT40 values corrected on the missing data. 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 averaged over five years overstepped the target values for the protection of vegetation only at mountain stations (Chopok, Kojšovská hoľa and Štrbské Pleso) and also in Jelšava.

In the period 1997-2002 the ambient air quality standard for the protection of vegetation (1-hour average) 200 µg.m^{-3} (at present not applied) was exceeded only in several cases. In 2003 exceedances were observed in Bratislava-Koliba (16 cases), Bratislava-Petržalka (16 cases) and Topoľníky (2 cases) (Tab. 3.7). Ambient air quality standard, 65 µg.m^{-3} (24-hour average) is exceeded regularly each year over the whole territory of Slovakia, mostly in higher mountain positions. In 2003 the most of exceedances was observed at Štrbské Pleso station, 285 cases (Tab. 3.7).

Tab. 3.6 **AOT40** [µg.m^{-3}.h]

Station	AOT40	AOT40cor[1]	Average
Bratislava Koliba	12780	14545	1999-2003
Bratislava Petržalka	8252	8350	1999-2003
Banská Bystrica	16304	16553	1999-2003
Hnúšťa	16455	16940	1999-2003
Humenné	9143	9539	1999-2003
Chopok	19014	22825	1999-2003
Jelšava	18619	19868	1999-2003
Košice Podhradová	9967	10330	1999-2003
Kojšovská hoľa	29716	31596	2000-2003
Martin	10677	12802	1999-2003
Prešov Solivar	10802	10993	1999-2003
Prievidza	9578	10324	1999-2003
Ružomberok Riadok	6881	8051	1999-2003
Stará Lesná	14313	14670	1999-2003
Starina	11034	11391	1999-2003
Topoľníky	8760	10161	1999-2003
Štrbské Pleso	16840	19082	2000-2003
Veľká Ida	7066	8817	1999-2003
Žiar nad Hronom	8181	9292	1999-2003
Žilina Vlčince	13200	13446	1999-2003

[1] *corrected on the missing data according to the relation*
AOT40 (cor) = AOT40 (measured) x total possible number of hours / number of measured hourly values

Tab. 3.7 **Number of exceedances in ozone short-term ambient air quality standards (AQS) for protection of vegetation during 1998-2003** (these standards already are not applied, the data is presented only for information)

Station	AQS_{1h} = 200 µg.m^{-3}						AQS_{24h} = 65 µg.m^{-3}					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
Banská Bystrica	0	0	0	0	0	0	61	63	72	88	57	98
Bratislava - Koliba	0	-	0	0	0	16	98		112	116	134	191
Bratislava - Petržalka	0	0	2	0	0	16	6	105	115	50	97	125
Hnúšťa	0	0	0	0	0	0	42	53	78	126	128	160
Humenné	0	0	0	0	0	0	133	111	56	110	137	196
Chopok	0	0	0	–	0	0	**182	**217	**147	–	279	211
Jelšava	0	0	0	0	0	0	101	115	80	109	111	149
Košice – Podhradová	0	0	0	0	0	0	14	12	143	147	178	217
Kojšovská hoľa	*	*	8	0	0	0	*	*	259	298	300	273
Martin	0	0	0	–	0	0	91	89	48	–	53	89
Poprad (Gánovce)	*	*	0	0	0	0	*	*	65	56	120	192
Prešov	*	0	9	0	0	0	*	8	93	109	68	97
Prievidza	0	0	0	0	0	0	25	134	88	78	55	121
Ružomberok	-	0	0	0	0	0	-	**0	38	56	65	25
Stará Lesná	0	0	0	0	0	0	72	173	132	124	117	178
Starina	0	0	0	0	0	0	106	128	157	157	182	224
Štrbské Pleso	*	*	*	0	0	0	*	*	*	206	261	285
Topoľníky	0	0	1	0	0	2	**31	100	133	39	65	201
Veľká Ida	*	0	0	0	0	0	*	44	**36	27	64	7
Žiar nad Hronom	0	0	2	–	0	0	81	76	**46	–	86	154
Žilina	0	4	0	0	0	0	59	48	85	41	85	116

** station installed later* – *station closed down, respectively long-term failure of station*

*** 50-75 % of measurements*

It may be stated in conclusion, that in the extremely warm, dry and photochemical active year 2003 the highest values of the most ground level ozone indicators in Slovakia were observed from the beginning of observations (since 1992). This reality is to some extend surprising taking into account a massive decrease of anthropogenic precursor emissions (NOx, VOC and CO) in Slovakia (already below Göteborg 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 year 2003 demonstrates the limitations of national ozone mitigation strategy. The Slovak results support the conclusions of the EUROTRAC-2 project, that stressed regional and global aspects of ground level ozone and proposed to shift the problem among global issues, for example into Kyoto Protocol.

3.3 TOTAL ATMOSFERIC OZONE OVER THE TERRITORY OF THE SLOVAK REPUBLIC IN 2003

Since August 1993 total atmospheric ozone over the territory of Slovakia has been measured with the Brewer ozone spectrophotometer MKIV #097 in the Centre of Aerology and Ozone Measurements of the Slovak Hydrometeorological Institute (SHMI) at Gánovce near Poprad. As well the solar UV spectra is regularly scanned through the range 290-325 nm at 0.5 nm increments. In June 2003 the SHMI instrument took part in an international comparison and calibration of Brewer ozone spectrophotometers with World traveling standard which was held in Warsaw. 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.

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 Centre of Aerology and Ozone Measurements has been providing 24 hour UV Index forecast for the public. 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 333.9 Dobson Units in 2003. This is 1.3 % below the long-term average (calculated upon the Hradec Kralove measurements in the period 1962-1990). The ozone layer state was more favourable comparing with the situation in 2002, when the deficiency was 4.6 %. Since 1994 higher annual mean has been recorded in 1998. Total ozone statistics for the year 2003 (daily means, relative deviations from long term averages, monthly means, standard deviations and extremes) are in Table 3.8.

The monthly means above an average were observed in January and February. Despite this fact extreme deficiencies to –25 % were recorded in the middle of January. They have been compensated by extreme positive differences reached 30 %, which demonstrate the highest total ozone variability in winter and early spring. Nearly coherent period of negative differences started in the second April decade and continued to the late August. During whole period total ozone amount slightly exceeded long term average only sporadically. The most unfavourable situation with 7 % deficiency on average was in May. The ozone layer was in good state in Autumn. Significant and continues deficiencies were observed in December again.

Total ozone weekly averages are in Figure 3.3. The graph illustrates a behaviour of the ozone layer in the year 2003 and shows significant short-term variations in total ozone amount in our geographical region.

Figure 3.4 shows the biologically effective irradiance (in units of mW/m^2) weighted by CIE erythemal action spectra (McKinlay and Diffey 1987). 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 express the UV level relevant to the erythemal effect on human skin. Its values are used to derive 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 intensity of 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 was defined for the most sensitive skin. 1 MED/hod 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 SHMI Web site.

Fig. 3.3 **Total atmospheric ozone over the territory of Slovakia in 2003**

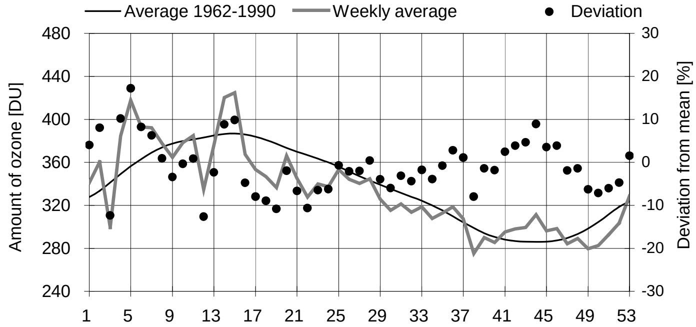


Fig. 3.4 **Annual course of DUV (Diffey) radiation noon values Gánovce 2003**

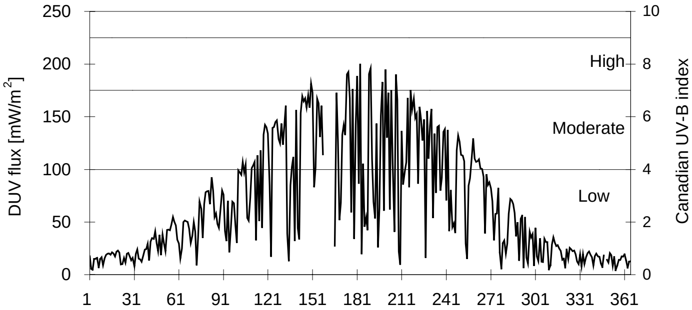
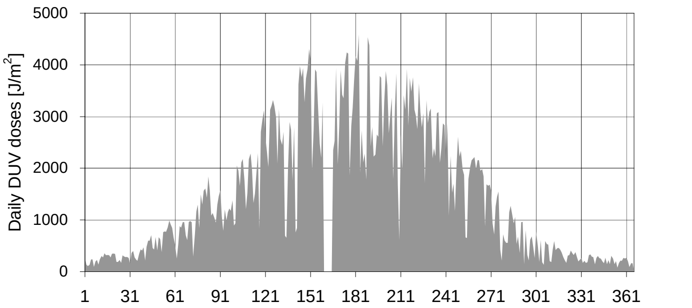


Fig. 3.5 **Annual course of harmfull ultraviolet solar radiation daily doses – Gánovce 2003**



The maximal noon value of CIE-weighted irradiance 200 mW/m^2 (which correspondents to 3.43 MED/hod) was measured on July 2. This has been only day with irradiance over 200 mW/m^2 in 2003.

UV-B radiation has been monitored every day at regular 1-hour or half an hour increments. The observing schedule was only temporarily stopped during thunderstorms. Daily CIE-erythemal doses are presented in Figure 3.5. A maximum of 4590 J/m^2 (which correspondents to 21.8 MED) was measured on July 2. It has been the same day when the yearly maximal irradiance was recorded.

Total CIE-erythemal dose for the period April-September 2002 was 461 720 J/m^2. Missing values in June when the instrument was moved for calibration have been replaced by an average of 10 values before and 10 values after that period. Daily dose total nearly reaches a value of the year 2000 when the highest total of 462 267 J/m^2 has been recorded since 1994.

Tab. 3.8 **Total atmospheric ozone [DU] in 2003 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	312	-4	411	15	366	-3	416	8	342	-10	339	-7	316	-9	322	-3	315	1	282	-3	313	9	285	-4
2	345	5	401	11	359	-5	410	6	345	-9	349	-4	335	-4	319	-3	332	7	288	-1	316	11	255	-14
3	361	10	420	17	386	2	414	7	345	-9	345	-5	346	0	305	-8	352	13	270	-7	296	4	248	-17
4	341	4	432	20	394	4	421	9	364	-4	342	-6	342	-1	303	-8	317	2	302	4	301	5	275	-8
5	346	5	449	24	359	-5	419	8	356	-6	343	-6	367	6	295	-10	314	1	300	4	304	6	281	-6
6	338	2	403	11	360	-5	470	21	341	-10	330	-9	346	0	305	-7	303	-2	298	3	335	17	294	-2
7	387	17	340	-7	386	2	479	24	331	-12	331	-9	341	-1	313	-5	298	-3	301	4	295	3	319	6
8	360	8	365	0	386	1	458	18	350	-7			342	-1	322	-2	318	4	325	13	282	-2	271	-10
9	340	2	343	-6	380	0	470	21	344	-9			337	-2	333	2	303	-1	332	15	261	-9	282	-7
10	392	17	377	3	350	-8	423	9	349	-7			351	2	325	0	299	-2	272	-5	283	-1	286	-6
11	365	9	398	8	347	-9	385	0	316	-16			354	3	330	1	312	2	275	-4	303	6	301	-1
12	343	2	375	2	369	-3	384	-1	333	-11			322	-6	326	0	309	2	264	-8	289	1	293	-4
13	318	-6	390	6	425	11	375	-3	334	-11			366	7	314	-3	308	2	273	-5	294	2	266	-13
14	254	-25	338	-8	442	16	362	-6	356	-5	335	-7	348	2	316	-3	305	1	293	2	301	5	280	-9
15	261	-23	408	10	401	5	372	-4	391	5	340	-5	344	1	320	-1	281	-7	302	5	314	9	282	-9
16	274	-20	458	23	360	-6	366	-5	400	7	366	2	333	-2	314	-3	278	-7	327	14	305	6	319	3
17	342	0	398	7	361	-6	378	-2	368	-1	340	-5	311	-8	310	-4	273	-9	312	9	318	10	274	-12
18	320	-7	386	4	344	-10	391	1	381	3	349	-2	314	-7	311	-3	282	-6	302	6	300	4	279	-10
19	326	-5	359	-4	321	-16	367	-5	353	-5	345	-3	316	-7	311	-3	275	-8	276	-4	276	-5	285	-9
20	320	-7	342	-9	321	-16	362	-6	330	-11	331	-7	315	-7	307	-4	267	-10	281	-2	268	-8	285	-9
21	329	-5	374	0	347	-9	362	-6	376	2	382	8	314	-7	310	-3	270	-9	274	-4	289	0	326	3
22	369	6	388	3	340	-11	354	-8	367	-1	362	2	311	-8	303	-5	279	-6	293	2	275	-5	315	0
23	397	14	395	5	309	-20	373	-3	344	-7	329	-7	321	-5	306	-4	291	-2	311	9	265	-9	326	3
24	415	18	406	8	310	-19	357	-7	334	-9	333	-6	320	-4	305	-4	291	-1	304	6	276	-5	347	9
25	457	30	374	-1	341	-11	349	-9	313	-15	345	-2	320	-4	324	2	294	0	321	12	295	1	283	-11
26	406	15	330	-12	391	2	347	-9	325	-12	337	-4	321	-4	314	-1	304	4	315	10	296	1	282	-12
27	427	21	360	-5	391	2	333	-13	323	-12	363	3	301	-10	311	-2	288	-2	326	14	289	-2	271	-15
28	385	9	358	-5	395	2	360	-6	321	-13	355	1	314	-6	305	-3	284	-3	266	-7	305	4	302	-6
29	404	14			405	5	337	-12	331	-10	347	-1	345	4	308	-2	280	-4	307	7	284	-4	313	-3
30	425	19			400	4	336	-12	323	-12	329	-6	321	-3	310	-1	277	-5	329	15	280	-5	308	-5
31	472	32			394	2			332	-9			323	-3	317	1			324	13			275	-15
Ø	359	5	385	4	369	-3	388	1	346	-7	344	-3	331	-3	313	-3	297	-2	298	4	294	2	291	-6
Std	51	14	32	10	32	8	41	10	21	6	13	4	17	4	9	3	19	5	20	7	17	6	22	6
Max	472	32	458	24	442	16	479	24	400	7	382	8	367	7	333	2	352	13	332	15	335	17	347	9
Min	254	-25	330	-12	309	-20	333	-13	313	-16	329	-9	301	-10	295	-10	267	-10	264	-8	261	-9	248	-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:

- the information of the responsible bodies, expert and lay public
- the definition of environmental priorities and identification of causes of problems
- the assessment of environmental impact on different plans and strategies
- the assessment of environmental costs and benefits on different approaches
- the monitoring of effect, respective effectiveness of adopted measures
- the support by agreement with adopted commitments

STATIONARY SOURCES

Information related to stationary sources of air pollution was in period 1985-1999 compiled according the Air act No 35/1967 in system EAPSI (Emission and Air Pollution Source Inventory). This system was divided according to 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)

According to the changes in the air protection legislations the amendment of EAPSI was not occurring, therefore was created the new module NEIS (National Emission Inventory System) in 1997 in the frame of project of the Ministry of Environment in coordination with SHMI and close cooperation with the regional offices, district offices and selected operators. The NEIS software product is constructed as a multi-module system, corresponding fully to the requirements of current legislation in air protection. Module NEIS BU enables the execution of complex data acquisition and their processing in respective district offices, as well as carrying out the logical control on correctness in emission calculation on input data and provides the decision about the height of tax. It enables the feeding of the input data on sources exclusively in a way corresponding to the legislation. Data acquisition is carried out by a set of questionnaires, but it is possible also to use software module NEIS PZ, which also enables filling the questionnaires in electronic form and also emission calculation and data feeding from respective operators into the NEIS BU district databases. Data from district databases are then fed into the NEIS CU central database. 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 SR and the system was accepted by interdepartmental operative committee.

Positive contribution of NEIS

- Homogeneous system of processing data about sources and their emissions at local, regional and national level.
- Provision of an actual and effective tool to all primary process the data and thus give a guarantee for uniform level of acquisition, processing and control of data about the sources and their emissions.
- Better transparency of procedure to concede the quantity of emissions and thus payment of taxes for the pollution of the air by operators of the sources due to the built-in control system, and the necessity to provide the input data into NEIS exclusively in coincidence with the legislative regulations.
- Establishment of a Slovak national database that enables the top state administration bodies to optimally fulfill their tasks on the all ranks and to provide the input data for international emission inventories or special emission inventories.

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 source, change in categorization of sources and their division upon the output caused that the EAPSI system may be compared with the NEIS module only on the national level. Comparison of the individual parts of EAPSI (EAPSI 1and EAPSI 2) with the NEIS module (large, medium-size sources), respectively comparison of individual sources in both systems is difficult.

According to the Act No 478/2002 Act. Coll. 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 May 31 of the current year for the next processing to SHMI, the organization accredited by the Ministry of Environment to manage the central database NEIS CU and provide the data processing at the national level (Bulletin of MoE No 6/2000).

The NEIS system includes the sources of air pollution, which are assigned following the input and category according to the Decree No 706/2002, Act. Coll.

Large sources	Stationary sources containing stationary combustion units having cumulative heating input over 50 MW and other processes

Middle sources	Stationary sources containing stationary combustion units having cumulative heating input 0.3-50 MW and other processes

Small sources	Stationary equipment – domestic heating equipment for combustion of fuels (solid, natural gas) with heating input less than 0.3 MW (According to the Decree of MoE SR No 144/2000)

Results 1990-2003

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. the area-administrative units, defined according to the organisation inventory number, were in operation. 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, NOx, 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.

Large sources

Since 2000 the gathering of the selected data on sources and their emissions has been provided in the NEIS system. New system contained 921 large point sources from 79 the NEIS BU district databases in 2003. 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 difficult.

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.

Middle sources

Since 2000 the data updating in the NEIS system has been provided each year. In 2003 system NEIS registered 12 436 medium sources from 79 the NEIS BU district database. 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 difficult.

EAPSI 3 and small sources

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 (since 2001 in sense of the Decree No 144/2000), consumption of natural gas for the inhabitants (register of SPP,a.s) and respective 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 have 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 within 1990-2003 have been obtained.

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

MOBILE SOURCES

Emissions from mobile sources are calculated since 1990 annually. Emission calculation is being done by the COPERT method, recommended to the signatories of the UN ECE Convention on Long Range Transboundary Transmission of Air Pollutants. It is based on the number of individual types of cars, the amount of kilometers driven and the consumption of individual fuel types. Apart from road transport, inventory of mobile sources includes the railway, air and shipping transport, as well. These emissions are estimated according to the methods provided in IPCC Guidelines. In year 2002 emissions of mobile sources were estimated using COPERT III version based on the latest know-how in this area. In 2004 the solid matter emission balance from road transport was completed about the emissions from exhausts of petrol engines and about the abrasive emissions (abrasing of road surface, tyres and brake facing) in coincidence with the requests of the updated method EMEP/ CORINAIR[2] and in coincidence with the requests for reporting of these emissions for UN ECE (NFR[3]). For the calculation the method and emission factors recommended by the TNO-MEP agency were used. The results of PM emission balance from road transport are listed in Table 4.1.

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 Table 4.2 a,b and Figure 4.1.

Particulate matter and SO_2

Emissions of particulate matter and sulphur dioxide have been decreasing continuously since 1990. Apart from the decrease in energy production and consumption, this was caused by the change of 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 sulphur dioxide emissions up to 1996 continued also in 2000 and was caused by the decreasing consumption of brown coal, hard coal, heavy fuel oil, usage of low-sulphur fuel oil (Slovnaft) and installation of the desulphurisation systems for the large power sources (Power plants in Zemianske Kostoľany and Vojany). The fluctuation of SO_2 emissions within 2001 and 2003 was caused either by their partial or total operation, by the quality of combustion fuel and volume of production.

Oxides of nitrogen

Emissions of oxides of nitrogen 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 oxides of nitrogen in 1996 was caused by the change of emission factor, taking into consideration the present condition of technique and technology in combustion processes. Since 1997, the decrease in solid fuel consumption has led to a further decrease in NOx emissions. The further emissions decreasing in years 2002 and 2003 was caused by denitrification process (Power plant Vojany).

[2] *Emission Inventory Guidebook – 3rd edition*
[3] *New format for reporting*

CO A downward trend in carbon monoxide emissions since 1990 has been caused mainly by the decrease in consumption and a 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 carbon monoxide emissions from major sources. Carbon monoxide emission 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 carbon monoxide emissions increased proportionally, as well. A decrease in carbon monoxide emissions in 1996 was due to the effects of measures (determined on the results of measurements) being taken to limit carbon dioxide emissions in the most important source in this sector. The fluctuation of CO emissions within 1997 and 2003 is connected also with the quantity of pig iron production as well as the fuel consumption.

EMISSIONS OF OTHER POLLUTANTS

Emission Inventories of NMVOC, HM and POPs follow up SNAP97 sectors as defined in EMEP/ CORINAIR Guidebook and recommendations of TFEIP[4] working groups. Emissions are estimated at national level (activity data multiplied by emission factor) in cooperation with external experts.

NMVOC In 2001 a new subsector *road pavement* was included and emissions since 1990 were revised. The method is based on asphalt production balance. It is assumed that 65-80 % of asphalt produced is used on roads coverage. The NMVOC emissions have decreased since 1990. This development was caused by decreased consumption of solvent based paints and the step-by step 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 catalytic converters (Tab. 4.7, Fig. 4.4).

POPs Similarly the POPs emissions also show a decreasing trend since 1990. This is most pronounced in the polyaromatic hydrocarbons (PAHs) emissions. The decreasing trend is caused mainly by the replacement of obsolete polluting technology for aluminium production by modern technology, utilising pre-backed anodes and by the introduction of a thermal desorption control unit in the carbon black production plant at Elektrokarbon Topoľčany as well as by a change of wood impregnation technology (Tab. 4.8, Fig. 4.4).

HMs Heavy metals emissions also show a decreasing trend after 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 (Tab. 4.9, Fig. 4.5) since 1996.

Share of individual sectors in total emissions of the Slovak Republic in the year 2003

Figure 4.2 represents the contribution of stationary and mobile sources to air pollution. The graphs show that the share of traffic in air pollution by oxides of nitrogen and carbon monoxide is significant. On the other hand, combustion processes and industry do contribute to air pollution mainly by oxides of sulphur and particulate matter. Table 4.3 shows the total emission values in individual agglomerations and zones (in sense of the Annex No 8 to the Decree No 705/2002 Act Coll.).

[4] *Task Force on Emission Inventories and Projections*

Most important sources of air pollution in the Slovak Republic in the year 2003

Table 4.4 introduces 20 of the most important air pollution sources in Slovakia. The share of these sources in the total air emissions of Slovakia varies from 76.02 to 92.90 %. Table 4.5 lists top ten sources for each of 8 administrative regions based on basic pollutant emissions.

Specific territorial emissions in the year 2003

Table 4.6 and Figure 4.3 provide us with a certain imagination about the territorial distribution of the pollutants emitted. 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 on more distant areas, depending on the stack height and meteorological characteristics.

4.3 VERIFICATION OF THE RESULTS

Verification of the data gathered during the emission inventory was carried out by a comparison of:

- updated data to the 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 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 on the balance calculation and the recalculation from the results of measurements were significant. In the 1996 and 1999 EAPSI 1 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 to control emissions estimated on the district level and its implementation will decrease the uncertainty of national estimates.

Note: Structural changes of the current national emission inventory system, in accordance with the new air protection act (transposition of EU air pollution legislation), is ongoing process. Harmonisation of all pollutant inventories and ISO9001 are introducing. In accordance with these requirements the inventory results for the year N are completed to the 31 October (N+1) and the inventory results of the basic pollutants for the year N are completed to the 15 February (N+2).

Tab. 4.1 **Emissions of PM from road transport in the Slovak Republic within 1990-2003 [t]**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Emissions from diesel engine	2 916	2 339	2 040	1 889	2 020	2 200	2 263	2 292	2 397	2 260	1 975	2 167	2 564	2 262
Emissions from petrol engine	376	348	335	354	346	346	321	302	283	238	208	220	215	168
Total emissions from exhaust	3 292	2 687	2 375	2 243	2 366	2 546	2 584	2 594	2 680	2 498	2 183	2 387	2 779	2 430
Abrasion emissions	6 737	5 587	5 102	5 000	5 765	5 761	5 897	6 114	6 324	5 823	5 465	6 180	7 148	6 480
Total	10 029	8 274	7 477	7 243	8131	8 307	8 481	8 708	9 004	8 321	7 648	8 567	9 927	8 910

Tab. 4.2a **Emissions of basic pollutants in SR within 1990-1999 [thous. t]**

		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*	*8.855*	*7.978*	*7.644*	*8.544*	*8.755*	*8.940*	*9.142*	*9.509*	*8.766*
	Total	290.059	234.580	186.916	153.380	104.053	106.204	81.418	75.436	71.194	73.291
SO_2	EAPSI 1	421.981	347.084	296.034	246.411	182.746	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*	*14.189*
	EAPSI 4	3.424	2.722	2.390	2.175	2.313	2.490	2.536	2.554	2.724	1.088
	Total	526.111	445.488	389.630	328.219	245.219	246.288	230.594	204.689	184.112	172.965
NOx	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	47.375	43.738	42.362	43.535	45.453	45.038	44.914	46.210	43.225
	Total	221.616	200.802	188.396	180.075	169.800	177.709	134.696	127.241	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	142.135	140.621	150.676	154.804	156.743	151.133	153.216	153.946	144.655
	Total	505.458	482.368	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*

* ***in 2004 the balance of emissions was revised following the emission recalculation in the whole data time series 1990-2003***

** ***in 2004 PM emissions from road transport were completed about the abrasive emissions and petrol engine emissions in the whole data time series 1990-2003***

Tab. 4.2b **Emissions of basic pollutants in SR within 2000-2003 [thous. t]**

			2000	2001	2002	2003
PM	**Stationary sources – NEIS**	Large sources [1]	29.923	29.722	25.037	20.166
		Middle sources [1]	4.958	4.405	3.767	3.259
		Small sources [2]*	*19.877*	*20.550*	*17.217*	*18.300*
	Mobile sources	Road transport**	*7.648*	*8.567*	*9.927*	*8.910*
		Other transport	0.399	0.404	0.366	0.329
	Total		62.805	63.648	56.314	50.964
SO_2	**Stationary sources – NEIS**	Large sources [1]	101.955	109.823	91.461	95.283
		Middle sources [1]	8.083	6.655	3.964	3.620
		Small sources [2]*	*16.055*	*13.764*	*7.127*	*6.384*
	Mobile sources	Road transport	0.670	0.750	0.808	0.750
		Other transport	0.189	0.194	0.064	0.059
	Total		126.952	131.186	103.424	106.096
NOx	**Stationary sources – NEIS**	Large sources [1]	54.485	51.653	46.412	44.605
		Middle sources [1]	8.052	7.751	6.356	6.620
		Small sources [2]*	*7.993*	*8.391*	*7.137*	*7.356*
	Mobile sources	Road transport	33.438	35.719	39.883	34.814
		Other transport	4.860	4.899	4.808	4.305
	Total		108.828	108.413	104.596	97.700
CO	**Stationary sources – NEIS**	Large sources [1]	120.609	115.177	122.225	141.047
		Middle sources [1]	10.779	10.280	9.150	9.394
		Small sources [2]*	*53.792*	*50.178*	*33.815*	*33.811*
	Mobile sources	Road transport	120.190	131.954	138.960	116.050
		Other transport	1.719	1.626	1.591	1.463
	Total		307.089	309.215	305.741	301.765

[1] *according to the Decree of MoE SR No 706/2002 Act. Coll.*

[2] *according to Decree of MoE SR No144/2000 Act. Coll.*

* ***in 2004 the balance of emissions was revised following the emission recalculation in the whole data time series 1990-2003***

** ***in 2004 PM emissions from road transport were completed about the abrasive emissions and petrol engine emissions in the whole data time series 1990-2003***

Emissions, as they were appointed to October 31, 2004

Fig. 4.1 Development trends in basic pollutant emissions within 1990-2003

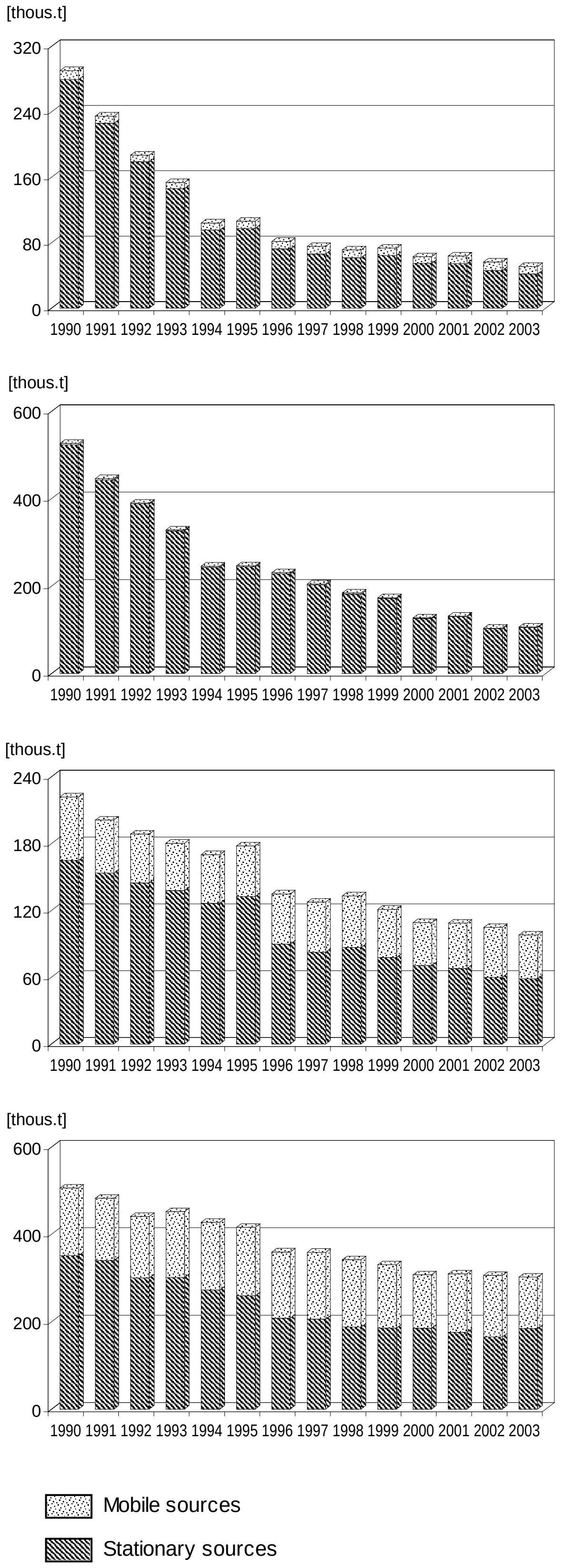
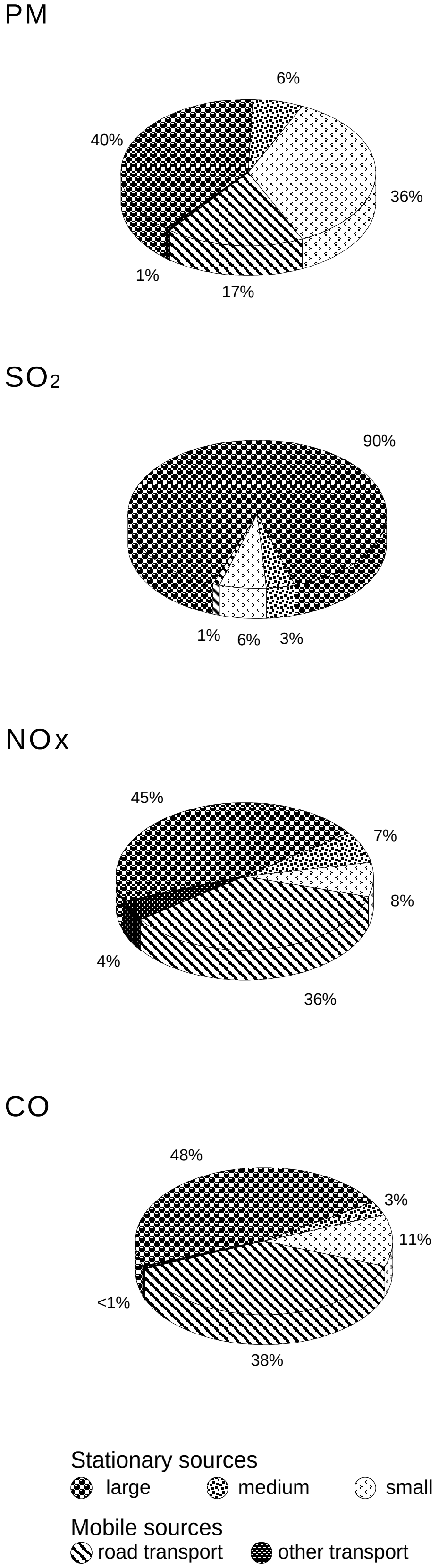


Fig. 4.2 Emissions of basic pollutants in 2003



Tab. 4.3 **Stationary source emissions of basic pollutants [t] in agglomerations and zones* within 2000-2003**

2000

		PM	SO_2	NOx	CO
Agglomeration	Bratislava	942	13 240	6 393	1 528
	Košice	15 758	18 307	12 382	84 544
Zone	Bratislava region	501	384	1792	1 951
	Trnava region	1 518	2 160	2 012	4 746
	Trenčín region	4 607	28 625	9 083	11 684
	Nitra region	3 057	4 752	3 905	7 964
	Žilina region	6 585	10 775	5 433	19 357
	Banská Bystrica region	6 320	10 654	6 541	26 309
	Prešov region	4 207	8 372	3 279	12 170
	Košice region	11 263	28 824	19 710	14 927
Total		54 758	126 093	70 530	185 180

2001

		PM	SO_2	NOx	CO
Agglomeration	Bratislava	477	13 594	5 151	1 319
	Košice	17 173	12 608	12 172	78 619
Zone	Bratislava region	546	380	1 900	1 638
	Trnava region	1 518	2 051	1 966	4 682
	Trenčín region	4 820	45 187	10 489	10 334
	Nitra region	2 921	4 749	3 974	7 379
	Žilina region	6 271	10 237	5 170	19 287
	Banská Bystrica region	6 355	10 043	6 666	26 301
	Prešov region	4 266	8 082	3 443	11 838
	Košice region	10 330	23 311	16 864	14 238
Total		54 677	130 242	67 795	175 635

2002

		PM	SO_2	NOx	CO
Agglomeration	Bratislava	444	11 348	5 313	1 264
	Košice	14 601	10 500	12 140	83 700
Zone	Bratislava region	493	208	1 972	1 488
	Trnava region	1 284	1 166	1 684	3 591
	Trenčín region	4 199	38 305	9 616	7 815
	Nitra region	2 476	3 799	3 843	5 470
	Žilina region	5 298	7 140	4 599	16 520
	Banská Bystrica region	5 334	8 814	6 316	24 299
	Prešov region	3 491	6 320	3 213	9 075
	Košice region	8 401	14 952	11 209	11 968
Total		46 021	102 552	59 905	165 190

2003

		PM	SO_2	NOx	CO
Agglomeration	Bratislava	482	12 263	5 414	1 204
	Košice	9 890	10 781	12 343	104 600
Zone	Bratislava region	465	150	1 590	2 789
	Trnava region	1 325	1 077	1 670	3 397
	Trenčín region	4 332	46 051	10 198	7 801
	Nitra region	2 478	3 648	3 993	5 615
	Žilina region	5 343	7 647	4 483	16 459
	Banská Bystrica region	5 346	7 983	5 843	25 729
	Prešov region	3 666	6 719	3 224	8 796
	Košice region	8 398	8 968	9 823	7 862
Total		41 725	105 287	58 581	184 252

** according to the Decree No 705/2002 Annex 8*

Tab. 4.4 **The most important air pollution sources in the SR and their share in the emissions of pollutants (NEIS) in 2003**

No.	PM		SO_2		NOx		CO	
	Source	[%]	Source	[%]	Source	[%]	Source	[%]
1	U.S. Steel, s.r.o., Košice	39.99	SE, a.s., Bratislava, o.z. ENO Zemianske Kostoľany	43.22	U.S. Steel, s.r.o., Košice	19.87	U.S. Steel, s.r.o., Košice	69.21
2	SE, a.s., Bratislava, Elektráreň Vojany I a II	24.81	SLOVNAFT, a.s., Bratislava	12.18	SE, a.s., Bratislava, Elektráreň Vojany I a II	11.64	SLOVALCO, a.s., Žiar nad Hronom	7.72
3	SE, a.s., Bratislava, o.z. ENO Zemianske Kostoľany	4.23	U.S. Steel, s.r.o., Košice	9.19	SE, a.s., Bratislava, o.z. ENO Zemianske Kostoľany	11.07	Dolvap, s.r.o., Varín, Kameňolom a vápenka	3.60
4	Novácke chemické závody, a.s., Nováky	1.64	BUKOCEL, a.s., Hencovce	3.93	SLOVNAFT, a.s., Bratislava	7.25	SLOVMAG, a.s., Lubeník	1.73
5	SLOVNAFT, a.s., Bratislava	1.38	Zvolenská teplárenská a.s., Zvolen	3.44	Tepláreň Košice a.s., Košice	2.86	BUKOCEL, a.s., Hencovce	1.44
6	Duslo, a.s., Šaľa	1.10	SE, a.s., Bratislava, Elektráreň Vojany I a II	3.33	Kappa Štúrovo a.s.	2.18	HOLCIM (Slovensko), a.s., Rohožník	1.34
7	Carmeuse Slovakia, s.r.o., Košice	1.02	ENERGETIKA s.r.o., Strážske	2.16	HOLCIM (Slovensko), a.s., Rohožník	2.15	OFZ, a.s., Istebné	1.25
8	Severoslov. celulózky a papierne, a.s., Ružomberok	0.84	Žilinská teplárenská, a.s., Žilina	1.70	SPP a.s., závod Veľké Kapušany	2.06	CEMMAC, a.s., Horné Sŕnie	0.96
9	BUKOCEL, a.s., Hencovce	0.79	Kappa Štúrovo a.s.	1.62	SPP,a.s.,SLOVTRANSGAZ, závod Veľké Zlievce	1.99	Slovenské magnezitové závody, a.s., Jelšava	0.61
10	CHEMES, a.s., Humenné	0.75	SIDERIT Nižná Slaná	1.50	Slovenské magnezitové závody, a.s., Jelšava	1.62	Calmit, s.r.o. Bratislava, prev. Margecany	0.61
11	Dolvap, s.r.o., Varín, Kameňolom a vápenka	0.68	CHEMES, a.s., Humenné	1.39	Považská cementáreň, a.s., Ladce	1.56	Calmit, s.r.o. Bratislava, prev. Tisovec	0.59
12	Žilinská teplárenská, a.s., Žilina	0.61	Tepláreň Košice a.s., Košice	1.35	Severoslov. celulózky a papierne, a.s., Ružomberok	1.46	KOVOHUTY, a.s., Krompachy	0.50
13	Považská cementáreň, a.s., Ladce	0.53	SLOVALCO, a.s. Žiar nad Hronom	1.35	CEMMAC, a.s., Horné Sŕnie	1.44	Kameňolom a vápenka, a.s. Žirany	0.45
14	Slovenské magnezitové závody, a.s., Jelšava	0.50	Duslo, a.s., Šaľa	1.21	BUKOCEL, a.s., Hencovce	1.40	SE, a.s., Bratislava, Elektráreň Vojany I a II	0.44
15	KVARTET Partizánske	0.50	Martinská teplárenská, a.s., Martin	1.19	Slovenský plynárenský priemysel,a.s., Rožňava	1.39	SLOVNAFT, a.s., Bratislava	0.38
16	HOLCIM (Slovensko), a.s., Rohožník	0.46	Severoslov. celulózky a papierne, a.s., Ružomberok	1.19	VETROPACK Nemšová, s.r.o.	1.32	SE, a.s., Bratislava, o.z. ENO Zemianske Kostoľany	0.38
17	KRONOSPAN SLOVAKIA, s.r.o., Prešov	0.44	ŽELBA, a.s., o.z. Siderit, Nižná Slaná	1.11	Duslo, a.s., Šaľa	1.30	Wienerberger Slov.tehelne s.r.o.,Zlaté Moravce	0.31
18	SLOVALCO, a.s. Žiar nad Hronom	0.43	MAYTEX, a.s., Liptovský Mikuláš	0.70	Žilinská teplárenská, a.s., Žilina	1.21	CENON, s.r.o., Strážske	0.27
19	Carmeuse Slovakia s.r.o., Dvorníky- Včeláre	0.42	Handlovská energetika, s.r.o., Handlová	0.60	CHEMES, a.s., Humenné	1.20	Wienerberger Slov.tehelne s.r.o., závod Boleráz	0.27
20	Kappa Štúrovo a.s.	0.42	KVARTET Partizánske	0.54	SPP, š.p., Bratislava, závod Ivanka pri Nitre	1.08	IZOMAT, a.s., Nová Baňa	0.21
Total		81.53		92.90		76.02		92.27

Tab. 4.5 **Sequence of the sources within the region according to the amount of emissions - 2003**

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	ISTROCHEM, a.s., Bratislava	Bratislava III
3.	Swedwood Slovakia, s.r.o., o.z. Malacky	Malacky	HOLCIM (Slovensko), a.s., Rohožník	Malacky
4.	Paroplynový cyklus, a.s., Bratislava	Bratislava III	Bratislavská teplárenská a.s. Bratislava	Bratislava II
5.	VOLKSWAGEN SLOVAKIA, a.s., Bratislava	Bratislava IV	Bratislavská vodárenská spoločnosť Bratislava	Bratislava V
6.	HASIT SLOVAKIA, s.r.o., Lozorno	Malacky	VÚ 1238 - PSB Nitra	Pezinok
7.	Bratislavská teplárenská a.s., Bratislava	Bratislava III	Fakultná nemocnica Bratislava	Bratislava I
8.	Fakultná nemocnica Bratislava	Bratislava I	Stredná odborná škola policajného zboru Pezinok	Pezinok
9.	Bratislavská teplárenská, a.s., tepláreň západ	Bratislava IV	Odvoz a likvidácia odpadu, a.s., Bratislava	Bratislava II
10.	VÚ 1238 - PSB Nitra	Pezinok	VÚ Kuchyňa-posádková správa budov Kuchyňa	Malacky
	NOx		**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.	Paroplynový cyklus, a.s., Bratislava	Bratislava III	Swedwood Slovakia, s.r.o., o.z., Malacky,	Malacky
4.	Odvoz a likvidácia odpadu, a.s., Bratislava	Bratislava II	VOLKSWAGEN SLOVAKIA, a.s.,Bratislava	Bratislava IV
5.	VOLKSWAGEN SLOVAKIA, a.s., Bratislava	Bratislava IV	Paroplynový cyklus, a.s., Bratislava	Bratislava III
6.	Bratislavská teplárenská a.s., Bratislava	Bratislava III	Bratislavská teplárenská, a.s., Bratislava	Bratislava III
7.	Bratislavská teplárenská a.s., tepláreň západ	Bratislava IV	Bratislavská teplárenská a.s, tepláreň západ	Bratislava IV
8.	NAFTA GAS, a.s., Malacky	Malacky	ISTROCHEM, a.s., Bratislava	Bratislava III
9.	Swedwood Slovakia, s.r.o., o.z., Malacky	Malacky	Slovenská Grafia, a.s., Bratislava	Bratislava III
10.	TECHNICKÉ SKLO, a.s., Bratislava	Bratislava IV	VÚ Kuchyňa-posádková správa budov Kuchyňa	Malacky

TRNAVA REGION

	PM		SO_2	
	Source	District	Source	District
1.	Eastern Sugar Slovensko,a.s., Dunajská Streda	Dunajská Streda	Eastern Sugar Slovensko,a.s., Dunajská Streda	Dunajská Streda
2.	AMYLUM SLOVAKIA, s.r.o., Boleráz	Trnava	CUKROVAR NOVA, a.s., Sereď	Galanta
3.	Zlieváreň Trnava, s.r.o.	Trnava	JM SKLOPLAST, a. s. Trnava	Trnava
4.	Liehovar Krystal Sedín,s.r.o.	Galanta	Slovenský hodváb, a.s., Senica	Senica
5.	ŽOS Trnava, a. s.,	Trnava	Wienerberger Slov. tehelne s.r.o., závod Boleráz	Trnava
6.	TRNAVSKÝ CUKROVAR, a. s., Trnava	Trnava	Liehovar Krystal Sedín,s.r.o.	Galanta
7.	JM SKLOPLAST, a. s., Trnava	Trnava	Baňa Záhorie, Holíč, stredisko Čáry	Senica
8.	Poľnohospodárske družstvo Jaslovské Bohunice	Trnava	PD Siladice	Hlohovec
9.	Slovenský hodváb, a.s., Senica	Senica	Zlieváreň Trnava, s.r.o.	Trnava
10.	Mach-Trade Bratislava, prev. Sereď	Galanta	Technické služby mesta Galanta	Galanta
	NOx		**CO**	
	Source	District	Source	District
1.	JM SKLOPLAST, a. s., Trnava	Trnava	Wienerberger Slov.tehelne s.r.o., závod Boleráz	Trnava
2.	Eastern Sugar Slovensko,a.s., Dunajská Streda	Dunajská Streda	Zlieváreň Trnava, s.r.o.	Trnava
3.	AMYLUM SLOVAKIA, s.r.o., Boleráz	Trnava	Drôtovňa Drôty, a.s., Hlohovec	Hlohovec
4.	CUKROVAR NOVA, a.s., Sereď	Galanta	JM SKLOPLAST, a. s., Trnava	Trnava
5.	Slovenský hodváb, a.s., Senica	Senica	INA Skalica, s r.o., Skalica	Skalica
6.	Trnavská teplárenská a.s., Trnava	Trnava	Liehovar Krystal Sedín,s.r.o.	Galanta
7.	SWEDWOOD SLOVAKIA, s.r.o., o.z. Trnava	Trnava	Eastern Sugar Slovensko,a.s., Dunajská Streda	Dunajská Streda
8.	TRNAVSKÝ CUKROVAR, a. s., Trnava	Trnava	Medea-S, s.r.o. ,Sládkovičovo	Galanta
9.	SOUTHERM, s.r.o., Dunajská Streda	Dunajská Streda	TRNAVSKÝ CUKROVAR, a. s., Trnava	Trnava
10.	Drôtovňa Drôty, a.s., Hlohovec	Hlohovec	AMYLUM SLOVAKIA, s.r.o., Boleráz	Trnava

NITRA REGION

	PM		SO_2	
	Source	District	Source	District
1.	Duslo, a.s., Šaľa	Šaľa	Kappa Štúrovo, a.s.	Nové Zámky
2.	Kappa Štúrovo a.s.	Nové Zámky	Duslo, a.s., Šaľa	Šaľa
3.	Kameňolom a vápenka, a.s. Žirany	Nitra	JCP IZOLÁCIE, a.s., Štúrovo	Nové Zámky
4.	SES REAL, a.s., Tlmače	Levice	Železničná spoločnosť, a.s., Bratislava	Nové Zámky
5.	Lencos s.r.o., Levice	Levice	SES REAL, a.s., Tlmače	Levice
6.	SES ,a.s. ,Tlmače	Levice	Energo – Bytos s.r.o., Levice	Levice
7.	PTZ Levice, s.r.o	Levice	Posádková správa budov Štúrovo	Nové Zámky
8.	ELEKTROKARBON a.s., Topoľčany	Topoľčany	PTZ Levice, s.r.o	Levice
9.	Kameňolomy a štrkopieskovne, lom Pohranice	Nitra	FERRENIT, a.s., Nitra	Nitra
10.	CERAM ČAB akciová spoločnosť Čab	Nitra	SES a.s. Tlmače	Levice
	NOx		**CO**	
	Source	District	Source	District
1.	Kappa Štúrovo a.s.	Nové Zámky	Kameňolom a vápenka, a.s. Žirany	Nitra
2.	Duslo, a.s. Šaľa	Šaľa	Wienerberger Slov.tehelne s.r.o., Zlaté Moravce	Zlaté Moravce
3.	SPP, a.s., Bratislava, závod Ivanka pri Nitre	Nitra	Kappa Štúrovo, a.s. Štúrovo	Nové Zámky
4.	Nitrianska teplárenská spoločnosť Nitra	Nitra	SES , a.s., Tlmače	Levice
5.	Bytkomfort s.r.o.Nové Zámky	Nové Zámky	Duslo, a.s., Šaľa	Šaľa
6.	Leven a.s., Levice	Levice	DANFOSS COMPRESSORS, s.r.o., Zlaté Moravce	Zlaté Moravce
7.	OPM1SR Nitra	Nitra	SPP, a.s., Bratislava, závod Ivanka pri Nitre	Nitra
8.	SES a.s. Tlmače	Levice	DECODOM Topoľčany	Topoľčany
9.	DECODOM Topoľčany	Topoľčany	PTZ Levice, s.r.o	Levice
10.	TOMA s.r.o. Topoľčany	Topoľčany	RED COLLIN, Kamenná	Topoľčany

TRENČÍN REGION

	PM		SO_2	
	Source	District	Source	District
1.	SE, a.s., Bratislava, o.z., ENO Zemianske Kostoľany	Prievidza	SE, a.s., Bratislava, o.z., ENO Zemianske Kostoľany	Prievidza
2.	Novácke chemické závody, a.s., Nováky	Prievidza	Handlovská energetika, s.r.o., Handlová	Prievidza
3.	Považská cementáreň, a.s., Ladce	Ilava	KVARTET Partizánske	Partizánske
4.	KVARTET Partizánske	Partizánske	MATADOR, a.s., Púchov	Púchov
5.	DNV -ENERGO, Dubnica n.Váhom	Ilava	HBP, a.s., Baňa Nováky , o.z. Nováky	Prievidza
6.	PASINVEST v konkurze, Partizánske	Partizánske	PASINVEST v konkurze, Partizánske	Partizánske
7.	HBP, a.s., Baňa Nováky	Prievidza	Tepláreň, a.s., Považská Bystrica	Považská
8.	VETROPACK Nemšová, s.r.o.	Trenčín	VETROPACK Nemšová, s.r.o.	Trenčín
9.	CEMMAC, a.s., Horné Sŕnie	Trenčín	TSM,s.r.o., Partizánske	Partizánske
10.	HBP, a.s., Baňa Handlová	Prievidza	Syenit a.s., Púchov	Púchov
	NOx		**CO**	
	Source	District	Source	District
1.	SE, a.s., Bratislava, o.z., ENO Zemianske Kostoľany	Prievidza	CEMMAC, a.s., Horné Sŕnie	Trenčín
2.	Považská cementáreň, a.s., Ladce	Ilava	SE, a.s., Bratislava, o.z. ENO Zemianske Kostoľany	Prievidza
3.	CEMMAC, a.s., Horné Sŕnie	Trenčín	KVARTET Partizánske	Partizánske
4.	VETROPACK NEMŠOVÁ, S.R.O.	Trenčín	Považská cementáreň, a.s., Ladce	Ilava
5.	RONA a.s. Lednické Rovne	Púchov	PASINVEST v konkurze, Partizánske	Partizánske
6.	Novácke chemické závody, a.s., Nováky	Prievidza	Novácke chemické závody, a.s., Nováky	Prievidza
7.	MATADOR, a.s., Púchov	Púchov	Linea - D, Bánovce n.Bebravou	Bánovce n. Bebr.
8.	KVARTET Partizánske	Partizánske	TSM,s.r.o., Partizánske	Partizánske
9.	Tepláreň, a.s., Považská Bystrica	Považská Bystrica	HBP, a.s., Baňa Nováky	Prievidza
10.	Handlovská energetika, s.r.o., Handlová	Prievidza	Tepláreň, a.s., Považská Bystrica	Považská Bystrica

BANSKÁ BYSTRICA REGION

	PM		SO_2	
	Source	District	Source	District
1.	Slovenské magnezitové závody, a.s., Jelšava	Revúca	Zvolenská teplárenská a.s., Zvolen	Zvolen
2.	SLOVALCO, a.s., Žiar nad Hronom	Žiar nad Hronom	SLOVALCO, a.s., Žiar nad Hronom	Žiar nad Hronom
3.	Calmit, s.r.o., Bratislava	Rimavská Sobota	ZSNP, a.s, Žiar nad Hronom	Žiar nad Hronom
4.	ANB, a.s. , prevádzka Žarnovica	Žarnovica	Slovenské magnezitové závody, a.s., Jelšava	Revúca
5.	SLOVMAG, a.s., Lubeník	Revúca	SLOVMAG, a.s., Lubeník	Revúca
6.	Zvolenská teplárenská a.s., Zvolen	Zvolen	IZOMAT, a.s., Nová Baňa	Žarnovica
7.	Bučina, a.s., Zvolen	Zvolen	PETROCHEMA, a.s., Dubová	Brezno
8.	Lovinit, a.s., Lovinobaňa	Lučenec	Lovinit, a.s., Lovinobaňa	Lučenec
9.	IZOMAT, a.s., Nová Baňa	Žarnovica	BAŇA DOLINA, a.s, Veľký Krtíš	Veľký Krtíš
10.	Smrečina Holding, a.s.,Banská Bystrica	Banská Bystrica	ÚS MV SR Slovenská Ľupča	Banská Bystrica
	NOx		**CO**	
	Source	District	Source	District
1.	SPP, a.s., SLOVTRANSGAZ, závod Veľké Zlievce	Veľký Krtíš	SLOVALCO, a.s., Žiar nad Hronom	Žiar nad Hronom
2.	Slovenské magnezitové závody, a.s., Jelšava	Revúca	SLOVMAG, a.s., Lubeník	Revúca
3.	SLOVALCO, a.s. Žiar nad Hronom	Žiar nad Hronom	Slovenské magnezitové závody, a.s., Jelšava	Revúca
4.	Zvolenská teplárenská a.s., Zvolen	Zvolen	Calmit, s.r.o., Bratislava	Rimavská Sobota
5.	SLOVMAG, a.s., Lubeník	Revúca	IZOMAT, a.s., Nová Baňa	Žarnovica
6.	ZSNP, a.s, Žiar nad Hronom	Žiar nad Hronom	ŽIAROMAT, a. s., Kalinovo	Poltár
7.	Slovglass, a.s., Poltár	Poltár	ZSNP, a.s, Žiar nad Hronom	Žiar nad Hronom
8.	Železiarne Podbrezová, a.s.	Brezno	Železiarne Podbrezová, a.s.	Brezno
9.	Bučina, a.s., Zvolen	Zvolen	SPP, a.s., SLOVTRANSGAZ, závod Veľké Zlievce	Veľký Krtíš
10.	ANB, a.s. , prevádzka Žarnovica	Žarnovica	Bloomsbury pacific Slovakia-Novoker Lučenec	Lučenec

ŽILINA REGION

	PM		SO_2	
	Source	District	Source	District
1.	Severoslov. celulózky a papierne, a.s., Ružomberok	Ružomberok	Žilinská teplárenská, a.s., Žilina	Žilina
2.	Dolvap, s.r.o., Varín, Kameňolom a vápenka	Žilina	Martinská teplárenská, a.s., Martin	Martin
3.	Žilinská teplárenská, a.s., Žilina	Žilina	Severoslov. celulózky a papierne, a.s., Ružomberok	Ružomberok
4.	ŽOS, a.s, Vrútky	Martin	MAYTEX, a.s., Liptovský Mikuláš	Liptovský Mikuláš
5.	SOTE, s.r.o.,výhrevňa Sihly	Čadca	OFZ, a.s., Istebné	Dolný Kubín
6.	ZŤS Strojárne, a.s., Námestovo	Námestovo	ŽOS, a.s, Vrútky	Martin
7.	OFZ, a.s., Istebné	Dolný Kubín	SOTE, s.r.o.,výhrevňa Sihly	Čadca
8.	Ľudová tvorba, Veľké Rovné	Bytča	Ružomberská energetická spoločnosť Ružomberok	Ružomberok
9.	Automobilová výroba Čadca	Čadca	ZŤS Strojárne, a.s., Námestovo	Námestovo
10.	Martinská teplárenská, a.s., Martin	Martin	ENERGODIT, s.r.o., Liptovský Mikuláš	Liptovský Mikuláš
	NOx		**CO**	
	Source	District	Source	District
1.	Severoslov. celulózky a papierne, a.s., Ružomberok	Ružomberok	Dolvap, s.r.o., Varín, Kameňolom a vápenka	Žilina
2.	Žilinská teplárenská, a.s., Žilina	Žilina	OFZ, a.s., Istebné	Dolný Kubín
3.	OFZ, a.s., Istebné	Dolný Kubín	STP s.r.o. Martin	Martin
4.	Martinská teplárenská, a.s., Martin	Martin	STP Ružomberok, s r.o.	Ružomberok
5.	Slovenská. paroplynová spol., a.s., Ružomberok	Ružomberok	SOTE, s.r.o., výhrevňa Sihly	Čadca
6.	MAYTEX, a.s., Liptovský Mikuláš	Liptovský Mikuláš	ŽOS, a.s, Vrútky	Martin
7.	SPECIALITY MINERALS SLOVAKIA, Ružomberok	Ružomberok	Žilinská teplárenská, a.s., Žilina	Žilina
8.	AQUACHEMIA,s.r.o., Žilina	Žilina	ZŤS Strojárne, a.s., Námestovo	Námestovo
9.	Ružomberská energetická spoločnosť, a.s.	Ružomberok	Severoslov. celulózky a papierne, a.s., Ružomberok	Ružomberok
10.	SOTE, s.r.o.,výhrevňa Sihly	Čadca	Turzovská drevárska fabrika Makov	Čadca

PREŠOV REGION

	PM		SO_2	
	Source	District	Source	District
1.	BUKOCEL, a.s., Hencovce	Vranov nad Topľou	BUKOCEL, a.s., Hencovce	Vranov nad Topľou
2.	CHEMES, a.s., Humenné	Humenné	CHEMES, a.s., Humenné	Humenné
3.	KRONOSPAN SLOVAKIA, s.r.o., Prešov	Prešov	Vihorlat, s.r.o., Snina	Snina
4.	Vihorlat s.r.o. Snina	Snina	Zeocem Bystré	Vranov nad Topľou
5.	Bukoza Preglejka a.s., Hencovce	Vranov nad Topľou	TP real, s r.o., Hrabušice	Poprad
6.	TATRAVAGÓNKA, a.s., Poprad	Poprad	Posádková správa budov Prešov	Prešov
7.	TP real, s r.o., Hrabušice	Poprad	TESLA, Stará Ľubovňa	Stará Ľubovňa
8.	Posádková správa budov Prešov	Prešov	SAD, a.s. Poprad-prevádzkáreň Kežmarok	Poprad
9.	Legno Export , s r.o., Beňadikovce	Svidník	Ekop Prešov, s.r.o	Vranov nad Topľou
10.	Zeocem Bystré	Vranov nad Topľou	EUROKOV Orlov	Stará Ľubovňa
	NOx		**CO**	
	Source	District	Source	District
1.	BUKOCEL, a.s., Hencovce	Vranov nad Topľou	BUKOCEL, a.s., Hencovce	Vranov nad Topľou
2.	CHEMES, a.s., Humenné	Humenné	Vihorlat s.r.o. Snina	Snina
3.	Vihorlat, s.r.o., Snina	Snina	KRONOSPAN SLOVAKIA, s.r.o., Prešov	Prešov
4.	KRONOSPAN SLOVAKIA, s.r.o., Prešov	Prešov	CHEMES, a.s., Humenné	Humenné
5.	Dalkia, a.s.,Poprad	Poprad	Posádková správa budov Prešov	Prešov
6.	Chemosvit-Energochem, a.s., Svit	Poprad	SCOTTISH WOODLANDS SLOVAKIA, Dlhé n. Cir.	Snina
7.	Pivovar Šariš, a.s. Veľký Šariš	Prešov	Posádková správa budov Michalovce	Humenné
8.	TATRAVAGÓNKA, a.s., Poprad	Poprad	CHEMOSVIT STROJCHEM, a.s., SVIT	Poprad
9.	Nemocnica s poliklinikou J.A. Reimana, Prešov	Prešov	SLOV-VIA a.s. Poprad	Poprad
10.	Tepláreň Košic,e a.s., tepláreň Prešov	Prešov	Ekop Prešov, s.r.o	Vranov nad Topľou

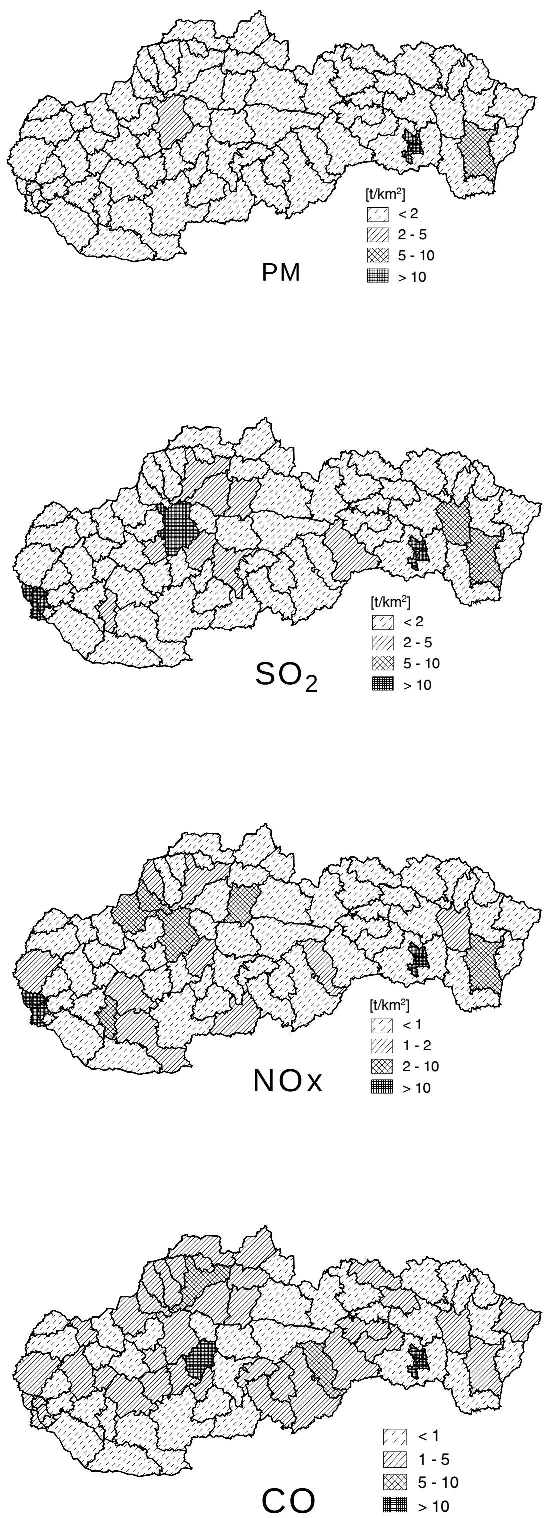
KOŠICE REGION

	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.	SE, a.s., Bratislava, Elektráreň Vojany I a II	Michalovce	SE, a.s., Bratislava, Elektráreň Vojany I a II	Michalovce
3.	Carmeuse Slovakia, s.r.o., Košice	Košice II	ENERGETIKA s.r.o., Strážske	Michalovce
4.	Carmeuse Slovakia, s.r.o., Dvorníky - Včeláre	Košice - okolie	SIDERIT Nižná Slaná	Rožňava
5.	Tepláreň Košice, a.s.	Košice IV	Tepláreň Košice, a.s.	Košice IV
6.	VSH, a.s., Turňa nad Bodvou	Košice - okolie	ŽELBA, a.s., o.z. Siderit, Nižná Slaná	Rožňava
7.	Železničná spoločnosť a.s. Bratislava, depo Košice	Košice IV	Slovenské magnezitové závody a.s., Jelšava	Košice II
8.	SIDERIT Nižná Slaná	Rožňava	KOSIT, a.s.,Spaľovňa odpadov,Krásna nadHornádom	Košice IV
9.	Slovenské magnezitové závody a.s., Jelšava	Košice II	KOVOHUTY, a.s. Krompachy	Spišská Nová Ves
10.	KERKO Michalovce	Michalovce	Železničná spoločnosť a.s. Bratislava, depo Košice	Košice IV
	NOx		**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	Calmit, s.r.o., Bratislava	Gelnica
3.	Tepláreň Košice, a.s.	Košice IV	KOVOHUTY, a.s. Krompachy	Spišská Nová Ves
4.	SPP, a.s., závod Veľké Kapušany	Michalovce	SE, a.s., Bratislava, Elektráreň Vojany I a II	Michalovce
5.	Slovenský plynárenský priemysel, a.s., Rožňava	Rožňava	CENON, s.r.o., Strážske	Michalovce
6.	VSH, a.s., Turňa nad Bodvou	Košice - okolie	HNOJIVÁ, a.s., Strážske	Michalovce
7.	Carmeuse Slovakia, s.r.o., Košice	Košice II	Slovenské magnezitové závody a.s., Jelšava	Košice II
8.	ENERGETIKA, s.r.o., Strážske	Michalovce	Slovenský plynárenský priemysel,a.s., Rožňava	Rožňava
9.	Slovenské magnezitové závody a.s., Jelšava	Košice II	SPP, a.s., závod Veľké Kapušany	Michalovce
10.	KOSIT, a.s.,Spaľovňa odpadov,Krásna nad Hornádom	Košice IV	Zlieváreň SEZ Krompachy, a.s.	Spišská Nová Ves

Tab. 4.6 **Stationary source emissions by districts in 2003**

District	Emissions [t/year]				Specific territorial emis. [t/year.km²]			
	PM	SO_2	NO_x	CO	PM	SO_2	NO_x	CO
1. Bratislava	482	12263	5414	1204	1.31	33.32	14.71	3.27
2. Malacky	315	88	1393	2459	0.33	0.09	1.47	2.59
3. Pezinok	81	40	106	170	0.21	0.11	0.28	0.45
4. Senec	70	21	90	161	0.19	0.06	0.25	0.44
5. Dunajská Streda	298	365	336	558	0.28	0.34	0.31	0.52
6. Galanta	188	323	271	405	0.29	0.50	0.42	0.63
7. Hlohovec	88	34	101	331	0.33	0.13	0.38	1.24
8. Piešťany	157	54	135	311	0.41	0.14	0.35	0.82
9. Senica	228	119	188	453	0.33	0.17	0.27	0.66
10. Skalica	142	51	91	324	0.40	0.14	0.25	0.90
11. Trnava	224	131	549	1014	0.30	0.18	0.74	1.37
12. Bánovce n/B	170	62	83	370	0.37	0.13	0.18	0.80
13. Ilava	359	125	970	606	1.00	0.35	2.70	1.69
14. Myjava	232	83	89	423	0.71	0.25	0.27	1.30
15. Nové Mesto n/V	225	83	146	436	0.39	0.14	0.25	0.75
16. Partizánske	298	852	211	680	0.99	2.83	0.70	2.26
17. Považská Bystrica	406	272	229	808	0.88	0.59	0.50	1.74
18. Prievidza	1931	43823	6141	1721	2.01	45.65	6.40	1.79
19. Púchov	379	476	646	688	1.01	1.27	1.72	1.84
20. Trenčín	332	274	1682	2070	0.49	0.41	2.50	3.08
21. Komárno	267	98	246	535	0.24	0.09	0.22	0.49
22. Levice	741	293	350	1427	0.48	0.19	0.23	0.92
23. Nitra	318	98	915	1280	0.36	0.11	1.05	1.47
24. Nové Zámky	501	1817	1447	981	0.37	1.35	1.07	0.73
25. Šaľa	342	1228	760	237	0.96	3.45	2.14	0.67
26. Topoľčany	148	58	170	325	0.25	0.10	0.28	0.54
27. Zlaté Moravce	161	56	105	830	0.31	0.11	0.20	1.59
28. Bytča	296	129	103	519	1.05	0.46	0.37	1.84
29. Čadca	902	501	321	1724	1.19	0.66	0.42	2.27
30. Dolný Kubín	267	397	446	2319	0.54	0.81	0.91	4.73
31. Kysucké Nové Mesto	176	58	81	311	1.01	0.33	0.47	1.79
32. Liptovský Mikuláš	477	990	381	874	0.36	0.75	0.29	0.66
33. Martin	449	1483	513	998	0.61	2.02	0.70	1.36
34. Námestovo	910	517	228	1484	1.32	0.75	0.33	2.15
35. Ružomberok	699	1530	1294	1070	1.08	2.37	2.00	1.65
36. Turčianske Teplice	148	51	49	266	0.38	0.13	0.12	0.68
37. Tvrdošín	138	60	74	261	0.29	0.12	0.15	0.54
38. Žilina	882	1929	993	6634	1.08	2.37	1.22	8.14
39. Banská Bystrica	465	176	359	792	0.57	0.22	0.44	0.98
40. Banská Štiavnica	174	66	59	311	0.63	0.24	0.21	1.12
41. Brezno	532	351	312	1057	0.42	0.28	0.25	0.84
42. Detva	282	102	99	518	0.59	0.22	0.21	1.09
43. Krupina	247	92	79	462	0.42	0.16	0.13	0.79
44. Lučenec	529	242	275	947	0.69	0.31	0.36	1.23
45. Poltár	155	95	255	553	0.31	0.19	0.50	1.10
46. Revúca	516	636	1246	4124	0.71	0.87	1.71	5.65
47. Rimavská Sobota	854	297	309	2277	0.58	0.20	0.21	1.55
48. Veľký Krtíš	354	176	1147	729	0.42	0.21	1.35	0.86
49. Zvolen	390	3546	680	658	0.51	4.67	0.90	0.87
50. Žarnovica	417	292	208	920	0.98	0.69	0.49	2.16
51. Žiar n/H	432	1914	818	12380	0.81	3.60	1.54	23.27
52. Bardejov	277	96	140	513	0.30	0.10	0.15	0.55
53. Humenné	407	1459	715	613	0.54	1.93	0.95	0.81
54. Kežmarok	295	112	128	558	0.35	0.13	0.15	0.66
55. Levoča	144	54	63	274	0.40	0.15	0.18	0.77
56. Medzilaborce	120	42	40	219	0.28	0.10	0.09	0.51
57. Poprad	228	92	239	455	0.20	0.08	0.21	0.40
58. Prešov	438	127	401	919	0.47	0.14	0.43	0.98
59. Sabinov	278	101	117	543	0.57	0.21	0.24	1.12
60. Snina	351	378	282	856	0.44	0.47	0.35	1.06
61. Stará Ľubovňa	369	155	126	688	0.59	0.25	0.20	1.10
62. Stropkov	96	34	42	176	0.25	0.09	0.11	0.45
63. Svidník	202	62	80	350	0.37	0.11	0.14	0.64
64. Vranov n/T	461	4007	852	2633	0.60	5.21	1.11	3.42
65. Gelnica	304	111	99	1450	0.52	0.19	0.17	2.48
66. Košice	9890	10781	12343	104600	40.37	44.01	50.38	426.94
67. Košice - okolie	714	227	733	1134	0.47	0.15	0.48	0.74
68. Michalovce	5994	5471	7548	1748	5.88	5.37	7.41	1.72
69. Rožňava	687	2834	1011	1372	0.59	2.42	0.86	1.17
70. Sobrance	119	47	54	213	0.22	0.09	0.10	0.40
71. Spišská Nová Ves	281	159	171	1418	0.48	0.27	0.29	2.42
72. Trebišov	299	119	209	526	0.28	0.11	0.19	0.49
Slovakia	41725	105287	58581	184252	0.85	2.15	1.20	3.76

Fig. 4.3 **Specific territorial emission - 2003**



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

Sektor / Subsektor	1990	1993	1995	1996	1997	1998	1999	2000	2001	2002
Combustion on energy and transformation industries	335	276	258	257	247	265	228	201	221	215
Public power	223	190	187	189	182	192	166	139	159	147
District heating plants	112	86	71	68	65	73	62	62	62	67
Non-industrial combustion plants	9 576	5 496	3 095	3 590	2 761	2 761	2 761	2 899	2 590	1 505
Commercial and institutional plants	226	226	150	134	134	134	134	33	34	32
Agriculture	IE	IE	IE	IE	IE	IE	IE	14	15	1 459
Residential plants	9 349	5 270	2 945	3 457	2 627	2 627	2 627	2 853	2 541	15
Combustion in manufacturing industry	1 171	1 169	1 083	1 270	1 291	993	632	868	850	685
Comb. in boilers, gas turb. and stat. engines	206	152	150	152	144	126	124	159	231	147
Iron production	32	29	29	26	28	25	27	29	29	32
Ore aglomeration	628	500	635	582	601	443	462	679	480	421
Copper production	305	488	268	510	518	399	19	2	109	85
Production processes	145 554	60 853	66 111	72 898	55 704	53 483	55 057	19 341	20 829	19 540
Processes in petroleum industries	17 188	12 119	7 474	8 359	7 717	7 960	6 563	6 627	6 306	5 571
Coke production	1 053	844	834	769	779	640	681	719	719	765
Steel production	43	35	36	31	31	32	33	34	37	40
Rolling mills	233	250	297	283	301	290	304	300	267	304
Aluminium production	0.101	0.058	0.049	0.167	0.165	0.162	0.164	0.160	0.170	0.165
Proc. in organic chemical industries	6 437	3 519	1 369	1 386	1 364	870	785	651	644	690
Food production	3 224	3 233	2 359	2 252	2 567	1 590	1 546	1 538	1 556	1 556
Road paving with asphalt	117 376	40 852	53 742	59 818	42 944	42 101	45 145	9 471	11 300	10 615
Exploitation&distrib. of natural resources	8 822	8 868	8 535	8 104	9 336	5 854	6 606	5 929	6 156	6 018
Exploitation&distribution of crude oil	5 198	5 194	4 298	4 296	3 803	3 801	4 193	3 750	3 848	3 801
Distribution of fuel	3 624	3 674	4 237	3 808	5 533	2 053	2 412	2 179	2 307	2 217
Solvent and other products use	48 071	38 301	41 166	39 781	30 762	32 221	29 429	29 063	30 515	30 796
Use of paints and glues	32 811	19 349	20 687	19 122	15 653	16 035	14 365	13 214	14 025	15 110
Dry cleaning and degreasing	6 650	10 366	11 838	12 108	6 498	7 563	6 483	7 273	8 021	7 167
Processing of fat and oil	332	308	363	273	332	345	303	299	191	240
Products	8 278	8 278	8 278	8 278	8 278	8 278	8 278	8 278	8 278	8 278
Road traffic	32 611	30 332	32 373	31 235	31 456	31 238	28 502	24 479	26 079	26 755
Other traffic	953	543	599	609	584	659	571	528	524	500
Waste treatment and disposal	4 538	1 339	259	147	153	226	180	208	180	163
Incineration of municipal waste	102	102	102	59	77	98	95	133	93	75
Incineration of Industrial waste	157	157	157	74	67	122	79	66	81	81
Incineration of hospital waste	IE	IE	IE	14	9	6	6	9	6	6
Agricultural waste*	4 279	1 080	–	–	–	–	–	–	–	–
Agriculture	651	436	436	436	436	436	436	436	436	436
Total	252 281	147 613	153 914	158 326	132 730	128 135	124 402	84 552	88 379	86 613

Emissions, as they were appointed to February 15, 2004

IE *included in other source category*

* *agricultural waste combustion is prohibited from the year 1994*

Because of changeover from EAPSI to NEIS in the year 2000 some changes of source appointment have to be done in the framework of subsectors Combustion in boilers…, Commercial and institutional plants and new subsector Agriculture (sector Non-industrial combustion plants) was established.

Tab. 4.8 **Emissions of persistent organic pollutants in the SR in 2002**

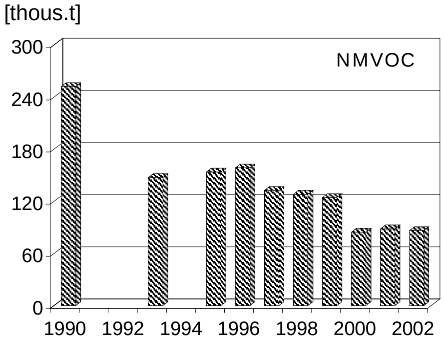
Sector / Subsector	PCDD/PCDF*	PCB	PAH				
			sum PAH	B(a)P	B(k)F	B(b)F	I(1,2,3-cd)P
	[g]	[kg]	[kg]	[kg]	[kg]	[kg]	[kg]
Combustion on energy and transformation industries	4.685	15.458	12528.597	4793.655	6799.734	425.214	509.994
Public power	4.022	14.479	0.260	0.015	0.108	0.108	0.029
District heating plants	0.272	0.979	0.281	0.002	0.138	0.138	0.003
Coke production	0.391		12528.057	4793.639	6799.488	424.968	509.962
Non-industrial combustion plants	4.231	5.487	1589.292	373.285	187.304	485.901	542.802
Commercial and institutional plants	0.161	0.361	0.396	0.017	0.148	0.203	0.027
Residential plants	4.022	5.041	1588.509	373.260	186.983	485.503	542.763
Agriculture	0.048	0.085	0.387	0.007	0.173	0.195	0.012
Combustion in manufacturing industry	34.338	28.386	581.272	175.087	30.656	298.658	76.872
Comb. in boilers, gas turb. and stat. eng.	1.925	6.911	28.124	0.075	13.954	13.959	0.135
Iron production	17.666		60.064	60.064			
Ore aglomeration	11.486	9.954	459.424	114.856		267.998	76.571
Pig iron production	0.061						
Others	3.200	11.521	33.660	0.092	16.702	16.702	0.166
Production processes	26.772	0.000	802.906	309.187	229.587	234.021	30.110
Aluminium production	0.220		403.124	131.776	127.383	127.383	16.582
Steel production	26.463		74.979	74.979			
Carbon mineral production	0.089	0.000	323.666	101.977	101.977	106.411	13.301
Wood impregnation			1.137	0.455	0.227	0.227	0.227
Road traffic	0.821	83.318	1100.150	275.083	164.870	385.116	275.083
Other traffic	0.042	0.833	98.943	24.740	14.827	34.636	24.740
Waste treatment and disposal	50.940	1.430	0.135	0.135			
Incineration of municipal waste	23.709	0.558	0.074	0.074			
Incineration of Industrial waste	22.301	0.811	0.057	0.057			
Incineration of hospital waste	4.929	0.060	0.004	0.004			
Total	121.829	134.912	16701.296	5951.171	7426.977	1863.547	1459.601

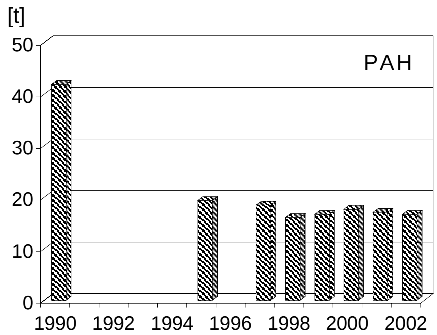
B(a)P - Benzo(a)pyrene, B(k)F - Benzo(k)fluorantene, B(b)F - Benzo(b)fluorantene, I(1,2,3-cd)P - Indeno(1,2,3-cd)pyrene

**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, as they were appointed to February 15, 2004

Fig. 4.4 **Development trends in NMVOC a PAH emissions**



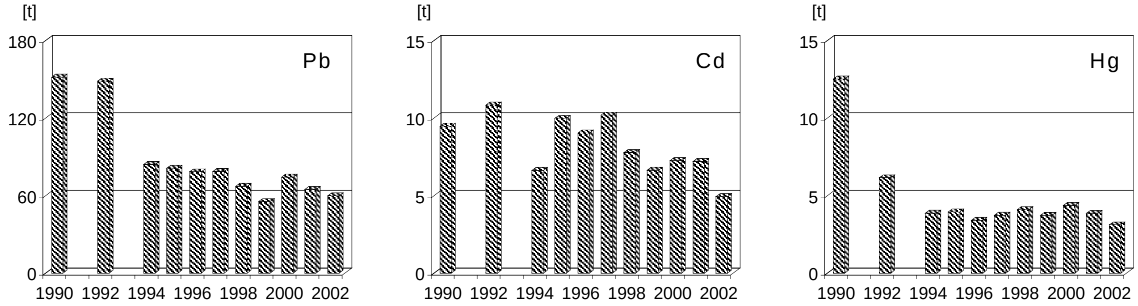


Tab. 4.9 **Emissions of heavy metals in the SR in 2002** [t]

Sector / Subsector	Pb	As	Cd	Cr	Cu	Hg	Ni	Se	Zn	Sn	Mn
Combustion on energy and transformation industries	0.414	1.180	0.016	0.784	0.702	0.028	0.836	0.159	0.906	0.140	4.251
Public power	0.381	1.139	0.015	0.764	0.686	0.026	0.744	0.155	0.853	0.137	4.117
District heating plants	0.033	0.041	0.001	0.020	0.016	0.002	0.092	0.003	0.053	0.003	0.134
Non-industrial combustion plants	0.522	2.216	0.020	0.735	0.684	0.023	0.685	0.047	1.202	0.174	7.451
Commercial and institutional plants	0.100	0.265	0.004	0.097	0.090	0.004	0.098	0.008	0.198	0.022	0.907
Residential plants	0.375	1.915	0.014	0.624	0.582	0.017	0.509	0.036	0.934	0.150	6.440
Agriculture	0.047	0.036	0.002	0.014	0.012	0.002	0.078	0.002	0.070	0.002	0.104
Combustion in manufacturing industry	47.378	7.969	4.336	2.787	15.011	2.237	12.496	6.826	29.252	1.524	6.616
Comb. in boilers, gas turb. and stat. engines	3.033	1.124	0.138	1.153	0.871	0.168	8.310	0.335	4.270	0.124	3.779
Iron production	0.120	0.011	0.191	0.908	0.071	0.304	3.024	0.039	7.564		
Glass production	15.679	2.484	3.959	0.601	0.150	0.013	0.476	4.506	2.53		
Ore agglomeration	25.977	0.643	0.015	0.084	8.538	1.690	0.655	1.206	13.591	0.976	2.837
Copper production	2.321	3.641	0.028		5.373	0.011		0.741	0.993	0.424	
Cement production	0.246	0.003	0.001	0.027		0.051	0.029		0.063		
Aluminium oxide production											
Magnesite production	0.003	0.064	0.004	0.014	0.009	0.0002	0.003		0.017		
Production processes	1.492	0.076	0.028	1.430	2.810	0.374	7.862	0.013	16.953	0.044	6.158
Steel production	1.217	0.066	0.013	0.154	2.404	0.013	2.430	0.013	5.072	0.044	1.010
Aluminium production			0.011				1.098		1.098		
Ferro alloys production	0.096	0.007	0.003	0.445	0.004		0.004		0.551		5.031
Pig iron production	0.074	0.003	0.002	0.012			0.006		0.052		0.023
Galvanizing	0.094			0.818	0.282		4.324		8.178		0.094
Alloys (Cu-Zn) production	0.012				0.120				2.002		
Inorganic chemical industry						0.361					
Road traffic	2.230		0.016	0.082	2.793		0.115	0.016	1.643		
Other traffic			0.001	0.004	0.142		0.006	0.001	0.083		
Waste treatment and disposal	7.792	0.010	0.525	0.516	0.915	0.455	0.293	0.007	3.621		
Incineration of municipal waste	4.742	0.005	0.263	0.474	0.653	0.190	0.285	0.001	1.791		
Incineration of Industrial waste	2.838	0.004	0.243	0.039	0.243	0.243	0.008	0.005	1.703		
Incineration of hospital waste	0.212	0.0003	0.018	0.003	0.018	0.018	0.0006	0.0004	0.127		
Cremation						0.004					
Total	59.829	11.450	4.943	6.338	23.057	3.117	22.293	7.068	53.661	1.883	24.476

Emissions, as they were appointed to February 15, 2004

Fig. 4.5 **Development trends in heavy metals emissions**



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 November 23, 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) plus the states of Central and Eastern Europe – known collectively as Annex I countries – committed themselves to adopting policies and measures aimed at returning their greenhouse gas (GHG) emissions to 1990 levels by the year 2000. This target was successfully executed.

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. Emissions targets for the post-2000 period are addressed by the Kyoto Protocol for the all Annex I countries. The Slovak Republic and the most countries of the Central and East Europe should reduce the total emissions of GHGs by 8 % until 2008 compared to the base year (1990) and hereby hold this level by 2008-2012. The Slovak Republic and the EU countries ratified the Kyoto protocol on May 31, 2002.[2]

In accordance with accession of the Slovak Republic into the EU (2004, May, 1) appeared new requirements for implementation of legislation in air protection. The European Union considers the area of climate change for the one of the four environmental priorities.[3]

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) con-

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

[2] *Kyoto protocol will come into force 90. day following the ratification by at least 55 countries, among them have to be included countries of Annex I contributing at least 55% to the total 1990 carbon dioxide emissions, as is listed in attachment B to the report 25 of the Protocol.*

[3] *New environmental action program: Environment 2010 Our Future, Our Choice*

tributes 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 Kyoto Protocol[2] 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.[4] 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.

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.

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[4] *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 (Congress of Parties), where the latest knowledge in association with the global warming is included.*

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 semi-conductors, 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

The emissions of greenhouse gas in the Slovak Republic are estimated in accordance with the requirements of UN FCCC[1] and the Kyoto Protocol.[2] 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 IPCC Guidelines[5] and Good Practice Guidance (GPG).[6]

Total anthropogenic emissions of greenhouse gases in the Slovak Republic [CO_2 equivalent (Tg)][7]

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CO_2	59.6	52.5	48.7	45.8	42.9	44.2	44.7	45.0	44.0	43.1	40.6	43.0	42.5
CH_4	6.5	6.0	5.6	5.2	5.1	5.2	5.3	5.0	4.7	4.6	4.5	4.6	4.7
N_2O	6.0	5.2	4.4	3.8	4.0	4.2	4.2	4.2	4.0	3.8	3.8	4.0	3.8
F-Gases	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
GHGs*	72.4	63.9	58.9	55.0	52.1	53.7	54.3	54.4	52.7	51.6	49.0	51.7	51.2

Emissions, as determinated to April 15, 2004 ** CO_2 emissions without LUC&F (Land Use Change & Forestry)*

CO_2 – carbon dioxide

Emissions

A most important anthropogenic source of CO_2 emissions in the atmosphere is combustion and transformation of fossil fuels (Table 5.1, Figure 5.1), which account for about 95 % 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.

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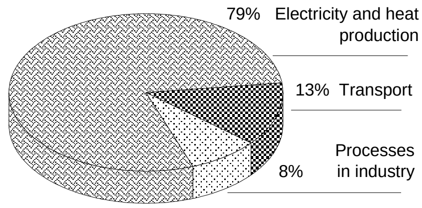
[5] *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventory, Volume 1-3*
[6] *Good Practice Guidance and Uncertainty Management in National GHGs Inventories, IPCC 2000*
[7] *According to the currently valid convention the emission reduction expressed in CO_2 equivalent should be reported*

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 1950-2002, 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.

Fig. 5.1 **CO_2 emissions in 2002**



Tab. 5.1 **Total emissions and sinks of CO_2 [Gg] within 1990-2002**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Anthropogenic emissions *	57 193	49 001	44 586	41 522	39 613	41 504	42 285	43 596	42 062	41 385	38 180	37 757	37 202
Net CO_2 emissions	59 619	52 477	48 714	45 788	42 900	44 187	44 712	45 007	43 998	43 036	40 623	43 021	42 479
Fossil fuel combustion	55 724	49 487	45 731	42 907	39 802	41 062	41 628	41 803	40 089	39 010	36 947	39 270	38 866
Electricity and heat production	50 653	45 257	41 785	39 016	35 682	36 685	37 186	37 196	35 136	34 191	32 628	34 377	33 276
Transport	5 071	4 230	3 946	3 891	4 120	4 377	4 442	4 607	4 953	4 819	4 319	4 893	5 590
Processes in industry	3 895	2 990	2 982	2 881	3 098	3 125	3 084	3 204	3 909	4 026	3 578	3 617	3 471
Mineral products	3 354	2 498	2 523	2 433	2 646	2 688	2 572	2 676	3 382	3 459	2 998	3 009	2 822
Forest ekosystems	-2 427	-3 476	-4 128	-4 266	-3 287	-2 683	-2 428	-1 411	-1 936	-1 651	-2 443	-5 265	-5 278
Changes in stock of wood mass	-1 753	-2 603	-3 333	-3 344	-2 479	-1 786	-1 734	-975	-1 474	-1 107	-1 410	-4 761	-4 779
Deforestation	141	130	129	128	126	119	111	111	131	125	113	115	117
Aforestation	-815	-1 003	-924	-1 050	-934	-1 016	-805	-547	-593	-669	-1 146	-619	-616
Waste	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	98	135	143
Burning biomass**	1 686	1 382	1 254	720	717	326	316	349	303	269	263	417	508

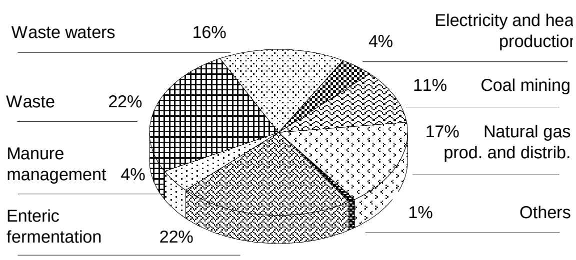
Emissions, as they were appointed to April 15, 2004

* *Emissions after subtraction of sinks in sector LUC&F (Land Use Change & Forestry)*

** *CO_2 emissions from biomass burning are not being accounted into the total emissions*

CH_4 – methane

Fig. 5.2 **CH_4 emissions in 2002**



Agriculture, large-scale beef cattle and pig breeding, are major sources of methane on our territory (Table 5.2, Figure 5.2). 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.

Tab. 5.2 **CH_4 emissions [Gg] within 1990-2002**

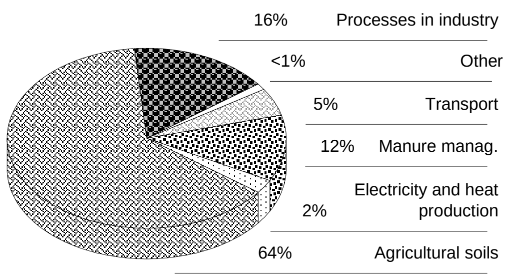
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total CH_4 emissions	309.8	287.2	264.6	246.8	241.3	149.4	253.4	239.6	222.3	220.0	214.5	219.2	224.8
Energetic	76.9	74.2	69.0	68.7	68.4	70.8	73.0	73.6	71.6	70.1	68.1	75.8	72.5
Fossil fuel combustion	17.4	15.0	13.4	11.7	10.9	9.7	9.7	9.5	8.9	8.8	8.2	12.0	10.9
Electricity and heat prod.	16.4	14.0	12.5	10.7	9.8	8.6	8.5	8.3	7.6	7.5	7.1	10.7	9.5
Transport	1.0	1.0	0.9	1.0	1.1	1.1	1.2	1.2	1.3	1.3	1.1	1.3	1.4
Fugitive emissions	59.4	59.3	55.6	57.0	57.5	61.1	63.3	64.1	62.7	61.3	59.8	63.9	61.6
Coal mining	24.2	25.6	24.6	24.8	25.4	26.3	26.9	27.4	27.7	25.1	24.5	24.0	23.6
Natural gas produc.&distrib.	35.2	33.7	31.0	32.2	32.1	34.8	36.4	36.7	35.0	36.2	35.3	39.9	38.0
Agriculture	133.8	116.6	101.1	87.3	81.9	86.9	80.3	74.1	65.2	63.2	62.4	61.9	59.2
Enteric fermentation	116.2	100.3	86.3	73.7	69.0	73.6	67.7	62.5	55.0	53.3	52.3	52.4	49.5
Manure management	17.6	16.3	14.8	13.6	12.9	13.3	12.6	11.6	10.2	9.9	10.1	9.5	9.7
Forest ecosystems	0.7	0.6	0.5	0.5	0.4	0.5	0.5	0.5	0.5	0.6	0.7	0.7	0.7
Biomass burning/forest fires	0.7	0.6	0.5	0.5	0.4	0.5	0.5	0.5	0.5	0.6	0.7	0.7	0.7
Waste	98.5	95.8	94.0	90.3	90.6	91.3	99.6	91.3	84.9	86.2	83.4	80.8	92.4
Solid waste disposal sites	50.3	50.3	50.3	50.3	50.3	50.9	59.6	51.0	45.8	46.6	48.3	45.4	56.9
Waste waters	48.2	45.5	43.7	40.0	40.3	40.4	40.0	40.3	39.1	39.6	35.1	35.4	35.5

Emissions, as they were appointed to April 15, 2004

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 unfavorable 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.[5,6] The N_2O emission, arising by manipulation of sewage and sludge has been estimated also for municipal and industrial waste water treatment plants (Table 5.3, Figure 5.3).

Fig. 5.3 **N_2O emissions in 2002**



Tab. 5.3 **N_2O emissions [Gg] within 1990-2002**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Emisie N_2O spolu	19.5	16.7	14.2	12.4	12.9	13.4	13.6	13.6	12.8	12.4	12.1	12.8	12.4
Fossil fuel combustion	0.8	0.7	0.6	0.6	0.7	0.8	0.8	0.8	0.9	0.8	0.8	0.9	0.9
Electricity and heat production	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
Transport	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6
Processes in industry	1.6	1.5	1.4	1.2	1.9	2.0	2.4	2.5	2.3	2.5	2.3	2.6	2.0
Agriculture	16.9	14.3	12.1	10.6	10.3	10.6	10.3	10.2	9.5	9.1	9.0	9.2	9.3
Manure management	3.5	3.2	2.8	2.4	2.2	2.4	2.2	2.0	1.7	1.7	1.6	1.6	1.5
Agricultural soils	13.4	11.1	9.3	8.2	8.1	8.2	8.1	8.2	7.8	7.4	7.4	7.6	7.8
Forest ecosystems	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Biomass burning/forest fires	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Waste	0.06	0.07	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.07	0.12
Waste waters	0.06	0.07	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.06	0.11

Emissions, as they were appointed to April 15, 2004

HFCs, PFCs, SF_6

Sources and emissions of the so-called “F-gases” have been assessed on the territory of Slovak Republic. The procedure was carried out in coincidence with the methodology IPCC[5,6] and true and potential emissions were estimated within 1995-2002 (Table 5.4). 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, SF_6 has risen since 1995 and this trend is expected in the future, as well.

Tab. 5.4 **HFCs, PFCs and SF_6 emissions within 1990-2002**

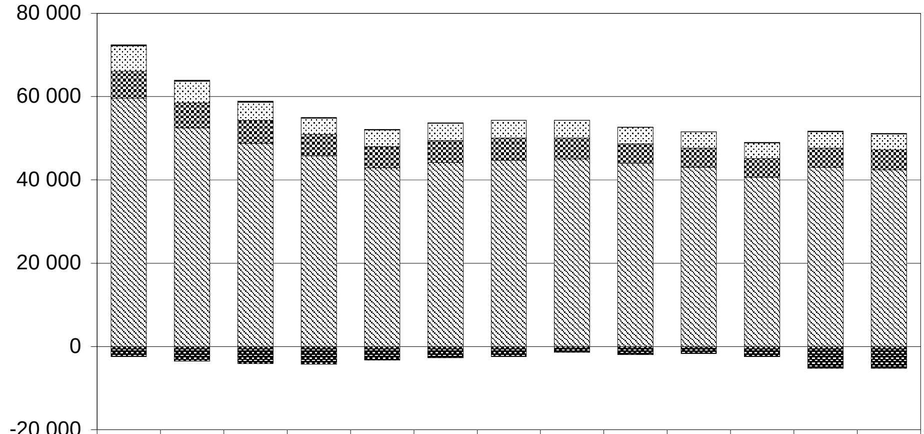
	GWP		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total emissions CO_2 ekv		[Gg]	272	267	249	156	144	148	91	114	80	93	103	108	130
HFCs emissions CO_2 ekv.		[Gg]					2.9	24.5	44.9	69.8	43.6	66.0	78.3	83.2	103.7
HFC-23	11 700	[Mg]						<0.01	0.07	0.07	0.05	0.05	0.05	0.06	0.04
HFC-32	650	[Mg]							0.02	0.11	0.07	0.10	0.32	0.58	1.2
HFC-41	150														
HFC-43-10mee	1 300														
HFC-125	2 800	[Mg]						0.01	0.08	0.26	0.43	0.76	1.91	3.37	5.76
HFC-134	1 000														
HFC-134a	1 300	[Mg]					0.01	10.98	25.45	41.80	29.18	44.43	47.73	42.88	47.41
HFC-152a	140	[Mg]							<0.01	0.14	0.32	0.61	0.83	1.01	1.20
HFC-143	300														
HFC-143a	3 800	[Mg]							0.12	0.31	0.46	0.80	1.92	3.48	5.5
HFC-227ea	2 900	[Mg]					1.00	3.52	3.52	4.39	0.71	0.80	0.80	0.80	0.44
HFC-236fa	6 300												0.05	0.22	0.38
HFC-245ca	560														
PFCs emissions CO_2 ekv.		[Gg]	271.9	267.1	249.0	155.8	132.3	113.9	35.2	33.2	23.8	13.9	11.7	11.4	11.4
CF_4	6 500	[Mg]	36.6	36.0	33.5	21.0	17.8	15.4	4.7	4.5	3.2	1.9	1.6	1.5	1.5
C_2F_6	9 200	[Mg]	3.7	3.6	3.4	2.1	1.8	1.5	0.5	0.4	0.3	0.2	0.2	0.2	0.2
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 ekv		[Gg]	0.03	0.03	0.04	0.06	9.27	9.91	10.76	11.34	12.24	12.68	13.11	13.48	14.41
SF_6	23 900	[Mg]	0.001	0.001	0.002	0.003	0.388	0.415	0.450	0.474	0.512	0.531	0.549	0.564	0.603

Emissions, as they were appointed to April 15, 2004

Aggregated emissions

These are the emissions of greenhouse gases recalculated via GWP100 (Global Warming Potential)[7] on the CO_2 equivalent. Expressed as the CO_2 equivalent, carbon dioxide emissions contributed in 2002 by 83 % to the total emissions, CH_4 emissions by about 10 %, N_2O emissions by about 7 % and the contribution of "F-gases" is below 1 % (Figure 5.4 and 5.5).

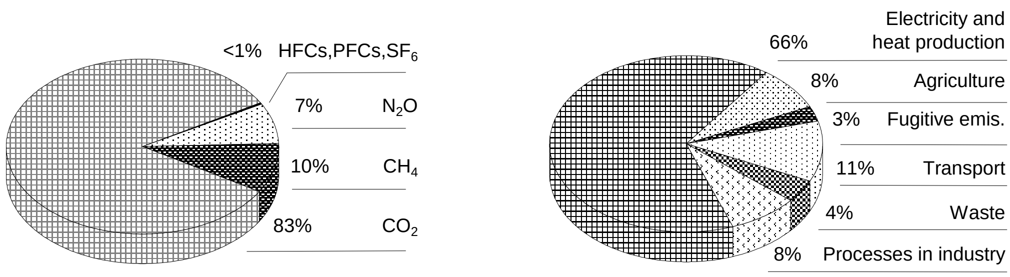
Fig. 5.4 **Aggregated emissions of greenhouse gases, 1990-2002**



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
HFCs,PFCs,SF6	272	267	249	156	144	148	91	114	80	93	103	108	130
N2O	6 039	5 165	4 387	3 849	4 008	4 154	4 210	4 218	3 969	3 840	3 764	3 971	3 833
CH4	6 506	6 030	5 556	5 183	5 067	5 237	5 320	5 031	4 667	4 620	4 503	4 604	4 720
CO2 (without LUCF)	59 619	52 477	48 714	45 788	42 900	44 187	44 712	45 007	43 998	43 036	40 623	43 021	42 479
CO2 (sink)	-2 426	-3 476	-4 128	-4 266	-3 287	-2 683	-2 427	-1 411	-1 936	-1 651	-2 443	-5 264	-5 278

Emissions, as they were appointed to April 15, 2004

Fig. 5.5 **Aggregated emissions of GHG in 2002**



5.3 ASSESSMENT

In accordance with the generally expected results, the aggregated emission of GHGs in year 2002 moderate decreased comparable to the year 2001 about more than 500 Gg without LUC&F (app. 1 %). There is the significant decreasing of aggregated emission against the base year (1990) about approximately 21 250 Gg it means the decreasing about almost 30 %. A major share of aggregated emission covers the energy sector by about 72 %, the industry sector covers about 7.5 %, the agricultural sector about 7 %, the land-use and forest about 9 % and the waste sector about 4 %

Emissions of greenhouse gases reached the highest level by the end of the 1980s. Within the period 1990-1994 they dropped by 25 % and since 1995 emissions of greenhouse gases oscillate approximately around the same level. In the last years was registered moderate increasing of CO_2 emissions caused mostly revitalisation of industry, transport and modification of fuel's base.

On a balance relating to the year 2002, the total anthropogenic emissions of CO_2 reached almost 42.5 Tg and decreased relating the previous year 2001 more than 0.5 Tg. The total anthropogenic emissions of carbon dioxide decreased relating to the base year (1990) by about 29 %. The total anthropogenic emissions of methane reached in the 2002 almost 225 Gg and increased relating the previous year about 5.5 Gg. The significant increasing of CH_4 emissions from waste management caused this effect. On the other hand, the total anthropogenic emissions remarked the 27 % decreasing comparable with the base year (1990). The total emissions of N_2O decreased relating the previous year to 12.43 Gg it means the total decreasing comparable with the base year presents 36 %. The total emissions of "F-gases" are increased comparable with the previous year's inventory by about 20 Gg, but beside the base year (1990) shows a more than 50 % decreasing (13 % beside 1995), caused by decreasing a consumption of perfluorocarbons.

The share of Slovak Republic in the global anthropogenic greenhouse gas emission accounts for about 0.2 %. Annual per capita emission is approximately 7.7 t/year and thus ranks Slovak Republic among the countries with the greatest per capita emissions in the world and the second greatest in Europe after Czech Republic. National total emissions decrease since 1990 by about 30 % - Slovak Republic met the commitment of the Framework Convention and it can be assumed, that targets of Kyoto protocol and European Union can be reached.

AIR POLLUTION
IN THE SLOVAK REPUBLIC
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