Slovak
Hydrometeorological Institute

Ministry of Environment
of the Slovak Republic

AIR POLLUTION

IN THE SLOVAK REPUBLIC

2001

Bratislava 2003

Report was elaborated by

Slovak Hydrometeorological Institute
Department of Air Quality
Jeséniova 17, 833 15 Bratislava

Ministry of Environment of the Slovak Republic
Air Protection Section
Nám. Ľ. Štúra 1, 811 02 Bratislava

Responsible: *RNDr. K. Marečková*

Co-ordination: *RNDr. K. Pukančíková*

Responsible for chapter 1 - RNDr. M. Mitošinková
2 - RNDr. Ľ. Kozakovič
3 - RNDr. D. Závodský, CSc.
4 - RNDr. E. Sajtáková
5 - RNDr. K. Marečková

Editorial work: *RNDr. K. Pukančíková*

C O N T E N T

AMBIENT AIR

EMISSIONS

APPENDICES

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

Implementation of the Co-operative Programme for Monitoring and Evaluation on Long Range Transport of Air Pollutants in Europe (EMEP - Environment Monitoring and Evaluation Programme) 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. MSC-W (Meteorological Synthesising Centre-West) - Norwegian Meteorological Institute in Oslo, CCC (Chemical Coordinating Centre) - NILU (Norwegian Institute for Air Research) in Kjeller and MSC-E (Meteorological Synthesising Centre-East) - Institute for Applied Geophysics in Moscow are three international co-ordinating centres within EMEP. The EMEP monitoring network (Figure 1.1) comprises approximately 100 regional stations. Five stations in the territory of Slovakia belonging to the national network of regional stations of the Slovak Hydrometeorological Institute are at the same time also a part of EMEP network. The programme of measurement in EMEP stations has been gradually extended, first for sulphate, oxides of nitrogen, ammonium and ozone. In 1994 the measurement of volatile organic compounds (VOCs) have started to be carried out under the auspices of CCC - NILU. At present the 7th phase of EMEP is under way and includes the measurements of heavy metals (HMs), persistent organic compounds (POPs) and PM10. Measurements of POPs within EMEP are carried out in a very few European countries and for the time being on a voluntary basis.

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 limit is 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 differ themselves for individual pollutants and individual ecosystems. In the Draft Manual for Mapping Critical Levels/Leads, UN ECE, 1990, the following critical levels are suggest

Pollutant	Ecosystem	CL [μg.m^{-3}]	Period
SO_2 - S	Forest	10	annual average
	Natural vegetation	10	
	Agricultural crops	15	
NO_x - 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 to be 200 μg.m^{-3} as 1-hour average and 65 μg.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 hidden deposition. Dry deposition represents interception of gases and particles on the surface, mainly by vegetation. Wet deposition represents substances in rainwater and hidden 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, hidden 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 this fact, that 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 2000 are summarized in the following table:

Sulphur deposition	Danube lowlands	Mountain position (> 1 500 m)
Dry	0.6	0.2
Wet	0.4	1.3 (1.8)$^{+}$
Hidden	0.1	0.6 (0.8)$^{++}$
Total	**1.1**	**2.1 (2.8)**

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 hidden 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 transport of air pollutants as well as the EIA studies of the new large air pollution sources.

1.2 NATIONAL NETWORK OF REGIONAL STATIONS IN THE SLOVAK REPUBLIC

In 2001, 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. Apart from the above-mentioned, chemical composition of precipitation is regularly analysed from the Bratislava-Koliba station, in elevation 286 m.

Regional stations

Chopok Meteorological observatory of the Slovak Hydrometeorological Institute, located on the crest of the Low Tatras, 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 Pump station Aszód on the small Danube, 7 km south-east of the village Topoľníky, 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 became a part of the EMEP network.

Liesek Meteorological observatory of the Slovak Hydrometeorological Institute on east-western side of Roháče mountain, nearby to the village Liesek, 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 been a part of the EMEP network.

Stará Lesná Station is situated in the region of the Astronomic institute of the Slovak Academy of Sciences on the south-eastern edge of TANAP (National Park of the Tatra), 2 km north from the 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 been a part of the EMEP network.

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

Measurement programme

Ambient air	**Gas components**	SO_2, NO_x, 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
	Atmospheric aerosol	SP mass concentration - 7 day sampling interval
		Pb, Cu, Zn, Mn, Cr, Ni, Cd – 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+}, F^-, PO_4^{3-}
	Monthly precipitation	pH, conductivity, SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, Zn, Mn, Fe, Al, Pb, Cd, F^-, PO_4^{3-}

Methods of determination

Ambient air

	Collection	Determination
SO_2	filter W41 impregnated by KOH solution	IC - Dionex
NO_x	after oxidation into NaOH absorption solution with guajacol	spectrophotometrically, spectrophotometer Unicam - modified Saltzman method
HNO_3	filter W41 impregnated KOH	IC - Dionex
O_3	registration by TE analyzer	principle - UV absorption
VOCs C_2 - C_6	stainless steel canister	GC-Perkin Elmer + FID
SP weight mass	nitrocellulose filter Sartorius	gravimetrically
Heavy metals – Pb, Cu, Mn, Cr, Ni, Cd	nitrocellulose filter Sartorius	after digestion in MW-oven by AAS Perkin Elmer in flame, or graphite atomiser
SO_4^{2-}	filter W40	ITP from water solution
NO_3^-	filter W40	ITP from water solution

Precipitation

	Collection	Determination
pH	“wet only" - rain gauges WADOS	pH meter ORION, glass electrode
Conductivity		conductometer WTW
SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, K^+, Na^+, Mg^{2+}, Ca^{2+}, PO_4^{3-}, F^-		IC - Dionex
Zn, Mn, Fe, Al, Pb, Cd	"bulk" - PE bucket	AAS – Perkin-Elmer, in flame or graphite atomiser

1.3 IASSESSMENT OF RESULTS FROM MEASUREMENT IN 2001

SO_2, sulphate

Regional concentrations of sulphur dioxide (Table 1.1, Figure 1.3) ranged between 0.90 µg $S.m^{-3}$ (Chopok) and 2.80 µg $S.m^{-3}$ (Topoľníky), in 2001. As compared to 2000, the values of sulphur dioxide were lower at all stations apart from Chopok. The upper value of this concentration range represents less than 30% of the critical sulphur dioxide level (critical level for forest and natural vegetation is 10 µg$S.m^{-3}$ and for agricultural crop 15 µg$S.m^{-3}$). Concerning order of magnitude, the concentrations of sulphates in atmospheric aerosols differed only about decimals or hundreds at all stations as compared to the previous year. The biggest difference appeared at Chopok (Table 1.1, Figure 1.4). The regional level of sulphates at Chopok was 0.48 µg $S.m^{-3}$, at Stará Lesná and Starina 0.99 µg $S.m^{-3}$. The stations Liesek and Topoľníky overreached 1 µg $S.m^{-3}$ and the Topoľníky station reached the highest value, 1,56 µg $S.m^{-3}$. Sulphates contributed to the total mass of suspended particles by 12-16% (Figure 1.7). Concentration ratio of sulphates to sulphur dioxide, expressed in sulphur presents interval 0.53- 0.88, corresponding to the regional level of pollution.

NOx, nitrates

Regional concentrations of oxides of nitrogen at regional stations, expressed in NO_2-N (Table 1.1, Figure 1.5) varied within the range 1.28-2.81 µg $N.m^{-3}$. The smallest annual average value was recorded at Chopok 1.28 µg $N.m^{-3}$, the higher one at Starina 1.44 µg $N.m^{-3}$, Stará Lesná 1.85 µg $N.m^{-3}$, Liesek 1.98 µg $N.m^{-3}$ and value 2.81 µg $N.m^{-3}$ at the lowland station Topoľníky. A critical level of concentrations of nitrogen oxides (9µg $N.m^{-3}$ for all ecosystems) was not exceeded at any of the stations in 2001.The highest concentrations of oxides of nitrogen in Topoľníky 2.81 µg $N.m^{-3}$ represents less than 30% of critical level. Nitrates in ambient air occurred predominantly in the form of particulates (Table 1.1, Figure 1.6). Concentrations of nitric acid (Table 1.1) are substantially lower at the Topoľníky, Liesek, Stará Lesná and Chopok stations as compared to particulate nitrates, however at Starina the level of nitric acid and particulate nitrate is 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 atmospheric aerosol 4-17% (Figure 1.7). Concentration ratio of total nitrates (HNO_3 +NO_3) to NO_2 expressed in nitrogen represented the range 0.17-0.43.

Suspended, particles, heavy metals

Concentrations of total suspended particles ranged from 12.2 to 28.2 µg.m^{-3} in 2001 (Table 1.1). All stations showed slightly lower concentrations of suspended particles as compared to 2000. In Table 1.1 and in Figure 1.8

the concentrations of heavy metals in particulate matter are listed at regional stations in 2001. As compared to 2000, in 2001 the concentrations of manganese, cadmium and zinc were lower at all stations, concerning the rest of the measured metals the values were either lower or higher at all stations. The trend in the majority of metals is downward, with the most outstanding manifestation 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 metals measured in suspended particles varied within 0.18-0.30% (Figure 1.7).

Ozone

In Figures 1.9-1.12 the annual course of 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 2001, the annual average ozone concentration at Starina reached 63 $\mu g.m^{-3}$, at Stará Lesná 60 $\mu g.m^{-3}$ and at Topoľníky 41 $\mu g.m^{-3}$. Chopok was not assessed due to the long-term problems resulting in lack of measurements. Measurements of ozone and exceedances of critical levels are completely assessed in Chapter 3 Atmospheric Ozone.

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

VOCs C_2-C_6

VOCs C_2-C_6, or the so-called light hydrocarbons, started to be sampled in autumn 1994 in Starina station. Starina is one of the small number of European stations, included into 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 decimals of ppb up to several ppb (Figure 1.13). Remarkable was the presence of isoprene, releasing itself out of near forest growth. Measurements of identical samples carried out in the Slovak Hydrometeorological Institute and in 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.

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 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 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.

Chemical analysis documents a slight increase of acidity in 2001 as compared to 2000 at Chopok and Liesek. The station in Bratislava as sub-urban background also showed higher acidity. All other stations recorded either a slight decrease in acidity or the value of pH was the same as in previous year. Figure 1.15 illustrates the amount of precipitation in 2001 varying from 500 mm up to 1316 mm, depending on the location of the individual stations. Interval of pH values in monthly precipitation ranged between 4.5-5.1 (Table 1.2, Figure 1.17). Annual course of sulphates, nitrates and pH based upon daily measurements is depicted in Figures 1.21-1.25. Time series and trend of pH values within a long-time period indicate clearly the decrease in acidity (Figure 1.14). Values of pH are in a good coincidence with the pH values according to the EMEP maps. Concentrations of dominant sulphates in precipitation were bigger as compared to previous year. Concentrations of ammonium were higher at all stations apart from the Topoľníky station. The values of conductivity (Table 2.1, Figure 1.16) were bigger at the most of the stations compared to the previous year, slight decrease was recorded at the Starina and Stará Lesná stations. Total decrease in sulphates in long-term time series has corresponded to SO_2 emission reduction since 1980.

All other components in precipitation (Table 1.2, Figures 1.18, 1.19 and 1.20) did not show any significant trend, a slight increase was observed in heavy metals, mainly for zinc and iron as compared to the previous year. In 2000 the measurements of lead and cadmium in precipitation have been included into regular programme of measurement. Critical load of wet deposition has not been indicated yet. USA and Canada indicated the value of wet sulphate deposition 0.7 $gS.m^{-2}.year^{-1}$ as the target load for forests. This value was exceeded over the territory of Slovakia in 2001.

Station	Wet sulphate deposition [g $S.m^{-2}.r^{-1}$]
Chopok	1.34
Topoľníky	0.40
Starina	0.78
Stará Lesná	0.70
Liesek	0.73
Bratislava	0.62

According to the measurements of EMEP 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.

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

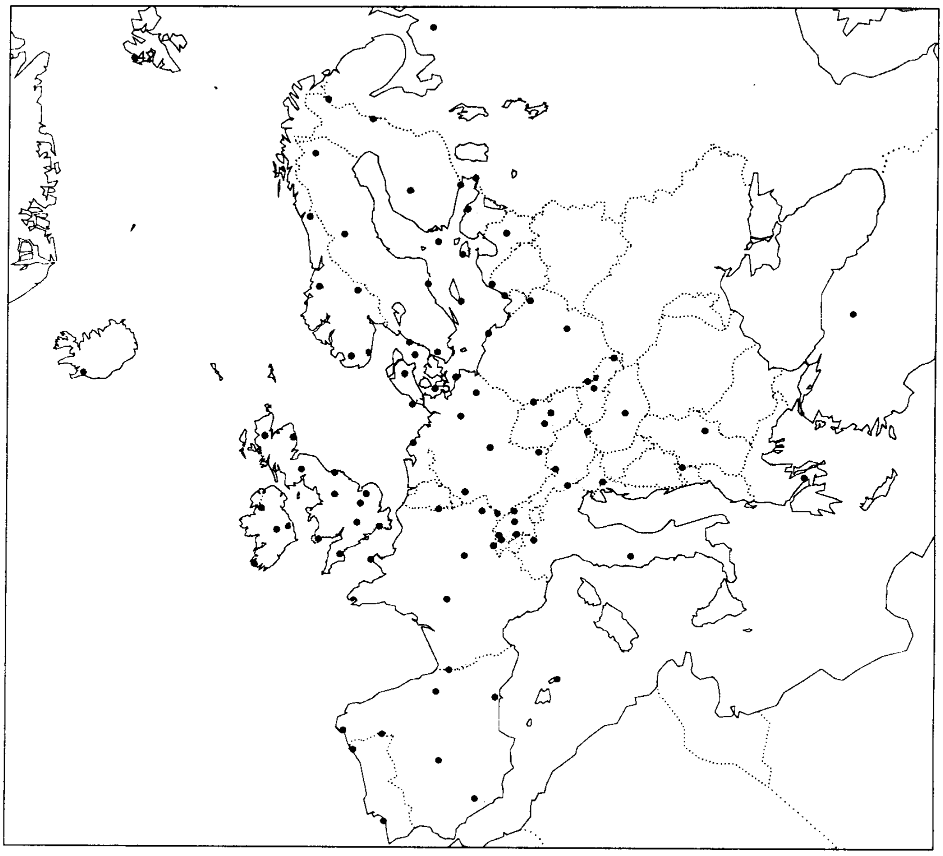
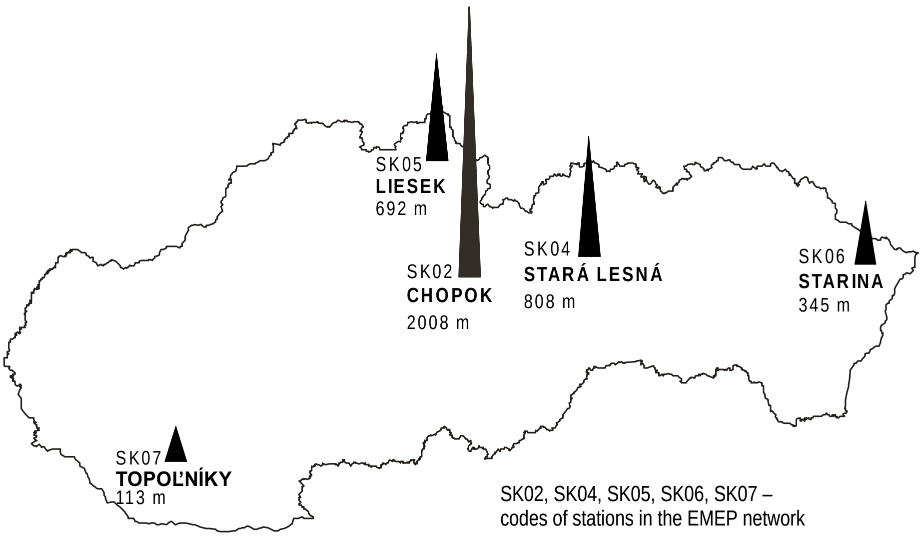


Fig. 1.2 **Network of regional stations in the Slovak Republic - 2001**



Tab. 1.1 **Annual average concentrations in ambient air - 2001**

	SP µg/m^3	SO_2-S µg/m^3	NO_2-N µg/m^3	HNO_3-N µg/m^3	SO_4^{2-}-S µg/m^3	NO_3^--N µg/m^3	O_3 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
Chopok	12.2	0.90	1.28	0.10	0.48	0.19	125	2.69	2.09	4.69	0.02	3.23	1.58	8.18
Topoľníky	28.8	2.80	2.81	0.10	1.56	1.10	41	18.25	8.07	4.51	0.21	6.82	4.33	33.33
Starina	20.6	1.53	1.44	0.24	0.99	0.20	63	15.51	4.31	4.13	0.22	1.63	2.31	16.02
Stará Lesná	18.5	1.12	1.85	0.08	0.99	0.25	58	7.79	4.18	2.67	0.11	0.64	0.70	24.92
Liesek	25.4	2.25	1.98	0.13	1.23	0.45	-	12.66	20.18	15.08	0.15	1.07	2.29	23.56

Tab. 1.2 **Annual weighted means in monthly precipitation - 2001**

	Precip. mm	pH	Conduct. µS/cm	Na^+ mg/l	K^+ mg/l	Mg^{2+} mg/l	Ca^{2+} mg/l	Zn^{2+} µg/l	Fe^{2+} µg/l	Al^{3+} µg/l	Mn^{2+} µg/l	Cd^{2+} µg/l	Pb^{2+} µg/l	Cl^- mg/l	NH_4^+-N mg/l	NO_3^--N mg/l	SO_4^{2-}-S mg/l	F^- mg/l	PO_4^{3-} mg/l
Chopok	1316.0	4.5	23.48	0.17	0.15	0.057	0.35	82	91	22	4.5	0.80	3.94	0.33	0.57	0.44	1.02	0.005	0.02
Bratislava	556.1	5.1	23.75	0.18	0.18	0.177	1.51	47	53	25	5.1	0.13	2.03	0.39	0.79	0.67	1.12	0.005	0.03
Topoľníky	500.0	4.5	24.24	0.15	0.23	0.102	0.66	16	70	20	3.9	0.04	1.25	0.27	0.32	0.66	0.80	0.005	0.02
Starina	980.7	4.6	19.50	0.27	0.17	0.061	0.36	16	80	22	3.0	0.14	3.07	0.35	0.45	0.39	0.80	0.005	0.02
Stará Lesná	952.5	4.8	17.47	0.27	0.24	0.054	0.32	12	93	95	3.8	0.33	2.09	0.50	0.38	0.39	0.73	0.005	0.04
Liesek	902.9	4.5	19.53	0.13	0.13	0.058	0.34	19	103	19	4.5	0.13	2.28	0.23	0.47	0.36	0.81	0.005	0.03

Tab. 1.3 **Annual average concentrations of VOC [ppb] in ambient air - 2001**

	etane	etene	propane	propene	i-butane	n-butane	acetylene	butene	pentene	i-pentane	n-pentane	isoprene	n-hexane	benzene	toluene
Starina	2.070	2.354	1.009	0.666	0.367	0.857	4.456	0.887	0.301	0.796	0.981	0.264	0.493	0.570	0.853

Monthly average concentration in ambient air - 2001

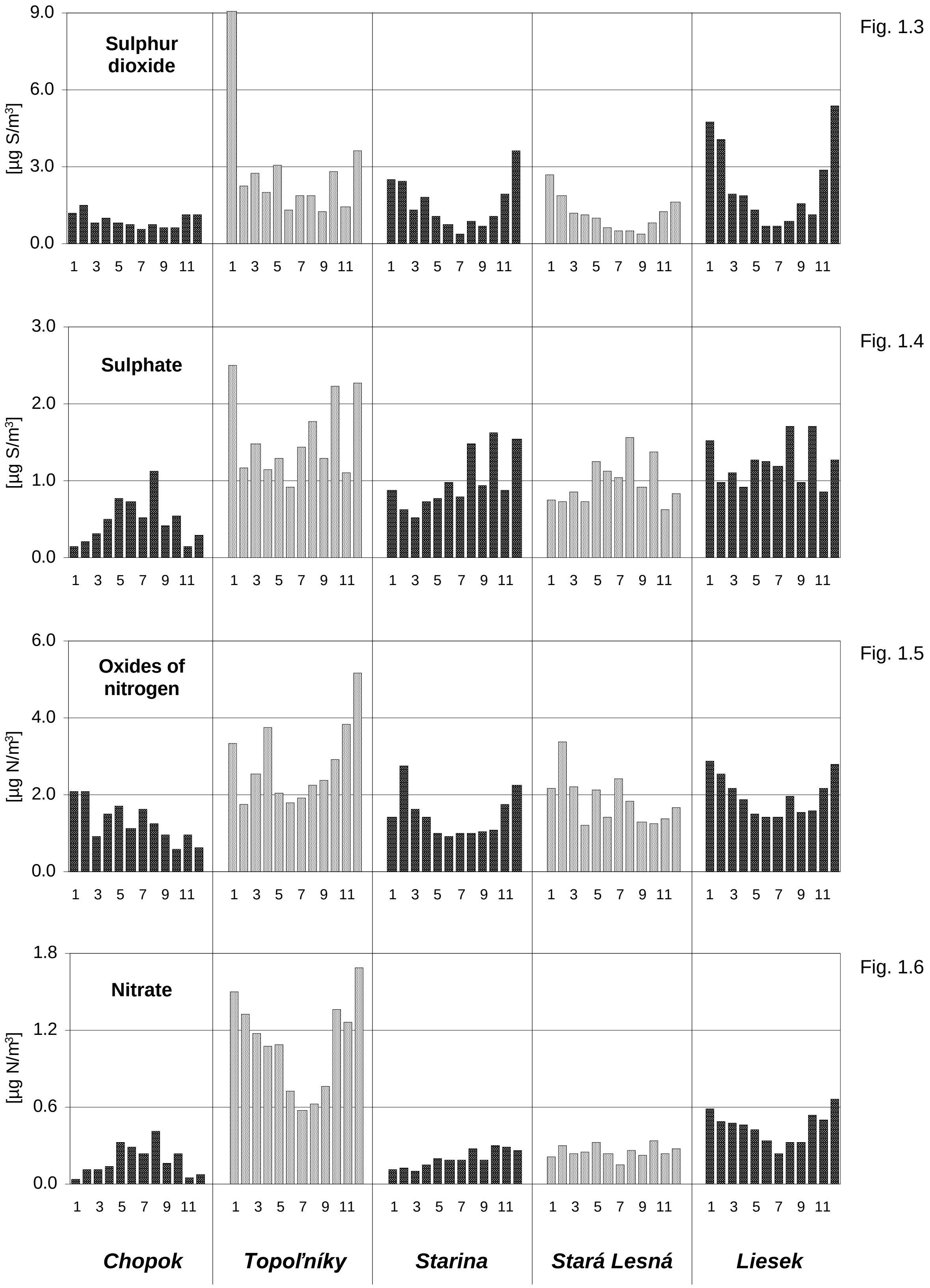


Fig. 1.7 **Composition of aerosol and proportional share of heavy metals - 2001**

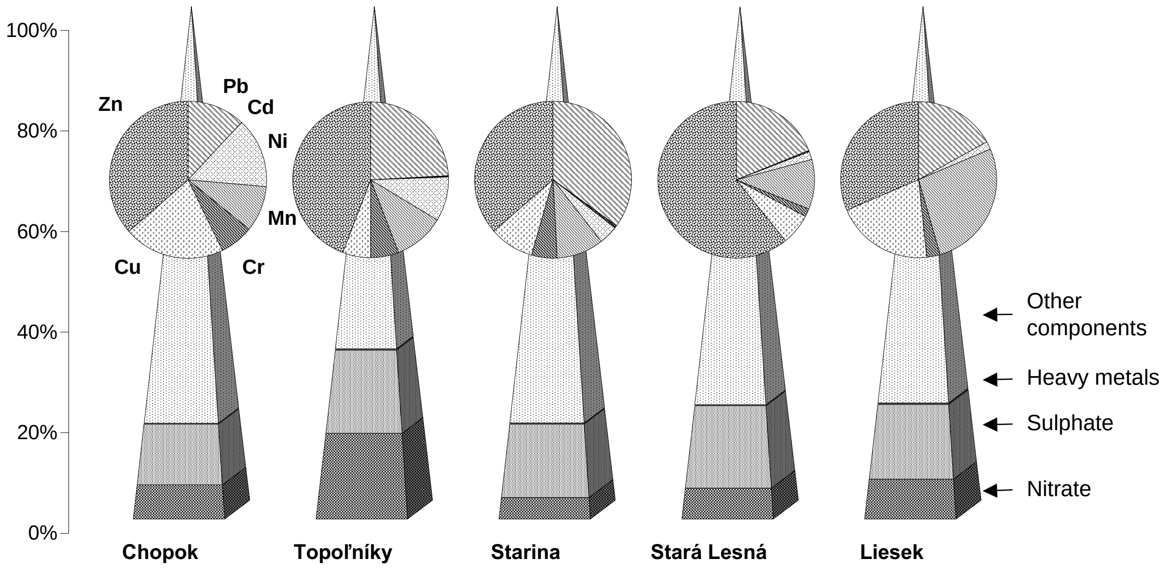
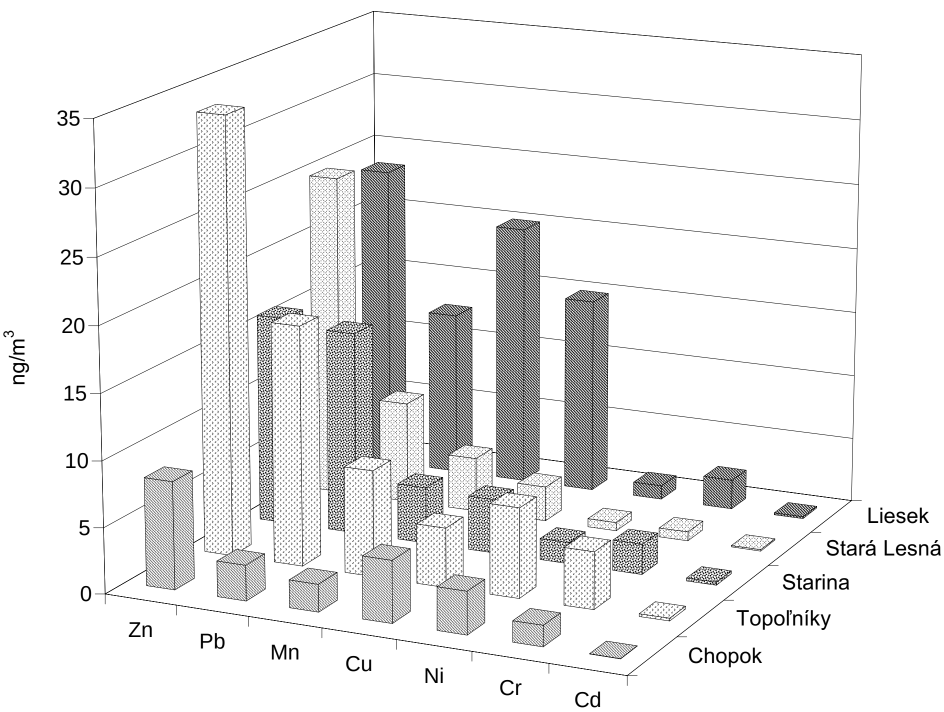


Fig. 1.8 **Heavy metals in ambient air - 2001**



Ground level ozone – 2001

daily average   1-hour maximum

Fig. 1.9

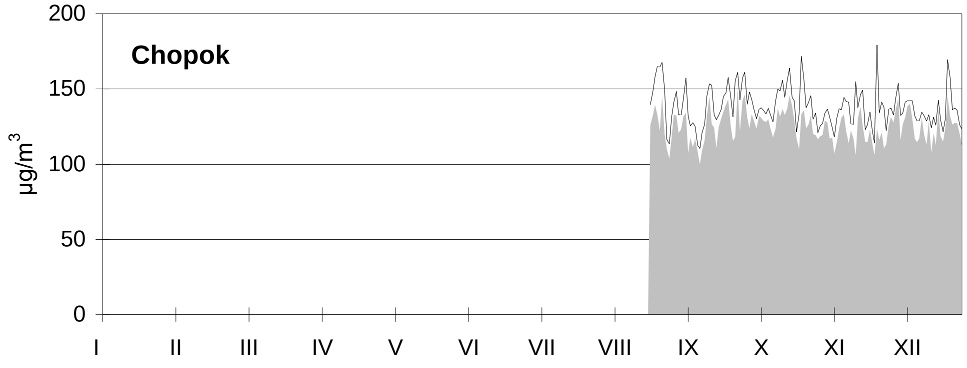


Fig. 1.10

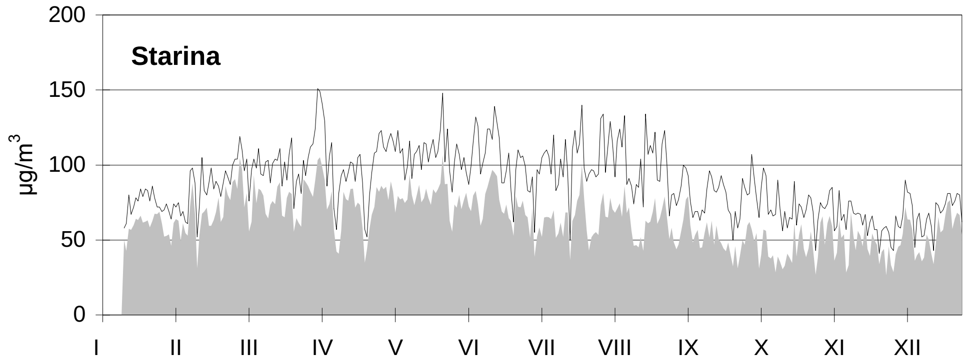


Fig. 1.11

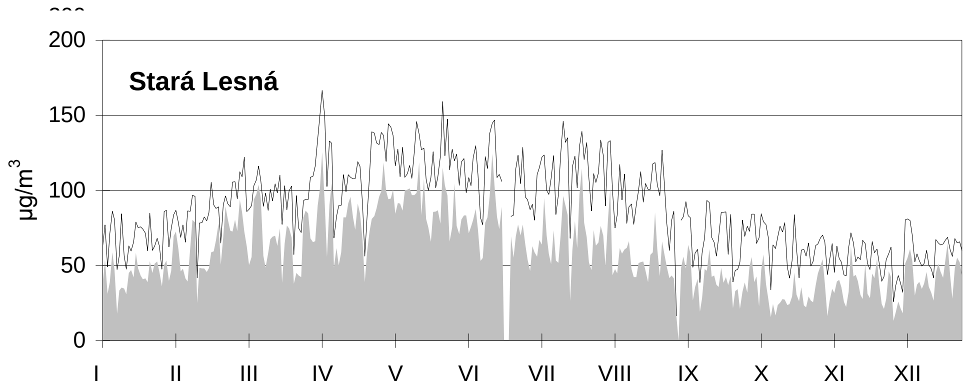


Fig. 1.12

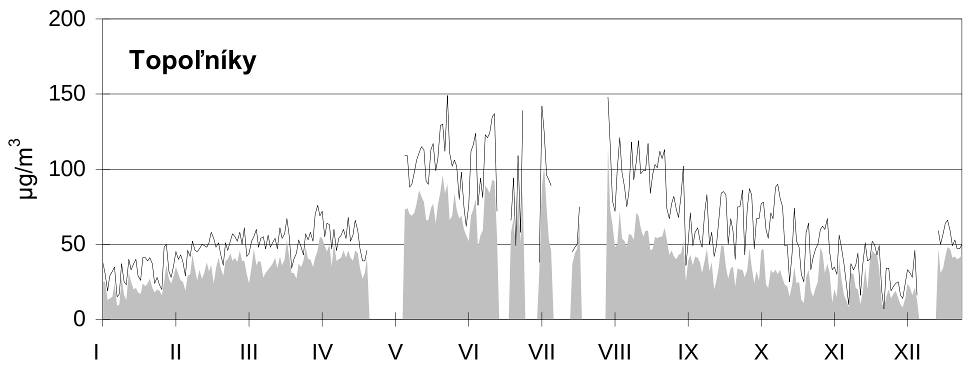


Fig. 1.13 **VOCs [ppb] - Starina - 2001**

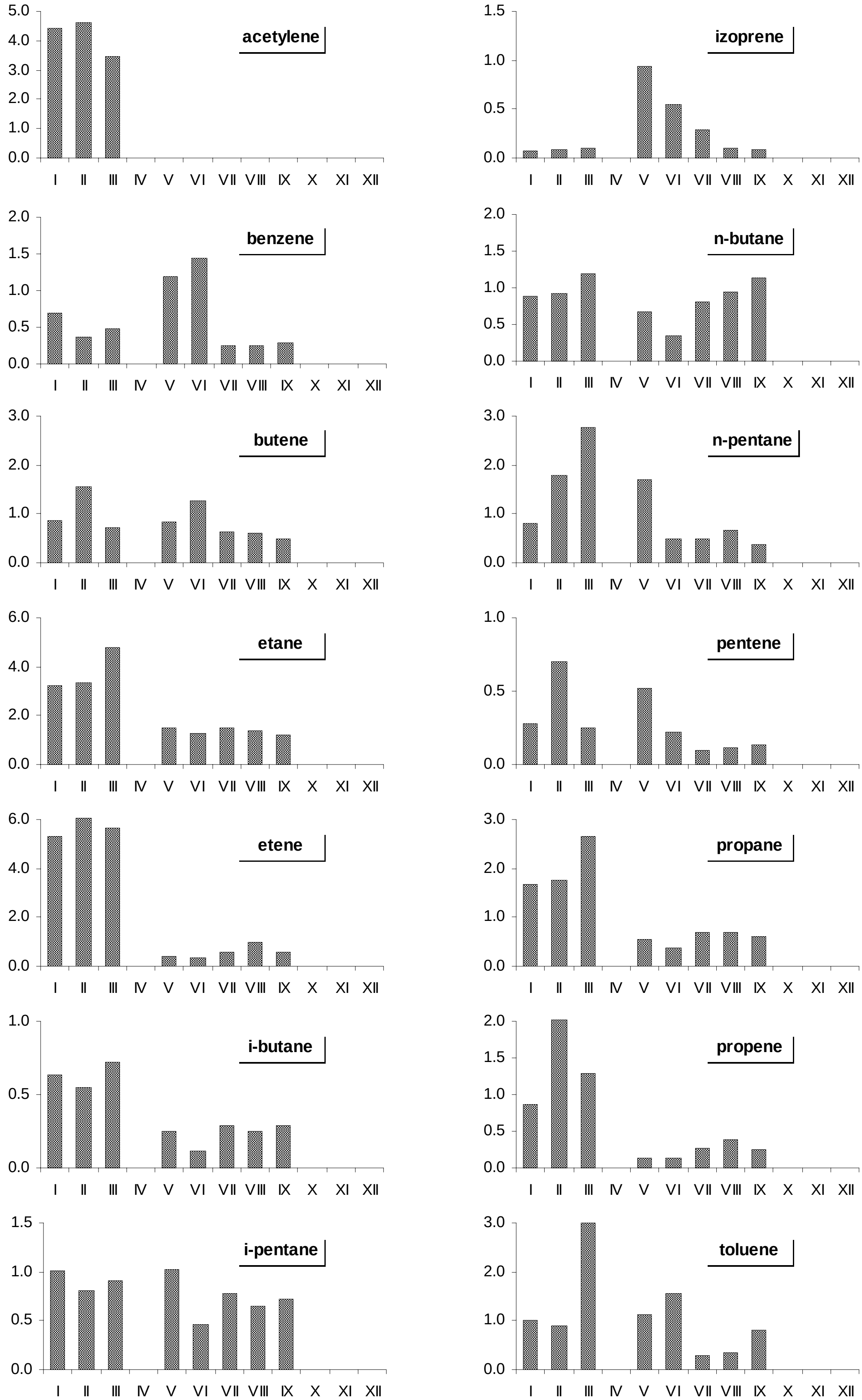
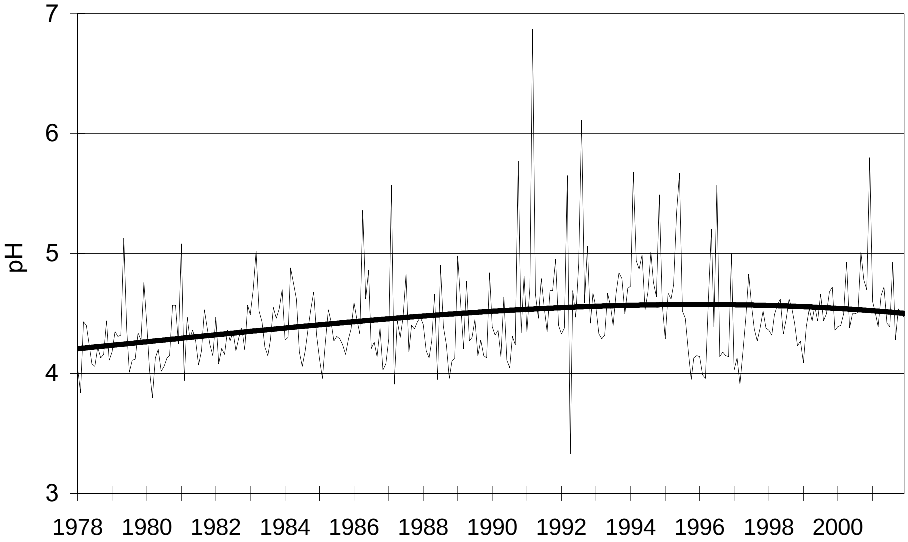


Fig. 1.14 **pH in precipitation - Chopok**



Monthly precipitation – 2001

Fig. 1.15 **Precipitation amount** [mm]

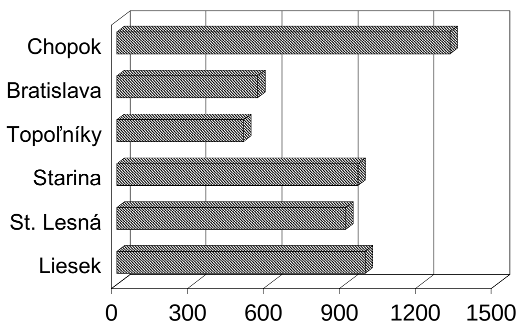


Fig. 1.16 **Conductivity in precipitation** [µS/cm]

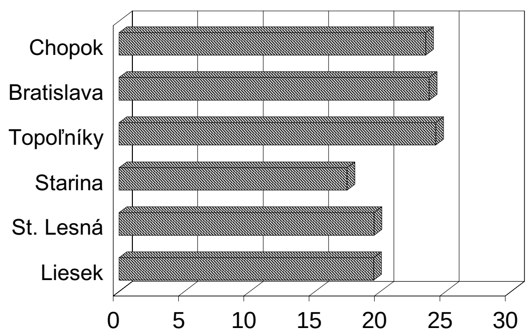
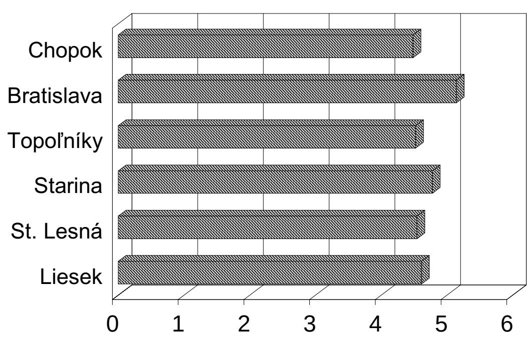


Fig. 1.17 **pH in precipitation**



Monthly precipitation – 2001

Fig. 1.18

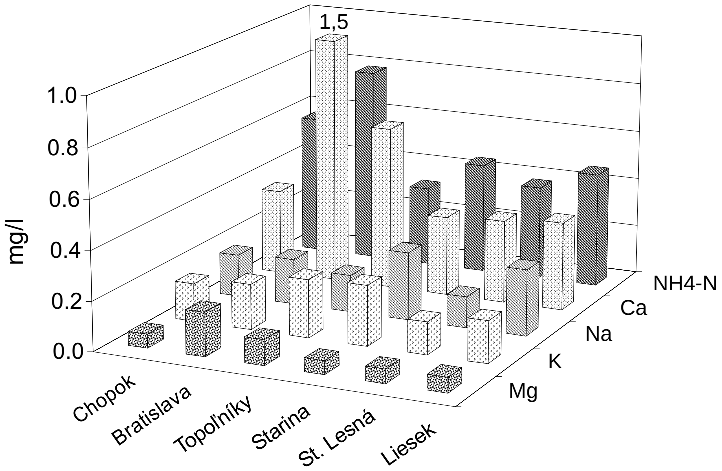


Fig. 1.19

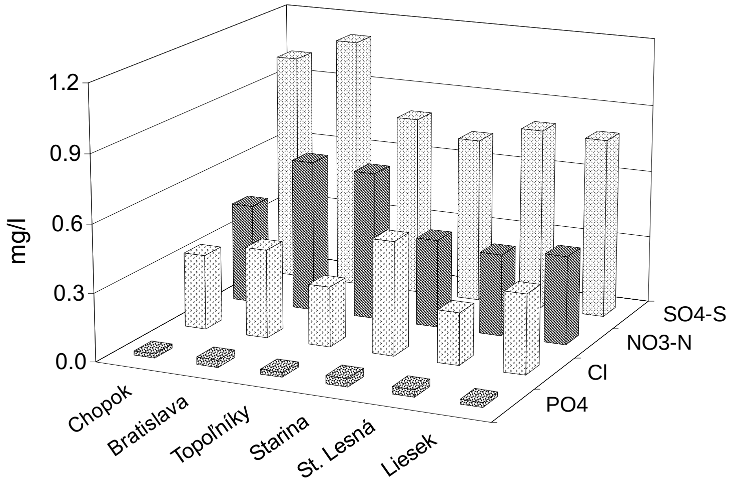
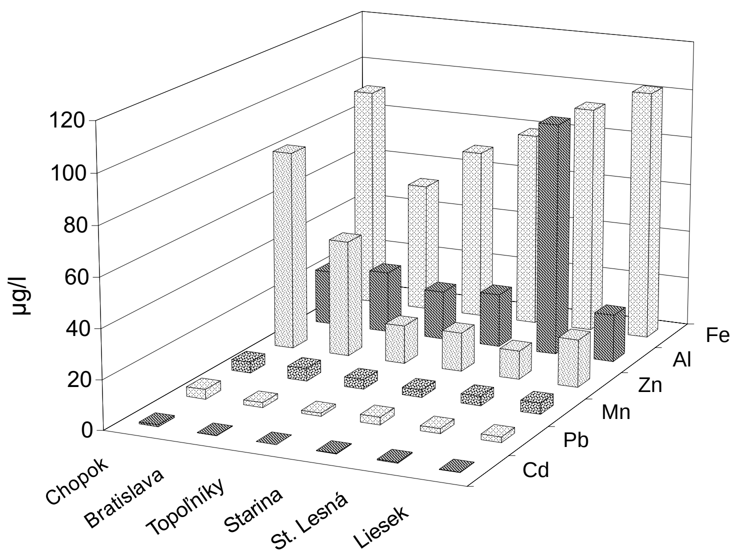


Fig. 1.20



Daily precipitation – 2001

Sulphate   Nitrate   pH

Fig. 1.21 **Chopok**

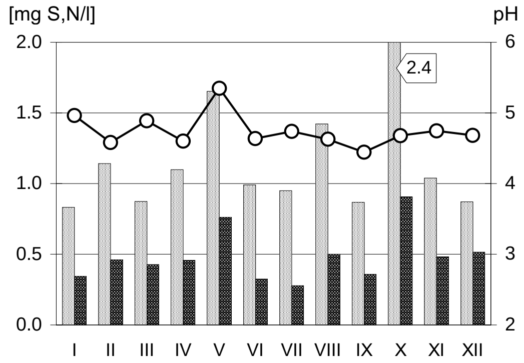


Fig. 1.22 **Topoľníky**

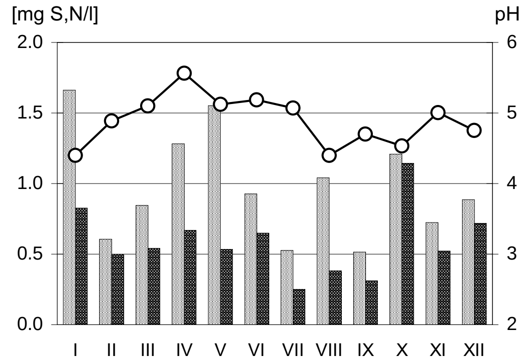


Fig. 1.23 **Stará Lesná**

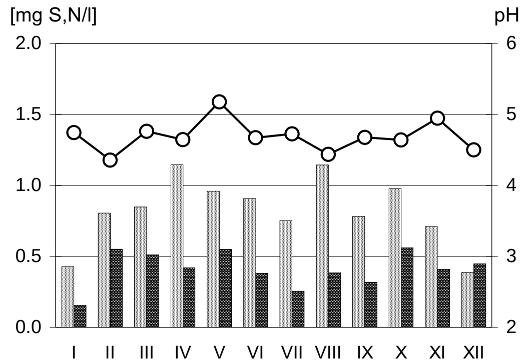


Fig. 1.24 **Starina**

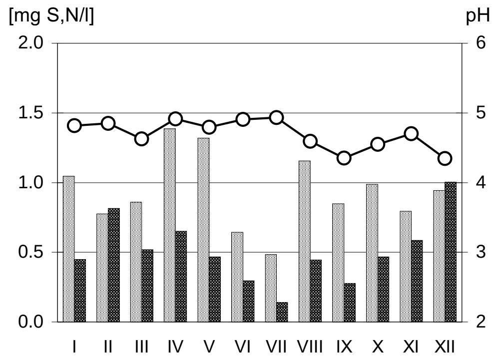
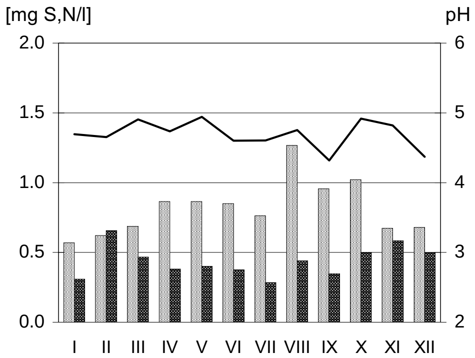


Fig. 1.25 **Liesek**



2.1 LOCAL AIR POLLUTION

According to Act No 134/1992 Coll. of the Slovak National Council on the State Administration of Air Pollution as amended by the following regulations the Ministry of Environment of the Slovak Republic (MoE SR) is obliged, beyond others, to ensure pursuing the transfer and dispersion of the air pollutants in the ambient air. The MoE SR authorized the Slovak Hydrometeorological Institute (SHMI) to monitor the air quality around the territory of the Slovak Republic. The duty to ensure the air quality control for the SHMI also results from the Decree of the MoE SR No 112/1993 Coll.

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 (PM10). In 2001, 25 stations were deployed on the territory of the SR, of these 23 had monitored the level of pollution caused by the basic pollutants (SO_2, NO_x, NO_2, CO, O_3 and PM10), at two others (Koliba Podhradová) only ground level concentrations of ozone were monitored. The air pollution by ground-level ozone was monitored on 20 localities on the whole. At two stations, beyond these pollutants, also the level of pollution by H_2S was monitored. In line with the Decree No 112/1993 Coll. of the MoE SR on the specification of Special Protection Areas and on Operation of Smog Warning and Control Systems, all the stations, with exemption of the city of Martin, were situated in heavy polluted territories that require special air protection. Under the legislation in force relating to the air protection, the level of pollution for every single one of the pollutants is judged separately in accordance with the air quality standards, which are set in the Annex No 6 of the Order No 92/1996 of the Government of the Slovak Republic. The complex lump assessment of the pollution is made under the indices of the air pollution, the calculation of which is set by the Annex No 1 of the Decree No 112/1993 Coll. To reduce the negative impact on human health for the cases of air pollution Annex No 3 of the mentioned Decree sets special air quality standards aimed at calling the signals of attention and regulation. The competent regional offices are in power to issue operational instructions on the smog and regulation system in the form of a binding decree that specify the range of activities to be implemented when the air pollution reaches the smog level. Until now the decrees on smog were issued in the district of Košice (for the non-attainment area of the city of Košice), in the district of Prešov (for the non-attainment area of Prešov) and in the district of Trenčín (for the non-attainment area of Horná Nitra).

Currently the process of harmonization of the Slovak legislation to the European one in the field of the air quality is in progress. This process will result in a new Act on Air, as well as in pertinent decrees by means of which the provisions of the Act will be implemented. This is the reason why in the submitted report the air pollution was also assessed under the European directives 1999/30/EC and 2000/69/EC respectively.

2.2 CHARACTERIZATION OF AIR POLLUTION MONITORING AREAS

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.

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.

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.

Žiar nad Hronom

The area of the Žiarska 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.

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 unfavourable conditions for emission dispersion and transport. The dominant cause of air pollution in this area is power generation. To a lesser extent emissions from sources of chemical industry and local heating 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.

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.

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.

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.

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.

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.

Krompachy

Krompachy is located in a valley system with good developed local air circulation. The southern part of the town lies in the valley of the Slovinský brook. Surrounding elevations reach up to 350 m. The northern part of the town lies in the valley of the river Hornád. This valley is east-west oriented. Air circulation is indicated by the orientation of the valley. The annual average wind speed is low, achieving 1.4 $m.s^{-1}$. The main cause of air pollution is due to the Krompachy Non-ferrous metal works, situated north-east and also to local heating systems.

Strážske

Strážske is located to the east of Vihorlat, in the northern part of the East-Slovakian lowlands, at the so-called Brekovská gate, where air circulation speed is strengthened, mainly from the north quadrant. The average wind speed is 3.4 $m.s^{-1}$. The wind speed is distinguished by a distinctive daily course having a minimum during night hours. The local chemical industry is the main source of air pollution in this area.

Vranov nad Topľou

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.

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.

2.3 CHARACTERIZATION OF AUTOMATIC MONITORING STATION LOCATIONS

West Slovakia

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.

Central Slovakia

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.
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.
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.
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.
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 are. The position is open in all directions and representative for wind speed and wind direction measurements.
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.

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.
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.

East Slovakia

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. The station has monitored only surface ozone.
Košice - Veľká Ida	The station is located in the south-easteern 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.
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.
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.

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.

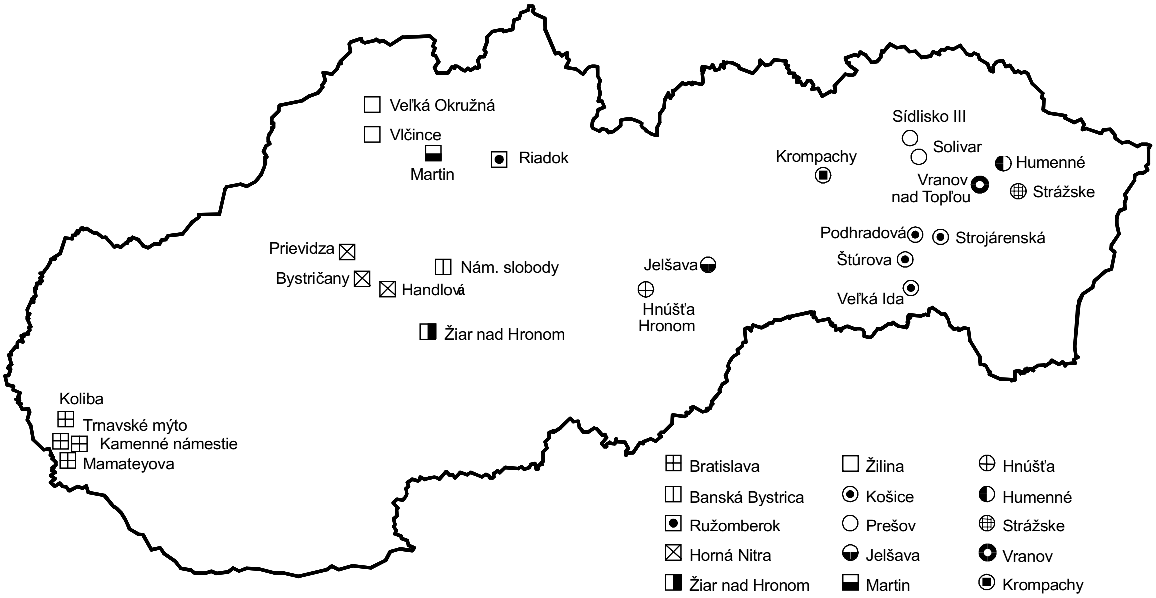
Humenné

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.

Tab. 2.1 **Geographical co-ordinates of monitoring stations**

Area	**Station**	**Longitude**	**Latitude**	**Altitude** [m]
Bratislava	Mamateyova	17°08'05"	48°07'43"	136
	Trnavské mýto	17°07'45"	48°09'32"	136
	Kamenné námestie	17°07'00"	48°08'45"	139
	Koliba	17°07'09"	48°10'20"	287
Banská Bystrica	Nám. slobody	19°09'30"	48°44'12"	343
Ružomberok	Riadok	19°18'27"	49°04'32"	485
Žiar nad Hronom	Žiar nad Hronom	18°51'07"	48°35'17"	263
Horná Nitra	Prievidza	18°37'30"	48°45'11"	269
	Handlová	18°45'32"	48°44'00"	437
	Bystričany	18°31'00"	48°40'02"	251
Žilina	Veľká Okružná	18°44'18"	49°13'12"	390
	Vlčince	18°46'20"	49°12'40"	368
Martin		18°55'26"	49°04'03"	396
Jelšava		20°14'18"	48°37'48"	255
Hnúšťa		19°57'12"	48°35'04"	315
Košice	Štúrova	21°15'47"	48°43'01"	199
	Strojárenská	21°15'17"	48°43'37"	200
	Podhradová	21°14'45"	48°45'17"	248
	Veľká Ida	21°10'34"	48°35'31"	207
Prešov	Sídlisko III.	21°13'54"	49°00'03"	245
	Solivar	21°15'59"	48°58'43"	255
Krompachy		20°52'24"	48°55'04"	385
Strážske		21°49'48"	48°52'21"	134
Vranov nad Topľou		21°41'26"	48°53'12"	128
Humenné		21°53'08"	48°54'35"	160

Fig. 2.1 **Location of automatic air pollution monitoring stations in the Slovak Republic**



2.4 DATA QUALITY AND PROCESSING OF MEASUREMENT RESULTS

Measurements of ambient air concentrations by continuous instruments perform the highest technical level of ambient air pollution control. The results of measurements are being used for the approval of new air pollution sources, at ambient air protection planning within the frame of smog alert systems, as well as with the ordinary checking of condition to see if permissible ambient air standards are exceeded.

The testing of analysers is carried out regularly by zero gas and calibration gas of known concentration. Measurement spans are tested in the laboratory by an external calibrator, which enables the changing the concentrations. Testing of analysers comprises the checking of all parameters recommended by the producer in compliance with international standards. The composition of calibration gas must be constant during the entire process of testing. The supplying lines for calibration gases have to be made of borosilicate glass or teflon. When calibration gas is rarefied, it is necessary to use zero gas, which does not contain the ingredients for evolving a response from the analyser. It is necessary to take into account possible interferences. To use ambient air as the zero air, primary chemical cleaning is needed, or synthetic air of corresponding composition and purity may be used. The testing of linearity does include at least 7 calibration points within the measuring range. The data acquired is assessed by the method of the least squares. The testing on interfering gases must not involve greater deviations than the producer of the instrument states.

To process the huge amount of data, a graphical presentation was chosen and significant statistical characteristics as well as the ambient air quality indices are given in the tables.

Daily average concentrations and maximum half-hour concentrations on respective day are presented in each graph. Values of pollutants having identified ambient air quality standards AQS_d and AQS_s, are marked in graphs.

Annual average concentrations, calculated on the daily average concentrations as arithmetic mean, 95-percentiles for daily and half-hour concentrations, daily maximum and short-term concentrations, measured in respective years, are given in the table appendices.

For selected locations, the concentration roses were processed for suspended particles, oxides of nitrogen and sulphur dioxide. Wind speed and wind direction data from meteorological stations were also used for the assessment.

The frequency and pollution duration time was processed individually according to the special ambient air quality standards for signal purposes: Attention, Warning and Regulation.

Air pollution indices were assessed according to the method of the Ministry of Environment of the Slovak Republic. The Table "Air pollution indices" provides information about the share of respective pollutants (SO_2, NO_x and suspended particles) in total air pollution index in individual areas.

To compare polluted areas, air pollution indices (API) were assessed taking three pollutants SO_2, NO_x and suspended particles (S_i) into consideration.

Three ways how to express API are distinguished:

- $\mathbf{API_y}$ - long-term (annual) air pollution index
- $\mathbf{API_s}$ - short-term air pollution index
- $\mathbf{API_d}$ - daily air pollution index

The indices are defined as follows:

$$\mathbf{API_y} = \sum_{i=1}^{3} [\text{annual average concentration} / AQS_y]_{Si}$$

$$\mathbf{API_s} = \sum_{i=1}^{3} [\text{95 percentile}_s / AQS_s]_{Si}$$

$$\mathbf{API_d} = \sum_{i=1}^{3} [\text{95 percentile}_d / AQS_d]_{Si}$$

Classification of air pollution degrees according to the indices (API_y, API_s, API_d):

API range	0.0 - 0.4	0.5 - 0.9	1.0 - 1.4	1.5 - 2.0	over 2.0
Air pollution degree	favourable	slight	moderate	unhealthy	very unhealthy

The air pollution was assessed also according to the new daughter EU directives 1999/30/EC and 2000/69/EC, separately for limit values, limit values and margin for tolerance for the years 2001, upper an lower assessment thresholds. At present measures for the improvement of quality of measurements are continuously implemented to be fully compatible with European air quality legislation.

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

Pollutant measured	Principle of measurement	Range of measurement [mg/m³]	Detection limit [µg/m³]	Producer	Type
SO_2	UV-Fluorescence	0...2.6	2.6	TEI	Model 43A, 43B
	UV-Fluorescence	0...2.6	1.3	Monitor Labs	ML 9850
H_2S	UV-Fluorescence	0...1.3	1.3	Monitor Labs	ML 9850 + ML 8770
NO, NO_2, NO_x	Chemilumiscence	0...1.9	0.9	TEI	Model 42, 42C
	Chemilumiscence	0...1	< 0.9	Monitor Labs	ML 9841
CO	GFC	0...72.5	< 72.5	TEI	Model 48, 48C
	GFC	0...72.5	< 11.5	Monitor Labs	ML 9830
O_3	UV-photometry	0...2	4, 2	TEI	Model 49, 49C
	UV- photometry	0...1	2	Monitor Labs	ML 9810,9811
	Beta-Absorbtion	0....1000	10	VEREWA	F 703
PM10	Beta- Absorbtion	0....1000	3	ESM ANDERSEN	FH 62I - R
PM10	TEOM	0....5000	1	Rupprecht& Patashnick	1400, 1400A, 1400AB

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

Tab. 2.3 **List of pollutants monitored in Slovakia in 2001**

Area	Station	SO_2	NOx	PM10	PM2,5	O_3	CO	H_2S
Bratislava	Mamateyova	*	*		*	*		
	Trnavské mýto	*	*	*			*	
	Kamenné námestie	*	*	*				
	Koliba					*		
Banská Bystrica	Nám. slobody	*	*	*		*	*	
Ružomberok	Riadok	*	*	*		*		*
Žiar nad Hronom	Žiar nad Hronom	*	*	*		*		
Horná Nitra	Prievidza	*	*	*		*		
	Handlová	*	*	*				
	Bystričany	*	*	*				
Žilina	Veľká Okružná	*	*	*			*	
	Vlčince	*	*	*		*		*
Martin		*	*			*		
Jelšava		*	*	*		*		
Hnúšťa		*	*	*		*		
Košice	Štúrova	*	*	*			*	
	Strojárenská	*	*	*				
	Podhradová					*		
	Veľká Ida	*	*	*		*	*	
Prešov	Sídlisko III.	*	*	*				
	Solivar	*	*	*		*	*	
Krompachy		*	*	*				
Strážske		*	*	*				
Vranov nad Topľou		*	*	*				
Humenné		*	*	*		*		

Fig. 2.2 **Concentration of NOx** [μg.m^{-3}]

daily average concentrations — maximum short-term concentrations

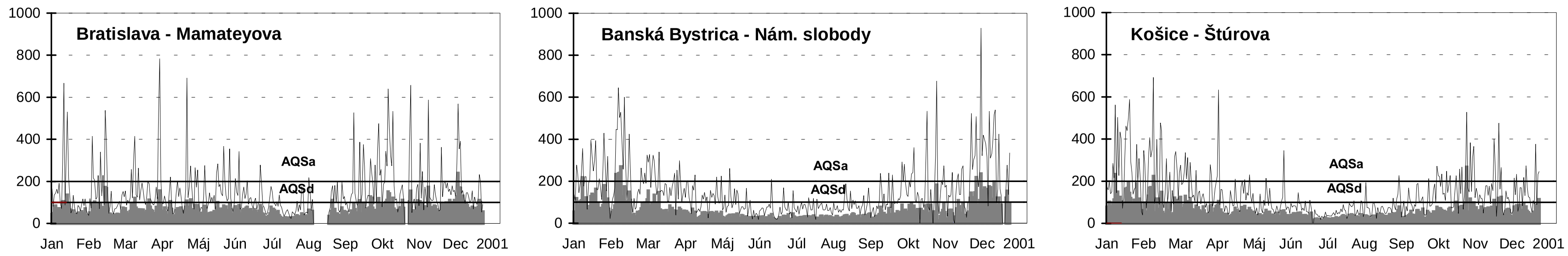


Fig. 2.3 **Concentration of SO_2** [μg.m^{-3}]

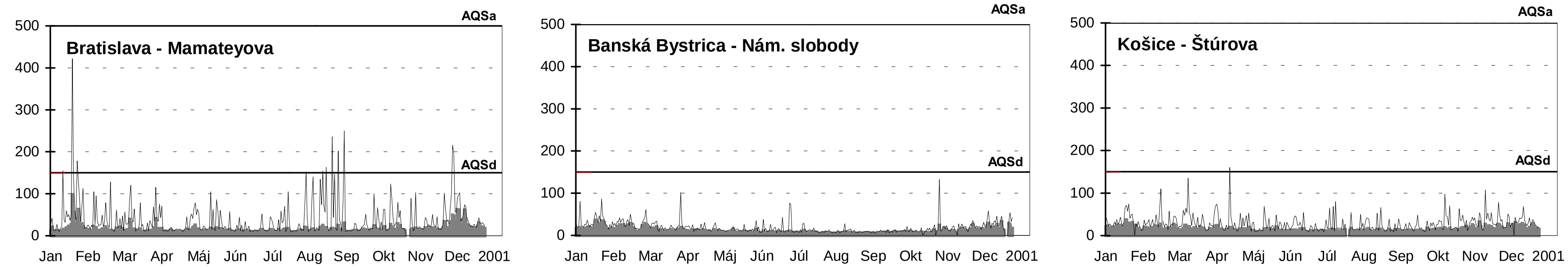


Fig. 2.4 **Concentration of PM10** [μg.m^{-3}]

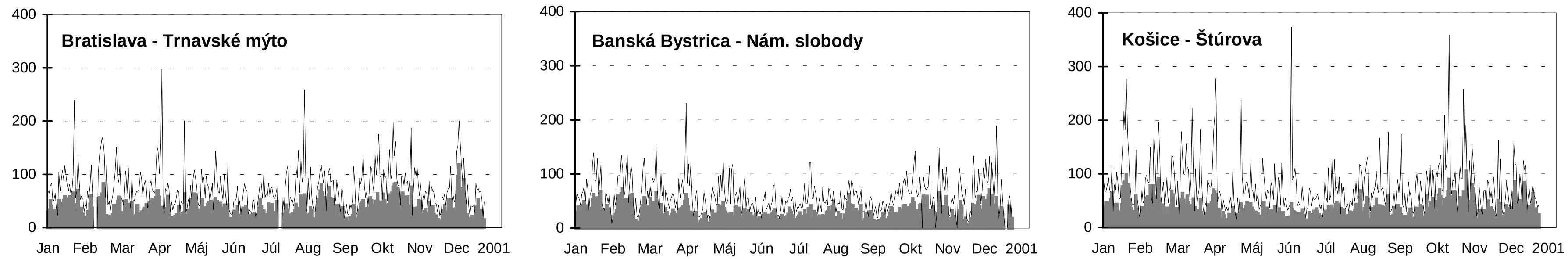


Fig. 2.5 **Concentration of CO** [$\mu g.m^{-3}$]

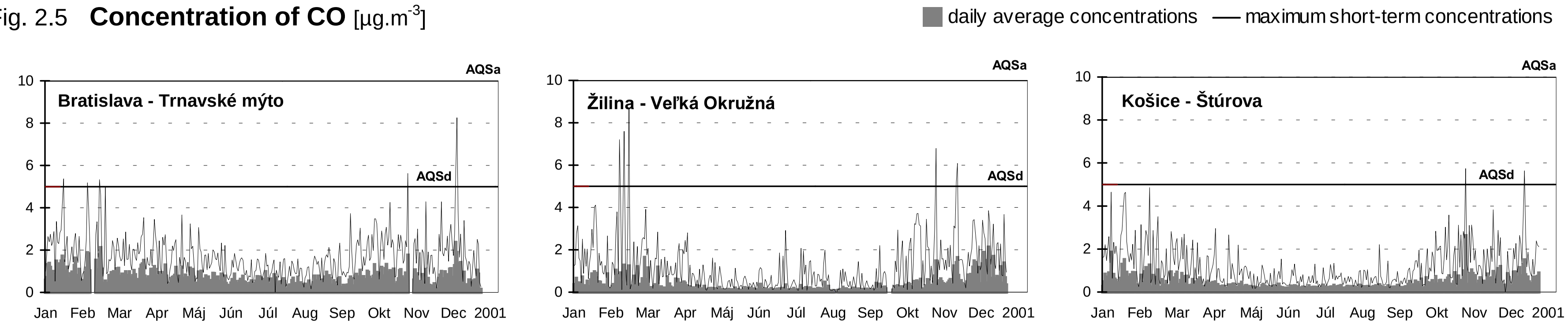


Fig. 2.6 **Concentration of O_3** [$\mu g.m^{-3}$]

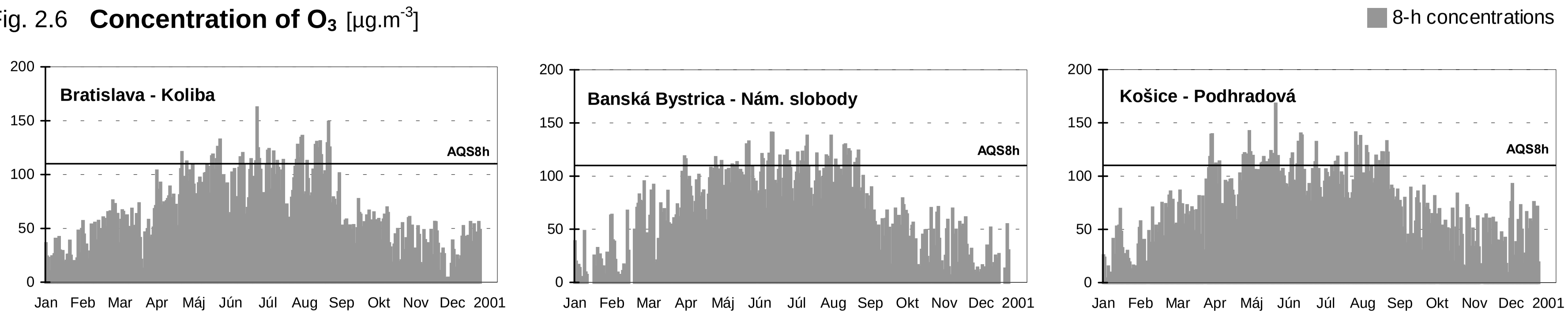
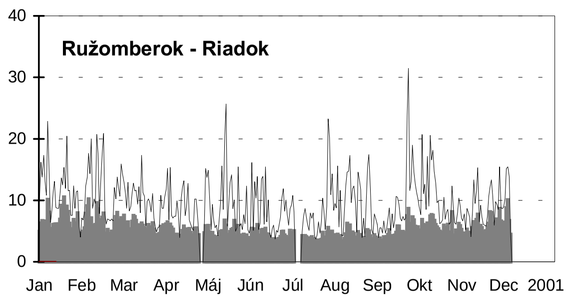


Fig. 2.7 **Concentration of H_2S** [$\mu g.m^{-3}$]



Wind roses - 2001 | Concentration roses - 2001

Fig. 2.8

Bratislava – Kamenné námestie

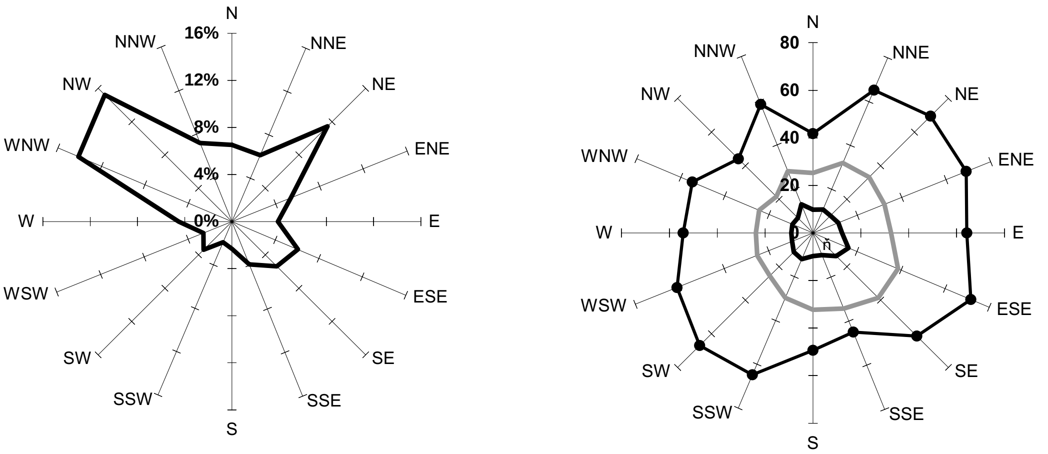


Fig. 2.9

Žiar nad Hronom

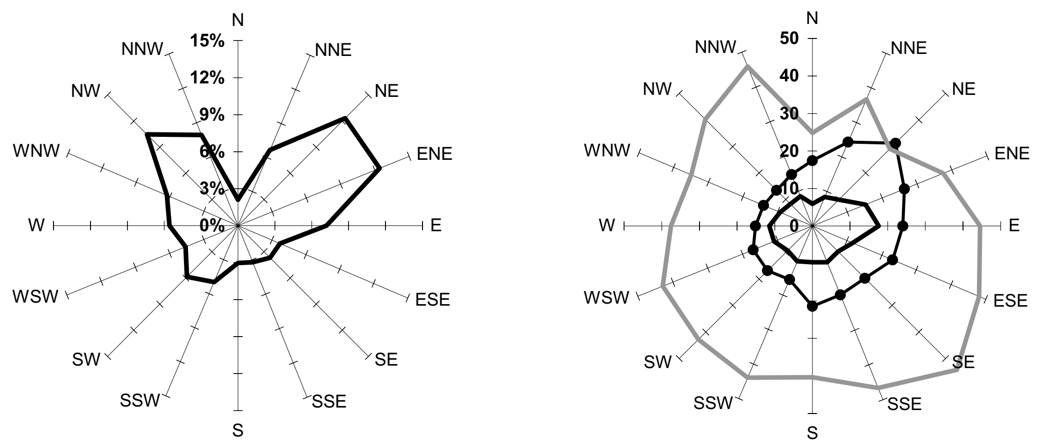
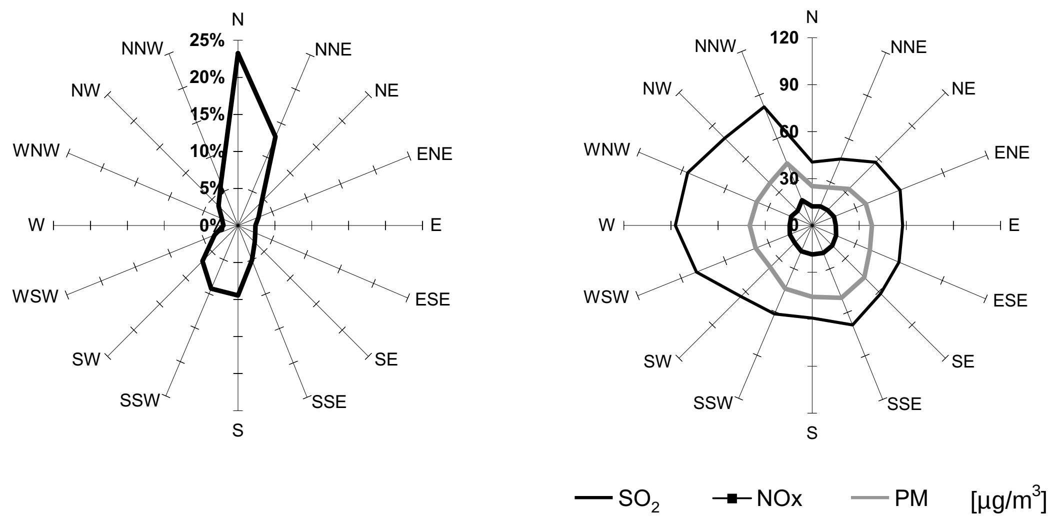


Fig. 2.10

Košice - Štúrova



Tab. 2.4 **Statistical characteristics of air pollution [μg/m^3] assessed within period 1.1.- 31.12.2001**

West and East Slovakia		Bratislava			Košice			Strážske	Prešov		Krompachy	Humenné	Vranov nad Topľou
		Mamateyova	Trnavské mýto	Kamenné nám.	Štúrova	Strojárenská	Veľká Ida		Solivar	Sídlisko III			
Annual average concentration	NO_x	66.1	**122.0**	56.6	57.9	53.0	27.9	38.1	46.6	39.9	24.0	28.8	38.1
	SO_2	16.0	11.3	20.0	14.9	18.7	27.7	16.1	19.5	15.0	13.1	14.6	12.1
	PM	**	43.3[1]	30.8[1]	42.3[1]	35.6[1]	**64.9[1]**	30.7[1]	38.4[1]	33.7[1]	28.8[1]	30.0[1]	36.0[1]
	H_2S												
	CO		698.9		410.9		731.3		361.1				
95-percentile from daily concentrations	NO_x	**119**	**241**	**127**	**121**	**131**	51	59	94	75	38	53	59
	SO_2	32	21	36	26	29	40	26	40	30	30	26	20
	PM	**	78[1]	60[1]	82[1]	69[1]	142[1]	58[1]	71[1]	68[1]	55[1]	56[1]	70[1]
	H_2S												
	CO		1 349		936		1344		832				
95-percentile from 30-min. concentrations	NO_x	144	**339**	138	148	149	64	70	115	86	44	59	68
	SO_2	36	23	37	29	33	40	30	42	34	29	29	25
	PM	**	98[1]	68[1]	96[1]	85[1]	187[1]	67[1]	84[1]	77[1]	67[1]	66[1]	79[1]
	H_2S												
	CO		1 852		1258		1480		1025				
Daily maximum concentration	NO_x	238	438	259	267	202	81	89	143	98	58	87	89
	SO_2	98	40	86	37	37	78	37	54	49	50	44	35
	PM	**	142[1]	113[1]	126[1]	101[1]	240[1]	86[1]	107[1]	111[1]	84[1]	80[1]	92[1]
	H_2S												
	CO		2 363		2626		1905		1265				
30-min. maximum concentration	NO_x	783	1016	563	692	550	207	482	440	375	145	267	453
	SO_2	422	80	265	160	101	513	299	124	125	982	220	132
	PM	**	357[1]	195[1]	448[1]	391[1]	598[1]	320[1]	312[1]	203[1]	435[1]	315[1]	323[1]
	H_2S												
	CO		8 260		5743		5406		3204				

** 50 -75 % of measurements* *** <50 % of measurements* *[1] Calculated according to PM=PM10 x 1.2*

Tab. 2.5 **Statistical characteristics of air pollution [µg/m^3] assessed within period 1.1.- 31.12.2001**

Central Slovakia		B.Bystrica Nám. Slobody	Ružomberok Riadok	Žiar nad Hronom	Martin	Jelšava	Prievidza	Bystričany	Handlová	Žilina Veľ. Okružná	Žilina Vlčince	Hnúšťa
Annual average concentration	NO_x	58.6	37.6	22.0	22.5	23.0	36.9	23.2	23.6	73.6	44.9	19.7
	SO_2	10.9	16.1	8.3	15.4	7.2	13.9	13.0	23.9	20.5	15.1	11.4
	PM	35.0[1]	*40.2[1]	**		43.0[1]	*48.0[1]	*45.0[1]	29.4[1]	38.0[1]	34.5[1]	39.9[1]
	H_2S		5.3								2.9	
	CO	226.7								336.7		
95-percentile from daily concentrations	NO_x	**156**	81	46	47	50	88	46	49	**169**	**100**	39
	SO_2	24	35	18	28	10	34	35	58	39	39	18
	PM	70[1]	84[1]	**		73[1]	92[1]	80[1]	59[1]	76[1]	70[1]	70[1]
	H_2S		8								5	
	CO	777								1192		
95-percentile from 30-min. concentrations	NO_x	185	94	54	63	57	107	59	58	197	120	48
	SO_2	25	40	25	32	11	42	37	64	42	41	19
	PM	80[1]	97[1]	**		104[1]	115[1]	108[1]	66[1]	97[1]	88[1]	95[1]
	H_2S		10								5	
	CO	827								1433		
Daily maximum concentration	NO_x	269	148	88	82	74	150	85	89	303	161	72
	SO_2	36	51	58	49	22	92	107	108	55	63	30
	PM	88[1]	131[1]	**	-	123[1]	181[1]	151[1]	96[1]	131[1]	112[1]	111[1]
	H_2S		11								7	
	CO	1378								2130		
30-min. maximum concentration	NO_x	928	357	149	267	149	436	180	191	1269	511	273
	SO_2	133	136	146	185	69	523	563	272	178	212	120
	PM	277[1]	508[1]	**		353[1]	474[1]	328[1]	212[1]	438[1]	384[1]	600[1]
	H_2S		31								27	
	CO	6804								8656		

** 50 -75 % of measurements* *** <50 % of measurements* *[1] Calculated according to PM=PM10 x 1.2*

Tab. 2.6 **Annual average concentrations of heavy metals [ng/m^3] in suspended particles in 2001**

Area	Station	Pb	Cd
Bratislava	Koliba Kamenné nám Trnavské mýto Lachova	23 35 20 39	0.1 0.3 0.6 0.5
Banská Bystrica	Nám slobody	34	
Horná Nitra	Prievidza	10	3.4
Žiar nad Hronom	Žiar nad Hronom	14	
Ružomberok	Riadok	14	
Košice	Strojárenská Veľká Ida	34 174	0.8 4.8
Krompachy		152	0.7

Tab. 2.7 **Air pollution indices in 2001**

Area	Station	API_y				API_d				API_s			
		NO_x	SO_2	PM	**Sum**	NO_x	SO_2	PM	**Sum**	NO_x	SO_2	PM	**Sum**
Bratislava	Mamateyova	0.8	0.3			1.2	0.3			0.7	0.1		
	Kamenné nám.	0.7	0.3	0.5	**1.5**	1.3	0.3	0.4	**2.0**	0.7	0.1	0.1	**0.9**
	Trnavské mýto	1.5	0.2	0.7	**2.4**	2.4	0.2	0.5	**3.1**	1.7	0.1	0.2	**2.0**
Banská Bystrica	Nám. slobody	0.7	0.2	0.6	**1.5**	1.6	0.2	0.5	**2.3**	0.9	0.1	0.1	**1.1**
Ružomberok	Riadok	0.3	0.5	0.7	**1.5**	0.8	0.3	0.6	**1.7**	0.5	0.1	0.2	**0.8**
Žiar nad Hronom		0.3	0.1			0.5	0.2			0.3	0.1		
Horná Nitra	Prievidza	0.5	0.2	0.8	**1.5**	0.9	0.3	0.6	**1.8**	0.5	0.1	0.2	**0.8**
	Handlová	0.3	0.4	0.5	**1.2**	0.5	0.5	0.4	**1.4**	0.3	0.2	0.1	**0.6**
	Bystričany	0.3	0.2	0.8	**1.3**	0.5	0.3	0.5	**1.3**	0.3	0.1	0.2	**0.6**
Žilina	Veľká Okružná	0.9	0.3	0.6	**1.8**	1.7	0.3	0.5	**2.5**	1.0	0.1	0.2	**1.3**
	Vlčince	0.6	0.3	0.6	**1.5**	1.0	0.4	0.5	**1.9**	0.6	0.1	0.2	**0.8**
Hnúšťa		0.3	0.2	0.7	**1.2**	0.4	0.2	0.5	**1.1**	0.2	0.1	0.2	**0.5**
Martin		0.3	0.3			0.5	0.2			0.3	0.1		
Jelšava		0.3	0.1	0.7	**1.1**	0.5	0.1	0.5	**1.1**	0.3	0.03	0.2	**0.6**
Košice	Štúrova	0.7	0.3	0.7	**1.7**	1.2	0.2	0.5	**1.9**	0.7	0.1	0.2	**1.0**
	Strojárenská	0.7	0.3	0.6	**1.6**	1.3	0.2	0.5	**2.0**	0.7	0.1	0.1	**0.9**
	Veľká Ida	0.4	0.5	1.1	**2.0**	0.5	0.3	1.0	**1.8**	0.3	0.1	0.3	**0.7**
Krompachy		0.3	0.2	0.5	**1.0**	0.4	0.3	0.4	**1.1**	0.2	0.1	0.1	**0.4**
Humenné		0.4	0.2	0.5	**1.1**	0.5	0.2	0.4	**1.1**	0.3	0.1	0.1	**0.5**
Prešov	Solivar	0.6	0.3	0.6	**1.5**	0.9	0.3	0.5	**1.7**	0.6	0.1	0.1	**0.8**
	Sídlisko III	0.5	0.3	0.6	**1.4**	0.8	0.2	0.5	**1.5**	0.4	0.1	0.1	**0.6**
Strážske		0.5	0.3	0.5	**1.3**	0.6	0.2	0.4	**1.2**	0.4	0.1	0.1	**0.6**
Vranov n. Topľou		0.5	0.2	0.6	**1.3**	0.6	0.2	0.5	**1.3**	0.3	0.1	0.1	**0.5**

2.5 ASSESSMENT OF AIR POLLUTION IN THE SLOVAK REPUBLIC

Comparison of statistical characteristics of the pollutants measured with the respective ambient air quality standards, which characterise the unfavourable impact of air pollution on population, enables the assessment of air pollution levels by individual pollutants. Assessment of ambient air quality indices, where cumulative effect of selected pollutants is considered, enables more complex air pollution classification. Statistical characteristics were assessed only for those pollutants, where the number of data measured exceeded 50%. In selected sites the concentration roses were processed for sulphur dioxide, oxides of nitrogen and particulate matter using the base of wind direction frequencies from professional meteorological stations in Bratislava, Žiar nad Hronom and Košice. The total look at the level of pollution creeping the assessment of occurrence, and duration time of concentrations exceeding the special ambient air quality standards appointed for signals: attention, warning and regulation. Pollutants, which exceeded air quality standards, are written in bold in Table 2.4-2.5. Because, the air quality standard has not been set up for particulate matter with an aerodynamic diameter smaller than 10 µm (PM10), the statistical parameters for total particulate matter (PM) were calculated on the base of the relation: PM= PM10*1.2.

West Slovakia

Three automatic monitoring stations (AMSs) were in operation in west Slovakia, in 2001. All of them are located in Bratislava in such a way as to provide the information about the level of air pollution in different parts of the city. The Koliba station only monitors ozone air pollution.

Area

Bratislava

Among the pollutants monitored, mostly oxides of nitrogen, exceeding long-term ambient air quality standards in stations located near to heavy traffic roads, contribute to high level of pollution. Taking into account all locations, the highest level of pollution due to oxides of nitrogen is represented in the area at Trnavské mýto (annual average 122.0 $\mu g.m^{-3}$). Daily ambient air quality standard (AQSd) was exceeded in this location for more than 56% of days in a year. Pollution by sulphur dioxide is relatively small and annual average concentrations reached the extent from 11.3 $\mu g.m^{-3}$ (Trnavské mýto) to 20.0 $\mu g.m^{-3}$ (Kamenné námestie). Pollution by sulphur dioxide is seasonal, reaching maximum concentrations in winter. On the whole, the 2001 level of pollution by sulphur dioxide was below ambient air quality standards. From the concentration rose it is evident that the influence of the major emission source of sulphur dioxide, the petrochemical complex Slovnaft, Ltd. occurs, when under the south-eastern circulation causes relatively high values of sulphur dioxide concentrations. The level of suspended particles contributes considerably to the pollution of the city. Apart from emissions of solid particles from industrial sources, the secondary suspended particles play an important role due to high wind speeds in this area. The highest level was reached in Trnavské mýto, where annual average concentration reached 43.3 $\mu g.m^{-3}$. Carbon monoxide concentrations did not exceed ambient air quality standards. According to index classification the individual locations belong to the considerably or very polluted. In Bratislava and Trnavské mýto the level of pollution exceeded the special ambient air quality standards, for signal Attention in 58 cases (duration 157.5 hours) and for signal Regulation 1 in 4 times (duration 9 hours). Trnavské mýto is a typical traffic station, located several metres from a busy road and such high values occur only in the distance of several metres along busy roads.

Central Slovakia

Eleven automatic monitoring stations were in operation in central Slovakia, in 2001. These are localised in areas of high air pollution levels, which belong to the list of non-attainment areas.

Area

Banská Bystrica

The Námestie slobody station is situated in the city centre, in an area, exposed considerable to emissions from car transport, industrial and municipal sources. Daily concentrations of oxides of nitrogen did exceed daily ambient air quality standards (AQS_d) 14.2% of days in a year. The level of pollution exceeded the special ambient air quality standards, for signal Attention in 8 cases. Air pollution by suspended particles was considerably higher as well, annual average concentration reached 35.0 $\mu g.m^{-3}$. Air pollution by sulphur dioxide did not exceed hygienic standards in any parameter, annual average concentrations reached 10.9 $\mu g.m^{-3}$. Correspondingly air pollution by carbon monoxide was below the permissible ambient air quality standards. The value of air pollution index 2.3 documents that the location is of a high air pollution degree (very unhealthy), originating mostly from oxides of nitrogen and suspended particles.

Ružomberok

In this location the number of stations was reduced to one AMS, which monitors hydrogen sulphide as an indicator of sulphur compound emissions from the technology of the Slovak pulp and paper processing plants. Oxides of nitrogen and suspended particulates play a most important share in the town air pollution apart from the odour substances. The annual average concentration of hydrogen sulphide at the Riadok station was 5.3 $\mu g.m^{-3}$ which is approximately a two times higher value than the annual concentration in Žilina.

Žiar nad Hronom

Only one automatic monitoring station in Žiar nad Hronom is in operation in this area. The station monitors major air pollution sources in the area of the SNP, Ltd and Slovaco Ltd. The annual average concentration of nitrogen dioxide was 22.0 $\mu g.m^{-3}$ and sulphur dioxide 8.3 $\mu g.m^{-3}$.

Horná Nitra

Three automatic monitoring stations were installed in the area of Horná Nitra. The Station in Bystričany is oriented in the direction of the predominant air circulation from the major emission source in the area, the SEZ (Slovak power plants), Ltd. Nováky. The other stations monitor ambient air quality in Prievidza and Handlová. Especially suspended particles and oxides of nitrogen contribute mainly to total air pollution. The highest annual average concentration of suspended particles (48.0 $\mu g.m^{-3}$) occurred in Prievidza. According to the index classification, these locations are moderately polluted (Handlová and Bystričany) and Prievidza to considerably polluted.

Žilina

Two automatic monitoring stations are located in this area. The Veľká Okružná station monitors the air pollution level in the town centre and the other one is located near the industrial zone, on the Vlčince housing estate. The major share in air pollution was due to the oxides of nitrogen (annual average 73.6 $\mu g.m^{-3}$). Daily concentrations of oxides of nitrogen exceeded the ambient air quality standard in Veľká Okružná station on 14.2% days within the year. In the city Žilina the level of pollution exceeded the special ambient air quality standards, for signal Attention in 13 cases (duration 32 hours). The annual average concentration of suspended particles was 38.0 $\mu g.m^{-3}$ in Veľká Okružná station. The air pollution by sulphur dioxide is substantially less, annual average 15.1 $\mu g.m^{-3}$ (Vlčince) and 20.5 $\mu g.m^{-3}$ (Veľká Okružná). According to the index classification, Veľká Okružná station belongs to the very polluted site (API=2.6 and Vlčince station is assessed as considerably polluted.

Martin

One AMS is placed in this area, and was put into operation in 1998. The annual average concentration of nitrogen dioxide was 22.5 $\mu g.m^{-3}$ and annual concentration of sulphur dioxide was 15.4 $\mu g.m^{-3}$. The limit values were not exceeded for any parameter.

Hnúšťa
Jelšava

According to the results monitored, Hnúšťa belongs to the moderately polluted areas. Suspended particles and oxides of nitrogen form the major share in air pollution. A relatively smaller level of air pollution is caused by sulphur dioxide, the annual average concentration accounts for 11.4 $\mu g.m^{-3}$. A value of air pollution index 1.2 classifies the area as moderately polluted. High concentrations of suspended particles in Jelšava contribute most distinctively to the total air pollution level. The annual average concentration of suspended particles 43.2 $\mu g.m^{-3}$ is below ambient air quality standard $AQS_{y.}$. The annual average concentration of sulphur dioxide 7.2 $\mu g.m^{-3}$ is the lowest in Slovakia. On the whole the area of API_d 1.1 belongs to the considerably polluted.

East Slovakia

Ten automatic monitoring stations were in operation in east Slovakia, in 2001. Two of them monitored air pollution levels at the territory of Košice, (Podhradová station monitored the level of surface ozone only) and one is situated in the adjacent municipality of Veľká Ida.

Area

Košice
Veľká Ida

From the pollutants monitored the main share in air pollution was mostly due to oxides of nitrogen and suspended particles. Among the locations the highest level of air pollution by oxides of nitrogen was in Štúrová (annual average 57.9 $\mu g.m^{-3}$), AQS_d was exceeded more than 5.5% of days within the year. Air pollution by sulphur dioxide is relatively small and annual average concentrations ranged between 14.9 $\mu g.m^{-3}$ (Štúrova) and 27,7 $\mu g.m^{-3}$ (Veľká Ida). The level of pollution by suspended particles also contributes to the city pollution. The highest level was reached at the Veľká Ida station, where annual average concentration reached 64.9 $\mu g.m^{-3}$. According to the index classification the individual locations belong to the considerably polluted.

Prešov
Krompachy
Strážske
Vranov n. Topľou
Humenné

According to the air pollution indices the locations belong among the considerably and moderate polluted. At the all locations the air pollution level was below air quality standard. In regard to the ambient air quality standards, the biggest share in air pollution was due to suspended particles and oxides of nitrogen. Annual average concentrations of suspended particles ranged from 28,8 $\mu g.m^{-3}$ (Krompachy) to 38,4 $\mu g.m^{-3}$ (Prešov-Solivar). Annual average concentrations of nitrogen dioxide were between 24.0 $\mu g.m^{-3}$ (Krompachy) and 46.6 $\mu g.m^{-3}$ (Prešov-Solivar). The level of pollution by sulphur dioxide is smaller and the annual average concentrations ranged between 12.1 $\mu g.m^{-3}$ and 19.5 $\mu g.m^{-3}$.

Assessment

In 2001, on the territory of the Slovak Republic, operated 23 automated stations, which measured major pollutants (PM/PM10, SO_2, NO_x, CO). According to the air pollution sources in respective locations, the monitoring stations are equipped with purpose-built analysers. Generally it might be stated, that mainly oxides of nitrogen and particulate matter contribute to the deterioration of ambient air quality. The detailed assessment of air pollution level in individual locations is introduced under the areas of west, central and east Slovakia. The final part provides only the total assessment of air pollution level in Slovakia, according to the ambient air quality standards and air pollution indices. Assessment of air pollution, according to the ambient air quality standards AQS_s AQS_d, on which the concentrations must not be exceeded by more than 5% of cases within a year, is as follows:

Sulphur dioxide

The level of sulphur dioxide pollution is distinguished by a considerable seasonal course, which is reflected also by a relatively low annual average not exceeding the annual air quality standard in any of the locations. In spite of this, the air quality standards were not exceeded at Bystričany station the special limits were exceeded several times. It is obvious from Table 2.8 that the warning signal lasted in Bystričany 2 hours.

Oxides of nitrogen

The short-term ambient air quality standard AQS_s was exceeded (above the permitted 5%) only in Bratislava (Trnavské mýto). Daily ambient air quality standard AQSd was exceeded more markedly in Bratislava (Trnavské mýto, Kamenné námestie and Petržalka), in Banská Bystrica (Námestie slobody), in Žilina (Veľká Okružná) and in Košice (Štúrová and Strojárenská). The annual average concentrations exceeded the annual ambient air quality standard AQS_y only in Bratislava at the Trnavské mýto station.

Particulate matter

The short-term ambient air quality standard AQS_s was not exceeded at any of the locations and daily ambient air quality standard AQS_d was exceeded over the permitted 5% at station Veľká Ida. Air pollution caused by suspended particles, exceeding the annual ambient air quality standard AQS_y, occured in Veľká Ida.

Among the 20 locations in Slovakia, assessed according to the air pollution index classification, three belong to the very polluted areas.

To mutually compare the air pollution levels in the most number of areas in Slovakia, the air pollution indices were assessed for three main pollutants only (SO_2, NOx and particulate matter), monitored at most of the stations. An assessment of the air pollution levels according to the index classification was proceeded in such a way, as the individual location was classified according to the highest air pollution index, which reached the level of air pollution index API_d in most cases.

The level of air pollution has been assessed also according to the attachment No 3 of Provision No 112/93 Act Coll. on "Special ambient air quality standards for purposes to announce signals Attention and Regulation". Table 2.8 assesses the number of days with the occurrence and time duration of air pollution at the level "Attention" (At) and "Regulation" (Reg.1 and Reg.2) for individual pollutants and individual stations in non-attainment areas. Most cases for signal Attention occurred in the Bratislava area, namely 58. Oxides of nitrogen contributed decisively to the high level of air pollution, mainly in locations with heavy traffic (Trnavské Mýto). On the whole, the emissions from traffic contributed decisively to the exceedances of special ambient air quality standards over the whole territory of Slovakia: in 76 cases signal Attention occurred, in 7 cases signal Regulation 1. The number of exceedances of special standards for the rest of pollutants was substantially lower. For sulphur dioxide, one case of exceedance occurred for signal Attention. Unfavourable meteorological factors, mainly in winter half-year contributed substantially to the exceedances of special ambient air quality standards for sulphur dioxide.

Respective regional administration issues the operational rules for smog regulation system as a generally binding regulation. Until now they have been issued only in Košice, Prešov and Trenčín regions.

Tab. 2.8 **Occurrence and pollution duration time at level "Attention" (At) and "Regulation" (Reg. 1 and Reg. 2) for respective pollutants in 2001**

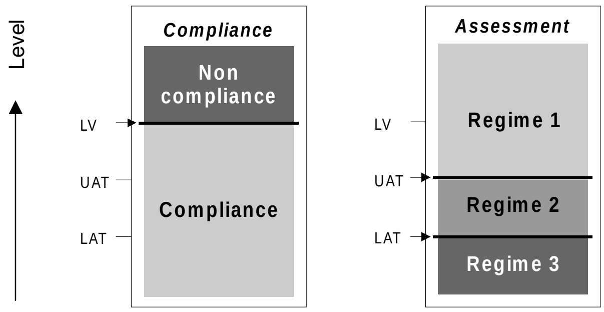
Station / pollutant	Number of occurrences									Total duration time [h]								
	At			Reg. 1			Reg. 2			At			Reg. 1			Reg. 2		
	NO_x	SO_2	SO_2+PM	NO_x	SO_2	SO_2+PM	NO_x	SO_2	SO_2+PM	NO_x	SO_2	SO_2+PM	NO_x	SO_2	SO_2+PM	NO_x	SO_2	SO_2+PM
BA Mamateyova	8	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
BA Trnavské mýto	48	0	0	4	0	0	0	0	0	140.5	0	0	9	0	0	0	0	0
BA Kamenné nám.	2	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Total	**58**	**0**	**0**	**4**	**0**	**0**	**0**	**0**	**0**	**157.5**	**0**	**0**	**9**	**0**	**0**	**0**	**0**	**0**
BB Nám. slobody	8	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0
RK Riadok	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Žiar nad Hronom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prievidza	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bystričany	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Handlová	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
ZA Veľká Okružná	12	0	0	3	0	0	0	0	0	31.5	0	0	4	0	0	0	0	0
ZA Vlčince	1	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0
Total	**13**	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**32**	**0**	**0**	**4**	**0**	**0**	**0**	**0**	**0**
Hnúšťa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Martin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jelšava	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KE Štúrova	4	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0
KE Strojárenská	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Veľká Ida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
PO Sídlisko III.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PO Solivar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Krompachy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strážske	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vranov nad Topľou	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Humenné	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

2.6 PROCESSING OF MEASUREMENT RESULTS ACCORDING TO EC DIRECTIVES

Council of European Communities (EC) in the framework directive „The Air Quality Framework Directive“ (Council Directive 96/62/EC on ambient air quality assessment and management) defined the principles of air quality assessment.

For the air pollution assessment of EU member countries, the whole territory shall be divided into the individual zones. Regime of assessment in each zone depends on the actual level of pollution. Three different regimes might be distinguished upon the level of pollution. These regimes are presented in Figure 2.11 and the requirements for the air quality assessment for individual regimes are specified in Table 2.9.

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



Tab. 2.9 **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] *Lower assessment threshold, as defined in Directive 1999/30/EC*

[2] *Upper assessment threshold as defined in Directive 1999/30/EC*

[3] *Limit value*

For several pollutants the margin of tolerance were defined table 2.11. These margins of tolerances are gradually decreasing year by year to zero value, which will reach at the year when the limit values will come in force. For their distinction these **limit values** from the limit values itself, they are marked as **limit values 2001** in the following text. Limit values upper assessment thresholds and lower assessment thresholds according to the Directive 99/30/EC and 2000/69/EC are listed in Tables 2.10 a 2.11. Alert thresholds were indicated only for:

- SO_2 - if the values of concentrations are above 500 μg.m^{-3} during 3 hours
- NO_2 - if the values of concentrations are above 400 μg.m^{-3} during 3 hours

Statistical characteristics quoted in tables were processed for all monitoring stations in Slovakia. Stations, where the limit values and limit values 2001 were exceeded, are highlighted in tables by bold (Tables 2.12-2.15). Values of pollution, corresponding to the Regime 1, are presented in tables (Tables 2.16 and 2.17).

Sulphur dioxide Neither exceedance of limit values 2001 nor the limit values was recorded at any of the stations. Upper assessment threshold was exceeded at one station and lower assessment threshold at 4 stations.

Nitrogen dioxide Limit value for nitrogen dioxide were exceeded at the Trnavské mýto and Kamenné námestie stations, but the level was below limit 2001. Upper assessment threshold was exceeded at all stations in Bratislava.

PM10 In 2001 PM10 was monitored at 21 stations. Limit value was exceeded at stations: Bratislava, Jelšava, Prievidza, Bystričany and Košice. Limit value 2001 was exceeded at station Veľká Ida. In the year 2001 were put in operation first monitoring stations measuring PM2,5 particles.

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

Lead At present air pollution by lead does not represent a serious problem. The highest annual average concentration 0.174 μg.m^{-3} (Veľká Ida) is smaller than the lower assessment threshold (0.250 μg.m^{-3}).

Tab. 2.10 **Upper and lower assessment threshold**

	Receptor	Interval of averaging	Limit value [μg/m^3]	Assessment threshold [μg/m^3]	
				Upper*	Lower*
SO_2	Human health	1h	350 (24)		
	Human health	24h	125 (3)	75 (3)	50 (30)
	Vegetation	1r, 1/2r	20 (-)	12 (-)	8 (-)
NO_2	Human health	1h	200 (18)	140 (18)	100 (18)
	Human health	1r	40 (-)	32 (-)	26 (-)
NO_x	Vegetation	1r	30 (-)	24 (-)	19.5 (-)
PM10	Human health	24h	50 (35)	30 (7)	20 (7)
	Human health	1r	40 (-)	14 (-)	10 (-)
Pb	Human health	1r	0.5 (-)	0.35 (-)	0.25 (-)
CO	Human health	8h (maximum)	10 000 (-)	7 000 (-)	5 000 (-)
Benzene	Human health	1r	5 (-)	3.5 (-)	2 (-)

** allowed exceedances per year are in brackets*

Tab. 2.11 **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**	1/1/05	**150 µg/m³**	500	470	440	410	380	350					
SO_2	24h	**125**	1/1/05	**-**											
SO_2^e	1r, W[1]	**20**	19/07/01	**-**											
NO_2	1h	**200**	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
NO_x^e	1r	**30**	19/07/01	**-**											
PM10	24h	**50**	1/01/05	**50%**	75	70	65	60	55	50					
PM10	1r	**40**	1/01/05	**20%**	48	46	45	43	42	40					
Pb	1r	**0.5**	1/01/05	**100%**	1.0	0.9	0.8	0.7	0.6	0.5					
Pb[2]	1r	**0.5 (1.0)**	1/1/10 (1/1/05)	**100%**	1.0	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5
CO	Max. 8 hour daily value	**10 000**	1/1/2003 (1/1/2005)		16 000	16 000	16 000	14 000	12 000	10 000					
Benzén	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

Tab. 2.12 **Assessment of pollution according to EU directives**

	Component	Time of averaging	Limit values for the year 2001 [µg/m³] *(number of exceedances)*	Bratislava Mamteyova	Bratislava Trnavské mýto	Bratislava Kamenné nám.	Banská Bystrica Nám. slobody	Ružomberok Riadok	Žiar nad Hronom	Martin	Jelšava	Prievidza	Bystričany	Handlová	Hnúšťa
Health protection	SO_2	1 hour	350 (24)	1	0	0	0	0	0	0	0	1	2	0	0
		24 hours	125 (3)	0	0	0	0	0	0	0	0	0	0	0	0
	NO_2	1 hour	200 (18)	0	2	5	0	0	0	0	0	0	0	0	0
		1 year	40	39.4	**45.1**	**42.1**	31.7	19.9	15.2	15.5	14.8	23.7	13.8	16.1	12.3
	PM_{10}	24 hours	50 (35)	**	**69**	17	34	28	**		**53**	**59**	**49**	17	34
		1 year	40	**	36.2	25.7	29.3	33.5*	**		36.1	**40.5***	38.1*	24.4	33.6
	Lead[#]	1 year	500[#]	39	20	35	34	14	14			10			
	CO	8 hours (moving average)	10 000		3633[2]		3229[2]								
	Benzene	1 year	5												
AT	SO_2	3 subsequent hours	500	0	0	0	0	0	0	0	0	0	0	0	0
	NO_2	3 subsequent hours	400	0	0	0	0	0	0	0	0	0	0	0	0
Vegetation protection	SO_2	1 year	20	16.0[1]	11.3[1]	20.0[1]	10.9[1]	16.12[1]	8.3[1]	15.4[1]	7.2[1]	13.9[1]	13.0[1]	**23.9**[1]	11.4[1]
		winter half-year	20	19.0[1]	12.7[1]	18.5[1]	16.2[1]	**21.7**[1]	13.1[1]	**24.2**[1]	9.5[1]	**25.4**[1]	**26.2**[1]	**32.8**[1]	**29.9**[1]
	NO_x	1 year	30	**66.1**[1]	**122.0**[1]	**56.6**[2]	**58.6**[1]	**38.6**[1]	22.0[1]	22.5[1]	23.0[1]	**36.9**[1]	23.2[1]	23.6[1]	19.7[1]

[1] stations are located in urban areas *[2] maximum of 8h moving average value*

AT - alert threshold (number of days), ** 50-75% of measurements,* *** less than 50% of measurements,* *[#] lead in ng/m³* *figures in bold are above limit value*

Tab. 2.13 **Assessment of pollution according to EU directives**

	Component	Time of averaging	Limit values for the year 2001 [µg/m³] (*number of exceedances*)	Žilina Veľká Okružná	Žilina Vlčince	Strážske	Prešov Solivar	Prešov Sídlisko III	Krompachy	Humenné	Vranov nad Topľou	Košice Štúrova	Košice - Strojárenská	Veľká Ida
Health protection	SO_2	1 hour	350 (*24*)	*0*	*0*	*0*	*0*	*0*	*4*	*0*	*0*	*0*	*0*	*1*
		24 hours	125 (*3*)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
	NO_2	1 hour	200 (*18*)	*0*	*1*	*0*	*0*	*2*	*0*	*0*	*0*	*1*	*0*	*0*
		1 year	40	30.9	27.3	26.4	25.2	27.3	12.4	21.0	17.1	27.8	29.3	19.1
	PM_{10}	24 hours	50 (*35*)	***42***	*29*	*17*	*35*	*22*	*15*	*11*	*27*	***61***	*33*	***116***
		1 year	40	32.1	29.1	25.7	32.2	28.1	30.1	25.0	30.1	35.2	29.8	**54.0**
	Lead	1 year	500#						152				34	174
	CO	8 hours (moving average)	10 000	3333[2]			1869[2]					3698[2]		2656[2]
	Benzene	1 year	5											
AT	SO_2	3 subsequent hours	500	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
	NO_2	3 subsequent hours	400	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Vegetation protection	SO_2	1 year	20	**20.5**[1]	15.1[1]	16.1[1]	19.5[1]	15.0[1]	13.1[1]	14.6[1]	12.1[1]	14.9[1]	18.7[1]	**27.7**[1]
		winter half-year	20	**25.8**[1]	**27.9**[1]	18.4[1]	**21.5**[1]	**21.8**[1]	15.0[1]	18.9[1]	15.6[1]	18.2[1]	**22.0**[1]	**34.8**[1]
	NO_x	1 year	30	**73.6**[1]	**44.9**[1]	**38.1**[1]	**46.6**[1]	**39.9**[1]	24.0[1]	28.8[1]	**38.1**[1]	**57.9**[1]	**53.0**[1]	27.9[1]

[1]stations are located in urban areas *[2]maximum of 8h moving average value*
AT - alert threshold (number of days), ** 50-75% of measurements,* *** less than 50% of measurements,* *# lead in ng/m³* *figures in bold are above limit value*

Tab. 2.14 **Assessment of pollution according to EU directives**

	Component	Time of averaging	Limit value + margin of tolerance [µg/m^3] *(number of exceedances)*	Bratislava Mamteyova	Bratislava Trnavské mýto	Bratislava Kamenné nám.	Banská Bystrica Nám. slobody	Ružomberok Riadok	Žiar nad Hronom	Martin	Jelšava	Prievidza	Bystričany	Handlová	Hnúšťa
Health protection	SO_2	1 hour	470 (*24*)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*1*	*0*	*0*
		24 hours	125 (*3*)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
	NO_2	1 hour	290 (*18*)	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
		1 year	58	39.4	45.1	42.1	31.7	19.9	15.2	15.5	14.8	23.7	13.8	16.1	12.3
	PM_{10}	24 hours	70 (*35*)	**	*13*	*4*	*2*	*9*	**		*8*	*20*	*8*	*1*	*4*
		1 year	46	**	36.2	25.7	29.3	33.5*	**		36.1	40.5*	38.1*	24.4	33.6
	Lead	1 year	900[#]	39	20	35	34	14	14			10			
	CO	8 hours (moving average)	16 000		3633[2]		3229[2]								
	Benzene	1 year	10												
AT	SO_2	3 subsequent hours	500	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
	NO_2	3 subsequent hours	400	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Vegetation protection	SO_2	1 year	20	16.0[1]	11.3[1]	20.0[1]	10.9[1]	16.1[1]	8.3[1]	15.4[1]	7.2[1]	13.9[1]	13.0[1]	**23.9**[1]	11.4[1]
		winter half-year	20	19.0[1]	12.7[1]	18.5[1]	16.2[1]	**21.7**[1]	13.1[1]	**24.2**[1]	9.5[1]	**25.4**[1]	**26.2**[1]	**32.8**[1]	**29.9**[1]
	NO_x	1 year	30	**66.1**[1]	**122.0**[1]	**56.6**[1]	**58.6**[1]	**38.6**[1]	22.0[1]	22.5[1]	23.0[1]	**36.9**[1]	23.2[1]	23.6[1]	19.7[1]

[1]stations are located in urban areas *[2]maximum of 8h moving average value*
AT - alert threshold (number of days), ** 50-75% of measurements,* *** less than 50% of measurements,* *[#] lead in ng/m^3*
figures in bold are above limit value+margin of tolerance

Tab. 2.15 **Assessment of pollution according to EU directives**

	Component	Time of averaging	Limit value + margin of tolerance [µg/m³] (*number of exceedances*)	Žilina Veľká Okružná	Žilina Vlčince	Strážske	Prešov Solivar	Prešov Sídlisko III	Krompachy	Humenné	Vranov nad Topľou	Košice Štúrova	Košice - Strojárenská	Veľká Ida
Health protection	SO_2	1 hour	470 (*24*)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
		24 hours	125 (*3*)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
	NO_2	1 hour	290 (*18*)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
		1 year	58	30.9	27.3	26.4	25.2	27.3	12.4	21.0	17.1	27.8	29.3	19.1
	PM_{10}	24 hours	70 (*35*)	*10*	*2*	*1*	*7*	*4*	*0*	*0*	*6*	*14*	*7*	***70***
		1 year	46	32.1	29.1	25.7	32.2	28.1	30.1	25.0	30.1	35.2	29.8	**54.0**
	Lead	1 year	900#						152				34	174
	CO	8 hours (moving average)	16 000	3333[2]			1869[2]					3698[2]		2656[2]
	Benzene	1 year	10											
AT	SO_2	3 subsequent hours	500	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
	NO_2	3 subsequent hours	400	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Vegetation protection	SO_2	1 year	20	**20.5**[1]	15.1[1]	16.1[1]	19.5[1]	15.0[1]	13.1[1]	14.6[1]	12.1[1]	14.9[1]	18.7[1]	**27.7**[1]
		winter half-year	20	**25.8**[1]	**27.9**[1]	18.4[1]	**21.5**[1]	**21.8**[1]	15.0[1]	18.9[1]	15.6[1]	18.2[1]	**22.0**[1]	**34.8**[1]
	NO_x	1 year	30	**73.6**[1]	**44.9**[1]	**38.1**[1]	**46.6**[1]	**39.9**[1]	24.0[1]	28.8[1]	**38.1**[1]	**57.9**[1]	**53.0**[1]	27.9[1]

[1] stations are located in urban areas *[2] maximum of 8h moving average value*
*AT - alert threshold (number of days), * 50- 75% of measurements, ** less than 50% of measurements, # lead in ng/m³*
figures in bold are above limit value+margin of tolerance

Tab. 2.16 **Assessment of pollution according to EU directives**

	Component	Time of averaging		Threshold values [µg/m^3] (number of exceedances)	Bratislava Mamteyova	Bratislava Trnavské mýto	Bratislava Kamenné nám.	Banská Bystrica Nám. slobody	Ružomberok Riadok	Žiar nad Hronom	Martin	Jelšava	Prievidza	Bystričany	Handlová	Hnúšťa
Health protection	SO_2	24 hours	UAT	75 (3)	1	0	1	0	0	0	0	0	1	1	**5**	0
			LAT	50 (3)	6	0	2	0	1	1	0	0	3	2	27	0
	NO_2	1 hour	UAT	140 (18)	16	**27**	**114**	0	0	0	0	0	0	0	0	0
			LAT	100 (18)	143	423	459	12	0	0	0	0	0	0	0	0
		1 year	UAT	32	**39.4**	**45.1**	**42.1**	31.7	19.9	15.2	15.5	14.8	23.7	13.8	16.1	12.3
			LAT	26	39.4	45.1	42.1	31.7	19.9	15.2	15.5	14.8	23.7	13.8	16.1	12.3
	PM_{10}	24 hours	UAT	30 (7)	**	**194**	**98**	**141**	**102**	**		**216**	**137**	**131**	**83**	**175**
			LAT	20 (7)	**	269	207	237	149	**		304	190	176	175	280
		1 year	UAT	14	**	**36.2**	**25.7**	**29.3**	**33.5***	**		**36.1**	**40.5***	**38.1***	**24.4**	**33.6**
			LAT	10	**	36.2	25.7	29.3	33.5*	**		36.1	40.5*	38.1*	24.4	33.6
	Pb	1 year	UAT	350#	39	20	35	34	14	14			10			
			LAT	250#	39	20	35	34	14	14			10			
	CO	8 hours (moving average)	UAT	7 000		3633[2]		3229[2]								
			LAT	5 000		3633[2]		3229[2]								
	Benzene	1 year	UAT	3.5												
			LAT	2												
Vegetation protection	SO_2	winter half-year	UAT	12	**19.0[1]**	**12.7[1]**	**18.5[1]**	**16.2[1]**	**21.7[1]**	**13.1[1]**	**24.2[1]**	9.5[1]	**25.4[1]**	**26.2[1]**	**32.8[1]**	**29.9[1]**
			LAT	8	19.0[1]	12.7[1]	18.5[1]	16.2[1]	21.7[1]	13.1[1]	24.2[1]	9.5[1]	25.4[1]	26.2[1]	32.8[1]	29.9[1]
	NO_x	1 year	UAT	24	**66.1[1]**	**122.0[1]**	**56.6[1]**	**58.6[1]**	**38.6[1]**	22.0[1]	22.5[1]	23.0[1]	**36.9[1]**	23.2[1]	23.6[1]	19.7[1]
			LAT	19,5	66.1[1]	122.0[1]	56.6[1]	58.6[1]	38.6[1]	22.0[1]	22.5[1]	23.0[1]	36.9[1]	23.2[1]	23.6[1]	19.7[1]

*UAT - upper assessment threshold, LAT - lower assessment threshold, * 50-75% of measurements, ** less than 50% of measurements, # lead is in v ng/m^3*

[1] stations are located in urban areas [2] maximum of 8h moving average value

figures in bold are above upper assessment threshold underlined figures are above lower assessment threshold

Tab. 2.17 **Assessment of pollution according to EU directives**

	Component	Time of averaging	Threshold values [µg/m³] (number of exceedances)		Žilina Veľká Okružná	Žilina Vlčince	Strážske	Prešov Solivar	Prešov Sídlisko III	Krompachy	Humenné	Vranov nad Topľou	Košice Štúrova	Košice - Strojárenská	Veľká Ida
Health protection	SO_2	24 hours	UAT	75 (3)	0	0	0	0	0	0	0	0	0	0	0
			LAT	50 (3)	4	8	0	3	0	0	0	0	0	0	7
	NO_2	1 hour	UAT	140 (18)	1	2	1	0	7	0	0	0	1	2	0
			LAT	100 (18)	11	3	4	5	41	0	0	0	4	44	0
		1 year	UAT	32	30.9	27.3	26.4	25.2	27.3	12.4	21.0	17.1	27.8	29.3	19.1
			LAT	26	30.9	27.3	26.4	25.2	27.3	12.4	21.0	17.1	27.8	29.3	19.1
	PM_{10}	24 hours	UAT	30 (7)	**162**	**146**	**95**	**158**	**126**	**85**	**86**	**144**	**196**	**141**	**232**
			LAT	20 (7)	255	240	201	275	219	194	199	260	292	239	270
		1 year	UAT	14	**32.1**	**29.1**	**25.7**	**32.2**	**28.1**	**30.1**	**25.0**	**30.1**	**35.2**	**29.8**	**54.0**
			LAT	10	32.1	29.1	25.7	32.2	28.1	30.1	25.0	30.1	35.2	29.8	54.0
	Pb	1 year	UAT	350#	3333[2]			1869[2]					3698[2]		2656[2]
			LAT	250#	3333[2]			1869[2]					3698[2]		2656[2]
	CO	8 hours (moving average)	UAT	7 000											
			LAT	5 000											
	Benzene	1 year	UAT	3.5						152				34	174
			LAT	2						152				34	174
Vegetation protection	SO_2	winter half-year	UAT	12	**25.8**[1]	**27.9**[1]	**18.4**[1]	**21.5**[1]	**21.8**[1]	**15.0**[1]	**18.9**[1]	**15.6**[1]	**18.2**[1]	**22.0**[1]	**34.8**[1]
			LAT	8	25.8[1]	27.9[1]	18.4[1]	21.5[1]	21.8[1]	15.0[1]	18.9[1]	15.6[1]	18.2[1]	22.0[1]	34.8[1]
	NO_x	1 year	UAT	24	**73.6**[1]	**44.9**[1]	**38.1**[1]	**46.6**[1]	**39.9**[1]	**24.0**[1]	**28.8**[1]	**38.1**[1]	**57.9**[1]	**53.0**[1]	**27.9**[1]
			LAT	19,5	73.6[1]	44.9[1]	38.1[1]	46.6[1]	39.9[1]	24.0[1]	28.8[1]	38.1[1]	57.9[1]	53.0[1]	27.9[1]

*UAT - upper assessment threshold, LAT - lower assessment threshold, * 50-75% of measurements, ** less than 50% of measurements, # lead is in v ng/m³*
[1] stations are located in urban areas [2] maximum of 8h moving average value
figures in bold are above upper assessment threshold underlined figures are above lower assessment threshold

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 develop the whole range of unfavourable biological effects such as skin cancer, eye irritation, 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 state is expected in the middle of this century.

The growth of ozone concentrations in the troposphere approximately 1 $\mu g.m^{-3}$ annually was observed over the industrial continents of the Northern Hemisphere by the end of 1980s. It is associated with the increasing emission of ozone precursors (NO_x, VOCs, CO) from car transport, power generation and industry. Since the early 1990s the concentration of ground level ozone in Europe has been more or less stagnant, which is also evident in the measurements in Slovakia. Increased ozone concentrations in a free troposphere intensify greenhouse effects of the atmosphere. In a boundary layer of the atmosphere they impact unfavourably on human health (mainly on the respiratory system of human beings), vegetation (mainly on agricultural crops and forest growth) and various materials.

3.2 GROUND LEVEL OZONE IN THE SLOVAK REPUBLIC DURING 1996-2001

Ambient air quality standards, critical values for ozone

In association with the protection of human health and vegetation, the number of standard values, critical levels and ambient air quality standards for the evaluation of ground level ozone concentrations, was proposed by the respective international organisations. Risk areas may be identified in the comparison of measured ozone concentrations and critical values, respectively ambient air quality standards. In Table 3.1 the recommended ambient air quality standards are listed according to the EU Directive 92/72 EEC.

Tab. 3.1 Ambient air quality standards for ground level ozone concentrations

Ambient air quality standards	O_3 concentration [$\mu g.m^{-3}$]	Average within the time interval
for human health protection	110	8 h *
for protection of vegetation	200/65	1 h / 24 h
for information to the public	180	1 h
for warning to the public	360 (240**)	1 h

* *8-hour average is calculated as moving average, 4-times per day, upon the base of values within the time intervals 0.00-9.00 h, 8.00-17.00 h, 16.00-1.00 h and 12.00 -21.00 h*

** *Proposed standard in new EU ozone directive*

The ambient air quality standard 110 µg.m^{-3} (8-h average), the same as within the EU, has been adopted in Slovakia since 1996 to assess the effect of ozone on human health. Until then the less strict standard 160 µg.m^{-3} (8-h average) has been adopted. Ambient air quality standard 50 µg.m^{-3}, recommended by the United Nations Economic Commission for Europe (UN ECE) is often used to assess the long-term effect of ozone on vegetation. It is calculated as an average of ozone concentration from daily hours (9-16 h), during the vegetation period (April-September).

The cumulative effects of exposure on agricultural crops, forest growth and other ecosystems at concentrations of ozone over a certain threshold level are characterised by the so-called index of exposure (AOT40), expressed in ppb.h (1ppb = 2 µg.m^{-3} at STP). According to the UN ECE experts, threshold level of ozone concentration 40 ppb.h has been proposed at the same time. A critical level AOT40 3 000 ppb.h corresponds to a 5% decrease in agricultural crop yield. The AOT40 value is calculated for the daily hours (characterised by an average value of global radiation at least 50 W.m^{-2}), during three subsequent months, May, June and July. Preliminary proposed short-term critical value AOT40 for visible damage to agricultural crops is 500 ppb.h, under high water vapour pressure deficit (dry weather) and 200 ppb.h under low water vapour pressure deficit (wet weather), calculated for daily hours during five subsequent days. For protection of forests in Europe, the preliminary critical level 10 000 ppb.h is proposed. In this case as well, the cumulation is calculated for the daily values, but during the 6 months April - September. This critical value is the same for deciduous and coniferous trees as well. For natural vegetation it is recommended to use the same critical value AOT40 as for an agricultural crop. The third daughter directive for ozone (draft) stated the objective limit (for 2010) for vegetation protection AOT40 = 9 000 ppb.h (sum of hourly concentration (within 8-20 CET) exceeded 40 ppb for the period May-July) calculated as an 5 year average. The value of AOT40 = 3 000 ppb.h is long term prospect by this Directive.

Long-term and short-term characteristics of ground level ozone in Slovakia during 1996-2001

The measurement of ground level ozone concentrations in Slovakia started in 1991, 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 1994) are part of the EMEP monitoring network. In 2001 new ozone measurements were introduced at the station at Štrbské Pleso. For monitoring of ground level ozone concentrations, the ozone analysers of the US companies Thermoelectron and MLU have been used in most of the stations. All these analysers operate on the principle of UV radiation 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 2001 the number of missing data did not exceed 10% at most of the stations (Table 3.2). Exceptional gaps in data were at the Martin, Žiar n.H., and Chopok stations. The results are not reported from these stations.

In 2001, the annual average concentrations of ground level ozone in polluted urban and industrial locations of Slovakia ranged within the interval 37-49 µg.m^{-3} (Table 3.3). The concentrations in the rest of the territory ranged between 54 and 89 µg.m^{-3}, mainly depending on the altitude. The highest annual average of ground level ozone concentrations was reached in the apical station at Kojšovská hoľa (89 µg.m^{-3}). The data from the EMEP station at Chopok (2 000 m a.s.l.) is usually not complete, including the yr. 2001, because of the remote location of this mountain station. The critical value 50 µg.m^{-3} (UN ECE), calculated as the average of daily hours during the vegetation period is regularly exceeded each year over the whole territory of Slovakia (with the exception of some urban positions). In 2001 this limit was exceeded at all stations (Table 3.3). As it follows from the above, the injuries to vegetation due to the increased ozone concentrations are to be considered even in photochemically less favourable years (1993, 1997, and 1998). The year 2001, according to annual averages, belongs to the photochemically active years, but on the contrary by maximum concentrations ranges among photochemically less active years.

Tab. 3.2 Number of missing daily averages of ground level ozone concentrations [%] during 1996-2001

Station	1996	1997	1998	1999	2000	2001
Banská Bystrica	19.1	5.1	2.4	2.5	3.0	9.3
Bratislava -Koliba	*	*	*	*	5.7	4.7
Bratislava -Petržalka	8.5	9.7	5.8	0.5	18.6	3.6
Hnúšťa	1.5	3.0	7.2	4.9	2.7	3.3
Humenné	–	32.3	1.7	15.1	2.7	3.0
Chopok	41.5	17.4	42.7	32.8	30.0	66.3
Jelšava	*	*	0.6	4.9	20.5	1.6
Košice -Podhradová	14.7	11.1	21.0	17.8	9.6	4.4
Kojšovská hoľa	*	*	*	*	24.0	7.9
Martin	0.2	18.5	0.9	6.3	1.4	90.4
Poprad (Gánovce)	*	*	*	*	25.4	6.0
Prešov	*	*	*	10.9	16.7	3.3
Prievidza	30.3	43.2	10.2	9.3	10.1	13.4
Ružomberok	0.6	32.9	–	47.4	7.1	7.7
Stará Lesná	14.6	11.5	9.2	3.8	8.7	2.4
Starina	5.3	13.4	8.4	0.8	8.2	3.6
Štrbské Pleso	*	*	*	*	*	11.2
Topoľníky	51.9	19.5	58.5	11.2	10.1	25.8
Veľká Ida	*	*	*	4.7	34.2	15.0
Žiar nad Hronom	2.7	2.6	2.3	5.7	53.0	63.0
Žilina	1.0	5.1	4.6	7.4	13.1	1.4

** 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}] during 1996-2001

Station	1996		1997		1998		1999		2000		2001	
	AA	AVP	AA	AVP	AA	AVP	AA	AVP	AA	AVP	AA	AVP
Banská Bystrica	28	58	35	80	42	83	42	65	41	62	44	63
Bratislava - Koliba	51	64	78	97	55	78	–	–	52	62	54	61
Bratislava - Petržalka	30	47	29	52	30	47	52	66	57	70	40	53
Hnúšťa	46	82	40	89	39	82	42	61	48	69	54	78
Humenné	–	–	52	85	57	91	54	69	48	63	54	67
Chopok	86	90	78	82	80**	84	90**	88**	75**	73**	–	–
Jelšava	*	*	*	*	50	75	50	69	47	65	49	68
Košice -Podhradová	55	79	43	66	40	62	34	40	60	72	58	69
Kojšovská hoľa	*	*	*	*	*	*	*	*	100	100	89	87
Martin	49	75	47	86	49	91	49	64	46	62	–	–
Poprad (Gánovce)					*	*	*	*	51	66	46	57
Prešov	*	*	*	*	*	*	37	50	54	75	49	65
Prievidza	26	39	40	62	35	67	47	60	46	61	45	58
Ružomberok	34	50	37	64	–	–	34**	49**	39	53	46	61
Stará Lesná	68	94	48	70	49	73	65	82	60	76	55	70
Starina	62	82	53	72	56	76	59	70	60	77	63	76
Štrbské Pleso	*	*	*	*	*	*	*	*	*	*	75	80
Topoľníky	76	90	31	49	43**	78	53	65	59	69	41**	52**
Veľká Ida	*	*	*	*	*	*	44	60	47**	66**	37	53
Žiar nad Hronom	54	80	48	85	47	84	49	66	54**	67**	–	–
Žilina	30	51	39	72	41	84	42	59	47	64	38	52

AA - annual average AVP- average from daily hours (9.00-16.00 h) during vegetation period (April-September)
** station installed later ** 50-75 % of measurements – station closed down, respectively long-term failure of station*

In Figure 3.1, the seasonal change of daily ozone concentrations in Stará Lesná during 1992-2001 is depicted. The seasonal course is typical for lowlands and valley (not apical) 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 boundary layer of the atmosphere. At the same time it follows from this Figure, that the ambient air quality standard for protection of vegetation 65 $\mu g.m^{-3}$ (daily average) 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 exceedance of average level in daily maximum values of ozone concentrations about 30-40 $\mu g.m^{-3}$ in photochemically favourable years (1992, 1994, 1995, 1999 and 2000) as compared to those in less favourable years. Values in 1997, 1998 and 2001 are the smallest in the monitoring period.

The number of exceedances of recommended ozone short-term ambient air quality standards in Slovakia during 1996-2001 is summarised in Tables 3.4-3.6. The standard when the public must be warned (360 $\mu g.m^{-3}$) was not exceeded in the whole period 1996-2001. Occasionally, mainly in the photochemically active years, the information standard 180 $\mu g.m^{-3}$ was exceeded. In 2001, 6 exceedances in Bratislava-Koliba and 3 exceedances in Bratislava-Petržalka were registered (Table 3.4).

Tab. 3.4 Number of exceedances in ozone short-term ambient air quality standards (AQS) for warning and information of the public during 1996-2001

Station	AQS_{1h} = 360 $\mu g.m^{-3}$						AQS_{1h} = 180 $\mu g.m^{-3}$					
	1996	1997	1998	1999	2000	2001	1996	1997	1998	1999	2000	2001
Banská Bystrica	0	0	0	0	0	0	0	0	2	0	0	0
Bratislava - Koliba	0	0	0	-	0	0	0	0	1	-	2	6
Bratislava - Petržalka	0	0	0	0	0	0	0	0	0	5	6	3
Hnúšťa	0	0	0	0	0	0	2	0	0	0	0	0
Humenné	-	0	0	0	0	0	-	0	0	0	0	0
Chopok	0	0	0	0	0	0	0	2	2	0	0	0
Jelšava	*	*	0	0	0	0	*	*	0	0	0	0
Košice - Podhradová	0	0	0	0	0	0	0	0	0	0	2	0
Kojšovská hoľa	*	*	*	*	0	0	*	*	*	*	45	0
Martin	0	0	0	0	0	0	0	0	1	0	4	0
Poprad (Gánovce)	*	*	*	*	0	0	*	*	*	*	0	0
Prešov	*	*	*	0	0	0	*	*	*	0	23	0
Prievidza	0	0	0	0	0	0	1	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
Topoľníky	0	0	0	0	0	0	0	0	0	0	23	0
Veľká Ida	*	*	*	0	0	0	*	*	*	0	2	0
Žiar nad Hronom	0	0	0	0	0	0	0	0	1	0	5	0
Žilina	0	0	0	0	0	0	0	0	3	30	0	0

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

Fig. 3.1 **Seasonal change of ground level ozone concentration in Stará Lesná during 1992-2001**

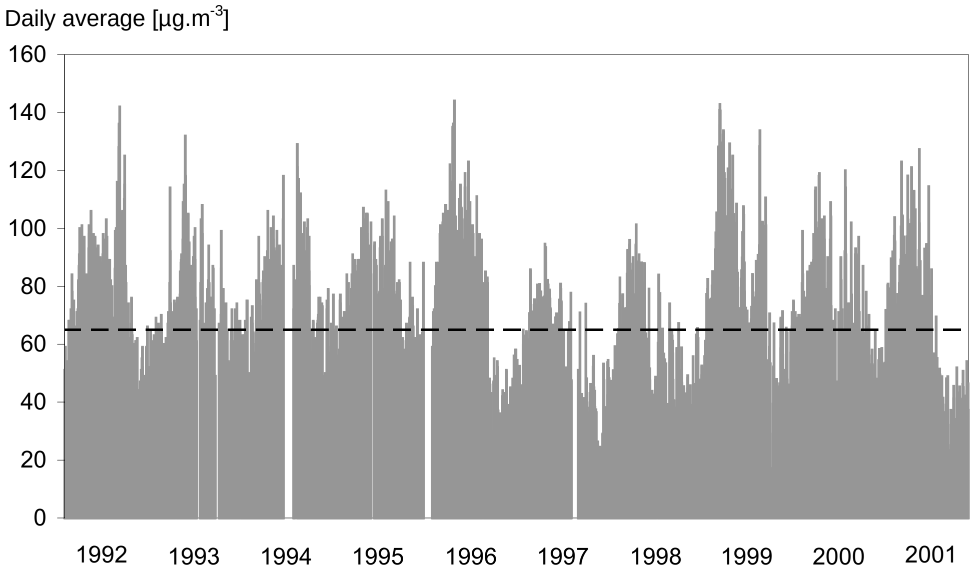
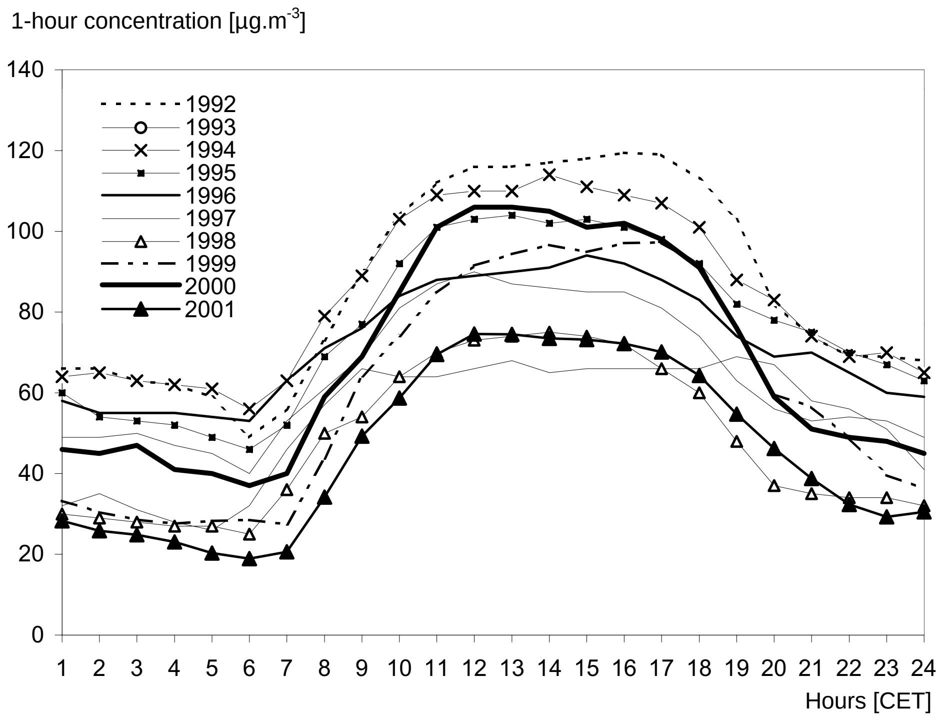


Fig. 3.2 **Average daily change of ground level ozone concentration in Stará Lesná, in August 1992-2001**



Tab. 3.5 Number of exceedances in ozone short-term ambient air quality standards (AQS) for protection of human health, accepted in EU and in Slovakia during 1996-2001

	AQS_{8h} = 110 µg.m^{-3}																							
	1996				1997				1998				1999				2000				2001			
Časový interval	0-9	9-17	16-01	12-21	0-9	9-17	16-01	12-21	0-9	9-17	16-01	12-21	0-9	9-17	16-01	12-21	0-9	9-17	16-01	12-21	0-9	9-17	16-01	12-21
Banská Bystrica	0	0	0	1	0	7	1	5	0	40	1	32	0	23	1	19	0	40	1	31	1	42	3	41
Bratislava - Koliba	1	8	9	20	5	42	33	55	0	15	4	15		–			0	24	1	20	2	34	19	44
Bratislava - Petržalka	0	0	0	0	0	0	0	0	0	1	0	1	0	46	13	40	0	58	14	52	0	21	1	21
Hnúšťa	2	36	7	61	0	26	1	17	0	19	0	15	0	25	5	21	0	34	0	12	0	82	7	66
Humenné		–			0	20	1	17	0	39	6	35	0	12	8	15	0	9	0	10	0	11	3	11
Chopok	38	24	30	23	10	12	13	11	24	17	21	17	70	56	71	68	28	18	29	23		–		
Jelšava		*				*			0	49	6	37	2	53	13	43	0	28	1	20	0	47	7	44
Košice - Podhradová	1	14	5	14	0	1	0	1	0	0	0	0	0	1	1	1	0	65	24	58	0	49	18	46
Kojšovská hoľa		*				*				*				*			95	101	109	114	55	50	69	62
Martin	0	14	6	43	0	17	1	15	0	39	6	41	0	13	0	14	0	23	9	25		–		
Poprad (Gánovce)		*				*				*				*			0	11	1	12	0	2	0	3
Prešov		*				*				*			0	0	0	0	0	57	6	52	0	28	4	26
Prievidza	1	1	1	4	0	1	0	0	0	4	0	2	0	29	6	18	0	38	2	30	0	23	4	17
Ružomberok	0	2	1	6	0	0	0	0		–			0	0	0	0	0	9	1	11	0	12	1	15
Stará Lesná	11	58	34	56	0	1	0	2	0	7	0	3	14	68	39	74	1	33	15	31	7	41	12	36
Starina	0	20	6	26	0	10	0	6	0	7	0	3	0	9	2	8	0	21	2	16	0	20	4	14
Štrbské Pleso		*				*				*				*				*			16	48	26	40
Topoľníky	1	29	14	36	0	1	0	2	0	9	2	9	0	3	5	27	4	50	52	61	0	15	1	7
Veľká Ida		*				*				*			0	1	0	2	0	23	1	14	0	11	0	7
Žiar nad Hronom	0	10	7	39	0	18	2	23	0	30	7	29	2	20	14	23	0	20	6	20		–		
Žilina	0	0	0	3	0	0	0	0	0	29	3	30	2	16	11	18	0	40	3	47	0	10	5	25

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

Tab. 3.6 Number of exceedances in ozone short-term ambient air quality standards (AQS) for protection of vegetation during 1996-2001

Stanica	AQS_{1h} = 200 µg.m^{-3}						AQS_{24h} = 65 µg.m^{-3}					
	1996	1997	1998	1999	2000	2001	1996	1997	1998	1999	2000	2001
Banská Bystrica	0	0	0	0	0	0	4	18	61	63	72	88
Bratislava - Koliba	0	0	0	-	0	0	101	198	98		112	116
Bratislava - Petržalka	0	0	0	0	2	0	6	0	6	105	115	50
Hnúšťa	0	0	0	0	0	0	84	40	42	53	78	126
Humenné	-	-	0	0	0	0	-	71	133	111	56	110
Chopok	0	1	0	0	0	–	189	259	**182	**217	**147	–
Jelšava	*	*	0	0	0	0	*	*	101	115	80	109
Košice – Podhradová	0	0	0	0	0	0	134	36	14	12	143	147
Kojšovská hoľa	*	*	*	*	8	0	*	*	*	*	259	298
Martin	0	0	0	0	0	–	97	70	91	89	48	–
Poprad (Gánovce)	*	*	*	*	0	0	*	*	*	*	65	56
Prešov	*	*	*	0	9	0	*	*	*	8	93	109
Prievidza	0	0	0	0	0	0	8	14	25	134	88	78
Ružomberok	0	0	-	0	0	0	34	4	-	**0	38	56
Stará Lesná	0	0	0	0	0	0	184	68	72	173	132	124
Starina	0	0	0	0	0	0	147	92	106	128	157	157
Štrbské Pleso	*	*	*	*	*	0	*	*	*	*	*	206
Topoľníky	0	0	0	0	1	0	123	**2	**31	100	133	39
Veľká Ida	*	*	*	0	0	0	*	*	*	44	**36	27
Žiar nad Hronom	0	0	0	0	2	–	130	80	81	76	**46	–
Žilina	0	0	0	4	0	0	11	27	59	48	85	41

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

The ambient air quality standard 110 µg.m^{-3} (8-hour average), adopted within the EU, as well as in Slovakia in 1996, was in the period 1996-2001 most frequently exceeded in the summer 2000 (Table 3.5). In 2001 was the number of exceedances in average only a little lower. The highest number of exceedances (236 cases) was observed at Kojšovská hoľa station.

In the period 1996-2001 the ambient air quality standard for the protection of vegetation 200 µg.m^{-3} (1-hour average) was exceeded only in several cases. In 2001 no exceedance was observed (Table 3.6). 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 2001 a record number of exceedances was observed at Kojšovská hoľa, 298 cases (Table 3.6).

Table 3.7 comprises the cumulative characteristics of ground level ozone in Slovakia during 1996-2001. It follows from the data in Table 3.7, that the critical values of exposure index AOT40 for crops 3 000 ppb.h (5% reduction in agricultural crop yields) are regularly exceeded over most of the Slovak territory, at some locations even more times. Similarly the critical value of AOT40 for forest (10 000 ppb.h) was exceeded over most of the Slovak territory. In 1999 - 2001 the highest values of exposure indexes were observed since the beginning of measurements. If measurements were complete, the respective values of index of exposure would be expected to be even higher.

It may be stated in conclusion, that the existing measurements confirmed the high level of ground level ozone concentrations in Slovakia. Primary and secondary standards accepted for protection of human health and vegetation are often exceeded.

Tab. 3.7 Index of exposure AOT40 (over a threshold 40 ppb) for protection of vegetation during 1996-2001 [ppb.h]

Station	AOT40 (1)						AOT40 (2)					
	1996	1997	1998	1999	2000	2001	1996	1997	1998	1999	2000	2001
Banská Bystrica	1 090	4 960	5 594	10 101	9 648	10 587	2 190	7 517	10 854	17 235	16 300	17 022
Bratislava - Koliba	2 966	8 182	3 080	–	7 004	8 640	5 436	16 665	8 217	–	11 660	14 538
Bratislava - Petržalka	416	300	201	12 024	12 598	4 577	730	486	872	19 856	17 242	8 948
Hnúšťa	9 010	7 106	5 879	4 333	7 003	15 257	16 068	11 455	10 386	8 922	13 175	23 486
Humenné	–	6 647	8 037	5 316	4 281	5 853	–	9 292	15 067	9 505	7 569	10 258
Chopok	4 874	6 150	**3 113	14 760	2 598	–	11 452	10 359	**11 063	21 713	**9 583	–
Jelšava	*	*	7 373	15 481	7 708	10 436	*	*	14 406	20 036	12 308	17 066
Košice - Podhradová	3 664	281	**109	–	13 051	11 378	6 646	1 783	**926	1 896	22 138	18 407
Kojšovská hoľa	*	*	*	*	21 491	11 110	*	*	*	*	34 390	22 547
Martin	5 840	5 236	9 720	5 530	3 643	–	10 893	10 179	15 443	9 495	10 697	–
Poprad (Gánovce)	*	*	*	*	4 733	2 410	*	*	*	*	7 355	3 845
Prešov	*	*	*	623	11 786	7 055	*	*	*	1 062	20 161	13 019
Prievidza	412	795	2 292	8 956	7 892	5 679	1 125	1 746	3 133	17 038	14 608	10 305
Ružomberok	1 620	477	–	**178	4 082	5 450	2 952	999	–	**474	7 275	8 758
Stará Lesná	11 502	1 208	1 775	12 500	6 881	11 156	19 342	1 964	4 350	26 133	14 295	15 227
Starina	5 506	2 211	2 053	4 139	6 575	6 883	9 968	4 399	6 276	7 709	11 378	11 050
Štrbské Pleso	*	*	*	*	*	12 603	*	*	*	*	*	16 689
Topoľníky	5 626	**559	**1 038	7 156	8 763	4 231	9 810	**788	**3 893	13 140	18 851	**5 247
Veľká Ida	*	*	*	2 747	6 506	4 490	*	*	*	4 486	**7 952	5 608
Žiar nad Hronom	5 758	6 628	7 390	3 310	7 209	–	10 946	10 166	12 859	14 336	**7 589	–
Žilina	1 470	1 665	7 180	2 892	10 058	6 289	2 348	4 354	13 215	10 624	16 961	10 586

(1) *calculation for daily hours of the months May, June and July*
(2) *calculation for daily hours during vegetation period (April - September)*

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

3.3 TOTAL ATMOSPHERIC OZONE OVER THE TERRITORY OF THE SLOVAK REPUBLIC IN 2001

Since August 1993 total atmospheric ozone over the territory of Slovakia has been measured with the Brewer ozone spectrophotometer in the Centre of Aerology and Ozone Measurements of the Slovak Hydrometeorological Institute at Gánovce near Poprad. As well the total ozone solar UV spectra is regularly scanned through the range 290-325 nm at 0.5 nm increments. In May 2001 the SHMI Brewer instrument took a part in the international comparison and calibration campaign held in Budapest. Three field instruments were calibrated against the World total ozone traveling standard. 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. Since April 2000 the Centre of Aerology and Ozone Measurements has been providing 24 hour UV Index forecasts 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/). SHMI in cooperation with the Slovak Dermato-Venerological Society translated and modified the brochure UV Index for the Public originally issued in the frame of the COST-713 project. Limited number of copies sponsored by cosmetic firm was distributed to participants in the conference DERMAPARTY Bratislava 2001.

The annual mean of the total atmospheric ozone was 328.6 Dobson Units in 2001. This is 2.8% 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 2000, when the deficiency was 5.5%. Total ozone statistics (daily means, relative deviations from long term averages, monthly means, standard deviations and extremes) are in Table 3.8.

The monthly means below average were observed in the period January-August and in October. Differences were less significant then last year. Maximal monthly mean difference from long-term average -7% in October could be considered an exception because the ozone layer is normally most stable in autumn. Most significant daily deficiencies about 25% were observed in the middle of February. In the last decade they have been compensated by positive differences that is why the monthly total ozone deficiency resulted in 4%. With respect to biological effects the negative differences in June observed in period 1996-2000 are of great importance. In the spring and summer seasons the solar elevation is high and the path of the solar rays through the ozone layer is short. That is why the UV-B radiation (range of 280-320 nm) is very intensive. In the year 2001 the harmful trend was not confirmed because the average ozone decline in June was only 2%.

Total ozone weekly averages are in Figure 3.3. The graph illustrates a behavior of the ozone layer in the year 2001 and shows generally significant short-term variations in total ozone amount in our geographical region.

Figure 3.4 shows the biologically effective irradiance (the power incident upon a surface unit area - in units of W/m^2) weighted by CIE erythemal action spectra (McKinlay and Diffey 1987).

Values were measured at local noon (about 10:39 UTC), when the daily maximal solar elevation is achieved. During a clear day 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.

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.

The maximal noon value of CIE-weighted irradiance 190 mW/m^2 (which correspondents to 3.26 MED/hour) was measured on June 28. The same low yearly noon maximum was in 1996. Rather low values in June and July are caused either by frequent cloudiness or by relatively good ozone layer state in those months. Absolute maximum 196 mW/m^2 (which correspondents to 3,36 MED/hour) observed on July 1 at 11:10 UTC has been 10% below that one measured in 2000.

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 4400 J/m^2 (which correspondents to 21 MED) was measured on June 28. It is the same day when maximal irradiance for June was observed. The daily dose is much lower than last year as well. The ozone loss was 10% during that day.

Total CIE-erythemal dose for the period April-September 2001 was significantly lower than in 2000, which is mainly caused by a relatively low sunshine duration. The value is not mentioned here intentionally, because it is significantly affected by three gaps (instrument failure April 18 and May 5-9, regular calibration May 28-June 1).

Fig. 3.3 **Total atmospheric ozone over the territory of Slovakia in 2001**

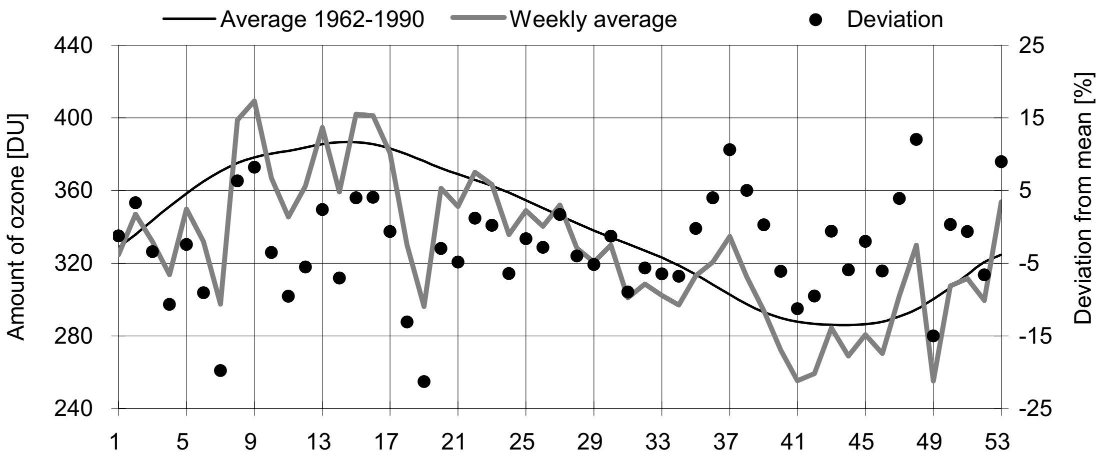


Fig. 3.4 **Annual course of DUV (Diffey) radiation noon values Gánovce 2001**

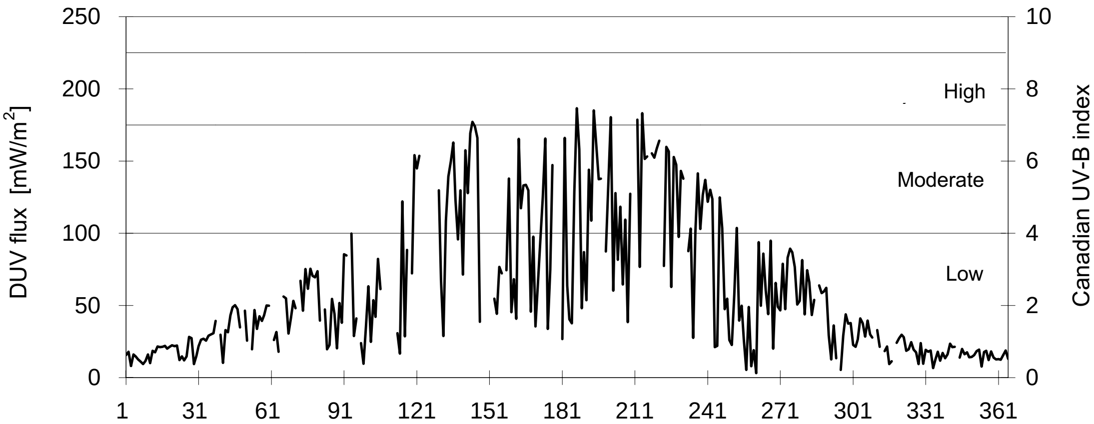
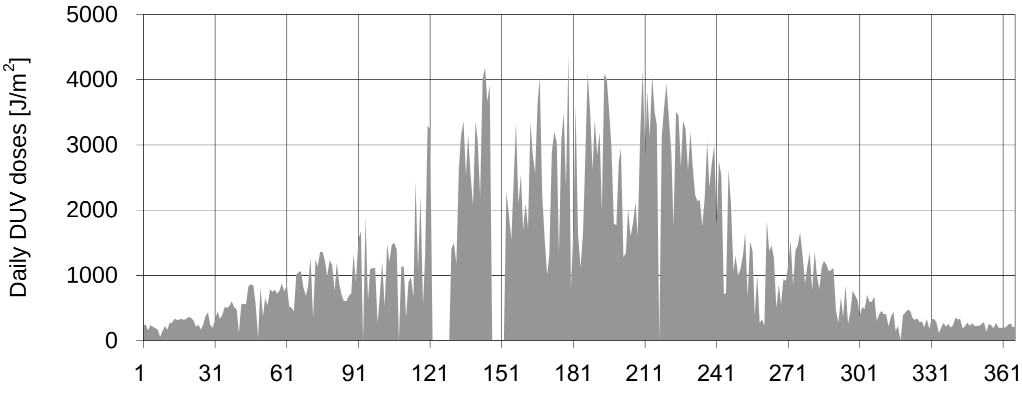


Fig. 3.5 **Annual course of harmful ultraviolet solar radiation daily doses Gánovce 2001**



Tab. 3.8 Total atmospheric ozone [DU] in 2001 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	340	4	333	-7	381	1	386	0	341	-11			334	-4	295	-11	331	6	276	-5	283	-1	360	22
2	303	-7	371	3	437	15	381	-1	323	-15	364	0	349	0	301	-9	324	4	261	-10	268	-6	328	11
3	325	-1	391	8	382	1	343	-11	320	-16	376	3	367	6	306	-7	309	0	259	-11	256	-11	347	17
4	346	5	325	-10	383	1	319	-18	340	-10	409	12	364	5	296	-10	304	-2	273	-6	270	-6		
5	359	9	315	-13	418	10	360	-7			404	11	364	5	302	-8	318	3	299	3	269	-6	328	10
6	316	-5	306	-16	385	1	382	-1			360	-1	341	-1	310	-6	332	8	278	-4	287	0	297	-1
7	285	-14	298	-18	382	1	383	-1			372	3	328	-5	309	-6	311	1	259	-10	276	-3	257	-15
8	305	-8	325	-11	326	-14	346	-10			346	-5	351	2	291	-11	322	5	255	-12	283	-1	280	-7
9	350	5	360	-2	321	-16	371	-4			337	-7	340	-1	308	-6	348	14	253	-12	266	-7	276	-9
10	376	12	368	0	376	-1	356	-8	361	-4	316	-12	353	3	306	-6	346	13	247	-14	332	16	300	-1
11	345	3	351	-5	361	-5	363	-6	372	-1	319	-12	325	-5	314	-4	330	8	247	-14	252	-12	295	-3
12	358	6	337	-9	313	-18	375	-3	375	0	356	-1	328	-4	322	-1	342	13	254	-12	256	-11	296	-3
13	363	7	274	-26	341	-11	443	15	372	-1	344	-4	315	-8	314	-3	331	9	264	-8	276	-4	293	-5
14	332	-2	273	-26	383	0	449	16	368	-2	332	-7	320	-6	307	-5	326	8	267	-7	288	0	299	-3
15	337	-1	270	-27	361	-6	458	18	366	-2	346	-3	317	-7	309	-5	321	7	270	-6	305	6	310	1
16	323	-5	278	-25	335	-12	405	5	385	3	318	-11	308	-9	304	-6	348	16	253	-12	272	-6	360	16
17	331	-3	285	-24	321	-16	402	4	341	-8	336	-6	308	-9	296	-8	357	19	243	-15	244	-15	333	7
18	356	4	366	-2	364	-5			339	-9	362	2	314	-7	295	-8	335	12	268	-6	251	-13	302	-3
19	337	-2	347	-7	339	-11	409	6	377	2	353	-1	311	-8	291	-10	314	5	266	-7	262	-10	295	-6
20	315	-9	405	8	400	4	390	1	352	-5	359	1	302	-11	298	-7	303	2	262	-9	290	0	311	-1
21	325	-6	336	-10	350	-9	407	6	358	-3	328	-8	351	4	304	-5	280	-6	253	-12	279	-4	307	-3
22	319	-8	394	5	393	3	395	3	380	3	327	-8	352	5	304	-5	296	0	275	-4	297	2	293	-7
23	335	-4	429	14	355	-7	393	2	351	-5	362	2	333	-1	298	-6	303	3	295	3	330	13	341	8
24	307	-12	442	17	359	-7	394	3	327	-11	353	0	338	1	294	-8	303	3	277	-3	347	19	301	-5
25	298	-15	439	17	341	-11	397	3	337	-9	346	-2	338	1	287	-10	293	0	276	-3	311	6	297	-7
26	315	-11	436	16	381	-1	367	-4	349	-5	334	-5	335	0	295	-7	283	-4	279	-3	328	12	305	-5
27	318	-10	451	19	391	2	411	7	356	-3	343	-2	345	4	297	-6	297	1	293	2	289	-1	326	2
28	304	-14	397	5	391	2	381	0			315	-10	319	-4	293	-7	284	-3	296	4	297	1	253	-21
29	335	-6			412	7	322	-16			346	-1	302	-9	328	4	296	1	291	2	339	15	305	-5
30	342	-4			396	3	327	-14			366	5	312	-6	311	-1	302	4	265	-7	369	25	310	-4
31	352	-1			407	5							295	-11	309	-1			251	-12			354	9
∅	331	-3	354	-4	370	-3	383	-1	354	-5	349	-2	331	-3	303	-6	316	5	268	-7	289	0	309	0
Std	21	7	55	14	31	8	34	9	19	5	23	6	20	5	9	3	21	6	15	5	31	10	26	9
Max	376	12	451	19	437	15	458	18	385	3	409	12	367	6	328	4	357	19	299	4	369	25	360	22
Min	285	-15	270	-27	313	-18	319	-18	320	-16	315	-12	295	-11	287	-11	280	-6	243	-15	244	-15	253	-21

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

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 35/67 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

Since 1990 new legislation on air protection has been created and at the same time the bodies of state administration in air protection were established. Operators of large and medium size sources have a legal duty to announce annually data about the emission and additional associated parameters to the respective district office for the purpose of identifying taxes. Since 1997 the transformation of a national inventory system - project NEIS (National Emission Inventory System) has been under realisation. The aim of the NEIS project was to substitute the present duplicity in data acquisition on air pollution sources and their emissions with a unified system. This system enables the rational acquisition, processing and further utilising of data on a local (NEIS BU) and national level (NEIS CU), in coincidence with the needs following from the legal reform of air protection, state environmental policy and international commitments of the Slovak Republic.

The NEIS software product is constructed as a multi-module system, corresponding fully to the requirements of current legislation. 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, placed at the Slovak Hydrometeorological Institute.

Positive contribution of the new emission inventory system transformation is as follows:

- Elimination of duplicate acquisition and processing of data on sources and their emissions, provision of data standardisation at all levels.
- Provision of a modern and effective tool to all, who 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 in all districts.
- 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.

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 134/1992 as amended, the district offices are obliged since 1st of January 2001 to elaborate yearly reports about operational characteristics of air pollution sources in their district and provide them electronically (in the NEIS BU format) to an organisation appointed by the Ministry of Environment. This organisation is SHMI.

In the new system the sources are assigned into 3 categories according to the Decree 92/1996 to the Act 309/1991.

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

Medium sources	Stationary sources containing stationary combustion units having cumulative heating output over 0.2-50 MW and other processes

Small sources	Equipments with heating output less than 0.2 MW (decision 144/2000 of MoE SR)

Results 1990-2000

EAPSI 1

The EAPSI 1 database has been represented by a coherent set of data since 1985-1999 . In the present inventory, the 967 air pollution sources, i.e. the area-administrative units, defined according to the organisation inventory number, are 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. 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

New system contained 667 large point sources in 2000. 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 co-operation with the Offices of Environment within the period 1993-1996 and ended in December 1996.

Middle sources

In year 2000 system NEIS registered 10 364 medium sources. System EAPSI was included in evidence of 9044 sources, but here were plated only stationary sources of the heating output of 0.2-5 MW .

EAPSI 3

The EAPSI 3 database has been updated annually until 1997. Local furnaces were assessed as the area sources at district level. Emission factors and total fuel consumption data by the retail consumers were used to calculate emissions. The decree 268/97 amended by 144/00 of the Ministry of Environment of the Slovak Republic has accommodated the requirements on data quality, keeping the operational evidence and providing the data to the state administration bodies since 1997. The balance of emissions for 1998 and 1999 has not been processed.

Small sources

The emission balance in 2000 was processed in the NEIS CU module by the same calculation as done up to 1997. The input data (fuel amounts, according to the types, sold for households and retail consumers, and quality marks) necessary for the emission balance were collected from Regional Offices in NEIS BU module.

MOBILE SOURCES

Emissions are updated according to the requirements of the Ministry of Environment of the Slovak Republic. 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 kilometres 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.

4.2 DEVELOPMENT TRENDS IN BASIC POLLUTANTS

EMISSIONS OF BASIC POLLUTANTS

Trends in basic pollutants compiled in systems EAPSI and NEIS are listed in Table 4.1 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 (Slovnaft a.s.), respectively advancing of its effectiveness shared in the particulate matter emission reduction. A downward trend of sulphur dioxide emissions in 1996 has also continued in 1999 as a consequence of the decreased consumption of brown coal, hard coal and heavy fuel oil (Power plants in Zemianske Kostolany, Vojany and Slovnaft). Since 1998 the desulphurisation process of large power sources has been in partial operation (Power plant Zemianske Kostolany). At the same time the consumption of natural gas is growing.

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.

CO

A downward trend in carbon monoxide emissions since 1989 has been caused mainly by the decrease in consumption and a change of fuel composition in the sphere of retail consumers (EAPSI 3). 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 1989 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.

EMISSIONS OF OTHER POLLUTANTS

Emission Inventories of NMVOC, HM and POP follow up SNAP97 sectors as defined in EMEP/ CORINAIR Guidebook and recommendations of TFEIP[1] working groups. Emissions are estimated at national level (activity data multiplied by emission factor) in cooperation with external experts. Revisions of NMVOC, POPs and HM emissions are expected in next years as a result of harmonisation of national system with requirements of EU directives.

NMVOC

In 2001 a new source *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. The NM VOC emissions have decreased since 1990 by about 50%. 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 (Table 4.7. Fig. 4.4.) Due to the harmonization of inventories with the requirements of EU directions there will be a further revision of sources and emission NMVOC in the future in Slovakia.

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 a, b, 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 was influenced 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 since 1996 (Tab. 4.9 a,b, Fig. 4.5).

Share of individual sectors in total emissions of the Slovak Republic in the year 2000

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. In table 4.3 the emissions of pollutants of EAPSI 1 in non-attainment areas are shown (Decree of the Ministry of Environment of the Slovak Republic No.112/93 Act coll.). Table 4.2 lists summary emission data for the selected type of productions according to the OKEČ division.

Most important sources of air pollution in the Slovak Republic in the year 2000

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 78.4 to 92.8%. Table 4.5 lists top ten sources for each of 8 administrative regions.

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

Specific territorial emissions in the year 2000

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 December (N+1).

Tab. 4.1a **Emissions of basic pollutants in SR in 2000 and 2001***** [thous.t]

		PM		SO_2		NOx		CO	
		2000	2001	2000	2001	2000	2001	2000	2001
Stationary sources - NEIS	Large sources*	29.923	29.722	101.955	109.823	54.485	51.653	120.609	115.177
	Middle sources*	4.958	4.405	8.083	6.655	8.052	7.751	10.779	10.280
	Small sources**	15.196	13.086	12.983	11.150	5.549	5.606	40.758	35.327
Mobile sources	Road transport	1.969	2.149	0.670	0.750	32.979	35.551	110.434	118.501
	Other transport	0.399	0.404	0.189	0.194	4.860	4.899	1.719	1.626
Total		52.445	49.766	123.880	128.572	105.925	105.460	284.299	280.911

* *according to the Ordinance of the Slovak Government 92/1996*

** *according to the Decree of the MoE SR 144/2000*

*** *preliminary data*

Tab. 4.1b **Development trends in basic pollutants of the Slovak Republic within 1990-1999** [thous. t]

					PM emissions					
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
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	#36.425	#36.425	#36.425	#17.097	#17.097	9.478	*9.478	*9.478	*9.478
EAPSI 3	54.868	39.593	30.511	26.968	17.869	16.111	19.038	14.166	**14.166	**14.166
EAPSI 4	3.128	2.513	2.113	1.998	2.420	2.622	2.688	2.696	2.918	2.693
Total	**302.496**	**232.121**	**179.594**	**145.317**	**89.722**	**91.600**	**69.665**	**62.986**	**57.730**	**61.150**

					SO_2 emissions					
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
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	#37.509	#37.509	#37.509	#27.091	#27.091	10.577	*10.577	*10.577	*10.577
EAPSI 3	79.487	57.298	44.091	39.255	25.926	20.706	16.314	12.087	**12.087	**12.087
EAPSI 4	3.424	2.722	2.390	2.175	2.313	2.490	2.536	2.393	2.724	1.088
Total	**542.401**	**444.613**	**380.024**	**325.350**	**238.076**	**238.877**	**226.735**	**201.620**	**179.110**	**170.862**

					NO_x emissions					
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
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	#4.961	#4.961	#4.961	#5.193	#5.193	3.960	*3.960	*3.960	*3.960
EAPSI 3	6.783	5.352	4.639	4.218	3.692	5.203	5.852	5.177	**5.177	**5.177
EAPSI 4	56.198	46.898	43.380	42.113	43.377	45.181	44.938	44.485	46.238	42.861
Total	**214.416**	**192.601**	**180.433**	**173.461**	**163.878**	**173.616**	**131.603**	**124.205**	**129.697**	**117.434**

					CO emissions					
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
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	#27.307	#27.307	#27.307	#11.409	#11.409	12.037	*12.037	*12.037	*12.037
EAPSI 3	143.633	103.121	78.846	70.107	46.712	42.594	50.794	38.029	**38.029	**38.029
EAPSI 4	152.282	139.516	139.403	149.028	152.574	150.413	142.387	144.244	144.598	132.486
Total	**485.269**	**430.535**	**378.431**	**406.554**	**379.256**	**370.131**	**334.605**	**335.945**	**313.245**	**304.701**

 # data based on expert estimate ** the 1996 data* *** the 1997 data*

Fig. 4.1 **Development trends in basic pollutant emissions within 1990-2001**

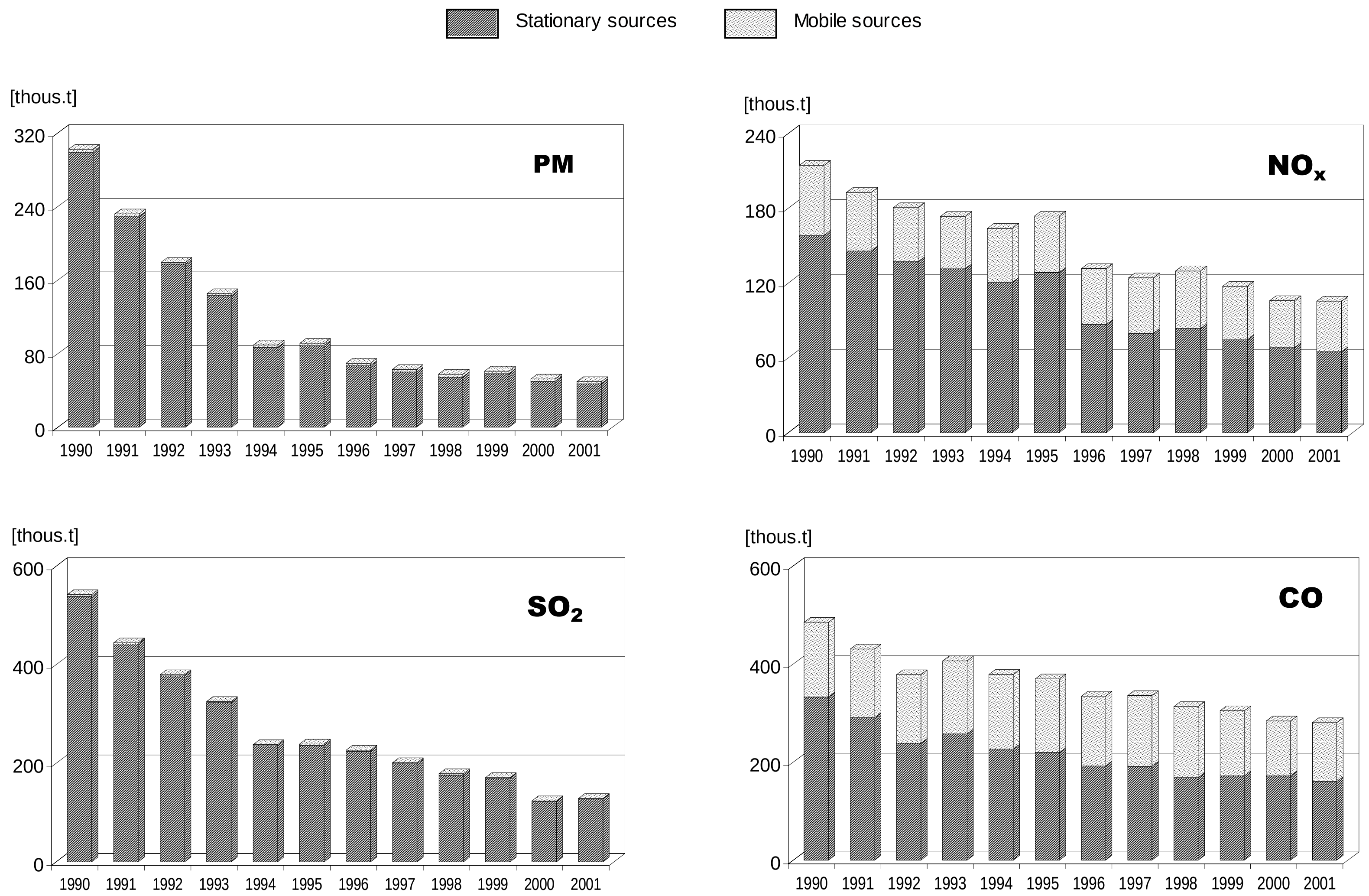
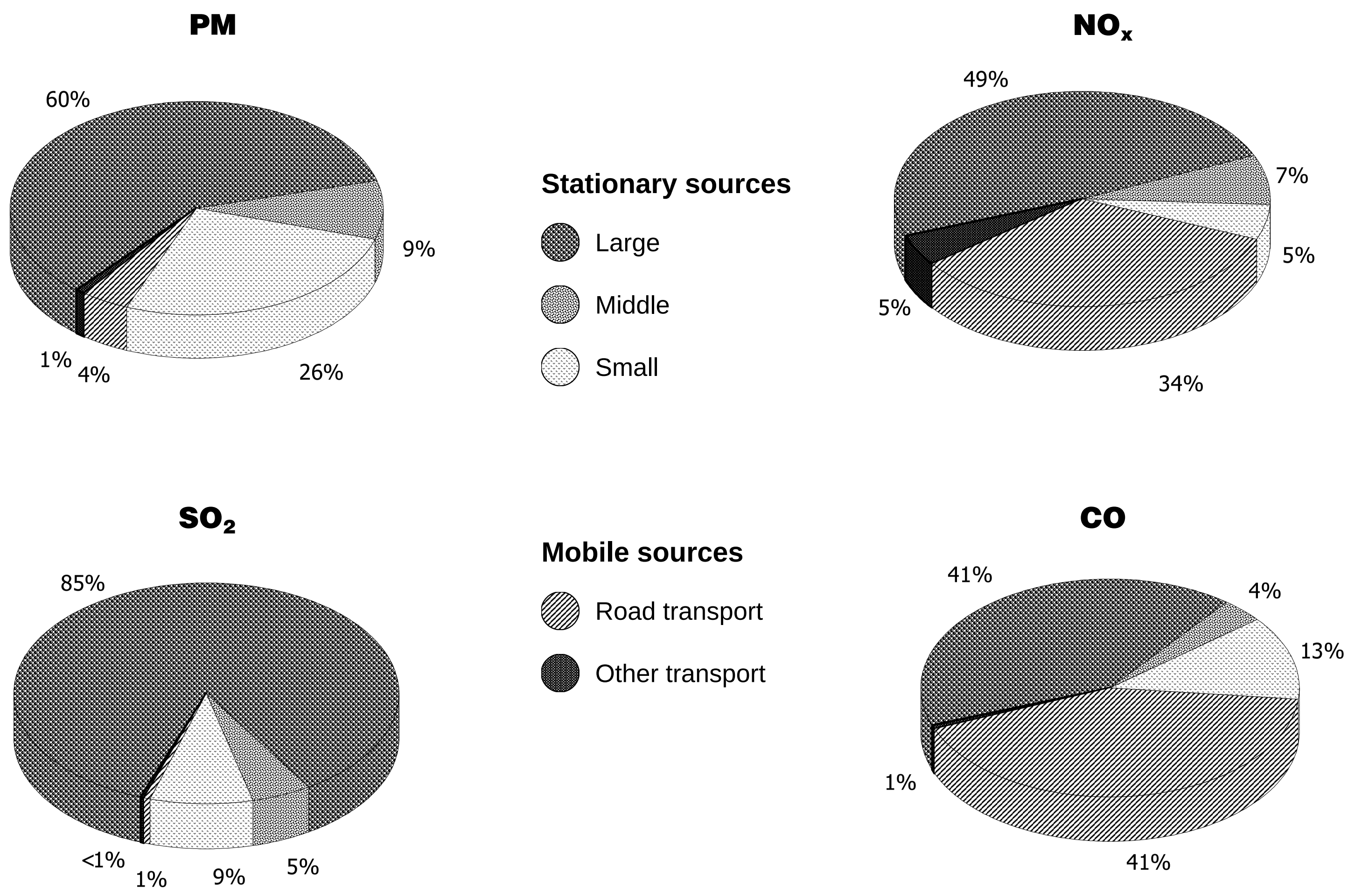


Fig. 4.2

Emissions of basic pollutants in 2000



Tab.4.2 **Air pollution in the Slovak Republic (NEIS), emission quantity according to Section classification of economic activities (SCEA) in 2000** [thous.t/year]

Type of production	Kód OKEČ	Tuhé látky	SO_2	NO_x	CO
Electricity production and distribution	**40.1**	9.25	43.02	23.01	2.07
Steam and hot water produc. and distrib.	**40.3**	0.44	5.43	2.39	0.87
Small sources*	**X**	15.20	12.98	5.55	40.76
Industrial technological processes	**15-37**	21.81	53.73	28.84	115.14
Iron and steel production and processing	**27.1 - 27.3**	15.30	16.98	10.25	84.60
Non-ferrous metal produc. and processing	**27.4, 27.53, 27.54**	0.20	2.47	0.61	7.97
Production of metalloid mineral products	**26**	1.66	1.37	6.25	10.11
Production of motor vehicles	**34**	0.02	0.01	0.09	0.07
Production of chemicals, chemical fibres	**24**	1.28	9.67	2.32	5.18
Coke production, refined crude oil products and nuclear fuels	**23**	0.88	13.05	4.77	0.79
Paper and cellulose production	**21**	0.66	7.39	2.07	2.77
Production of food-stuffs and drinks	**15**	0.21	1.01	0.81	0.38
Other stationary sources	**X**	3.38	7.86	8.30	13.31
Stationary sources total	**X**	**50.08**	**123.02**	**68.09**	**172.15**

* *according to the Decree of Ministry of Environment of the Slovak Republic No 144/2000*

Tab. 4.3 **Emissions of pollutants in non-attainment areas**: EAPSI 1 - 1997, 1998, 1999 a NEIS - 2000** [t/year]

Area	Year	Pollutant			
		PM	SO_2	NO_x	CO
Banská Bystrica	1997	237	562	786	448
	1998	144	437	460	208
	1999	108	188	709	130
	2000	151	139	840	220
Bratislava	1997	1509	23408	5674	1043
	1998	1415	21338	5396	1011
	1999	1354	20589	5738	1142
	2000	878	13192	6259	1325
Hnúšťa-Tisovec	1997	112	76	80	74
	1998	131	50	74	73
	1999	67	17	38	37
	2000	81	26	56	61
Horná Nitra	1997	1612	45079	4244	1134
	1998	1581	41942	5232	1020
	1999	1455	45173	5325	1112
	2000	1399	25127	5234	1087
Jelšava-Lubeník	1997	285	47	683	1252
	1998	309	90	705	1086
	1999	270	181	603	1125
	2000	291	352	959	3817
Košice	1997	10558	17689	15893	83959
	1998	9177	13390	20518	72558
	1999	16344	15122	13365	85031
	2000	15735	18288	12327	84469

Area	Year	Pollutant			
		TZL	SO_2	NO_x	CO
Prešov	1997	50	22	173	101
	1998	123	21	180	136
	1999	50	1	162	80
	2000	28	16	121	125
Ružomberok	1997	1101	2696	1276	2256
	1998	629	1994	1100	1934
	1999	201	2927	1111	414
	2000	201	2878	1132	603
Strážske-Vranov-Humenné	1997	1540	14975	3519	3439
	1998	977	13951	3404	3395
	1999	910	13441	2915	3557
	2000	526	9580	1431	5264
Stredný Spiš	1997	310	7283	117	746
	1998	167	2562	109	736
	1999	29	636	25	202
	2000	55	26	17	275
Žiarska kotlina	1997	352	2609	426	10715
	1998	263	2296	343	10685
	1999	218	2678	500	8601
	2000	226	2497	621	8014
Žilina	1997	333	3682	1298	7059
	1998	154	2117	1161	138
	1999	128	1748	1061	128
	2000	503	1386	1159	345

** *according to the Decree of Ministry of Environment of the Slovak Republic No 112/1993 Act Coll.*

Tab. 4.4 **The most important air pollution sources in the Slovak Republic and their share in the emissions of pollutants (NEIS) in 2000**

No.	PM		SO_2		NO_x		CO	
	Source	[%]	Source	[%]	Source	[%]	Source	[%]
1	U.S. Steel Košice, s.r.o.	43.74	SE, a.s., Elektrárne Nováky, o.z. Zemianske Kostoľany	22.57	SE, a.s., Elektráreň Vojany I a II	23.59	U.S.Steel Košice, s.r.o.	64.03
2	SE, a.s., Elektráreň Vojany I a II	22.22	U.S.Steel Košice, s.r.o.	15.39	U.S.Steel Košice, s.r.o.	16.16	SLOVALCO, a.s.,Žiar n/Hronom	6.00
3	SE, a.s., Elektrárne Nováky, o.z. Zemianske Kostoľany	2.14	SE, a.s., Elektráreň Vojany I a II	12.88	SE, a.s., Elektrárne Nováky, o.z. Zemianske Kostoľany	7.99	CENON, s.r.o., Strážske	3.39
4	SLOVNAFT, a.s., Bratislava	1.84	SLOVNAFT, a.s., Bratislava	11.72	SLOVNAFT, a.s., Bratislava	7.51	SLOVMAG, a.s., Lubeník	2.83
5	NCHZ, a.s., Nováky	1.46	CHEMKO, a.s., Strážske	7.13	SE, a.s., Tep. Energetika Košice	2.56	Dolvap, s.r.o., Varín, Kameňolom a váp.	2.00
6	SSE, š.p., Žilina, Tepláreň Žilina	1.26	Želba, a.s., o.z. Nižná Slaná	4.01	HIROCEM, a.s., Rohožník	2.13	OFZ, a.s., Istebné	1.62
7	DUSLO, a.s., Šaľa	1.23	BUKOCEL, a.s., Hencovce	3.21	SPP, a.s.,Bratislava, záv. Veľké Kapušany	2.00	CEMMAC, a.s., Horné Srnie	1.62
8	OFZ, a.s., Istebné	0.88	SSE, š.p., Žilina, Tepláreň Zvolen	2.89	SPP, a.s., Bratislava, záv. Jablonov nad Turňou	1.70	BUKOCEL, a.s., Hencovce	1.54
9	KERAMIKA, s.r.o., Košice	0.84	SCP, a.s., Celpap, Ružomberok	2.58	SPP, a.s., Bratislava, záv. Veľké Zlievce	1.61	Vápenka, a.s., Margecany	0.92
10	BUKOCEL, a.s., Hencovce	0.82	CHEMES, a.s., Humenné	1.53	CHEMKO, a.s., Strážske	1.40	Hirocem, a.s., Rohožník	0.68
11	CHEMKO, a.s., Strážske	0.78	DUSLO, a.s., Šaľa	1.37	SCP, a.s., Celpap, Ružomberok	1.40	Kameňolom a vápenka Glassner a.s., Žirany	0.60
12	Petrochema a.s., Dubová	0.67	ZSNP, a.s., Žiar nad Hronom	1.18	SPP, š.p., Bratislava, záv. Ivanka pri Nitre	1.40	SLOVNAFT, a.s., Bratislava	0.58
13	Považská cementáreň, a.s., Ladce	0.64	SSE, š.p., Žilina, Tepláreň Žilina	1.17	DUSLO, a.s., Šaľa	1.38	Považská cementáreň, a.s., Ladce	0.53
14	CHEMES, a.s., Humenné	0.63	SLOVALCO,a.s., Žiar nad Hronom	1.07	SSE, š.p., Žilina, Tepláreň Žilina	1.31	SE, a.s., Elektrárne Nováky, o.z. Zemianske Kostoľany	0.46
15	Cementáreň,a.s., Turňa n/Bodvou	0.48	SE, a.s., Tep. Energetika Košice	0.97	SKLOOBAL, a.s. Nemšová	1.19	SE, a.s., Elektráreň Vojany I a II	0.43
16	SCP, a.s., Celpap, Ružomberok	0.47	SSE, š.p., Žilina, Tepláreň Martin	0.95	SMZ, a.s., Jelšava	1.12	ŽELBA, a.s., Nižná Slaná	0.43
17	Bučina, a.s., Zvolen	0.46	AssiDomän a.s., Štúrovo,	0.89	BUKOCEL, a.s., Hencovce	1.05	CHEMKO, a.s., Strážske	0.42
18	ENERGO Plus, Partizánske	0.46	Juhocukor a.s., Dunajská Streda	0.48	Považská cementáreň, a.s., Ladce	1.00	Bučina, a.s., Zvolen	0.42
19	SMZ,a.s.,Jelšava	0.43	ENERGO Plus, Partizánske	0.48	OFZ, a.s., Istebné	0.97	Wienerberger slov. tehelne, s.r.o., Zlaté Moravce	0.36
20	SLOVMAG, a.s., Lubeník	0.41	Tepláreň, a.s., Považská Bystrica	0.32	Stredoslovenská cementáreň, s.r.o., Banská Bystrica	0.88	Kronospan Slovakia, s.r.o.,Prešov	0.33
Total		**81.86**		**92.79**		**78.35**		**89.19**

Tab. 4.5 **Sequence of the sources within the region according to the amount of emission - 2000**

BRATISLAVA REGION

	PM		SO_2	
	Source	District	Source	District
1.	SLOVNAFT, a.s., Bratislava	Bratislava II	SLOVNAFT, a.s., Bratislava	Bratislava II
2.	HIROCEM, a.s., Rohožník	Malacky	ISTROCHEM, a.s., Bratislava	Bratislava III
3.	Odvoz a likvidácia odpadu, a.s., Bratislava	Bratislava II	Odvoz a likvidácia odpadu, a.s., Bratislava	Bratislava II
4.	Vojenský útvar 5949 Pezinok	Pezinok	Psychiatrická nemocnica Philippa Pinela,	Pezinok
5.	TERMING s.r.o., Bratislava	Bratislava I	HIROCEM, a.s., Rohožník	Malacky
6.	Paroplynový cyklus, a.s., Bratislava	Bratislava III	TERMING s.r.o., Bratislava	Bratislava I
7.	VOLKSWAGEN SLOVAKIA,a.s.,Bratislava	Bratislava IV	Vojenský útvar 5949 Pezinok	Pezinok
8.	VÚ Kuchyňa	Malacky	ZEZ, š.p., Bratislava, Výhrevňa - juh	Bratislava II
9.	Fakultná nemocnica Bratislava	Bratislava I	CEVASERVIS, a.s., Stupava	Malacky
10	ZEZ, š.p., Bratislava, Tepláreň II	Bratislava III	Fakultná nemocnica Bratislava	Bratislava I

	NOx		CO	
	Source	District	Source	District
1.	SLOVNAFT, a.s., Bratislava	Bratislava II	HIROCEM, a.s., Rohožník	Malacky
2.	HIROCEM, a.s., Rohožník	Malacky	SLOVNAFT, a.s., Bratislava	Bratislava II
3.	Paroplynový cyklus, a.s., Bratislava	Bratislava III	TERMING s.r.o., Bratislava	Bratislava I
4.	ZEZ, š.p., Bratislava, Tepláreň II	Bratislava III	SkyLife s.r.o., Bratislava	Malacky
5.	C – term s.r.o., Bratislava	Bratislava V	Technické služby Bratislava, s.r.o.	Bratislava III
6.	TECHNICKÉ SKLO, a.s., Bratislava	Bratislava IV	ZEZ, š.p., Bratislava, Tepláreň II	Bratislava III
7.	Odvoz a likvidácia odpadu, a.s., Bratislava	Bratislava II	VÚ Kuchyňa	Malacky
8.	ZEZ, š.p., Bratislava, Tepláreň-západ	Bratislava IV	VOLKSWAGEN SLOVAKIA,a.s.,Bratislava	Bratislava IV
9.	NAFTA GAS, a.s., Malacky	Malacky	C – term s.r.o., Bratislava	Bratislava V
10	VOLKSWAGEN SLOVAKIA,a.s.,Bratislava	Bratislava IV	Paroplynový cyklus, a.s., Bratislava	Bratislava III

TRNAVA REGION

	PM		SO_2	
	Source	District	Source	District
1.	SKLOPLAST, a.s., Trnava	Trnava	JUHOCUKOR, a.s., Dunajská Streda	Dunajská
2.	JUHOCUKOR, a.s., Dunajská Streda	Dunajská	CUKROVAR NOVA, a.s., Sereď	Galanta
3.	AMYLUM SLOVAKIA, s.r.o., Boleráz	Trnava	Slovenský hodváb, a.s., Senica	Senica
4.	Zlieváreň Trnava, s.r.o.	Trnava	Železničné opravovne a strojárne, a.s., Trnava	Trnava
5.	Slovenský hodváb, a.s., Senica	Senica	SKLOPLAST, a.s., Trnava	Trnava
6.	Poľnohospodárske družstvo Zavar	Trnava	Drôtovňa Drôty, a.s., Hlohovec	Hlohovec
7.	Malokarpatské štrkopieskovne	Trnava	D-APETIT, s.r.o., Dunajská Streda	Dunajská
8.	Technické služby mesta Galanta	Galanta	Wienerbergetr Slov.tehelne s.r.o., závod	Trnava
9.	TZK a.s. Trnava	Trnava	SE a.s., AE Bohunice o.z., Jaslovské Bohunice	Trnava
10	Liehovar Krystal Sedín,s.r.o.	Galanta	Baňa Záhorie, Holíč, stredisko Čáry	Senica

	NOx		CO	
	Source	District	Source	District
1.	SKLOPLAST, a.s., Trnava	Trnava	Wienerberger Slov.tehelne s.r.o.	Trnava
2.	AMYLUM SLOVAKIA, s.r.o., Boleráz	Trnava	Zlieváreň Trnava, s.r.o.	Trnava
3.	CUKROVAR NOVA, a.s., Sereď	Galanta	Drôtovňa Drôty, a.s., Hlohovec	Hlohovec
4.	JUHOCUKOR, a.s., Dunajská Streda	Dunajská	SKLOPLAST, a.s., Trnava	Trnava
5.	Slovenský hodváb, a.s., Senica	Senica	SWEDWOOD SLOVAKIA, s.r.o., o.z. Trnava	Trnava
6.	ZEZ, š.p., Bratislava, Tepláreň Trnava	Trnava	Liehovar Krystal Sedín, s.r.o.	Galanta
7.	Drôtovňa Drôty, a.s., Hlohovec	Hlohovec	Cesty Nitra, a.s., Obaľovacia súprava	Trnava
8.	SOUTHERM s.r.o. Dunajská Streda	Dunajská	VÚ 2755 Senica	Senica
9.	Slovakofarma a.s., Hlohovec	Hlohovec	AMYLUM SLOVAKIA, s.r.o., Boleráz	Trnava
10	Bytový podnik, s.r.o., Piešťany	Piešťany	Slovenský hodváb, a.s., Senica	Senica

NITRA REGION

	PM		SO_2	
	Source	District	Source	District
1.	Duslo, a.s., Šaľa	Šaľa	Duslo, a.s., Šaľa	Šaľa
2.	AssiDomän Štúrovo, a.s., Štúrovo	Nové Zámky	AssiDomän Štúrovo, a.s.,Štúrovo	Nové Zámky
3.	JCP IZOLÁCIE, a.s., Štúrovo	Nové Zámky	FERRENIT, a.s., Nitra	Nitra
4.	Kameňolom a vápenka GLASSNER, a.s., Žirany	Nitra	MENERT-THERM, s.r.o., Šaľa	Šaľa
5.	IDEA NOVA, s.r.o., Nitra	Nitra	ŽSR Bratislava, zdroje – Štúrovo, Nové Zámky	Nové Zámky
6.	SES REAL, s.r.o., Tlmače	Levice	JCP IZOLÁCIE, a.s., Štúrovo	Nové Zámky
7.	ŽSR Bratislava, zdroje – Štúrovo, Nové Zámky	Nové Zámky	SES Kotly, a.s., Tlmače	Levice
8.	Poľnonákup NAVYS, a.s.	Nitra	Energo – Bytos s.r.o., Levice	Levice
9.	DECODOM, s.r.o., Topoľčany	Topoľčany	SES REAL, a.s., Tlmače	Levice
10	PTZ Levice, s.r.o.	Levice	SLUŽBYT Nitra, s.r.o.	Nitra

	NOx		CO	
	Source	District	Source	District
1.	SPP, š.p., Bratislava, závod Ivanka pri Nitre	Nitra	Kameňolom a vápenka, a.s., Žirany	Nitra
2.	Duslo, a.s., Šaľa	Šaľa	Wienerberger Slov.tehelne s.r.o.,Zlaté	Zlaté Moravce
3.	AssiDomän Štúrovo, a.s., Štúrovo	Nové Zámky	SPP, š.p., Bratislava, závod Ivanka pri Nitre	Nové Zámky
4.	Službyt, a.s., Nitra	Nitra	AssiDomän Štúrovo, a.s., Štúrovo	Nitra
5.	LEVITEX, a.s., Levice	Levice	FERRENIT, a.s., Nitra	Nitra
6.	Heineken Slovensko,a.s., prevádzka Hurbanovo	Komárno	PTZ Levice, s.r.o	Levice
7.	Tekom – therm s.r.o. Komárno	Komárno	DECODOM,s.r.o.,Topoľčany	Topoľčany
8.	Bytový podnik Nové Zámky	Nové Zámky	JCP Izolácie a.s., Štúrovo	Nitra
9.	TOMA s.r.o,Topoľčany	Topoľčany	Duslo, a.s. Šaľa	Šaľa
10	Fortunae, s.r.o., Levice	Levice	IDEA NOVA, s.r.o., Nitra	Nitra

TRENČIN REGION

	PM		SO_2	
	Source	District	Source	District
1.	SE, a.s., Bratislava, o.z. Zemianske Kostoľany	Prievidza	SE, a.s., Bratislava, o.z. Zemianske Kostoľany	Prievidza
2.	Novácke chemické závody, a.s., Nováky	Prievidza	ENERGO PLUS,s.r.o., Partizánske	Partizánske
3.	Považská cementáreň, a.s., Ladce	Ilava	Tepláreň, a.s., Považská Bystrica	Považská Bystr.
4.	ENERGO PLUS,s.r.o., Partizánske	Patizánske	HBP, a.s., Baňa Cígeľ, o.z.	Prievidza
5.	ZTS-ENERGO, a.s., Dubnica nad Váhom	Ilava	Syenit a.s., Púchov	Púchov
6.	SKLOOBAL a.s., Nemšová	Trenčín	SKLOOBAL a.s., Nemšová	Trenčín
7.	LR CRYSTAL,a.s., Lednické Rovne	Púchov	Považská cementáreň, a.s., Ladce	Ilava
8.	HBP, a.s., Baňa Cígeľ, o.z.	Prievidza	TSM,s.r.o., Partizánske	Partizánske
9.	CEMMAC,a.s., Horné Sŕnie	Trenčín	ZTS-ENERGO, a.s., Dubnica nad Váhom	Ilava
10	LUDOPRINT a.s., Bobot	Trenčín	TATRA SIPOX, a.s., Bánovce nad Bebravou	Bánovce

	NOx		CO	
	Prevádzkovateľ	District	Prevádzkovateľ	District
1.	SE, a.s., Bratislava, o.z. Zemianske Kostoľany	Prievidza	CEMMAC, a.s., Horné Sŕnie	Trenčín
2.	SKLOOBAL a.s., Nemšová	Trenčín	Považská cementáreň, a.s., Ladce	Ilava
3.	Považská cementáreň, a.s., Ladce	Ilava	SE, a.s., Bratislava, o.z. Zemianske Kostoľany	Prievidza
4.	LR CRYSTAL, a.s., Lednické Rovne	Púchov	ENERGO PLUS,s.r.o.,Partizánske	Partizánske
5.	CEMMAC, a.s., Horné Sŕnie	Trenčín	ZŤS-Metalurgia, a.s., Dubnica nad Váhom	Ilava
6.	Novácke chemické závody, a.s., Nováky	Prievidza	V.O.S.R., s.r.o., Pravenec	Prievidza
7.	MATADOR, a.s., Púchov	Púchov	Novácke chemické závody, a.s., Nováky	Prievidza
8.	Tepláreň, a.s., Považská Bystrica	Považská Bystr.	Tepláreň, a.s., Považská Bystrica	Považská
9.	ENERGO PLUS,s.r.o., Partizánske	Partizánske	HBP, a.s., Baňa Cígeľ, Prievidza	Prievidza
10	ZŤS-Energo, a.s., Dubnica nad Váhom	Ilava	TSM,s.r.o., Partizánske	Partizánske

BANSKÁ BYSTRICA REGION

	PM		SO$_2$	
	Source	District	Source	District
1.	PETROCHEMA, a.s., Dubová	Brezno	SSE, š.p., Tepláreň Zvolen	Zvolen
2.	Bučina, a.s., Zvolen	Zvolen	ZSNP, a.s, Žiar nad Hronom	Žiar nad
3.	Slovenské magnezitové závody, a.s., Jelšava	Revúca	SLOVALCO, a.s. Žiar nad Hronom	Žiar nad
4.	SLOVMAG, a.s., Lubeník	Revúca	SLOVMAG, a.s., Lubeník	Revúca
5.	SLOVALCO, a.s. Žiar nad Hronom	Žiar nad	PETROCHEMA, a.s., Dubová	Brezno
6.	ZSNP, a.s., Žiar nad Hronom	Žiar nad	IZOMAT, a.s., Nová Baňa	Žarnovica
7.	ANB, a.s. , prevádzka Žarnovica	Žarnovica	Slovenské magnezitové závody, a.s., Jelšava	Revúca
8.	SSE, š.p. ,Tepláreň Zvolen	Zvolen	Biotika, a.s., Slovenská Ľupča	Banská Bystrica
9.	Lovinit, a.s.,Lovinobaňa	Lučenec	BAŇA DOLINA, a.s, Veľký Krtíš	Veľký Krtíš
10	Smrečina Holding, a.s.,Banská Bystrica	Banská Bystrica	Gemercukor, a.s. Rim. Sobota	Rim. Sobota
	NOx		**CO**	
	Source	District	Source	District
1.	SPP, š.p., SLOVTRANSGAZ, závod Veľké	Veľký Krtíš	SLOVALCO, a.s. Žiar nad Hronom	Žiar nad
2.	Slovenské magnezitové závody, a.s., Jelšava	Revúca	SLOVMAG, a.s., Lubeník	Revúca
3.	Stredoslov. cementáreň, s.r.o., Banská	Banská Bystrica	Bučina, a.s., Zvolen	Zvolen
4.	SSE š.p. Tepláreň Zvolen	Zvolen	IZOMAT, a.s., Nová Baňa	Žarnovica
5.	ZSNP, a.s, Žiar nad Hronom	Žiar nad	Železiarne Podbrezová, a.s.	Brezno
6.	SLOVALCO, a.s. Žiar nad Hronom	Žiar nad	SPP, š.p., SLOVTRANSGAZ, závod Veľké	Veľký Krtíš
7.	SLOVMAG, a.s., Lubeník	Revúca	Slovenské magnezitové závody, a.s., Jelšava	Revúca
8.	Bučina Zvolen a.s.	Zvolen	ZŤS Sabinov, Zlieváreň Hronec	Brezno
9.	Slovglass, a.s., Poltár	Poltár	ZSNP, a.s, Žiar nad Hronom	Žiar n/Hronom
10	Železiarne Podbrezová, a.s.	Brezno	Liečebné termálne kúpele, a.s.,Sklené Teplice	Žiar n/Hronom

ŽILINA REGION

	PM		SO$_2$	
	Source	District	Source	District
1.	SEZ, š.p., Tepláreň Žilina	Žilina	Severoslov. celulózky a papierne, a.s.,	Ružomberok
2.	Oravské ferozliatinárske závody, a.s., Istebné	Dolný Kubín	SEZ, š.p., Tepláreň Žilina	Žilina
3.	Severoslov. celulózky a papierne, a.s.,	Ružomberok	SEZ, š.p., Tepláreň Martin	Martin
4.	Dolvap, s.r.o., Varín, Kameňolom a vápenka	Žilina	ZŤS Strojárne, a.s., Námestovo	Námestovo
5.	ŽOS , a.s, Vrútky	Martin	Oravské ferozliatinárske závody, a.s., Istebné	Dolný Kubín
6.	ZŤS Strojárne, a.s., Námestovo	Námestovo	ŽOS , a.s, Vrútky	Martin
7.	Drevomax, s.r.o., Liptovský Mikuláš	Dolný Kubín	SOTE, s.r.o.,výhrevňa Sihly	Čadca
8.	ŽSR Bratislava, zdroje – Žilina, Strečno, Varín	Žilina	ENERGODIT, s.r.o., Liptovský Mikuláš	Lipt. Mikuláš
9.	OFZ – Profily, a.s.,Istebné	Dolný Kubín	Drevoprodukt s.r.o., Turany	Martin
10	Ľudová tvorba, Veľké Rovné	Bytča	Drevina s.r.o., Turany	Martin
	NOx		**CO**	
	SE, a.s., Bratislava, o.z. Zemianske Kostoľany	Prievidza	CEMMAC, a.s., Horné Sŕnie	Trenčín
1.	Severoslov. celulózky a papierne, a.s.,	Ružomberok	Dolvap, s.r.o., Varín, Kameňolom a vápenka	Žilina
2.	SEZ, š.p., Tepláreň Žilina	Žilina	OFZ, a.s., Istebné	Dolný Kubín
3.	OFZ, a.s., Istebné	Dolný Kubín	Severoslov.celulózky a papierne, a.s.,	Ružomberok
4.	SEZ, š.p., Tepláreň Martin	Martin	SEZ, š.p., Tepláreň Žilina	Žilina
5.	Aquachema, s.r.o.,Žilina	Žilina	Drevoindustria Súľov 01,s.r.o.	Bytča
6.	Slovenská. paroplynová spol., a.s., Ružomberok	Ružomberok	ZŤS Strojárne, a.s., Námestovo	Námestovo
7.	MAYTEX, a.s., Liptovský Mikuláš	Liptovský	ŽOS , a.s, Vrútky	Martin
8.	OFZ – Profily, a.s.,Istebné	Dolný Kubín	Speciality Minerals Slovakia, s.r.o.,	Ružomberok
9.	Bavlnárske závody – TEXICOM, s.r.o.,	Ružomberok	OFZ – Profily, a.s.,Istebné	Dolný Kubín
10	ŽOS, a.s, Vrútky	Martin	Drevomax, s.r.o., Liptovský Mikuláš	Lipt.Mikuláš

PREŠOV REGION

	PM		SO_2	
	Source	District	Source	District
1.	BUKOCEL, a.s., Hencovce	Vranov n/Topľou	BUKOCEL, a.s., Hencovce	Vranov n/Topľou
2.	CHEMES, a.s., Humenné	Humenné	CHEMES, a.s., Humenné	Humenné
3.	KRONOSPAN SLOVAKIA, s.r.o., Prešov	Prešov	VIHORLAT, a.s., Snina	Snina
4.	VIHORLAT, a.s., Snina	Snina	Tehelne Temako a.s., Hanušovce	Vranov nad
5.	Bukóza Preglejka a.s., Hencovce	Vranov nad	UNIOL-VRANOV, s.r.o., tehelňa Vranov nad	Vranov nad
6.	INWOOD, a.s, Kružlov	Bardejov	Obuv Bardejov,a.s.,Bardejov	Bardejov
7.	ZELBA, a.s. , Kovostroj Švábovce	Poprad	ŽELBA, a.s., Kovostroj Švábovce	Poprad
8.	Bukóza Progres s.r.o., Vranov n.T.	Vranov nad	TESLA,a.s., Stará Ľubovňa	Stará Ľubovňa
9.	Cestné stavby a.s.,Košice,obaľ. súprava	Prešov	Zastrova, a.s. Spišská Stará Ves	Kežmarok
10	TATRAVAGÓNKA, a.s., Poprad	Poprad	Cestné stavby a.s. Košice, obaľ.súprava	Michalovce
	NOx		**CO**	
	Source	District	Source	District
1.	BUKOCEL, a.s., Hencovce	Vranov n/Topľou	BUKOCEL, a.s., Hencovce	Vranov n/Topľou
2.	CHEMES, a.s., Humenné	Humenné	KRONOSPAN SLOVAKIA, s.r.o., Prešov	Prešov
3.	VIHORLAT, a.s, Snina	Snina	CHEMES, a.s., Humenné	Humenné
4.	KRONOSPAN SLOVAKIA, s.r.o., Prešov	Prešov	VIHORLAT, a.s., Snina	Snina
5.	SPRAVBYT, a.s., Prešov	Prešov	Cest. stav., a.s., Košice, Obaľ. súpr.	Prešov
6.	SPRAVBYT, a.s., Bardejov	Bardejov	Chemosvit-Strojchem, a.s., Svit	Poprad
7.	Chemosvit-Energochem, a.s., Svit	Poprad	Cest. stav., a.s., Košice, Obaľ. súpr. Kvetnica	Poprad
8.	Dalkia, a.s.,Poprad	Poprad	VÚ 1018 – VSB 1017, Prešov	Prešov
9.	Malterie Soufflet Slovaquie,s.r.o.,Veľký Šariš	Prešov	Inž.stav.,a.s,Košice, obaľ.súpr.Krásna	Prešov
10	Bardejovské kúpele a.s.	Bardejov	Spravbyt, a.s., Prešov	Prešov

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.	Keramika, a.s., Košice	Košice II	CHEMKO, a.s., Strážske	Michalovce
4.	CHEMKO, a.s., Strážske	Michalovce	ŽELBA, a.s., o.z. Siderit, Nižná Slaná	Rožňava
5.	Cementáreň Turňa, a.s., Turňa nad Bodvou	Košice-okolie	SE, a.s., Tepelná energetika Košice	Košice IV
6.	FINIS-NOVA,s.r.o, Spišská Nová Ves	Spišská N.Ves	FINIS – NOVA s.r.o., Spišská Nová Ves	Spišská N.Ves
7.	ŽELBA, a.s., o.z. Siderit, Nižná Slaná	Rožňava	Keramika, a.s., Košice	Košice II
8.	Carmeuse Slovakia s.r.o., Dvorníky- Včeláre	Košice - okolie	EKOTHERMAL 99,s.r.o, SPAKO-Krásna	Košice IV
9.	Kalcit, s.r.o., Slaveč	Rožňava	Tepelné hospodárstvo Moldava a.s.	Košice - okolie
10	SE, a.s., Tepelná energetika Košice	Košice IV	ŽSR SR, zdroje-Košice IV	Košice IV
	NOx		**CO**	
	Source	District	Source	District
1.	SE, a.s., Bratislava, Elektráreň Vojany I a II	Michalovce	U.S. Steel,s.r.o., Košice	Košice II
2.	U.S. Steel, s.r.o., Košice	Košice II	CENON, s.r.o., Strážske	Michalovce
3.	SE, a.s., Tepelná energetika Košice	Košice IV	Vápenka, a.s., Margecany	Gelnica
4.	SPP a.s., závod Veľké Kapušany	Michalovce	SE, a.s., Bratislava, Elektráreň Vojany I a II	Michalovce
5.	SPP a.s., závod Jablonov nad Turňou	Rožňava	ŽELBA, a.s., o.z. Siderit, Nižná Slaná	Rožňava
6.	CHEMKO, a.s., Strážske	Michalovce	CHEMKO, a.s., Strážske	Michalovce
7.	Keramika, a.s., Košice	Košice II	Zlieváreň SEZ Krompachy,a.s., Krompachy	Spišská N. Ves
8.	Cementáreň Turňa, a.s., Turňa nad Bodvou	Košice-okolie	SPP a.s., závod Jablonov nad Turňou	Rožňava
9.	ŽELBA, a.s., o.z. Siderit, Nižná Slaná	Rožňava	SPP a.s., závod Veľké Kapušany	Michalovce
10	EKOTHERMAL 99,s.r.o, SPAKO-Krásna n/Hornád	Košice IV	Cementáreň Turňa, a.s., Turňa nad Bodvou	Košice-okolie

Tab. 4.6 **Stationary source emissions by districts in 2000**

District	Emissions [t/y]				Specific territorial emissions [t/y.km^2]			
	TZL	SO_2	NO_x	CO	TZL	SO_2	NO_x	CO
1. Bratislava	923	13227	6385	1476	2.509	35.942	17.351	4.011
2. Malacky	206	97	1520	1169	0.237	0.111	1.743	1.340
3. Pezinok	127	158	122	301	0.340	0.423	0.326	0.802
4. Senec	86	76	119	291	0.239	0.210	0.331	0.805
5. Dunajská Streda	395	857	301	1034	0.367	0.797	0.280	0.962
6. Galanta	523	676	313	1371	0.815	1.054	0.487	2.138
7. Hlohovec	99	115	126	407	0.371	0.431	0.470	1.524
8. Piešťany	122	95	117	348	0.320	0.248	0.308	0.913
9. Senica	293	353	205	870	0.385	0.463	0.269	1.143
10. Skalica	117	99	70	309	0.327	0.275	0.195	0.860
11. Trnava	342	344	863	1382	0.727	0.730	1.832	2.934
12. Bánovce n/B	57	63	61	147	0.124	0.137	0.132	0.318
13. Ilava	422	234	812	1189	1.176	0.651	2.261	3.312
14. Myjava	93	81	60	250	0.286	0.248	0.184	0.768
15. Nové Mesto n/V	324	271	131	843	0.559	0.467	0.227	1.454
16. Partizánske	219	641	180	553	0.729	2.129	0.599	1.837
17. Považská Bystrica	206	518	208	597	0.445	1.119	0.448	1.290
18. Prievidza	2578	26126	5516	4141	2.685	27.215	5.746	4.313
19. Púchov	276	318	616	658	0.736	0.849	1.643	1.755
20. Trenčín	229	295	1254	2598	0.339	0.437	1.857	3.849
21. Komárno	148	127	203	432	0.134	0.116	0.184	0.393
22. Levice	710	665	301	1760	0.458	0.429	0.194	1.135
23. Nitra	378	348	1218	1771	0.434	0.400	1.398	2.034
24. Nové Zámky	597	1474	773	1277	0.444	1.094	0.574	0.948
25. Šaľa	705	1792	980	752	1.980	5.034	2.754	2.114
26. Topoľčany	283	221	156	745	0.474	0.370	0.262	1.248
27. Zlaté Moravce	125	114	91	839	0.239	0.219	0.174	1.610
28. Bytča	283	226	87	737	1.002	0.800	0.309	2.612
29. Čadca	677	822	286	1944	0.890	1.081	0.377	2.559
30. Dolný Kubín	617	384	760	2764	1.260	0.784	1.551	5.640
31. Kysucké Nové Mesto	176	166	98	493	1.014	0.952	0.562	2.832
32. Liptovský Mikuláš	427	543	276	1006	0.323	0.411	0.208	0.761
33. Martin	525	1665	522	1113	0.713	2.262	0.709	1.512
34. Námestovo	346	531	94	607	0.501	0.769	0.137	0.879
35. Ružomberok	699	3328	1241	1850	1.080	5.144	1.919	2.860
36. Turčianske Teplice	110	90	34	281	0.280	0.229	0.087	0.715

District	Emissions [t/y]				Specific territorial emissions [t/y.km^2]			
	TZL	SO_2	NO_x	CO	TZL	SO_2	NO_x	CO
37. Tvrdošín	1025	906	225	2654	2.140	1,891	0,470	5,540
38. Žilina	1240	1956	1397	4589	1.522	2,400	1,714	5,631
39. Banská Bystrica	335	296	915	676	0.414	0,366	1,131	0,836
40. Banská Štiavnica	63	55	29	182	0.226	0,197	0,103	0,655
41. Brezno	602	502	283	1153	0.476	0,397	0,224	0,911
42. Detva	151	137	67	414	0.318	0,288	0,140	0,871
43. Krupina	75	67	34	210	0.128	0,115	0,058	0,360
44. Lučenec	488	305	201	1021	0.633	0,395	0,261	1,324
45. Poltár	109	75	234	273	0.216	0,149	0,463	0,540
46. Revúca	420	460	1024	4149	0.575	0,630	1,402	5,684
47. Rimavská Sobota	362	328	197	765	0.246	0,223	0,134	0,520
48. Veľký Krtíš	400	387	1120	1054	0.471	0,455	1,319	1,241
49. Zvolen	610	3563	863	1596	0.804	4,694	1,137	2,103
50. Žarnovica	248	261	155	676	0.582	0,612	0,364	1,588
51. Žiar n/H	402	2652	686	8561	0.755	4,985	1,289	16,093
52. Bardejov	299	256	166	703	0.319	0,273	0,177	0,751
53. Humenné	317	1765	567	485	0.420	2,340	0,752	0,643
54. Kežmarok	109	104	81	293	0.129	0,124	0,096	0,349
55. Levoča	151	135	59	424	0.424	0,378	0,166	1,187
56. Medzilaborce	35	36	17	99	0.082	0,085	0,041	0,232
57. Poprad	446	363	296	1208	0.397	0,323	0,263	1,076
58. Prešov	329	227	373	1188	0.352	0,243	0,400	1,272
59. Sabinov	268	225	99	737	0.554	0,466	0,205	1,523
60. Snina	147	261	217	270	0.183	0,325	0,270	0,336
61. Stará Ľubovňa	323	293	96	846	0.518	0,469	0,154	1,355
62. Stropkov	33	28	25	95	0.086	0,073	0,064	0,244
63. Svidník	39	29	37	98	0.071	0,052	0,067	0,178
64. Vranov n/T	433	3699	758	2230	0.563	4,811	0,986	2,900
65. Gelnica	142	116	63	1586	0.243	0,198	0,108	2,716
66. Košice	15872	18407	12402	84850	64.783	75,132	50,621	346,328
67. Košice - okolie	662	421	397	1087	0.432	0,274	0,259	0,709
68. Michalovce	8209	22125	17071	6140	8.056	21,712	16,752	6,025
69. Rožňava	513	4750	1436	1671	0.437	4,049	1,224	1,425
70. Sobrance	62	61	30	89	0.114	0,113	0,055	0,165
71. Spišská Nová Ves	409	379	186	976	0.696	0,645	0,317	1,662
72. Trebišov	303	256	182	793	0.282	0,238	0,170	0,738
Slovakia	50077	123021	68086	172146	1,027	2,523	1,396	3,530

Fig. 4.3

Specific territorial emissions - 2000

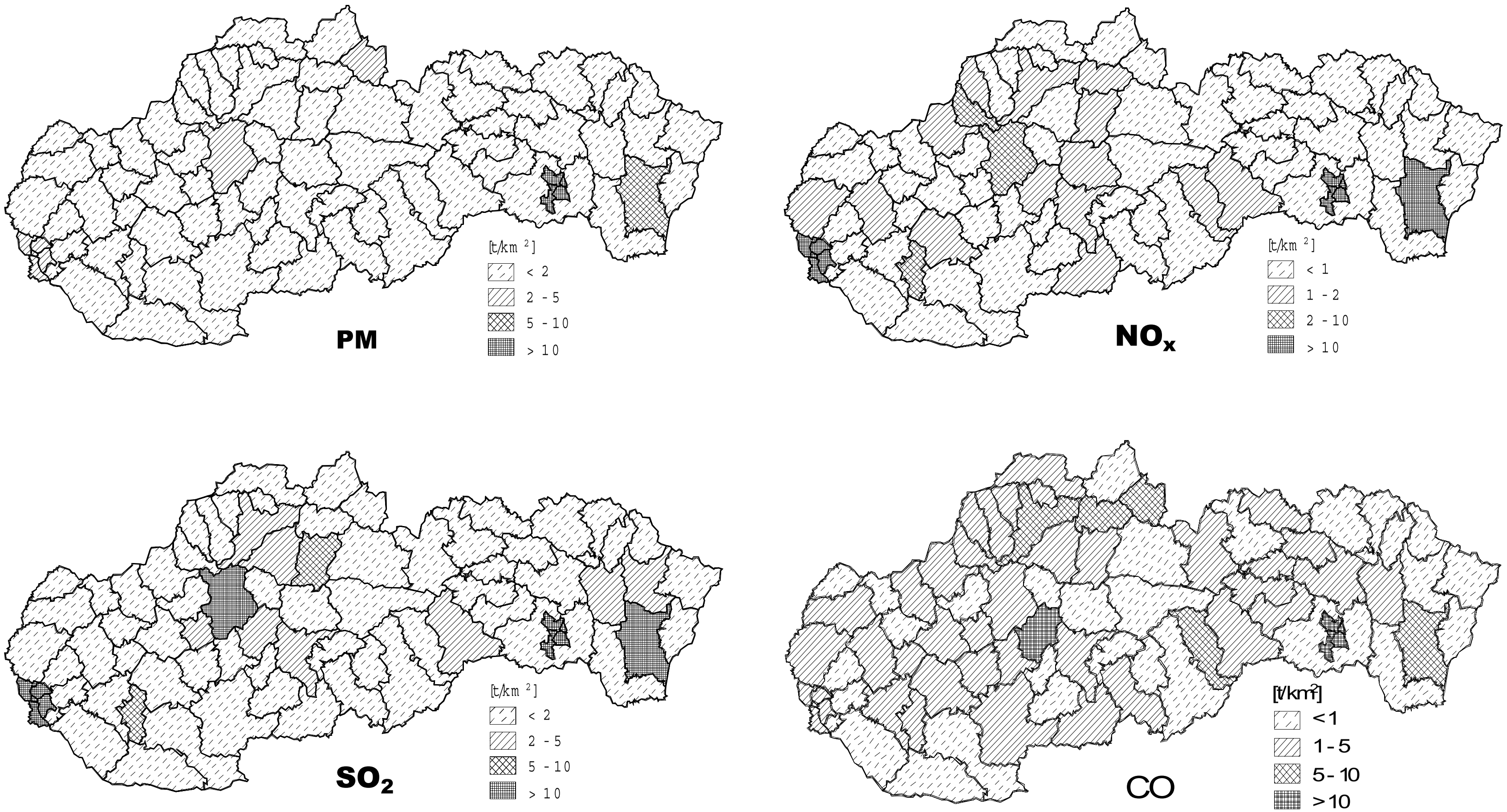


Fig. 4.4 **Development trends in NMVOC and PAH emissions**

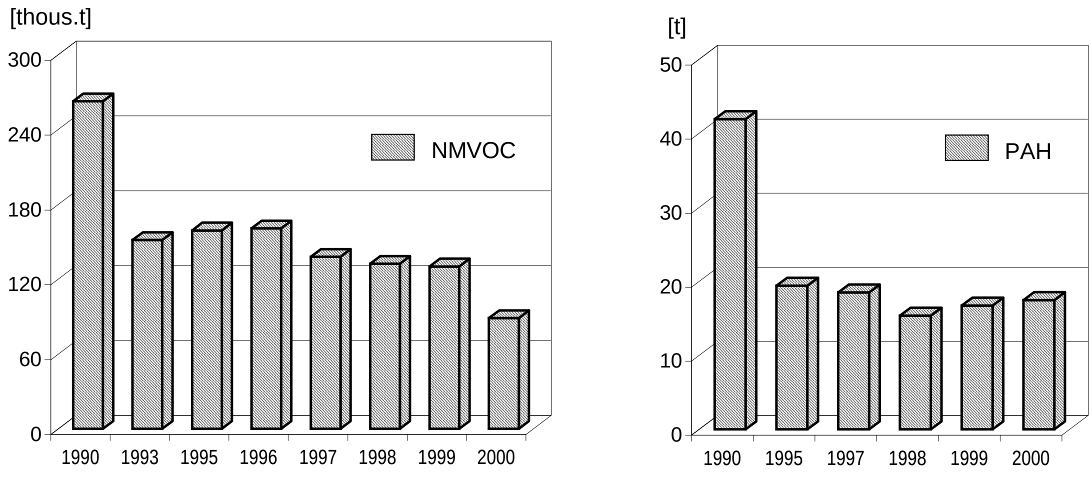
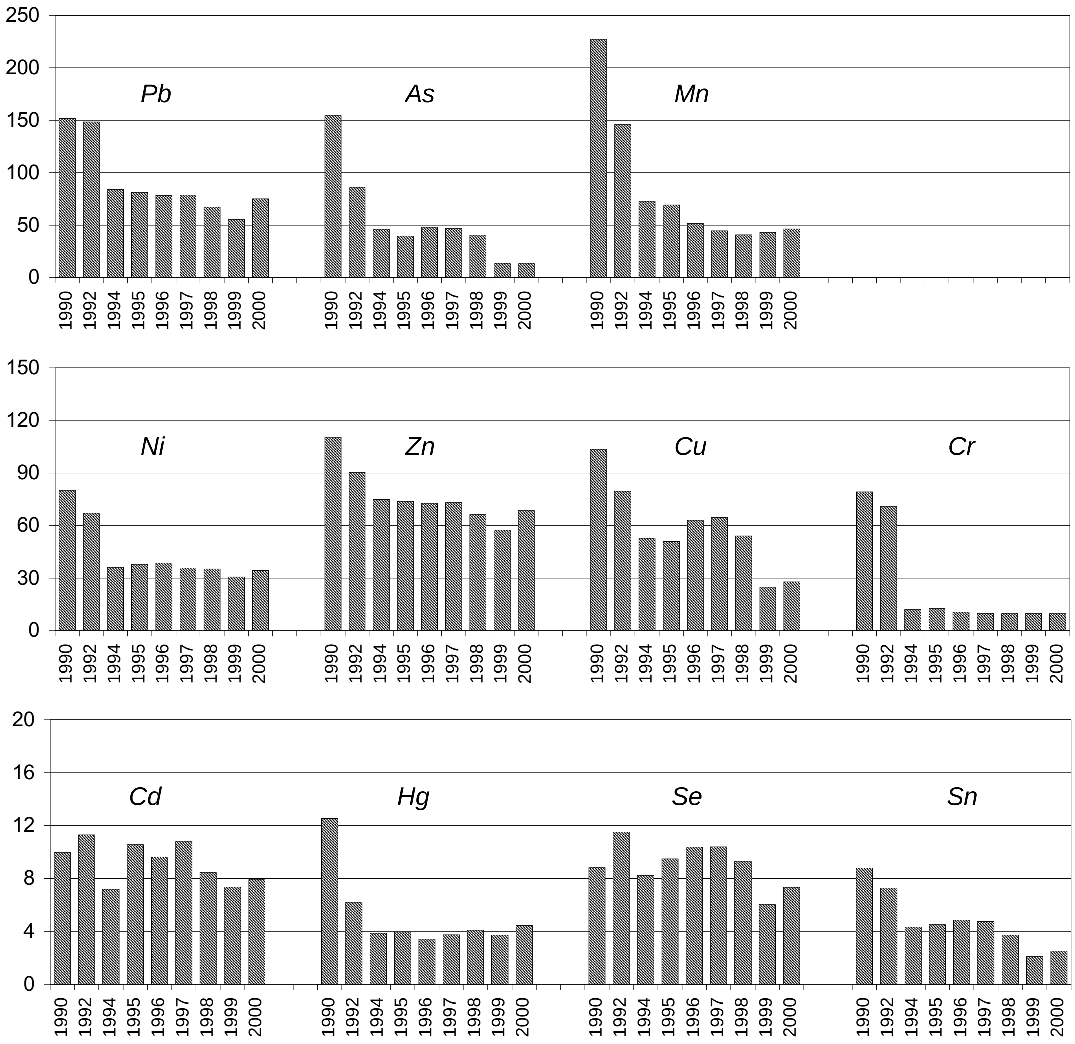


Fig. 4.5 **Development trends in heavy metals emissions** [t]



Tab. 4.7 **NMVOC emissions in the Slovak Republic** [t]

Sector / Sub-sector	1990	1993	1995	1996	1997	1998	1999	2000
Combustion on energy and transformation industries	335	276	258	257	247	265	228	201
Public power	223	190	187	189	182	192	166	139
District heating plants	112	86	71	68	65	73	62	62
Non-industrial combustion plants	9576	5496	3095	3590	2761	2761	2761	2899
Commercial and institutional plants	226	226	150	134	134	134	134	33
Agriculture	IE	IE	IE	IE	IE	IE	IE	14
Residential plants	9350	5270	2945	3456	2627	2627	2627	2853
Combustion in manufacturing industry	1063	1169	1083	1270	1291	993	632	868
Comb. in boilers, gas turb. and stat. engines	206	152	151	152	144	126	124	159
Iron production	32	29	29	26	28	25	27	28
Ore aglomeration	628	500	635	582	601	443	462	679
Copper production	197	488	268	510	518	399	19	2
Production processes	155410	64160	70961	74840	60632	56758	61112	24494
Processes in petroleum industries	17188	12119	7474	8359	7717	7960	6563	6627
Coke production	1053	844	834	769	779	640	681	719
Steel production	43	35	36	31	31	32	33	34
Rolling mills	233	250	297	283	302	290	304	300
Aluminium production	0,101	0,058	0,049	0,167	0,165	0,162	0,164	0,160
Proc. in organic chemical industries	6437	3519	1369	1386	1364	870	785	652
Food production	3224	3233	2359	2252	2567	1590	1546	1538
Road paving with asphalt	127232	44160	58592	61760	47872	45376	51200	14624
Exploitation&distrib. of natural resources	8822	8868	8535	8104	9336	5854	6606	5929
Exploitation&distribution of crude oil	5198	5194	4298	4296	3803	3801	4194	3750
Distribution of fuel	3624	3674	4237	3808	5533	2053	2412	2179
Solvent and other products use	48071	38301	41166	39781	30762	32221	29429	29063
Use of paints and glues	32811	19349	20687	19122	15653	16035	14365	13214
Dry cleaning and degreasing	6650	10366	11838	12108	6498	7563	6483	7272
Processing of fat and oil	332	308	363	273	332	345	303	299
Products	8278	8278	8278	8278	8278	8278	8278	8278
Road traffic	33070	30699	32651	31510	31617	32023	28240	24371
Other traffic	953	543	599	609	584	659	571	528
Waste treatment and disposal	4538	1339	259	147	153	226	180	208
Incineration of municipal waste	102	102	102	59	77	98	95	133
Incineration of Industrial waste	157	157	157	74	67	122	79	66
Incineration of hospital waste	IE	IE	IE	14	9	6	6	9
Agricultural waste*	4279	1080	–	–	–	–	–	–
Agriculture	651	436	436	436	436	436	436	436
Total	262488	151287	159042	160544	137819	132195	130195	88997

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 sub-sector Agriculture (sector Non-industrial combustion plants) was established.

Tab. 4.8a **Emissions of persistent organic pollutants in the Slovak Republic in 1990**

Sector / Sub-sector	PCDD/PCDF*	PCB	PAH				
			suma 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	**8.047**	**27.031**	**17266.448**	**6598.875**	**9370.216**	**595.216**	**702.140**
Public power	6.028	21.699	11.159	0.048	5.511	5.511	0.089
District heating plants	1.481	5.332	9.489	0.028	4.705	4.705	0.051
Coke production	0.538		17245.800	6598.800	9360.000	585.000	702.000
Non-industrial combustion plants	**35.130**	**42.205**	**12258.882**	**2871.733**	**1542.160**	**3788.942**	**4056.048**
Commercial and institutional plants	3.286	4.853	5.456	0.517	1.161	2.938	0.839
Residential plants	31.844	37.352	12253.426	2871.216	1540.998	3786.003	4055.209
Combustion in manufacturing industry	**41.287**	**36.628**	**803.787**	**231.997**	**28.801**	**428.501**	**114.489**
Comb. in boilers, gas turb. and stat. engines	5.081	18.290	37.500	0.107	18.599	18.599	0.195
Iron production	17.805		60.537	60.537			
Ore aglomeration	17.130	14.846	685.200	171.300		399.700	114.200
Pig iron production	0.301						
Others	0.970	3.492	20.551	0.053	10.202	10.202	0.094
Production processes	**28.813**		**10167.878**	**4081.115**	**2863.235**	**2863.235**	**360.293**
Aluminium production	0.135		9527.664	3774.400	2708.132	2708.132	337.000
Steel production	28.674		81.243	81.243			
Carbon material production	0.004		536.655	216.545	150.640	150.640	18.830
Wood impregnation			22.316	8.927	4.463	4.463	4.463
Road traffic	**0.714**	**53.653**	**1195.462**	**298.915**	**179.151**	**418.481**	**298.915**
Other traffic	**0.082**	**1.629**	**193.513**	**48.386**	**28.999**	**67.741**	**48.386**
Waste treatment and disposal	**75.333**	**2.327**	**0.210**	**0.210**			
Incineration of municipal waste	32.169	0.758	0.100	0.100			
Incineration of Industrial waste	43.163	1.570	0.110	0.110			
Total	**189.405**	**163.474**	**41886.180**	**14131.231**	**14012.562**	**8162.116**	**5580.271**

**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)*
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

Tab. 4.8b **Emissions of persistent organic pollutants in the Slovak Republic in 2000**

Sector / Sub-sector	**PCDD/PCDF*** [g]	**PCB** [kg]	**PAH** suma PAH [kg]	B(a)P [kg]	B(k)F [kg]	B(b)F [kg]	I(1,2,3-cd)P [kg]
Combustion on energy and transformation industries	**5.016**	**16.738**	**11773.534**	**4503.343**	**6389.759**	**401.305**	**479.126**
Public power	4.496	16.187	2.243	0.021	1.091	1.091	0.041
District heating plants	0.153	0.551	1.983	0.005	0.984	0.984	0.010
Coke production	0.367		11769.308	4503.317	6387.684	399.230	479.076
Non-industrial combustion plants	**9.230**	11.268	**3134.357**	**733.241**	**404.446**	**972.994**	**1023.676**
Commercial and institutional plants	1.009	**1.873**	2.277	0.133	0.739	1.187	0.217
Residential plants	8.221	9.395	3132.080	733.108	403.706	971.807	1023.459
Combustion in manufacturing industry	**39.967**	35.989	**858.019**	**239.177**	**31.498**	**463.581**	**123.761**
Comb. in boilers, gas turb. and stat. engines	2.460	8.855	30.966	0.083	15.367	15.367	0.149
Iron production	15.832		53.828	53.828			
Ore aglomeration	18.518	16.049	740.714	185.178		432.083	123.452
Pig iron production	0.078						
Others	3.079	11.085	32.511	0.088	16.131	16.131	0.16
Production processes	**23.105**		**792.249**	**298.66**	**229.575**	**234.013**	**30.001**
Aluminium production	0.220		403.124	131.776	127.383	127.383	16.582
Steel production	22.796		64.589	64.589			
Carbon material production	0.089		324.019	102.088	102.088	106.527	13.316
Wood impregnation			0.517	0.207	0.103	0.103	0.103
Road traffic	**0.628**	**66.267**	**807.622**	**201.939**	**121.031**	**282.714**	**201.939**
Other traffic	**0.042**	**0.846**	**100.470**	**25.122**	**15.056**	**35.170**	**25.122**
Waste treatment and disposal	**67.503**	**1.744**	**0.184**	**0.184**			
Incineration of municipal waste	42.349	0.998	0.132	0.132			
Incineration of Industrial waste	18.156	0.660	0.046	0.046			
Incineration of hospital waste	6.999	0.086	0.006	0.006			
Total	**145.491**	**132.851**	**17466.435**	**6001.666**	**7191.365**	**2389.778**	**1883.625**

** 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)*
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

Tab. 4.9a **Emissions of heavy metals in the Slovak Republic in 1990** [t]

Sector / Subsector	**Pb**	**As**	**Cd**	**Cr**	**Cu**	**Hg**	**Ni**	**Se**	**Zn**	**Sn**	**Mn**
Combustion on energy and transform. industries	**5.046**	**28.244**	**0.204**	**9.552**	**7.885**	**0.424**	**16.220**	**1.311**	**12.203**	**1.876**	**69.705**
Public power	3.415	22.250	0.135	7.138	5.732	0.324	11.014	1.031	8.730	1.373	49.089
District heating plants	1.632	5.994	0.069	2.414	2.153	0.101	5.206	0.280	3.473	0.503	20.616
Non-industrial combustion plants	**5.278**	**26.078**	**0.204**	**8.257**	**7.701**	**0.228**	**7.010**	**0.428**	**12.864**	**2.003**	**86.871**
Commercial and institutional plants	2.246	10.260	0.090	3.246	3.026	0.096	2.941	0.170	5.279	0.785	34.088
Residential plants	3.032	15.818	0.114	5.011	4.675	0.132	4.069	0.257	7.585	1.218	52.783
Combustion in manufacturing industry	**66.460**	**97.477**	**8.200**	**9.547**	**74.460**	**10.067**	**26.342**	**7.021**	**52.219**	**4.866**	**60.366**
Comb. in boilers, gas turb. and stat. engines	5.198	16.426	0.225	7.061	6.109	0.360	21.042	0.962	10.277	1.379	56.123
Iron production	0.121	0.011	0.192	0.915	0.071	0.306	3.048	0.039	7.624		
Glass production	10.226	1.416	7.338	0.560	0.140	0.012	0.443	4.199	2.566		
Ore aglomeration	38.742	1.324	0.023	0.126	12.733	3.506	0.976	1.799	20.271	1.456	4.231
Copper production	5.181	77.744	0.369		55.339	4.310			9.547	1.870	
Cement production	6.971	0.086	0.021	0.764		1.431	0.808	0.011	1.779		
Aluminium oxide production				0.016		0.139			0.027		0.011
Magnesite production	0.021	0.471	0.033	0.105	0.067	0.002	0.023	0.011	0.128	0.160	
Production processes	**1.940**	**2.541**	**0.034**	**50.977**	**4.979**	**1.074**	**24.226**	**0.014**	**19.477**	**0.048**	**9.756**
Steel production	1.319	0.072	0.014	0.167	2.605	0.014	2.633	0.014	5.496	0.048	1.094
Aluminium production			0.007				0.674		0.674		
Ferro alloys production	0.182	0.012	0.006	2.138	0.010		0.014		1.312		8.528
Pig iron production	0.361	0.015	0.008	0.060			0.030		0.256		0.113
Galvanizing	0.020			0.174	0.060		0.920		1.740		0.020
Alloys (Cu-Zn) production	0.060	2.442		48.438	2.305	0.843	19.955		9.999		
Inorganic chemical industry			0.0002			0.217					
Road traffic	**61.000**		**0.487**	**0.219**	**6.266**		**5.172**	**0.022**	**7.141**		
Other traffic			**0.008**		**0.815**		**0.815**		**0.815**		
Waste treatment and disposal	**11.927**	**0.015**	**0.828**	**0.719**	**1.357**	**0.731**	**0.402**	**0.011**	**5.727**		
Incineration of municipal waste	6.434	0.007	0.357	0.643	0.886	0.257	0.386	0.002	2.431		
Incineration of Industrial waste	5.494	0.008	0.471	0.075	0.471	0.471	0.016	0.009	3.296		
Cremation						0.003					
Total	**151.66**	**154.35**	**9.97**	**79.27**	**103.46**	**12.52**	**80.19**	**8.81**	**110.45**	**8.79**	**226.70**

Tab. 4.9b **Emissions of heavy metals in the Slovak Republic in 2000** [t]

Sector / Sub-sector	Pb	As	Cd	Cr	Cu	Hg	Ni	Se	Zn	Sn	Mn
Combustion on energy and transform. industries	**0.764**	**1.650**	**0.032**	**1.267**	**1.103**	**0.059**	**2.741**	**0.280**	**1.484**	**0.211**	**6.296**
Public power	0.585	1.463	0.024	1.171	1.031	0.048	2.087	0.260	1.219	0.197	5.731
District heating plants	0.178	0.187	0.008	0.096	0.073	0.011	0.654	0.020	0.264	0.014	0.565
Non-industrial combustion plants	**1.461**	**6.355**	**0.057**	**2.031**	**1.898**	**0.061**	**1.684**	**0.110**	**3.390**	**0.491**	**21.201**
Commercial and institutional plants	0.682	2.251	0.028	0.745	0.699	0.027	0.642	0.047	1.435	0.177	7.548
Residential plants	0.779	4.104	0.029	1.285	1.199	0.034	1.042	0.063	1.954	0.314	13.652
Combustion in manufacturing industry	**58.468**	**5.230**	**6.450**	**3.264**	**15.504**	**3.722**	**16.642**	**6.867**	**34.967**	**1.775**	**9.980**
Comb. in boilers, gas turb. and stat. engines	2.478	1.515	0.118	1.652	1.208	0.191	12.346	0.481	3.428	0.174	5.406
Iron production	0.108	0.009	0.171	0.814	0.063	0.272	2.710	0.035	6.779		
Glass production	13.474	2.030	6.129	0.587	0.147	0.012	0.465	4.404	2.692		
Ore aglomeration	41.881	1.163	0.025	0.136	13.765	3.068	1.056	1.944	21.913	1.574	4.574
Copper production	0.001	0.425			0.309	0.070					
Cement production	0.523	0.006	0.002	0.057		0.107	0.061	0.001	0.133		
Aluminium oxide production											
Magnesite production	0.003	0.080	0.006	0.018	0.011		0.004	0.002	0.022	0.027	
Production processes	**1.415**	**0.071**	**0.029**	**1.924**	**2.459**	**0.041**	**8.817**	**0.011**	**17.268**	**0.038**	**8.887**
Steel production	1.049	0.057	0.011	0.133	2.071	0.011	2.093	0.011	4.369	0.038	0.870
Aluminium production			0.011				1.098		1.098		
Ferro alloys production	0.150	0.010	0.005	0.714	0.007		0.006		0.867		7.866
Pig iron production	0.093	0.004	0.002	0.016			0.008		0.066		0.029
Galvanizing	0.122			1.061	0.366		5.612		10.614		0.122
Alloys (Cu-Zn) production	0.002				0.015				0.254		
Inorganic chemical industry						0.030					
Road traffic	**1.800**		**0.630**	**0.298**	**5.083**		**3.591**	**0.030**	**6.276**		
Other traffic			**0.005**		**0.423**		**0.423**		0.423		
Waste treatment and disposal	**11.081**	**0.013**	**0.694**	**0.883**	**1.391**	**0.566**	**0.516**	**0.007**	**4.766**		
Incineration of municipal waste	8.470	0.009	0.471	0.847	1.167	0.339	0.508	0.002	3.200		
Incineration of Industrial waste	2.311	0.003	0.198	0.032	0.198	0.198	0.007	0.004	1.386		
Incineration of hospital waste	0.301	0.0004	0.026	0.004	0.026	0.026	0.001	0.001	0.180		
Cremation						0.004					
Total	**75.00**	**13.32**	**7.90**	**9.67**	**27.86**	**4.45**	**34.41**	**7.31**	**68.57**	**2.51**	**46.36**

Emissions, as they were appointed to July 31,.2002

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 Convention came into force on November 23, 1994 and in August 1995 it was ratified by parliament. Slovakia accepted all the commitments of the Convention, including reduction of the greenhouse gas emissions by 2000 to the 1990 level. One of the commitments, resulting from the Convention, is to provide a regularly greenhouse gas emission inventory.

Kyoto protocol

At the conference of member states (COP Conference of Parties) in Kyoto, the so-called Kyoto protocol was adopted, by which further reduction of greenhouse gas emissions is demanded. Slovakia and most of the European countries should reduce the total emissions by 8% by 2008-2012 as compared to the base year (1990). The Slovak Republic signed the Kyoto protocol on February 26, 1999[2].

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 33°C warmer than it would be without the greenhouse gases. Finally, this enables the life on our planet.

Greenhouse gases

The most important greenhouse gas in the atmosphere is water vapour (H_2O), which is responsible for approximately two thirds of the total greenhouse effect. Its content in the atmosphere is not directly affected by human activity, in principle it is determined by the natural water cycle, expressed in a very simple way, as the difference between evaporation and precipitation. Carbon dioxide (CO_2) contributes to the greenhouse effect 30%, methane (CH_4), nitrous oxide (N_2O) and ozone (O_3), all three together 3%. The group of man-made (artificial) substances - chlorofluoro-

---

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

[2] *Kyoto protocol will come into force 90 days following the ratification by at least 55 countries, among them have to be included countries of ANNEX 1 contributing at least 55% to the total 1990 carbon dioxide emissions, as is listed in attachment to the report 25 of the Protocol.*

carbons (CFCs), their substitutes, hydrofluorocarbons (HCFCs, HFCs) and others such as fluorocarbons (PFCs) and SF_6, also belong to the greenhouse gases. 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.

Whilst mentioning the emissions of greenhouse gases, we must also include CO_2, CH_4 N_2O and "new gases", as they are defined in the Kyoto protocol. Though they belong to natural components of the ambient air, their present content in the atmosphere is significantly affected by human activity. 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.

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

Globally[3], the annual anthropogenic emission of carbon dioxide ranges between 4-8 billion tons of carbon (about 4t of CO_2 per capita in the globe). The most important source of "new" carbon dioxide is presented by the fossil fuel combustion and cement production. The CO_2 is also released from the soil (deforestation, forest fires and conversion of grasslands into agricultural soil), but this contribution is more difficult to quantify. Carbon dioxide is very stable in the atmosphere, its residence time is tens of years (60-200) and is removed from the atmosphere by a complex of natural sink mechanisms. It is expected that 40% of carbon dioxide presently emitted is absorbed by the oceans. Photosynthesis by vegetation and sea plankton is a further important sink mechanism, though only a transitional one, because after the death (eating) of a plant, carbon dioxide is released again.

The level of methane in the ambient air is affected by human activity in more ways. Land transformation into an agricultural one (mainly rice fields), animal husbandry, coal mining, natural gas mining, its transport and use as well as the biomass burning are all anthropogenic activities. The natural methane sources have not yet been fully investigated and thus the role of methane in the climate change mechanism is not quite clear. 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, emission from natural sources is about 0.16 billion tons (IPCC[4] 1995).

---

[3] *Climate change 1995, The Science of Climate Change, Contribution of WGI to the 2nd Assessment Report.*

[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*

PFCs, HCFCs, HFCs (perfluorocarbons, chloroflourocarbons, halons, bromocarbons, etc.) and SF_6 are entering the atmosphere only because of human activity. They are used as carrier gases for sprays, fillings in cooling and extinguishing systems, as insulating substances, as solvents at the production of semiconductors, etc. Apart from the fact that they attack atmospheric ozone, they are very "high-powered" inert greenhouse gases having a residence time e.g. perfluoromethane (CF_4) of 50 000 years. It means that even minor emissions have a great negative effect.

The ground level ozone concentrations are growing as a consequence of CO, NO_x and NMVOC emissions. They have very important source in exhaust gases, fossil fuel combustion and as far as NMVOCs are considered, the use of solvents, as well.

N_2O enters the atmosphere from several small sources. The most important source does seem to be the emission from soil (nitrogen surpluses as a consequence of intensive fertilising 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. The N_2O is disintegrated mainly photochemically in the stratosphere.

5.2 GREENHOUSE GAS EMISSIONS IN THE SLOVAK REPUBLIC

Emissions were estimated in compliance with the methods provided in IPCC Guidelines[5] and Good Practice Guidance (GPG)[6]. 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.

Total anthropogenic emissions of greenhouse gases in Slovakia

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO_2*	[Tg]	60	53	49	46	43	45	45	46	45	44	41
CH_4	[Gg]	323	295	269	251	244	249	254	241	224	221	215
N_2O	[Gg]	20	17	15	12	12	13	11	11	10	10	10

Emissions, as determinated to April 15, 2002   ** CO_2 emissions without LUC&F (Land Use Change & Forestry)*

Several small revisions have been performed by the revisions in 2002. In the *Industry sector* cement and lime consumption was revised (magnezit is now reported separately) and EF related to the amount of clinker produced was applied. EF for production of nitric acid was improved. In the *agriculture sector* was revised EF for indirect emissions from soils in line with IPCC GPG. In LUCF sector was the trend were completed (new estimates for 1991, 1992, 1993, and 1995)

[5] *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventory, Volume 1-3.*
[6] *IPCC Good Practice Guidance and Uncertainty Management, 2000*

CO_2 - carbon dioxide

Emissions

The most important sources of CO_2 in Slovakia are the combustion of fossil fuels due to power generation and transport (Table 5.1, Figure 5.1). 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.

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 1950-1999, the amount of carbon fixed in the forests of Slovakia was increased approximately 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 Slovakia 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. Annual CO_2 sink ranges between 1500 and 4000 Gg. An assumed uncertainty of the assessment is approximately 30-50%.

CH_4 - methane

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 of the Slovak Republic 1996, 1998. 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.

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 fertilising) and unfavourable aerial soil conditions (heavy mechanical tillage) are the main cause of N_2O emissions. Emissions in power industry and traffic were estimated on the balance in fossil fuel consumption, by applying the default emission factors according to the IPCC 1996. 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).

HFCs, PFCs, SF_6

Sources and emissions of the so-called "new gases" have been assessed on the territory of Slovakia. The procedure was carried out in coincidence with the methodology IPCC 1996 and true and potential emissions were estimated within 1995-1998 (Table 5.4). These gases have not been produced in Slovakia. 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.

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 2000 by 85% to the total emissions, CH_4 emissions by about 9%, N_2O emissions by about 6% and the contribution of "new gases" is below 1%. (Figure 5.4 and 5.5).

5.3 ASSESSMENT

On the balance relating to the year 2000, total anthropogenic emissions of carbon dioxide reached 41 mil. tons (in 1990 they reached 60 mil. t). Emissions of methane dropped from 323 thousand tons in 1990 to 212 thousand tons in 2000. Total emissions of N2O were on the level of 10 thousand tons (in 1990 it was approximately 19 thousand tons). 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 2000 the biggest GHGs source was fossil fuel combustion in electricity and heat production (more than 70%), followed by transport with contribution around 10%. Direct emissions from industrial technologies and from agriculture[8] are both ranging at the level of 7%. Emission from waste treatment is about 3% and emissions from extraction and transport of fossil fuels is about 2%.

Slovakia's share in the global anthropogenic greenhouse gas emission accounts for about 0.2%. Annual per capita emission is approximately 7.5 t/year and thus ranks Slovakia among the countries with the greatest per capita emissions in the world. National total emissions decrease since 1990 by about 30% - Slovakia met the commitment of the UNFCCC. According the scenarios presented in *the 3rd National Communication* it can be assumed, that targets of Kyoto protocol can be reached.

[7] *According to the currently valid convention the emission reduction expressed in CO2 equivalent should be reported.*

[8] *Note: sectors of industry and agriculture in the IPCC nomenclature do not correspond to sectors as defined e.g. in the statistical Yearbook of the Slovak Republic. The total contribution of industry and agriculture is significantly higher.*

CO_2 – carbon dioxide

Tab. 5.1 **Total emissions and sinks of CO_2 [Gg] within 1990-2000**

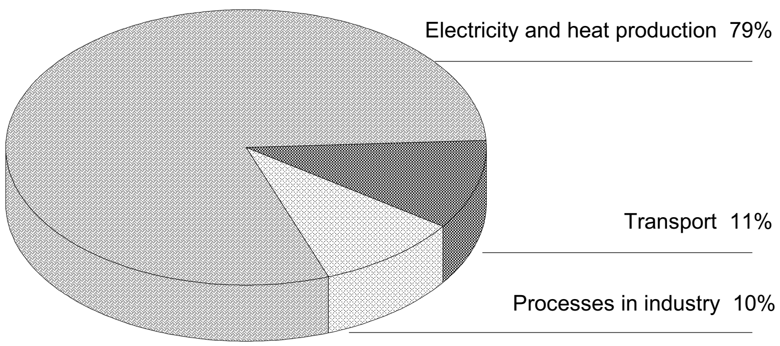
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Anthropogenic CO_2 emissions	**59746**	**52658**	**49179**	**46232**	**43365**	**44898**	**45156**	**45556**	**44811**	**43600**	**40935**
Net CO_2 emissions*	**57319**	**49182**	**45051**	**41966**	**40078**	**42215**	**42728**	**44145**	**42875**	**41950**	**38492**
Fossil fuel combustion	**55724**	**49487**	**45731**	**42908**	**39802**	**41062**	**41628**	**41803**	**40089**	**38886**	**36965**
Electricity and heat production	50654	45257	41784	39016	35684	36684	37194	37212	35139	34066	32646
Transport	5070	4229	3947	3892	4118	4378	4434	4591	4950	4820	4319
Processes in industry	**4022**	**3171**	**3447**	**3324**	**3563**	**3836**	**3527**	**3753**	**4722**	**4714**	**3970**
Mineral products	4022	3171	3447	3324	3563	3836	3527	3753	4722	4714	3970
Forest ecosystems	**-2427**	**-3475**	**-4128**	**-4266**	**-3287**	**-2683**	**-2427**	**-1411**	**-1936**	**-1651**	**-2443**
Changes in stock of wood mass	-1753	-2603	-3333	-3344	-2479	-1786	-1734	-975	-1474	-1107	-1410
Deforestation	141	130	129	128	126	119	111	111	131	125	113
Aforestation	-815	-1002	-924	-1050	-934	-1016	-804	-547	-593	-669	-1146
CO_2 emissions from biomass burning**	**1686**	**1382**	**1254**	**720**	**717**	**326**	**316**	**349**	**303**	**269**	**263**

Emissions, as they were appointed to April 15, 2002

* *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*

Fig. 5.1 **CO_2 emissions in 2000**



CH_4 - methane

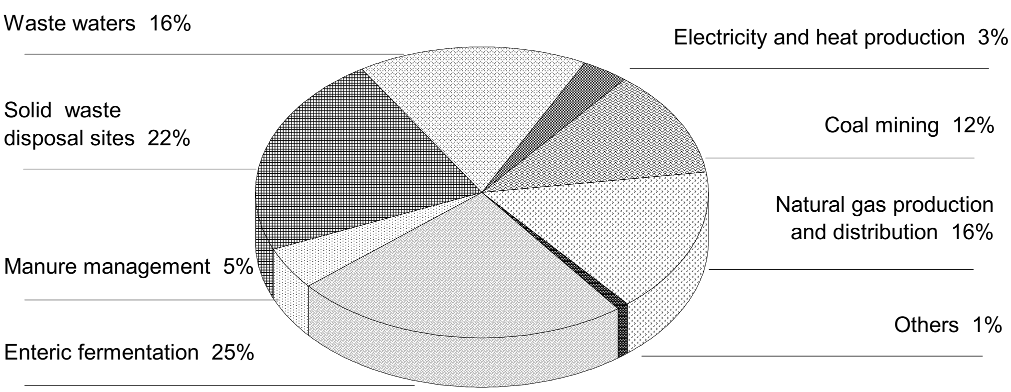
Tab. 5.2 CH_4 emissions [Gg] within 1990-2000

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total CH_4 emissions	**322.7**	**294.8**	**268.8**	**250.5**	**244.0**	**248.8**	**254.4**	**241.1**	**223.6**	**221.4**	**215.0**
Energetic	**85.9**	**77.4**	**69.0**	**68.6**	**68.1**	**70.5**	**72.6**	**73.4**	**71.3**	**70.6**	**68.5**
Fossil fuel combustion	17.4	14.9	13.4	11.7	10.8	9.7	9.7	9.5	8.8	8.5	8.1
Electricity and heat prod.	16.4	14.0	12.5	10.7	9.8	8.7	8.6	8.4	7.7	7.4	7.1
Transport	1.0	0.9	0.9	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.0
Fugitive emissions	68.5	62.5	55.6	56.9	57.3	60.8	62.9	63.9	62.5	62.1	60.4
Coal mining	33.4	29.0	24.7	24.8	25.4	26.3	26.8	27.4	27.7	26.2	25.5
Natural gas produc.&distribution	35.1	33.5	30.9	32.1	31.9	34.5	36.1	36.5	34.8	35.9	34.9
Agriculture	**135.1**	**118.4**	**102.6**	**88.4**	**82.9**	**84.7**	**81.3**	**74.6**	**66.9**	**64.0**	**62.5**
Enteric fermentation	116.3	100.9	86.8	73.9	69.2	70.8	67.9	62.3	56.0	53.6	52.3
Manure management	18.8	17.5	15.8	14.5	13.7	13.9	13.4	12.3	10.9	10.4	10.2
Forest ecosystems	**3.2**	**3.2**	**3.2**	**3.2**	**2.3**	**2.3**	**0.9**	**1.9**	**0.5**	**0.6**	**0.7**
Biomass burning/forest fires	3.2	3.2	3.2	3.2	2.3	2.3	0.9	1.9	0.5	0.6	0.7
Odpady	**98.5**	**95.8**	**94.0**	**90.3**	**90.7**	**91.3**	**99.6**	**91.3**	**84.9**	**86.2**	**83.4**
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
Waste waters	48.2	45.5	43.7	40.0	40.4	40.4	40.0	40.3	39.1	39.6	35.1

Emissions, as they were appointed to April 15, 2002

Fig. 5.2

CH_4 emissions in 2000



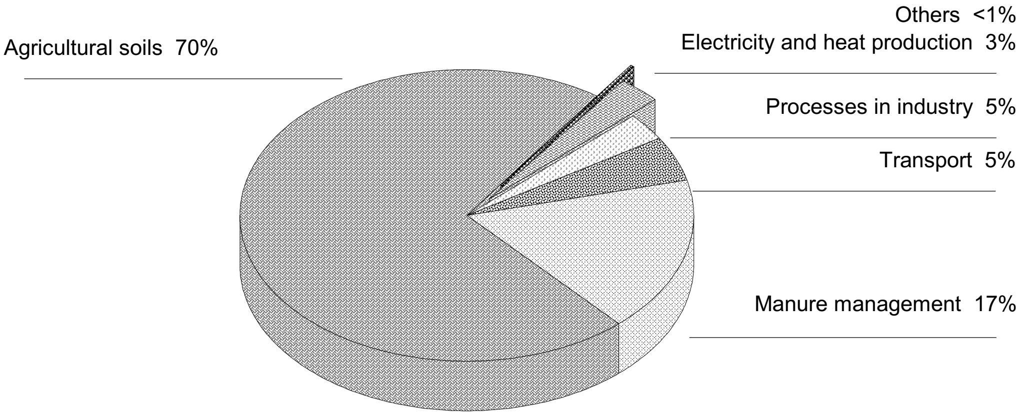
N_2O – nitrous oxide

Tab. 5.3 N_2O emissions [Gg] within 1990-2000

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total N_2O emissions	**19.8**	**16.7**	**14.6**	**12.2**	**12.3**	**12.9**	**11.1**	**10.9**	**10.4**	**10.1**	**10.0**
Energy	**0.8**	**0.7**	**0.6**	**0.6**	**0.7**	**0.8**	**0.8**	**0.8**	**0.9**	**0.9**	**0.8**
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
Transport	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.4	0.5	0.6	0.5
Processes in industry	**1.9**	**1.8**	**1.6**	**1.3**	**2.1**	**2.3**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**
Agriculture	**17.0**	**14.1**	**12.3**	**10.2**	**9.5**	**9.8**	**9.7**	**9.5**	**9.0**	**8.6**	**8.7**
Manure management	3.6	3.2	2.8	2.5	2.3	2.3	2.2	2.0	1.8	1.7	1.7
Agricultural soils	13.4	10.9	9.5	7.7	7.2	7.5	7.5	7.5	7.2	6.9	7.0
Forest ecosystems											
Biomass burning/forest fires	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Wastes	**0.07**	**0.07**	**0.05**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.03**
Industrial waste treatment plants/ Municipal waste waters	0.07	0.07	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03

Emissions, as they were appointed to April 15, 2002

Fig. 5.3 **N_2O emissions in 2000**



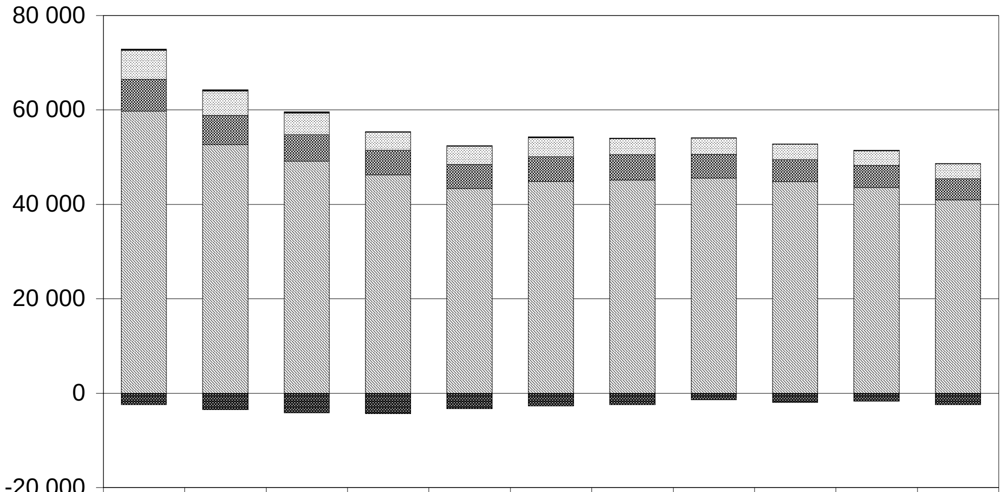
HFCs, PFCs a SF_6

Tab. 5.4 HFCs, PFCs and SF_6 emissions within 1990-2000

	GWP		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total emissions CO_2 equivalent		**[Gg]**	**272**	**267**	**249**	**156**	**144**	**148**	**91**	**114**	**80**	**93**	**103**
HFCs emissions CO_2 equivalent		**[Gg]**					**2.91**	**24.52**	**44.86**	**69.83**	**43.58**	**66.01**	**78.3**
HFC-23	11700	[Mg]						<0.01	0.07	0.07	0.05	0.05	0.05
HFC-32	650	[Mg]							0.02	0.11	0.07	0.10	0.32
HFC-41	150												
HFC-43-10mee	1300												
HFC-125	2800	[Mg]						0.01	0.08	0.26	0.43	0.76	1.91
HFC-134	1000												
HFC-134a	1300	[Mg]					0.01	10.98	25.45	41.80	29.18	44.43	47.73
HFC-152a	140	[Mg]							<0.01	0.14	0.32	0.61	0.83
HFC-143	300												
HFC-143a	3800	[Mg]							0.12	0.31	0.46	0.80	1.92
HFC-227ea	2900	[Mg]					1.00	3.52	3.52	4.39	0.71	0.80	0.80
HFC-236fa	6300												0.05
HFC-245ca	560												
PFCs emissions CO_2 equivalent		**[Gg]**	**271.9**	**267.1**	**249.0**	**155.8**	**132.3**	**113.9**	**35.2**	**33.2**	**23.8**	**13.93**	**11.60**
CF_4	6500	[Mg]	36.6	36.0	33.5	21.0	17.8	15.4	4.7	4.5	3.2	1.9	1.6
C_2F_6	9200	[Mg]	3.7	3.6	3.4	2.1	1.8	1.5	0.5	0.4	0.3	0.2	0.2
C_3F_8	7000												
C_4F_{10}	7000												
c-C_4F_8	8700												
C_5F_{12}	7500												
C_6F_{14}	7400												
SF_6 emissions CO_2 equivalent		**[Gg]**	**0.03**	**0.03**	**0.04**	**0.06**	**9.27**	**9.91**	**10.76**	**11.34**	**12.24**	**12.68**	**13.11**
SF_6	23900	[Mg]	0.001	0.001	0.002	0.003	0.388	0.415	0.450	0.474	0.512	0.531	0.549

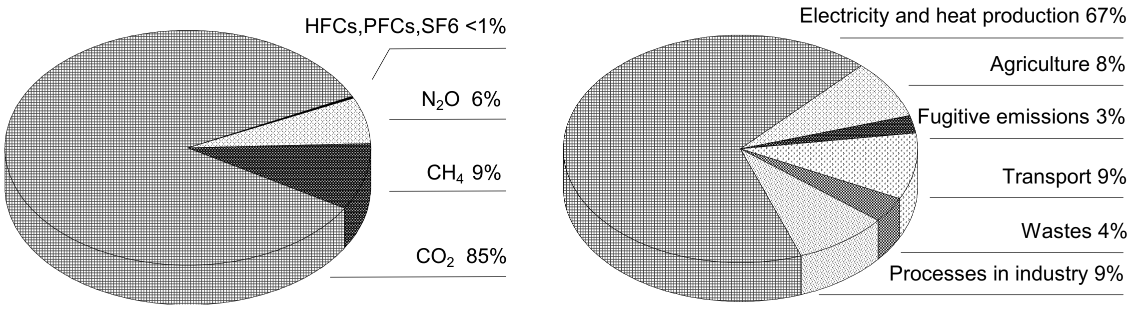
Aggregated emissions

Fig. 5.4 **Aggregated emissions of greenhouse gases, 1990-2000**



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
HFCs,PFCs,SF6	272	267	249	156	144	148	91	114	80	93	103
N2O	6 141	5 177	4 536	3 784	3 829	4 012	3 429	3 400	3 225	3 120	3 113
CH4	6 778	6 191	5 645	5 261	5 125	5 225	5 342	5 064	4 696	4 648	4 516
CO2 (without LUCF)	59 746	52 658	49 179	46 232	43 365	44 898	45 156	45 556	44 811	43 600	40 935
CO2 (sink)	-2 427	-3 475	-4 128	-4 266	-3 287	-2 683	-2 427	-1 411	-1 936	-1 651	-2 443

Fig. 5.5 **Aggregated emissions of greenhouse gases in 2000**[9]



[9] *Note: sectors of industry and agriculture in the IPCC nomenclature do not correspond to sectors as defined e.g. in the statistical Yearbook of the Slovak Republic. The total contribution of industry and agriculture is significantly higher.*

APPENDIX 1 Air quality standards according to the Provision of government of the Slovak Republic No. 92/1996 of the Act Coll., by which the Act No. 309/1991 Coll. about the air protection against pollutants, listed in Appendix 6 of this Provision is being carried out

Pollutant	Expressed as	Air quality standards [µg.m^{-3}]			
		AQS_y	AQS_d	AQS_{8h}	AQS_s
Suspended particles		60	150		500
Sulphur dioxide	SO_2	60	150		500
Sulphur dioxide and suspended particles	SO_2 + SP		250*		
Oxides of nitrogen	NO_2	80	100		200
Carbon dioxide	CO		5 000		10 000
Ozone	O_3			110	
Pb in suspended particles	Pb	0.5			
Cd in suspended particles	Cd	0.01			
Odorous substances	Must not be in concentrations to nuisance the public				

Conditions to meet the standard: Concentration of AQS_d and AQS_s for SP, SO_2, NO_x and CO must not be exceeded within the year in more than 5% of cases.

Explanatory notes to the symbols:

*** -** Calculated arithmetic sum of daily average concentrations of both components.

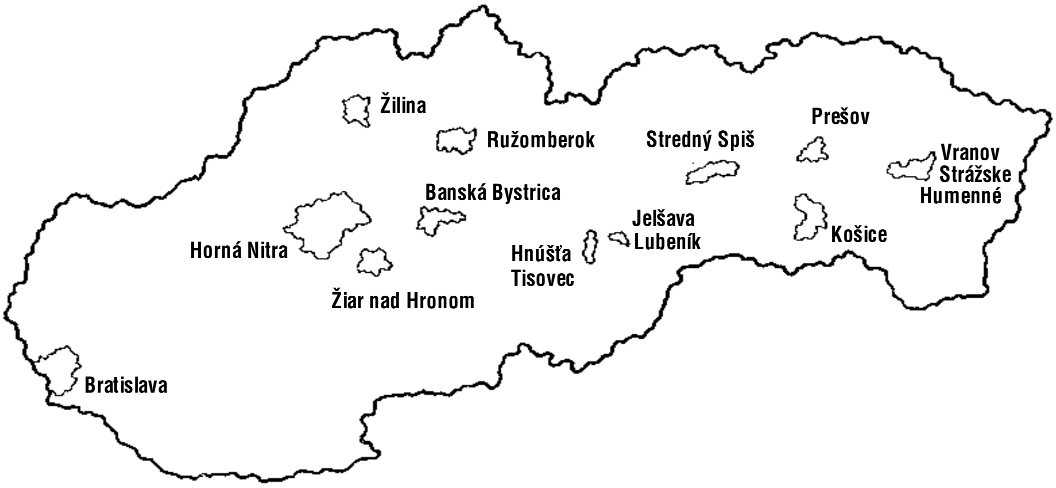
AQS_y - Annual average concentration of pollutant. Average concentration is mid value of concentration, found out at a given place within a time period of one year, as an arithmetic mean of average 24-hour concentrations.

AQS_d - Daily average concentration of pollutant. Daily average concentration is mid value of concentration, found out at given place, within the time period of 24 hours. Daily average concentration is also mid value of at least 12 regular measurements of average half-hour concentrations within the time period of 24 hours (arithmetic mean).

AQS_{8h} - Average 8-hour concentration of pollutant. Average 8-hour concentration is mid value of concentration, found out at a given place, within the time period of 8 hours.

AQS_s - Average half-hour concentration of pollutant is mid value of concentration, found out at a given place, within the time period of 30 minutes.

APPENDIX 2 Polluted areas of the Slovak Republic



Area	Definition of a territory - cadastral territories of cities/towns and districts
Banská Bystrica	Banská Bystrica, Kynceľová, Selce, Slovenská Ľupča
Bratislava	Bratislava,hl. mesto SR, Hamuliakovo, Kalinkovo, Rovinka
Hnúšťa - Tisovec	Brádno, Hačava, Hnúšťa, Likier, Polom, Rimavská Píla, Rimavské Brezovo, Tisovec
Upper Nitra	Prievidzký okres
Jelšava - Lubeník	Chyžné, Jelšava, Lubeník, Magnezitovce, Mokrá Lúka, Revúcka Lehota
Košice	Bočiar Haniska, Košice, Sokoľany, Veľká Ida
Prešov	Prešov
Ružomberok	Biely Potok, Likavka, Liptovská Štiavnica, Lisková, Ludrová, Martinček, Ružomberok, Sliače, Štiavnička
Strážske - Vranov - Humenné	Brekov, Dlhé Klčovo, Hudcovce, Humenné, Kladzany, Kučín, Majerovce, Nižný Hrabovec, Nižný Hrušov, Pusté Čemerné, Sedliská, Staré, Strážske, Topoľovka, Továrnianska Polianka, Voľa, Vranov nad Topľou, Závadka
Middle Spiš	Hrišovce, Chrásť nad Hornádom, Kaľava, Kluknava, Kolinovce, Krompachy, Markušovce, Matejovce, Olcnava, Richňava, Rudňavy, Spišské Vlachy, Vítkovce, Vojkovce
Žiarska kotlina	Dolná Trnávka, Dolná Ždaňa, Hliník nad Hronom, Horná Ždaňa, Ladomierska Vieska, Lehôtka pod Brehmi, Lovča, Lovčica - Trubín, Lutila, Prestavlky, Stará Kremnička, Šášovské Podhradie, Žiar nad Hronom
Žilina	Žilina, Lietavská Lúčka

AIR POLLUTION
IN THE SLOVAK REPUBLIC
2001

Issued by

Ministry of Environment of the Slovak Republic
Nám. Ľ. Štúra 1, 811 02 Bratialava
Slovak Hydrometeorological Institute
Jeséniova 17, 833 15 Bratislava 37

Printing

Special publication: 116 pp., 41 tab., 51 fig.
Number of copies: 100

Report No OKO-2003/18
ISBN 80-88907-31-4