Slovak
Hydrometeorological Institute

Ministry of Environment
of the Slovak Republic

# AIR POLLUTION

## IN THE SLOVAK REPUBLIC

# 2009

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**Report was elaborated by**

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**SLOVAK HYDROMETEOROLOGICAL INSTITUTE**
**2011**

# C O N T E N T

## AMBIENT AIR



## EMISSIONS

# AMBIENT AIR

# 1

## REGIONAL AIR POLLUTION AND QUALITY OF PRECIPITATION

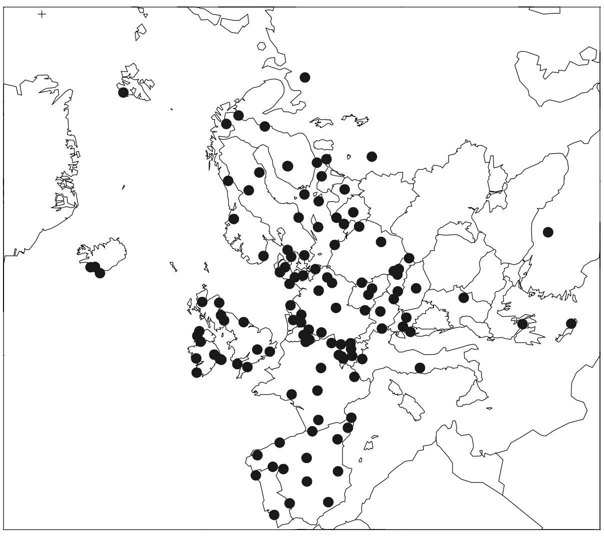
# 1.1 REGIONAL AIR POLLUTION AND QUALITY OF PRECIPITATION

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

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

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

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



The EMEP monitoring programme has been gradually extended. The monitoring of sulphur compounds and precipitation has been enhanced for oxides of nitrogen, ammonium in ambient air, particulate matter and ozone. In 1994, the measurements of volatile organic compounds (VOCs) have begun to be carried out under the auspices of CCC - NILU. Later on also heavy metals (HMs) and persistent organic pollutants (POPs) have been included into the measurement programme. In 2003 the new monitoring strategy has been adopted classifying stations into three levels (more details on www.emep.int).

# 1.2 EMEP STATIONS OF NATIONAL AIR QUALITY MONITORING NETWORK

In 2009, there were 4 EMEP stations of National Monitoring Network in operation in the Slovak Republic to monitor regional air pollution and chemical composition of precipitation. Locations and elevations of the individual stations are indicated in Figure 1.2. All these stations are part of the European EMEP network.

## EMEP stations

### Chopok

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

### Stará Lesná

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

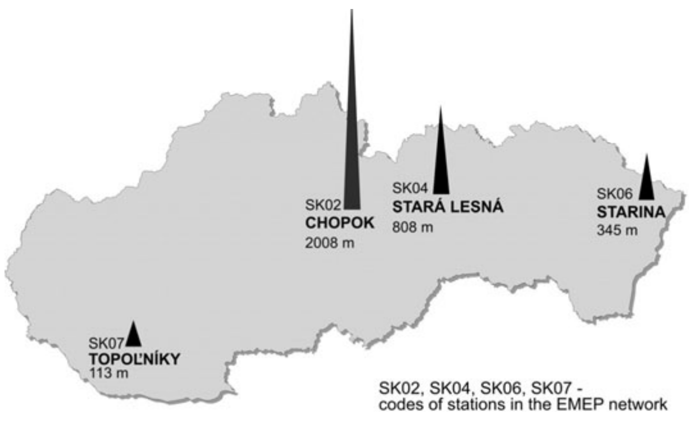
### Topoľníky

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

### Starina

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

Fig. 1.2 **EMEP stations in the Slovak Republic – 2009**



### Measurement programme

**AMBIENT AIR**

| Station | Sulphur dioxide ($SO_2$) | Oxides of nitrogen (NOx) | Sulphates ($SO_4^{2-}$) | Nitrates ($NO_3^-$) | Nitric acid ($HNO_3$) | Ammonia, ammon. ions ($NH_3$, $NH_4^+$) | Alkali ions ($K^+$, $Na^+$, $Ca^{2+}$, $Mg^{2+}$) | Ozone ($O_3$) | VOC | $PM_{10}$ | TSP* | Lead (Pb) | Arsenic (As) | Cadmium (Cd) | Nickel (Ni) | Chromium (Cr) | Copper (Cu) | Zinc (Zn) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chopok** | x | x | x | x | x | | | x | | | x | x | x | x | x | x | x | x |
| **Topoľníky** | | | | | | | | x | | x | | x | x | x | x | x | x | x |
| **Starina** | x | x | x | x | x | x | x | x | x | x | | x | x | x | x | x | x | x |
| **Stará Lesná** | | | | | | | | x | | x | | x | x | x | x | x | x | x |

** TSP – Total suspended particles in ambient air*

**ATMOSPHERIC PRECIPITATION**

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

# 1.3 ASSESSMENT OF RESULTS FROM MEASUREMENTS IN 2009

### $SO_2$, sulphates

Background concentrations of sulphur dioxide recalculated in sulphur (Tab. 1.1, Fig. 1.3) reached 0.24 µg.m$^{-3}$ on the Chopok station and 0.60 µg.m$^{-3}$ on the Starina station, in 2009. ***In coincidence with the Annex 1 to the Decree of the Ministry of Environment of the Slovak Republic No. 705/2002 on air quality, the limit value for protection of ecosystems is 20 µg $SO_2$.m$^{-3}$ in calendar year and winter season. This value has been exceeded neither at the calendar year (Chopok 0.48 µg $SO_2$.m$^{-3}$ and Starina 1.2 µg $SO_2$.m$^{-3}$), nor in winter season (Chopok 0.6 µg $SO_2$.m$^{-3}$ and Starina 1.9 µg $SO_2$.m$^{-3}$).*** Sulphates contributed to the total weight mass of particulate matter (Fig. 1.4) 17.1% on the Chopok station and 15.8% on the Starina station. Concentration ratio of sulphates to sulphur dioxide, recalculated in sulphur represents interval 1.2 on the Chopok station and 1.3 on the Starina station.

### NOx, nitrates

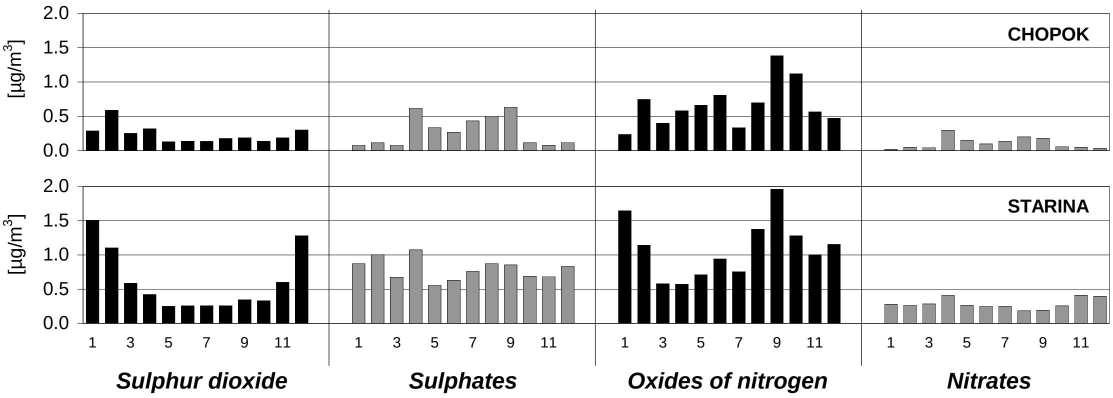
Background level of concentrations of oxides of nitrogen, recalculated in nitrogen (Tab. 1.1, Fig. 1.3) presented 0.67 µg.m$^{-3}$on the Chopok station and 1.1 µg.m$^{-3}$ on the Starina station, in 2009. ***In coincidence with the Annex 1 to the Decree of the Ministry of Environment of the Slovak Republic No. 705/2002 on air quality, the limit value for protection of vegetation is 30 µg $NO_x$.m$^{-3}$ in calendar year. This limit value was not exceeded in calendar year (Chopok 2.21 µg NOx.m$^{-3}$ and Starina 3.63 µg NOx.m$^{3}$).*** Nitrates in ambient air on the Chopok and Starina stations occurred predominantly in the form of particles in 2009. Concentrations of nitric acid were substantially lower in 2009 as compared to particulate nitrates on both stations. Both these forms of nitrogen are collected on filters separately and also measured separately and their phase division is dependent upon the ambient air temperature and humidity. Nitrates contributed to the total mass of particulate matter 9.9% on the Chopok station and 8.5% on the Starina station. Concentration ratio of total nitrates ($HNO_3 + NO_3$) to NOx-$NO_2$ recalculated in nitrogen represented the value of 0.18 at the Chopok station and 0.28 at the Starina station.

Tab. 1.1 **Annual averages of gaseous and particulate components in ambient air, 2007 – 2009**

| | | $SO_2$ (S) | $SO_4^{2-}$ (S) | $NO_x$ (N) | $NO_3^-$ (N) | $HNO_3$ (N) | $O_3$ | $PM_{10}$ | Pb | Cu | Cd | Ni | Cr | Zn | As |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | μg/m³ | μg/m³ | μg/m³ | μg/m³ | μg/m³ | μg/m³ | μg/m³ | ng/m³ | ng/m³ | ng/m³ | ng/m³ | ng/m³ | ng/m³ | ng/m³ |
| Chopok | 2007 | 0.18 | 0.27 | 0.72 | 0.08 | 0.01 | 92 | *5.1 | 1.59 | 0.84 | 0.05 | 0.44 | 0.60 | 4.14 | 0.13 |
| | 2008 | 0.15 | 0.23 | 0.54 | 0.06 | 0.01 | 92 | *3.5 | 1.31 | 0.64 | 0.04 | 0.28 | 0.51 | 4.36 | 0.11 |
| | 2009 | 0.24 | 0.28 | 0.67 | 0.11 | 0.01 | 90 | *4.9 | 1.37 | 0.92 | 0.04 | 0.39 | 0.67 | 3.59 | 0.25 |
| Topoľníky | 2007 | - | - | - | - | - | 58 | 23.2 | 11.09 | 4.11 | 0.28 | 1.15 | 1.01 | 19.44 | 0.83 |
| | 2008 | - | - | - | - | - | 60 | 18.0 | 8.82 | 3.02 | 0.24 | 0.63 | 0.81 | 18.00 | 0.84 |
| | 2009 | | | | | | 59 | 22.7 | 9.44 | 3.11 | 0.24 | 0.69 | 0.83 | 17.78 | 1.07 |
| Starina | 2007 | 0.80 | 0.86 | 1.24 | 0.32 | 0.02 | 63 | 17.7 | 8.46 | 2.10 | 0.29 | 0.58 | 0.59 | 12.61 | 0.45 |
| | 2008 | 0.66 | 0.79 | 1.27 | 0.30 | 0.02 | 59 | 13.9 | 6.58 | 1.56 | 0.22 | 0.51 | 0.61 | 11.81 | 0.49 |
| | 2009 | 0.60 | 0.79 | 1.10 | 0.29 | 0.02 | 58 | 15.0 | 5.21 | 1.37 | 0.18 | 0.50 | 0.62 | 10.03 | 0.55 |
| Stará Lesná | 2007 | - | - | - | - | - | 68 | 12.6 | 5.92 | 2.39 | 0.20 | 0.44 | 0.48 | 13.03 | 0.52 |
| | 2008 | - | - | - | - | - | 74 | 11.6 | 5.80 | 1.75 | 0.16 | 0.35 | 0.36 | 13.34 | 0.58 |
| | 2009 | | | | | | 61 | 13.3 | 5.87 | 1.95 | 0.18 | 0.41 | 0.46 | 13.44 | 0.61 |

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

Fig. 1.3 **Monthly mean concentrations of sulpur and nitrogen compounds in ambient air – 2009**
(recalculated in sulphur, resp. nitrogen)




## Ammonia, ammonium ions and alkali ions

In coincidence with the requests of the EMEP monitoring strategy for the EMEP stations "level one" the measurements of ammonia, ammonium ions, ions of sodium, potassium, calcium and magnesium in ambient air started to be measured in May 2005 on the Stará Lesná station. Averaged concentrations of these components ($NH_3$ and $NH_4^+$ recalculated in nitrogen) for years 2006, 2007 a 2008 are listed in table. In the Stará Lesná station these ions have been measured until the beginning of September 2007 and since July 2007 the measurements started to be measured at the Starina station. Annual concentrations of the listed components ($NH_3$ and $NH_4$ recalculated in nitrogen) from the Starina station within 2007 – 2009 are listed in table. Ammonium ions in annual average 0.71 μg.m$^{-3}$ share 5.3% of PM. Annual concentration of ammonia presents 0.2 μg.m$^{-3}$.Concentration ratio of ammonium ions and ammonia expressed in nitrogen is 3.3.

| Station | Year | $NH_3$ (N) [μg/m³] | $NH_4^+$ (N) [μg/m³] | $Na^+$ [μg/m³] | $K^+$ [μg/m³] | $Mg^{2+}$ [μg/m³] | $Ca^{2+}$ [μg/m³] |
|---|---|---|---|---|---|---|---|
| Stará Lesná | 2005* | 0.39 | 0.88 | 0.18 | 0.16 | 0.02 | 0.15 |
| | 2006 | 0.36 | 1.05 | 0.19 | 0.18 | 0.02 | 0.15 |
| | 2007** | 0.40 | 0.77 | 0.09 | 0.15 | 0.03 | 0.14 |
| Starina | 2007*** | 0.18 | 0.80 | 0.08 | 0.14 | 0.02 | 0.08 |
| | 2008 | 0.20 | 0.78 | 0.08 | 0.12 | 0.02 | 0.10 |
| | 2009 | 0.22 | 0.71 | 0.06 | 0.12 | 0.02 | 0.10 |

** since May 2005* *** until September 2007* **** since July 2007*

## Particulate matter $PM_{10}$, respectively TSP and heavy metals

In Table 1.1 are presented the concentrations of $PM_{10}$ (Stará Lesná, Starina, Topoľníky), variating within range of 13.3 – 22.7 μg.m$^{-3}$ and TSP 4.9 μg.m$^{-3}$ (Chopok) in 2009. Concentrations of heavy metals from $PM_{10}$, resp. TSP are listed in Table 1.1 and Figure 1.4. The share of the sum of all measured metals in mass weight of suspended particles ($PM_{10}$, resp. TSP) varied at regional stations within 0.12 – 0.17%.

Fig. 1.4 **Heavy metals in ambient air – 2009**

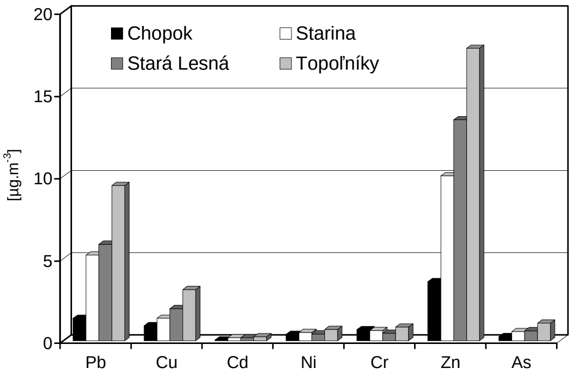
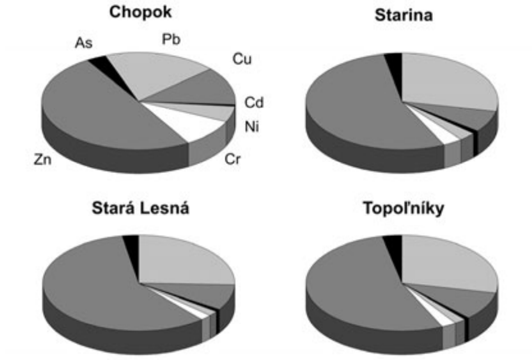



Fig. 1.5 **Proportional share of heavy metals – 2009**

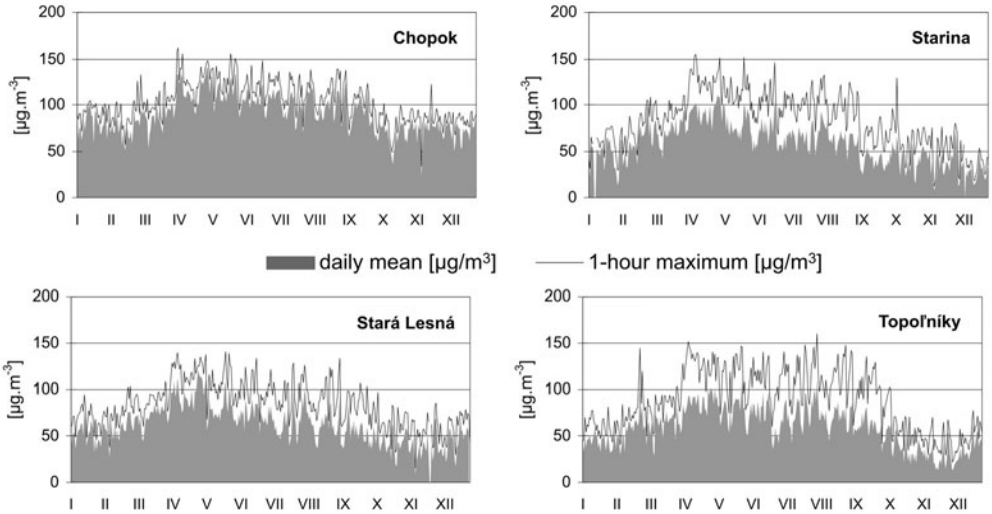



## Ozone

In Figure 1.6 the annual course of ground level ozone concentrations at the regional stations Chopok, Stará Lesná, Starina and Topoľníky are depicted. The longest time series of ozone measurements has been at the Stará Lesná station, since 1992. The measurements of ozone in Topoľníky, Starina and Chopok began to be carried out later, in 1994. In 2009, the annual average of ozone concentration at the Chopok station reached 90 μg.m$^{-3}$, at Starina 58 μg.m$^{-3}$, Stará Lesná 61 μg.m$^{-3}$, and Topoľníky 59 μg.m$^{-3}$. Measurements of ozone and exceedances of critical levels are completely assessed in Chapter 3 Atmospheric Ozone.

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

Fig. 1.6 **Ground level ozone [μg.m$^{-3}$] – 2009**



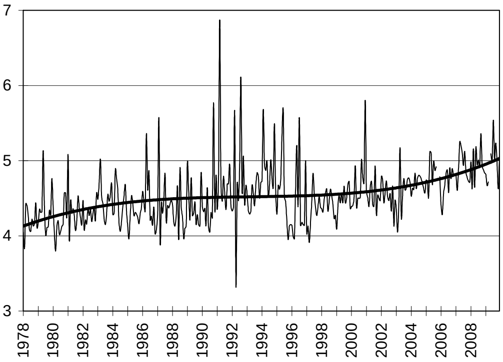
## VOCs $C_2$–$C_6$

VOCs (Volatile Organic Compounds) $C_2$–$C_6$, or the so-called light hydrocarbons, started to be sampled in autumn 1994 at the Starina station. Starina is one of the few European stations, included into the EMEP network with regular sampling of volatile organic compounds. They are measured and assessed according to the EMEP method elaborated by CCC-NILU. Their concentrations ranged within one order of magnitude from the tenth of ppb up to several ppb. However since October 2008 the VOCs measurements are not available due to long-lasting problems with the operation of new GC in Tested laboratory.

## Atmospheric precipitation

### *Major ions, pH, hydrogen ions, conductivity*

Fig. 1.7 **pH in daily precipitation – Chopok**

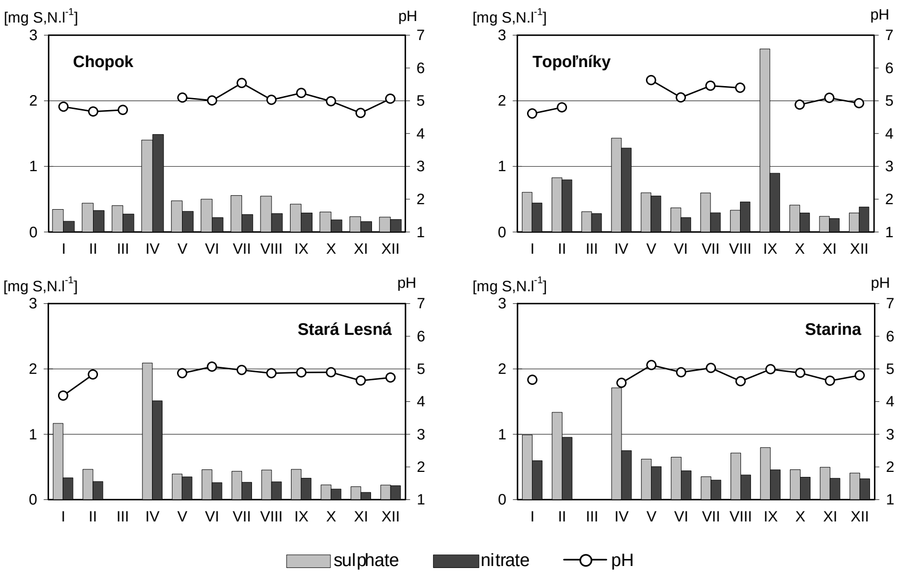



In 2009 the amount of precipitation recorded at background stations ranged between 589 and 1520 mm. The upper level of amount of precipitation does belong to the highest situated station Chopok and the lower one to Topoľníky with the lowest elevation. Acidity of atmospheric precipitation ranged from 4.80 – 5.01 (Tab. 1.2, Fig. 1.8). Figure 1.9 illustrates the annual courses of pH, sulphates and nitrates at the Chopok station based upon the daily sampling. Time series and trend of pH values within a long-time period indicate clearly the decrease in acidity (Fig. 1.7). Values of pH are in a good coincidence with the pH values according to the EMEP maps.

Concentrations of dominant sulphates in precipitation recalculated in sulphur varied within the range 0.40 – 0.64 mg.l$^{-1}$. Concentrations of sulphates on the three stations Chopok, Stará Lesná and Topoľníky are very similar in annual mean and slightly higher at the Starina station. Total decrease of sulphates in long-term time series has corresponded to the $SO_2$ emission reduction since 1980.

The share of nitrate in acidity of precipitation was substantially smaller than those of sulphates and varied within the concentration range, recalculated in nitrogen 0.25 – 0.42 mg.l$^{-1}$. Ammonium ions also do belong to the major ions and their concentration range was 0.31 – 0.46 mg.l$^{-1}$.

Fig. 1.9 **Atmospheric precipitation – 2009**



Tab.1.2 **Annual averages of main components in daily precipitation, 2007 – 2009**

| | | Precip mm | pH | Cond µS/cm | $SO_4^{2-}$(S) mg/l | $NO_3^-$ (N) mg/l | $NH_4^+$(N) mg/l | $Cl^-$ mg/l | $Na^+$ mg/l | $K^+$ mg/l | $Mg^{2+}$ mg/l | $Ca^{2+}$ mg/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chopok** | 2007 | 1087 | 4.93 | 13.3 | 0.54 | 0.30 | 0.43 | 0.19 | 0.23 | 0.07 | 0.04 | 0.15 |
| | 2008 | 1353 | 4.93 | 13.3 | 0.49 | 0.29 | 0.43 | 0.23 | 0.18 | 0.08 | 0.04 | 0.16 |
| | 2009 | 1520 | 4.83 | 12.5 | 0.42 | 0.26 | 0.41 | 0.11 | 0.07 | 0.06 | 0.02 | 0.13 |
| **Topoľníky** | 2007 | 551 | 5.07 | 13.3 | 0.49 | 0.34 | 0.49 | 0.18 | 0.14 | 0.10 | 0.06 | 0.31 |
| | 2008 | 528 | 5.30 | 11.7 | 0.37 | 0.32 | 0.48 | 0.22 | 0.16 | 0.08 | 0.08 | 0.37 |
| | 2009 | 589 | 5.01 | 14.6 | 0.45 | 0.38 | 0.45 | 0.16 | 0.13 | 0.08 | 0.04 | 0.35 |
| **Starina** | 2007 | 738 | 4.54 | 18.4 | 0.54 | 0.38 | 0.32 | 0.19 | 0.19 | 0.08 | 0.03 | 0.18 |
| | 2008 | 858 | 4.75 | 16.1 | 0.52 | 0.32 | 0.32 | 0.21 | 0.16 | 0.08 | 0.04 | 0.23 |
| | 2009 | 789 | 4.80 | 15.8 | 0.64 | 0.42 | 0.46 | 0.15 | 0.20 | 0.11 | 0.04 | 0.30 |
| **Stará Lesná** | 2007 | 790 | 4.80 | 16.4 | 0.54 | 0.28 | 0.58 | 0.28 | 0.25 | 0.18 | 0.04 | 0.26 |
| | 2008 | 747 | 4.82 | 15.6 | 0.48 | 0.27 | 0.27 | 0.29 | 0.28 | 0.09 | 0.04 | 0.24 |
| | 2009 | 829 | 4.88 | 11.9 | 0.40 | 0.25 | 0.31 | 0.17 | 0.14 | 0.10 | 0.03 | 0.23 |

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

### *Heavy metals*

Since 2000 the measurement programme of heavy metals in precipitation has been gradually modified to meet the requirements of the CCC EMEP monitoring strategy. In Bratislava-Jeséniova the measurement of the same set of heavy metals in precipitation was implemented as in background stations of Slovakia (Tab. 1.3). This station serves for comparison and is not considered as the background station. The results of annual weighted means of heavy metals concentrations in monthly precipitation in 2009 are presented in Table 1.3.

Tab. 1.3 **Annual weighted means of heavy metals concentrations in atmospheric precipitation, 2007 – 2009**

| | | Precip. mm | Pb µg/l | Cd µg/l | Cr µg/l | As µg/l | Cu µg/l | Zn µg/l | Ni µg/l |
|---|---|---|---|---|---|---|---|---|---|
| **Chopok** | 2007 | 941 | 1.94 | 0.06 | 0.13 | 0.15 | 0.70 | 20.36 | 0.48 |
| | 2008 | 1159 | 3.39 | 0.09 | 0.22 | 0.17 | 1.41 | 20.92 | 0.64 |
| | 2009 | 1258 | 1.51 | 0.19 | 0.45 | 0.18 | 0.93 | 16.12 | 0.64 |
| **Topoľníky** | 2007 | 571 | 0.92 | 0.04 | 0.07 | 0.10 | 1.28 | 9.21 | 0.44 |
| | 2008 | 560 | 1.30 | 0.05 | 0.11 | 0.11 | 3.03 | 11.92 | 0.84 |
| | 2009 | 600 | 1.00 | 0.06 | 0.16 | 0.17 | 1.06 | 7.30 | 0.62 |
| **Starina** | 2007 | 625 | 1.72 | 0.06 | 0.07 | 0.13 | 1.93 | 9.76 | 0.40 |
| | 2008 | 708 | 2.12 | 0.06 | 0.12 | 0.16 | 1.67 | 10.17 | 0.60 |
| | 2009 | 745 | 1.36 | 0.07 | 0.11 | 0.16 | 1.47 | 9.06 | 0.91 |
| **Stará Lesná** | 2007 | 673 | 1.18 | 0.09 | 0.08 | 0.13 | 0.99 | 10.74 | 0.28 |
| | 2008 | 616 | 2.05 | 0.14 | 0.10 | 0.17 | 3.40 | 13.74 | 0.62 |
| | 2009 | 827 | 1.28 | 0.19 | 0.14 | 0.12 | 2.98 | 12.55 | 0.92 |
| **Bratislava-Koliba** | 2007 | 554 | 2.01 | 0.07 | 0.21 | 0.22 | 2.31 | 15.8 | 1.07 |
| | 2008 | 625 | 1.45 | 0.05 | 0.20 | 0.16 | 2.89 | 14.55 | 0.57 |
| | 2009 | 848 | 1.53 | 0.06 | 0.20 | 0.18 | 2.18 | 17.43 | 0.74 |

## Conclusion

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

# AMBIENT AIR

## LOCAL AIR POLLUTION

# 2

# 2.1 LOCAL AIR POLLUTION

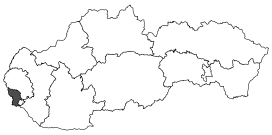
Air quality assessment is claimed by Air Protection Act No. 478/2002 Coll. as amended. Criterions for air quality assessment (upper and lower assessment thresholds, margin of tolerance, limit and target values) are given in Decree No. 705/2002 Coll. about Air Quality amended by Decree No. 351/2008 Coll. Fundamental air quality assessment is performed on the basis of measured data. Slovak hydrometeorological institute (SHMÚ) carried out measurements at monitoring stations of National air quality monitoring network (NAQMN).

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

In 1991 modernization of the air quality monitoring network began. The manual stations were gradually substituted by automatic ones, which enable the continuous monitoring of pollution and made it possible to evaluate time changes and the extremes of the short-term concentrations. In the course of the last ten years the air quality monitoring network has kept developing. In 2009, 29 stations (without EMEP and ozone stations) were located on the territory of the SR. Most of them monitored the level of pollution caused by the basic pollutants ($SO_2$, $NO_2$, $NO_x$, and $PM_{10}$). In the year 2009 measurements of benzene were carried out at 9 and $PM_{2,5}$ at 3 automatic stations. The air pollution monitoring by heavy metals (Pb, Cd, As and Ni) were performed at 10 localities and benzo(a)pyrene on 8 sites.

In accordance to the Air Protection Act the territory of the Slovak Republic was divided into 8 zones and 2 agglomerations for the following pollutants: $SO_2$, $NO_2$, NOx, Pb, $PM_{10}$, $PM_{2.5}$, benzene and CO. The delimitation of zones is identical with the higher administrative units – regions. From Bratislava and Košice regions geographical extension of cities Bratislava and Košice were selected and these cities are assessed separately as agglomerations. According to the Decree No. 705/2002 Coll. about Air Quality amended by Decree No. 351/2007 Coll. for pollutants: As, Cd, Ni, BaP, Hg and $O_3$ was territory of Slovakia divided only into agglomeration Bratislava and rest represents zone Slovakia.

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



## AGGLOMERATION - BRATISLAVA

AREA: 368 km$^2$ POPULATION: 428 791

### Characterization of area

**Bratislava**

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

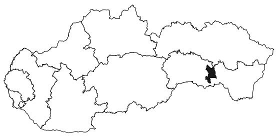
### Location of stations


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

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

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

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



## AGGLOMERATION - KOŠICE

AREA: 245 km$^2$ POPULATION: 233 880

### Characterization of area

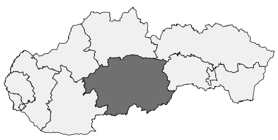
**Košice**

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

### Location of stations

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

**Košice – Amurská**
Station is located in open area 100 m far from housing estate built-up area, which surrounded station from south, west and north directions. Easterly in distance of 120 m is located a lake.

## ZONE - BANSKÁ BYSTRICA REGION

AREA: 9 455 km$^2$ POPULATION: 653 186

### Characterization of area

**Banská Bystrica**

The town is located in the Bystrica valley, which is by the northern part of the Zvolen basin surrounded by the Staré Hory hills to the north, by the Horehron valley to the north-east and by the Kremnica hills to the south-east. The annual average temperature is 8°C. Prevailing wind is from the north and north-east, an average speed 2.1 m.s$^{-1}$ with high occurrence of temperature inversion in valley positions of about 33%. Air pollution is affected by wood processing industries releasing emissions of suspended particles, but also by a large number of local heating sources. Traffic does contribute to the high level of air pollution in the town centre, as well.

**Zvolen**

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

**Žiar nad Hronom**

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

**Hnúšťa**

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

**Jelšava**

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

## Location of stations


**Banská Bystrica - Štefánikovo nábrežie**

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

**Banská Bystrica – Zelená**

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

**Zvolen - J. Alexyho**

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

**Hnúšťa - Hlavná**

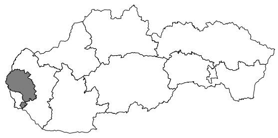
The station is situated in open middle building area on the north edge of the town, approximately 50 m far from state road No. 531.

**Jelšava - Jesenského**

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

**Žiar nad Hronom - Dukelských hrdinov**

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



## ZONE - BRATISLAVA REGION

AREA: 1 685 km$^2$ POPULATION: 193 314

### Characterization of area

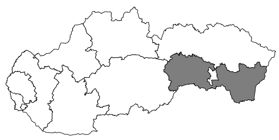
**Malacky**

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

### Location of stations

**Malacky – Sasinkova**

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



## ZONE - KOŠICE REGION

AREA: 6 508 $km^2$ POPULATION: 544 240

### Characterization of area

**Krompachy**

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

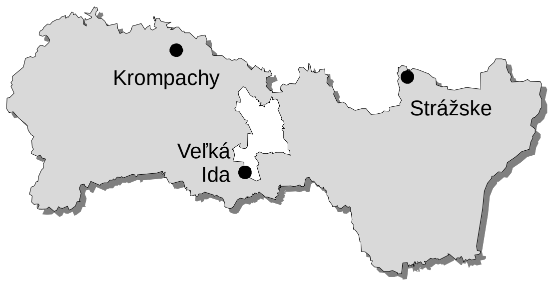
**Strážske**

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

**Veľká Ida**

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

### Location of stations




**Krompachy - Lorenzova**

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

**Krompachy - SNP**

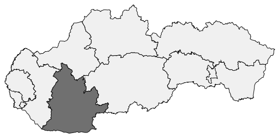
Monitoring station is located close to the main route Košice - Spišská Nová Ves. The surrounding built-up area comprises multi-storey houses.

**Strážske - Mierová**

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

**Veľká Ida - Letná**

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



## ZONE - NITRA REGION

AREA: 6 343 km$^2$ POPULATION: 705 661

### Characterization of area

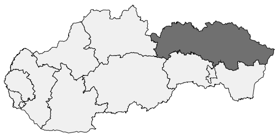
**Nitra**

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

### Location of stations

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

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



## ZONE - PREŠOV REGION

AREA: 8 993 km$^2$ POPULATION: 807 011

### Characterization of area

**Prešov**

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

**Humenné**

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

**Vranov**

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

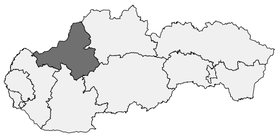
### Location of stations

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

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


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

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



## ZONE - TRENČÍN REGION

AREA: 4 502 km$^2$ POPULATION: 599 214

### Characterization of area

**Horná Nitra**

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

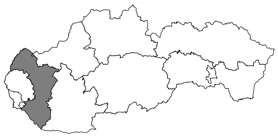
### Location of stations

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

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

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


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



## ZONE - TRNAVA REGION

AREA: 4 148 km$^2$ POPULATION: 561 525

### Characterization of area

**Senica**

The town itself is located on the southern slopes of Myjava hills in the altitude of 208 m. From western and partly northern side as well, the territory is bordered by the Little Carpathians. It is open only alongside Myjava river from east side, where the promontory of Záhorie lowlands intervenes. From the standpoint of emission transport and dispersion the wind conditions are favourable under the prevailing north-west wind, as this is associated with the relatively higher wind speeds. Main share in air pollution of the town is due to chemical industry (Slovenský hodváb a.s., Senica), power generation and car transport.

**Trnava**

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

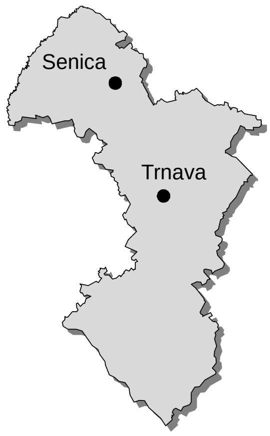
### Location of stations

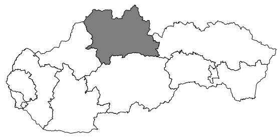
**Senica - Hviezdoslavova**

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

**Trnava - Kollárova**

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





# ZONE - ŽILINA REGION

AREA: 6 788 km$^2$ POPULATION: 697 502

## Characterization of area

**Ružomberok**

The location of the city comprises the area of the western part of the Liptov basin, on the confluence of rivers Váh, Revúca and Likavka. The Veľká Fatra mountains constitute the border in the west, the Choč mountains in the north and the Low Tatras in the south. The most frequently occur winds from west sector, at an average speed 1.6 m.s$^{-1}$. The North Slovakian pulp and paper processing plants (Mondi scp a.s., Ružomberok) are the largest industrial source of air pollution. A considerable share in this pollution is caused by small local sources, as well. Specific air pollution represents a mixture of predominantly organic-sulphur compounds.

**Žilina**

The town itself is spread in the central valley of the Váh river, in the basin of central Považie. Žilina basin is classified as a moderately high basin. From the east the Little Fatra mountains intervene into the area, from the south the White Carpathians and from the north-west the Javorníky mountains. According to the climate characteristics the area belongs to a moderately warm region. In a basin area, the relative humidity of air is higher and also the number of foggy days is the highest throughout the year. Slight windiness of average wind speed 1.3 m.s$^{-1}$ and the up to 60% occurrences of calm characterise this area. From the standpoint of potential air pollution, the wind conditions in the Žilina basin are very unfavourable and thus relatively small sources of emissions lead to the high level of air pollution at the ground level layer. Air pollution by classical pollutants is due to the local heating plant of the Slovak Power Plants, but local chemical industry and mainly heavy traffic in the town centre contribute as well.

**Martin**

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

## Location of stations

**Žilina - Obežná**

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

**Ružomberok - Riadok**

The station is located in the kindergarten close to a low traffic route way. In the surrounding built-up area low family housing prevails. A major pollution source pulp and paper processing plant - Mondi scp a.s., Ružomberok is situated north-east of the monitoring station.

**Martin - Jesenského**

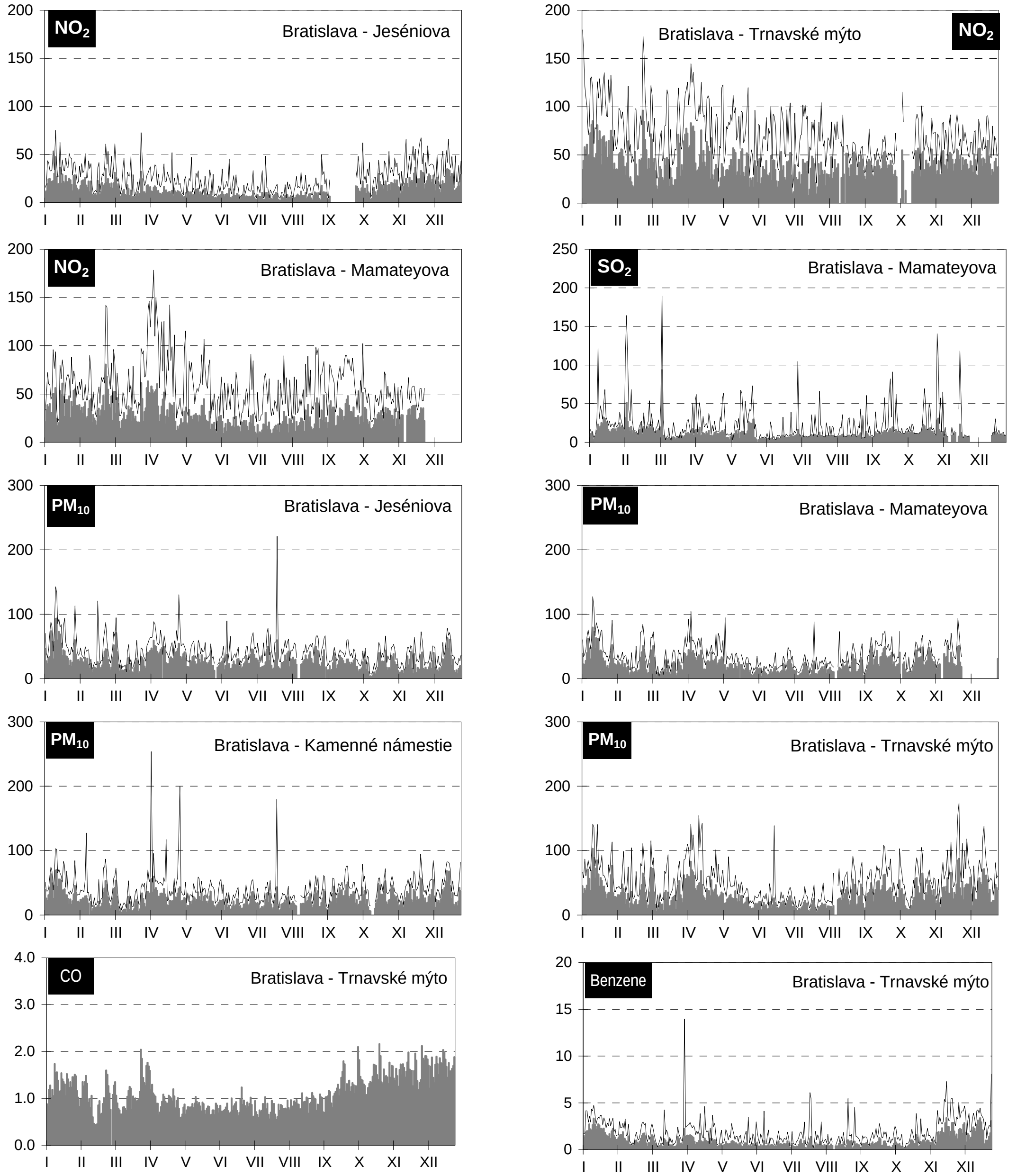
The station is located 5 m from the kerbside of the main street. Station is located in the southern part of the city in area mainly build up by family houses.

Tab. 2.1 **Geographical co-ordinates of monitoring stations and list of pollutants monitored in – 2009**

| AGGLOMERATION/ zone | | Longitude | Latitude | Altitude [m] | $SO_2$ | $NO_2$ | $PM_{10}$ | $PM_{2.5}$ | CO | $C_6H_6$ | Pb | Cd | Ni | As | BaP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BRATISLAVA | Bratislava, Kamenné nám | 17°06'48" | 48°08'41" | 139 | | | * | | | | | | | | |
| | Bratislava, Trnavské mýto | 17°07'43" | 48°09'30" | 136 | | * | * | | * | * | | | | | * |
| | Bratislava, Jeséniova | 17°06'22" | 48°10'05" | 287 | | * | * | | | | | | | | * |
| | Bratislava, Mamateyova | 17°07'32" | 48°07'30" | 138 | * | * | * | | | | * | * | * | * | |
| KOŠICE | Košice, Strojárska [1)]<br>Košice, Amurská [1)] | 21°15'07"<br>21°17'11" | 48°43'36"<br>48°41'28" | 202<br>201 | | | * | | | | | | | | |
| Banskobystrický region | Banská Bystrica, Štefánikovo nábr. | 19°09'16" | 48°44'07" | 346 | * | * | * | | * | * | * | * | * | * | |
| | Banská Bystrica, Zelená | 19°06'55" | 48°44'00" | 425 | | * | | | | | | | | | |
| | Zvolen, J. Alexyho | 19°09'24" | 48°33'29" | 321 | | | * | | | | | | | | |
| | Jelšava, Jesenského | 20°14'26" | 48°37'52" | 289 | | | * | | | | | | | | |
| | Hnúšťa, Hlavná | 19°57'06" | 48°35'02" | 320 | | | * | | | | | | | | |
| | Žiar nad Hronom, Dukelských hrdinov | 18°51'01" | 48°35'09" | 285 | | | * | | | | | | | | |
| Bratislava region | Malacky, Sasinkova | 17°01'11" | 48°26'15" | 198 | * | * | * | | * | * | | | | | |
| Košice region | Veľká Ida, Letná | 21°10'30" | 48°35'32" | 209 | | | * | | * | | * | * | * | * | * |
| | Strážske, Mierová | 21°50'15" | 48°52'26" | 133 | | | * | | | | | | | | |
| | Krompachy, Lorenzova [2)]<br>Krompachy, SNP [2)] | 20°52'23" | 48°54'45" | 387 | * | * | * | | * | * | * | * | * | * | * |
| Nitra region | Nitra, Janka Kráľa | 18°04'29" | 48°18'38" | 142 | * | * | * | | * | * | | | | | |
| | Nitra, Janíkovce | 18°08'27" | 48°17'00" | 149 | | * | * | | | | | | | | |
| Prešov region | Humenné, Nám. slobody | 21°54'50" | 48°55'51" | 160 | | * | * | | | | | | | | |
| | Prešov, Solivarská [3)]<br>Prešov, Arm. gen. L.Svobodu [3)] | 21°15'52"<br>21°16'03" | 48°58'40"<br>48°59'36" | 258<br>252 | | * | * | | * | * | | | | | |
| | Vranov nad Topľou, M. R. Štefánika | 21°41'15" | 48°53'11" | 133 | * | | * | | | | | | | | |
| Trenčín region | Prievidza, Malonecpalská | 18°37'40" | 48°46'58" | 276 | * | | * | * | | | * | * | * | * | * |
| | Bystričany, Rozvodňa SSE | 18°30'51" | 48°40'01" | 261 | * | | * | | | | | | | | |
| | Handlová, Morovianska cesta | 18°45'23" | 48°43'59" | 448 | * | | * | | | | | | | | |
| | Trenčín, Hasičská | 18°02'28" | 48°53'47" | 214 | * | * | * | | * | * | | | | | |
| Trnava region | Senica, Hviezdoslavova | 17°21'48" | 48°40'50" | 212 | * | | * | | | | | | | | |
| | Trnava, Kollárova | 17°35'06" | 48°22'16" | 152 | | * | * | | * | * | | | | | * |
| Žilina region | Martin, Jesenského | 18°55'17" | 49°03'35" | 383 | | * | * | * | * | * | | | | | |
| | Ružomberok, Riadok | 19°18'10" | 49°04'44" | 475 | * | | * | | | | * | * | * | * | |
| | Žilina, Obežná | 18°46'15" | 49°12'41" | 356 | | * | * | * | | | | | | | |

*[1)] Strojárska until 16. 9. 2009, Amurská from 5. 10. 2009 [2)] Lorenzova until 17. 7. 2009, SNP from 20. 7. 2009*
*[3)] Solivarská until 16. 9. 2009, Arm. gen. L. Svobodu from 21. 10. 2009*

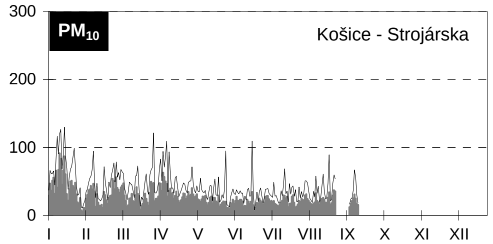
Fig. 2.1 **Concentrations of $NO_2$, $SO_2$, $PM_{10}$, benzene and CO – agglomeration Bratislava – 2009**




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

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

Fig. 2.2 **Concentrations of $NO_2$, $PM_{10}$, CO and benzene – agglomeration Košice – 2009**




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

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

Fig. 2.3 **Concentrations of $NO_2$, $SO_2$, $PM_{10}$, CO and benzene – zone Banská Bystrica region – 2009**

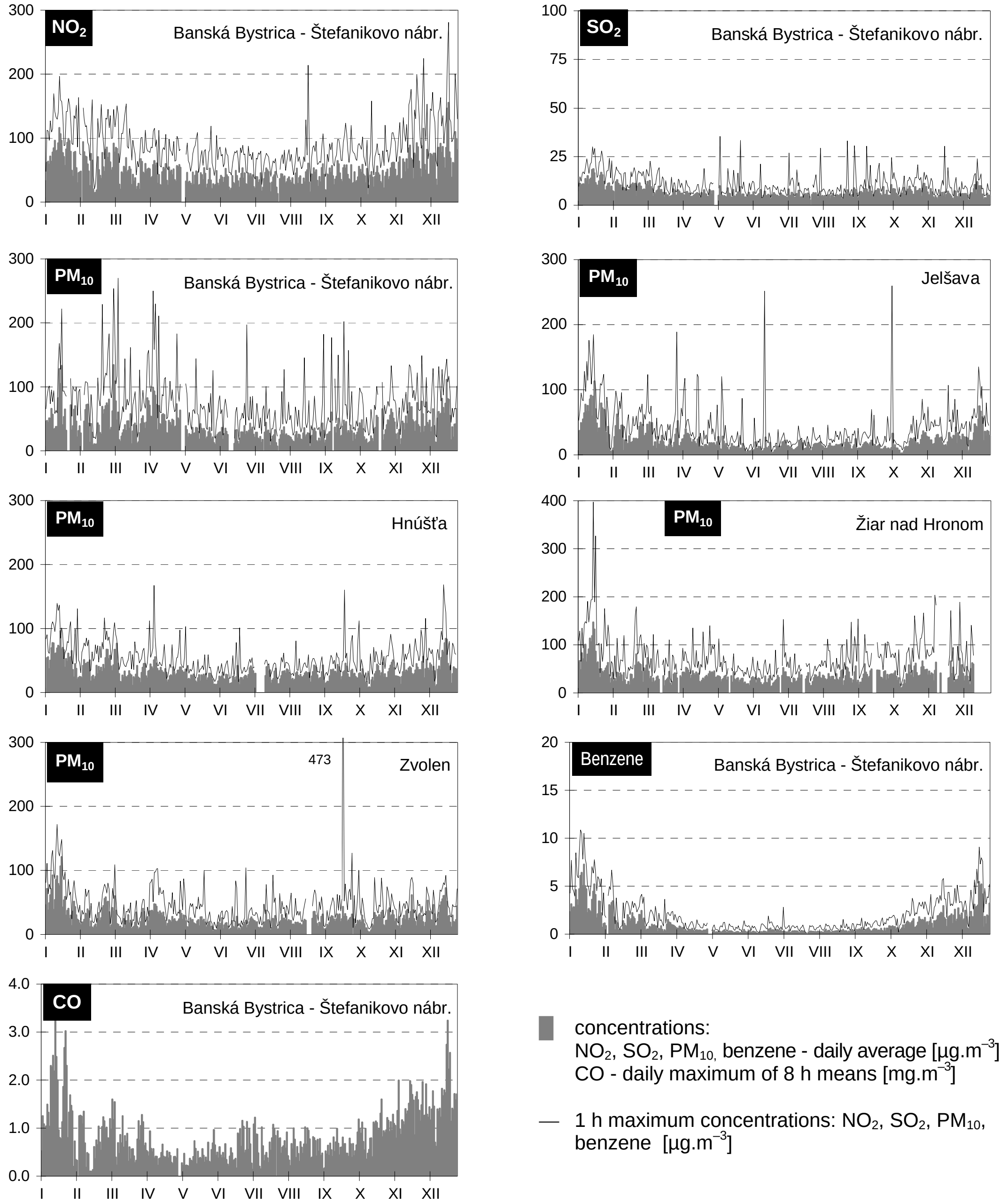
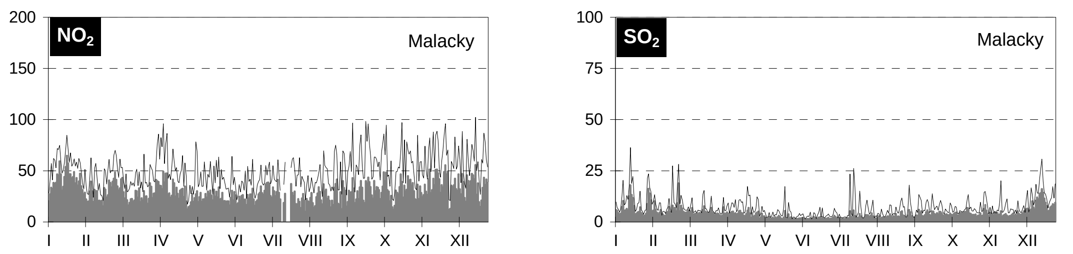
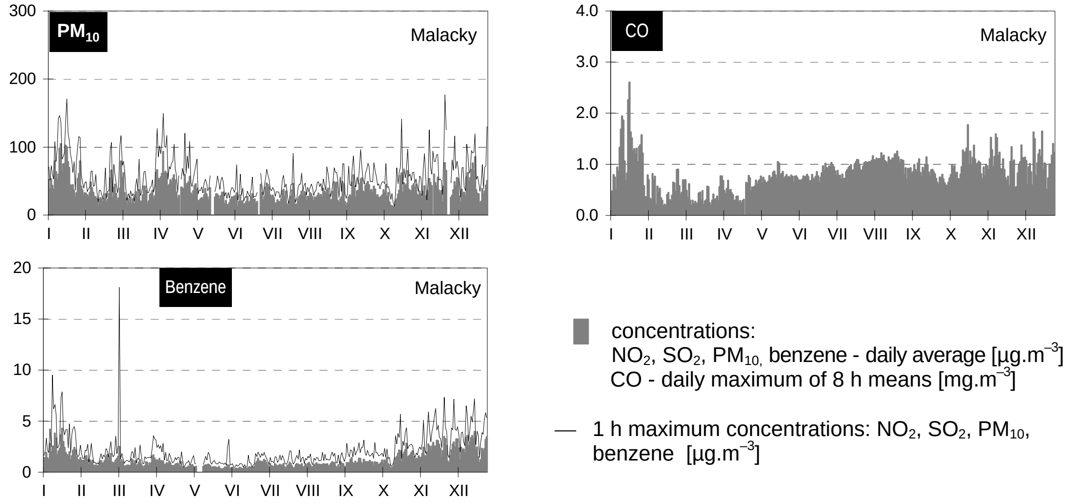



Fig. 2.4 **Concentrations of $NO_2$, $SO_2$, $PM_{10}$ , CO and benzene – zone Bratislava region – 2009**

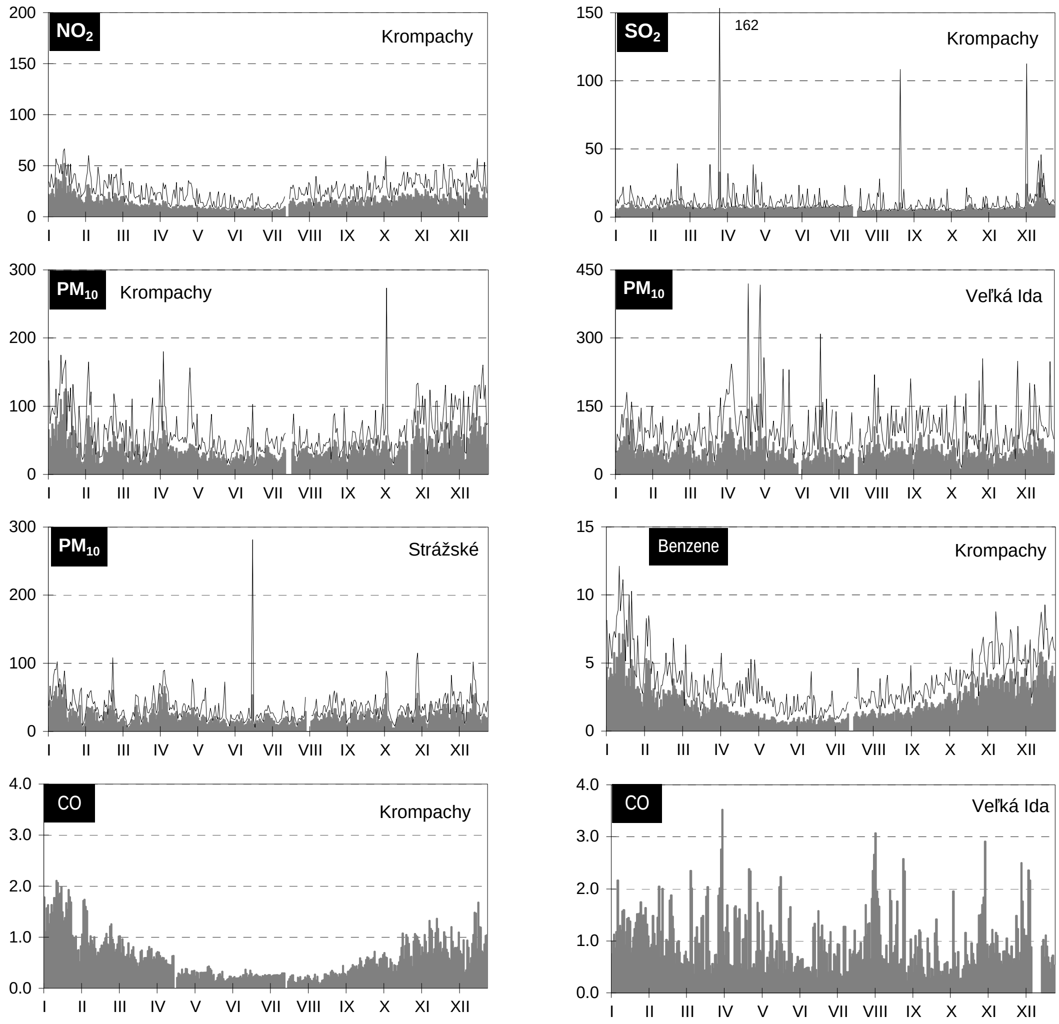





concentrations:
$NO_2$, $SO_2$, $PM_{10}$, benzene - daily average [μg.m$^{-3}$]
CO - daily maximum of 8 h means [mg.m$^{-3}$]

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

Fig. 2.5 **Concentrations of $NO_2$, $SO_2$, $PM_{10}$, CO and benzene – zone Košice region – 2009**




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

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

Fig. 2.6 **Concentrations of $NO_2$, $SO_2$, $PM_{10}$, CO and benzene – zone Nitra region – 2009**

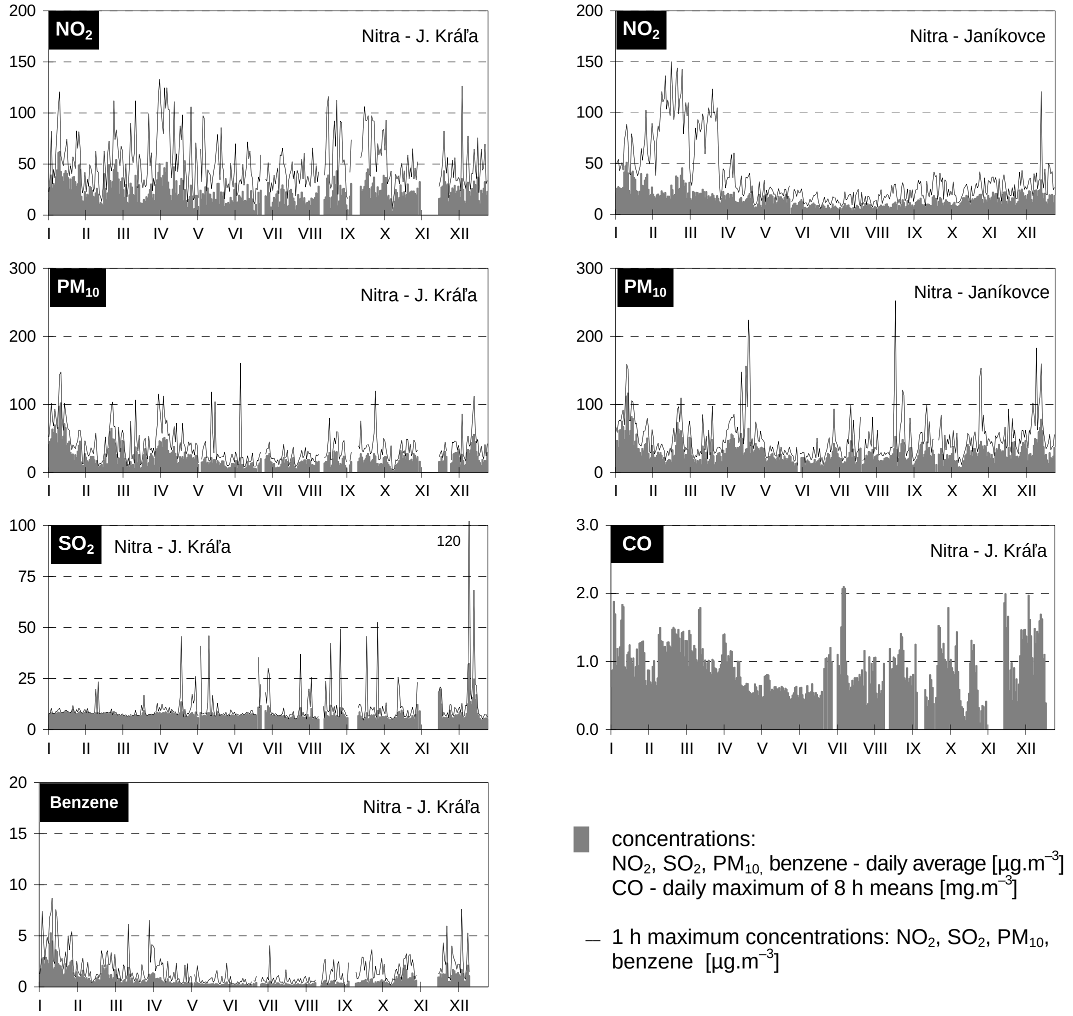
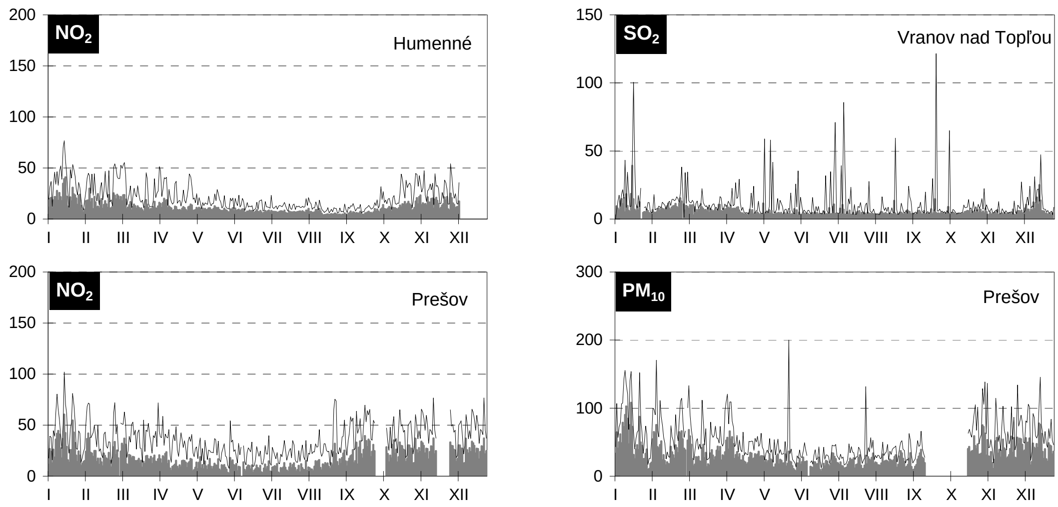
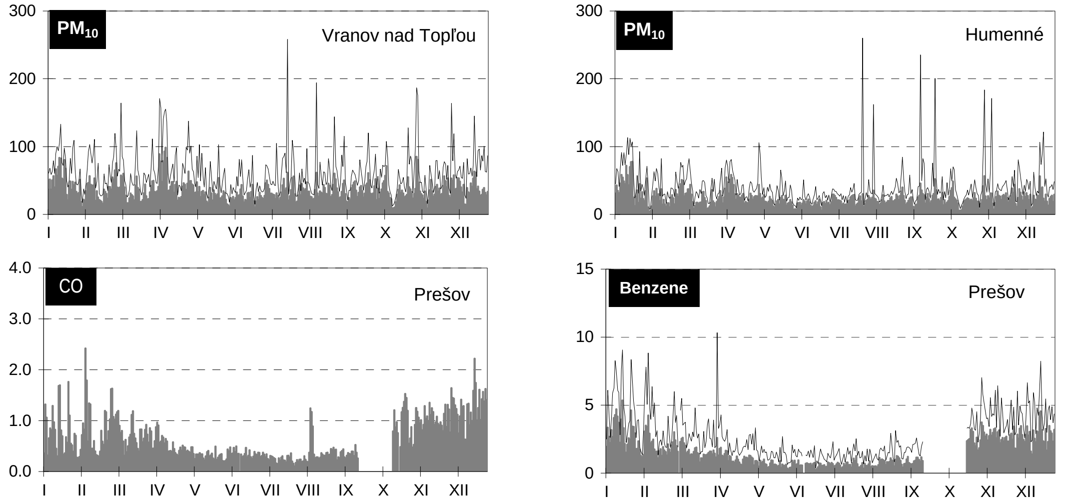



Fig. 2.7 **Concentrations of $NO_2$, $SO_2$, $PM_{10}$, $PM_{2.5}$, CO and benzene – zone Prešov region – 2009**

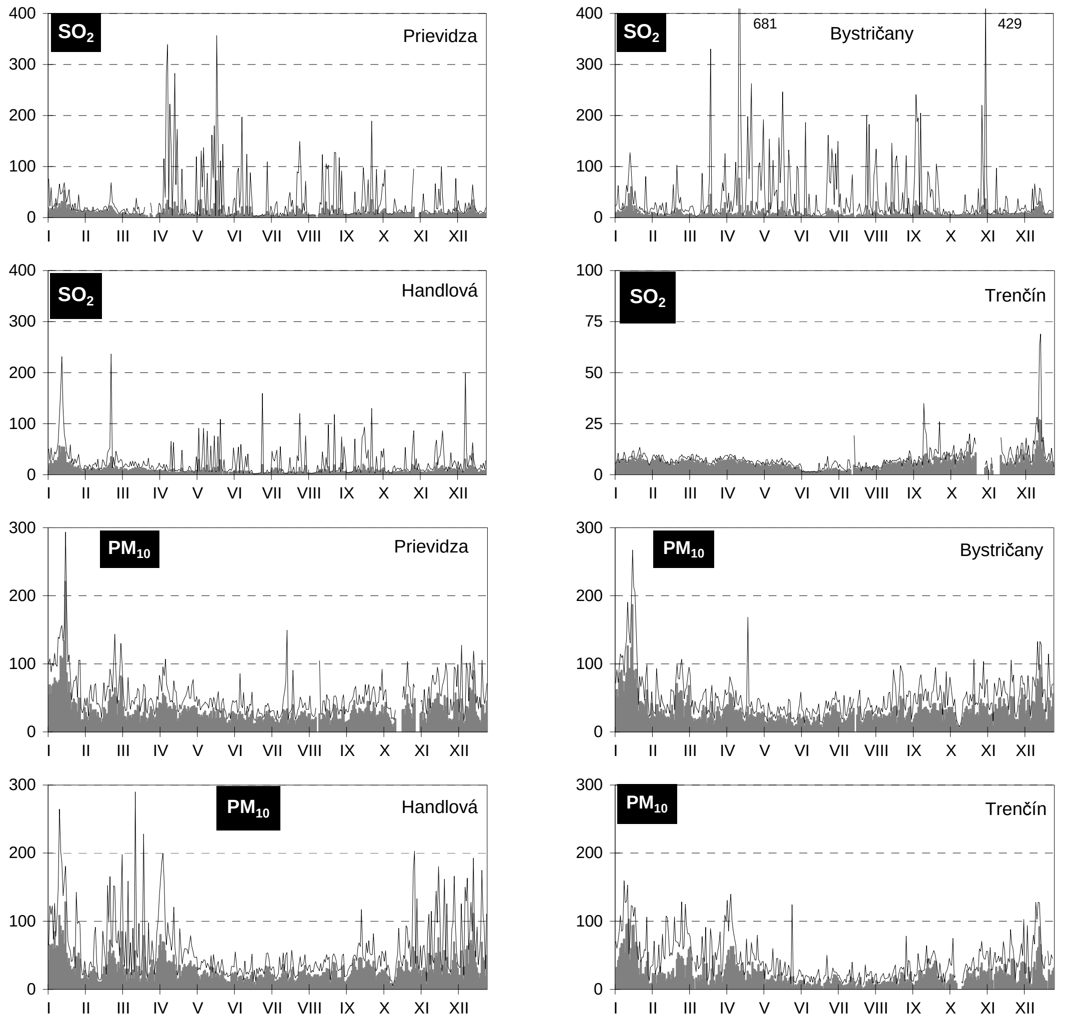


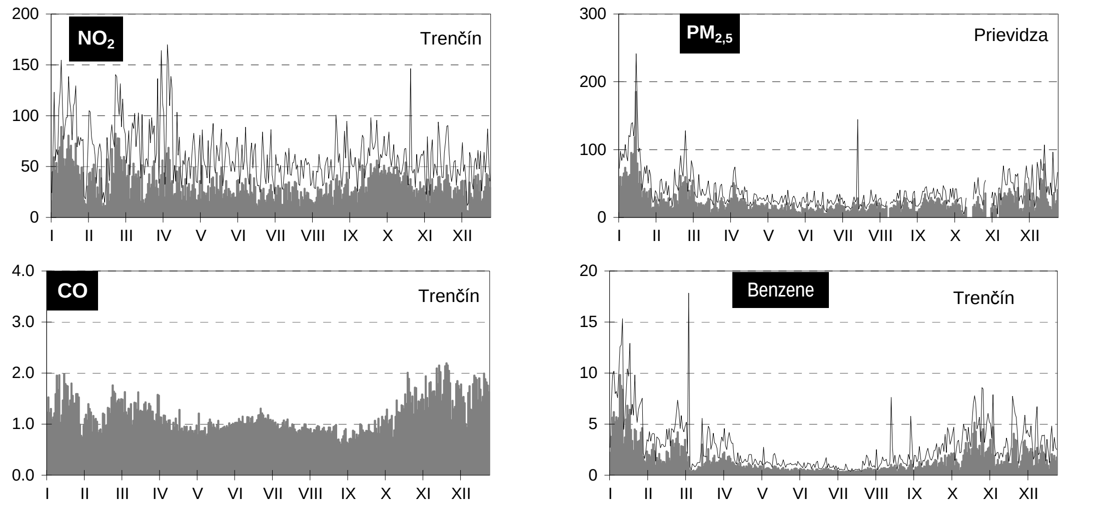



█ concentrations: $NO_2$, $SO_2$, $PM_{10}$, benzene - daily average [µg.m$^{-3}$] CO - daily maximum of 8 h means [mg.m$^{-3}$]

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

Fig. 2.8 **Concentrations of $NO_2$, $SO_2$, $PM_{10}$, $PM_{2.5}$, CO and benzene – zone Trenčín region – 2009**

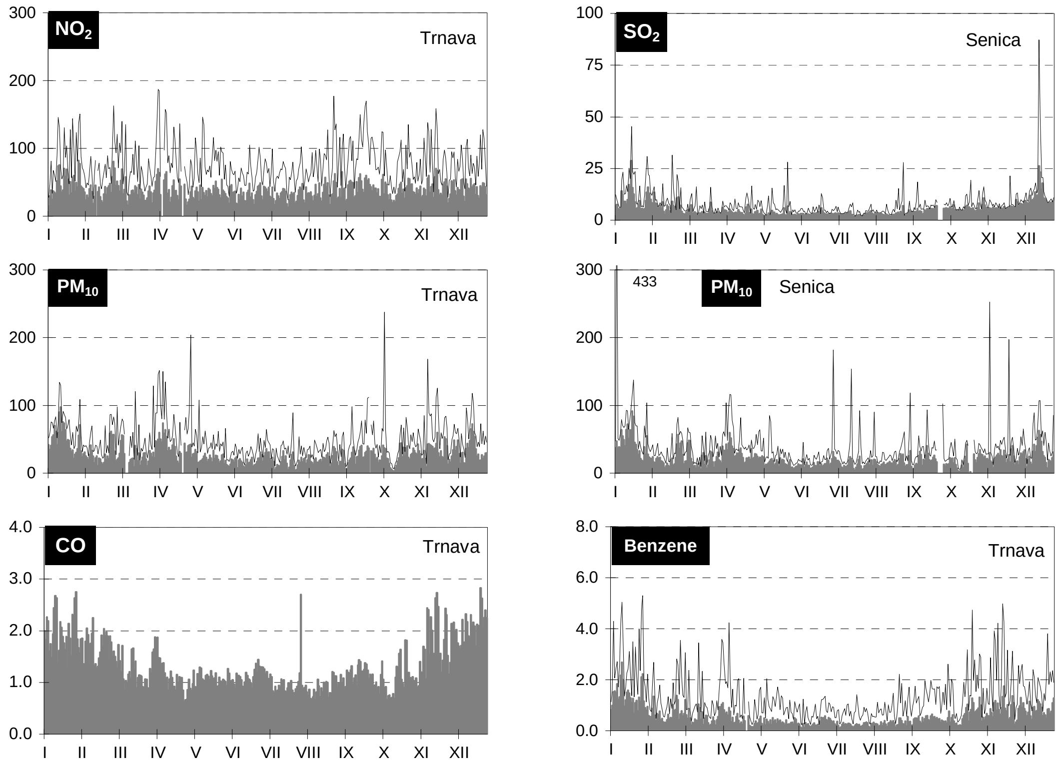





concentrations: $NO_2$, $SO_2$, $PM_{10}$, benzene - daily average [µg.m$^{-3}$] CO - daily maximum of 8 h means [mg.m$^{-3}$]

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

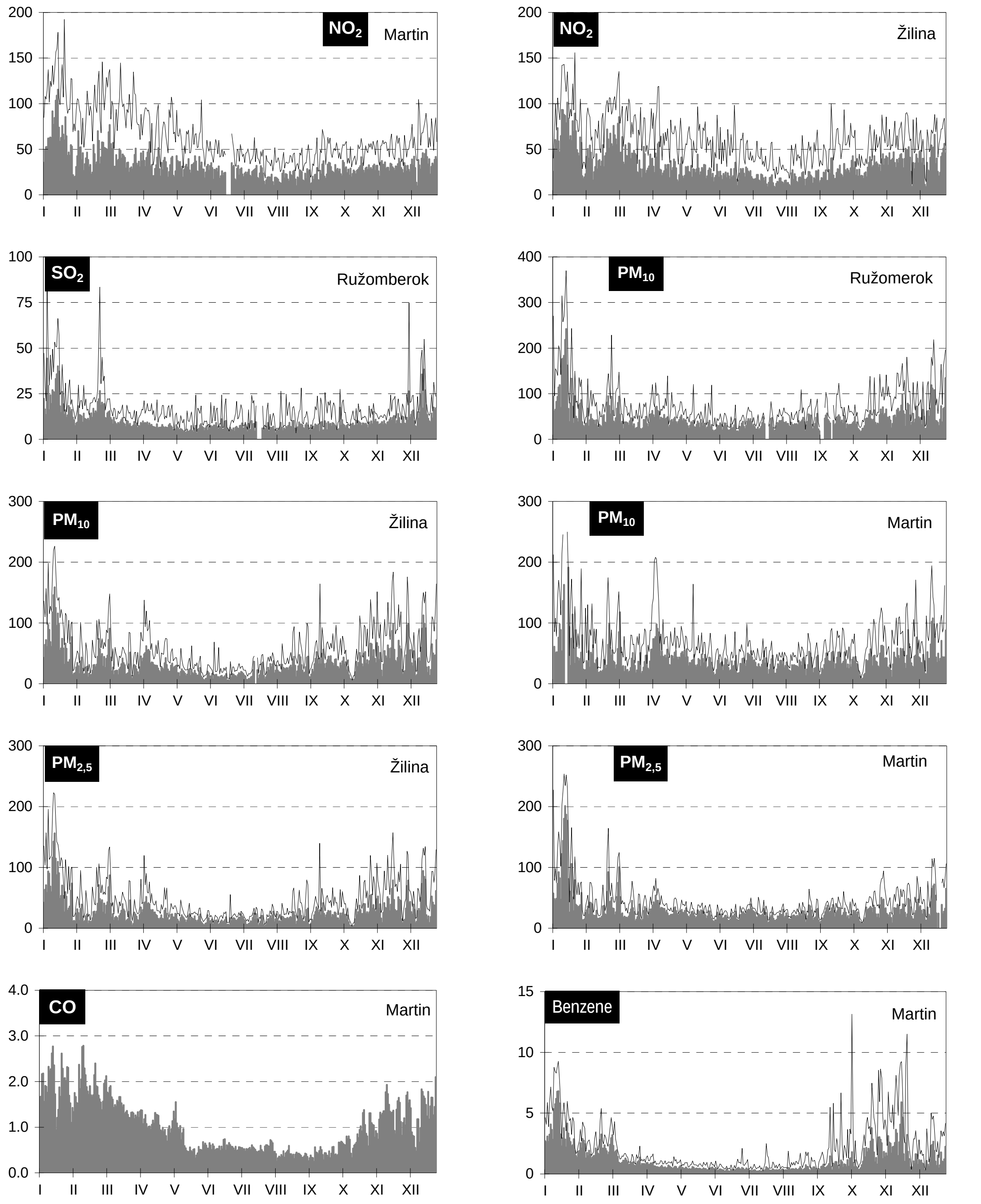
Fig. 2.9 **Concentrations of $NO_2$, $SO_2$, $PM_{10}$, $PM_{2.5}$, CO and benzene – zone Trnava region – 2009**




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

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

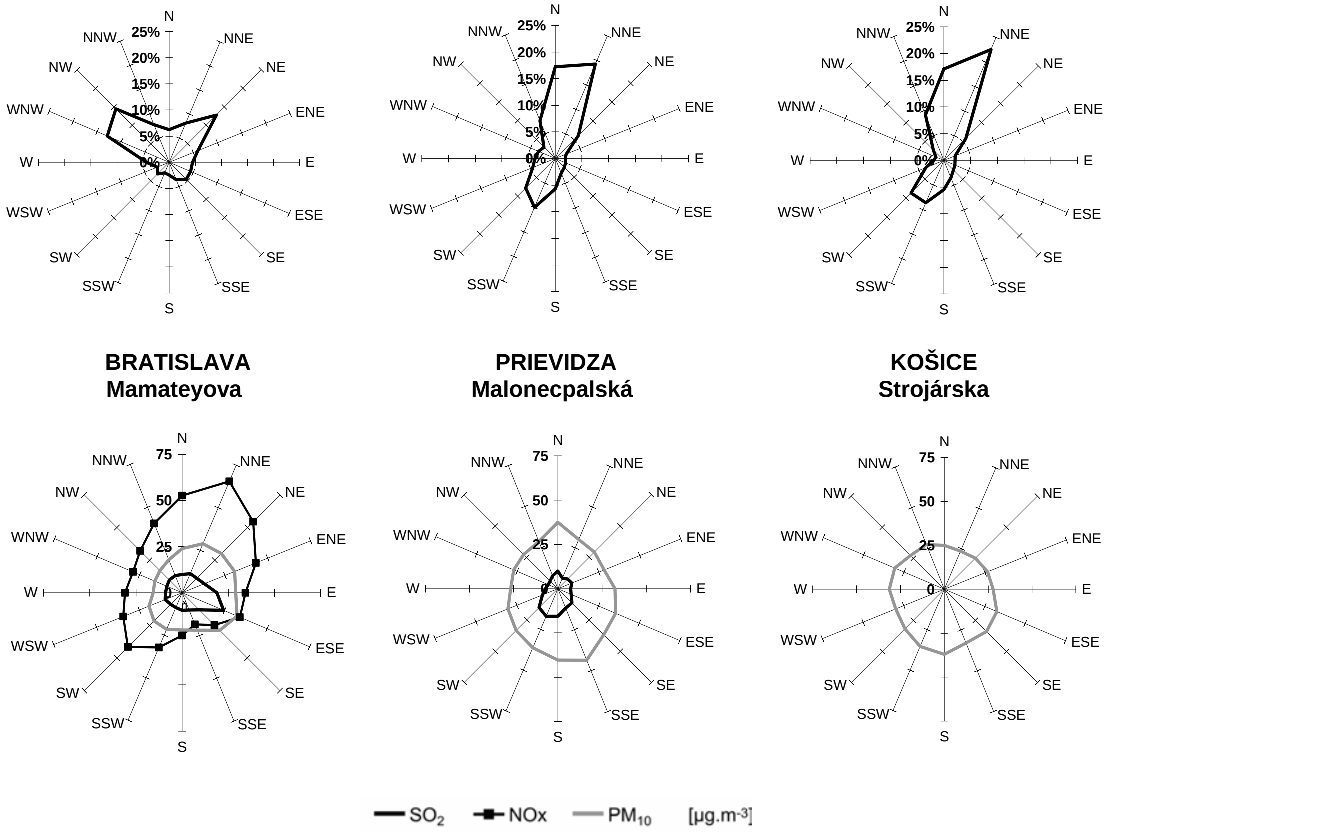
Fig. 2.10 **Concentrations of $NO_2$, $SO_2$, $PM_{10}$, $PM_{2.5}$, CO and benzene – zone Žilina region – 2009**




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

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

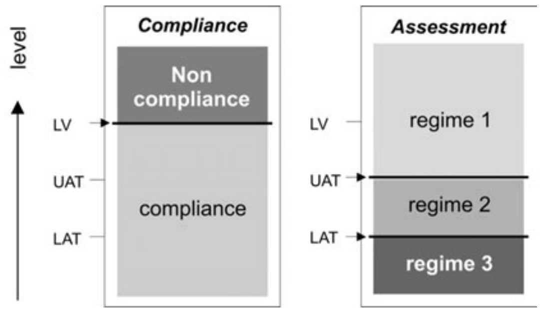
Fig. 2.11 **Wind and concentration roses – 2009**



# 2.3 PROCESSING OF MEASUREMENT RESULTS ACCORDING TO LIMIT VALUES

The Air Protection Act 478/2002 harmonized the principles of air quality assessment with the EU AQ legislation. Accordingly to these requirements the whole territory of the Slovak Republic was divided into zones and agglomerations and on the basis of air quality assessment in each zone/ agglomeration the monitoring regimes were defined. This assessment performed for the period of the last five years distinguishes three particular monitoring regimes. These are schematically illustrated on the Figure 2.12, and in Table 2.2 are specified requirements for air quality assessment for specific regimes.

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




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

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

For several pollutants the margins of tolerance (MoT) were set up (Tab. 2.3). The margins of tolerance are gradually decreasing since, they will meet the zero value at the date when limit values will come into force. In the year 2009 margin of tolerance was given only for annual limit values of $NO_2$ and benzene. Limit values, upper and lower assessment thresholds defined in Decree No. 705/2002 Coll. about Air Quality are presented in tables 2.3 and 2.4. Alert thresholds and limit values for signals "INFORMATION" and "REGULATION" were set up for:

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

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

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

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

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

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

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

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

**Sulphur dioxide** In the year 2009 in none of agglomeration or zone the hourly or daily limit values were exceeded in more cases than it is allowed. Also none short term concentration for signals INFORMATION and REGULATION has not been exceeded as well.

**Nitrogen dioxide** Annual limit value plus margin of tolerance was exceeded only at station Banská Bystrica-Štefánikovo nábrežie. In this location to the emissions from road traffic contributed also emissions from reconstruction works. Annual limit value 40 µg.m$^{-3}$ which will come in force in the year 2010 was exceeded also in Bratislava at the crossroad Trnavské mýto.

**$PM_{10}$** The major air pollution problem in Slovakia similarly to the whole Europe is pollution by particulate matter. In the year 2009 daily limit value was exceeded at 15 stations and at 3 of them annual limit value was exceeded as well.

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

**Benzene** The highest annual concentration 2.2 µg.m$^{-3}$ in Krompachy is deeply bellow the limit value 5 µg.m$^{-3}$, which come in force in the year 2010.

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

**As, Ni, Cd** In the year 2009 none of these pollutants exceeded the target value at any station. These target values has to be attained in the year 2012.

**BaP** The target value which has to be attained in the year 2012 was exceeded at stations Veľká Ida-Letná, Prievidza-Malonecpalská, Krompachy-Lorenzova (SNP) and Trenčín-Hasičská.

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

| | Interval of averaging | Limit value* [µg.m⁻³] | To be met by | Margin of tolerance | Limit value + margin of tolerance [µg.m⁻³] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Since 31/12/00 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| $SO_2$ | 1h | 350 (24) | 1/1/05 | 150 µg/m³ | 500 | 470 | 440 | 410 | 380 | 350 | | | | | |
| $SO_2$ | 24h | 125 (3) | 1/1/05 | - | | | | | | | | | | | |
| $SO_2$[e] | 1r. W[1] | 20 (-) | 1/01/03 | - | | | | | | | | | | | |
| $NO_2$ | 1h | 200 (18) | 1/01/10 | 50% | 300 | 290 | 280 | 270 | 260 | 250 | 240 | 230 | 220 | 210 | 200 |
| $NO_2$ | 1r | 40 (-) | 1/01/10 | 50% | 60 | 58 | 56 | 54 | 52 | 50 | 48 | 46 | 44 | 42 | 40 |
| NOx[v] | 1r | 30 (-) | 1/01/03 | - | | | | | | | | | | | |
| $PM_{10}$ | 24h | 50 (35) | 1/01/05 | 50% | 75 | 70 | 65 | 60 | 55 | 50 | | | | | |
| $PM_{10}$ | 1r | 40 (-) | 1/01/05 | 20% | 48 | 46 | 45 | 43 | 42 | 40 | | | | | |
| Pb | 1r | 0.5 (-) | 1/01/05 | 100% | 1.0 | 0.9 | 0.8 | 0.7 | 0.6 | 0.5 | | | | | |
| CO | max. 8 hour daily value | 10000 (-) | 1/1/2003 (1/1/2005) | 6000 | 16000 | 16000 | 16000 | 14000 | 12000 | 10000 | | | | | |
| Benzene | 1r | 5 (-) | 1/1/2006 (1/1/2010) | 100 % | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 8 | 7 | 6 | 5 |

[1] *winter period (October 1 - March 31)*
[e] *for protection of ecosystems* [v] *for protection of vegetation*
** allowed exceedances per year are in brackets*

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

| | Receptor | Interval of averaging | Limit value [µg.m⁻³] | Assessment threshold [µg.m⁻³] | |
|---|---|---|---|---|---|
| | | | | upper* | lower* |
| $SO_2$ | Human health | 1h | 350 (24) | | |
| $SO_2$ | Human health | 24h | 125 (3) | 75 (3) | 50 (3) |
| $SO_2$ | Vegetation | 1r. 1/2r | 20 (-) | 12 (-) | 8 (-) |
| $NO_2$ | Human health | 1h | 200 (18) | 140 (18) | 100 (18) |
| $NO_2$ | Human health | 1r | 40 (-) | 32 (-) | 26 (-) |
| NOx | Vegetation | 1r | 30 (-) | 24 (-) | 19.5 (-) |
| $PM_{10}$ | Human health | 24h | 50 (35) | 30 (7) | 20 (7) |
| $PM_{10}$ | 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*

| | Interval of averaging | Target value [ng.m⁻³] | To be met by |
|---|---|---|---|
| As | 1r | 6 | 31. 12. 2012 |
| Cd | 1r | 5 | 31. 12. 2012 |
| Ni | 1r | 20 | 31. 12. 2012 |
| BaP | 1r | 1 | 31. 12. 2012 |

Tab. 2.5 **Assessment of air quality according to limit values and limit values plus margin of tolerance (MoT) in 2009**

| AGLOMERATION/ Zone | | Human protection | | | | | | | | | | | | VHP [2)] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pollutant | $SO_2$ | | $NO_2$ | | $NO_2$+MoT | | $PM_{10}$ | | Pb | CO | Ben-zene | Ben. +MoT | $SO_2$ | $NO_2$ |
| | Time of averaging | 1 hour | 24 hour | 1 hour | 1 year | 1 hour | 1 year | 24 hour | 1 year | 1 year | 8 hour [1)] | 1 year | 1 year | 3 subsequent hour | 3 subsequent hour |
| | Limit value [µg.m⁻³] *(number of exceedances)* | 350 *(24)* | 125 *(3)* | 200 *(18)* | 40 | 210 *(18)* | 42 | 50 *(35)* | 40 | 500 [ng.m⁻³] | 10000 | 5 | 6 | 500 | 400 |
| BRATISLAVA | Bratislava, Kamenné nám. | | | | | | | 19 | 25.8 | | | | | | |
| | Bratislava, Trnavské mýto | | | 0 | 40.9 | 0 | 40.9 | 53 | 31.8 | | 2162 | 1.0 | 1.0 | | 0 |
| | Bratislava, Jeséniova | | | 0 | 13.6 | 0 | 13.6 | 18 | 27.6 | | | | | | 0 |
| | Bratislava, Mamateyova | 0 | 0 | 0 | 28.6 | 0 | 28.6 | 11 | 23.3 | 8.0 | | | | 0 | 0 |
| KOŠICE | Košice, Strojárska / Amurská * | | | | | | | 15 | 26.5 | | | | | | |
| Banská Bystrica region | Banská Bystrica, Štefánik. nábr. | 0 | 0 | 13 | 49.5 | 9 | 49.5 | 76 | 38.8 | 27.9 | 3397 | 1.1 | 1.1 | 0 | 0 |
| | Banská Bystrica, Zelená | | | [b] 0 | [b]12.3 | [b] 0 | [b]12.3 | | | | | | | | 0 |
| | Jelšava, Jesenského | | | | | | | 25 | 21.9 | | | | | | |
| | Hnúšťa, Hlavná | | | | | | | 40 | 33.3 | | | | | | |
| | Zvolen, J. Alexyho | | | | | | | 26 | 25.8 | | | | | | |
| | Žiar n. H., Dukelských hrdinov | | | | | | | 51 | 37.9 | | | | | | |
| Bratislava region | Malacky, Sasinkova | 0 | 0 | 0 | 30.3 | 0 | 30.3 | 60 | 36.4 | | 2603 | 1.2 | 1.2 | 0 | 0 |
| Košice region | Veľká Ida, Letná | | | | | | | 166 | 51.3 | 39.9 | 3521 | | | | |
| | Strážske, Mierová | | | | | | | 17 | 22.9 | | | | | | |
| | Krompachy, Lorenzova / SNP * | 0 | 0 | 0 | 0.9 | 0 | 0.9 | 72 | 38.4 | 115.5 | 2110 | 2.2 | 2.2 | 0 | 0 |
| Nitra region | Nitra, J. Kráľa | 0 | 0 | 0 | 23.1 | 0 | 23.1 | 15 | 21.6 | | 2100 | 0.7 | 0.7 | 0 | 0 |
| | Nitra, Janíkovce | | | 0 | 15.2 | 0 | 15.2 | 27 | 29.1 | | | | | | 0 |
| Prešov region | Humenné, Nám. Slobody | | | 0 | 11.7 | 0 | 11.7 | 16 | 24.9 | | | | | | 0 |
| | Prešov, Solivarská / Arm. gen. L. Svobodu* | | | [a] 0 | [a]15.6 | [a] 0 | [a]15.6 | [a] 45 | [a]32.5 | | 2420 | 1.6 | 1.6 | | 0 |
| | Vranov nad Topľou, M. R. Štefánika | 0 | 0 | | | | | 55 | 37.0 | | | | | 0 | |
| | Stará Lesná, AÚ SAV, EMEP[3)] | | | | | | | 1 | 14.9 | | | | | | |
| | Kolonické sedlo, Hvezdáreň[3)] | | | | | | | 6 | 25.5 | | | | | | |
| Trenčín region | Prievidza, Malonecpalská | 1 | 0 | | | | | 39 | 32.4 | 9.4 | | | | 0 | |
| | Bystričany, Rozvodňa SSE | 3 | 0 | | | | | 43 | 32.2 | | | | | 0 | |
| | Handlová, Morovianska cesta | 0 | 0 | | | | | 48 | 30.8 | | | | | 0 | |
| | Trenčín, Hasičská | 0 | 0 | 0 | 33.2 | 0 | 33.2 | 27 | 23.3 | | 2196 | 1.6 | 1.6 | 0 | 0 |
| Trnava region | Senica, Hviezdoslavova | 0 | 0 | | | | | 16 | 22.1 | | | | | 0 | |
| | Trnava, Kollárova | | | 0 | 38.8 | 0 | 38.8 | 32 | 28.6 | | 2823 | 0.6 | 0.6 | | 0 |
| | Topoľníky, Aszód, EMEP[3)] | | | | | | | 15 | 18.4 | | | | | | |
| Žilina region | Martin, Jesenského | | | 0 | 33.3 | 0 | 33.3 | 76 | 41.8 | | 2788 | 1.2 | 1.2 | | 0 |
| | Ružomberok, Riadok | 0 | 0 | | | | | 94 | 46.3 | 12.7 | | | | 0 | |
| | Žilina, Obežná | | | 0 | 33.0 | 0 | 33.0 | 64 | 33.9 | | | | | | 0 |

*[1)] maximal 8 hour value of moving average*
*[2)] alert threshold limit values*
*[3)] stations located in rural background areas*
** the data from both stations was merged together*
*Pollutants which exceeded limit values are in bold*

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

Tab. 2.6 **Assessment of air quality according to target values for As, Cd and Ni for the protection of human health in 2009**

| AGLOMERATION/ zone | Pollutant | As | | | | | Cd | | | | | Ni | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year | 2005 | 2006 | 2007 | 2008 | 2009 | 2005 | 2006 | 2007 | 2008 | 2009 | 2005 | 2006 | 2007 | 2008 | 2009 |
| | Target value [ng.m⁻³] | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 5 | 5 | 5 | 5 | 5 | 20 | 20 | 20 | 20 | 20 |
| | Upper assessment threshold [ng.m⁻³] | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3 | 3 | 3 | 3 | 3 | 14 | 14 | 14 | 14 | 14 |
| | Lower assessment threshold [ng.m⁻³] | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2 | 2 | 2 | 2 | 2 | 10 | 10 | 10 | 10 | 10 |
| BRATISLAVA | Bratislava, Mamateyova | 1.7 | 1.1 | 0.7 | 1.0 | 1.3 | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 2.9 | 1.9 | 1.3 | 1.3 | 1.9 |
| Slovensko | Banská Bystrica, Štefánikovo nábr. [1] | 5.1 | 3.6 | 2.4 | 3.0 | 2.7 | 1.3 | 1.2 | 1.0 | 0.9 | 0.7 | 4.4 | 5.6 | 1.7 | 2.0 | 2.7 |
| | Veľká Ida, Letná | 2.6 | 1.7 | 1.8 | 1.9 | 1.8 | 1.9 | 1.1 | 1.1 | 0.8 | 0.8 | 2.3 | 1.6 | 1.8 | 2.1 | 2.0 |
| | Krompachy, Lorenzova / SNP [3] | 6.4 | 4.7 | 4.3 | 3.6 | 3.7 | 2.7 | 2.6 | 1.3 | 1.6 | 1.1 | 2.8 | 3.6 | 1.6 | 1.5 | 1.7 |
| | Prievidza, Malonecpalská [2] | 5.6 | 7.9 | 5.3 | 5.7 | 4.9 | 0.5 | 0.4 | 0.3 | 0.3 | 0.3 | 1.4 | 1.0 | 1.3 | 1.0 | 1.2 |
| | Ružomberok, Riadok | 4.0 | 5.0 | 2.6 | 2.4 | 2.5 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 1.5 | 1.5 | 1.3 | 1.2 | 1.7 |

Tab. 2.7 **Assessment of air quality according to target values for BaP for the protection of human health in 2009**

| AGLOMERATION / zone | Pollutant | BaP |
|---|---|---|
| | Target value [ng.m⁻³] | 1.0 |
| | Upper assessment threshold [ng.m⁻³] | 0.6 |
| | Lower assessment threshold [ng.m⁻³] | 0.4 |
| BRATISLAVA | Bratislava, Trnavské mýto | 0.7 |
| | Bratislava, Jeséniova | 0.5 |
| Slovensko | Veľká Ida, Letná | 3.8 |
| | Krompachy, Lorenzova / SNP [3] | 1.9 |
| | Prievidza, Malonecpalská [2] | 1.8 |
| | Trnava, Kollárova | 0.9 |
| | Nitra, Janka Krála | 0.6 |
| | Trenčín, Hasičská | 1.3 |

[1] *till the year 2007 Nám. slobody* [2] *till the year 2006 J. Hollého*
[3] *until 17. 7. 2009 Lorenzova, from 20. 7. 2009 SNP*

# AMBIENT AIR

## ATMOSPHERIC OZONE

# 3

# 3.1 ATMOSPHERIC OZONE

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

The growth of ozone concentrations in the troposphere approximately 1 µg.m$^{-3}$ annually was observed over the industrial continents of the Northern Hemisphere by the end of 1980s. It is associated with the increasing emission of ozone precursors (NOx, VOCs, CO) from car transport, power generation and industry. Since the early 1990s no trend of the average concentration level of ground level ozone in Slovakia, like as in many European countries, has been observed. In spite of considerable decrease of ozone precursor emission reduction in Slovakia and in surrounding countries during nineties the effect was not adequate. Only ozone peaks decreased significantly. It was shown the average level of ozone concentration is more controlled by large scale processes (downward mixing from the free troposphere, long-range transport and global warming). The extremely warm and dry year 2003 represented the absolute exception from these trends. Most of the ozone level indicators reached the highest values at all Slovak suburban, rural and mountain stations in the period 1993 – 2003. The alert thresholds 240 µg.m$^{-3}$ (the first time since 1995) was overstepped in six cases in south-west Slovakia. The level of concentrations in 2009 was lower as in 2003. The high ground level ozone concentrations, mainly during photochemical smog episodes in summer, impact unfavourably on human health (mainly on the respiratory system of human beings), vegetation (mainly on agricultural crops and forests) and various materials.

# 3.2 GROUND LEVEL OZONE IN THE SLOVAK REPUBLIC DURING 2004 – 2009

### Target and thresholds values for ground level ozone

In Table 3.1 the target values for ground level ozone are listed according to the Act 478/2002 Coll. on air protection, that in accordance with EU legislation have to be fulfilled to 2010, and information and alert thresholds. If ground level ozone concentration exceeds some of the threshold values the population has to be informed or warned.

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

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

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

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

## Assessment of ground level ozone in Slovakia during 2004 – 2009

The measurement of ground level ozone concentrations in Slovakia started in 1992, within the operation of monitoring network under the Slovak Hydrometeorological Institute. The number of monitoring stations has been gradually extended. The stations at Stará Lesná, Starina (in operation since 1994) Topoľníky and Chopok (in operation since 1995) are part of the EMEP monitoring network. For monitoring of ground level ozone concentrations, the ozone analysers have been used. All these analysers operate on the principle of UV absorption. In 1994, the secondary national ozone standard was installed in the Slovak Hydrometeorological Institute and regular audits by portable calibrator started to be carried out in the stations. A secondary standard of the Slovak Hydrometeorological Institute is regularly compared with the primary ozone standard in the Czech Hydrometeorological Institute in Prague. In 2009 the number of missing data did not exceed 8% at all stations (Tab. 3.2). Large gaps were only at the Bratislava Mamateyova.

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

| Station | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|
| **Banská Bystrica**, Zelená | | | | | | *42.5 |
| **Bratislava**, Jeséniova | 2.2 | 5.8 | 16.8 | 0.6 | 1.6 | 0.1 |
| **Bratislava**, Mamateyova | 2.7 | 6.3 | 2.3 | 0.8 | 1.1 | 7.2 |
| **Humenné**, Nám. Slobody | 0.3 | 0.3 | 10.3 | 9.5 | 0.5 | 0.1 |
| **Jelšava**, Jesenského | 0 | 0.3 | 8.2 | 5.0 | 0.1 | 3.0 |
| **Košice,** Ďumbierska | 0.5 | 8.6 | 44.4 | 1.1 | 0.1 | 2.1 |
| **Nitra**, Janíkovce | | | | | | *13.7 |
| **Prievidza**, Malonecpalská | | | | 1.9 | 0.4 | 3.4 |
| **Žilina**, Obežná | 0.3 | 0.5 | 0.5 | 1.0 | 0.05 | 1.5 |
| **Gánovce**, Meteo. st. | 24.9 | 15.9 | 7.8 | 0.01 | 1.7 | 0.1 |
| **Chopok**, EMEP | 9.6 | 1.9 | 29.0 | 1.0 | 1.7 | 0.3 |
| **Kojšovská hoľa** | 1.1 | 9.9 | 6.3 | 0.7 | 1.9 | 0.1 |
| **Stará Lesná**, AÚ SAV, EMEP | 0.5 | 0.3 | 10.9 | 0.2 | 0.3 | 0.6 |
| **Starina**, Vodná nádrž, EMEP | 17.3 | 7.1 | 24.8 | 6.6 | 2.6 | 0.8 |
| **Topoľníky**, Aszód, EMEP | 3.6 | 6.6 | 1.7 | 1.4 | 0.6 | 0.6 |

** ozone measurement introduced in 2009*

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

| Station | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|
| **Banská Bystrica**, Zelená | | | | | | **53 |
| **Bratislava**, Jeséniova | 64 | 68 | 66 | 59 | 59 | 60 |
| **Bratislava**, Mamateyova | 48 | 53 | 50 | 49 | 48 | 48 |
| **Humenné**, Nám. slobody | 58 | 60 | 62 | 56 | 55 | 59 |
| **Jelšava**, Jesenského | 51 | 52 | 55 | 56 | 51 | 49 |
| **Košice**, Ďumbierska | 60 | 67 | *49 | 57 | 56 | 81 |
| **Nitra**, Janíkovce | | | | | | **74 |
| **Prievidza**, Malonecpalská | | | | 48 | 53 | 50 |
| **Žilina**, Obežná | 42 | 41 | 44 | 44 | 46 | 48 |
| **Gánovce**, Meteo. st. | 66 | 67 | 68 | 60 | 65 | 62 |
| **Chopok**, EMEP | 91 | 95 | *96 | 91 | 92 | 90 |
| **Kojšovská hoľa** | 86 | 86 | 84 | 79 | 76 | 85 |
| **Stará Lesná**, AÚ SAV, EMEP | 62 | 70 | 73 | 68 | 74 | 61 |
| **Starina**, Vodná nádrž, EMEP | 66 | 66 | *62 | 62 | 59 | 58 |
| **Topoľníky**, Aszód, EMEP | 59 | 60 | 60 | 58 | 60 | 59 |

** 50 – 75% of valid measurements* *** ozone measurement introduced in 2009*

In 2009, the annual average concentrations of ground level ozone in urban and industrial locations of Slovakia ranged within the interval 48 – 81 μg.m$^{-3}$ (Tab. 3.3). The concentrations in the rest of the territory ranged between 58 and 90 μg.m$^{-3}$, mainly depending on the altitude. The highest annual average of ground level ozone concentrations was reached at the summit station Chopok (90 μg.m$^{-3}$). The effect of ozone from the accumulation zone (800–1500 m over the ground) over the Europe is evident. The year 2009, according to vegetation period averages, belongs to the photochemically less active years. Annual averages of ground level ozone concentration in 2009 were lower than in record year 2003.

In Figure 3.1, the seasonal cycle of daily ozone concentrations in Stará Lesná during 1992 – 2009 is depicted. The seasonal course is typical for lowlands and valley (not summit) positions of industrial continents. Original spring maximums of ozone concentrations, associated with the transport of ozone from upper atmospheric layers, is extended for the whole summer period, as a consequence of photochemical ozone formation in a atmospheric boundary layer.

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

The number of exceedances of ozone threshold values in Slovakia during 2004 – 2009 is summarised in Tables 3.4 – 3.6. The alert threshold when the public must be warned (240 µg.m$^{-3}$) was not exceed in 2009 (Tab. 3.4). The information threshold to the public (180 µg.m$^{-3}$) in 2009 was exceeded at two stations (Bratislava-Mamateyova and Nitra-Janíkovce).

Fig. 3.1 **Seasonal variability of ground level ozone concentration in Stará Lesná during 1992–2009**

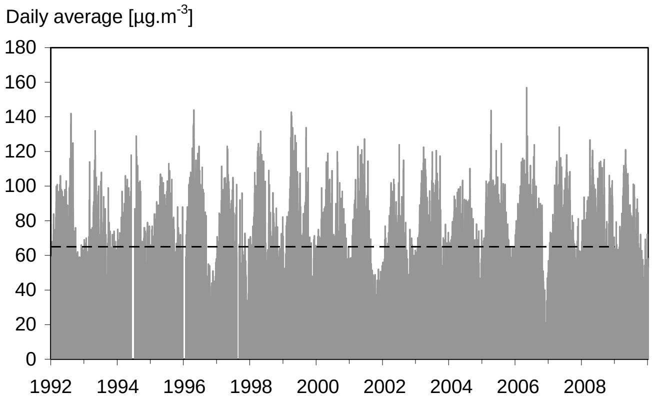
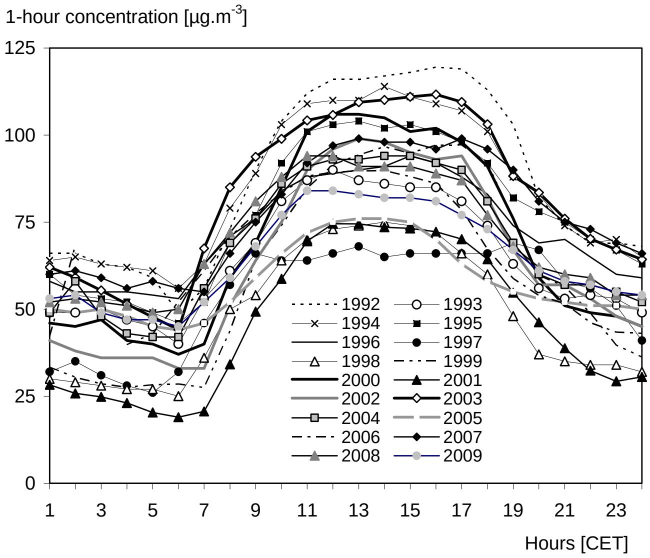



Fig. 3.2 **Average daily cycles of ground level ozone concentration in Stará Lesná, in August 1992–2009**




Tab. 3.4 **Number of exceedances of ozone information threshold (IT) and alert threshold (AT) to the public during 2004–2009**

| Station | AT = 240 µg.m$^{-3}$ | | | | | | IT = 180 µg.m$^{-3}$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| **Banská Bystrica**, Zelená | | | | | | 0 | | | | | | 0 |
| **Bratislava**, Jeséniova | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 19 | 10 | 0 | 0 |
| **Bratislava**, Mamateyova | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 8 | 11 | 17 | 1 | 2 |
| **Humenné**, Nám. Slobody | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **Jelšava**, Jesenského | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 6 | 0 | 0 |
| **Košice**, Ďumbierska | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| **Nitra**, Janíkovce | | | | | | 0 | | | | | | 1 |
| **Prievidza**, Malonecpalská | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| **Žilina**, Obežná | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 |
| **Gánovce**, Meteo. st. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Chopok**, EMEP | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| **Kojšovská hoľa** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 2 | 2 | 0 |
| **Stará Lesná**, AÚ SAV, EMEP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **Starina**, Vodná nádrž, EMEP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| **Topoľníky**, Aszód, EMEP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 |

In Table 3.5 is presented the number of exceedances of ozone target value for protection of human health (8 h mean 120 µg.m$^{-3}$) averaged over 2007 – 2009. The target value not to be exceeded on more than 25 days per calendar year averaged over three years. In 2007 – 2009 was the number of 25 days overstepped at ten monitoring stations. The highest exceedance was observed at Chopok station (65 days) and Kojšovská hoľa (61 days).

Tab. 3.5 **Number of exceedances of ozone target value for protection of human health (8 h average 120 µg.m$^{-3}$) during 2007–2009**

| Station | 2007 | 2008 | 2009 | Average 2007–2009 |
|---|---|---|---|---|
| **Banská Bystrica**, Zelená | | | 18 | * |
| **Bratislava**, Jeséniova | 31 | 32 | 32 | **32** |
| **Bratislava**, Mamateyova | 37 | 24 | 22 | **28** |
| **Humenné**, Nám. slobody | 31 | 10 | 43 | **28** |
| **Jelšava**, Jesenského | 50 | 22 | 17 | **30** |
| **Košice**, Ďumbierska | 20 | 6 | 106 | **44** |
| **Nitra,** Janíkovce | | | 85 | * |
| **Prievidza**, Malonecpalská | 21 | 13 | 19 | 18 |
| **Žilina**, Obežná | 40 | 21 | 36 | **32** |
| **Gánovce**, Meteo. st. | 25 | 14 | 5 | 15 |
| **Chopok**, EMEP | 66 | 66 | 62 | **65** |
| **Kojšovská hoľa** | 74 | 39 | 71 | **61** |
| **Stará Lesná**, AÚ SAV, EMEP | 36 | 32 | 15 | **28** |
| **Starina**, Vodná nádrž, EMEP | 18 | 5 | 22 | 15 |
| **Topoľníky**, Aszód, EMEP | 46 | 39 | 41 | **42** |

* *ozone measurement was introduced in 2009, the value is not included in the average*

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

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

| Station | 2007 | 2008 | 2009 | Average 2005–2009 |
|---|---|---|---|---|
| **Banská Bystrica**, Zelená | | | 17178 | * |
| **Bratislava**, Jeséniova | 20654 | 20644 | 17765 | **23504** |
| **Bratislava**, Mamateyova | 22900 | 19894 | 13479 | **20728** |
| **Humenné**, Nám. slobody | 21608 | 14998 | 23878 | **21760** |
| **Jelšava**, Jesenského | 25987 | 18677 | 14469 | **19882** |
| **Košice**, Ďumbierska | 18397 | 12229 | 38806 | **22365** |
| **Nitra**, Janíkovce | | | 32110 | ***** |
| **Prievidza**, Malonecpalská | 17466 | 16853 | 12742 | 15687 |
| **Žilina**, Obežná | 21891 | 16816 | 18767 | **19808** |
| **Gánovce**, Meteo. st. | 19028 | 19572 | 13990 | **19741** |
| **Chopok**, EMEP | 26477 | 32240 | 27828 | **30035** |
| **Kojšovská hoľa** | 29146 | 19811 | 25276 | **25920** |
| **Stará Lesná**, AÚ SAV, EMEP | 20505 | 19844 | 11536 | **19253** |
| **Starina**, Vodná nádrž, EMEP | 19320 | 11648 | 15215 | 15348 |
| **Topoľníky**, Aszód, EMEP | 26102 | 25159 | 20768 | **24505** |

* *ozone measurement was introduced in 2009, the value is not included in the average*

It may be stated in conclusion, that in the extremely warm, dry and photochemical active year 2003 the highest values of the most ground level ozone indicators in Slovakia were observed from the beginning of observations (since 1992). This reality is to some extend surprising taking into account a massive decrease of anthropogenic precursor emissions (NOx, VOC and CO) in Slovakia (already below Gothenburg ceilings) and in Europe as well during the last 10 – 15 years. It documents the large share of "uncontrollable" ozone at the territory of Slovakia. Downward mixing, long-range transport (including intercontinental transport), formation of ozone from biogenic precursors and climate change apparently play much more significant role as was previously assumed. The ground level ozone over Slovakia is mostly of advective origin. This conclusion demonstrates the limitations of national ozone mitigation strategy. One of the conclusions the European TOR2 project (ended in 2003) is proposal to shift the ground level ozone problem among global issues, for example into Kyoto Protocol. The level of surface ozone concentrations indicators in Slovakia in 2009 was in average close below the 2003 level.

# 3.3 TOTAL ATMOSFERIC OZONE OVER THE TERRITORY OF THE SLOVAK REPUBLIC IN 2009

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

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

The annual mean of the total atmospheric ozone was 331.7 Dobson Units in 2009. This is 1.9% below the long-term average (calculated upon the Hradec Kralove measurements in the period 1962 – 1990).

Since 1994 annual means measured at Poprad-Gánovce station have been available. The 1994-2009 long-term average is 326.3 Dobson units. In mentioned period the year 2009 has belonged to 4 years with the highest annual mean ozone. In comparison with the year 2008 the annual mean was higher by 3.6%. Total ozone statistics for the year 2009 (daily means, relative deviations from long term average, monthly means, standard deviations and extremes) are in Table 3.8.

Although the mean annual difference from the long-term average belongs to the lower values in history of the total ozone measurements in Slovakia, distribution of monthly differences was not favourable in 2009. The monthly means lower than long-term average were observed continuously from March to September. The biggest negative deviation from long-term average of –10% was measured in April. Negative deviations of –9% and –7% were found in May and July, respectively. The total ozone values did not drop below the long-term average in winter months. The mean December positive deviation of total ozone from long-term average +10% was the biggest one in the history of total ozone measurements at Poprad-Gánovce.

Total ozone weekly averages are shown in Figure 3.3. The graph illustrates the total ozone amount in year 2009 with respect to long-term mean values and shows significant short-term variations in total column ozone in our geographical region. Continuous period with positive deviations from the long-term average was found in cold half-year, negative deviations predominated in warm half-year.

Solar ultraviolet (UV) radiation has many biological effects. If UV dose exceeds critical limits for some biological processes it can be very harmful. An active band of wavelengths in range of 290 – 325 nm which is significantly influenced by the total ozone amount in the atmosphere is indicated as UV-B radiation. The wavelength-depending weighting factor is applied on the spectral irradiance to calculate the effective UV-B irradiance causing a particular biological effect. The CIE Erythemal action spectrum is most frequently used to express a detrimental effect on human health. McKinlay and Diffey derived the erythemal action spectrum in 1987. It is internationally accepted and indicated as the CIE (Commission Internationale de l´Eclairage). All values of solar ultraviolet radiation shown in this text and graphs are modified by the CIE erythemal action spectrum. Figure 3.4. shows the biologically effective irradiance (in units of mW.m$^{-2}$). Values have been measured at local noon (about 10:39 UTC) when the daily maximal solar elevation is achieved. Daily UV-B maximum on clear sky days should be measured around local noon. A significant variability of values demonstrates the weather condition (especially cloudiness) influence. As the UV irradiance depends on the solar elevation it has a distinctive daily and annual course. Noon UV-B irradiances are more than 10-times lower in winter as compared to summer. Comparable attenuation is also caused by cloudiness and precipitation in summer. The annual course is not symmetrical by solstices after filtering of cloud and aerosol influence. Decreasing phase in annual course of total ozone causes shift in occurrence of the highest UV irradiances toward period after the summer solstice - to the last decade of June and early July. Solar UV irradiances observed before summer solstice are lower than those ones measured after the summer solstice by the same solar elevation, cloud and aerosol attenuation due to typical annual course of the total ozone.

Fig. 3.3 **Total atmospheric ozone over the territory of Slovakia in 2009**

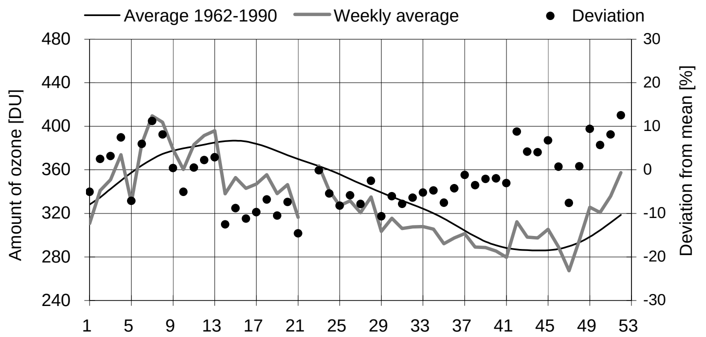
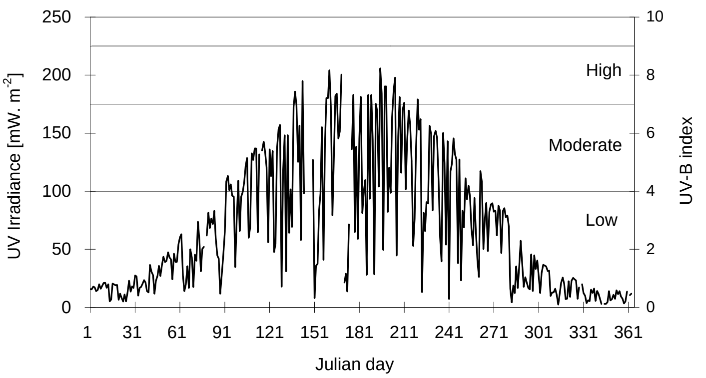



Fig. 3.4 **Annual course of CIE effective irradiance noon values - Gánovce 2009**




The UV Index is also shown in Figure 3.4. It is a unit to simplify expression of the UV irradiance level relevant to the erythemal effect on human skin and has been standardised by relationship 1 UV Index = 25 mW.m$^{-2}$ of UV irradiance modified by CIE erythemal action spectrum. Its values are used to express a recommended sunburn time. Individual sunburn time has to be modified depending on skin type and skin adaptation by producing melanin. Values over 7 attained in spring and summer months are classified as high. The sun exposure without protection should be limited to several minutes. Values below 4 attained from October to March are classified as low. Sunburn time over one hour is not dangerous even if the ozone layer is attenuated. The only protective tool should be glasses. However considerably high UV-B radiation doses are relevant in snowy high mountain positions at the beginning of spring. Practical unit to describe a quantity of the erythemal ultraviolet radiation is Minimal Erythemal Dose (MED). 1 MED is defined as the minimal UV dose that causes a reddening of previously unexposed human skin. However, because the sensitivity of human individuals depends on skin type, the relationship between MED and physical units has been defined for the most sensitive skin type. Irradiance 1 MED.hour$^{-1}$ corresponds to 0.0583 W.m$^{-2}$ for the dose 1 MED = 210 J.m$^{-2}$. More information about total ozone, solar UV radiation and the protection against a harmful solar radiation are available on the SHMI internet site.

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

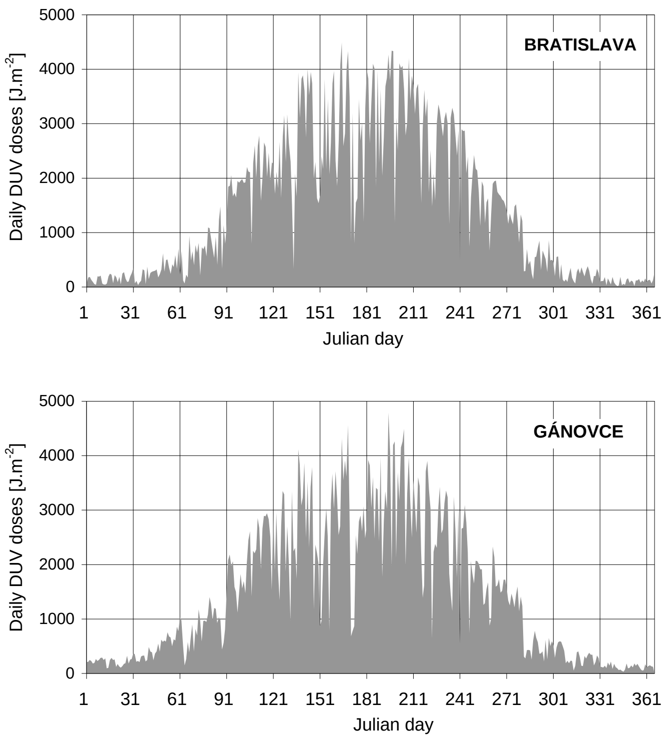
The biggest 1 min average of the CIE-erythemal UV irradiance was registered at Poprad-Gánovce as well as in Bratislava (48º10'N, 17º06'E, 304 m a.s.l.) on June 16. The registered maximum was 237.0 mW.m$^{-2}$ (4.06 MED.h$^{-1}$) at Poprad-Gánovce and 232.5 mW.m$^{-2}$ (3.99 MED.h$^{-1}$) at Bratislava. Deviation of the daily total column ozone from the long-term average was -16% on that day.

The 1 min CIE-erythemal UV irradiance exceeded the limit of 200 mW.m$^{-2}$ (UV-index 8) on 3 days in Bratislava and on 12 days at Poprad-Gánovce. Incidence of days with high CIE-erythemal UV irradiance was registered from June 9 to July 14.

Daily doses of the CIE-erythemal UV radiation are presented in Figure 3.5. Annual maximum of daily CIE-erythemal UV radiation dose 4791 J.m$^{-2}$ (which correspondents to 22.8 MED) was measured at Poprad-Ganovce on July 14. That day daily total ozone value was 15% below long-term average. Annual maximum of daily dose 4490 J.m$^{-2}$ (21.4 MED) was measured in Bratislava on June 14. Daily total ozone value at Poprad-Ganovce was 7% below long-term average but it dropped below long-term average 15% and 16% in following two days.

Total CIE-erythemal UV radiation dose was 458 128 J.m$^{-2}$ at Poprad-Gánovce in the period April – September 2009. This value was nearly the same (0.01% higher) as in 2008. Total CIE-erythemal dose was 465 734 J.m$^{-2}$ in Bratislava for the same period. It is 1.7% higher than at Poprad-Gánovce.

Fig. 3.5 **Annual course of CIE effective UV radiation daily doses in 2009**



Tab. 3.7 **Total atmospheric ozone [DU] in 2009 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 | 319 | −2 | 380 | 6 | 340 | −10 | 335 | −13 | 347 | −9 | 405 | 11 | 324 | −7 | 311 | −6 | 283 | −9 | 282 | −3 | 296 | 3 | 337 | 14 |
| 2 | 294 | −10 | 408 | 14 | 344 | −9 | 331 | −14 | 345 | −9 | 371 | 2 | 319 | −8 | 302 | −9 | 282 | −9 | 288 | −1 | 299 | 4 | 347 | 17 |
| 3 | 321 | −2 | 394 | 9 | 335 | −12 | 326 | −16 | 347 | −9 | 352 | −3 | 319 | −8 | 319 | −3 | 290 | −7 | 293 | 1 | 308 | 8 | 344 | 16 |
| 4 | 308 | −6 | 371 | 3 | 367 | −3 | 339 | −12 | 361 | −5 | 362 | −1 | 315 | −9 | 309 | −6 | 296 | −5 | 272 | −6 | 318 | 11 | 300 | 0 |
| 5 | 347 | 5 | 378 | 4 | 365 | −4 | 329 | −15 | 357 | −6 | 362 | 0 | 314 | −9 | 319 | −3 | 311 | 1 | 268 | −7 | 322 | 13 | 314 | 5 |
| 6 | 385 | 16 | 370 | 2 | 379 | 0 | 335 | −13 | 343 | −9 | 362 | 0 | 314 | −9 | 306 | −7 | 318 | 3 | 272 | −6 | 306 | 7 | 304 | 1 |
| 7 | 320 | −3 | 387 | 6 | 387 | 2 | 345 | −11 | 345 | −9 | 332 | −8 | 320 | −7 | 301 | −8 | 303 | −1 | 273 | −5 | 312 | 9 | 320 | 6 |
| 8 | 345 | 4 | 379 | 4 | 344 | −10 | 355 | −8 | 352 | −7 | 341 | −6 | 325 | −6 | 297 | −9 | 302 | −1 | 266 | −8 | 274 | −4 | 313 | 4 |
| 9 | 348 | 4 | 399 | 9 | 342 | −10 | 340 | −12 | 303 | −19 | 317 | −12 | 358 | 4 | 302 | −8 | 307 | 0 | 282 | −2 | 286 | 0 | 317 | 5 |
| 10 | 324 | −3 | 380 | 4 | 390 | 2 | 354 | −9 | 305 | −19 | 330 | −9 | 340 | −1 | 305 | −7 | 299 | −2 | 292 | 1 | | | 302 | 0 |
| 11 | 319 | −5 | 412 | 12 | 407 | 7 | 366 | −5 | 332 | −12 | 346 | −4 | 344 | 0 | 339 | 4 | 297 | −2 | 304 | 6 | 288 | 0 | 330 | 8 |
| 12 | 327 | −3 | 416 | 13 | 394 | 3 | 374 | −3 | 347 | −8 | 365 | 2 | 345 | 1 | 299 | −8 | 300 | −1 | 311 | 8 | 277 | −3 | 328 | 7 |
| 13 | 330 | −2 | 414 | 12 | 407 | 7 | 366 | −5 | 369 | −2 | 354 | −2 | 309 | −10 | 298 | −8 | 302 | 0 | 317 | 10 | 277 | −3 | 338 | 10 |
| 14 | 364 | 7 | 430 | 16 | 364 | −5 | 346 | −11 | 384 | 3 | 334 | −7 | 291 | −15 | 303 | −7 | 306 | 1 | 327 | 14 | 286 | −1 | 323 | 5 |
| 15 | 357 | 5 | 416 | 12 | 378 | −1 | 352 | −9 | 352 | −6 | 306 | −15 | 295 | −13 | 304 | −6 | 304 | 1 | 314 | 10 | 321 | 11 | 318 | 3 |
| 16 | 355 | 4 | 392 | 6 | 392 | 3 | 332 | −14 | 331 | −11 | 301 | −16 | 303 | −11 | 307 | −5 | 295 | −2 | 297 | 3 | 299 | 4 | 326 | 5 |
| 17 | 343 | 0 | 449 | 21 | 338 | −12 | 311 | −20 | 310 | −17 | 344 | −4 | 300 | −12 | 308 | −5 | 295 | −1 | 308 | 7 | 247 | −14 | 339 | 9 |
| 18 | 380 | 11 | 395 | 6 | 411 | 7 | 351 | −9 | 308 | −17 | 316 | −11 | 303 | −11 | 319 | −1 | 288 | −4 | 312 | 9 | 246 | −15 | 333 | 7 |
| 19 | 403 | 17 | 396 | 6 | 449 | 17 | 352 | −9 | 303 | −19 | 311 | −13 | 325 | −4 | 311 | −3 | 267 | −11 | 308 | 7 | 265 | −8 | 329 | 5 |
| 20 | 368 | 6 | 403 | 8 | 382 | 0 | 366 | −5 | 316 | −15 | 351 | −1 | 325 | −4 | 300 | −6 | 270 | −9 | 319 | 11 | 268 | −8 | 382 | 22 |
| 21 | 317 | −9 | 406 | 8 | 362 | −5 | 340 | −12 | 318 | −14 | 362 | 2 | 311 | −8 | 298 | −7 | 267 | −10 | 308 | 7 | 276 | −5 | 388 | 23 |
| 22 | 372 | 7 | 386 | 3 | 407 | 6 | 340 | −12 | 321 | −13 | 343 | −3 | 308 | −8 | 294 | −8 | 285 | −4 | 303 | 6 | 271 | −7 | 366 | 16 |
| 23 | 414 | 19 | 384 | 2 | 389 | 1 | 345 | −10 | 329 | −11 | 310 | −12 | 298 | −11 | 310 | −3 | 291 | −2 | 305 | 7 | 287 | −1 | 375 | 18 |
| 24 | 396 | 13 | 397 | 6 | 435 | 13 | 343 | −11 | 320 | −13 | 338 | −4 | 303 | −10 | 299 | −6 | 285 | −3 | 286 | 0 | 300 | 3 | 322 | 1 |
| 25 | 346 | −1 | 390 | 4 | 417 | 9 | 350 | −9 | | | 332 | −6 | 322 | −4 | 291 | −8 | 305 | 4 | 259 | −9 | 262 | −10 | 331 | 4 |
| 26 | 324 | −8 | 369 | −2 | 424 | 10 | 344 | −10 | | | 330 | −6 | 341 | 2 | 294 | −7 | 295 | 1 | 276 | −3 | 267 | −9 | 339 | 6 |
| 27 | 316 | −10 | 406 | 8 | 385 | 0 | 342 | −11 | | | 331 | −6 | 306 | −8 | 301 | −5 | 293 | 0 | 310 | 8 | 297 | 1 | 381 | 19 |
| 28 | 317 | −10 | 364 | −4 | 369 | −4 | 360 | −6 | | | 337 | −4 | 304 | −9 | 283 | −10 | 298 | 2 | 279 | −2 | 316 | 8 | 387 | 20 |
| 29 | 307 | −14 | | | 351 | −9 | 376 | −2 | | | 338 | −3 | 309 | −7 | 284 | −10 | 284 | −3 | 315 | 10 | 338 | 15 | 387 | 20 |
| 30 | 328 | −8 | | | 357 | −8 | 372 | −3 | 407 | 11 | 315 | −10 | 302 | −9 | 294 | −6 | 282 | −3 | 312 | 9 | 334 | 13 | 357 | 10 |
| 31 | 338 | −5 | | | 350 | −9 | | | 412 | 12 | | | 310 | −6 | 301 | −4 | | | 295 | 3 | | | 369 | 14 |
| Ø | 343 | 0 | 395 | 7 | 379 | −1 | 347 | −10 | 341 | −9 | 340 | −5 | 316 | −7 | 303 | −6 | 293 | −3 | 295 | 3 | 291 | 1 | 340 | 10 |
| Std | 30 | 9 | 19 | 5 | 30 | 8 | 15 | 4 | 29 | 8 | 22 | 6 | 16 | 4 | 11 | 3 | 12 | 4 | 18 | 7 | 24 | 8 | 27 | 7 |
| Max | 414 | 19 | 449 | 21 | 449 | 17 | 376 | −2 | 412 | 12 | 405 | 11 | 358 | 4 | 339 | 4 | 318 | 4 | 327 | 14 | 338 | 15 | 388 | 23 |
| Min | 294 | −14 | 364 | −4 | 335 | −12 | 311 | −20 | 303 | −19 | 301 | −16 | 291 | −15 | 283 | −10 | 267 | −11 | 259 | −9 | 246 | −15 | 300 | 0 |

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

# 4

# EMISSION AND AIR POLLUTION SOURCE INVENTORY

# 4.1 EMISSION AND AIR POLLUTION SOURCE INVENTORY

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

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

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

## STATIONARY SOURCES

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

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

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

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

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

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

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

## Positive contribution of database NEIS

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

## The comparison of the EAPSI and NEIS systems

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

According to the Act 478/2002 Coll. (§33, section 3, chapter g, m) as amended, the district offices are obliged to elaborate yearly reports about the operational characteristics of air pollution sources in their district and provide them electronically at the latest till 31$^{st}$ May of the current year for the next processing to SHMÚ, the organization accredited by the Ministry of Environment to manage the central database NEIS CU and provide the data processing at the national level.

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

| | |
|---|---|
| **Large sources** | Stationary sources containing stationary combustion units having cumulative heating input over 50 MW and other technological units with a production capacity above the defined limit. |

| | |
|---|---|
| **Middle sources** | Stationary sources containing stationary combustion units having cumulative heating input 0.3 – 50 MW and other technological units with a production capacity under the defined limit for the large sources and above the defined limit. |

| | |
|---|---|
| **Small sources** | Stationary equipment – domestic heating equipment for combustion of solid fuels and natural gas with heating input less than 0.3 MW. |

## Results (1990 – 2009) – evaluation

**Large sources**

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

**NEIS** Since 2000 the gathering of the selected data on sources and their emissions has been provided in the NEIS. The system contained 837 (714 of it in operation) large point sources in 2009. As the sources of 5 MW and above were included to the evidence of large point sources in the EAPSI system, the comparison of numbers of sources in both systems is not possible.

**Middle sources**

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

**NEIS** Since 2000 the data updating in the NEIS system has been provided each year. In 2009, NEIS registered 12 809 (10 947 of it in operation) medium sources. System EAPSI 2 registered only sources of heating output 0.2 – 5 MW and therefore to compare the number of sources in the individual systems is not possible.

**Small sources**

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

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

## MOBILE SOURCES

Emissions from mobile sources have been down every year since 1990. To balance emissions from road transport has been used since the 2008 model program COPERT IV [2], approved and recommended Executive Committee, the UNECE Convention on Long-Range Transboundary Air Pollution [3]. Subsequently, using a new version of COPERT need to undertake retrospective conversion of the time series of emissions after the year 2000, since we expect relevant changes in the type and age structure of the cars. Emissions, including carbon content of fuels and integrated national emission factor for petrol and diesel have been converted – recalculation with program COPERT version IV, 7.1. This version updates the technical information about the different categories of vehicles and the parameters specific to that country. The program allows to change parameters according to user requirements and update them. Calculation of emissions from road transport is based on five main types of input parameters such as total fuel consumption, vehicle fleet, driving conditions, emission factors and other parameters, such as. average annual driving performance of vehicles. The upgrade and conversion of emissions from road transport was necessary to conduct a more detailed classification of vehicles into different categories according to age, type of energy and payload. When estimating emissions from road transport in 2009 should be based on development and international economic situation, economic crisis, which has strongly influenced the fuel consumption. Consumption of gasoline fell in 2009 to almost 4.5% compared to 2008, consumption of diesel oil decreased by 5% compared to 2008. The actual decrease in fuel consumption was affected by a road emissions, but also in non-road transport. In order to prevent further recessive economic development in the automobile sales are to introducing the so-called two waves. “Scrapping”, which was significantly restored fleet of passenger cars, which had a positive impact on stopping the growth of emissions from road transport overall upward trend in emissions Notwithstanding these circumstances did not change significantly and still have increased the number of cars, number of traffic performance and increase emissions.

In addition to road transport emissions are evaluated and the sources of pollution and of rail, air and water transport in Slovakia. Methodology balances of emissions from the operation of railway traction units is processed according to the methodology EMEP/CORINAIR [4] and non-road sources using emission factors according to the methodological manual Emission Inventory Guidebook. The balance of production of emissions from water transport in the SR is limited to waterway activity in the Slovak Danube. Methodology used assessing the annual production of pollutants from the operation of waterway traffic traction activities of vessels on the Danube is a simplified methodology EMEP/CORINAIR non-road sources based on the calculations of applying average emission factors recommended by the CORINAIR working group. An important factor in the appraisal emissions in aviation is altitude. Different impacts on air pollution have emissions from air traffic on air and road to the landing and take-off maneuvers. The methodology for objectively assessing the impact of air pollutants in larger altitude from aircraft engines is not clearly developed yet, therefore, emission inventory is prepared on the base of local pollution on major airports in Slovakia. Operationally essential input – the number of statistics are made of aircraft movements, flight (LTO) cycle, fuel consumption and an overview of fuel sold. Innovative methodology is also based on knowledge of emission factors of individual aircraft types.

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[2] *http://lat.eng.auth.gr/copert*
[3] *http://www.unece.org/env/lrtap/*
[4] *http://reports.eea.europa.eu/EMEPCORINAIR5/*

# 4.2 DEVELOPMENT OF TRENDS IN BASIC POLLUTANTS

## EMISSIONS OF BASIC POLLUTANTS

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

**Particulate matter and $SO_2$**

Emissions of particulate matter and $SO_2$ have been decreasing continuously since 1990. Apart from the decrease in energy production and energy efficiency, this was caused by the change of the fuel base in favour of high-grade fuels, as well as the improvement of fuel quality characters used. A further spreading of separation techniques used, respectively advancing of its effectiveness shared in the particulate matter emission reduction. The downward trend of $SO_2$ emissions up to year 2000 was caused by the decreasing consumption of brown coal, hard coal, heavy fuel oil, use of low-sulphur fuel oil (Slovnaft Ltd., Bratislava) and installation of the desulphurisation systems for the large power sources (power plants in Zemianske Kostoľany and Vojany). The fluctuations of $SO_2$ emissions within 2001 and 2003 were caused either by their partial or total operation, or by the quality of combusted fuel and volume of production of energetic sources. In 2004 till 2006 the another decrease of $SO_2$ emissions was recorded mainly at large sources. This decrease was caused mainly by the combustion of low-sulphur-content fuel oils and coal (Slovnaft Ltd., Bratislava, TEKO Ltd., Košice) and by the reduction of production volume (power plants in Zemianske Kostoľany and Vojany). Increase of PM emissions in 2004 and 2005 was caused by the extended wood consumption in the sector small sources (heating households) as a result of growing retail price of natural gas and coal. Considerable decrease of $SO_2$ emission of about 77% was observed in road transport category in 2005. This decrease, contrary to the increase in consumption of fuel substances was caused by the implementation of measures referring to the content of sulphur in fuel substances (Decree No. 53/2004). The decrease of particulate matter emissions in 2006 was achieved mainly by reconstruction of separators in some sources in energy and industry (Power plants in Zemianske Kostoľany, U.S. Steel Ltd., Košice). Another decrease of the particulate matter and $SO_2$ emissions in 2007 and 2008 for the large stationary sources was mostly caused by the power plant in Vojany, of which some combustion units was out of operation. Since 2008, the trend of emissions of $SO_2$ and PM is stable.

**Oxides of nitrogen**

Emissions of nitrogen oxides have showed a smooth decrease since 1990, although in the years 1994-1995 they increased slightly in order to the increase in consumption of natural gas. A decrease of emissions of $NO_x$ since 1996 was caused by the change of emission factor, taking into consideration the resent condition of technique and technology in combustion processes. Since 1997, the decrease in solid fuel consumption has led to a further decrease in $NO_x$ emissions. In the further emissions decrease in years 2002 and 2003 participated the denitrification process (power plant Vojany). In 2006 $NO_x$ emissions decreased mainly at large and middle stationary sources. This decline is related to the reduction of production (power plants in Zemianske Kostoľany and Vojany) and consumption of solid fuel (since 2007 each year significantly reduces the consumption of anthracite, a downward trend has the consumption of Polish coal too) and natural gas (power plants in Zemianske Kostoľany, Slovak Gas Industry Ltd. Nitra). Significant decline of $NO_x$ emissions was achieved in mobile sources, mainly in the road transport. This decrease is connected to the renovation of rolling stock in case of both passenger and good vehicles, and to the use of more accurate emission factor.

**CO** The downward trend in CO emissions since 1990 has been caused mainly by the decrease in consumption and by the change of composition of fuel combusted by retail consumers. Carbon monoxide emissions from the large sources have been slightly decreasing as well. The iron and steel industry participate most significantly in the total CO emissions, therefore the emission trend is following the iron and steel production volume. The decrease in CO emissions since 1996 was due to the effects of policy and measures (determined on the results of measurements) to reduce CO emissions from the most significantly sources. The emission trend changes of CO within 1997 and 2003 is also affected by the quantity of pig iron production as well as the fuel consumption. In 2004 the CO emissions slightly increased mainly at large sources (the CO emissions specified by continuous measurement in U.S. Steel Ltd., Košice), since then the emissions have had only moderately decreasing trend. In 2005 the decrease of CO emissions was announced at large sources too, mainly as a consequence of agglomerate production cutting down in U.S. Steel Ltd., Košice and by the implementation of a new technology with effective combustion at lime production (Dolvap Ltd., Varín). Significant decrease in CO emissions of major sources in 2009 was mainly due to decrease in iron and steel production as a result of economic recession. Increase of CO emissions was achieved only in the sector of small sources (residential heating) and it is related to the increase of wood consumption caused by the increasing price of natural gas and coal. The emission decrease in the sector road transport is associated with onward renovation of rolling stock by the generationally new vehicles equipped by the three-way catalysts.

## EMISSIONS OF OTHER POLLUTANTS

The Slovak Republic is bound by the Convention on Long Range Transboundary Air Pollution (1979) to provide inventory of the selected pollutants. The emission inventories of non-methane volatile organic compounds (NMVOC), heavy metals (HMs), persistent organic pollutants (POPs) and particulate matter with aerodynamic diameter less than 10 or 2.5 µm ($PM_{10}$ and $PM_{2.5}$) are processed in accordance with the international methodology using the SNAP 97 nomenclature and recommendations of TFEIP working groups. Emissions at national level are estimated in cooperation with the external experts and balanced on the base of activity data multiplied by the emission factors. Estimated emissions of pollutants mentioned above as well as the other basic pollutants are transformed into the international NFR system according to the requirements for reporting and annually reported to the UNECE secretariat and EEA by the Ministry of Environment of the SR.

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

The NMVOC emissions have decreased since 1990 according to the balance. This development was caused by the decreased consumption of solvent based paints and the gradual introduction of low solvent paint, broad introduction of measures in the crude oil processing and fuel distribution sectors as well as a change of fuels in the energy sector and alteration of the cars in favour of cars equipped with catalysts (Tab. 4.7, Fig. 4.4). The NMVOC emissions have increased in the sector of paints and glues by about 54% since 2000 because the paints and glues are used as part of a large spectrum of industrial activities and various technological operations. Continually the consumption and import of print's ink and solvent paints has increased, too. In years 2004 and 2005 occurred expansion in automotive industry in Slovakia, many of paintshops was opened and so the consumption of paints has increased. Since 2007, entered into force Council Directive 1999/13/EC of 11 March 1999 with which operators had to adjust to emission limits. In 2007 was recalculated time series from sector dry cleaning and degreasing as a result of refinements counting solvent consumption in the use of paints and glues. In 2008, time series of landfilled and incinerated waste were recalculated on the basis of updated input data. Finally, emissions from road transport were recalculated in order to use an updated version of the model COPERT IV.

**POPs**

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

Downward trend of POPs emissions to the air proved to be most remarkable in the area of PAH emissions in the 90-ties, when it was caused mostly by the change of aluminium production technology (use of pre-baked anodes) (Tab. 4.8, Fig. 4.5). Increased emissions of polychlorinated biphenyls (PCB) were influenced by the increase of consumption in crude oil in the road transport and using wood in the residential sector. Increased consumption of wood in this sector influenced also total emission of PAHs. Emissions of PCDD/F have declined since 2000 because of reconstruction of some technologies (for example municipal and industrial waste incinerators). Total emissions PCDD/F depend on waste incineration, iron ore agglomeration and domestic heating., Variations in PCB and PAH emissions are given by variations of fuel consumption in road transport sector. HCB emissions are influenced by production of secondary copper and cement.

**HMs**

Emission inventory of heavy metals (HMs) is estimated according to the EMEP/EEA (Air Pollutant Emission Inventory Guidebook). In 2004 wood burning was included in the residential sector and emissions since 1990 were revised. Heavy metals emissions markedly decreased compared to the emission value from year 1990. Except the ceasing of several obsolete ineffective metallurgy plants this trend has been effected by a broad reconstruction of electrostatic precipitators and other dust control equipment, by a change of raw materials used, and in particular by the elimination of leaded petrol (Tab. 4.10, Fig. 4.7) since 1996. The Pb emissions increased since 2004 as a result of the increase of production in sector of ore agglomeration and copper production. In recent years slight variations in value have been typical for emission trends of HMs. In year 2007 emissions of Pb and Hg decreased in comparison to 2006 due to decrease in sector of ore agglomeration and glass production. At this stage we noticed increase of Cd emissions due to copper production increase. In 2008 increased emissions of lead, cadmium, mercury, copper, zinc and selenium due to increase of amount of incinerated industrial waste and due to

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

increase of emissions in public electricity and heat production, combustion in manufacturing industry. In 2008 were recalculated time series in sector land-filling and incineration of waste based on updated input data. Road transport emissions were recalculated because of update version of the COPERT IV was used in inventory.

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

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

Calculation of emissions $PM_{10}$ and $PM_{2.5}$ was elaborated using default indicators. Considering the fact that on the EU level are studies to determine the emission ceilings in Member States in accordance with GAINS [6] model (IIASA), the SR has decided to establish new methodology of emission estimation for $PM_{10}$ and $PM_{2.5}$ in accordance with the GAINS model (input data, emission factors). GAINS model uses the data aggregated from energy balance of the SR from Slovak Statistical Office; whereas country specific methodology uses the input data from NEIS database. The estimated emissions of $PM_{10}$ and $PM_{2.5}$ by country specific methodology are fully consistent with TSP emissions. This is a basic requirement for estimation of emission projections. The whole calculation is programmed in Microsoft Visual Basic in MS Excel [7].

### Share of individual sectors in total emissions of the Slovak Republic in 2009

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

### Most important sources of air pollution in the Slovak Republic in 2009

Table 4.4 introduces twenty the most important air pollution sources in the SR. The share of these sources in the total air emissions of the SR varies from 73.27% to 96.91%. Table 4.5 lists top ten sources in administrative regions according to the amount of emissions of basic pollutants.

### Specific territorial emissions in 2009

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

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

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

# 4.3 VERIFICATION OF THE RESULTS

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

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

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

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

| | | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PM** | EAPSI 1 | 208.075 | 153.590 | 110.545 | 79.925 | 52.335 | 55.770 | 38.461 | 36.646 | 31.168 | 34.813 |
| | EAPSI 2 | 36.425 | [1]36.425 | [1]36.425 | [1]36.425 | [1]17.097 | [1]17.097 | 9.478 | [2]9.478 | [2]9.478 | [2]9.478 |
| | EAPSI 3 | 34.795 | 35.710 | 31.968 | 29.386 | 26.077 | 24.582 | 24.539 | 20.170 | 21.039 | 20.234 |
| | EAPSI 4 | 10.764 | 8.852 | 7.980 | 7.641 | 8.544 | 8.755 | 8.940 | 9.142 | 9.509 | 8.766 |
| | **Total** | **290.059** | **234.577** | **186.918** | **153.377** | **104.053** | **106.204** | **81.418** | **75.436** | **71.194** | **73.291** |
| **$SO_2$** | EAPSI 1 | 421.983 | 347.084 | 296.036 | 246.413 | 182.747 | 188.590 | 197.308 | 176.564 | 153.723 | 147.111 |
| | EAPSI 2 | 37.509 | [1]37.509 | [1]37.509 | [1]37.509 | [1]27.091 | [1]27.091 | 10.577 | [2]10.577 | [2]10.577 | [2]10.577 |
| | EAPSI 3 | 63.197 | 58.173 | 53.697 | 42.124 | 33.069 | 28.117 | 20.173 | 14.994 | 17.088 | 14.489 |
| | EAPSI 4 | 3.423 | 2.733 | 2.389 | 2.175 | 2.313 | 2.490 | 2.536 | 2.554 | 2.724 | 1.088 |
| | **Total** | **526.112** | **445.499** | **389.631** | **328.221** | **245.220** | **246.288** | **230.594** | **204.689** | **184.112** | **173.265** |
| **$NO_x$** | EAPSI 1 | 146.474 | 135.389 | 127.454 | 122.169 | 111.616 | 118.040 | 76.853 | 70.583 | 74.322 | 65.436 |
| | EAPSI 2 | 4.961 | [1]4.961 | [1]4.961 | [1]4.961 | [1]5.193 | [1]5.193 | 3.960 | [2]3.960 | [2]3.960 | [2]3.960 |
| | EAPSI 3 | 13.331 | 13.077 | 12.243 | 10.583 | 9.456 | 9.023 | 8.845 | 7.784 | 8.355 | 8.201 |
| | EAPSI 4 | 56.850 | 47.509 | 43.738 | 42.362 | 43.535 | 45.453 | 45.038 | 44.915 | 46.210 | 43.225 |
| | **Total** | **221.616** | **200.936** | **188.396** | **180.075** | **169.800** | **177.709** | **134.696** | **127.242** | **132.847** | **120.822** |
| **CO** | EAPSI 1 | 162.047 | 160.591 | 132.874 | 160.112 | 168.561 | 165.715 | 129.388 | 141.636 | 118.581 | 122.149 |
| | EAPSI 2 | 27.307 | [1]27.307 | [1]27.307 | [1]27.307 | [1]11.409 | [1]11.409 | 12.037 | [2]12.037 | [2]12.037 | [2]12.037 |
| | EAPSI 3 | 161.905 | 152.335 | 139.809 | 113.629 | 92.663 | 81.778 | 66.759 | 51.933 | 56.990 | 51.171 |
| | EAPSI 4 | 154.199 | 142.872 | 140.621 | 150.676 | 154.804 | 156.743 | 151.133 | 153.216 | 153.946 | 144.655 |
| | **Total** | **505.458** | **483.105** | **440.611** | **451.724** | **427.437** | **415.645** | **359.317** | **358.822** | **341.554** | **330.012** |

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

Tab. 4.1b **Emissions of basic pollutants [thous. t] in the SR within 2000 – 2009**

| | | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PM** | **Stationary sources – NEIS** | Large sources [1] | 29.923 | 29.722 | 25.037 | 20.166 | 17.670 | 18.719 | 13.992 | 6.020 | 5.406 | 4.966 |
| | | Middle sources [1] | 4.958 | 4.405 | 3.767 | 3.259 | 2.748 | 2.392 | 2.281 | 1.979 | 1.764 | 1.554 |
| | | Small sources [2] | 19.877 | 20.550 | 17.217 | 18.300 | 21.504 | 28.709 | 26.980 | 26.821 | 26.921 | 27.083 |
| | **Mobile sources** | Road transport | 3.398 | 3.784 | 4.368 | 3.990 | 4.776 | 5.679 | 6.049 | 6.062 | 5.047 | 4.701 |
| | | Other transport | 0.399 | 0.404 | 0.366 | 0.329 | 0.343 | 0.359 | 0.336 | 0.353 | 0.325 | 0.295 |
| | **Total** | | **58.555** | **58.865** | **50.755** | **46.044** | **47.041** | **55.858** | **49.638** | **41.235** | **39.463** | **38.599** |
| **$SO_2$** | **Stationary sources – NEIS** | Large sources [1] | 101.956 | 109.822 | 91.461 | 95.283 | 87.932 | 81.592 | 80.104 | 64.974 | 64.059 | 59.739 |
| | | Middle sources [1] | 8.083 | 6.655 | 3.964 | 3.620 | 2.652 | 2.107 | 1.902 | 1.598 | 1.246 | 0.991 |
| | | Small sources [2] | 16.055 | 13.764 | 7.127 | 6.384 | 5.381 | 5.073 | 5.524 | 3.735 | 3.844 | 3.116 |
| | **Mobile sources** | Road transport | 0.669 | 0.676 | 0.732 | 0.155 | 0.159 | 0.189 | 0.176 | 0.204 | 0.209 | 0.195 |
| | | Other transport | 0.189 | 0.194 | 0.064 | 0.059 | 0.063 | 0.047 | 0.044 | 0.047 | 0.045 | 0.041 |
| | **Total** | | **126.952** | **131.111** | **103.348** | **105.501** | **96.187** | **89.008** | **87.75** | **70.558** | **69.403** | **64.082** |
| **$NO_x$** | **Stationary sources – NEIS** | Large sources [1] | 54.484 | 51.653 | 46.412 | 44.605 | 44.244 | 42.424 | 39.038 | 35.762 | 34.488 | 31.333 |
| | | Middle sources [1] | 8.052 | 7.751 | 6.356 | 6.620 | 4.926 | 4.377 | 4.992 | 3.542 | 3.575 | 3.389 |
| | | Small sources [2] | 7.993 | 8.391 | 7.137 | 7.356 | 7.582 | 8.866 | 8.336 | 7.819 | 7.979 | 7.990 |
| | **Mobile sources** | Road transport | 31.691 | 34.821 | 35.208 | 33.096 | 38.411 | 43.126 | 41.458 | 44.300 | 44.052 | 39.032 |
| | | Other transport | 4.860 | 4.899 | 4.808 | 4.305 | 4.506 | 4.723 | 4.427 | 4.654 | 4.568 | 3.854 |
| | **Total** | | **107.08** | **107.515** | **99.921** | **95.982** | **99.669** | **103.516** | **98.251** | **96.077** | **94.662** | **85.598** |
| **CO** | **Stationary sources – NEIS** | Large sources [1] | 120.609 | 115.177 | 122.225 | 141.047 | 147.317 | 133.787 | 147.318 | 141.062 | 136.530 | 106.635 |
| | | Middle sources [1] | 10.779 | 10.280 | 9.150 | 9.394 | 7.531 | 5.853 | 5.350 | 5.330 | 4.518 | 4.104 |
| | | Small sources [2] | 53.792 | 50.178 | 33.815 | 33.811 | 34.753 | 41.766 | 40.882 | 37.018 | 37.367 | 36.181 |
| | **Mobile sources** | Road transport | 115.497 | 131.625 | 123.438 | 107.665 | 104.875 | 97.481 | 72.982 | 63.471 | 62.703 | 58.796 |
| | | Other transport | 1.719 | 1.626 | 1.591 | 1.463 | 1.509 | 1.566 | 1.452 | 1.533 | 1.446 | 1.360 |
| | **Total** | | **302.396** | **308.886** | **290.219** | **293.38** | **295.985** | **280.453** | **267.984** | **248.414** | **242.564** | **207.076** |

[1] *According to the Decree of MŽP SR No.706/2002 Coll.*
[2] *According to the Decree of MŽP SR No.144/2000 Coll. (2001 – 2003), according to the Decree of MŽP SR No. 53/2004 Coll. (2004 – 2007).*
*Emissions estimated to November18th, 2010.*

Tab. 4.2a **Emissions of PM [t] from road transport in the SR within 1990 – 2009**

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

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|
| Emissions from diesel engine | 2218 | 2415 | 2877 | 2588 | 3319 | 3946 | 4050 | 4281 | 3269 | 2965 |
| Emissions from petrol engine | 325 | 390 | 342 | 351 | 341 | 391 | 337 | 339 | 364 | 323 |
| **Total emissions from exhaust** | **2543** | **2805** | **3219** | **2939** | **3660** | **4337** | **4387** | **4620** | **3633** | **3288** |
| Abrasion emissions | 855 | 979 | 1149 | 1051 | 1116 | 1342 | 1662 | 1442 | 1414 | 1413 |
| **Total** | **3398** | **3784** | **4368** | **3990** | **4776** | **5679** | **6049** | **6062** | **5047** | **4701** |

Tab. 4.2b **Emissions of $PM_{10}$ and $PM_{2,5}$ [t] from road transport in the SR within 2000 – 2009**

| | 2000 | | 2001 | | 2002 | | 2003 | | 2004 | | 2005 | | 2006 | | 2007 | | 2008 | | 2009 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $PM_{10}$ | $PM_{2,5}$ | $PM_{10}$ | $PM_{2,5}$ | $PM_{10}$ | $PM_{2,5}$ | $PM_{10}$ | $PM_{2,5}$ | $PM_{10}$ | $PM_{2,5}$ | $PM_{10}$ | $PM_{2,5}$ | $PM_{10}$ | $PM_{2,5}$ | $PM_{10}$ | $PM_{2,5}$ | $PM_{10}$ | $PM_{2,5}$ | $PM_{10}$ | $PM_{2,5}$ |
| Emissions from diesel engines | 1158 | 1060 | 1261 | 1154 | 1500 | 1377 | 1383 | 1205 | 1730 | 1589 | 2055 | 1891 | 2103 | 1947 | 2236 | 2045 | 1753 | 1516 | 1556 | 1409 |
| Emissions from petrol engines | 199 | 126 | 238 | 152 | 209 | 133 | 215 | 136 | 209 | 132 | 242 | 149 | 207 | 130 | 209 | 130 | 225 | 139 | 201 | 122 |
| **Total emissions from exhaust** | **1357** | **1186** | **1499** | **1306** | **1709** | **1510** | **1598** | **1341** | **1939** | **1721** | **2297** | **2040** | **2310** | **2077** | **2445** | **2175** | **1978** | **1655** | **1757** | **1531** |
| Abrasion emissions | 557 | 298 | 638 | 341 | 749 | 400 | 685 | 366 | 727 | 389 | 875 | 467 | 1084 | 578 | 943 | 499 | 922 | 492 | 923 | 490 |
| **Total** | **1914** | **1484** | **2137** | **1647** | **2458** | **1910** | **2283** | **1707** | **2666** | **2110** | **3172** | **2507** | **3394** | **2655** | **3388** | **2674** | **2900** | **2147** | **2680** | **2021** |

*Emissions estimated to November 18th, 2010*

Fig. 4.1 **Development trends in basic pollutant emissions within 1990 – 2009**

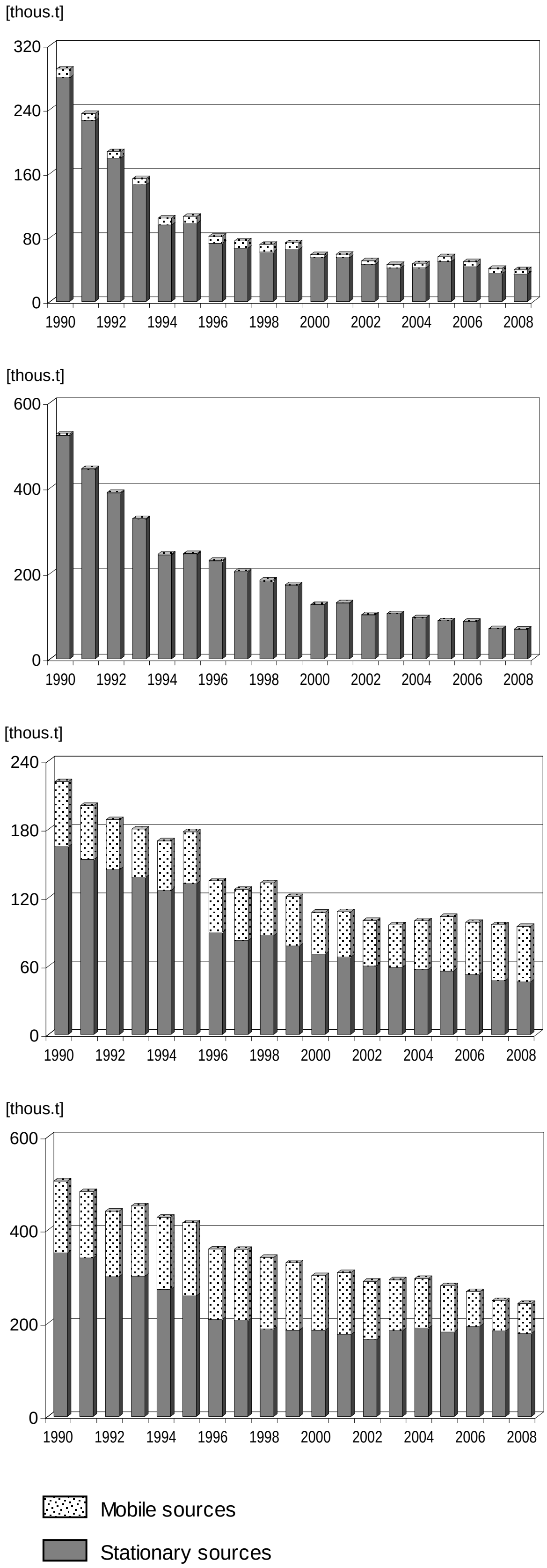
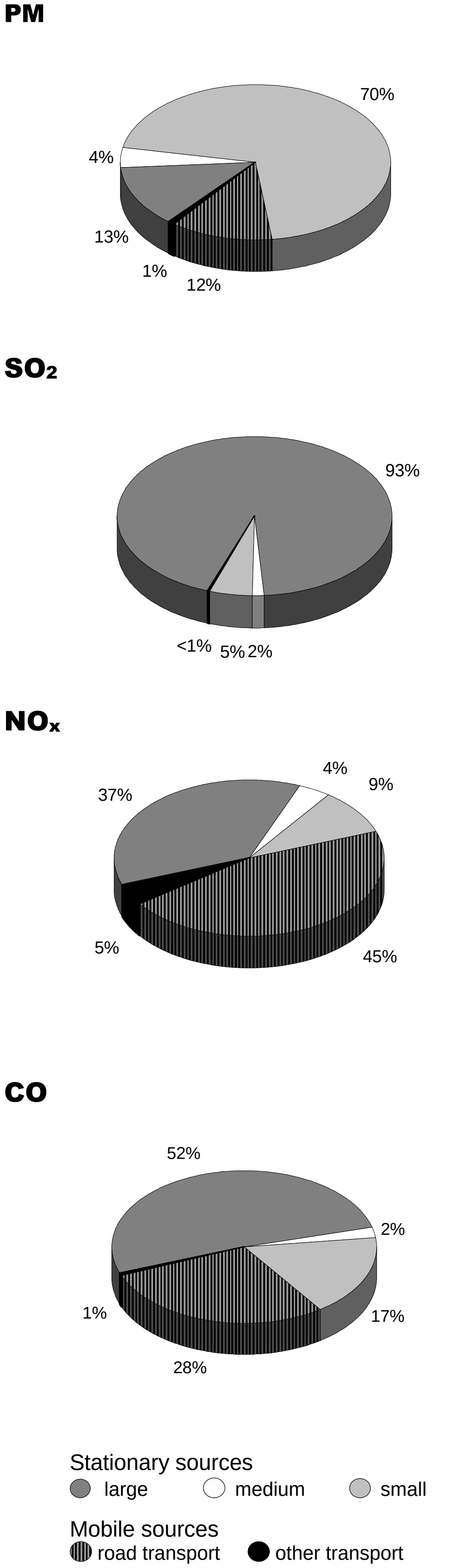



Fig. 4.2 **Emissions of basic pollutants in 2009**



Tab. 4.3 **Stationary source emissions of basic pollutants [t] in agglomerations and zones* within 2000 – 2009**

| **PM** | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Aglome-ration** | Bratislava | 942 | 477 | 444 | 484 | 470 | 472 | 430 | 353 | 339 | 332 |
| | Košice | 15758 | 17173 | 14601 | 9890 | 6807 | 4362 | 4107 | 3418 | 3056 | 3009 |
| **Zone** | Bratislava region | 501 | 546 | 493 | 466 | 457 | 506 | 452 | 469 | 477 | 469 |
| | Trnava region | 1518 | 1518 | 1284 | 1325 | 1522 | 1935 | 1825 | 1752 | 1770 | 1755 |
| | Trenčín region | 4607 | 4820 | 4199 | 4331 | 4804 | 5280 | 4712 | 4464 | 4312 | 4145 |
| | Nitra region | 3057 | 2921 | 2476 | 2474 | 2740 | 3414 | 3144 | 3074 | 3053 | 2991 |
| | Žilina region | 6585 | 6271 | 5298 | 5344 | 5852 | 7076 | 6540 | 6443 | 6459 | 6447 |
| | Banská Bystrica region | 6320 | 6355 | 5334 | 5346 | 5820 | 7378 | 6710 | 6579 | 6566 | 6497 |
| | Prešov region | 4207 | 4266 | 3491 | 3667 | 4588 | 5556 | 5158 | 4606 | 4514 | 4608 |
| | Košice region | 11262 | 10331 | 8400 | 8398 | 8862 | 13842 | 10176 | 3663 | 3545 | 3349 |
| **Total** | | **54758** | **54677** | **46022** | **41725** | **41922** | **49820** | **43254** | **34820** | **34090** | **33603** |

| **$SO_2$** | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Aglome-ration** | Bratislava | 13240 | 13594 | 11348 | 12263 | 9869 | 9285 | 11764 | 8648 | 8302 | 9265 |
| | Košice | 18307 | 12607 | 10500 | 10781 | 13113 | 12526 | 11417 | 10307 | 9910 | 9087 |
| **Zone** | Bratislava region | 384 | 380 | 208 | 150 | 290 | 377 | 207 | 176 | 169 | 178 |
| | Trnava region | 2160 | 2051 | 1166 | 1077 | 1141 | 1037 | 1039 | 566 | 566 | 423 |
| | Trenčín region | 28625 | 45187 | 38305 | 46051 | 44108 | 40937 | 39659 | 33450 | 36114 | 33251 |
| | Nitra region | 4752 | 4749 | 3799 | 3648 | 2485 | 2336 | 2367 | 1158 | 1134 | 1066 |
| | Žilina region | 10775 | 10237 | 7140 | 7647 | 6147 | 5035 | 4444 | 3751 | 3693 | 3384 |
| | Banská Bystrica region | 10654 | 10043 | 8814 | 7983 | 6300 | 6197 | 6791 | 5022 | 4724 | 4119 |
| | Prešov region | 8372 | 8082 | 6320 | 6719 | 4864 | 4856 | 4204 | 3407 | 1811 | 1945 |
| | Košice region | 28825 | 23310 | 14952 | 8969 | 7649 | 6185 | 5639 | 3823 | 2727 | 1128 |
| **Total** | | **126094** | **130242** | **102552** | **105287** | **95966** | **88772** | **87530** | **70307** | **69149** | **63847** |

| **$NO_x$** | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Aglome-ration** | Bratislava | 6393 | 5151 | 5313 | 5462 | 5318 | 4791 | 4521 | 4110 | 4112 | 4142 |
| | Košice | 12382 | 12172 | 12140 | 12355 | 11107 | 10929 | 12222 | 9975 | 8665 | 8167 |
| **Zone** | Bratislava region | 1792 | 1900 | 1972 | 1602 | 1670 | 1742 | 1700 | 1882 | 1874 | 1739 |
| | Trnava region | 2012 | 1966 | 1684 | 1675 | 1644 | 1667 | 1608 | 1470 | 1563 | 1381 |
| | Trenčín region | 9083 | 10489 | 9616 | 10167 | 9677 | 7822 | 7835 | 7219 | 7588 | 7328 |
| | Nitra region | 3905 | 3974 | 3843 | 3921 | 4356 | 3989 | 3653 | 2979 | 3465 | 3220 |
| | Žilina region | 5433 | 5170 | 4599 | 4491 | 4709 | 4674 | 4479 | 4550 | 4397 | 4256 |
| | Banská Bystrica region | 6541 | 6666 | 6316 | 5840 | 6160 | 6281 | 5522 | 5550 | 5699 | 4465 |
| | Prešov region | 3279 | 3443 | 3212 | 3244 | 3168 | 3459 | 3284 | 2849 | 2490 | 2781 |
| | Košice region | 19710 | 16864 | 11209 | 9825 | 8943 | 10314 | 7543 | 6538 | 6189 | 5233 |
| **Total** | | **70530** | **67794** | **59905** | **58581** | **56752** | **55666** | **52366** | **47122** | **46042** | **42712** |

| **CO** | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Aglome-ration** | Bratislava | 1528 | 1319 | 1264 | 1224 | 1277 | 1120 | 1065 | 879 | 821 | 837 |
| | Košice | 84544 | 78619 | 83700 | 104605 | 107218 | 93197 | 109060 | 102663 | 94378 | 68477 |
| **Zone** | Bratislava region | 1951 | 1638 | 1488 | 2794 | 1775 | 1576 | 1901 | 2020 | 2661 | 3520 |
| | Trnava region | 4746 | 4682 | 3591 | 3399 | 3493 | 3865 | 3563 | 3459 | 3306 | 2627 |
| | Trenčín region | 11684 | 10334 | 7815 | 7789 | 8036 | 9331 | 10854 | 9430 | 10043 | 10481 |
| | Nitra region | 7964 | 7379 | 5470 | 5586 | 5672 | 6627 | 6459 | 5690 | 6849 | 6385 |
| | Žilina region | 19357 | 19287 | 16520 | 16462 | 17257 | 15924 | 14990 | 14686 | 14210 | 11573 |
| | Banská Bystrica region | 26309 | 26301 | 24299 | 25727 | 27840 | 29375 | 26835 | 27382 | 29303 | 27604 |
| | Prešov region | 12170 | 11838 | 9075 | 8804 | 8800 | 9282 | 8714 | 7522 | 7080 | 7042 |
| | Košice region | 14927 | 14237 | 11969 | 7862 | 8232 | 11109 | 10108 | 9680 | 9764 | 8374 |
| **Total** | | **185180** | **175636** | **165191** | **184252** | **189601** | **181407** | **193550** | **183410** | **178415** | **146920** |

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

Tab. 4.4 **The most important air pollution sources in the SR and their share in the emissions of pollutants (NEIS – large and middle sources*) in 2009**

| | PM | | $SO_2$ | | $NO_x$ | | CO | |
|---|---|---|---|---|---|---|---|---|
| | Operator | [%] | Operator | [%] | Operator | [%] | Operator | [%] |
| 1 | U.S. Steel, s.r.o., Košice | 36.33 | SE, a.s., Bratislava, o.z. ENO Zem. Kostoľany | 53.39 | U.S. Steel, s.r.o., Košice | 16.87 | U.S. Steel, s.r.o., Košice | 60.44 |
| 2 | Carmeuse Slovakia, s.r.o., závod Košice | 7.95 | U.S. Steel, s.r.o., Košice | 12.88 | SE, a.s., Bratislava, o.z., ENO Zem. Kostoľany | 11.00 | SLOVALCO, a.s., Žiar nad Hronom | 12.16 |
| 3 | SE, a.s., Bratislava, o.z., ENO Zem. Kostoľany | 7.07 | CM European power Slovakia, s.r.o., Bratislava | 9.01 | TEKO, a.s., Košice | 4.31 | Calmit,, s.r.o., Bratislava, prev. Tisovec | 2.88 |
| 4 | SLOVALCO, a.s., Žiar nad Hronom | 2.29 | SLOVNAFT, a.s., Bratislava | 5.97 | SE, a.s., Bratislava, Elektráreň Vojany I a II | 4.00 | KOVOHUTY, a.s., Krompachy | 2.76 |
| 5 | Novácke chemické závody, a.s., Nováky | 2.00 | Žilinská teplárenská, a.s., Žilina | 2.28 | CM European power Slovakia, s.r.o., Bratislava | 3.98 | Holcim (Slovensko), a.s., Rohožník | 2.20 |
| 6 | BUKOCEL, a.s., Hencovce | 1.72 | SLOVALCO, a.s., Žiar nad Hronom | 2.28 | SLOVNAFT, a.s., Bratislava | 3.59 | CEMMAC, a.s., Horné Srnie | 2.16 |
| 7 | Duslo, a.s., Šaľa | 1.60 | Zvolenská teplárenská a.s., Zvolen | 1.83 | Holcim (Slovensko) , a.s., Rohožník | 3.37 | CALMIT, spol. s r.o., Bratislava, prev. Žirany | 1.90 |
| 8 | Carmeuse Slovakia, s.r.o., závod Včeláre | 1.57 | TEKO, a.s., Košice | 1.77 | Mondi scp, a.s., Ružomberok | 3.23 | Považská cementáreň, a.s., Ladce | 1.86 |
| 9 | Považská cementáreň, a.s., Ladce | 1.57 | BUKOCEL, a.s., Hencovce | 1.70 | V.S.H., a.s., Turňa nad Bodvou | 2.77 | DOLVAP, s.r.o., Varín | 1.52 |
| 10 | Mondi scp, a.s., Ružomberok | 1.52 | Martinská teplárenská, a.s., Martin | 1.38 | eustream , a.s., prev. Veľké Kapušany | 2.64 | Slovenské magnezitové závody, a.s., Jelšava | 1.18 |
| 11 | SLOVNAFT, a.s., Bratislava | 1.44 | Smurfit Kappa Štúrovo, a.s. | 1.14 | BUKOCEL, a.s., Hencovce | 2.36 | Carmeuse Slovakia ,s.r.o., závod Košice | 1.15 |
| 12 | SE, a.s., Bratislava, Elektráreň Vojany I a II | 1.26 | SE, a.s., Bratislava, Elektráreň Vojany I a II | 0.74 | Považská cementáreň, a.s., Ladce | 2.16 | OFZ, a.s., Istebné | 0.63 |
| 13 | CHEMES, a.s., HUMENNÉ | 1.16 | Dalkia Industry Žiar nad Hronom, a.s., Žiar n/H | 0.45 | eustream, a.s., prev. Jablonov nad Turňou | 1.90 | BUKOCEL a.s., Hencovce | 0.56 |
| 14 | CM European power Slovakia, s.r.o., Bratislava | 1.10 | Knauf Insulation, s.r.o., Nová Baňa | 0.43 | CEMMAC, a.s., Horné Srnie | 1.79 | SE, a.s., Bratislava, Elektráreň Vojany I a II | 0.41 |
| 15 | Žilinská teplárenská, a.s., Žilina | 1.03 | CHEMES, a.s., Humenné | 0.41 | Duslo, a.s., Šaľa | 1.71 | SLOVNAFT, a.s., Bratislava | 0.39 |
| 16 | Knauf Insulation, s.r.o., Nová Baňa | 1.00 | TEPLÁREŇ, a.s., Považská Bystrica | 0.33 | Smurfit Kappa Štúrovo, a.s. | 1.62 | SE, a.s., Bratislava, o.z., ENO Zem. Kostoľany | 0.33 |
| 17 | TEKO, a.s., Košice | 0.86 | TP 2, s.r.o., Strážske | 0.27 | Carmeuse Slovakia, s.r.o., závod Košice | 1.57 | Mondi scp, a.s., Ružomberok | 0.29 |
| 18 | Kronospan SK, s.r.o., Prešov | 0.64 | Slovenské magnezitové závody, a.s., Jelšava | 0.24 | eustream, a.s., prev. Ivanka pri Nitre | 1.50 | Novácke chemické závody, a.s., Nováky | 0.25 |
| 19 | DOLVAP, s.r.o., Varín | 0.62 | VETROPACK Nemšová, s.r.o. | 0.21 | SLOVALCO, a.s., Žiar nad Hronom | 1.49 | TEPLÁREŇ, a.s., Považská Bystrica | 0.25 |
| 20 | Holcim (Slovensko) , a.s., Rohožník | 0.54 | Mondi scp, a.s., Ružomberok | 0.20 | Žilinská teplárenská, a.s., Žilina | 1.47 | Slovmag a.s., Lubeník | 0.24 |
| Sum | | 73.27 | | 96.91 | | 73.32 | | 93.57 |

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

Tab. 4.5 **Sequence of the sources within the region according to the emissions in 2009 (NEIS – large and middle sources*)**

## BRATISLAVA REGION

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

## TRNAVA REGION

| | PM | | $SO_2$ | |
|---|---|---|---|---|
| | Source | District | Source | District |
| 1. | Amylum Slovakia, spol. s r.o., Boleráz | Trnava | Slovenské cukrovary, a.s., Sereď | Galanta |
| 2. | RaVOD Pata roľnícke a výrobnoobchodné družstvo | Galanta | Johns Manville Slovakia a.s. Trnava | Trnava |
| 3. | Slovenské cukrovary, a.s., Sereď | Galanta | Mach-Trade, s.r.o., Sereď | Galanta |
| 4. | Johns Manville Slovakia, a.s., Trnava | Trnava | Zlievareň Trnava, s.r.o. | Trnava |
| 5. | PENAM, a.s., Nitra, prev. Trnava | Trnava | Baňa Záhorie, a.s., Čáry | Senica |
| 6. | ENVIRAL, a.s., Leopoldov | Hlohovec | Slovasfalt Bratislava, obaľ. Moravský Sv. Ján | Senica |
| 7. | AGROPODNIK, a.s. Trnava | Trnava | PD Siladice | Hlohovec |
| 8. | Výroba kameňa a pieskov, spol. s r.o. Buková | Trnava | ENVIRAL, a.s., Leopoldov | Hlohovec |
| 9. | Zentiva, a.s., Hlohovec | Hlohovec | Tehelňa Gbely, s.r.o. | Skalica |
| 10. | Tehelňa Gbely, s.r.o. | Skalica | Obec Lakšárska Nová Ves, ZŠ Lakšárska Nová Ves | Senica |
| | $NO_x$ | | CO | |
| | Source | District | Source | District |
| 1. | Johns Manville Slovakia, a.s., Trnava | Trnava | Johns Manville Slovakia, a.s., Trnava | Trnava |
| 2. | Slovenské cukrovary, a.s., Sereď | Galanta | Swedwood Slovakia, s.r.o.,OZ Malacky prev. Trnava | Trnava |
| 3. | ENVIRAL, a.s., Leopoldov | Hlohovec | I.D.C. Holding, a.s., Pečivárne Sereď | Galanta |
| 4. | Amylum Slovakia, spol. s r.o. Boleráz | Trnava | ENVIRAL, a.s., Leopoldov | Hlohovec |
| 5. | Swedwood Slovakia, s.r.o., OZ Malacky prev. Trnava | Trnava | Zlievareň Trnava, s.r.o. | Trnava |
| 6. | Mach-Trade, s.r.o., Sereď | Galanta | Amylum Slovakia, spol. s r.o. Boleráz | Trnava |
| 7. | BEKAERT Hlohovec, a.s., | Hlohovec | Slovenské cukrovary, a.s., Sereď | Galanta |
| 8. | PCA Slovakia, s.r.o., TRNAVA | Trnava | Slovasfalt Bratislava, obaľ. Moravský Sv. Ján | Senica |
| 9. | Službyt, s.r.o., Senica | Senica | Službyt, s.r.o., Senica | Senica |
| 10. | Wienerberger Slov.tehelne, s.r.o., závod Boleráz | Trnava | Medea-S, s.r.o., Sládkovičovo | Galanta |

# NITRA REGION

| | PM | | $SO_2$ | |
|---|---|---|---|---|
| | **Source** | **District** | **Source** | **District** |
| 1. | Duslo, a.s., Šaľa | Šaľa | Smurfit Kappa Štúrovo, a.s. | Nové Zámky |
| 2. | Smurfit Kappa Štúrovo, a.s. | Nové Zámky | Icopal, a.s., Štúrovo | Nové Zámky |
| 3. | Lencos, s.r.o., Levice | Levice | BYTREAL Tlmače, s.r.o., Tlmače | Levice |
| 4. | BYTREAL Tlmače, s.r.o., Tlmače | Levice | Duslo, a.s., Šaľa | Šaľa |
| 5. | P.G.TRADE spol. s r.o., Komárno, zdroje v okrese | Nové Zámky | MO SR, Posádková správa budov Nitra | Nitra |
| 6. | SES, a.s., Tlmače | Levice | M Agrokom, s.r.o., Marcelová | Levice |
| 7. | Slovintegra Energy, s.r.o., Levice | Levice | EMGO Slovakia, a.s., Nové Zámky | Nové Zámky |
| 8. | PPC ČAB akciová spoločnosť Nové Sady | Nitra | N-ADOVA, spol. s r.o. Nitra | Nitra |
| 9. | Kameňolomy a štrkopieskovne, a.s., lom Pohranice | Nitra | CESTY NITRA A.S., NITRA, prev. Práznovce | Topoľčany |
| 10. | PALMA Group, a.s., Levice | Levice | ENERGO SK, a.s., Nitra | Levice |
| | **$NO_x$** | | **CO** | |
| | **Source** | **District** | **Source** | **District** |
| 1. | Duslo, a.s., Šaľa | Šaľa | CALMIT spol. s r.o., Bratislava, prev. Žirany | Nitra |
| 2. | Smurfit Kappa Štúrovo, a.s. | Nové Zámky | Slovintegra Energy, s.r.o., Levice | Levice |
| 3. | eustream, a.s., prev. Ivanka pri Nitre | Nitra | Duslo, a.s., Šaľa | Šaľa |
| 4. | Slovintegra Energy, s.r.o., Levice | Levice | Smurfit Kappa Štúrovo, a.s. | Nové Zámky |
| 5. | Bytkomfort, s.r.o., Nové Zámky | Nové Zámky | DANFOSS COMPRESSORS, s.r.o., Zlaté Moravce | Zlaté Moravce |
| 6. | SES, a.s., Tlmače | Levice | eustream, a.s., prev. Ivanka pri Nitre | Nitra |
| 7. | Nitrianska teplárenská spoločnosť, a.s., Nitra | Nitra | Wienerberger Slov. tehelne spol. s r.o., Zl. Moravce | Zlaté Moravce |
| 8. | OPM2SR, s.r.o., Nitra | Nitra | Komárňanské tlačiarne spol. s r.o., Komárno | Komárno |
| 9. | Fortunae, s.r.o., Levice | Levice | MO SR, Posádková správa budov Nitra | Nitra |
| 10. | COM-therm, s.r.o., Komárno | Komárno | Bytkomfort, s.r.o., Nové Zámky | Nové Zámky |

# TRENČÍN REGION

| | PM | | $SO_2$ | |
|---|---|---|---|---|
| | **Source** | **District** | **Source** | **District** |
| 1. | SE, a.s., Bratislava, o.z., ENO Zem. Kostoľany | Prievidza | SE, a.s., Bratislava, o.z., ENO Zem. Kostoľany | Prievidza |
| 2. | Novácke chemické závody, a.s., Nováky | Prievidza | TEPLÁREŇ, a.s., Považská Bystrica | Považská Bystrica |
| 3. | Považská cementáreň, a.s., Ladce | Ilava | VETROPACK NEMŠOVÁ, s.r.o. | Trenčín |
| 4. | VETROPACK NEMŠOVÁ, s.r.o. | Trenčín | HBP, a.s., Banská mech. a elektrifikácia Nováky | Prievidza |
| 5. | HBP, a.s., Banská mech. a elektrifikácia Nováky | Prievidza | Služby pre bývanie, s.r.o., Trenčín | Trenčín |
| 6. | TERMONOVA, a.s., Nová Dubnica | Ilava | Handlovská energetika, s.r.o., Handlová | Prievidza |
| 7. | LESS TIMBER SK, s.r.o., Lehota pod Vtáčnikom | Prievidza | PREFA – STAV, s.r.o., Podlužany | Bánovce n/B |
| 8. | KVARTET, a.s., Partizánske | Partizánske | Prefabetón Koš, a.s., Nováky | Prievidza |
| 9. | Považský cukor, a.s., Trenčianska Teplá | Trenčín | CEMMAC, a.s., Horné Srnie | Trenčín |
| 10. | CEMMAC, a.s., Horné Srnie | Trenčín | MO SR, zdroje v okrese Trenčín | Trenčín |
| | **$NO_x$** | | **CO** | |
| | **Source** | **District** | **Source** | **District** |
| 1. | SE, a.s., Bratislava, o.z., ENO Zem. Kostoľany | Prievidza | CEMMAC, a.s., Horné Srnie | Trenčín |
| 2. | Považská cementáreň, a.s., Ladce | Ilava | Považská cementáreň, a.s., Ladce | Ilava |
| 3. | CEMMAC, a.s., Horné Srnie | Trenčín | SE, a.s., Bratislava, o.z., ENO Zem. Kostoľany | Prievidza |
| 4. | RONA, a.s., Lednické Rovne | Púchov | Novácke chemické závody, a.s., Nováky | Prievidza |
| 5. | VETROPACK NEMŠOVÁ, s.r.o. | Trenčín | TEPLÁREŇ, a.s., Považská Bystrica | Považská |
| 6. | TEPLÁREŇ, a.s., Považská Bystrica | Považská Bystrica | Považský cukor, a.s., Trenčianska Teplá | Trenčín |
| 7. | Novácke chemické závody, a.s., Nováky | Prievidza | TSM Partizánske, s.r.o. | Partizánske |
| 8. | TERMONOVA, a.s., Nová Dubnica | Ilava | KVARTET, a.s., Partizánske | Partizánske |
| 9. | TSM Partizánske | Partizánske | Služby pre bývanie, s.r.o., Trenčín | Trenčín |
| 10. | Považský cukor, a.s., Trenčianska Teplá | Trenčín | PSL, a.s., Považská Bystrica | Považská Bystrica |

# BANSKÁ BYSTRICA REGION

| | PM | | $SO_2$ | |
|---|---|---|---|---|
| | **Source** | **District** | **Source** | **District** |
| 1. | SLOVALCO, a.s., Žiar nad Hronom | Žiar nad Hronom | SLOVALCO, a.s., Žiar nad Hronom | Žiar nad Hronom |
| 2. | Knauf Insulation, s.r.o., Nová Baňa | Žarnovica | Zvolenská teplárenská, a.s., Zvolen | Zvolen |
| 3. | Zvolenská teplárenská, a.s., Zvolen | Zvolen | Dalkia Industry Žiar nad Hronom, a.s. | Žiar nad Hronom |
| 4. | Smrečina Hofatex, a.s., Banská Bystrica | Banská Bystrica | Knauf Insulation, s.r.o., Nová Baňa | Žarnovica |
| 5. | Calmit, s.r.o., Bratislava, prev. Tisovec | Rimavská Sobota | Slovenské magnezitové závody, a.s., Jelšava | Revúca |
| 6. | Slovmag, a.s., Lubeník | Revúca | Slovmag, a.s., Lubeník | Revúca |
| 7. | Harmanec-Kuvert, s.r.o., Brezno | Brezno | MO SR, PS budov Banská Bystrica | Brezno |
| 8. | MO SR, PS budov Banská Bystrica | Brezno | Hriňovská energetická, spol. s r.o. Hriňová | Detva |
| 9. | Slovenské magnezitové závody, a.s., Jelšava | Revúca | Ipeľské tehelne, a.s., Lučenec, záv. Poltár | Poltár |
| 10. | Hriňovská energetická, spol. s r.o. Hriňová | Detva | Baňa Dolina, a.s., Veľký Krtíš | Veľký Krtíš |
| | **$NO_x$** | | **CO** | |
| | **Source** | **District** | **Source** | **District** |
| 1. | SLOVALCO, a.s., Žiar nad Hronom | Žiar nad Hronom | SLOVALCO, a.s., Žiar nad Hronom | Žiar nad Hronom |
| 2. | eustream, a.s., prev. Veľké Zlievce | Veľký Krtíš | Calmit, s.r.o., Bratislava, prev. Tisovec | Rimavská Sobota |
| 3. | Slovenské magnezitové závody, a.s., Jelšava | Revúca | Slovenské magnezitové závody, a.s., Jelšava | Revúca |
| 4. | Zvolenská teplárenská, a.s., Zvolen | Zvolen | Slovmag, a.s., Lubeník | Revúca |
| 5. | Dalkia Industry Žiar nad Hronom, a.s. | Žiar nad Hronom | Dalkia Industry Žiar nad Hronom, a.s. | Žiar nad Hronom |
| 6. | Slovmag, a.s., Lubeník | Revúca | Železiarne Podbrezová, a.s. | Brezno |
| 7. | Slovglass Poltár, s.r.o., Poltár | Poltár | VUM, a.s., Žiar nad Hronom | Žiar nad Hronom |
| 8. | Smrečina Hofatex, a.s., Banská Bystrica | Banská Bystrica | Ipeľské tehelne, a.s., Lučenec, záv. Poltár | Poltár |
| 9. | Železiarne Podbrezová, a.s. | Brezno | Zvolenská teplárenská, a.s., Zvolen | Zvolen |
| 10. | Knauf Insulation, s.r.o., Nová Baňa | Žarnovica | Knauf Insulation, s.r.o., Nová Baňa | Žarnovica |

# ŽILINA REGION

| | PM | | $SO_2$ | |
|---|---|---|---|---|
| | **Source** | **District** | **Source** | **District** |
| 1. | Mondi scp, a.s., Ružomberok | Ružomberok | Žilinská teplárenská, a.s., Žilina | Žilina |
| 2. | Žilinská teplárenská, a.s., Žilina | Žilina | Martinská teplárenská, a.s., Martin | Martin |
| 3. | DOLVAP, s.r.o., Varín | Žilina | Mondi scp, a.s., Ružomberok | Ružomberok |
| 4. | SOTE, s.r.o., Čadca | Čadca | SOTE, s.r.o., Čadca | Čadca |
| 5. | Martinská teplárenská, a.s., Martin | Martin | ŽOS Vrútky a.s. | Martin |
| 6. | OFZ, a.s., Istebné | Dolný Kubín | OFZ, a.s., Istebné | Dolný Kubín |
| 7. | Swedwood Slovakia, s.r.o., prev. Závažná Poruba | Liptovský Mikuláš | ZDROJ MT, s.r.o., Martin - Priekopa | Martin |
| 8. | DOLKAM Šuja ,a.s., Rajec | Žilina | Spojená škola internátna Námestovo | Námestovo |
| 9. | KOMTERM, a.s., Bratislava | Tvrdošín | Domov dôch. a domov soc. služieb pre dosp. Novoť | Námestovo |
| 10 | BEKAM, s.r.o Žilina | Žilina | Slovnaft Bratislava, terminál Horný Hričov | Žilina |
| | **$NO_x$** | | **CO** | |
| | **Source** | **District** | **Source** | **District** |
| 1. | Mondi scp, a.s., Ružomberok | Ružomberok | DOLVAP, s.r.o., Varín | Žilina |
| 2. | Žilinská teplárenská, a.s., Žilina | Žilina | OFZ, a.s., Istebné | Dolný Kubín |
| 3. | Martinská teplárenská, a.s., Martin | Martin | Mondi scp, a.s., Ružomberok | Ružomberok |
| 4. | OFZ, a.s., Istebné | Dolný Kubín | KOMTERM, a.s., Bratislava | Tvrdošín |
| 5. | Rettenmeier Tatra Timber s.r.o., Liptovský Hrádok | Liptovský Mikuláš | SOTE, s.r.o., Čadca | Čadca |
| 6. | SPECIALITY MINERALS SLOVAKIA, s.r.o., Ružomb. | Ružomberok | Rettenmeier Tatra Timber, s.r.o., Liptovský Hrádok | Liptovský Mikuláš |
| 7. | KIA Motors Slovakia, s.r.o., Žilina | Žilina | ŽOS Vrútky, a.s. | Martin |
| 8. | SOTE, s.r.o., Čadca | Čadca | Swedwood Slovakia, s.r.o., prev. Závažná Poruba | Liptovský Mikuláš |
| 9. | KYSUCA, s.r.o., Kysucké Nové Mesto | Kysucké Nové | Žilinská teplárenská, a.s., Žilina | Žilina |
| 10 | KOMTERM, a.s., Bratislava | Tvrdošín | Turzovská drevárska fabrika, s.r.o., Turzovka | Čadca |

## 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 SK, s.r.o., Prešov | Prešov | Energy Snina,a.s., | Snina |
| 4. | IS - Lom Maglovec, s.r.o., Vyšná Šebastová | Prešov | Zeocem Bystré, a.s. | Vranov n/Topľou |
| 5. | VSK MINERAL, s.r.o Vechec | Vranov n/Topľou | Zastrova, a.s., Spišská Stará Ves | Kežmarok |
| 6. | TATRAVAGÓNKA, a.s., POPRAD | Poprad | ZŠ Malcov | Bardejov |
| 7. | Zeocem Bystré, a.s. | Vranov n/Topľou | SAD š.p. Poprad - prevádzkareň Levoča | Levoča |
| 8. | TATRY-TEPLO, s r.o. Tatranská Lomnica | Poprad | ZŠ s MŠ Nižný Slavkov | Sabinov |
| 9. | EUROVIA - Kameňolomy, s.r.o., Košice - Barca | Prešov | MO SR, Posádková správa budov Prešov | Prešov |
| 10 | Lesy Slovenskej republiky o.z., Vranov n. Topľou | Vranov n/Topľou | ZŠ s MŠ Plavnica | Stará Ľubovňa |
| | **$NO_x$** | | **CO** | |
| | **Source** | **District** | **Source** | **District** |
| 1. | BUKOCEL, a.s., Hencovce | Vranov n/Topľou | BUKOCEL, a.s., Hencovce | Vranov n/Topľou |
| 2. | CHEMES, a.s., HUMENNÉ | Humenné | Leier Baustoffe SK, s.r.o., Petrovany | Prešov |
| 3. | Energy Snina,a.s., | Snina | CHEMES, a.s., HUMENNÉ | Humenné |
| 4. | SPRAVBYTKOMFORT, a.s., Prešov | Prešov | Kronospan SK, s.r.o., Prešov | Prešov |
| 5. | DALKIA POPRAD, a.s. | Poprad | SPRAVBYTKOMFORT, a.s., Prešov | Prešov |
| 6. | Kronospan SK, s.r.o., Prešov | Prešov | TENERGO BRNO, a.s., prev. Snina | Snina |
| 7. | CHEMOSVIT ENERGOCHEM, a.s., SVIT | Poprad | Energy Snina,a.s., | Snina |
| 8. | BARDTERM, s.r.o., Bardejov | Bardejov | SCHULE SLOVAKIA, s.r.o.,Poprad | Poprad |
| 9. | Zeocem, a.s., Bystré | Vranov n/Topľou | Inžinierske stavby, a.s., Obaľovačka Veľká Lomnica | Kežmarok |
| 10 | TATRAVAGÓNKA, a.s., POPRAD | Poprad | Zeocem, a.s., Bystré | Vranov n/Topľou |

## KOŠICE REGION

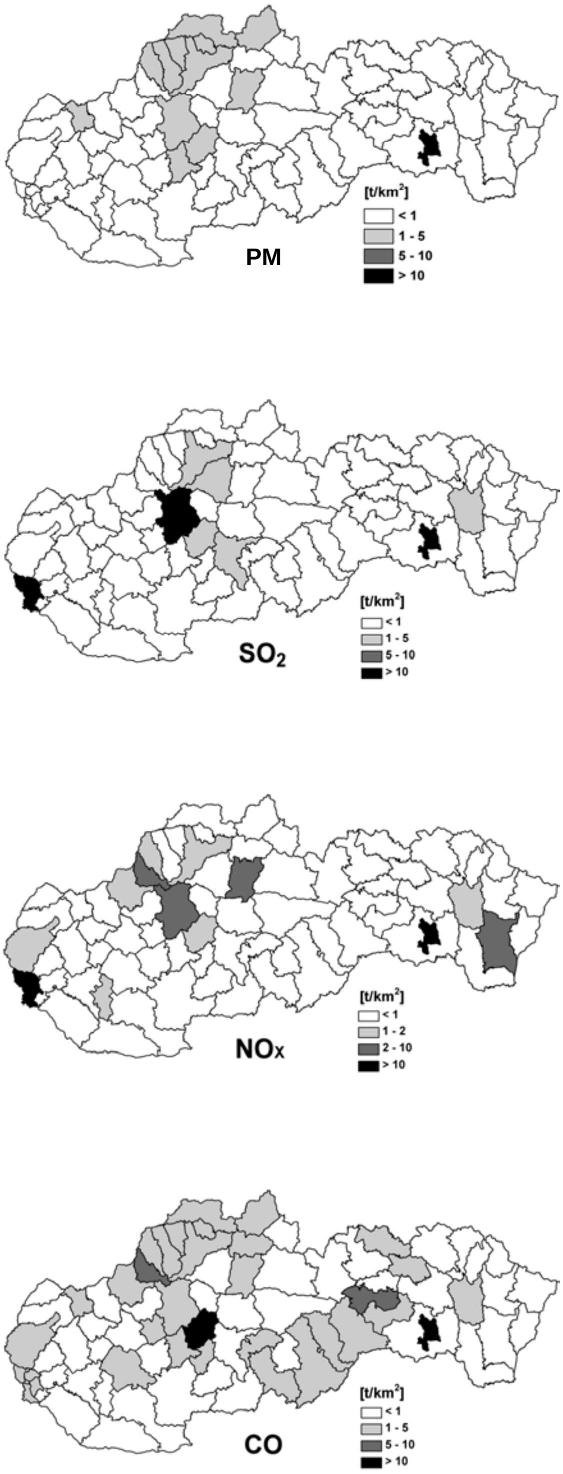
| | PM | | $SO_2$ | |
|---|---|---|---|---|
| | **Source** | **District** | **Source** | **District** |
| 1. | U.S. Steel, s.r.o., Košice | Košice II | U.S. Steel, s.r.o., Košice | Košice II |
| 2. | Carmeuse Slovakia, s.r.o., závod Košice | Košice II | TEKO, a.s., Košice | Košice IV |
| 3. | Carmeuse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

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

Tab. 4.6 **Stationary source emissions by districts in 2009**

| District | Emissions [t.year$^{-1}$] | | | | Specific territorial emis. [t.year$^{-1}$.km$^{-2}$] | | | |
|---|---|---|---|---|---|---|---|---|
| | PM | $SO_2$ | $NO_x$ | CO | PM | $SO_2$ | $NO_x$ | CO |
| 1. Bratislava | 332 | 9265 | 4142 | 837 | 0.90 | 25.18 | 11.25 | 2.27 |
| 2. Malacky | 267 | 146 | 1556 | 3185 | 0.28 | 0.15 | 1.64 | 3.35 |
| 3. Pezinok | 107 | 21 | 89 | 176 | 0.29 | 0.05 | 0.24 | 0.47 |
| 4. Senec | 95 | 11 | 93 | 160 | 0.26 | 0.03 | 0.26 | 0.44 |
| 5. Dunajská Streda | 372 | 43 | 201 | 515 | 0.35 | 0.04 | 0.19 | 0.48 |
| 6. Galanta | 256 | 166 | 296 | 412 | 0.40 | 0.26 | 0.46 | 0.64 |
| 7. Hlohovec | 124 | 18 | 141 | 192 | 0.47 | 0.07 | 0.53 | 0.72 |
| 8. Piešťany | 217 | 25 | 116 | 305 | 0.57 | 0.06 | 0.30 | 0.80 |
| 9. Senica | 322 | 52 | 137 | 468 | 0.47 | 0.08 | 0.20 | 0.68 |
| 10. Skalica | 208 | 25 | 88 | 279 | 0.58 | 0.07 | 0.25 | 0.78 |
| 11. Trnava | 255 | 94 | 402 | 457 | 0.34 | 0.13 | 0.54 | 0.62 |
| 12. Bánovce n/B | 231 | 35 | 80 | 309 | 0.50 | 0.08 | 0.17 | 0.67 |
| 13. Ilava | 337 | 34 | 887 | 2389 | 0.94 | 0.09 | 2.48 | 6.67 |
| 14. Myjava | 330 | 38 | 90 | 437 | 1.01 | 0.12 | 0.28 | 1.34 |
| 15. Nové Mesto n/V | 310 | 36 | 135 | 425 | 0.53 | 0.06 | 0.23 | 0.73 |
| 16. Partizánske | 160 | 18 | 106 | 419 | 0.53 | 0.06 | 0.35 | 1.39 |
| 17. Považská Bystrica | 575 | 264 | 299 | 1054 | 1.24 | 0.57 | 0.65 | 2.28 |
| 18. Prievidza | 1308 | 32561 | 4171 | 1609 | 1.36 | 33.92 | 4.34 | 1.68 |
| 19. Púchov | 494 | 64 | 454 | 671 | 1.32 | 0.17 | 1.21 | 1.79 |
| 20. Trenčín | 401 | 202 | 1106 | 3168 | 0.59 | 0.30 | 1.64 | 4.69 |
| 21. Komárno | 392 | 45 | 213 | 562 | 0.36 | 0.04 | 0.19 | 0.51 |
| 22. Levice | 1026 | 133 | 480 | 1432 | 0.66 | 0.09 | 0.31 | 0.92 |
| 23. Nitra | 319 | 42 | 781 | 2591 | 0.37 | 0.05 | 0.90 | 2.97 |
| 24. Nové Zámky | 598 | 776 | 833 | 872 | 0.44 | 0.58 | 0.62 | 0.65 |
| 25. Šaľa | 233 | 19 | 679 | 260 | 0.65 | 0.05 | 1.91 | 0.73 |
| 26. Topoľčany | 192 | 25 | 133 | 280 | 0.32 | 0.04 | 0.22 | 0.47 |
| 27. Zlaté Moravce | 232 | 27 | 102 | 389 | 0.44 | 0.05 | 0.20 | 0.75 |
| 28. Bytča | 389 | 48 | 107 | 518 | 1.38 | 0.17 | 0.38 | 1.84 |
| 29. Čadca | 1174 | 259 | 324 | 1680 | 1.54 | 0.34 | 0.43 | 2.21 |
| 30. Dolný Kubín | 322 | 76 | 274 | 1116 | 0.65 | 0.15 | 0.56 | 2.27 |
| 31. Kysucké Nové Mesto | 247 | 27 | 93 | 330 | 1.42 | 0.16 | 0.54 | 1.90 |
| 32. Liptovský Mikuláš | 600 | 74 | 326 | 934 | 0.45 | 0.05 | 0.24 | 0.70 |
| 33. Martin | 465 | 975 | 475 | 727 | 0.63 | 1.32 | 0.65 | 0.99 |
| 34. Námestovo | 1150 | 175 | 263 | 1533 | 1.66 | 0.25 | 0.38 | 2.22 |
| 35. Ružomberok | 761 | 205 | 1400 | 1211 | 1.18 | 0.32 | 2.16 | 1.87 |
| 36. Turčianske Teplice | 208 | 28 | 55 | 280 | 0.53 | 0.07 | 0.14 | 0.71 |
| 37. Tvrdošín | 192 | 23 | 75 | 350 | 0.40 | 0.05 | 0.16 | 0.73 |
| 38. Žilina | 939 | 1494 | 863 | 2895 | 1.15 | 1.83 | 1.06 | 3.55 |
| 39. Banská Bystrica | 537 | 63 | 338 | 794 | 0.66 | 0.08 | 0.42 | 0.98 |
| 40. Banská Štiavnica | 250 | 35 | 61 | 330 | 0.86 | 0.12 | 0.21 | 1.13 |
| 41. Brezno | 637 | 125 | 253 | 1035 | 0.50 | 0.10 | 0.20 | 0.82 |
| 42. Detva | 414 | 64 | 160 | 587 | 0.92 | 0.14 | 0.36 | 1.31 |
| 43. Krupina | 353 | 44 | 85 | 478 | 0.60 | 0.08 | 0.15 | 0.82 |
| 44. Lučenec | 618 | 74 | 194 | 847 | 0.75 | 0.09 | 0.23 | 1.03 |
| 45. Poltár | 210 | 44 | 185 | 360 | 0.44 | 0.09 | 0.39 | 0.76 |
| 46. Revúca | 497 | 281 | 687 | 2220 | 0.68 | 0.39 | 0.94 | 3.04 |
| 47. Rimavská Sobota | 1095 | 135 | 305 | 4641 | 0.74 | 0.09 | 0.21 | 3.15 |
| 48. Veľký Krtíš | 498 | 80 | 636 | 721 | 0.59 | 0.09 | 0.75 | 0.85 |
| 49. Zvolen | 352 | 1156 | 587 | 550 | 0.46 | 1.52 | 0.77 | 0.72 |
| 50. Žarnovica | 497 | 314 | 180 | 639 | 1.17 | 0.74 | 0.42 | 1.50 |
| 51. Žiar n/H | 539 | 1704 | 795 | 14402 | 1.04 | 3.29 | 1.53 | 27.80 |
| 52. Bardejov | 397 | 50 | 131 | 540 | 0.42 | 0.05 | 0.14 | 0.58 |
| 53. Humenné | 408 | 288 | 405 | 606 | 0.54 | 0.38 | 0.54 | 0.80 |
| 54. Kežmarok | 415 | 58 | 133 | 574 | 0.49 | 0.07 | 0.16 | 0.68 |
| 55. Levoča | 212 | 29 | 64 | 291 | 0.59 | 0.08 | 0.18 | 0.81 |
| 56. Medzilaborce | 176 | 20 | 43 | 232 | 0.41 | 0.05 | 0.10 | 0.54 |
| 57. Poprad | 293 | 31 | 190 | 441 | 0.27 | 0.03 | 0.17 | 0.40 |
| 58. Prešov | 518 | 56 | 281 | 884 | 0.55 | 0.06 | 0.30 | 0.95 |
| 59. Sabinov | 393 | 49 | 122 | 533 | 0.81 | 0.10 | 0.25 | 1.10 |
| 60. Snina | 414 | 158 | 203 | 611 | 0.51 | 0.20 | 0.25 | 0.76 |
| 61. Stará Ľubovňa | 511 | 65 | 144 | 699 | 0.82 | 0.10 | 0.23 | 1.12 |
| 62. Stropkov | 140 | 16 | 42 | 191 | 0.36 | 0.04 | 0.11 | 0.49 |
| 63. Svidník | 266 | 32 | 75 | 351 | 0.48 | 0.06 | 0.14 | 0.64 |
| 64. Vranov n/T | 465 | 1091 | 951 | 1089 | 0.60 | 1.42 | 1.24 | 1.42 |
| 65. Gelnica | 394 | 50 | 99 | 637 | 0.67 | 0.09 | 0.17 | 1.09 |
| 66. Košice | 3009 | 9087 | 8167 | 68477 | 12.38 | 37.39 | 33.61 | 281.80 |
| 67. Košice - okolie | 886 | 128 | 1212 | 1164 | 0.58 | 0.08 | 0.79 | 0.76 |
| 68. Michalovce | 244 | 630 | 2597 | 986 | 0.24 | 0.62 | 2.55 | 0.97 |
| 69. Rožňava | 873 | 103 | 921 | 1233 | 0.74 | 0.09 | 0.78 | 1.05 |
| 70. Sobrance | 171 | 24 | 50 | 230 | 0.32 | 0.04 | 0.09 | 0.43 |
| 71. Spišská Nová Ves | 403 | 142 | 175 | 3579 | 0.69 | 0.24 | 0.30 | 6.10 |
| 72. Trebišov | 379 | 51 | 179 | 545 | 0.35 | 0.05 | 0.17 | 0.51 |
| Slovakia | **33603** | **63847** | **42712** | **146920** | **0.69** | **1.30** | **0.87** | **3.00** |

Fig. 4.3 **Specific territorial emission in 2009**

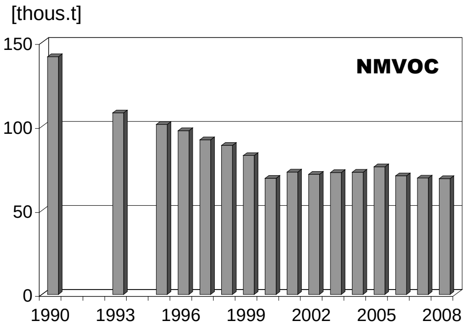


Tab. 4.7 **NMVOC emissions [t] in the SR in 1990 – 2008**

| **Sector** / Subsector | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Combustion processes I** | **335** | **258** | **201** | **221** | **215** | **214** | **203** | **185** | **174** | **158** | **172** |
| Public power | 223 | 187 | 139 | 159 | 147 | 161 | 156 | 139 | 131 | 121 | 130 |
| District heating plants | 112 | 71 | 62 | 62 | 67 | 53 | 47 | 46 | 43 | 37 | 42 |
| **Combustion processes II** | **12641** | **9618** | **7913** | **8305** | **7070** | **7505** | **8931** | **11934** | **11162** | **11113** | **11174** |
| Commercial and institutional plants | 226 | 150 | 26 | 27 | 23 | 24 | 25 | 28 | 27 | 29 | 33 |
| Agriculture | IE | IE | 6 | 7 | 7.5 | 7 | 7 | 9 | 8 | 6 | 6 |
| Residential plants | 12415 | 9468 | 7881 | 8271 | 7040 | 7474 | 8899 | 11897 | 11127 | 11078 | 11135 |
| **Combustion processes in industry** | **981** | **805** | **585** | **772** | **647** | **703** | **753** | **806** | **898** | **881** | **884** |
| Comb. in boilers, gas turb. and stat. engines | 206 | 150 | 159 | 231 | 146 | 168 | 121 | 121 | 117 | 94 | 94 |
| Iron production | 32 | 29 | 28 | 29 | 32 | 35 | 34 | 33 | 37 | 36 | 32 |
| Ore agglomeration | 438 | 358 | 396 | 403 | 383 | 409 | 403 | 384 | 390 | 367 | 338 |
| Copper production | 305 | 268 | 2 | 109 | 85 | 91 | 195 | 268 | 353 | 384 | 420 |
| **Production processes** | **27029** | **11129** | **8717** | **8343** | **7727** | **7149** | **7103** | **6434** | **5823** | **5474** | **4903** |
| Processes in petroleum industries | 17188 | 7474 | 6627 | 6306 | 5571 | 4671 | 4617 | 4058 | 3469 | 3166 | 2804 |
| Coke production | 1053 | 834 | 719 | 719 | 765 | 801 | 800 | 783 | 787 | 783 | 720 |
| Steel production | 43 | 36 | 34 | 37 | 40 | 42 | 41 | 41 | 47 | 47 | 42 |
| Rolling mills | 233 | 297 | 300 | 267 | 304 | 336 | 329 | 341 | 361 | 372 | 347 |
| Aluminium production | 0.101 | 0.049 | 0.165 | 0.165 | 0.165 | 0.167 | 0.235 | 0.2 | 0.2 | 0.3 | 0.2 |
| Proc. in organic chemical industries | 6437 | 1369 | 651 | 644 | 690 | 941 | 970 | 870 | 845 | 793 | 667 |
| Food production | 2073 | 1118 | 385 | 370 | 357 | 358 | 346 | 340 | 311 | 312 | 322 |
| Road paving with asphalt | 2.4 | 1.0 | 0.5 | 0.5 | 0.5 | 0.6 | 0.5 | 0.7 | 1.0 | 0.7 | 0.8 |
| **Exploitation&distrib. of natural resour.** | **8822** | **8535** | **5929** | **6161** | **6024** | **7431** | **7696** | **7104** | **6275** | **6170** | **6362** |
| Exploitation&distribution of crude oil | 5198 | 4298 | 3750 | 3848 | 3801 | 3999 | 4149 | 4280 | 4472 | 4266 | 4272 |
| Distribution of fuel | 3624 | 4237 | 2179 | 2313 | 2223 | 3432 | 3547 | 2824 | 1803 | 1904 | 2090 |
| **Solvent and other products use** | **52875** | **37065** | **26978** | **28724** | **31019** | **32272** | **32759** | **33561** | **34633** | **33579** | **33963** |
| Use of paints and glues | 32811 | 20687 | 13214 | 14025 | 15110 | 16369 | 18457 | 18918 | 19522 | 20003 | 20385 |
| Dry cleaning and degreasing | 11500 | 7695 | 5091 | 6171 | 7331 | 7408 | 5821 | 6101 | 6600 | 5057 | 5052 |
| Processing of fat and oil | 332 | 363 | 299 | 191 | 240 | 156 | 134 | 189 | 151 | 147 | 137 |
| Products | 8232 | 8320 | 8374 | 8337 | 8338 | 8339 | 8347 | 8353 | 8360 | 8371 | 8389 |
| **Road transport** | **32611** | **32373** | **17391** | **19022** | **17314** | **15620** | **13932** | **14471** | **10287** | **10577** | **9978** |
| **Other transport** | **953** | **599** | **528** | **524** | **500** | **460** | **477** | **496** | **449** | **477** | **442** |
| **Waste incineration** | **4631** | **388** | **428** | **322** | **580** | **759** | **449** | **542** | **510** | **382** | **614** |
| Municipal waste | 71 | 107 | 147 | 93 | 111 | 115 | 130 | 130 | 135 | 128 | 112 |
| Industrial waste | 281 | 281 | 281 | 229 | 469 | 642 | 317 | 409 | 371 | 251 | 499 |
| Hospital waste | IE | IE | 0.1 | 0.1 | 0.1 | 1.5 | 2.1 | 2.8 | 3.7 | 2.5 | 2.7 |
| Agricultural waste* | 4279 | | | | | | | | | | |
| **Agriculture** | **651** | **436** | **436** | **436** | **436** | **436** | **436** | **436** | **436** | **437** | **438** |
| **Total** | **141529** | **101206** | **69106** | **72830** | **71532** | **72550** | **72739** | **75969** | **70647** | **69248** | **68930** |

*Emissions from road and other transport estimated to November 18th, 2010, emissions from the other sectors estimated to February 15th, 2010.*
*IE = included in other source category*
** Agricultural waste combustion is prohibited since 1994*
*Because of changeover from EAPSI to NEIS in year 2000 some changes of source appointment have to be done in the framework of subsectors combustion in boilers, gas turbines and stationary engines; commercial and institutional plants and new sector agriculture (sector non-industrial combustion plants) was established.*

Fig. 4.4 **Development trends in NMVOC emissions in 1990 – 2008**

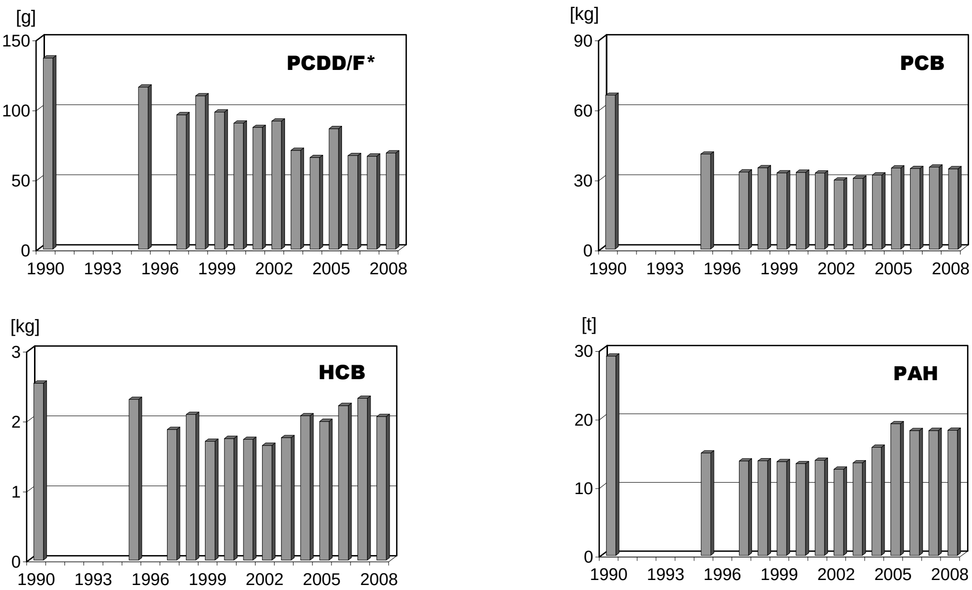


Tab. 4.8 **Emissions of persistent organic pollutants in the SR in 2008**

| **Sector** / Subsector | PCDD/F* | PCB | HCB | PAH | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | sum PAH | B(a)P | B(k)F | B(b)F | I(1,2,3-cd)P |
| | [g] | [kg] | [kg] | [kg] | [kg] | [kg] | [kg] | [kg] |
| **Combustion processes I** | **6.586** | **0.817** | **0.202** | **1473.529** | **189.791** | **401.780** | **401.873** | **480.084** |
| Public power | 1.688 | 0.811 | 0.196 | 0.466 | 0.039 | 0.134 | 0.225 | 0.068 |
| District heating plants | 0.098 | 0.007 | 0.006 | 3.320 | 0.009 | 1.646 | 1.649 | 0.016 |
| Coke production | 4.800 | 0.000 | 0.000 | 1469.743 | 189.743 | 400.000 | 400.000 | 480.000 |
| **Combustion processes II** | **3.288** | **8.867** | **0.166** | **15038.622** | **4299.841** | **1877.665** | **5645.289** | **3215.827** |
| Commercial and institutional plants | 0.025 | 0.007 | 0.002 | 0.424 | 0.005 | 0.200 | 0.212 | 0.008 |
| Residential plants | 3.259 | 8.859 | 0.164 | 15038.048 | 4299.835 | 1877.396 | 5645.001 | 3215.816 |
| Agriculture | 0.004 | 0.001 | 0.000 | 0.150 | 0.002 | 0.070 | 0.075 | 0.003 |
| **Combustion processes in industry** | **23.668** | **6.101** | **0.391** | **116.671** | **65.709** | **18.079** | **24.441** | **8.442** |
| Comb. in boilers, gas turb. and stat. eng. | 0.473 | 0.732 | 0.108 | 17.814 | 1.511 | 4.324 | 9.530 | 2.448 |
| Iron production | 0.354 | 0.023 | 0.000 | 60.168 | 60.168 | 0.000 | 0.000 | 0.000 |
| Ore agglomeration | 21.510 | 3.379 | 0.098 | 35.846 | 3.686 | 13.362 | 13.362 | 5.437 |
| Cast iron production | 0.122 | 0.023 | 0.000 | 0.019 | 0.004 | 0.006 | 0.006 | 0.003 |
| Others | 1.209 | 1.944 | 0.185 | 2.823 | 0.340 | 0.387 | 1.543 | 0.554 |
| **Production processes** | **6.696** | **1.927** | **0.672** | **1329.689** | **479.711** | **394.795** | **403.739** | **51.445** |
| Aluminium production | 0.527 | 0.088 | 0.000 | 598.372 | 195.595 | 189.082 | 189.082 | 24.613 |
| Steel production | 4.672 | 1.766 | 0.000 | 78.404 | 78.404 | 0.000 | 0.000 | 0.000 |
| Carbon mineral production | 0.000 | 0.000 | 0.000 | 652.913 | 205.712 | 205.712 | 214.656 | 26.832 |
| Wood impregnation | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Others | 1.498 | 0.073 | 0.672 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **Road transport** | **0.426** | **14.264** | **0.011** | **130.427** | **16.495** | **46.758** | **46.467** | **20.705** |
| **Other transport** | **0.007** | **0.725** | **0.058** | **8.705** | **2.258** | **1.355** | **3.162** | **2.258** |
| **Waste incineration** | **27.860** | **1.672** | **0.609** | **145.472** | **41.618** | **28.073** | **59.851** | **15.930** |
| Municipal waste | 3.769 | 0.929 | 0.526 | 6.815 | 0.123 | 3.331 | 3.331 | 0.030 |
| Industrial waste | 1.710 | 0.228 | 0.068 | 0.886 | 0.016 | 0.433 | 0.433 | 0.004 |
| Hospital waste | 21.602 | 0.432 | 0.002 | 1.679 | 0.030 | 0.821 | 0.821 | 0.007 |
| Others | 0.778 | 0.083 | 0.012 | 136.091 | 41.449 | 23.488 | 55.265 | 15.889 |
| **Total** | **68.531** | **34.373** | **2.109** | **18243.114** | **5095.423** | **2768.506** | **6584.821** | **3794.691** |

*B(a)P - Benzo(a)pyrene, B(k)F - Benzo(k)fluorantene, B(b)F - Benzo(b)fluorantene, I(1,2,3-cd)P - Indeno(1,2,3-cd)pyrene*
**Expressed as I-TEQ; I-TEQ is calculated from the values for 2,3,7,8 - substituted co-geners of PCDD and PCDF under using of I-TEF according NATO/CCMS (1988).*
*Emissions from road and other transport estimated to November 18$^{th}$, 2010, emissions from other sectors estimated to February 15$^{th}$, 2010.*

Fig. 4.5 **Development trends in POPs emissions in 1990 – 2008**

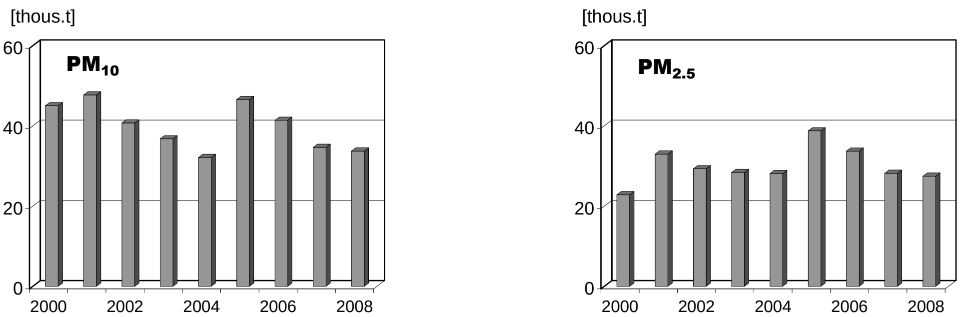


Tab. 4.9 **$PM_{10}$ and $PM_{2.5}$ emissions [thous. t] in the SR in 2003 – 2008**

| **Sector** / Subsector | 2003 | | 2004 | | 2005 | | 2006 | | 2007 | | 2008 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $PM_{10}$ [Gg] | $PM_{2,5}$ [Gg] | $PM_{10}$ [Gg] | $PM_{2,5}$ [Gg] | $PM_{10}$ [Gg] | $PM_{2,5}$ [Gg] | $PM_{10}$ [Gg] | $PM_{2,5}$ [Gg] | $PM_{10}$ [Gg] | $PM_{2,5}$ [Gg] | $PM_{10}$ [Gg] | $PM_{2,5}$ [Gg] |
| **Combustion processes I** | **7.127** | **6.459** | **6.934** | **6.356** | **10.611** | **9.976** | **6.985** | **6.531** | **1.474** | **1.085** | **1.365** | **1.022** |
| Public Electricity and Heat Production | 6.154 | 5.873 | 5.993 | 5.781 | 9.671 | 9.399 | 6.362 | 6.168 | 0.86 | 0.734 | 0.822 | 0.702 |
| Petroleum refining | 0.094 | 0.002 | 0.08 | 0.002 | 0.075 | 0.002 | 0.079 | 0.002 | 0.089 | 0.002 | 0.061 | 0.002 |
| Coke production | 0.879 | 0.584 | 0.861 | 0.573 | 0.865 | 0.575 | 0.544 | 0.361 | 0.525 | 0.349 | 0.482 | 0.318 |
| **Combustion processes II** | **17.185** | **14.613** | **20.298** | **17.872** | **27.232** | **24.46** | **25.428** | **22.679** | **25.33** | **23.047** | **25.465** | **23.141** |
| Commercial and institutional plants | 0.293 | 0.171 | 0.233 | 0.14 | 0.201 | 0.133 | 0.164 | 0.11 | 0.134 | 0.091 | 0.169 | 0.119 |
| Residential plants | 16.563 | 14.321 | 19.836 | 17.644 | 26.742 | 24.23 | 25.016 | 22.485 | 25.044 | 22.903 | 25.136 | 22.966 |
| Agriculture | 0.109 | 0.048 | 0.099 | 0.044 | 0.126 | 0.046 | 0.110 | 0.039 | 0.09 | 0.037 | 0.106 | 0.044 |
| Other combustion processes | 0.220 | 0.073 | 0.130 | 0.043 | 0.163 | 0.052 | 0.138 | 0.045 | 0.062 | 0.015 | 0.054 | 0.012 |
| **Combustion processes in industry** | **9.399** | **5.273** | **1.881** | **1.459** | **4.777** | **1.471** | **4.781** | **1.462** | **3.747** | **1.016** | **3.283** | **0.806** |
| Production of iron and steel | 6.345 | 4.229 | 0.849 | 0.730 | 2.111 | 0.511 | 2.532 | 0.569 | 2.005 | 0.363 | 1.748 | 0.274 |
| Production of non-ferrous metals | 0.133 | 0.025 | 0.014 | 0.006 | 0.164 | 0.025 | 0.126 | 0.022 | 0.119 | 0.021 | 0.169 | 0.023 |
| Chemical industry | 0.489 | 0.357 | 0.212 | 0.191 | 0.434 | 0.367 | 0.355 | 0.300 | 0.188 | 0.162 | 0.208 | 0.185 |
| Production of paper and cellulose | 0.328 | 0.115 | 0.094 | 0.080 | 0.418 | 0.127 | 0.325 | 0.096 | 0.099 | 0.055 | 0.102 | 0.048 |
| Food production | 0.093 | 0.063 | 0.086 | 0.069 | 0.101 | 0.081 | 0.100 | 0.079 | 0.060 | 0.030 | 0.054 | 0.024 |
| Other combustion processes in industry | 2.011 | 0.484 | 0.626 | 0.384 | 1.549 | 0.362 | 1.343 | 0.396 | 1.276 | 0.385 | 1.002 | 0.252 |
| **Transport** | **2.595** | **2.004** | **2.992** | **2.42** | **3.509** | **2.818** | **3.735** | **2.979** | **3.706** | **2.978** | **3.207** | **2.441** |
| Civil aviation | 0.007 | 0.007 | 0.008 | 0.008 | 0.01 | 0.010 | 0.009 | 0.009 | 0.01 | 0.01 | 0.012 | 0.012 |
| Road transport | 1.598 | 1.341 | 1.939 | 1.721 | 2.297 | 2.040 | 2.31 | 2.077 | 2.445 | 2.175 | 1.978 | 1.655 |
| Road transport - abrasion | 0.685 | 0.366 | 0.727 | 0.389 | 0.875 | 0.467 | 1.084 | 0.578 | 0.943 | 0.499 | 0.922 | 0.492 |
| Railways | 0.147 | 0.140 | 0.141 | 0.134 | 0.144 | 0.130 | 0.137 | 0.13 | 0.145 | 0.139 | 0.126 | 0.122 |
| Navigation | 0.158 | 0.150 | 0.177 | 0.168 | 0.183 | 0.171 | 0.195 | 0.185 | 0.163 | 0.155 | 0.169 | 0.160 |
| **Industrial technologies** | **0.473** | **0.072** | **0.023** | **0.001** | **0.459** | **0.048** | **0.467** | **0.057** | **0.402** | **0.047** | **0.413** | **0.046** |
| Mineral products | 0.254 | 0.003 | 0.015 | < 0.001 | 0.316 | 0.004 | 0.345 | 0.004 | 0.300 | 0.003 | 0.312 | 0.004 |
| Chemical industry | 0.062 | 0.045 | 0.002 | < 0.001 | 0.041 | 0.028 | 0.058 | 0.043 | 0.048 | 0.036 | 0.044 | 0.034 |
| Paper and pulp | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.001 | < 0.001 | 0.002 | < 0.001 | 0.002 | < 0.001 |
| Other industrial processes | 0.157 | 0.024 | 0.006 | 0.001 | 0.102 | 0.016 | 0.063 | 0.01 | 0.052 | 0.007 | 0.055 | 0.008 |
| **Total** | **36.779** | **28.421** | **32.128** | **28.108** | **46.588** | **38.773** | **41.396** | **33.708** | **34.659** | **28.173** | **33.733** | **27.456** |

*Emissions from road and other transport estimated to November 18th, 2010, emissions from other sectors estimated to February 15th, 2010.*

Fig. 4.6 **Development trends in $PM_{10}$ and $PM_{2.5}$ emissions in 2000 – 2008**

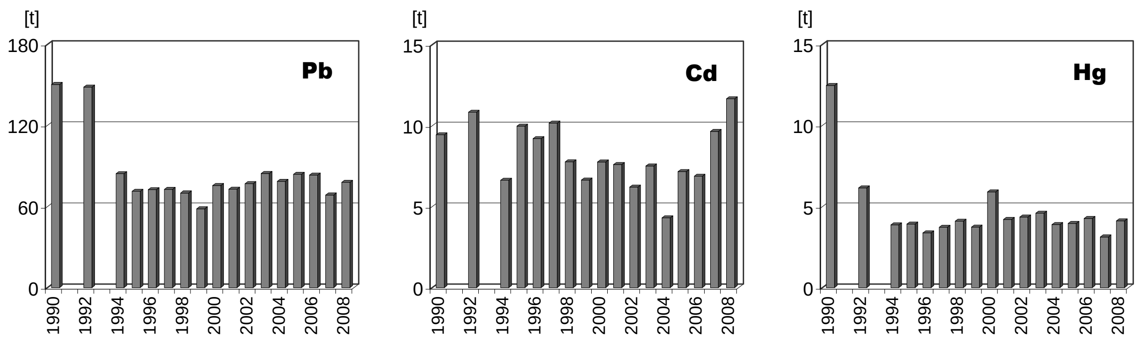


Tab. 4.10 **Emissions of heavy metals [t] in the SR in 2008**

| **Sector** / Subsector | Pb | As | Cd | Cr | Cu | Hg | Ni | Se | Zn |
|---|---|---|---|---|---|---|---|---|---|
| **Combustion processes I** | **0.664** | **0.356** | **0.028** | **0.080** | **0.069** | **0.022** | **0.160** | **0.010** | **0.995** |
| Public power | 0.035 | 0.297 | 0.001 | 0.076 | 0.056 | 0.004 | 0.160 | 0.009 | 0.094 |
| District heating plants | 0.629 | 0.059 | 0.027 | 0.004 | 0.013 | 0.018 | 0.003 | 0.0002 | 0.901 |
| **Combustion processes II** | **1.098** | **0.586** | **0.031** | **0.267** | **0.383** | **0.031** | **0.254** | **0.038** | **3.242** |
| Commercial and institutional plants | 0.110 | 0.055 | 0.005 | 0.016 | 0.016 | 0.003 | 0.013 | 0.001 | 0.167 |
| Residential plants | 0.962 | 0.524 | 0.025 | 0.250 | 0.365 | 0.026 | 0.240 | 0.037 | 3.036 |
| Agriculture | 0.026 | 0.007 | 0.001 | 0.002 | 0.002 | 0.001 | 0.001 | 0.0001 | 0.039 |
| **Combustion processes in industry** | **47.937** | **22.311** | **8.941** | **2.733** | **36.478** | **2.106** | **10.750** | **10.317** | **37.524** |
| Comb. in boilers, gas turb. and stat. engines | 4.284 | 0.506 | 0.191 | 0.413 | 0.246 | 0.181 | 6.398 | 0.164 | 5.868 |
| Iron production | 0.120 | 0.011 | 0.191 | 0.910 | 0.071 | 0.304 | 3.030 | 0.039 | 7.578 |
| Glass production | 5.634 | 0.365 | 8.306 | 0.810 | 0.203 | 0.017 | 0.641 | 6.074 | 3.712 |
| Ore agglomeration | 25.982 | 0.594 | 0.015 | 0.572 | 8.539 | 1.558 | 0.655 | 1.206 | 13.594 |
| Copper production | 11.699 | 20.814 | 0.237 | | 27.416 | 0.001 | | 2.834 | 6.712 |
| Cement production | 0.217 | 0.003 | | 0.024 | | 0.045 | 0.025 | 0.0003 | 0.055 |
| Aluminium oxide production | | | | | | | | | |
| Magnesite production | 0.001 | 0.018 | 0.001 | 0.004 | 0.003 | 0.0001 | 0.001 | | 0.005 |
| **Production processes** | **1.670** | **0.087** | **0.038** | **0.814** | **2.832** | **0.184** | **7.497** | **0.014** | **15.722** |
| Steel production | 1.273 | 0.069 | 0.014 | 0.161 | 2.514 | 0.014 | 2.541 | 0.014 | 5.304 |
| Aluminium production | | | 0.016 | | | | 1.630 | | 1.630 |
| Ferro alloys production | 0.169 | 0.012 | 0.005 | 0.003 | 0.006 | | 0.002 | | 0.820 |
| Pig iron production | 0.146 | 0.006 | 0.003 | 0.024 | | | 0.012 | | 0.104 |
| Galvanizing | 0.072 | | | 0.626 | 0.216 | | 3.312 | | 6.264 |
| Alloys (Cu-Zn) production | 0.010 | | | | 0.096 | | | | 1.600 |
| Inorganic chemical industry | | | | | | 0.170 | | | |
| **Road transport** | **2.904** | | **0.024** | **0.434** | **10.791** | | **0.198** | **0.027** | **4.728** |
| **Other transport** | | | **0.72** | **0.362** | **12.332** | | **0.508** | **0.72** | **7.255** |
| **Waste incineration** | **24.485** | **0.033** | **1.886** | **0.946** | **2.466** | **1.780** | **0.474** | **0.032** | **13.121** |
| Municipal waste | 7.065 | 0.008 | 0.393 | 0.707 | 0.973 | 0.283 | 0.424 | 0.002 | 2.669 |
| Industrial waste | 17.325 | 0.025 | 1.485 | 0.238 | 1.485 | 1.485 | 0.050 | 0.030 | 10.395 |
| Hospital waste | 0.095 | 0.0001 | 0.008 | 0.001 | 0.008 | 0.008 | 0.0003 | 0.0002 | 0.057 |
| Cremation | | | | | | 0.004 | | | |
| **Total** | **78.758** | **23.373** | **11.668** | **5.636** | **65.351** | **4.123** | **19.843** | **11.158** | **82.587** |

*Emissions from road and other transport estimated to November 18th, 2010*
*emissions from other sectors estimated to February 15th, 2010.*

Fig. 4.7 **Development trends in heavy metals emissions in 1990 – 2008**



# 5 GREENHOUSE GAS EMISSIONS

# 5.1 GREENHOUSE GAS EMISSIONS

## Framework Convention on Climate Change (UNFCCC)

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 (UNFCCC)[1] - the basic international legal instrument to protect global climate was adopted at the UN conference on the environment and sustainable development (Rio de Janeiro 1992). The final goal of the Convention is to achieve stabilisation of greenhouse gas concentrations in the atmosphere at a level that has not yet developed any dangerous interference in the climate system.

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

## Kyoto protocol

The Kyoto Protocol, adopted by consensus at the third session of the Conference of the Parties (COP-3) in Kyoto, December 1997, enforced the international responsibility for the climate change. The all Annex I countries which ratified the Kyoto Protocol (KP), formally defined their reduction targets in articles of the KP. The Kyoto Protocol came into force on February 16, 2005 after compliance of requirement determined in Article 25, paragraph 1; it means after signing of more than one-half of Annex I countries, that representing of minimum 55% of total $CO_2$ emissions of Annex I countries in 1990 (the signature of the Russian Federation ensured the majority).

The Slovak Republic and the most countries of Central and East Europe agreed to reduce base year level of all six GHG emissions by 8% during the 2008 – 2012 period. The KP targets for the "old" EU-15 member states represent the 8% reduction of all GHGs against base year for the 2008 – 2012 period. The different emission or reduction targets were agreed for each member state with the EU-15 approval as „burden-sharing agreement“ (Article 4, KP).[2] The priority of the Annex I countries to the KP is to achieve reduction target with the most effective economic tools calls as flexible mechanisms (joint implementation, clean development and emission trading).

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

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

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

## Post-Kyoto period

The EU Council agreed to a target to hold the increase in global temperature below 2 °C. This target was incorporated in the Copenhagen Accord and the subsequent agreement at Cancun. Meeting a 2 ºC target implies a restriction on the cumulative level of greenhouse gas emissions over the period to 2050. The actual challenge is to negotiate further international agreement for regulation and mitigation climate change impacts after 2012. EU together with the other Annex I countries push "step wise approach" to mitigate agreed reduction targets.

International action to combat climate change and respond to its adverse effects needs to be transparent, efficient and effective, if we are to achieve the ultimate objective of the UNFCCC, respecting its principles and provisions. The EU believes that a rigorous, robust and transparent system for Monitoring, Reporting and Verification (MRV) of commitments and actions is essential to support a reliable international climate framework for action on climate change. An enhanced system for MRV, based on existing provisions and including international consultation and analysis (ICA), should facilitate recognition of actions, sharing of expertise and experience, learning from each other and building capacity and trust. It will enable Parties to see whether we are on a trajectory globally towards the 2 degree goal. Furthermore, it will support Parties own efforts in transforming their economies onto a safe and sustainable low carbon pathway.

## The EU and legislative framework

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

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

The experiences with the implementation of Decision 280/2004/EC and the cooperation with Member States have also shown that there are areas in which the transparency, accuracy, consistency and efficiency of the existing monitoring and reporting system should be further improved and in which the monitoring and reporting of climate information should be better streamlined with reporting requirements in other EU legal instruments and with UNFCCC and KP reporting.

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

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

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

4 *OJ L 49, 19.2.2004, p. 1.*

5 *Communication from the Commission: Progress Towards Achieving the Kyoto Objectives, Brussels, 7 August 2008.*

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

- Regulation (EC) 443/2009 of the European Parliament and of the Council of 23rd April 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce $CO_2$ emissions from light-duty vehicles.
- Directive 2009/28/EC of the European Parliament and of the Council of 23rd April 2009 on the promotion of the use of energy from renewable resources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.
- Directive 2009/29/EC of the European Parliament and of the Council of 23rd April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission trading scheme of the Community.
- Directive 2009/30/EC of the European Parliament and of the Council of 23rd April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland navigation and repealing Directive 93/12/EEC.
- Directive 2009/31/EC of the European Parliament and of the Council of 23rd April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) 1013/2006.
- Decision 406/2009/EC of the European Parliament and of the Council of 23rd April 2009 on the effort sharing of Member States to reduce their greenhouse gas emissions to meet the Community’s greenhouse gas emission reduction commitments up to 2020.

## Greenhouse effect of the atmosphere

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

## Greenhouse gases

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

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

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

- emissions into the atmosphere
- weakening of natural sink mechanisms

Stabilizing atmospheric concentrations of greenhouse gases will demand a major effort. Without emissions – control policies motivated by concerns about climate change, atmospheric concentrations of carbon dioxide are expected to rise from today's 367 ppm to 490 – 1260 ppm by the year 2100. This would represent a 75 – 350% increase since the year 1750. Stabilizing concentrations at, for example, 450 ppm would require world-wide emissions to fall below 1990 levels within the next few decades. Carbon dioxide is currently responsible for over 60% of the "enhanced" greenhouse effect. This gas occurs naturally in the atmosphere, but burning coal, oil and natural gas is releasing the carbon stored in these "fossil fuels" at an unprecedented rate. Likewise, deforestation releases carbon stored in trees. Current annual emissions amount to over 23 billion $m^3$ of $CO_2$, or almost 1% of the total mass of carbon dioxide in the atmosphere.

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

Methane levels have already increased by a factor of two and a half during the industrial era and currently contribute 18% of the enhanced greenhouse effect. The rapid rise in methane started more recently due to intensive agriculture (mainly rice fields), animal husbandry, coal mining, natural gas mining, its transport and use as well as the biomass burning are all anthropogenic activities. As distinct from $CO_2$, the disintegration of methane in the atmosphere is via chemical reactions (by OH radical). Residence time of methane in the atmosphere is 10 – 12 years. At present, the annual total anthropogenic methane emission is said to be approximately 0.4 billion tons, but the global growth rate of methane budget seemed to have been at steady-state. Permafrost contains large reservoirs of organic carbon and methane accumulated in an ice structure. Rapid global warming and melting of permafrost in polar areas  is potential high risking of methane release into atmosphere.

Nitrous oxide (with an "adjustment-time" of 114 years), a number of industrial gases and ozone contribute the remaining 20% of the enhanced greenhouse effect. Nitrous oxide levels have risen by 16%, mainly due to intensive agriculture, overusing of fertilizers and inconvenient agriculture-technical procedures. Fuel combustion, some industrial technologies, large-scale livestock breeding and sewage are the sources of $N_2O$ emissions. Global anthropogenic emission is estimated to be 3 – 7 million tons of nitrogen per year. Natural sources are approximately twice as large as anthropogenic ones.

While chlorofluorocarbons (CFCs) are stabilizing due to emission controls introduced under Montreal Protocol to protect the stratospheric ozone layer, levels of long-lived gases such as HFCs, PFCs and sulphur hexafluoride are increasing. They are used as carrier gases for sprays, fillings in cooling and extinguishing systems, as insulating substances, as solvents at the production of semiconductors, etc. Apart from the fact that they attack atmospheric ozone, they are very inert gases so that even minor emissions have a great negative effect.

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

# 5.2 GREENHOUSE GAS EMISSIONS IN THE SLOVAK REPUBLIC

Total EU-27 greenhouse gas emissions were equal to 4 089 Mt $CO_2$-equivealents in 2008, this represent a decrease (–2%) compared to 2007, bringing emissions at the lowest level (–11.3%) since 1990 without emissions and removals from land use, land use change and forestry (LULUCF) and international bunkers (international aviation and maritime). The projected decrease in EU-27, compared to 1990, can reaches 20% in 2020 if additional domestic policies and measures are taken into account. Based on these data can be assumed, that the share of EU-27 GHG emissions on world emission is 11.7%.

Between 1990 and 2008, EU-27 per capita emissions declined to 9.9 tonnes $CO_2$ equivalents. The main decrease occurred particularly in the early 90-ies. Comparable with other world are higher (7 t $CO_2$ equivalents per capita). Emissions per capita differ among EU countries and correspond with energy intensity (primary energy consumption per capita) and energy mix (emission per produced energy unit). All new member states, except Cyprus, Malta and Slovenia have decreased their per capita emissions substantially since 1990.

Total aggregated GHG emissions decreased in new member states by 36.7% in 2008 comparable to the base year 1990, mainly due to introduction of market economies and the consequent restructuring or closure of heavily polluting and energy-intensive industries. Introducing more efficient low-carbon technologies and increasing share of services on total Gross Domestic Product (GDP) grow. The transport sector, especially road transport is most growing sector in all EU member states, where additional policies and measures are required.

The emissions of greenhouse gases in the Slovak Republic are estimated in accordance with the requirements of the UNFCCC[1] and the Kyoto Protocol. The values listed in tables are updated annually if information provided in the Statistical Yearbook of the Slovak Republic is revised and/or if methodology is changed. Emissions were estimated in compliance with the methods provided in the IPCC Guidelines,[7] Good Practice Guidance (GPG)[8] and in the SHMÚ's reports. The Fifth National Communication of the SR on Climate Change was submitted on December 31, 2009 to the UNFCCC secretariat. The Communication is accessible on the web page www.enviro.gov.sk and was revised by expert review team. In September 2010, the National Inventory System of the Slovak Republic[9] was revised under the in-depth review for the inventory submission 2010 of the SR by expert review team under responsibility of the UNFCCC secretariat. The list of potential problems was published into the outcome report from the review for the information for Ministry of Environment of the SR and SHMÚ. The in-depth revision was a tool for the analysis of current status in the parties of the KP and to get eligibility for participation of the Kyoto flexible mechanisms. Further information about the National Inventory System is available on the website http://ghg-inventory.shmu.sk.

Total GHG emission represented 48999.01 Gg in 2008 (without sinks from land use, land use change and forestry (LULUCF)). This represents a reduction by more than 34% in comparison with the base year 1990. In comparison with 2007, the emissions increased by 2.3%. The emissions signified in the literature as net emissions with the sinks from LULUCF in 2008 were 46922.65 Gg and decreased against base year by 34.4% caused by higher sinks in LULUCF and removing the consequences from the storm calamity in the High Tatra mountains. According to the decision of the Convention body the strictly recommended reporting software is CRFReporter, which generate automatically the required CRF Tables. The new reporting program was used also for recalculation the time series in the consistency way. The base year was agreed by national authority (the Ministry

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[7] *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventory, Volume 1-3*
[8] *Good Practice Guidance and Uncertainty Management in National GHGs Inventories, IPCC 2000*
[9] *Vestnik MZP SR, 2007, 3, pages 19-45*

of Environment). Total GHG emissions in the Slovak Republic are stable or slightly increasing due to recovery of economic activities, increase in transport, and expected increase in actual emissions of F-gases (mainly HFCs and $SF_6$). The first results of preliminary GHG inventory for 2009 show the decrease of emissions and increase of sinks caused by economic recession and natural gas crises from the beginning of 2009 (Tab. 5.1).

Tab. 5.1 **Aggregate[10] anthropogenic emissions of GHG [Tg] in Slovakia in 1990 – 2008**

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ | 62.69 | 56.34 | 52.74 | 48.41 | 46.29 | 44.79 | 43.25 | 42.15 | 42.76 | 42.31 | 41.18 | 42.36 | 40.83 | 42.17 | 41.96 | 41.48 | 40.76 | 38.96 | 39.86 |
| $CH_4$ | 4.81 | 4.67 | 4.40 | 4.10 | 4.09 | 4.27 | 4.23 | 4.26 | 4.53 | 4.72 | 4.45 | 4.49 | 5.20 | 4.96 | 4.87 | 4.66 | 4.74 | 4.62 | 4.76 |
| $N_2O$ | 6.16 | 5.04 | 4.22 | 3.58 | 3.93 | 4.16 | 4.29 | 4.19 | 3.78 | 3.33 | 3.54 | 3.72 | 3.77 | 3.79 | 3.84 | 3.83 | 4.20 | 4.03 | 4.06 |
| HFCs | NO | NO | NO | NO | 0.00 | 0.02 | 0.04 | 0.06 | 0.04 | 0.07 | 0.08 | 0.08 | 0.10 | 0.13 | 0.15 | 0.17 | 0.20 | 0.23 | 0.26 |
| PFCs | 0.27 | 0.27 | 0.25 | 0.16 | 0.13 | 0.11 | 0.03 | 0.03 | 0.03 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.04 | 0.02 | 0.04 |
| $SF_6$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| **Total*** | **73.93** | **66.32** | **61.61** | **56.25** | **54.45** | **53.37** | **51.86** | **50.71** | **51.14** | **50.46** | **49.26** | **50.68** | **49.94** | **51.10** | **50.86** | **50.17** | **49.95** | **47.88** | **49.00** |
| Total (with LULUCF) | 71.54 | 62.82 | 57.47 | 51.98 | 51.14 | 50.69 | 49.45 | 49.32 | 49.22 | 48.84 | 46.88 | 45.47 | 44.71 | 46.28 | 46.72 | 49.42 | 47.02 | 44.78 | 46.92 |

*Emissions, as submitted in November 11, 2010*
** GHG emissions without sinks from LULUCF, national total under KP*

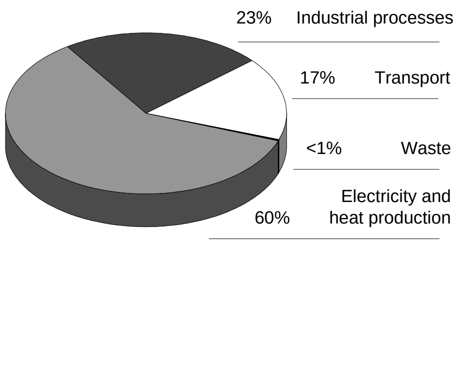
## $CO_2$ – carbon dioxide

### Emissions

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

Total net $CO_2$ emissions increased moderate in 2008 compared with the previous year (2.3%), totally decreased by more than 36% compared with the reference year 1990. The most feasible explanation of the significant $CO_2$ reduction is gradual decrease in energy demands in certain heavy energy demanding sectors (except for metallurgy) from 1993, higher share of services in the generation of the GDP, higher share of gas fuels in the primary energy resources consumption, restructuring of industries and the impact of air protection legislative measures influencing directly or indirectly the generation of greenhouse gas emissions. In the last year important changes of energy sources in the Slovak Republic were occurred.

Fig. 5.1 **$CO_2$ emissions in 2008**




[10] *According to the currently valid convention the emission reduction expressed in $CO_2$ equivalent should be reported, Climate Change 1995, The Science of Climate Change GWP100: $CO_2$=1, $CH_4$=21, $N_2O$=310, F-gases =140-23 900*

At the same time, the stable trend in the $CO_2$ emissions is observed since 2000. This year is considered for the break year in the regeneration of the economy. It is expected the long-time increasing of the $CO_2$ emissions, approved by national projections.[11] Among the most important reasons appears the recovery of the Slovak economy, followed by new sources of pollution, and a shift to solid fuels due to the increased prices of natural gas. Similarly, increased trend in $CO_2$ emissions is also at the transport sector. It is anticipated a gradual increase of $CO_2$ emissions in this sector not only at the regional level, but it is European problem, too.

**Sinks**

The Slovak Republic covers a territory of 49 036 $km^2$, of which 41% is forest areas. Since the beginning of the century part of the agricultural land has been gradually transformed into forest. In the period from 1950, the amount of carbon fixed in the forests of the SR was increased approximately to the more than 50 Tg as a consequence of the forest area enlargement and an increase in hectare yield of wood mass. Fixation of carbon in forest ecosystems of the SR was estimated on the carbon balance in the part of the forest above the ground (trees, plant canopy, overlying humus) and that, under the ground (roots, humus in soil) including an assessment of wood exploitation and forest fires (Tab. 5.2). The new IPPC methodology[12] was implemented in the last inventory year for the estimation the sinks in the LULUCF sector according to the good practice. Total emissions and sinks are balanced as changes in the area of the following categories: forest, cropland (arable land), grassland, wetlands, settlements and other land. The special categories are biomass burning controlled and wild forest fires. All GHGs are estimated in these categories.

Tab. 5.2 **Total emissions and sinks of $CO_2$ [Gg] in 1990, 1995 and 2000 – 2008**

| | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Net $CO_2$ | 60280 | 42092 | 38772 | 37132 | 35586 | 37339 | 37802 | 40696 | 37805 | 35838 | 37757 |
| **$CO_2$*** | **62687** | **44788** | **41175** | **42357** | **40829** | **42172** | **41956** | **41476** | **40758** | **38960** | **39859** |
| **Fossil fuel combustion** | **53477** | **36693** | **32352** | **33483** | **31463** | **32942** | **31909** | **31697** | **31004** | **29185** | **30483** |
| Electricity and heat prod. | 48584 | 32434 | 28216 | 28786 | 26619 | 28005 | 26689 | 25532 | 25311 | 22726 | 23866 |
| Transport | 4892 | 4259 | 4136 | 4696 | 4845 | 4937 | 5220 | 6165 | 5693 | 6458 | 6617 |
| **Industrial processes** | **9028** | **7948** | **8698** | **8756** | **9258** | **9127** | **9950** | **9693** | **9656** | **9693** | **9293** |
| Mineral products | 2690 | 2120 | 2244 | 2337 | 2373 | 2061 | 2507 | 2651 | 2715 | 2822 | 2991 |
| Chemical industry | 617 | 751 | 786 | 811 | 792 | 715 | 848 | 862 | 752 | 766 | 711 |
| Production of metals | 5721 | 5077 | 5669 | 5609 | 6093 | 6351 | 6595 | 6181 | 6188 | 6106 | 5591 |
| **Solvents** | **116** | **81** | **59** | **63** | **68** | **71** | **72** | **73** | **76** | **74** | **74** |
| **LULUCF** | **-2407** | **-2696** | **-2403** | **-5225** | **-5243** | **-4833** | **-4153** | **-780** | **-2953** | **-3122** | **-2102** |
| Forest land | -4454 | -4399 | -4318 | -5551 | -5641 | -5156 | -3995 | -701 | -3097 | -3266 | -2018 |
| Cropland | 3287 | 2063 | 4394 | 1002 | 1174 | 1416 | -14 | 1 | 1 | 2 | 2 |
| Grassland | 536 | 256 | -797 | -880 | -874 | -1363 | -373 | -442 | -439 | -439 | -360 |
| Other land | -1775 | -615 | -1682 | 204 | 98 | 269 | 229 | 362 | 582 | 582 | 274 |
| **Waste** | **67** | **67** | **67** | **55** | **39** | **33** | **25** | **13** | **23** | **8** | **9** |
| Waste incineration | 67 | 67 | 67 | 55 | 39 | 33 | 25 | 13 | 23 | 8 | 9 |
| **Burning biomass**** | *794* | *1183* | *1426* | *1632* | *1622* | *1734* | *2183* | *3045* | *2901* | *2976* | *5261* |
| **International bunkers**** | *129* | *103* | *45* | *69* | *72* | *79* | *86* | *91* | *132* | *150* | *167* |

*Emissions, as submitted in November 11, 2010*

* *$CO_2$ emissions without sinks from LULUCF*

** *$CO_2$ emissions are not being accounted into the total emissions*

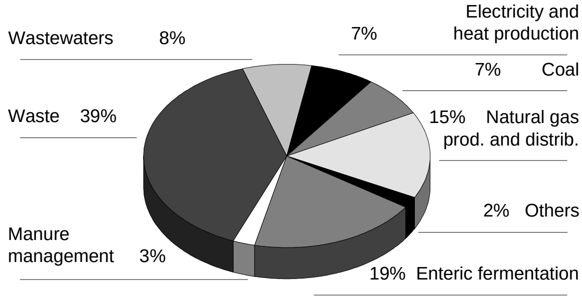
[11] *Biennial Report 2009 according to Decision 280/2004/EC*

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

## $CH_4$ – methane

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

Fig. 5.2 **$CH_4$ emissions in 2008**




Total methane emissions reached 226.86 Gg in 2008, what is slight increase comparable to the previous year. Emissions decreased by 1% compared to the reference year 1990. The most important changes were recorded in the sector of solid waste disposal sites (SWDS). The revision of emission factors and selection of appropriate parameters were carried out. The revision dealt with the data since 1960. The cooperation of sectoral expert with the expert for uncertainty was established. Using the Tier 2 method - First Order Decay, the total revision of methane emissions from solid waste disposal sites for time series 1960 – 2008 was performed. The uncertainty for the methane emissions from solid waste disposal site was decreased and accuracy was increased. The implementation of the kinetic model for SWDS´s emission balance was one of requirement for the acceptation of annual inventory for base year by expert review team during in-depth review. The important methodological changes in agricultural sector were performed based on Tier 2 methodology and regional input activity data in enteric fermentation of the key animal categories (cattle, sheep, swine), as well as. The methane emissions decreased in all sub-sectors except LULUCF and waste, caused by implementation of new methodologies. (Tab. 5.3).

**Tab. 5.3 Total emissions of $CH_4$ [Gg] in 1990, 1995 and 2000 – 2008**

| | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **$CH_4$** | **229.09** | **203.52** | **211.85** | **213.96** | **247.81** | **236.27** | **232.00** | **221.88** | **225.69** | **220.15** | **226.86** |
| **Energy** | **73.44** | **72.46** | **74.47** | **72.87** | **68.95** | **66.89** | **64.68** | **61.07** | **58.94** | **59.62** | **68.36** |
| Fossil fuel combustion | 21.79 | 13.63 | 11.59 | 11.68 | 9.51 | 9.85 | 10.59 | 12.94 | 12.15 | 10.65 | 17.50 |
| *Electricity and heat prod.* | *20.76* | *12.49* | *10.49* | *10.44* | *8.39* | *8.75* | *9.53* | *11.84* | *11.29* | *9.75* | *16.60* |
| *Transport* | *1.03* | *1.14* | *1.10* | *1.24* | *1.12* | *1.10* | *1.06* | *1.10* | *0.86* | *0.90* | *0.90* |
| Fugitive emissions | 51.65 | 58.83 | 62.88 | 61.19 | 59.44 | 57.04 | 54.09 | 48.13 | 46.80 | 48.96 | 50.86 |
| *Coal mining* | *27.20* | *29.70* | *28.82* | *26.33* | *25.69* | *21.11* | *19.77* | *16.17* | *14.67* | *13.52* | *15.95* |
| *Natural gas produc.& distrib.* | *24.45* | *29.13* | *34.06* | *34.86* | *33.74* | *35.93* | *34.32* | *31.96* | *32.13* | *35.45* | *34.91* |
| **Industrial processes** | **1.17** | **1.25** | **1.32** | **1.34** | **1.33** | **1.19** | **1.36** | **1.40** | **1.17** | **1.19** | **1.08** |
| Chemical industry | 1.17 | 1.25 | 1.32 | 1.34 | 1.33 | 1.19 | 1.36 | 1.40 | 1.17 | 1.19 | 1.08 |
| **Agriculture** | **112.32** | **80.15** | **59.68** | **61.08** | **59.52** | **56.91** | **52.69** | **53.19** | **52.28** | **51.36** | **48.98** |
| Enteric fermentation | 94.77 | 66.90 | 50.16 | 51.44 | 49.78 | 47.65 | 44.85 | 45.53 | 44.79 | 44.51 | 43.13 |
| Manure management | 17.56 | 13.25 | 9.52 | 9.63 | 9.74 | 9.26 | 7.84 | 7.66 | 7.49 | 6.84 | 5.85 |
| **LULUCF** | **0.70** | **0.46** | **0.67** | **0.68** | **0.66** | **0.73** | **0.82** | **1.07** | **0.90** | **0.91** | **0.99** |
| Forest | 0.70 | 0.46 | 0.67 | 0.68 | 0.66 | 0.73 | 0.82 | 1.07 | 0.90 | 0.91 | 0.99 |
| **Waste** | **42.16** | **49.66** | **76.38** | **78.67** | **118.00** | **111.28** | **113.27** | **106.22** | **113.30** | **108.00** | **108.45** |
| Solid waste disposal sites | 22.37 | 30.85 | 57.47 | 59.93 | 94.74 | 87.97 | 93.13 | 85.74 | 91.85 | 87.62 | 87.96 |
| Wastewaters | 19.71 | 18.67 | 18.77 | 18.56 | 18.57 | 18.52 | 18.33 | 18.08 | 18.04 | 17.96 | 17.83 |
| Composting | 0.08 | 0.14 | 0.15 | 0.17 | 4.69 | 4.79 | 1.81 | 2.40 | 3.41 | 2.42 | 2.65 |
| **International bunkers *** | **0.006** | **0.004** | **0.001** | **0.002** | **0.002** | **0.002** | **0.002** | **0.002** | **0.003** | **0.003** | **0.004** |

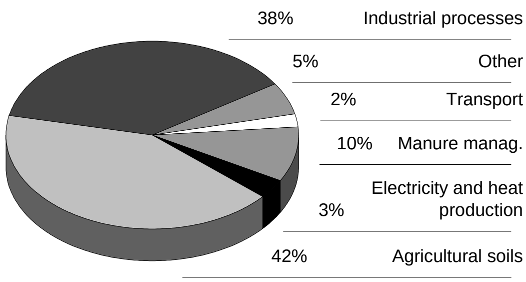
*Emissions, as submitted in November 11, 2010*
** $CH_4$ emissions are not being accounted into the total emissions*

## $N_2O$ – nitrous oxide

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

In 2008, the total $N_2O$ emissions slightly increased compared with the year 2007 and reached 13.09 Gg. However, the drop compared to the reference year 1990 is more than 34.15%. The $N_2O$ emissions raised from 2000, continuously. The most substantial increase was recorded in industrial processes sector by more than 32% regards to increase in chemical production (nitric acid). The moderate increase of $N_2O$ emissions in energy sector was caused by biomass burning. The higher increase of $N_2O$ emissions is observed in waste sector, the emissions raised about 37% from base year. This relates to the amount of industrial wastewater treatment and detailed methodology and changes in the consideration of the waste categories. Emissions of $N_2O$ are show the higher level of uncertainty and the time series is slightly inconsistent comparable with other gases (Tab. 5.4).

Fig. 5.3 **$N_2O$ emissions in 2008**




Tab. 5.4 **Total emissions of $N_2O$ [Gg] in 1990, 1995 and 2000 – 2008**

| | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total $N_2O$ emissions** | **19.88** | **13.44** | **11.41** | **11.98** | **12.17** | **12.24** | **12.38** | **12.35** | **13.54** | **13.00** | **13.09** |
| **Fossil fuel combustion** | **0.92** | **0.66** | **0.53** | **0.58** | **0.55** | **0.55** | **0.58** | **0.67** | **0.61** | **0.58** | **0.69** |
| Electricity and heat prod. | 0.53 | 0.33 | 0.28 | 0.30 | 0.27 | 0.29 | 0.30 | 0.33 | 0.31 | 0.29 | 0.41 |
| Transport | 0.39 | 0.33 | 0.25 | 0.28 | 0.27 | 0.26 | 0.28 | 0.34 | 0.29 | 0.29 | 0.28 |
| **Industrial processes** | **3.73** | **3.66** | **3.36** | **3.79** | **3.40** | **3.75** | **4.29** | **4.16** | **5.47** | **4.69** | **4.93** |
| Chemical industry | 3.73 | 3.66 | 3.36 | 3.79 | 3.40 | 3.75 | 4.29 | 4.16 | 5.47 | 4.69 | 4.93 |
| **Solvent use** | **0.06** | **0.10** | **0.06** | **0.10** | **0.18** | **0.19** | **0.26** | **0.28** | **0.27** | **0.26** | **0.25** |
| **Agriculture** | **14.84** | **8.73** | **7.20** | **7.26** | **7.40** | **7.14** | **6.88** | **6.82** | **6.70** | **7.03** | **6.75** |
| Manure management | 3.53 | 2.36 | 1.64 | 1.59 | 1.58 | 1.53 | 1.43 | 1.38 | 1.34 | 1.31 | 1.26 |
| Agricultural soils | 11.31 | 6.37 | 5.55 | 5.67 | 5.83 | 5.61 | 5.46 | 5.44 | 5.36 | 5.72 | 5.49 |
| **LULUCF** | **0.011** | **0.007** | **0.010** | **0.010** | **0.010** | **0.010** | **0.011** | **0.017** | **0.010** | **0.013** | **0.014** |
| Forest | 0.011 | 0.007 | 0.010 | 0.010 | 0.010 | 0.010 | 0.011 | 0.017 | 0.010 | 0.013 | 0.014 |
| **Waste** | **0.33** | **0.29** | **0.26** | **0.26** | **0.64** | **0.60** | **0.38** | **0.43** | **0.50** | **0.43** | **0.46** |
| Wastewaters | 0.31 | 0.26 | 0.23 | 0.22 | 0.26 | 0.22 | 0.22 | 0.23 | 0.23 | 0.23 | 0.23 |
| Waste incineration | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Composting | 0.01 | 0.01 | 0.01 | 0.01 | 0.35 | 0.36 | 0.14 | 0.18 | 0.26 | 0.18 | 0.20 |
| **International bunkers *** | **0.004** | **0.026** | **0.001** | **0.013** | **0.014** | **0.011** | **0.006** | **0.003** | **0.016** | **0.018** | **0.019** |

*Emissions, as submitted November 11, 2010*
* *$N_2O$ emissions are not being accounted into the total emission*

### HFCs, PFCs, $SF_6$

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

Tab. 5.5 **Total emissions of HFCs, PFCs and $SF_6$ in 1990, 1995 and 2000 – 2008**

| | GWP | | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total emissions** $CO_2$ *eq.* | | **[Gg]** | **271.40** | **146.38** | **100.49** | **111.86** | **130.88** | **169.00** | **188.68** | **209.20** | **251.87** | **269.31** | **317.91** |
| **HFCs emissions** $CO_2$ *eq.* | | **[Gg]** | **0.00** | **22.15** | **75.59** | **82.43** | **102.35** | **131.96** | **152.88** | **172.34** | **198.90** | **226.99** | **263.24** |
| HFC-23 | 11 700 | [Mg] | | <0.01 | 0.06 | 0.06 | 0.04 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.07 |
| HFC-32 | 650 | [Mg] | | | 0.30 | 0.56 | 1.15 | 1.85 | 2.39 | 3.55 | 5.02 | 7.06 | 8.78 |
| HFC-41 | 150 | | | | | | | | | | | | |
| HFC-43-10mee | 1 300 | | | | | | | | | | | | |
| HFC-125 | 2 800 | [Mg] | | 0.01 | 1.85 | 3.27 | 5.58 | 7.91 | 9.85 | 12.48 | 15.98 | 19.80 | 23.64 |
| HFC-134 | 1 000 | | | | | | | | | | | | |
| HFC-134a | 1 300 | [Mg] | | 9.17 | 45.94 | 42.75 | 47.19 | 60.07 | 66.49 | 70.69 | 76.57 | 81.76 | 91.85 |
| HFC-152a | 140 | [Mg] | | | 0.83 | 1.02 | 1.21 | 1.36 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 |
| HFC-143 | 300 | | | | | | | | | | | | |
| HFC-143a | 3 800 | [Mg] | | | 1.85 | 3.37 | 5.35 | 7.20 | 8.70 | 10.21 | 12.51 | 14.66 | 17.23 |
| HFC-227ea | 2 900 | [Mg] | | 3.52 | 0.80 | 0.80 | 0.44 | 0.23 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 |
| HFC-236fa | 6 300 | | | | 0.05 | 0.22 | 0.38 | 0.22 | 0.50 | 0.53 | 0.43 | 0.60 | 0.86 |
| HFC-245ca | 560 | | | | | | | | | | | | |
| **PFCs emissions** $CO_2$ *eq* | | **[Gg]** | **271.37** | **114.32** | **11.65** | **15.59** | **13.75** | **21.65** | **19.91** | **20.25** | **35.82** | **24.88** | **36.16** |
| $CF_4$ | 6 500 | [Mg] | 36.60 | 15.44 | 1.57 | 2.18 | 1.90 | 2.93 | 2.69 | 2.73 | 4.83 | 3.35 | 4.88 |
| $C_2F_6$ | 9 200 | [Mg] | 3.60 | 1.53 | 0.15 | 0.15 | 0.15 | 0.28 | 0.26 | 0.27 | 0.48 | 0.33 | 0.49 |
| $C_3F_8$ | 7 000 | | | | | | | | | | | | |
| $C_4F_{10}$ | 7 000 | | | | | | | | | | | | |
| $c\text{-}C_4F_8$ | 8 700 | | | | | | | | | | | | |
| $C_5F_{12}$ | 7 500 | | | | | | | | | | | | |
| $C_6F_{14}$ | 7 400 | | | | | | | | | | | | |
| **$SF_6$ emissions** $CO_2$ *eq.* | | **[Gg]** | **0.03** | **9.91** | **13.25** | **13.84** | **14.78** | **15.39** | **15.89** | **16.61** | **17.15** | **17.44** | **18.51** |
| $SF_6$ | 23 900 | [Mg] | 0.00 | 0.42 | 0.56 | 0.58 | 0.62 | 0.64 | 0.67 | 0.70 | 0.72 | 0.73 | 0.77 |

*Emissions, as submitted in November 11, 2010*

In 2008, total F-gases emissions considerable increased. This trend was expected due to a special feature of the emissions. They have a long lifespan and both actual and potential emissions are taken into account. Compared with 2007, the emissions increased by 18% and reached level of the reference year 1990. The most significant increase of emissions was recorded in the case of HFCs that substituted use of the PFCs. Emissions of $CF_4$ a $C_2F_6$ together with emissions of $SF_6$ are released in the production of aluminium. Their concentrations increased due to an increased production capacity (Tab. 5.5).

# 5.3 ASSESSMENT

The aggregated emission of GHGs in year 2008 increased and are again on 2006 level after decrease in 2007 (without LULUCF). There is the decreasing of aggregated emission against the base year (1990) about approximately 25 000 Gg it means the decreasing about almost 34% without sinks from LULUCF. A major share of aggregated emission covers the energy sector by about 76%, the industrial processes sector covers about 12%, the agriculture sector about 7% and the waste sector more than 5%. The solvent use sector covers less than 1% of the total emissions. These shares are determined as emissions in $CO_2$ of aggregated equivalents (Tab. 5.6).[11]

The GHG emission inventory should be assessed based upon its complexity due to uncertainty. These are caused and influenced by uncertainties of statistical data on fuel consumption. The applied emissions factors are another source of uncertainty. An additional error in calculation of the other GHG emissions may occur as a result of less exact methods and it can not be quantified. In spite of this, the uncertainty analysis determined by the Tier 1 method of the IPCC[8] estimated that the GHG emission inventory of 2008 is 10% (according level assessment) and 6% (according trend assessment). The calculation uncertainty by using the more sophisticated Tier 2 - Monte Carlo method is evaluated for the solid waste disposal site category, energy sector and industrial processes. The essential result from the Monte Carlo estimation of landfill emissions is fact that total uncertainty was reduced comparable to IPCC default recommended value by Tier 1 (50%). This value is ±48% for total methane emissions from SWDS according the time series since 1960. The uncertainty assessment of the sector energy, category combustion of fossil fuels was performed by Monte Carlo method and set unsymmetrical interval of uncertainty (–2.13%; 3.18%). The Monte Carlo uncertainty assessment of the industrial processes sector set unsymmetrical interval of uncertainty (–2.81%; 3.83%).

In order to reduce uncertainty of emission inventory, it is necessary to determine and classify key sources and categories. The key sources were selected according to a cumulative contribution to the total emissions. They represent more than 95% of total GHG emissions. Key sources and categories were determined according to the IPCC[8] method with and without LULUCF sector. In 2008, the Slovak Republic determined 23 key sources without LULUCF and 25 key sources with LULUCF to be assessed according to the level. According to anticipated trends was assessed 30 key sources without LULUCF and 30 with LULUCF. The most important key sources are combustion of fossil fuels, road transport, waste disposal, enteric fermentation, production of nitric acid, cement, iron and steel productions. Composition of key sources has not been changed. In the next submission the more detailed key source analyses will be prepared.

The GHG emissions reached the highest level at the end of 80-ies. In the period of 1990 – 1994 the reduction was about 25%. Since 1994, the emissions have been stable. In 2000, a significant decrease was recorded. In recent years, emissions increased, mainly emissions of $CO_{2,}$ due to recovery of the industrial production, transport and changes in fuels used (Fig. 5.4).

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

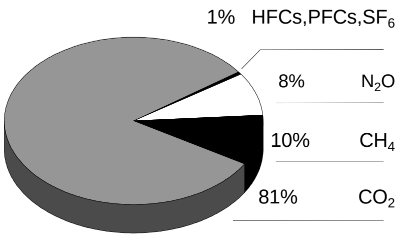
Concerning the actual and proposed dynamics of GDP growth in the Slovak Republic there exist legitimate assumption that GHG emissions will increase in line with it. Due to this scenario there is necessary to prepare investment strategies and programmes that allow us to achieve permanent distribution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

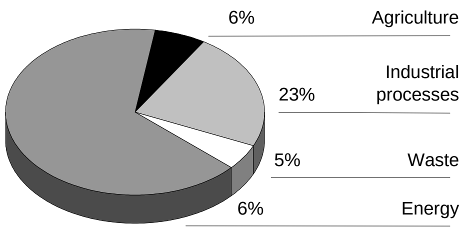
Tab. 5.6 **Aggregated emissions of GHGs according to the sectors in $CO_2$ *eq*. [Tg] in 1990, 1995 – 2008**

| | 1990 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Energy* | 55305 | 38419 | 37239 | 35865 | 35806 | 34892 | 34081 | 35193 | 33081 | 34516 | 33446 | 33187 | 32430 | 30617 | 32133 |
| Industrial Processes** | 10480 | 9254 | 9036 | 9274 | 9746 | 9950 | 9867 | 10072 | 10470 | 10484 | 11497 | 11221 | 11627 | 11443 | 11163 |
| Solvent Use | 133 | 112 | 107 | 91 | 87 | 84 | 79 | 93 | 125 | 130 | 152 | 160 | 158 | 153 | 153 |
| Agriculture | 6958 | 4389 | 4217 | 4025 | 3707 | 3467 | 3485 | 3533 | 3545 | 3409 | 3240 | 3230 | 3175 | 3258 | 3122 |
| LULUCF | -2388 | -2684 | -2409 | -1388 | -1926 | -1620 | -2386 | -5208 | -5226 | -4815 | -4133 | -752 | -2931 | -3099 | -2076 |
| Waste | 1055 | 1200 | 1261 | 1457 | 1799 | 2065 | 1750 | 1786 | 2716 | 2556 | 2521 | 2376 | 2558 | 2410 | 2428 |
| **Total with LULUCF** | **71543** | **50689** | **49452** | **49322** | **49219** | **48837** | **46876** | **45470** | **44710** | **46281** | **46723** | **49422** | **47016** | **44783** | **46923** |

*Emissions, as submitted in November 11, 2010* **Including transport* ***Including F-gases*

Fig. 5.4 **Aggregated emissions of GHGs in 2008**



# AIR POLLUTION
IN THE SLOVAK REPUBLIC

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