Notification of the postponement of attainment deadlines and exemption from the obligation to apply daily and annual limit values of PM_{10} and annual limit value of NO_2 for certain zones and agglomerations of Slovakia

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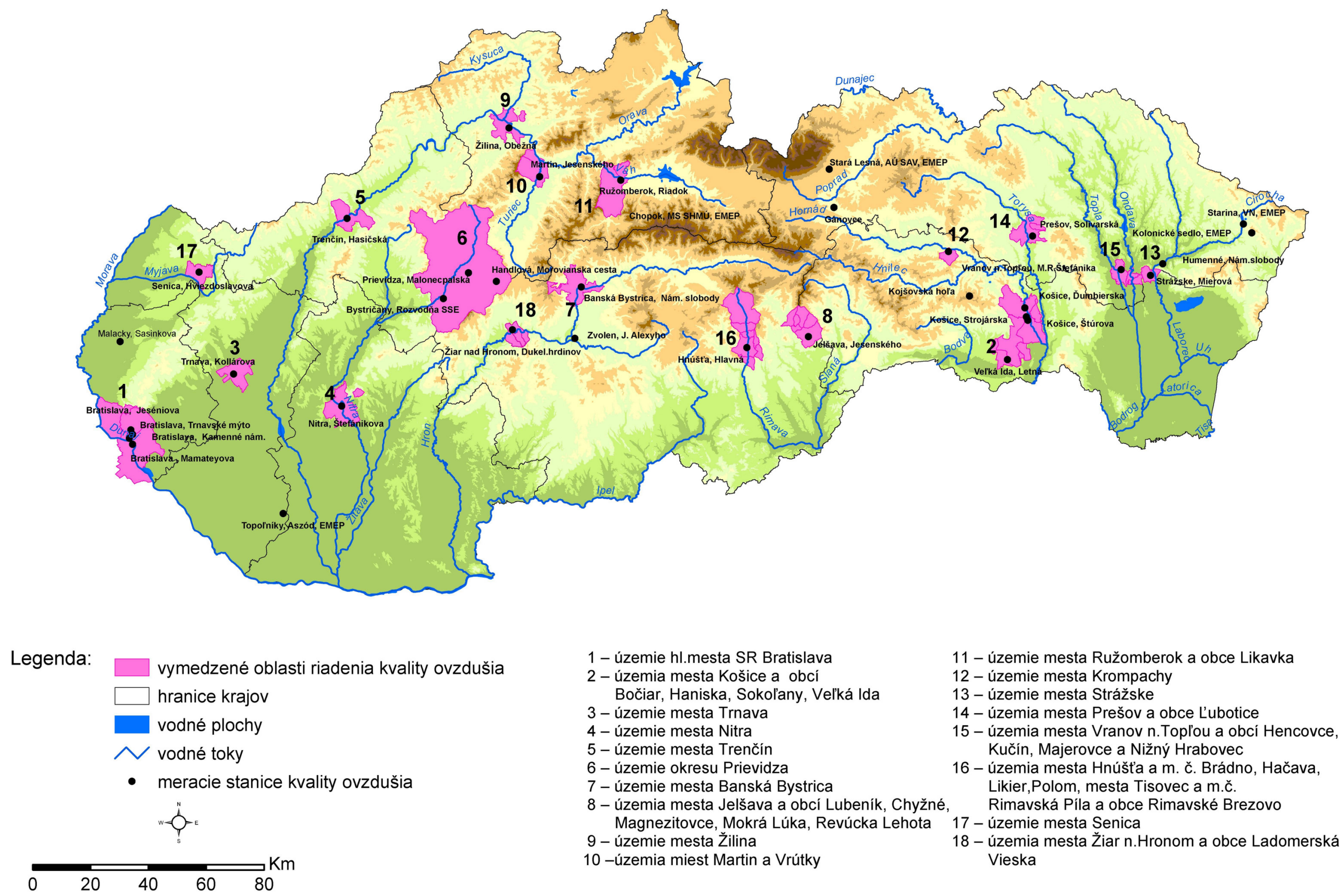
Introduction

Based on the Law 478/2002 on the Air Quality [3], the area of Slovak Republic is divided into 8 zones and 2 agglomerations – see Tab. 1., in which air quality assessment is carried out every year, reported to EU and published in annual reports Air Pollution in the Slovak Republic [4] and Air Quality Assessment in the Slovak Republic [5]. The latter contains the assessment on monitoring and complemented using mathematical modeling, and forms a basis for setting up the Air Quality Management Areas (AQMA), where one or more limit values for one or more pollutants are exceeded and Air Quality Plans (AQP) or Integrated Air Quality Plans (IAQP) need to be formulated or updated. Currently, there are 18 AQMA due to the PM_{10} limit value exceedances, from which 2 formulated IAQP due to annual SO_2 and NO_2 exceedances. Fig. 1 shows the map of Slovakia with current AQMA, while Tab. 2 list AQMA with details, such as their areas and populations and the reasons for non-compliance with the limit values. PM_{10} concentrations are measured in each AQMA at one or more stations of the Automatic Monitoring System (AMS) run by the Slovak Hydrometeorological Institute (SHMI).

Figure 1
Air quality management areas (AQMA) of the Slovak republic



The reference year for this Notification is 2005. Since that time the existing AQP and IAQP have been updated twice and many measures for the improvement of the air quality in the AQMA have been implemented and the air quality in most of AQMA has significantly improved, which is demonstrated by the decreasing trend in annual and daily PM_{10} concentrations, as shown in Fig. 2 and 3. However, the exceedances still exist, and the goal of this document is to demonstrate that the reasons for their persistency can by justified in accordance with the Directive [1].

Table 1. Zones and agglomerations of Slovakia

Agglomerations	Ref. code	Description
Bratislava	SKBA01	Territory of the city of Bratislava
Košice	SKKO01	Territory of the city of Košice
Zones		
Banskobystrický kraj	SKBB01	Territory of the region
Bratislavský kraj	SKBA02	Territory of the region except for the city of Bratislava
Košický kraj	SKKO02	Territory of the region except for the city of Košice
Nitriansky kraj	SKNI01	Territory of the region
Prešovský kraj	SKPR01	Territory of the region
Trenčiansky kraj	SKTR01	Territory of the region
Trnavský kraj	SKTN01	Territory of the region
Žilinský kraj	SKZI01	Territory of the region

Table 2. Air quality management areas (AQMA)

Zone/ Agglomeration	Ref. number	Air quality management area (AQMA)	No. of monitor. stations	Pollutant above LV	Area [km^2]	Population	Justifi-cation*
Bratislava	**1**	Territory of the city of Bratislava	4	PM_{10}	368	428 791	T
Košice Košický kraj	**2**	Territory of the city of Košice and municipalities of Bočiar, Haniska, Sokoľany, Veľká Ida	3	PM_{10}	295	239 524	T
Banskobystrický kraj	**7**	Territory of the city of Banská Bystrica	1	PM_{10}, NO_2	103	80 106	A
	16	Territory of the town of Hnúšťa, municipalities of Brádno, Hačava, Likier, Polom, town of Tisovec and municipalities of Rimavská Píla and Rimavské Brezovo	1	PM_{10}	191	12 331	A
	8	Territory of the town of Jelšava and municipalities of Lubeník, Chyžné, Magnezitovce, Mokrá Lúka, Revúcka Lehota	1	PM_{10}	109	6 180	A
	18	Territory fo the town of Žiar nad Hronom and Ladomerská Vieska municipality	1	PM_{10}	50	20 347	A
Košický kraj	**12**	Territory of the town of Krompachy	1	PM_{10}	23	8 929	A
	13	Territory of the town of Strážske	1	PM_{10}	25	4 594	A
Nitriansky kraj	**4**	Territory of the city of Nitra	1	PM_{10}	100	84 070	T
Prešovský kraj	**14**	Territory of the city of Prešov and the municipality of Ľubotice	1	PM_{10}	79	94 239	T
	15	Territory of the town of Vranov nad Topľou and municipalities of Hencovce, Kučín, Majerovce a Nižný Hrabovec	1	PM_{10}	59	26 952	A
Trenčiansky kraj	**6**	The territory of the district of Prievidza	3	PM_{10}, SO_2	960	139 639	A,T
	5	Territory of the city of Trenčín	1	PM_{10}	82	56 826	A,T
Trnavský kraj	**17**	Territory of the town of Senica	1	PM_{10}	50	20 751	A
	3	Territory of the city of Trnava	1	PM_{10}	72	67 726	T
Žilinský kraj	**10**	Territories of the cities of Martin and Vrútky	1	PM_{10}	86	65 821	A
	11	Territory of the city of Ružomberok and the municipality of Likavka	1	PM_{10}	145	32 794	A
	9	Territory of the city of Žilina	1	PM_{10}	80	85 327	A

** Justification for the notification according to Directive [1]: T- transboundary pollution, A – adverse climatic conditions*

According to the Directive [1] there are 3 legitimate reasons for the postponement of the attainment deadline: 1. site-specific dispersion characteristics, 2. adverse climatic conditions, and 3. transboundary contributions. Communication from the Commission [1] states the conditions under which they are applicable. Most of the territory of Slovakia is formed by mountains and most of the 18 AQMA fulfill the condition of adverse climatic conditions, as they are situated in valleys and most of them have mean annual wind speed below 1.5 m/s. The remaining sites are exposed to long range transboundary pollution from other regions of Europe. Last column of Tab. 2 indicates the justification for the LV exceedances for each particular AQMA.

Figure 2
Time development of the annual PM_{10} concentrations ($\mu g/m^3$)

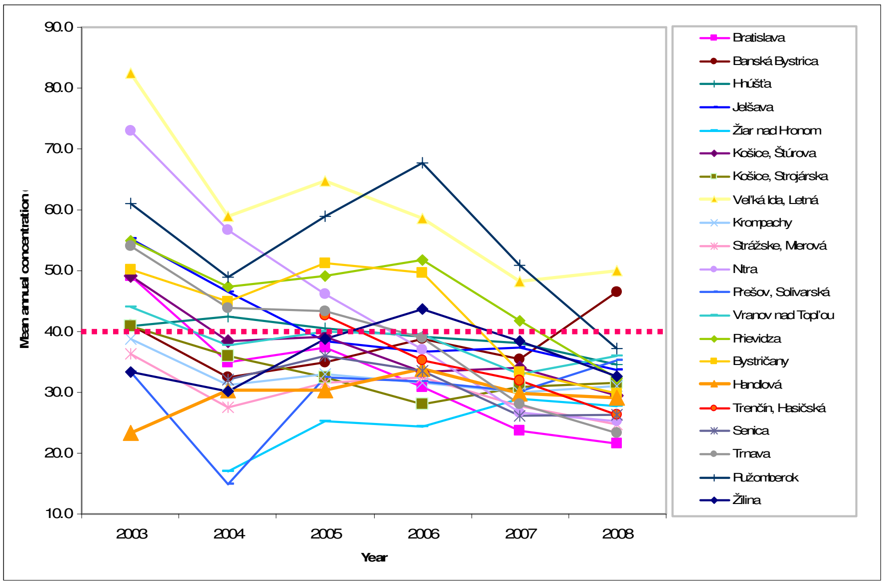
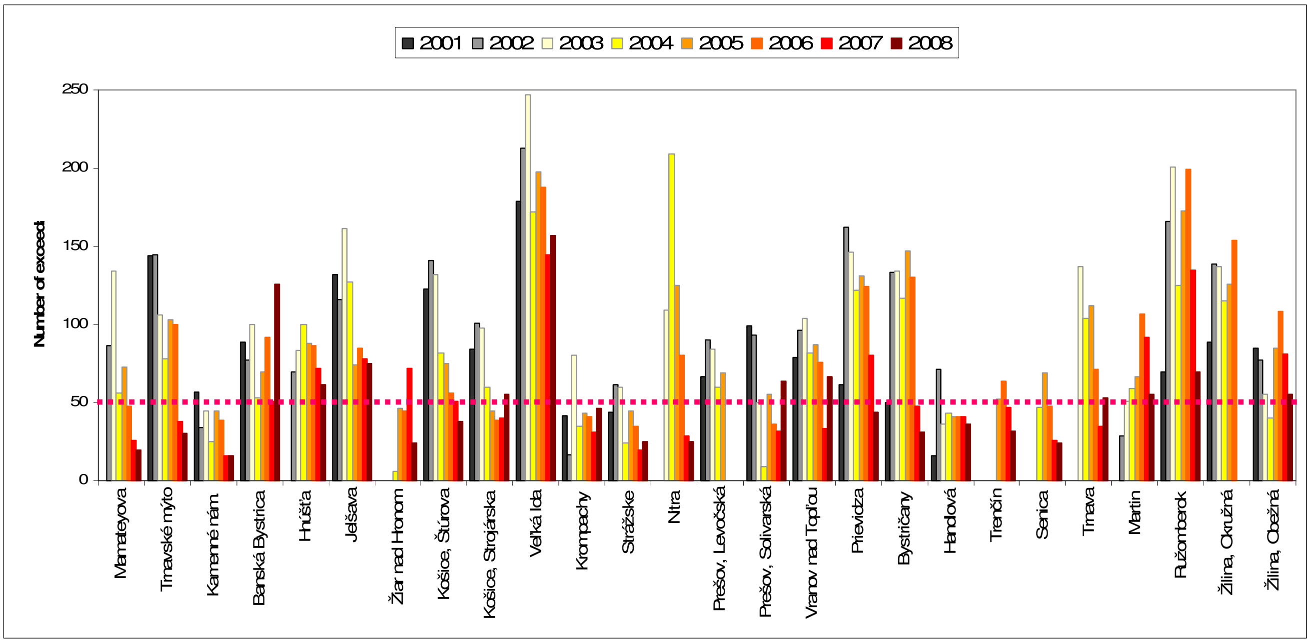


Figure 3
Time development of the exceedances of PM_{10} daily limit values



Organization of the document

This document is organized into 2 parts and one appendix. First part analyzes the two issues - climatic conditions and long-range transport of PM_{10} – in more general context of the whole country, because this is important for better understanding of the issues applied for concrete AQMA involved in this notification. The second part analyses the relevant facts in detail for each particular AQMA separately.

Appendix includes detailed tables for each AQMA containing meteorological conditions for each particular AQMA for all exceedance days as well as transboundary portion of measured concentration which was subtracted (where applicable).

PART 1

1.1 Climatologic characteristics of the AQMA relevant to the dispersion of pollutants in the atmosphere.

The most relevant climatologic parameters from the point of view of pollutant dispersion are the wind speed, wind direction and atmospheric stability. Wind speed and direction are measured hourly at synoptic meteorological stations; however, not all AMS monitoring stations (listed in Tab. 1.1) can be assigned a synoptic station which is geographically close enough to be representative of the AMS station. Therefore, climatologic stations were used instead for the analysis. Climatologic stations perform measurements three times a day, at 7th, 14th and 22nd hour of local time. Tab. 1.1 lists the AMS stations and respective climatologic stations.

Table 1.1
AMS stations and respective representative climatic stations used in the analysis

Code	**AMS station**	**Type**	**Climatic station***
SK0004A	Bratislava, Kamenné nám.	UB	**11816 Bratislava-letisko**
SK0001A	Bratislava, Mamateyova	UB	**11816 Bratislava-letisko**
SK0002A	Bratislava, Trnavské Mýto	UT	**11816 Bratislava-letisko**
SK0021A	Senica, Hviezdoslavova	UT	11800 Holíč
SK0045A	Trnava, Kollárova	UT	**11819 Jaslovské Bohunice**
SK0027A	Handlová, Morovianska cesta	UB	**11867 Prievidza**
SK00A	Prievidza, Hollého	UB	**11867 Prievidza**
SK0051A	Nitra, Janka Kráľa	UB	**11855 Nitra**
SK0039A	Martin, Jesenského	UT	11893 Martin
SK0008A	Ružomberok, Riadok	UB	11872 Ružomberok
SK0020A	Žilina, Obežná	UB	**11865 Žilina**
SK0005A	Banská Bystrica, Nám. Slobody	UB	11898 Banská Bystrica
SK0025A	Jelšava, Jesenského	UB	11953 Revúca
SK0022A	Hnúšťa, Hlavná	SB	11941 Ratková
SK0037A	Humenné, Nám. Slobody	UB	**11993 Kamenica**
SK00A	Prešov, Levočská	UB	**11955 Prešov**
SK0046A	Prešov, Solivarská	UB	**11955 Prešov**
SK0031A	Vranov, M.R.Štefánika	UB	11966 Čaklov
SK0014A	Košice, Štúrova	UT	**11968 Košice-letisko**
SK0015A	Košice, Strojárska	UB	**11968 Košice-letisko**
SK0018A	Veľká Ida, Letná	SI	**11968 Košice-letisko**
SK0030A	Strážske, Mierová	UB	**11993 Kamenica**
SK0028A	Krompachy, Lorenzova	UB	11949 Spišské Vlachy
SK0009A	Žiar nad Hronom	UB	11900 Žiar nad Hronom
SK0013A	Bystričany	SB	**11867 Prievidza**
SK0047A	Trenčín	UT	11803 Trenčín

** stations in bold are also synoptic stations, performing hourly measurments*

Last 10 years (1999 – 2008) of climatic data were included in the wind analysis at each AMS station. Fig. 1.2 shows the percentage of calms and low winds (0 – 2 m/s). Calms occur more than half of a year in 3 AQMA (Krompachy, Žilina, Hnúšťa), while low winds blow for the most part of a year practically in all AQMA located in mountain valleys. The long term (10 years) average annual wind speed (Fig. 1.3) is lower or close to 1.5 m/s at 11 AMS stations, while at other 2 AMS stations the average annual wind speed fell below 1.5 m/s at least once during the period of the last 10 years. Considering the fact that the limit of 1.5 m/s has been stated arbitrarily in [2], as there are also factors other then annual average wind speed, which influence the dispersion conditions, and taking into account the actual meteorological conditions at which the exceedances occurred, there is a justification for adverse climatic conditions at 13 AQMA (see the last column of Tab. 2), as will be demonstrated later in this document.

Figure 1.2
Mean annual percentage of calms and low winds at (or representative to) AMS stations during last ten years

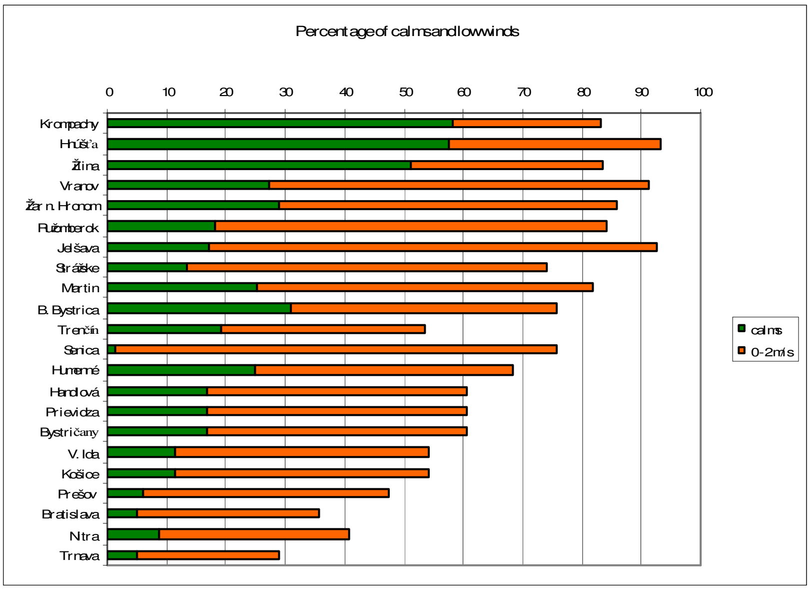
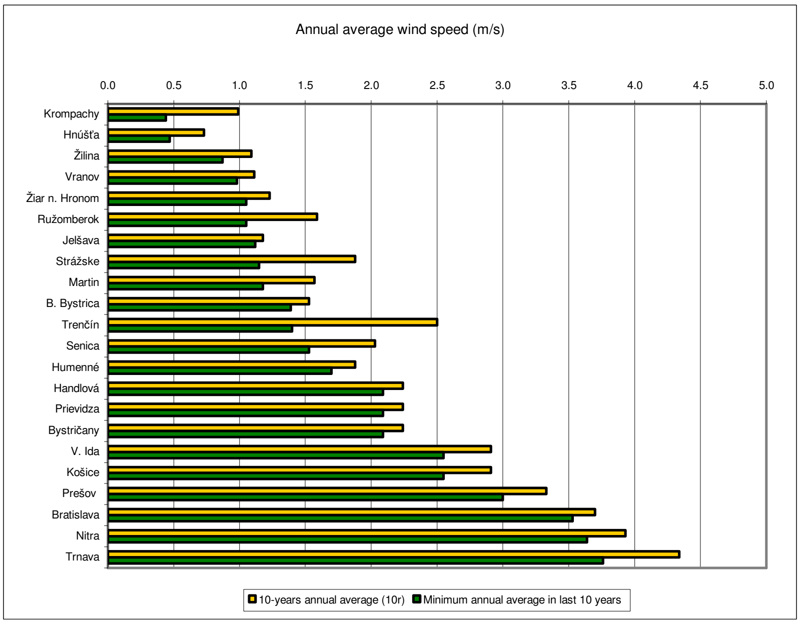


Figure 1.3
Annual average wind speed at (or representative to) AMS stations during Last 10 years



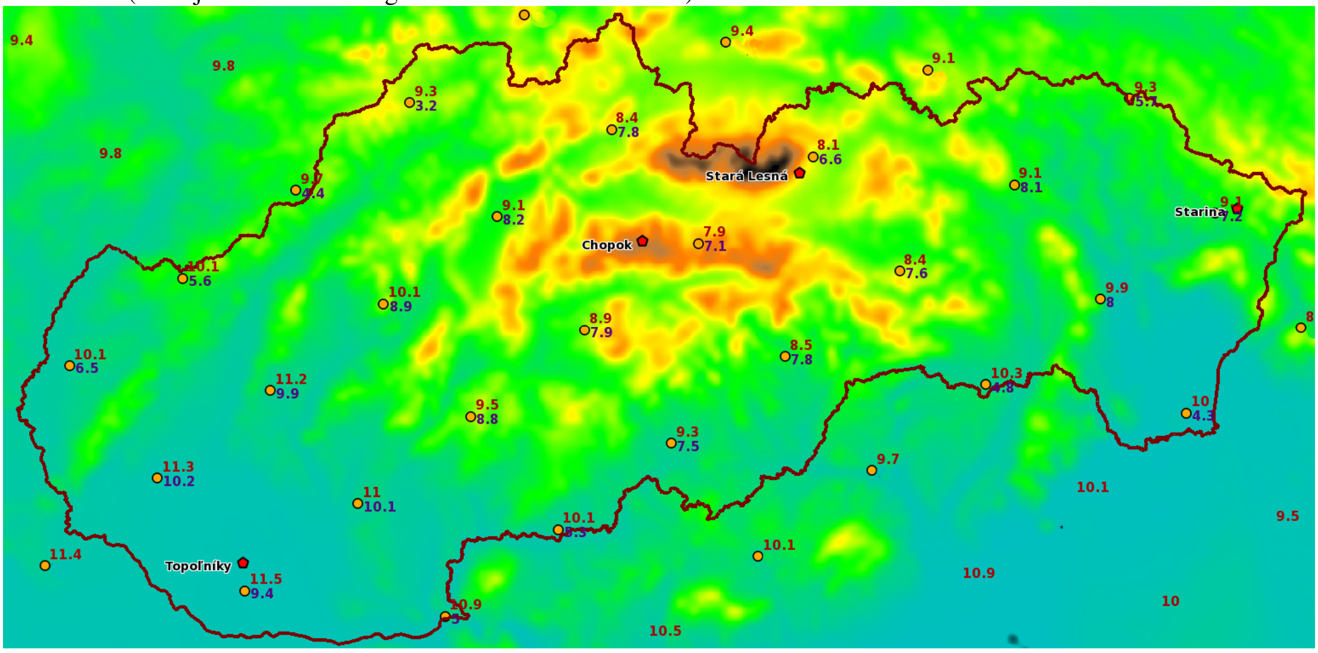
1.2 Contribution to PM_{10} concentrations due to transboundary (long-range) transport

PM_{10} is a pollutant, which is subject to rather efficient long-range transport, especially the fine particulate portion of the spectra. Another unpleasant property of PM_{10} is the multitude and variety of its emission sources, most of which is of fugitive character and their quantification is complicated and associated with huge uncertainty, if possible at all. However, many of the sources are possible to assess on larger scales such as district and national, using various activity statistics and emission factors. These data are then used in long-range chemical transport models such as, e.g., EMEP [10]. According to EMEP publication [6], only about 10%

of PM_{coarse} and 15% of $PM_{2.5}$ measured in Slovakia is contributed by sources on the territory of the country. Fig. 1.3 shows the mean annual PM_{10} concentrations (red) and transboundary contributions (blue) at model gridpoints as computed by EMEP model at the reference year of 2005.

Figure 1.3

EMEP model gridpoints (yellow circles) over Slovakia, with the total mean annual PM_{10} concentrations (red values, in μg/m^3) and mean annual transboundary contributions (blue values, in μg/m^3). Positions of EMEP monitoring stations are marked red (no adjustment to the negative biases has been made).



Unfortunately, the EMEP model underestimates the PM_{10} concentrations by about 45% (according to [9], EMEP station in Illmitz, AT, which may be nearest representative station in our geographic area). The underestimation is probably caused by the nature and uncertainties in gridded emission data, and cannot be used directly for the estimation of the transboundary contribution at each particular AMS station. However, using EMEP – derived data with caution, it can be used for determination of relative importance of the transboundary vs. local/regional origin of PM_{10} concentrations.

Transboudary contributions in the valley-situated AQMAs where low mean annual wind speeds occur will not play a major role due to the character of the local air circulation, except for the cases when the exceedance situation occurs during a windy day. However, it plays a major role in 4 lowland AQMAs, while in other 4 AQMAs, which do not completely fulfill the condition of mean annual wind 1.5 m/s for the adverse climatic conditions and in which part of exceedances occur during higher winds the transboundary contributions form significant portions of concentrations.

There are two issues needed to be solved in order to subtract the transboundary portion of the concentration from measured concentration:

1. prove that the PM_{10} measured at the day of an exceedance originated outside the territory of Slovakia
2. determine the portion of PM_{10} concentration which is to be extracted from the measured concentration

The first issue was solved using Hysplit model [11,12] for obtaining ensemble backward trajectories calculated for the period of 48 hours for each of the AMS station in question. For the cases of high variability in ensemble members, also the EMEP trajectory model [13] was run for a closest EMEP station.

The transboundary portion of PM_{10} concentration to be extracted from the measured concentration was determined in the following way:

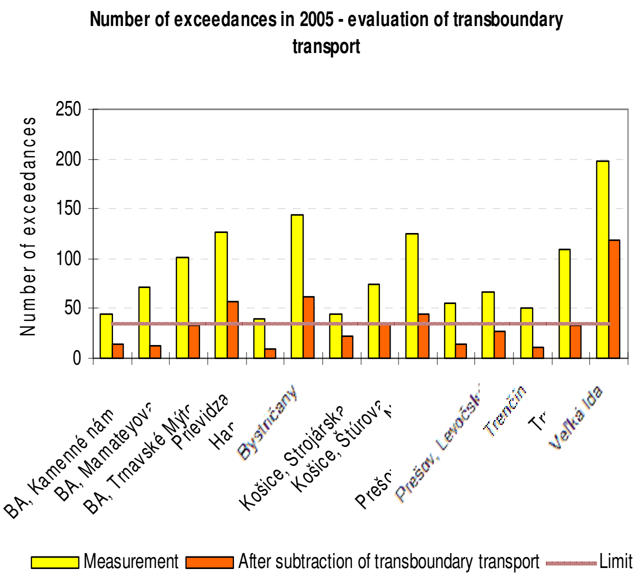
EMEP model was run for the whole year of 2005 in two modes: first the complete set of emission data was used, and second the Slovak emissions were set to zero. The ratio of the resulting concentrations computed from the two runs can be considered as the the ratio of regional and transboundary concentration contributions on the territory of Slovakia. However, for the abovementioned purposes, an absolute value of transboundary contribution is needed. As it was mentioned earlier in this chapter, EMEP model has rather large negative bias, which we need to eliminate. This was done by comparing EMEP model concentrations to the concentrations measured at EMEP station in Topoľníky. Model errors obtained this way were used for the correction of the EMEP-computed transboudary contributions in each concerned AMS station and each relevant exceedance day. The corrected transboundary contributions were then subtracted from the concentrations measured at the AMS stations, which reduced the number of exceedances under the limit value of 35, as is shown in Fig. 1.4.

Figure 1.4

Number of PM_{10} LV exceedances before and after substraction of the transboudary contributions

Number of exceedances				
AMS station	**Before subtraction**	**After subtraction**	**Excluded***	**Final**
BA, Kamenné nám.	45	12	2	14
BA, Mamateyova	71	11	1	12
BA, Trnavské Mýto	101	34		34
Prievidza	127	56	1	57
Handlová	40	10		10
Bystričany	144	61	1	62
Košice, Strojárska	45	21	1	22
Košice, Štúrova	75	34	1	35
Nitra	125	44	1	45
Prešov, Solivarská	55	14		14
Prešov, Levočská	66	26	1	27
Trenčín	51	11		11
Trnava	109	34		34
Veľká Ida	198	115	3	118

**Excluded based on the trajectory analysis for the sake of conservativeness*



Three stations remained above the LV in the reference year 2005 – they will be discussed later in this document.

PART 2

2.1 Methods used for the local PM_{10} source apportionment.

Part 1 of this document outlined the method how the EMEP and HYSPLIT models were used for the determination of the transboundary transport of PM_{10} to the territory of Slovakia.
The following paragraph describes a method used in *Air Quality Assessment* yearbooks [5] for the source apportionment of mean annual concentrations measured at the AMS stations:
The method is based on the fact, that the only PM_{10} emission sources which are quantified in detail sufficient for an application of local air quality model are large and medium pollution sources from national NEIS database [7], and traffic-related exhaust and non-exhaust emissions based on transportation statistics data, road network and known emission factors. These known emissions were input into CEMOD model [8] to obtain an annual PM_{10} concentration contribution from these sources. Afterwards, concentration measurements from EMEP background stations were used for the assessment of the regional contribution to mean annual PM_{10} concentrations. As the four EMEP stations represent different terrain elevations from lowlands to mountains (up to 2000 m), an empirical profile has been calculated and used to relate the regional concentration to particular elevations of different AMS stations in AQMA. Finally, the modeled contributions from the large and medium stationary sources and traffic, and the EMEP-based regional contributions were subtracted from the mean annual concentrations measured at AMS stations; resulting concentration residuals were assigned to the remaining *other* sources of PM_{10}, which are numerous and as such they are responsible for about 30 to 70% of annual PM_{10} concentrations. These *other* sources include individual local heating systems burning coal and wood, dust from roads including winter sanding material, construction sites, resuspension of dusty material from open surfaces, agricultural soil, seasonal farming activities (harvest, dry plowing, autumn burning of plant remnants), and probably more. The presence of these sources is known in most cases, but their quantification is problematic due to their transient character. However, some of them can be located using detailed photomap of a site.

Table 2.1
Source apportionment of mean annual PM10 concentration for each AMS station based on CEMOD modeling and measured data at EMEP stations (% of total)

AQMA/AMS station	Large and medium stationary sources	Mobile sources (exhaust and non-exhaust)	Regional background	*Other* sources
Kamenné námestie	0.3	6.9	66.0	26.8
Trnavské mýto	0.3	12.0	47.4	40.3
Mamateyova	0.3	6.2	62.1	31.4
Košice Štúrova	3.3	20.7	54.2	21.9
Košice, Strojárska	3.2	3.9	64.1	28.8
BB	0.0	1.6	47.4	51.0
Jelšava	0.3	0.3	45.0	51.5
Hnúšťa	1.3	0.5	49.6	48.6
Žiar nad Hronom	1.7	0.8	68.3	29.2
Veľká Ida	18.3	0.0	30.6	51.2
Strážske	0.9	0.6	59.4	39.1
Krompachy	0.6	0.3	57.5	41.6
Nitra	0.0	0.8	51.8	47.4
Humenné	0.7	0.7	63.3	35.4
Prešov	1.6	0.9	53.8	43.7
Vranov	1.3	0.3	49.0	49.5
Prievidza	0.6	0.4	32.1	67.0
Bystričany	1.0	0.0	34.3	64.7
Handlová	1.5	0.3	50.3	47.9
Trenčín	0.0	0.9	50.4	48.7
Senica	0.0	0.3	53.4	46.3
trnava	0.3	1.0	48.8	49.9
Martin	1.7	0.9	38.8	58.6
Ružomberok	0.2	0.3	24.5	75.1
Žilina, Veľká Okružná	0.0	1.0	35.5	63.6
Žilina, Obežná	0.0	0.7	43.8	55.5

The results of annual source apportionment for each AMS station in 2005, as published in [5] are listed in Tab. 2.1.
The method described above cannot be used for the source apportionment during the daily exceedance cases in the reference year of 2005 – the reason is that the gravimetric method used for the measurement of PM_{10} concentrations at EMEP stations used 7-day PM_{10} collection period at that time. However, it is rather useful for the first approximation on the PM_{10} balance at each particular AMS station.
To obtain more detail on the reasons of daily exceedances, another complementary method was used, which combines wind and concentration statistics and spatial distribution of potential PM_{10} sources at each AQMA. It also allows for the determination of the relative importance of the *other* sources and so provides the local authorities with the information necessary for more efficient application of the abatement strategies and measures for the improvement of the air quality in their territories.
Although the PM_{10} limit values apply to daily means, it was found out that a consistent statistical analysis of hourly wind and concentration data is more useful for the kind of analysis required. The wind and respective concentration data has been divided into 6 statistical bins based on the directional sector, and these bins were further divided according the wind speed into 15 bins each, in order to reflect not only the dependence of the concentration on the wind direction but also the wind speed. This distinction is particularly important in case of PM_{10}, in order to distinguish between 2 important source groups: local heating and transportation – causing high concentrations during low wind speeds, and local sources of re-suspended dust which occurs during higher wind speeds. To include sufficient number of higher wind speed cases, especially in the mountainous zones, complete set of hourly data for the last 4 years (2005-2008) was used.
The next part of the document analyses the air quality in the each zone/agglomeration with its respective AQMAs, using the methods described in the previous parts of this document, with the focus of on the justification of the reasons for the non-attainment of the PM_{10} limit values.

Next part of the document contains specific information needed for supporting the reasons for non-compliance with the PM_{10} LV for each AQMA specifically.

Agglomeration: Bratislava
AQMA: Territory of the city of Bratislava

Climate relevant to atmospheric dispersion
Climate of Bratislava is influenced by its lowland position and the Male Karpaty mountains on the NW which are causing increase in wind speeds blowing from the statistically prevailing NW direction.
The long term annual average wind speed is as high as 3.7 m/s, with calms occurring 5% of the year. Daytime inversions have 19% occurrence. With these parameters, Bratislava belongs among the most ventilated populated areas in Slovakia.

AMS stations
In 2005, there were 3 AMS stations on the territory of the city, two of which are characterized as urban background and one as urban transport. In the next years, one monitoring station was added to AMS. (see Tab. 2 and Tab. 1.1).

PM_{10} concentration data measured in the reference year 2005

Kamenné nám. (UB)

Number of exceedances before subtraction of transboundary portion: **45**
Number of exceedances after subtraction of transboundary portion: **14**

Mamateyova ul. (UB)

Number of exceedances before subtraction of transboundary portion: **71**
Number of exceedances after subtraction of transboundary portion: **12**

Trnavské Mýto (UT)

Number of exceedances before subtraction of transboundary portion: **101**
Number of exceedances after subtraction of transboundary portion: **34**

For the detailed information on meteorology and transboundary contributions during the exceedance days see Appendix A of this document.

Fig. 1 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 1
Development of the measured PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in µg/m^3.

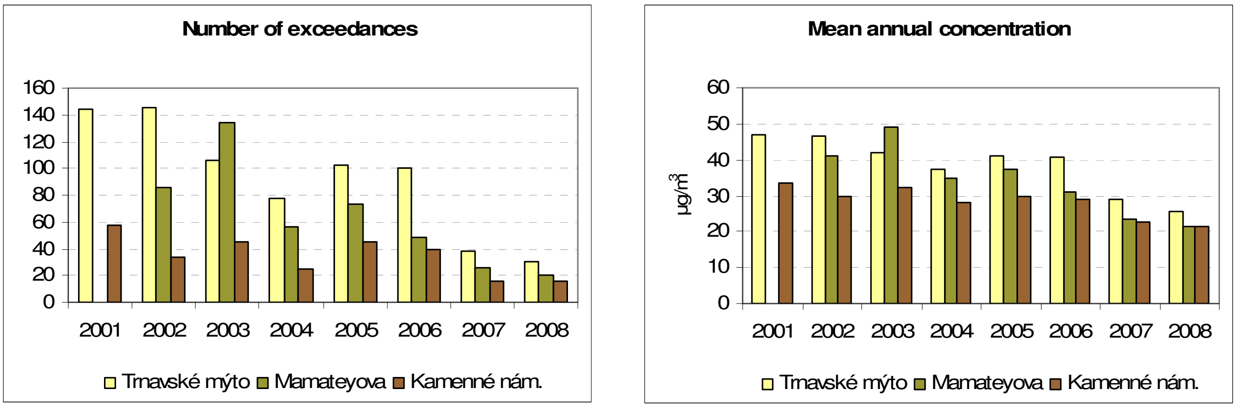
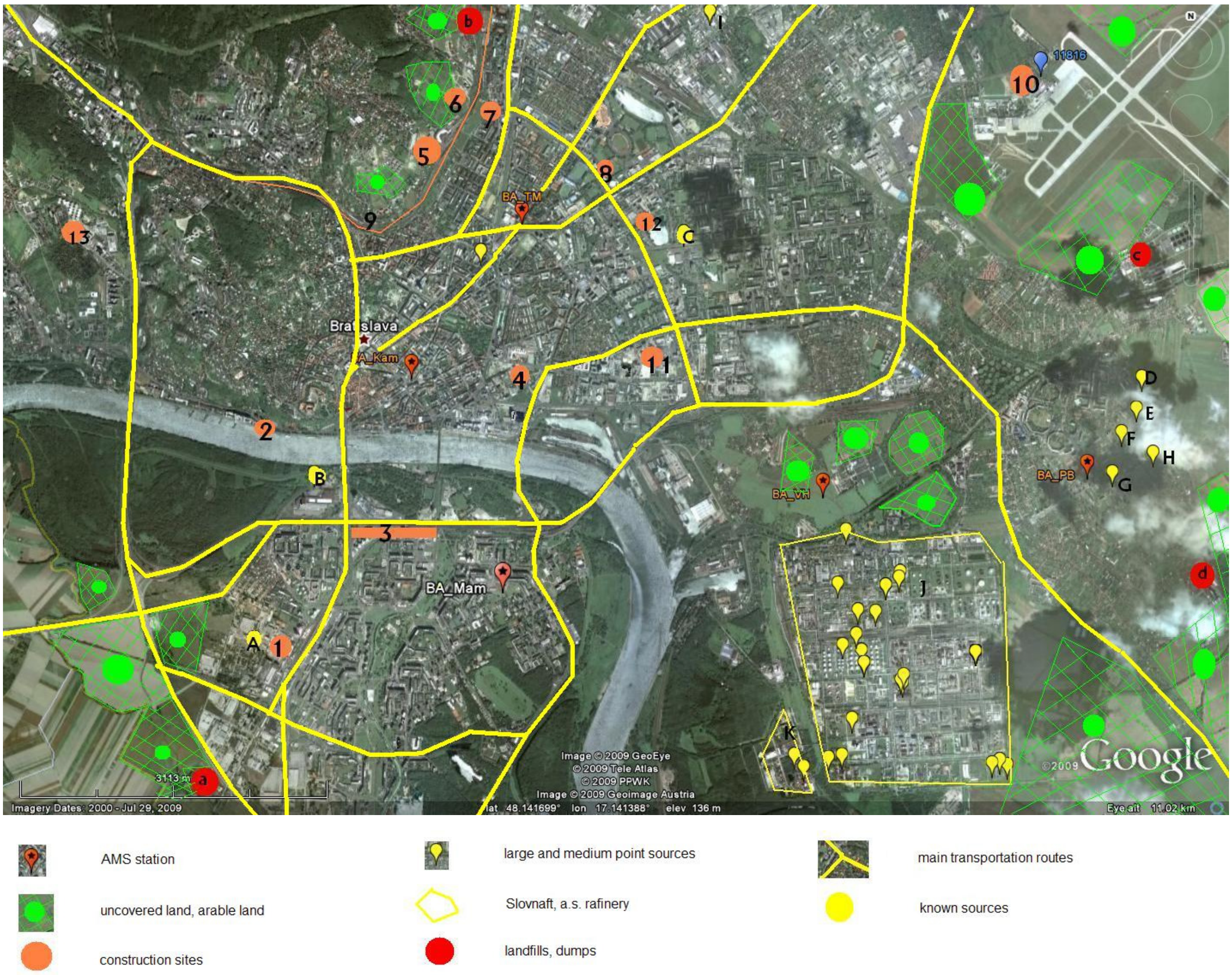


Fig. 2 shows the main potential sources of PM_{10} in Bratislava

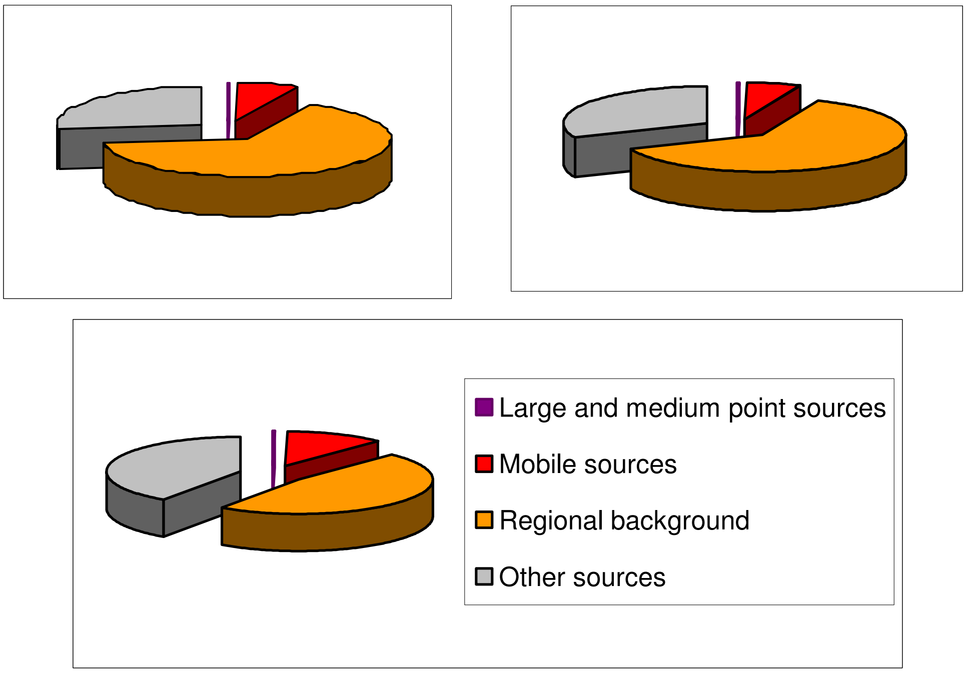
Figure 2.
Potential PM_{10} sources in the Bratislava



Source apportionment

The results of source apportionment according to [5] are represented on Fig. 3. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources had only minor impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify. Due to the high concentration of population and businesses, the traffic also contributes its portion of PM_{10}, especially at urban traffic AMS station of Trnavské Mýto.

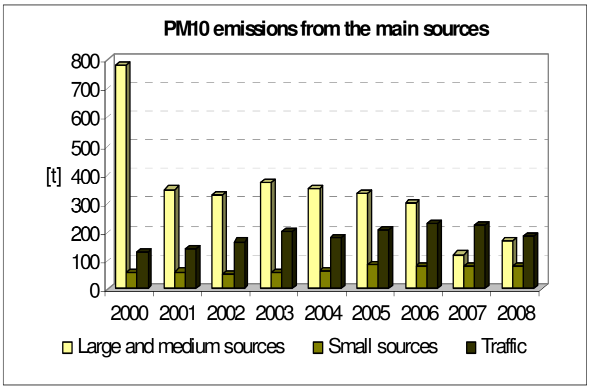
Figure 3
Contribution of different sources to mean annual concentration of PM_{10} in 2005 – Kamenné nám., Mamateyova ul., Trnavské Mýto.

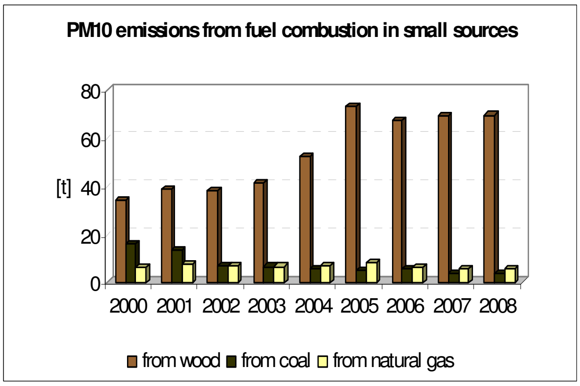


The *other* potential sources include resuspended material, occurring at higher wind speeds, from roads (other than exhaust and non-exhaust traffic emissions), non-stack emissions from industrial sources and dust from construction sites. Another important source of PM_{10} in winter is road sanding.
As demonstrated in Figure 4, listing the aggregate emissions from different types of sources in Bratislava, current emissions from large and medium point sources, are comparable in amount to traffic emissions. However, as they represent stack emissions which are mostly blown away from the city, they do not influence the city directly, but rather contribute to regional background.
From the *other* sources, the graph only includes *small* sources, which are calculated based on the amount of different types of fuel sold at retail, therefore represent mostly the individual heating systems in family houses. They are mostly fueled by gas and do not produce much emissions.

Due to its geographical position, terrain configuration and windy climate, the transboundary transport of PM_{10} forms a large part of concentrations measured during the exceedance days. For the reference year of 2005, it was demonstrated using EMEP model and HYSPLIT backward trajectories, as described in Part 1 of this document, and detailed results of the transboundary modeling for the exceedance situations are in Appendix B.

Figure 4.
Emissions from large, medium and small stationary sources and mobile sources on the territory of the city of Bratislava.[1]





We attempt to accomplish a qualitative apportionment of the *other* sources, using the spatial information on Fig. 2 in combination with wind and concentration statistics summarized in Fig. 5. This qualitative apportionment is not 2005 specific, but rather represents several recent years. This is largely caused by the fact that the resuspension plays important role due to the windy climate, and the sources of resuspension Bratislava are mostly large construction sites, which are temporary and those represented in Fig. 2 are current ones, initiated in last couple of years. Graphs in Fig. 5 represent average hourly PM_{10} concentrations for each respective AMS station, plotted for each wind direction and wind speed.

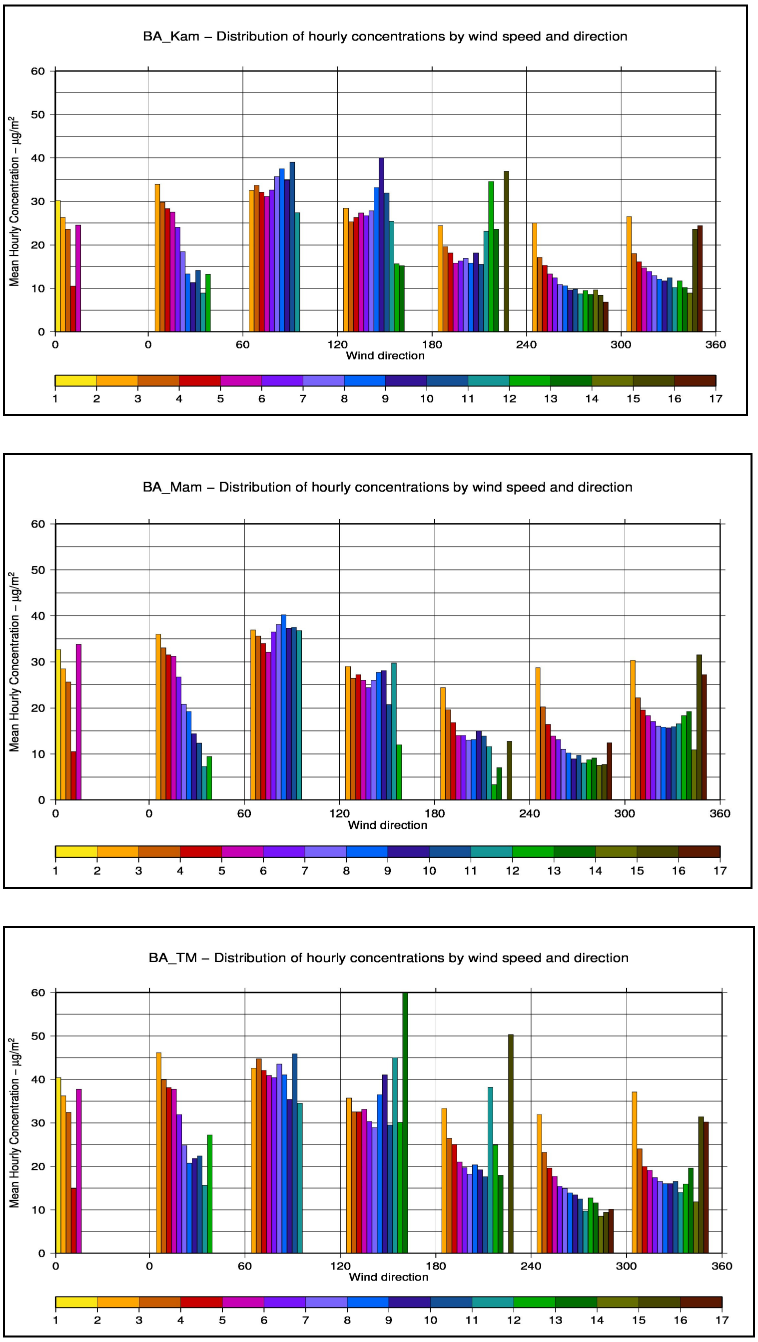
AMS station at Kamenne nam. is the least impacted by PM_{10} exceedances. The highest concentrations occur during high winds from south to east, where an intensive construction activities have been carried out (Einsteinova, Chalupkova, Trinity projects). A certain impact could came from Slovnaft refinery, which is located in ESE direction from the station.

AMS station Mamateyova is situated in the residential area with condominiums, 2.5 km west from the Slovnaft refinery. The highest concentrations occur at higher winds from E and SE, which would correspond to the refinery. Those emissions are probably mainly resuspended dust from polluted areas on the rafinery premises. A part of the PM_{10} coming from the east can be probably attributed to winter sanding of nearby roads.

AMS station at Trnavske Myto is an urban traffic station, located in the city center with heavy traffic load. Besides the traffic, which contributes to high PM_{10} concentrations by exhaust and abrasive emissions, but also by resuspension of dirt and sanding materials in winter, an intensive construction activity has been taking place in close vicinity – one large construction site is cca 100m SSE, another – hockey stadium – is being built cca 0.5 km E, another large construction site – Slovan – is the same distance NW. The positions of these sites reflect to the directions of concentration peaks at high wind speeds in the corresponding graph in Fig. 5.

[1] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

Figure 5
Hourly PM_{10} concentrations depending on wind speed and wind directions at AMS stations



Conclusion

It has been demonstrated that transboundary transport of PM_{10} contributes a large part to the concentrations during most of the exceedance situations in the reference year of 2005, and, in accordance with [1], can be subtracted from the measured concentrations. After subtraction, neither of the AMS stations exceeded the allowed number of 35 exceedances of daily PM_{10} limit value. Although only the year of 2005 was modeled, there are reasons to believe that the situation will not largely differ for the other years. However, it is recognized that there are also other sources on the territory of the city, which contribute to the PM_{10} pollution. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the city.

Fig. 1 shows the PM_{10} exceedances have strongly decreasing trend and putting into action further measures described in the air quality plan, there is a high probability that the PM_{10} limit values will not be exceeded in any of the AMS stations in Bratislava.

Zone/Agglomeration: **Košice/Košický kraj**
AQMA: **Territory of the city of Košice and municipalities of Bočiar, Haniska, Sokoľany, Veľká Ida**

Figure 1.
Košice agglomeration and Zone of Košický kraj (Veľká Ida, Haniska, Bočiar, Sokoľany)

Climate relevant to atmospheric dispersion

The city of Košice is situated in the valley of the Hornád river, with the long time average annual wind speed of 2.9 m/s and 12% of calms. The prevailing wind direction is N to NE and SW to S, in the direction of the valley.

AMS stations

There are 3 AMS stations on the territory of AQMA, two of which are situated in the city of Košice (urban background station on the Strojárska street and urban transport station on Štúrova street), and one - industrial AMS station is located in the vicinity of large steel production company - U.S. Steel.

PM_{10} concentration data measured in the reference year 2005

Strojárska. (UB)

Number of exceedances before subtraction of transboundary portion: **45**
Number of exceedances after subtraction of transboundary portion: **22**

Štúrova (UT)

Number of exceedances before subtraction of transboundary portion: **75**

Number of exceedances after subtraction of transboundary portion: **35**

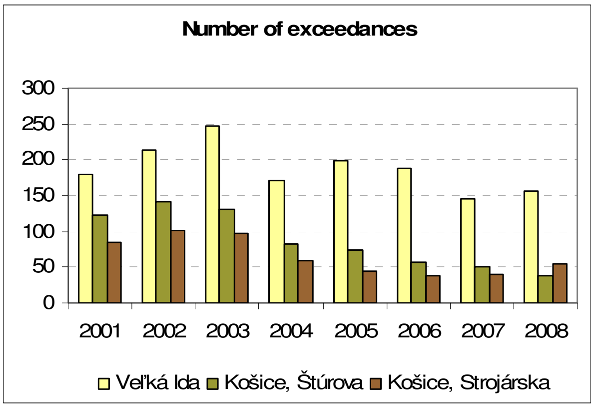
Veľká Ida (I)

Number of exceedances before subtraction of transboundary portion: **198**
Number of exceedances after subtraction of transboundary portion: **118**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 2 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 2
Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in µg/m^3.



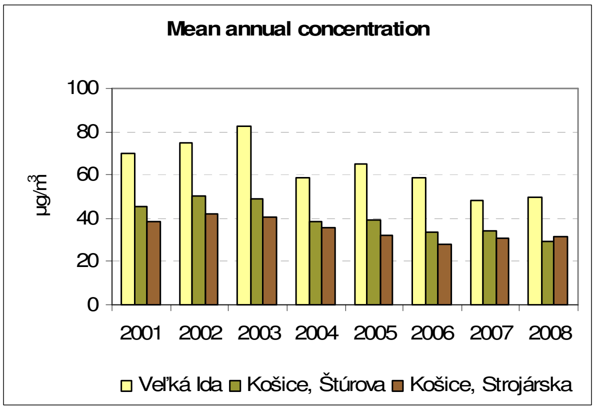


Fig. 3 and 4 show the main potential sources of PM_{10} on the territory of the city of Košice and municipalities of Bočiar, Haniska, Sokoľany, Veľká Ida.

Figure 3
Potential PM_{10} sources in the AQMA - Košice

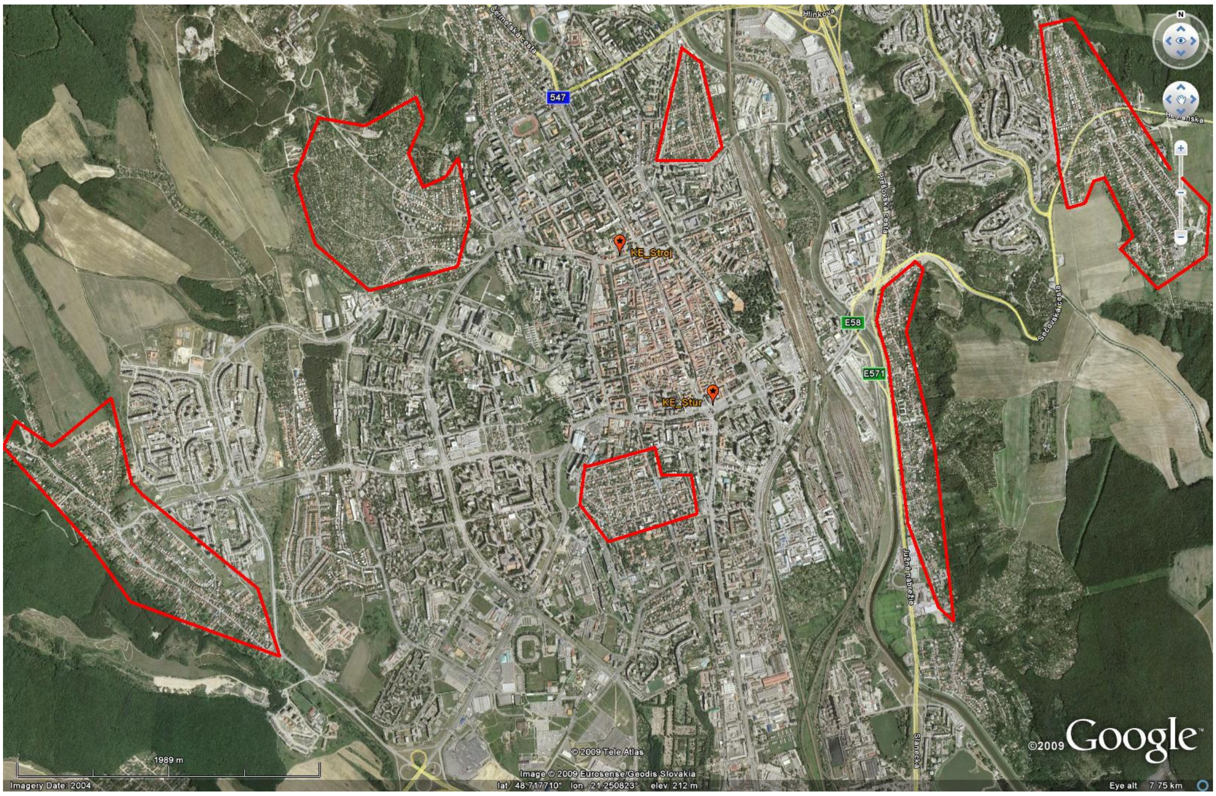
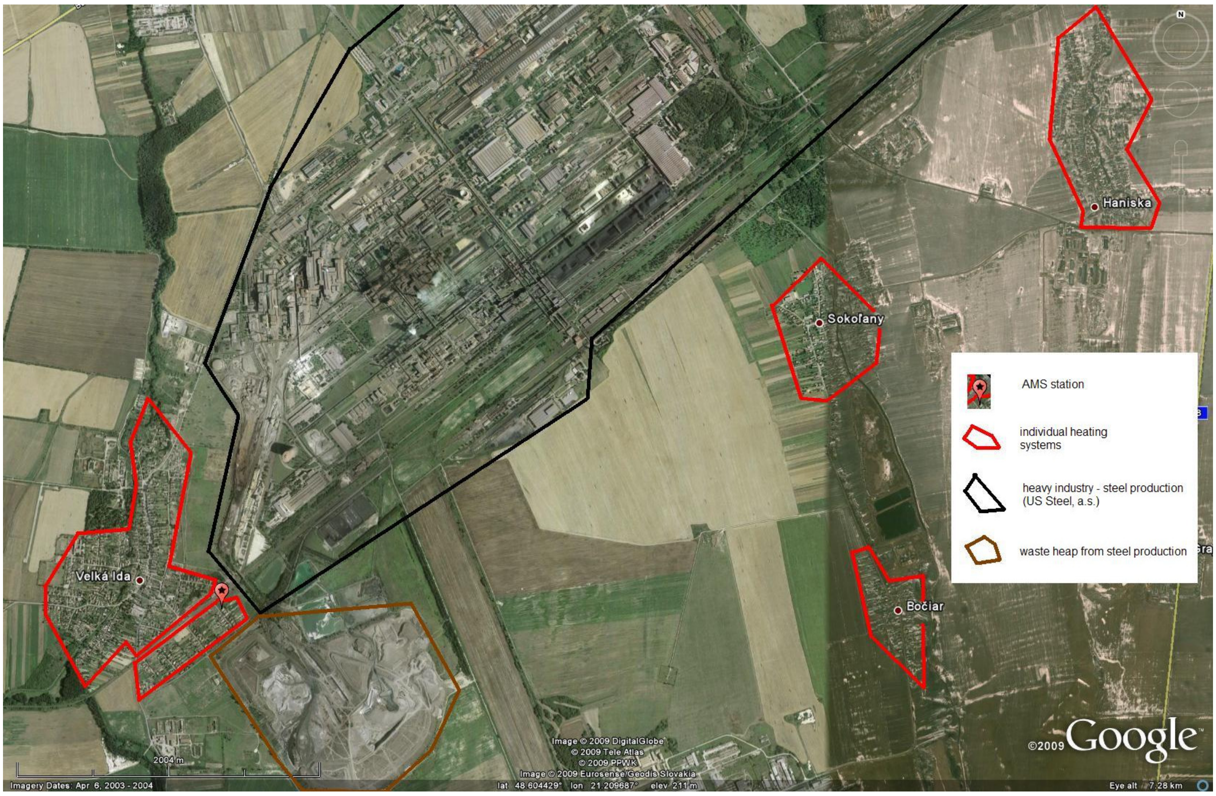


Figure 4
Potential PM_{10} sources in the AQMA – Veľká Ida, Haniska, Sokoľany, Bočiar



Source apportionment

The results of source apportionment according to [5] are represented on Fig. 5. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005.

In the city of Košice, the largest PM_{10} contributor is regional background, the essential part of which is transboundary portion. An important part is contributed by mobile sources, especially at AMS station of Štúrova. Large and medium point sources are only a minor contributor to annual average PM_{10} concentrations, they are represented mainly by U.S. Steel company which is located about 14 km SE from the city centre. Rather important contribution comes from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify.

The situation in Veľká Ida is different in that the U.S. Steel company premises start just next to the village, so large part of its PM_{10} concentrations can be attributed to the steel mill. Fig. 5 only includes stack emissions in the category of large and medium point sources. The fugitive emissions from the mill and material resuspended from the iron ore waste heap (see Fig. 4) are included in the category *other* sources. Regional background also contributes, but it is not a major part.

Figure 5
Contribution of different sources to mean annual concentration of PM_{10} in 2005.

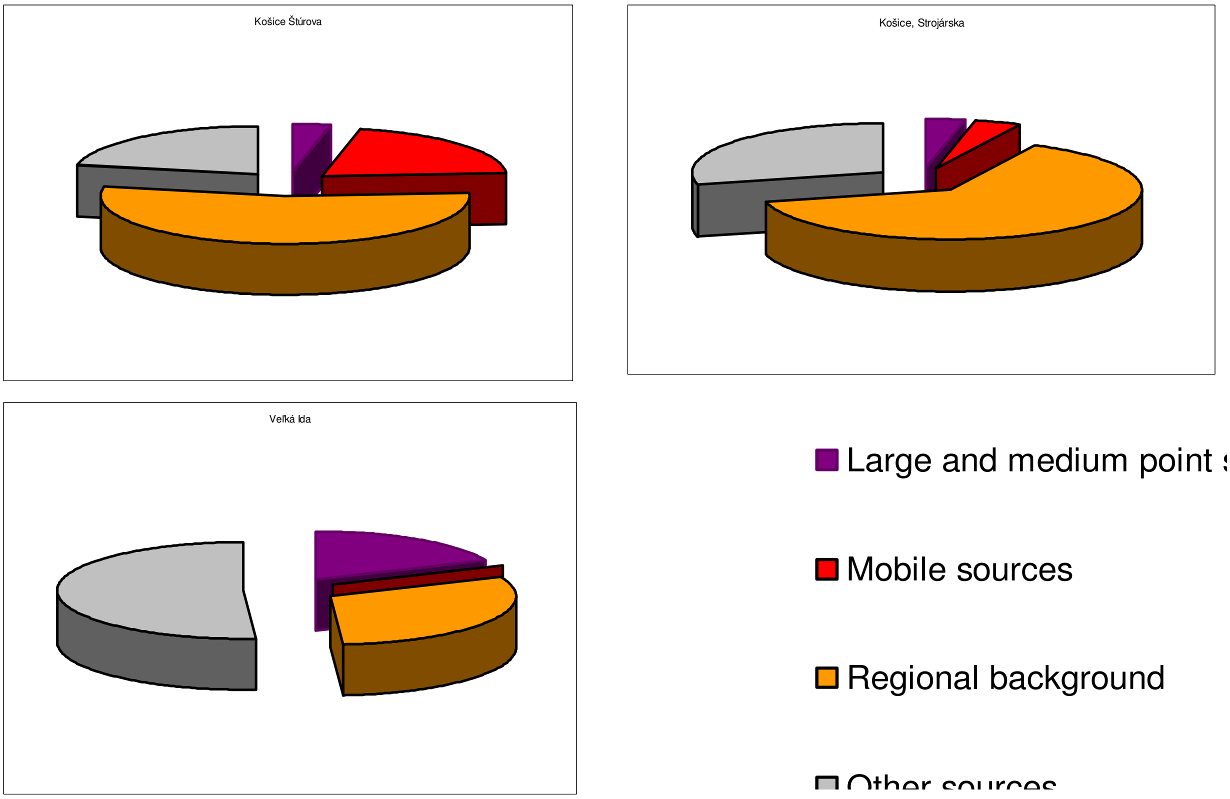


Fig. 6 shows the time development of emission totals according to emission sector in both Košice city and Veľká Ida. Clearly, the leading emitter of PM_{10} is industry, which is represented by U.S. Steel, contributing to local (Veľká Ida) as well as regional PM_{10} pollution.

Figure 6
Emissions from large, medium and small stationary sources and mobile sources on the territory of the city of Košice and municipalities of Bočiar, Haniska, Sokoľany, Veľká Ida.[2]

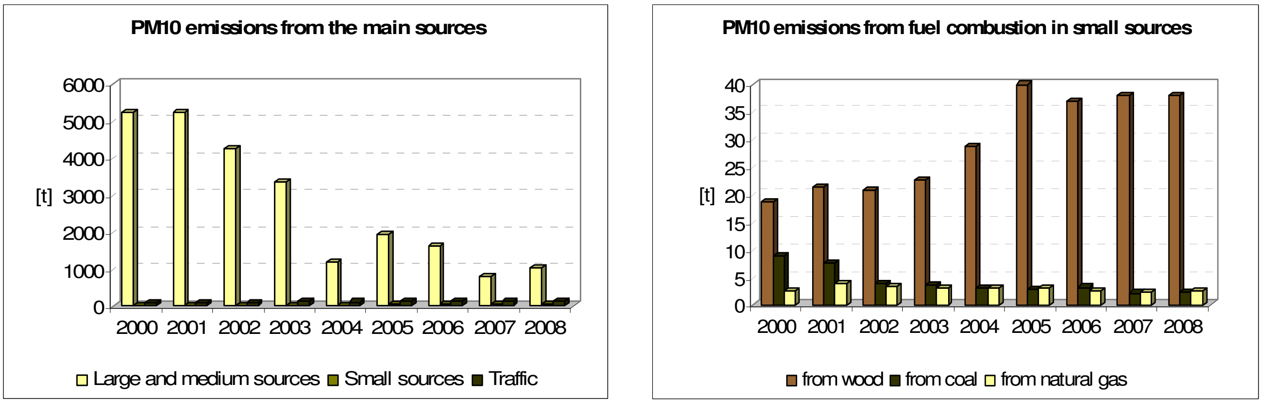
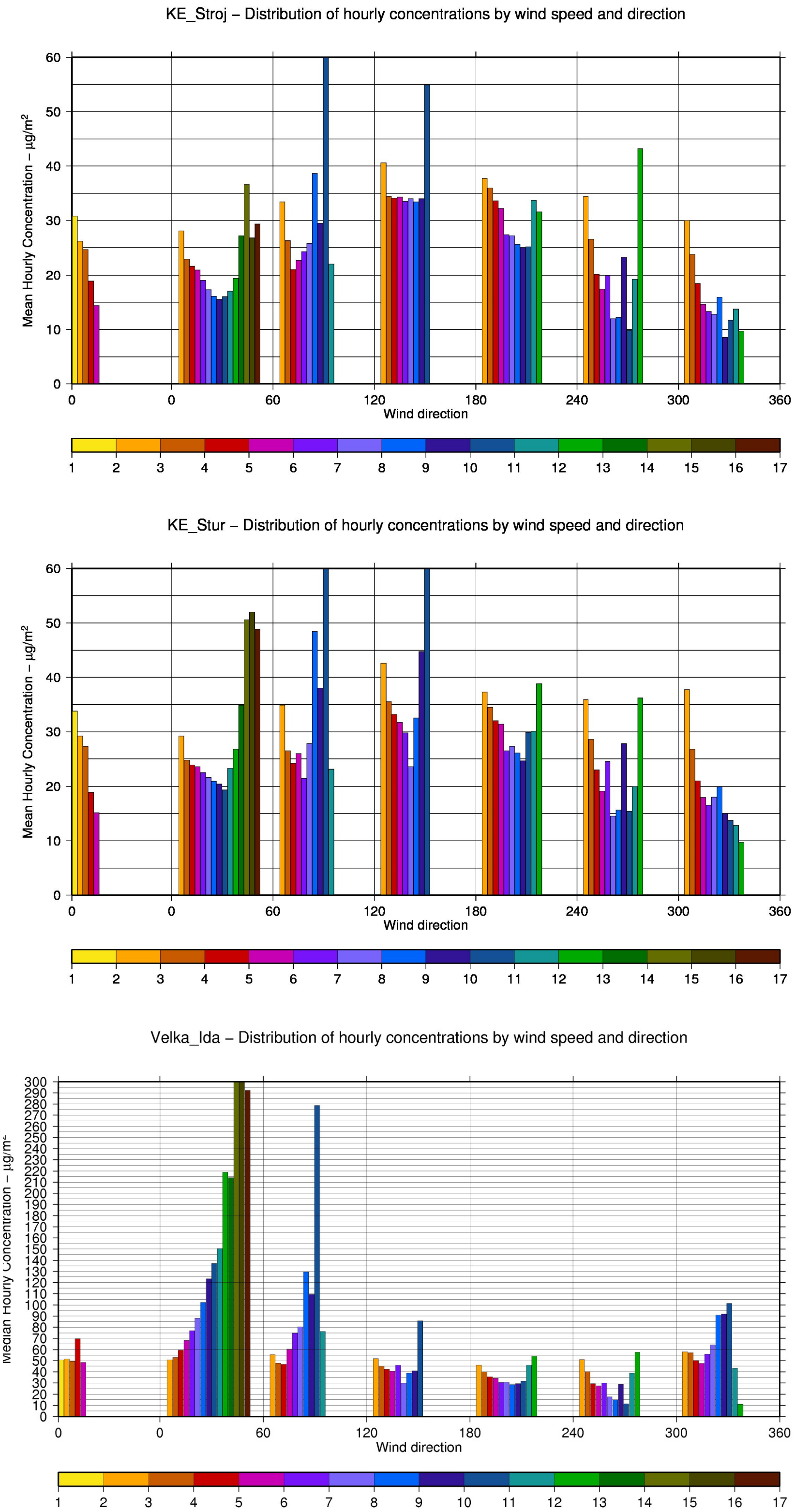


Fig. 7 shows the statistical distribution of hourly concentration means according the wind direction sector and wind speed at each respective AMS station. The graph corresponding to Veľká Ida AMS station clearly shows the dominant influence of the steel mill – maximum concentrations occur from NE direction, while large number of exceedances occurs when wind is blowing from southern directions where the heap is located. The high hourly PM_{10} concentrations and daily PM_{10} concentration exceedances in the city centre can be mostly attributed to southern directions, which correspond to the location of the steel mill (Fig. 7).

[2] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

Figure 7
Hourly PM_{10} concentrations depending on wind speed and wind directions at AMS stations



Conclusion

It has been demonstrated that in Košice agglomeration and the zone of Košický kraj the transboundary transport of PM_{10} contributes a large part to the concentrations during most of the exceedance situations in the reference year of 2005, and, in accordance with [1], can be subtracted from the measured concentrations. After subtraction, both AMS stations in the city centre did not exceed the allowed number of 35 exceedances of daily PM_{10} limit value. Although only the year of 2005 was modeled, there are reasons to believe that the situation will not largely differ for the other years. However, it is recognized that there are also other sources on the territory of the city, which contribute to the PM_{10} pollution, especially the traffic and resuspended dust. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the city.

Fig. 2 shows the PM_{10} exceedances have decreasing trend and putting into action further measures described in the air quality plan, there is a high probability that the PM_{10} limit values will not be exceeded in the Košice agglomeration.

The situation is different in Veľká Ida – even after the subtraction of the transboundary portion of PM_{10} concentration the number of exceedances (115) are high above the limit value. Although the number of exceedances have a decreasing trend, as shown in Fig. 2, we are not able to demonstrate that they will fall below the limit value of 35 in 2011 after all measures described in the air quality plan are implemented.

Zone: **Košický kraj**
AQMA: **Territory of the town of Krompachy**

Figure 1
Geographical position and terrain of AQMA (red balloon: AMS station, blue balloon – climatologic station)

Climate relevant to atmospheric dispersion

Krompachy is located in the valley system at the confluence of the Hornád river and Slovinský potok, between Levočské Vrchy mountains in the north and Slovenské Rudohorie in the south (Fig. 1). This geographical position creates adverse climatic conditions with respect to pollution dispersion, with the long-term (10 years) mean annual wind speed of 1 m/s and 58% of calms. Local circulation creates frequent inversions.

AMS station

The station is located in the valley of the Slovinský potok, 2 km SW from the copper plant of Kovohuty Krompachy. The surrounding built-up area comprises of multi-storey houses. The station is characterized as urban background.

PM_{10} concentration data measured in the reference year 2005

Total number of PM_{10} daily limit exceedances: **42**
Exceedances during days with mean wind speed lower than 1.5 m/s: **39**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 2 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 2
Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in µg/m^3.

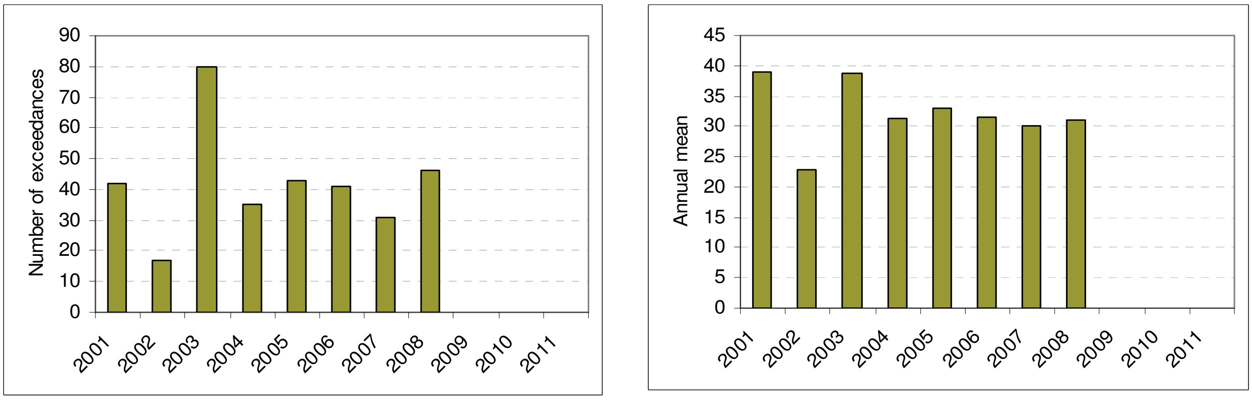
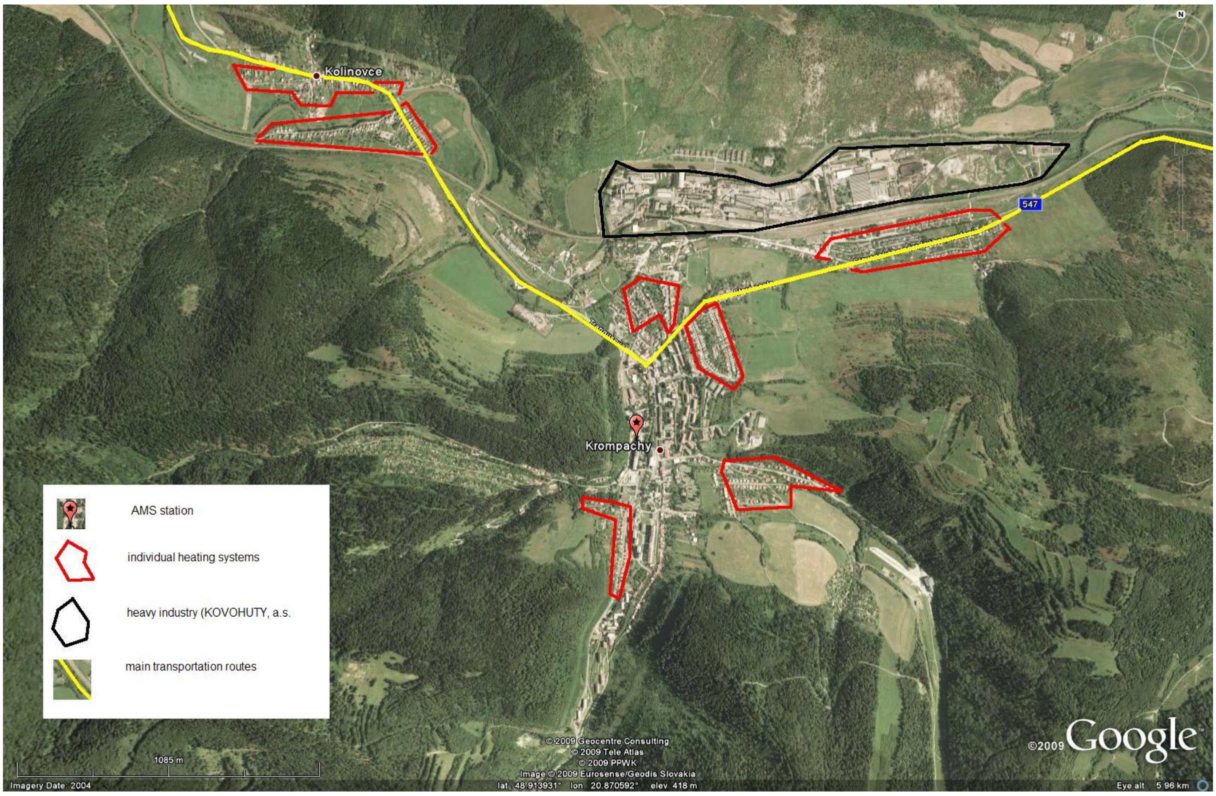


Figure 3 shows the main potential sources of PM_{10} on the territory of the town of Krompachy

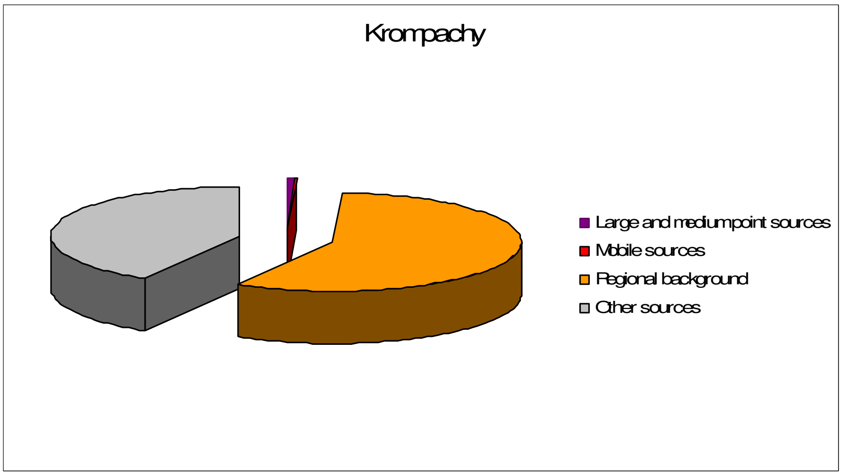
Figure 3
Potential PM_{10} sources in the AQMA of Krompachy



Source apportionment

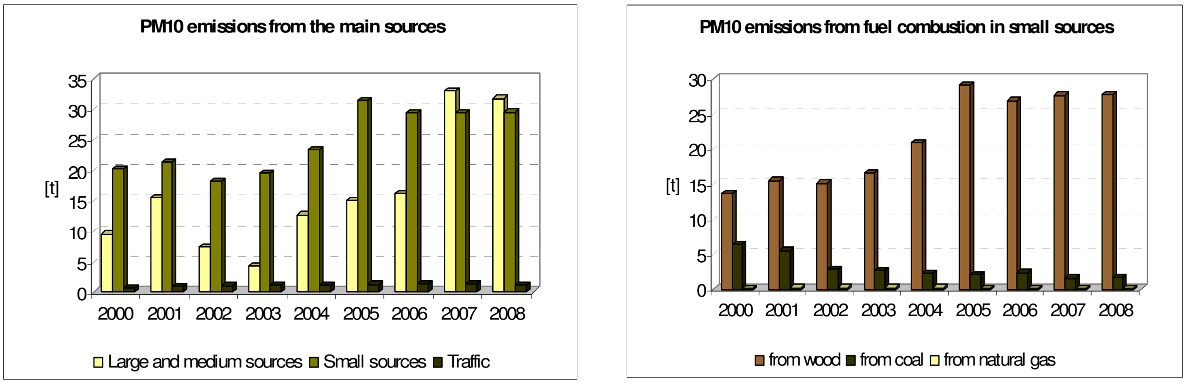
The results of source apportionment according to [5] are represented on Fig. 4. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources and traffic had only minor impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify.

Figure 4
Contribution of different sources to mean annual concentration of PM_{10} in 2005



This is also reflected in Fig. 5 showing aggregated emission by sector at the AQMA of Krompachy – emissions from small sources clearly dominated until the year 2006, but large and medium sources emissions associated with the increase of Kovohuty copper plant production overcame the small sources in 2007. However, the emissions are still relatively low and they did not cause increase in PM_{10} concentrations, which implies that the main contributors to high PM_{10} concentrations are really small sources, namely, residential heating fuelled by wood.

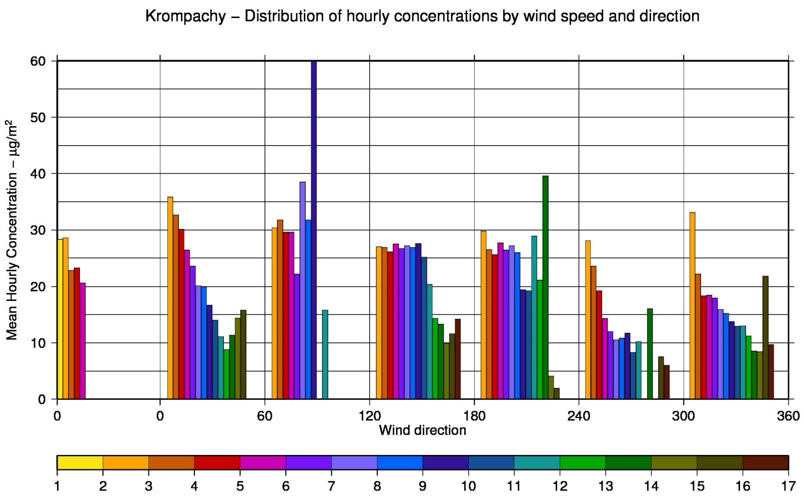
Figure 5
Emissions from large, medium and small stationary sources and mobile sources on the territory of the town of Jelšava and municipalities of Lubeník, Chyžné, Magnezitovce, Mokrá Lúka, Revúcka Lehota.[3]



Graph in Fig. 6 supports these findings, as winds from most directions decrease with increasing wind speed. Increasing concentrations with winds from eastern directions would indicate fugitive emissions from construction activities in Kovohuty in 2007/2008, or resuspension from surrounding arable lands – taking into account the climatic conditions in the valley they are not likely to contribute to daily PM_{10} LV exceedances.

[3] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

Figure 6
Hourly PM_{10} concentrations depending on wind speed and wind directions at Krompachy AMS station

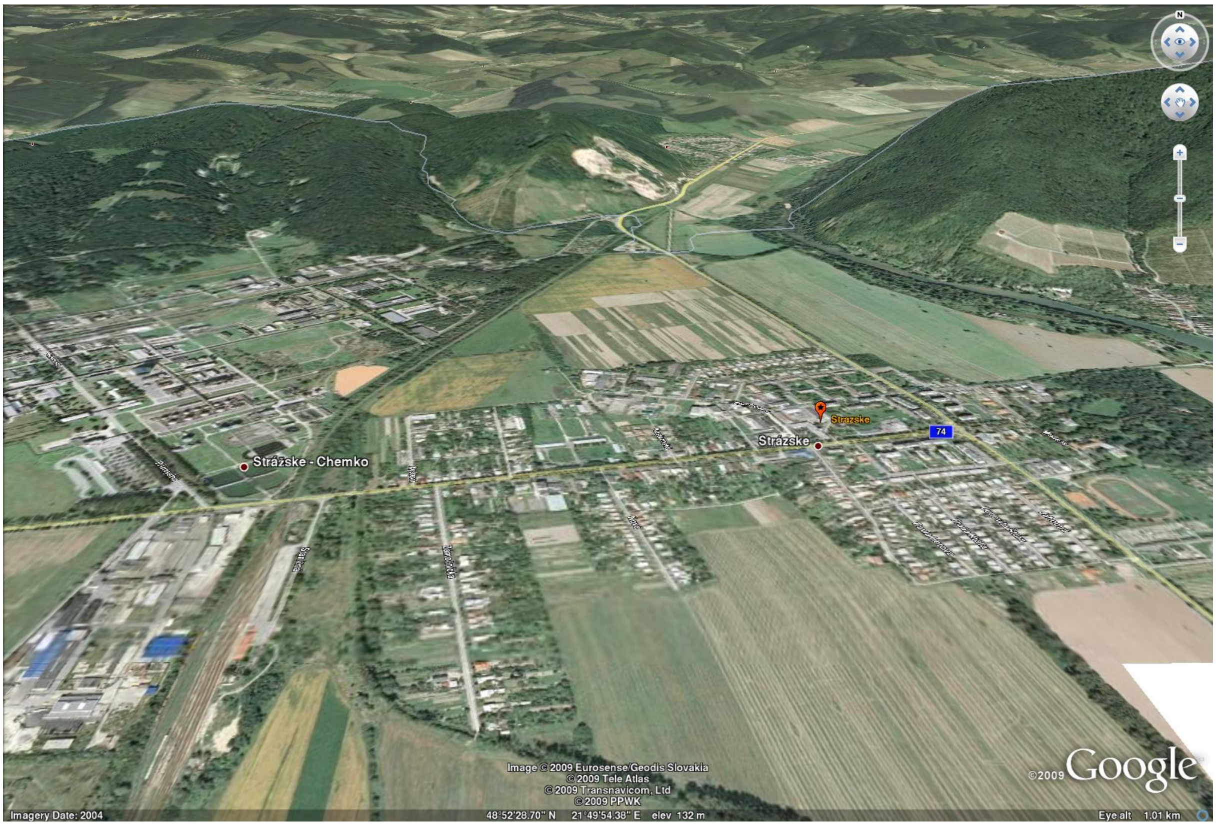


Conclusion

It has been demonstrated that the air quality in AQMA of Krompachy is highly influenced by its adverse dispersion conditions associated with its geographical position and adverse climatic conditions with the annual wind speed below 1.5 m/s. It has been demonstrated that 39 out of 42 daily PM_{10} LV exceedances in the reference year of 2005 occurred at days with the wind speed below 1.5 m/s. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the city. Fig. 3 shows that the PM_{10} exceedances have clear decreasing trend and the number of daily LV exceedances dropped below the allowed number of 35. It was shown that the increase in PM_{10} concentrations in 2008 was only temporary, associated with the construction works in the Kovohuty plant. Putting into action further measures described in the air quality plan, there is a high probability that the concentrations fall under the limit value in 2011.

Zone: **Košický kraj**
AQMA: **Territory of the town of Strážske**

Figure 1.
Geographical position and terrain of AQMA (red balloon: AMS station, blue balloon – climatologic station)



Climate relevant to atmosperic dispersion

Strážske is located in a valley between Slánske Vrchy and Vihorlat mountains. Long-term (10 years) mean annual wind speed is 1.9 m/s, but for last two years the annual mean was as low as 1.2 m/s. There is 13% of calms.

AMS station

Monitoring station is situated in the centre of town in an open area among buildings, gardens and green areas, approximately 1.5 km east-south-east from the Chemko Strážske chemical plant. It is characterized as urban background

PM_{10} concentration data measured in the reference year 2005

Total number of PM_{10} daily limit exceedances: **44**
Exceedances during days with mean wind speed lower than 1.5 m/s: **30**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 2 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 2.
Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in µg/m^3.

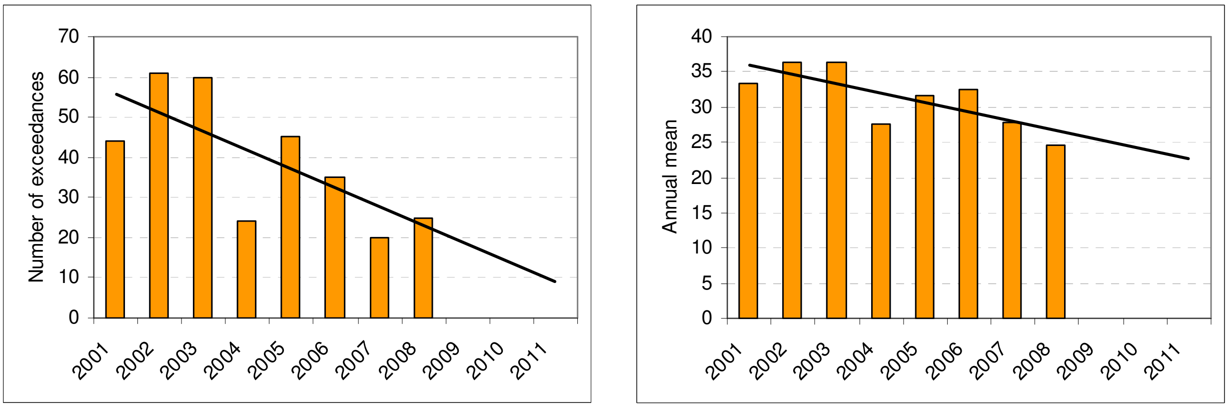
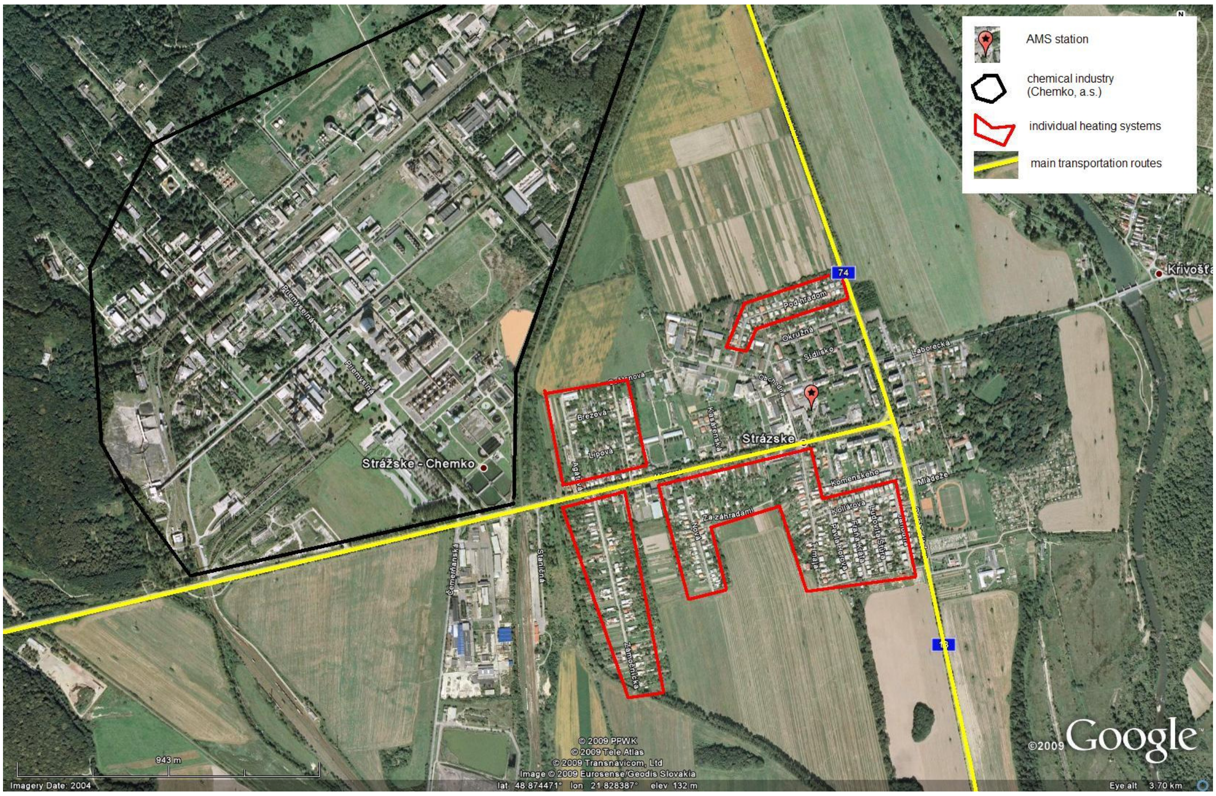


Fig. 3 shows the main potential sources of PM_{10} on the territory of the town of Strážske

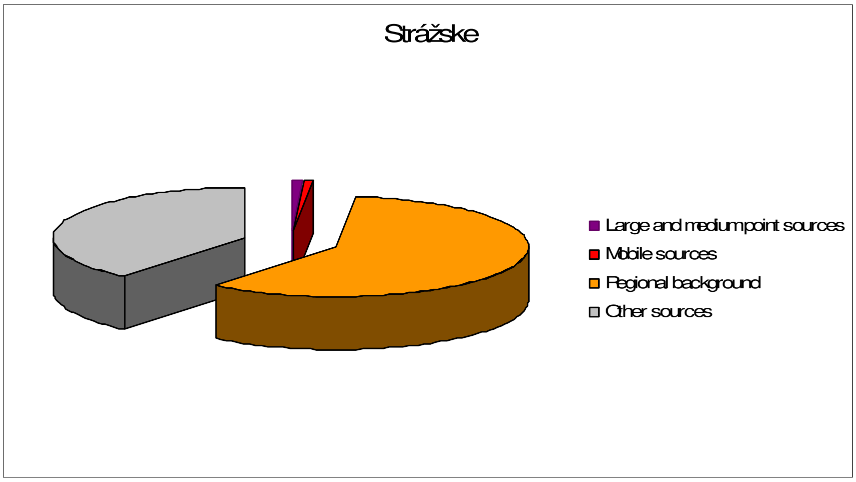
Figure 3.
Potential PM_{10} sources nearby the territory of the town of Strážske



Source apportionment

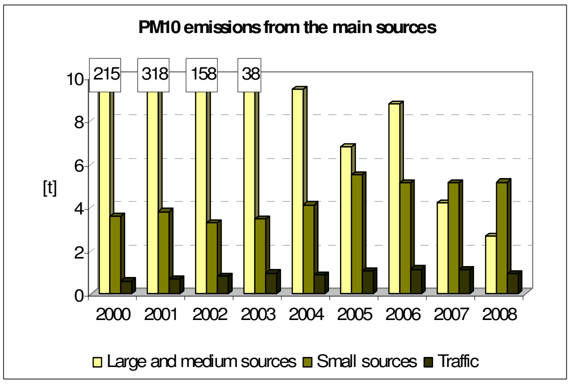
The results of source apportionment according to [5] are represented on Fig. 4. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources and traffic had only minor average impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify.

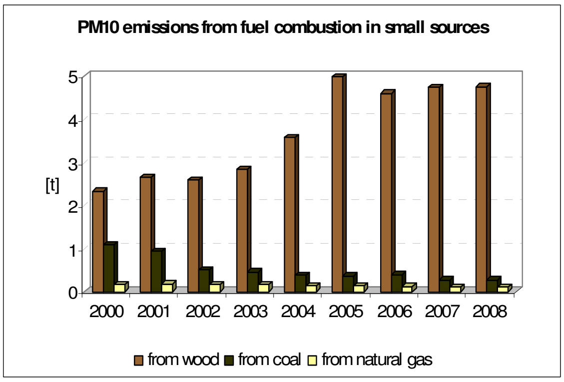
Figure 4.
Contribution of different sources to mean annual concentration of PM_{10} in 2005



Chemko a.s., chemical company used to be main industrial PM_{10} emitter in the AQMA area. Due to production decrease and application of scrubber filters and other measures, the emissions from large and medium sources decreased considerably, reaching the levels comparable to small sources in 2005. As demonstrated in Fig. 5, currently the main PM_{10} emission producers are small sources, namely, residential heating systems fuelled by wood.

Figure 5.
Emissions from large, medium and small stationary sources and mobile sources on the territory of the town of Strážske.[4]

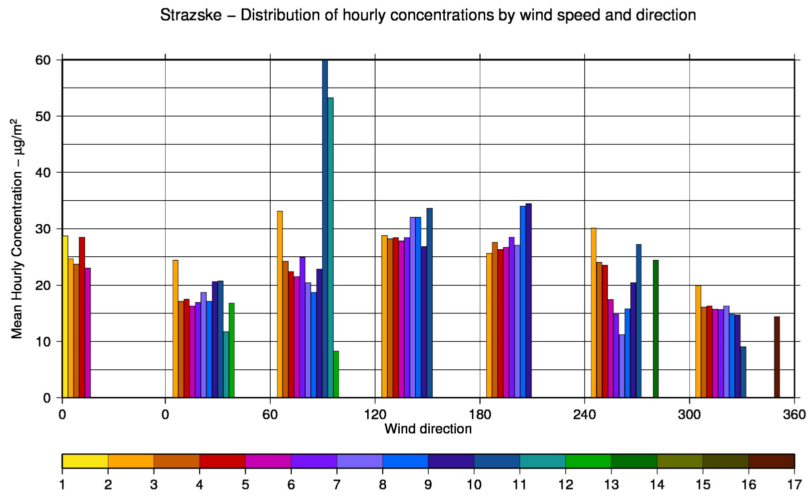




Graph in Fig. 6 shows that the high hourly concentrations occur from SE to SW directions independently on the wind speed, but the maximum occurs at high wind speeds from ENE direction. This would indicate a resuspension of dust from arable farming land or some seasonal works – it is probably time-limited to couple of hours and does not significantly contribute to daily PM_{10} exceedances.

[4] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

Figure 6.
Hourly PM_{10} concentrations depending on wind speed and wind directions at Strážske AMS station



Conclusion

It has been demonstrated that the air quality in the AQMA of Strážske is influenced by its adverse dispersion conditions associated with its valley circulation and climatic conditions with the long-term annual wind speed of 1.8 m/s and last two years annual wind speed of 1.2 m/s It has been demonstrated that 30 out of 44 daily PM_{10} LV exceedances in the reference year of 2005 occurred at days with the wind speed below 1.5 m/s. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the city. Fig. 3 shows that the PM_{10} exceedances have clear decreasing trend, with no exceedances of the allowed number of 35 daily LV exceedances in the past three years. There is a high probability that AQMA of Strážske complies with the EU air quality directive [1] also in 2011.

Zone: **Banskobystrický kraj**
AQMA: **Territory of the city of Banská Bystrica**

Figure 1
Geographical position and terrain of Banská Bystrica AQMA (red balloon: AMS station – original position, blue balloon – climatologic station)

Climate relevant to atmosperic dispersion
Banská Bystrica is situated in mountainous area in Central Slovakia, in a deep valley between Poľana, Žiar and Nízke Tatry mountain ranges (Fig. 1). Most of the winds are blocked by the mountains and long-term annual average wind speed is as low as 1.5 m/s, and there is 31% occurence of calms. It is characterized by frequent inversions especially in winter seasons, but due to mountain circulation they occur also in summer seasons in night and early morning hours.

AMS station
There is one monitoring station in the AQMA. It had been situated at Nam. Slobody until the end of year 2007, and was characterized as urban background. In 2008 it was moved to Štefánikovo Nábrežie, and its character changed to urban traffic. Both sites (past and present) are in lower parts of the city with adverse dispersion conditions.

PM_{10} concentration data measured in the reference year 2005

Total number of PM_{10} daily limit exceedances: **69**
Exceedances during days with mean wind speed lower than 1.5 m/s: **56**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.
Fig. 2 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 2.
Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in µg/m^3.

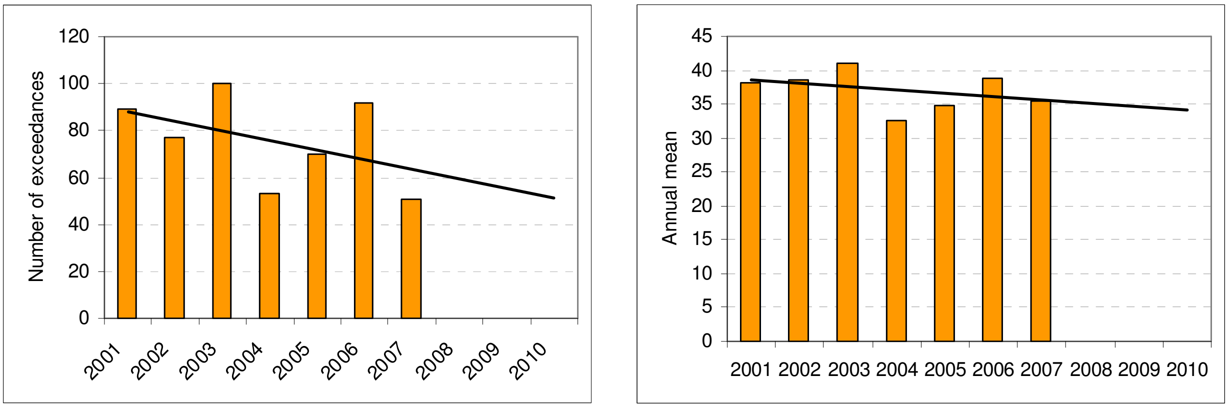
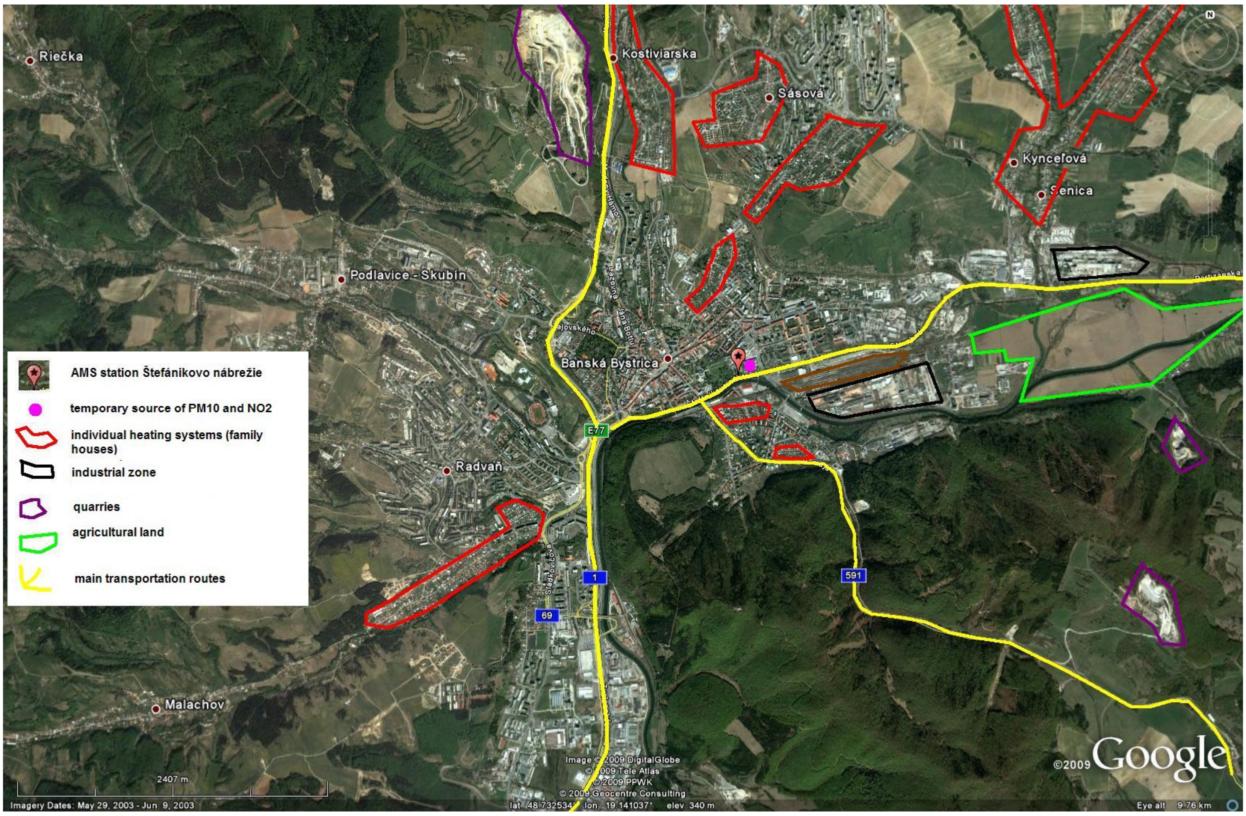


Fig. 3 shows the main potential sources of PM_{10} in Banská Bystrica.

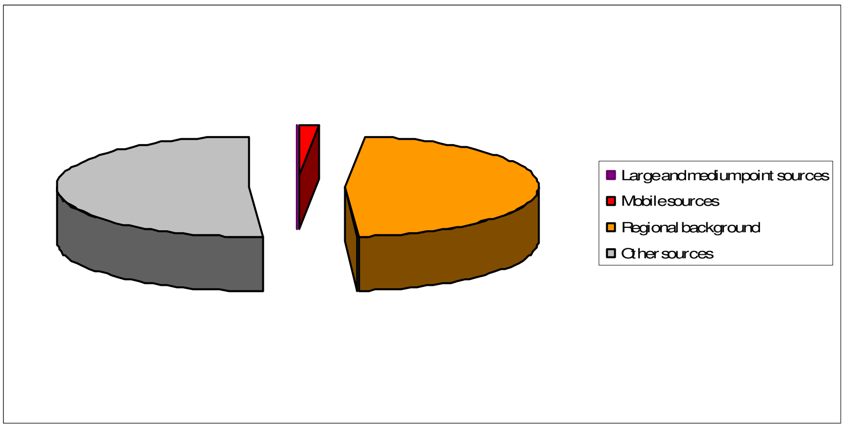
Figure 3.
Potential PM_{10} sources in the Banská Bystrica



Source apportionment

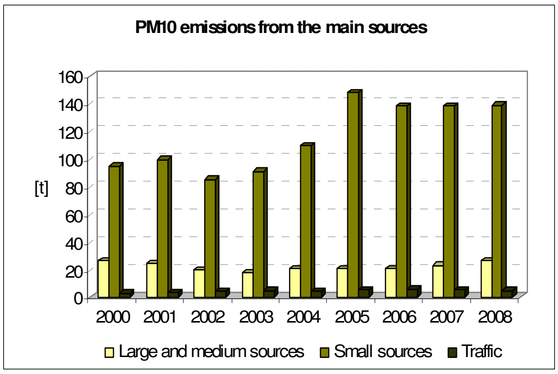
The results of source apportionment according to [5] are represented on Fig. 4. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources and traffic had only minor impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify. We attempt to accomplish a qualitative apportionment of the *other* sources using the spatial information on Fig. 3 in combination with wind and concentration statistics summarized in Fig. 6 and other supplementary information described further in the text.

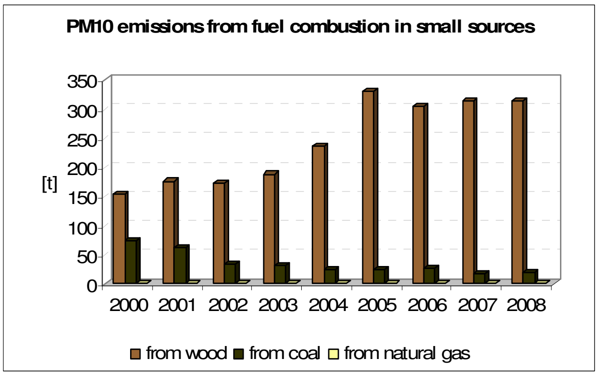
Figure 4.
Contribution of different sources to mean annual concentration of PM_{10} in 2005



Particularly in Banska Bystrica, the *other* potential sources include resuspended material, occurring at higher wind speeds, from roads (other than exhaust and non-exhaust traffic emissions), non-stack emissions from industrial sources (e.g. dust and dirt from the premises of Smrecina wood processing company and other industry) and dust from construction sites. Another important source of PM_{10} in winter are individual heating systems in family houses burning coal and wood – this contributes to PM_{10} concentrations at low wind speeds, and is probably responsible for large part of exceedances in winter months. Fig. 5 shows the total emissions of large and medium sources, traffic and small sources on the territory of the city. From the *other* sources, the graph only includes *small* sources, which are calculated based on the amount of different types of fuel sold at retail to individuals, threrefore represent mostly the individual heating systems in family houses. The second graph in Fig. 5 splits the emissions of the *small* sources into emissions from different fuels.

Figure 5.
Emissions from large, medium and small stationary sources and mobile sources on the territory of the city of Banská Bystrica.[5]

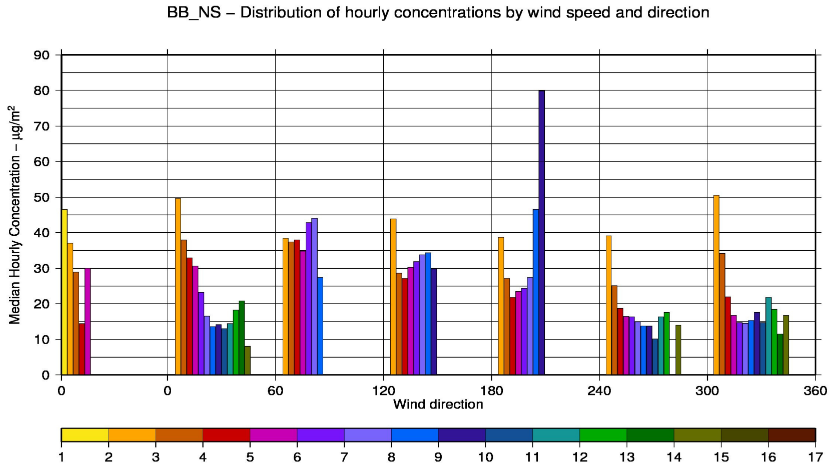


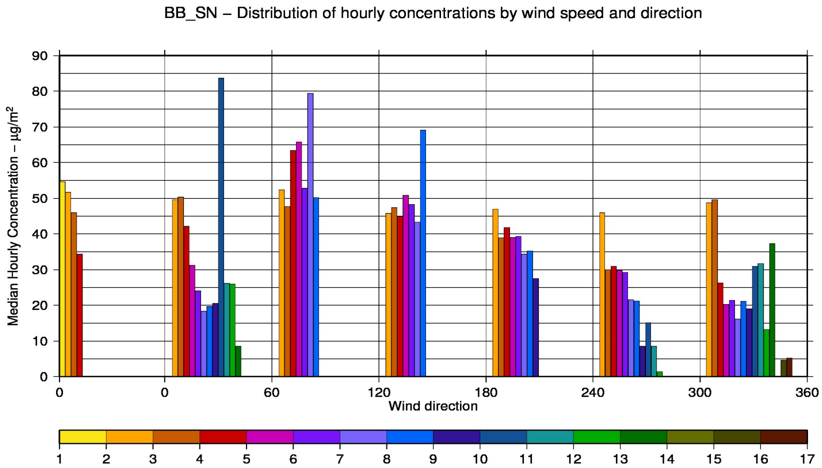


First graph on the Fig. 6, corresponding to the old position of AMS station in urban background, shows that winds blowing from north-west sector did not use to bring about high PM_{10} concentrations – the concentration falls with increasing wind speed. The situation was different at higher wind speeds from east to south-west sectors – the concentrations do not fall with wind, they even increase from the south sector, which points at some sources of resuspended dust at these sectors, which may be the Smrecina wood processing company, road transportation, railway depot or agricultural land.
In 2008 the monitoring station was moved to close vicinity to the road I/66, and changed the character from urban background to urban transport. In the same year a construction works on the new road bypass initiated, causing the existing road I/66 to be overloaded with all kind of transport. In addition to these activities, a reconstruction of infrastructure (sewage system) was taking place, and diesel machinery and heavy trucks have been operating just next to the new AMS station (purple dot on the map) from the middle of May 2008 until the middle of September 2009. All these facts caused the remarkable increase not only in daily PM_{10} LV exceedances, but also in the annual PM_{10} and NO_2 concentrations which exceeded the limit values in 2008. It is also demonstrated on the second graph in Fig. 6, where highest concentrations at all wind speed intervals are observed from NE to SE wind direction sectors.

[5] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

Figure 6.
Hourly PM_{10} concentrations depending on wind speed and wind directions at AMS stations Námestie Slobody (old) and Šafárikovo nábrežie (new).





Conclusion

It has been demonstrated that the air quality in Banská Bystrica is highly influenced by its adverse dispersion conditions associated with its geographical position in a valley and adverse climatic conditions with the annual wind speed below 1.5 m/s. It has been demonstrated that 56 of 69 daily PM_{10} LV exceedances in the reference year of 2005 occurred at days with the wind speed below 1.5 m/s. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the city. One of the most important measures taken in order to improve the air quality is the construction of the northern traffic bypass of the city, which will unload the transfer through the city center. Due to the construction works going on in the last year, the traffic load of the Stefanikovo nabrezie, where the AMS station is currently positioned, the concentrations of PM_{10} and NO_2 increased, but this worsened situation is temporary - should not last longer than until the year 2011 when the bypass is planned to be finished. Fig. 2 shows that excluding the last year, the PM_{10} exceedances have decreasing trend and putting into action further measures described in the air quality plan, there is a good chance that fall under the limit value.

Zone: **Banskobystrický kraj**
AQMA: **Territory of the town of Hnúšťa, municipalities of Brádno, Hačava, Likier, Polom, town of Tisovec and municipalities of Rimavská Píla and Rimavské Brezovo**

Figure 1
Geographical position and terrain of AQMA

Climate relevant to atmospheric dispersion
All the municipalities of the AQMA are situated in a rather narrow valley, oriented in north-south direction, of Slovenske Rudohorie mountain range (Fig. 1). The winds are blocked with mountains from N, W and E directions, resulting in as low long-term annual wind speed as 0.7 m/s, with 58% occurrence of calms. Mountain valley circulation determines a climate with percentage of inversions especially in cold seasons of the year.

AMS station
There is one monitoring station, located in the small town of Hnúšťa, characterized as suburban background. It is situated in the north outskirt of the town.

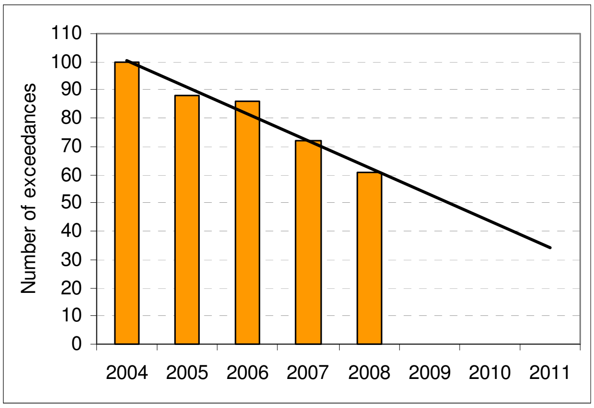
PM_{10} concentration data measured in the reference year 2005 and following years

Total number of PM_{10} daily limit exceedances in 2005: **83**
Exceedances during days with mean wind speed lower than 1.5 m/s: **82**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 2 gives the information on the annual means and number of exceedances prior and after the reference year of 2005 and shows the decreasing trend.

Figure 2.
Number of PM_{10} LV exceedances and mean anual PM_{10} concentration (µg/m^3) – AMS Hnúšťa



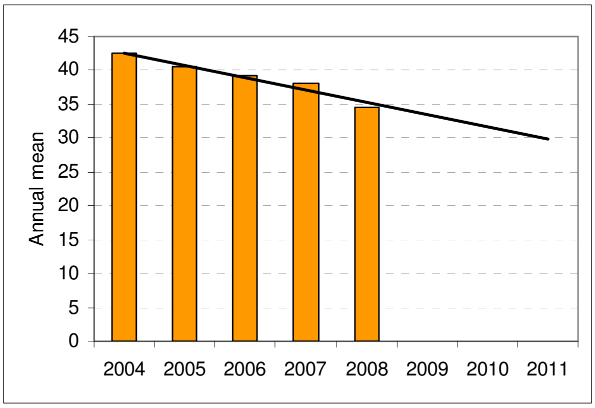
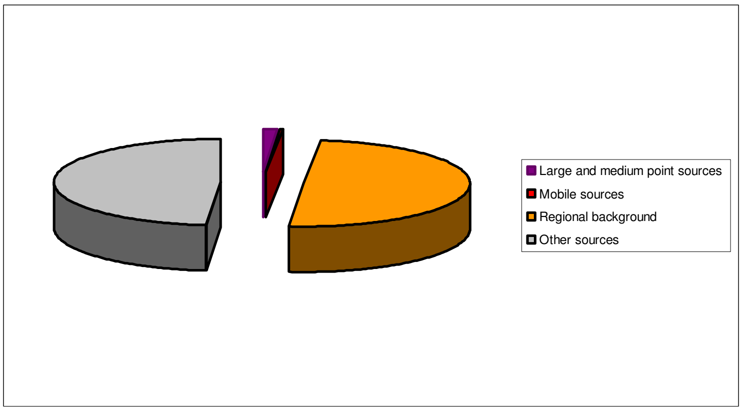


Fig. 4 contains a photomap of the AQMA with the sources of PM_{10}.

Source apportionment

The results of source apportionment according to [5] are represented in Fig. 3. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources and traffic had only minor impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify. We attempt to accomplish a qualitative apportionment of the *other* sources using the spatial information on Fig. 4 in combination with wind and concentration statistics summarized in Fig. 6 and other supplementary information described further in the text.

Figure 3
Contribution of diffeent sources to mean annual concentration of PM_{10}



AQMA involves a rather narrow valley, along which the main industrial sources are located. These industrial sources are not the main contributor to PM_{10} pollution in the AQMA – as demonstrated in Figures 2.9 and 2.11, the major emitter of PM_{10} are small sources involving mainly residential heating sources. Although the data in Fig. 5 is based on spatial disaggregation of statistical data and there are no data available on the composition of fuel in individual residential areas, information is reported that due to the high prices of gas many households shift back to using wood especially in forested areas like this AQMA.
It must be noted that the dust which may be resuspended from the dirty premises of the industrial plants is not included in the large and medium source emissions in Fig. 2.11. Neither is included in mobile sources the dust which is produced by dirty uncovered heavy trucks carrying out transport of material to and from the industrial plants along the whole valley, and passing by the AMS station in Hnusta. All these must be included in *other* – non-quantified - sources in Fig. 3.

Figure 4
Potential PM_{10} sources in Hnúšťa AQMA

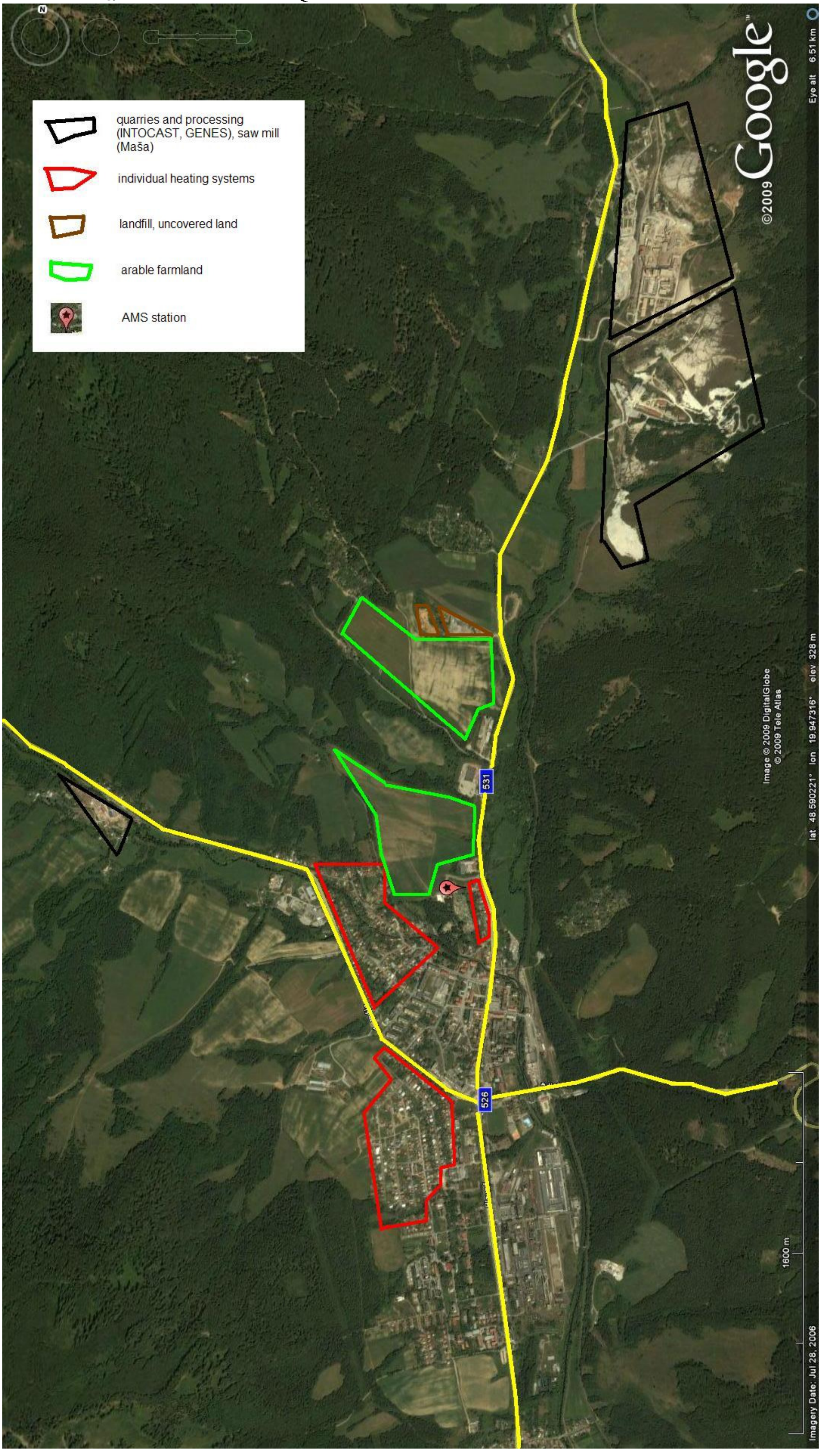
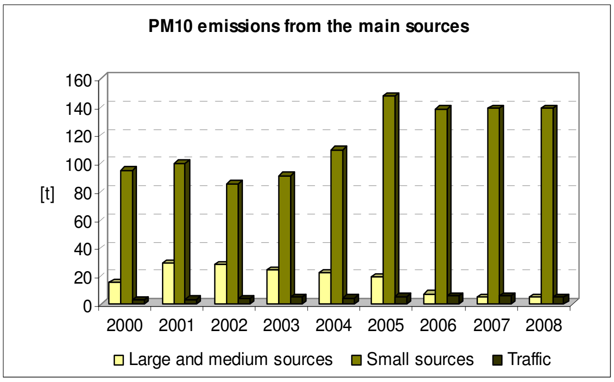
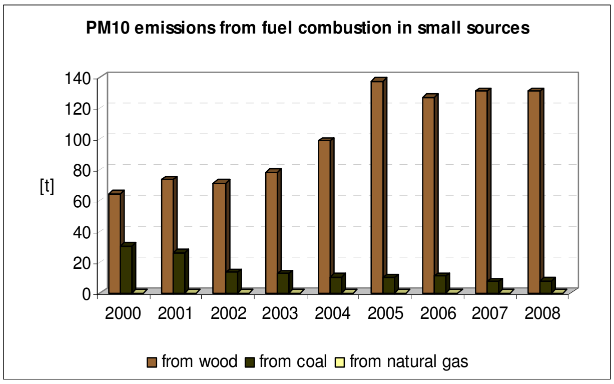


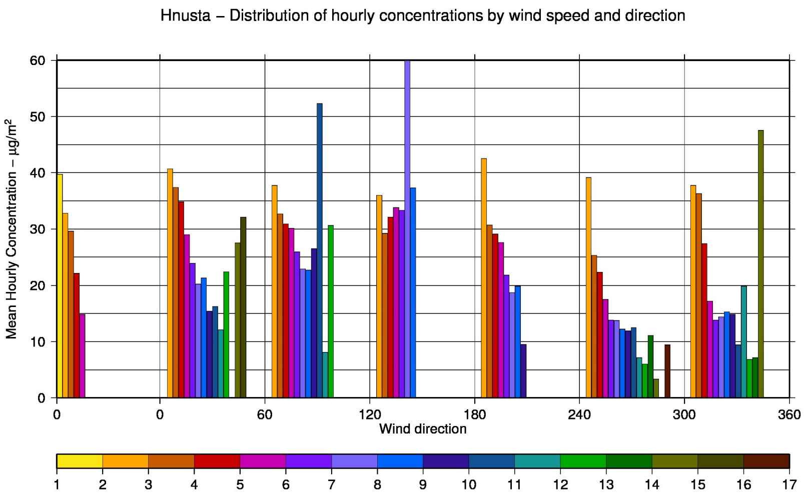
Figure 5
Emissions from large, medium and small stationary sources and mobile sources on the territory AQMA.[6]





Graph in Fig. 6 shows that the the main fugitive sources are located from NE to SE from the monitoring station which corresponds to the main road and industrial sites as a suspect sources. However, although the hourly concentrations during windy situations are high, the daily LV exceedances hardly occur during the windy situations.

Figure 6
Hourly PM_{10} concentrations depending on wind speed and wind directions at AMS stations Námestie Slobody (old) and Šafárikovo nábrežie (new).



Conclusion

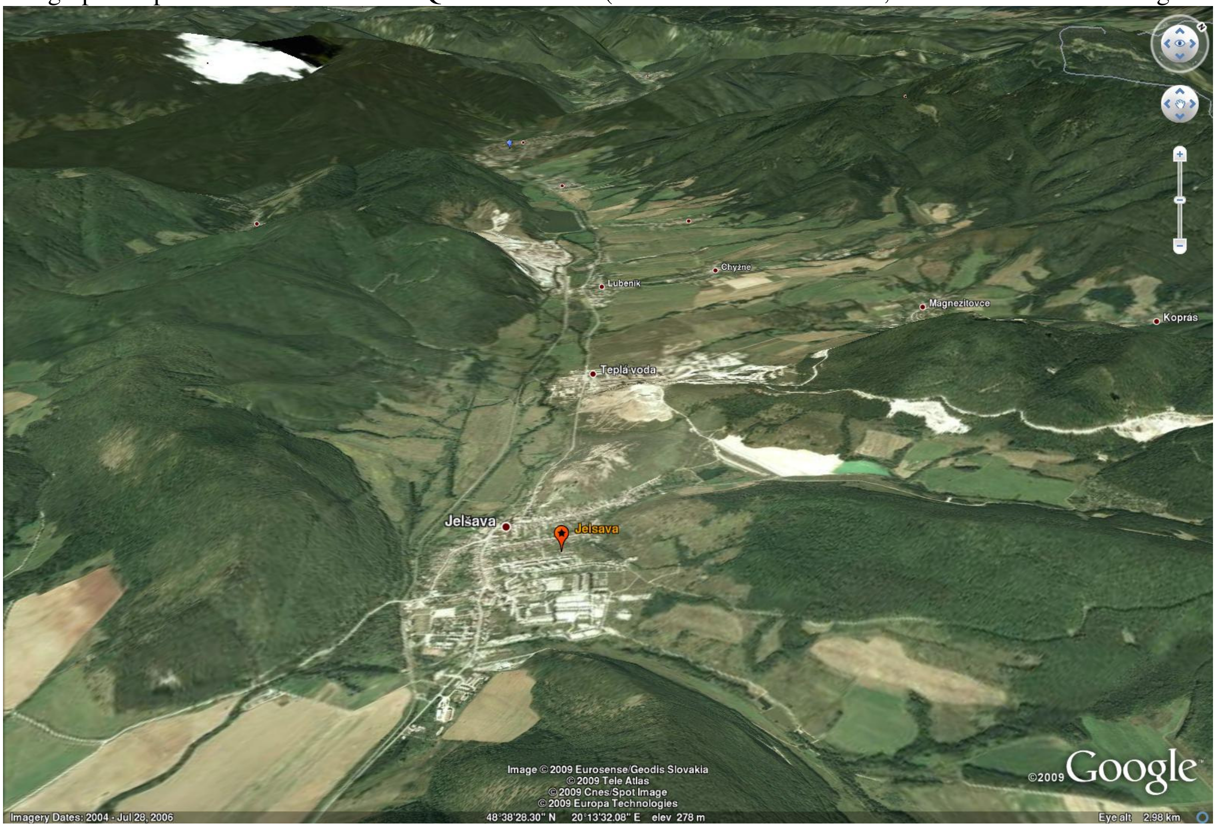
It has been demonstrated that the air quality in Hnúšťa AQMA is highly influenced by its adverse dispersion conditions associated with its geographical position in a valley and adverse climatic conditions with the annual wind speed below 1.5 m/s. It has been demonstrated that 82 out of 83 daily PM_{10} LV exceedances in the reference year of 2005 occurred at days with the wind speed far below 1.5 m/s. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the AQMA. Due to

[6] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

positive effect of the measures taken to improve the air quality, the daily pm10 LV exceedances have decreasing trend and there is a high probability that they will fall under the limit value in 2011.

Zone: **Banskobystrický kraj**
AQMA: **Territory of the town of Jelšava and municipalities of Lubeník, Chyžné, Magnezitovce, Mokrá Lúka, Revúcka Lehota**

Figure 1
Geographical position and terrain of AQMA of Jelšava (red balloon: AMS station, blue balloon – climatologic station)



Climate relevant to atmospheric dispersion

Jelšava (Fig. 1) is situated in a narrow valley of the Muráň river in the southern part of Slovenské Rudohorie mountains. The geographical position determines the adverse climatic conditions with regard to pollutant dispersion - long-term (10 years) annual wind speed is 1.2 m/s, with 17% occurrence of calms. Mountain valley circulation causes frequent occurrence of inversions even during the day time especially in cold seasons of the year.

AMS station

There is one monitoring station in the AQMA, situated in Jelšava, characterized as urban background

PM10 concentration data measured in the reference year 2005

Total number of PM_{10} daily limit exceedances: **74**
Exceedances during days with mean wind speed lower than 1.5 m/s: **63**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 2 gives the information on the annual PM_{10} mean concentrations and number of PM_{10} daily limit exceedances prior and after the reference year of 2005.

Figure 2
Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in µg/m^3.

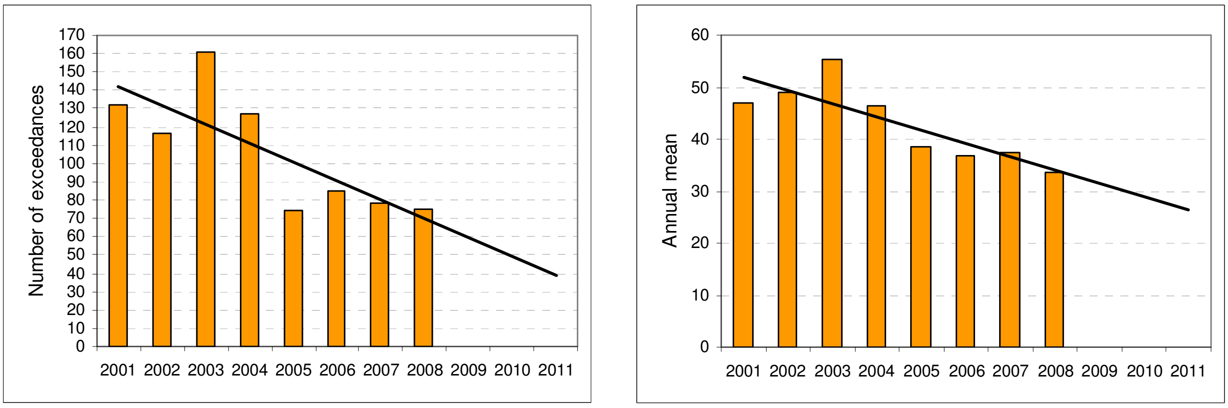
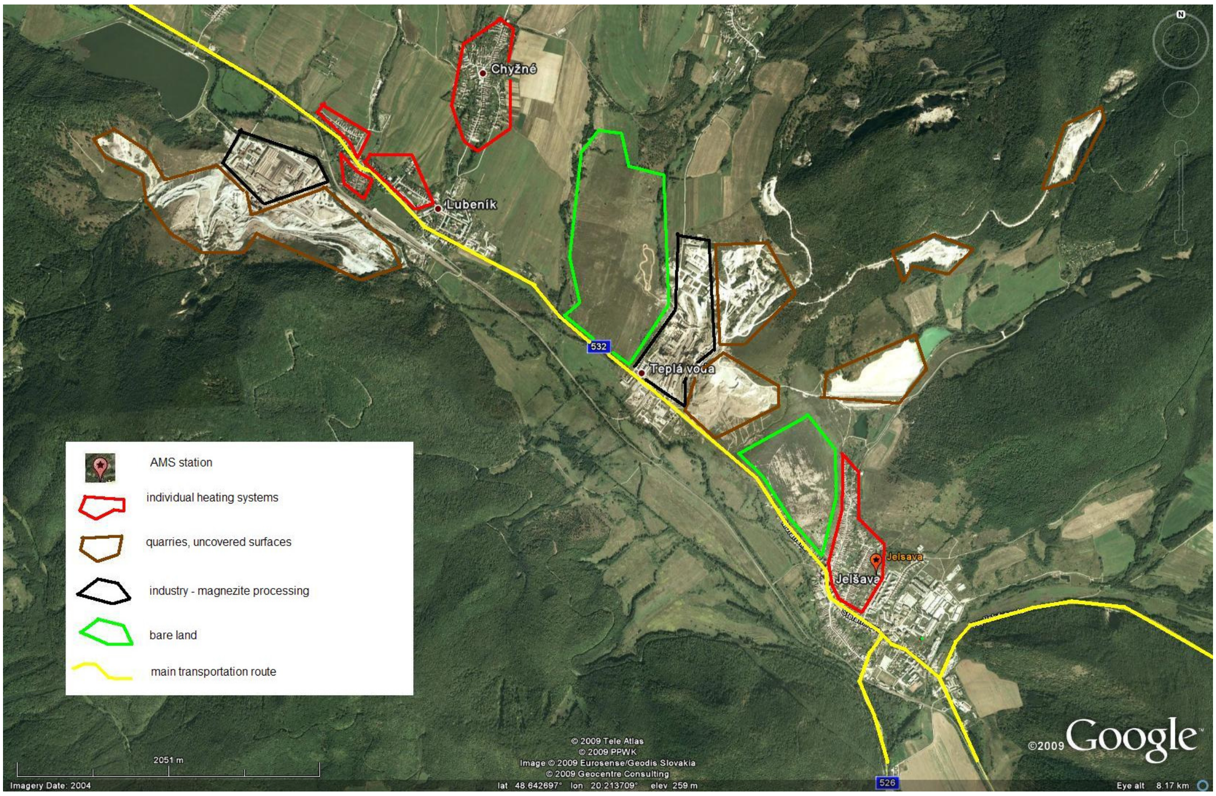


Figure 3 shows the main potential sources of PM_{10} on the territory of the town of Jelšava and municipalities of Lubeník, Chyžné, Magnezitovce, Mokrá Lúka, Revúcka Lehota

Figure 3
Potential PM_{10} sources AQMA of Jelšava



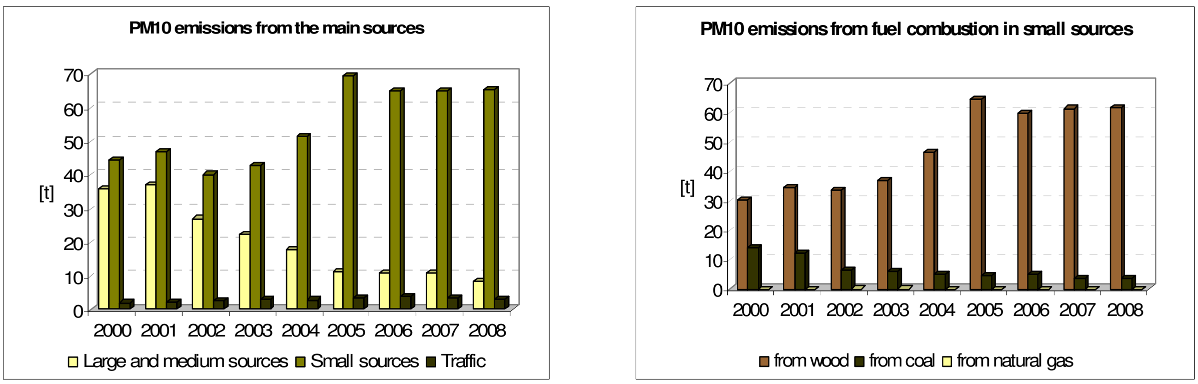
Source apportionment

The results of source apportionment according to [5] are represented in Fig. 4. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources and traffic had only minor impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify.

Figure 4
Contribution of different sources to mean annual concentration of PM_{10} in 2005

AQMA is located in a rather narrow valley and the main industrial sources are located mostly between the towns of Jelšava and Revúca. These industrial sources are not the main contributors to PM_{10} pollution in the AQMA – as demonstrated in Fig. 4 and 5, the major emitters of PM_{10} are small sources, involving mainly residential heating fuelled by wood. It must be noted that the dust which may be resuspended from the dirty premises of the industrial plants is not included in the large and medium source emissions in Fig. 5. Neither is included in mobile sources the dust which is produced by dirty uncovered heavy trucks transporting material to and from the industrial plants along the whole valley, and passing by the AMS station in Jelšava. All these fall below *other* –non-quantified - sources in Fig. 4.
A large number of small sources (80%) on this territory has been shifting back to using wood for heating in the last years, hence it is supposed that the residential sector could represent substantial portion of "other sources". However, the data in Fig. 5 are based on spatial disaggregation of statistical data and there are no data available on the actual composition of fuel in individual residential areas.

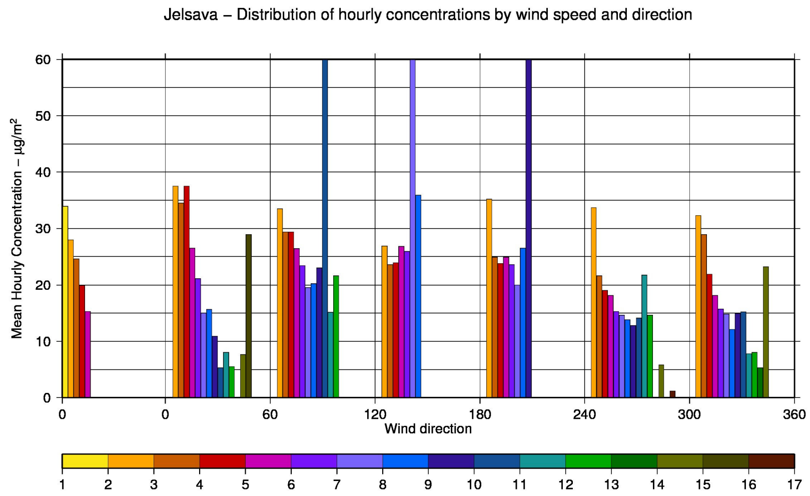
Figure 5
Emissions from large, medium and small stationary sources and mobile sources on the territory of the town of Jelšava and municipalities of Lubeník, Chyžné, Magnezitovce, Mokrá Lúka, Revúcka Lehota.[7]



Graph in Fig. 6 shows that the main fugitive sources are located from NW to SW from the monitoring station which corresponds to the locations of industrial sites.
As it is possible to see on the list of daily exceedances in Appendix A, the most daily LV exceedances occur in winter period, when the cold air is flowing from the mountains towards the AMS station directed by the shape of the valley. Episodically, the periods with long range transport could occur during each part of the year (e.g. 28. - 30.7.2005, … , 29.3. - 2.4.2008)
Note: Extremely high values in Fig. 6 correspond to the episode of long range transport from Ukraine in March 2006.

[7] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

Figure 6
Hourly PM_{10} concentrations depending on wind speed and wind directions at AMS station Jelšava



Conclusion

It has been demonstrated that the air quality in Jelšava is highly influenced by its adverse dispersion conditions associated with its geographical position in a valley and adverse climatic conditions with the annual wind speed bellow 1.5 m/s. It has been demonstrated that 63 out of 74 daily PM_{10} LV exceedances in the reference year of 2005 occurred at days with the wind speed below 1.5 m/s. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the AQMA. One of the measures planned in order to improve the air quality is modernization of technology in the large industrial source of Slovmag, a.s. An important measure is related to decrease of secondary dustiness in magnesite processing facility SMZ in Jelšava, which could be one of the sources of fugitive emissions. Fig. 2 shows that the PM_{10} exceedances have strongly decreasing trend and annual mean LV was not exceeded in the last years. Putting into action further measures described in the air quality plan, there is a good chance that they fall under the limit value in 2011.

Zone: **Banskobystrický kraj**
AQMA: **Territory of the town of Žiar nad Hronom and Ladomerská Vieska municipality**

Figure 1.
Geographical position and terrain of AQMA (red balloon: AMS station, blue balloon – climatologic station)

Climate relevant to atmosperic dispersion
The area of the Žiar basin is enclosed by the Pohronský Inovec mountains in the south-west, the Vtáčnik mountains and the Kremnické vrchy mountains from west up to the north, and by the Štiavnické vrchy mountains in the east to the south-east. Due to its geographic position it has adverse dispersion conditions, with the long-term mean annual wind speed of 1.2 m/s and 29% of calms.

AMS station
There is one monitoring station in the AQMA, was characterized as urban background

PM_{10} concentration data measured in the reference year 2005

Total number of PM_{10} daily limit exceedances:	**45**
Exceedances during days with mean wind speed lower than 1.5 m/s:	**37**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 2 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 2
Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in µg/m^3.

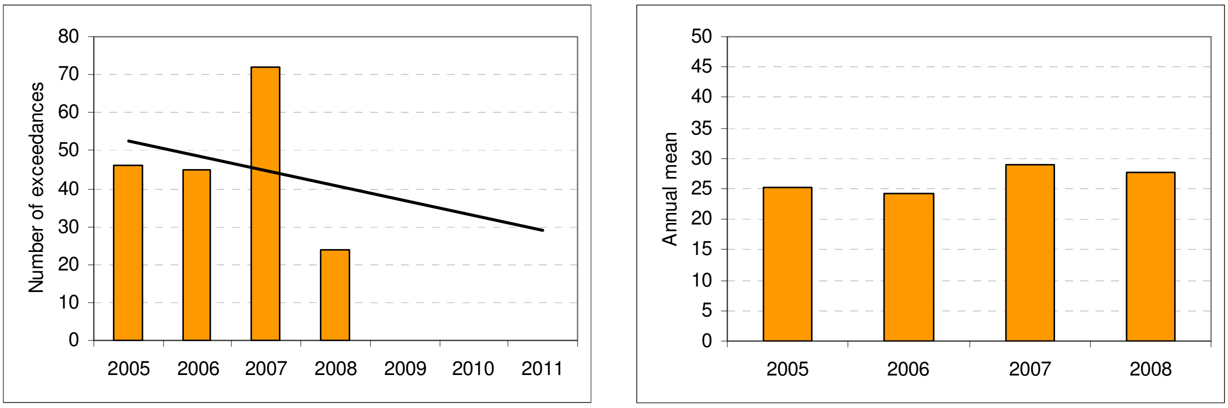
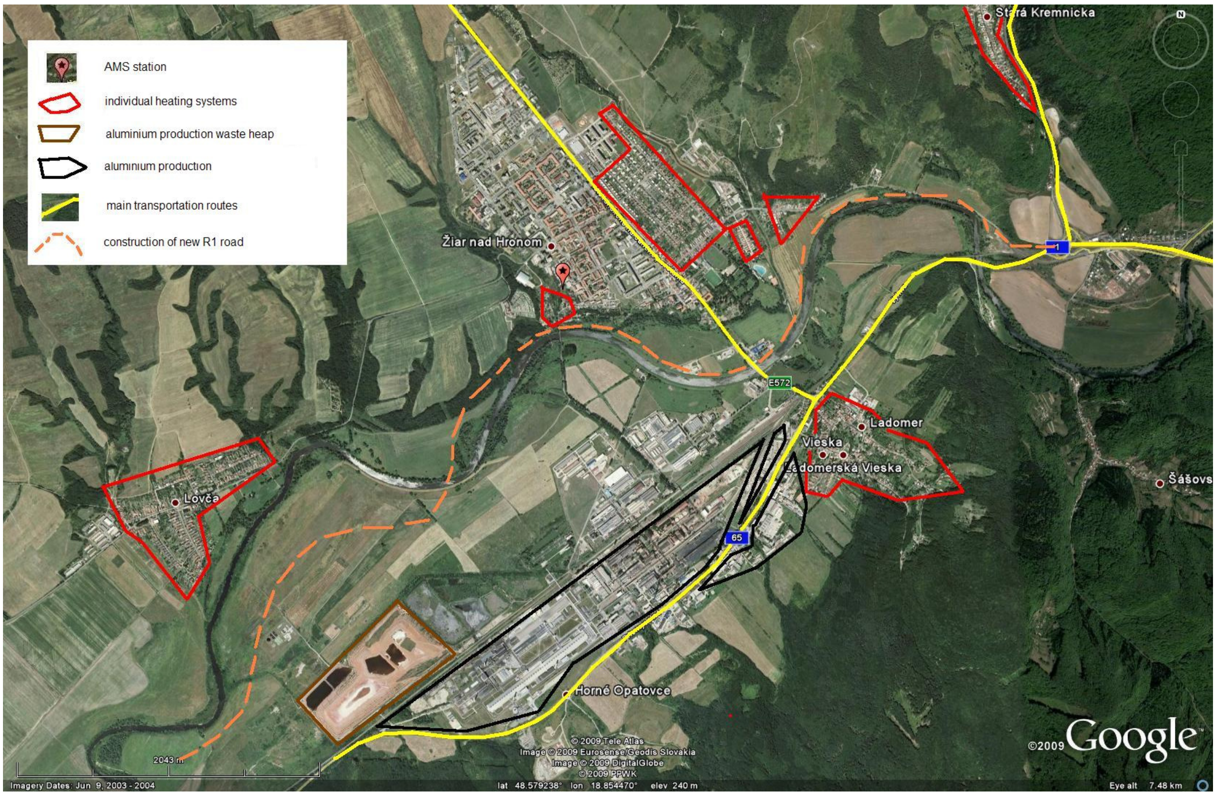


Fig. 3 shows the main potential sources of PM_{10} in Bratislava

Figure 3.
Potential PM_{10} sources in AQMA of Žiar nad Hronom



Source apportionment

The results of source apportionment according to [5] are represented on Fig. 4. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources and traffic had only minor average impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify.

Figure 4.
Contribution of different sources to mean annual concentration of PM_{10} in 2005

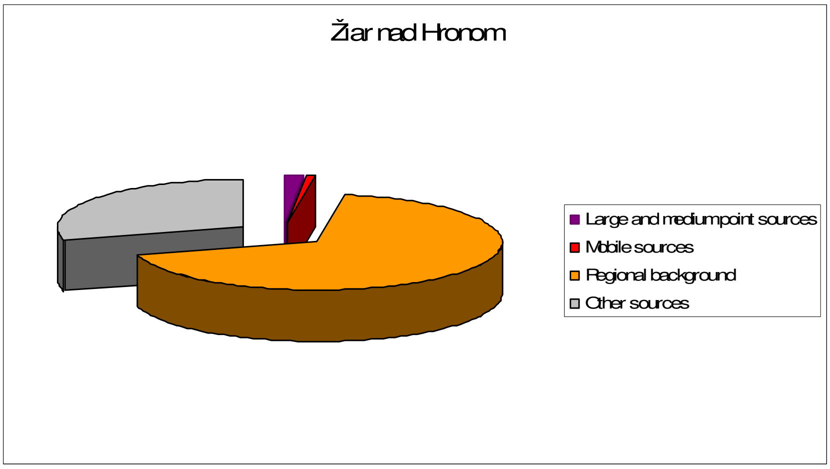
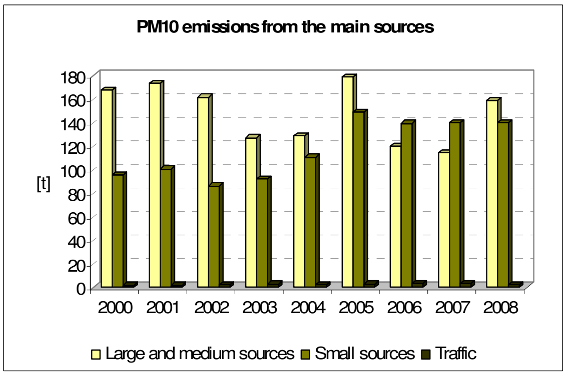
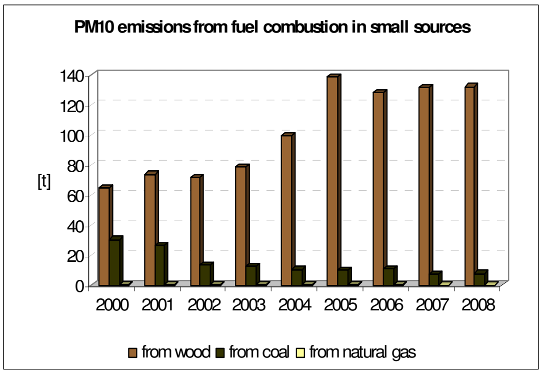


Fig. 5 shows that large and medium sources approximately equal the small sources in aggregated emissions of the AQMA. The major large industrial source in the area is SLOVALCO a.s. aluminum production plant. Besides stack emissions, which are explicitly included among large and medium sources category in Fig. 4 and 5, there is also large heap of waste from aluminium ore processing and fugitive emissions from the premises of the company, which may contribute to hourly concentrations among the *other* sources during occasional higher wind speeds. The concentration increases with wind from E to S directions would support this idea.

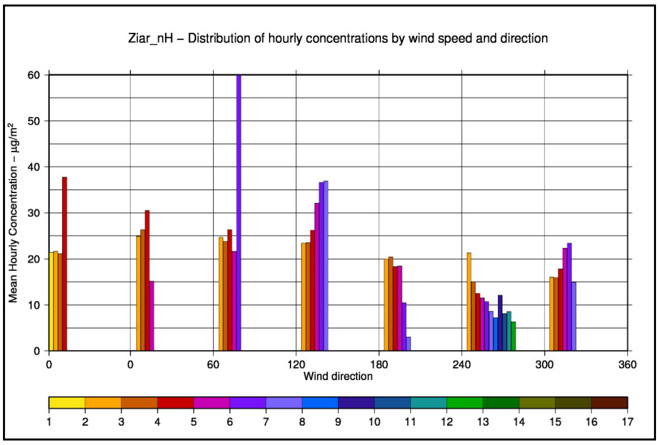
Figure 5
Emissions from large, medium and small stationary sources and mobile sources on the territory of the town of Žiar nad Hronom and Ladomerská Vieska municipality.[8]





[8] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

Figure 6.
Hourly PM_{10} concentrations depending on wind speed and wind directions



Conclusion

It has been demonstrated that the air quality in AQMA of Žiar nad Hronom is highly influenced by its adverse dispersion conditions associated with its geographical position and adverse climatic conditions with the annual wind speed below 1.5 m/s. It has been demonstrated that 37 out of 45 daily PM_{10} LV exceedances in the reference year of 2005 occurred at days with the wind speed below 1.5 m/s. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the city. Fig. 3 shows that the PM_{10} exceedances have clear decreasing trend and actually in 2008 the number of exceedances was far below the allowed 35 cases. Putting into action further measures described in the air quality plan, there is a high probability that they fall under the limit value in 2011.

Zone: **Nitriansky kraj**
AQMA: **Territory of the city of Nitra**

Climate relevant to atmosperic dispersion

Nitra is situated in the northern part of Podunajská nížina lowland, on the southwest tip of Tríbeč mountains, under the southern slopes of Zobor. It has long-term mean annual wind speed of 3.9 m/s, with 9% of calms.

AMS station
There is one monitoring station in the AQMA, characterized as urban traffic station

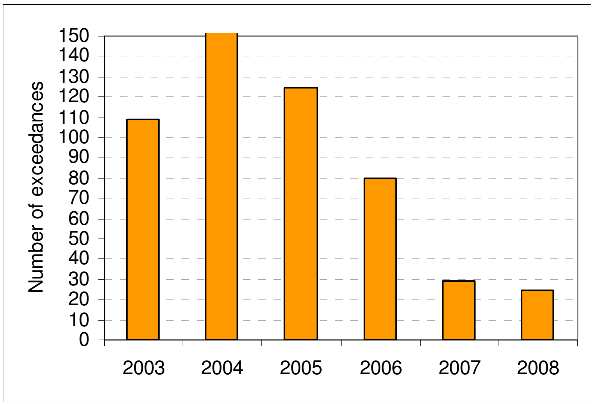
PM_{10} concentration data measured in the reference year 2005

Number of exceedances before subtraction of transboundary portion: **125**
Number of exceedances after subtraction of transboundary portion: **45**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 1 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 1.
Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in µg/m^3.



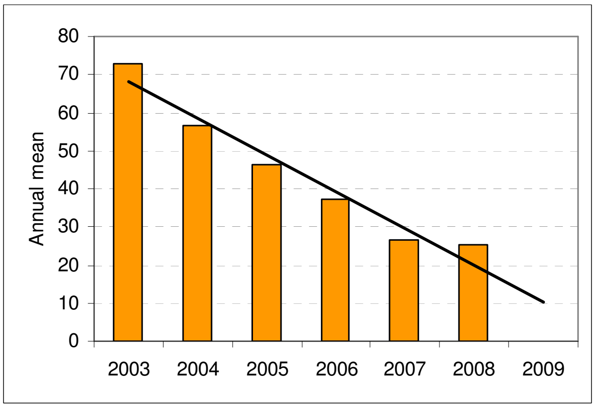
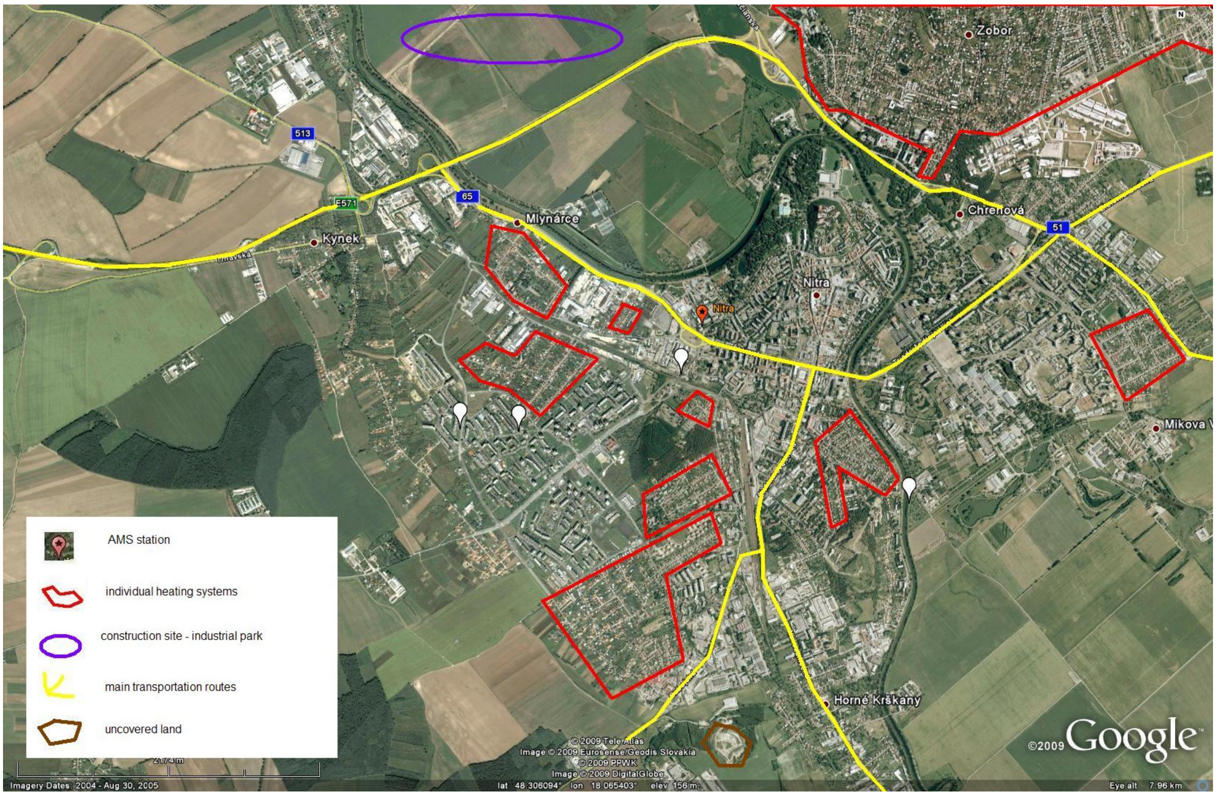


Fig. 2 shows the main potential sources of PM_{10} on the territory of the city of Nitra.

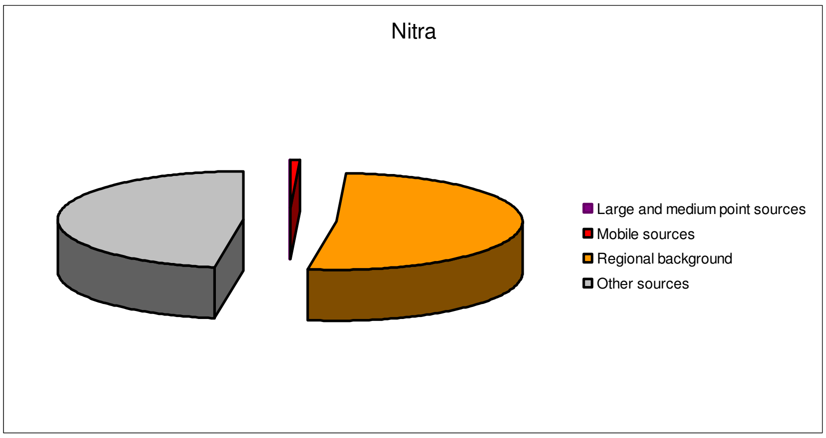
Figure 2.
Potential PM_{10} sources in the AQMA of Nitra



Source apportionment

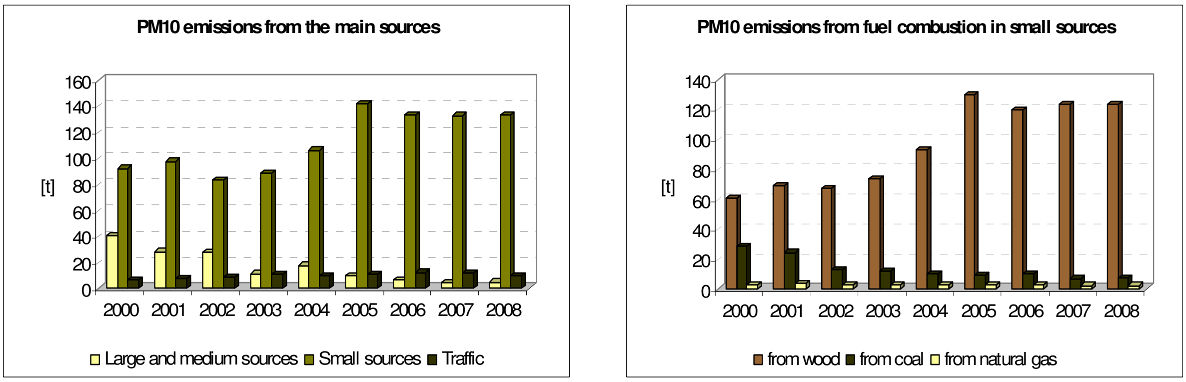
The results of source apportionment according to [5] are represented on Fig. 3. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources and traffic had only minor average impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify. We attempt to accomplish a qualitative apportionment of the *other* sources using the spatial information on Fig. 2 in combination with wind and concentration statistics summarized in Fig. 5 and other supplementary information described further in the text.

Figure 3.
Contribution of different sources to mean annual concentration of PM_{10} in 2005



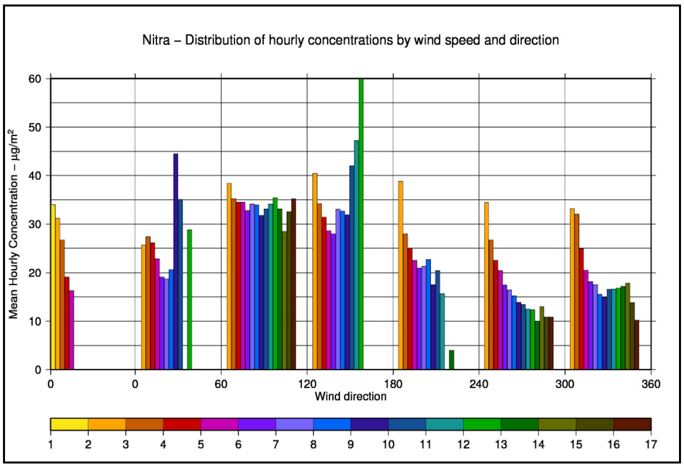
Nitra is a well ventilated area with a very small large and medium source stack emissions. The main contributors to the increased concentrations are probably traffic, mainly its non-exhaust emissions (resuspended dust, winter sanding), residential heating sources and arable land surrounding the city.

Figure 4.
Emissions from large, medium and small stationary sources and mobile sources on the territory of the town of Nitra.[9]



The detailed information on meteorology during the exceedance days in 2005 (Appendix B) shows that most of the exceedances occurred from NW and from E to S directions. This is also confirmed by the graph in Fig. 5, further revealing that high concentrations from the NW occur at low wind speeds, suggesting the family housing areas located in that direction, while high concentrations from the S to E directions occur at both low and high winds. This would point to the main road exhaust and fugitive emissions, residential housing and arable land.

Figure 5.
Hourly PM_{10} concentrations depending on wind speed and wind directions



Conclusion

It has been demonstrated that transboundary transport of PM_{10} contributes a large part to the concentrations during most of the exceedance situations in the reference year of 2005, and, in accordance with [1], can be

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[9] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

subtracted from the measured concentrations. After subtraction, the AMS station in Nitra still exceeded the allowed number of 35 exceedances of daily PM_{10} limit value.
It is recognized that there are also other sources on the territory of the city, which contribute to the PM_{10} pollution. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the city.
Fig. 1 shows that the PM_{10} exceedances have strongly decreasing trend with the concentrations measured in last two years in full compliance with the Air Quality Directive [1]. Implementing further measures described in the air quality plan, there is a high probability that the PM_{10} limit values will not be exceeded in 2011.

Zone: **Prešovský kraj**
AQMA: **Territory of the city of Prešov and the municipality of Ľubotice**

Climate relevant to atmosperic dispersion

Prešov is situated in the northern part of the Torysa river valley, among Čergov, Slánske vrchy and Slovenské Rudohorie mountains. The Stráža hill located in the north of the town, protects it from the invasion of cool Arctic air masses. Good ventilation of the town is provided by the widening of the valley at the confluence of the Sečkov and Torysa rivers. It has long-term (10 years) mean annual wind speed of 3.3 m/s and 6% of calms.

AMS station

In 2005, there were 2 monitoring station in the AQMA, one of them was canceled in the 2006. Both AMS station were characterized as urban background.

PM_{10} concentration data measured in the reference year 2005

Levočská (UB)

Number of exceedances before subtraction of transboundary portion: **66**
Number of exceedances after subtraction of transboundary portion: **27**

Solivarská (UB)

Number of exceedances before subtraction of transboundary portion: **55**
Number of exceedances after subtraction of transboundary portion: **14**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 1 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 1
Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in $\mu g/m^3$.

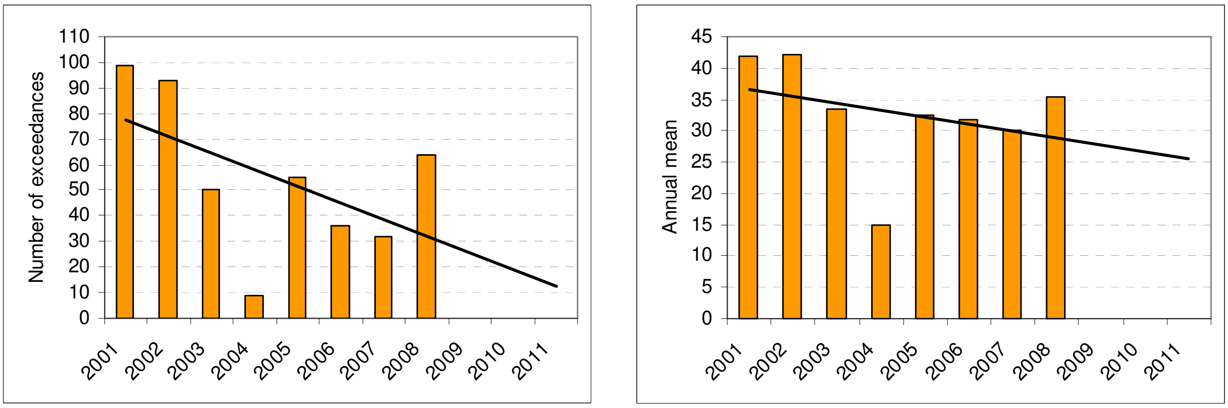
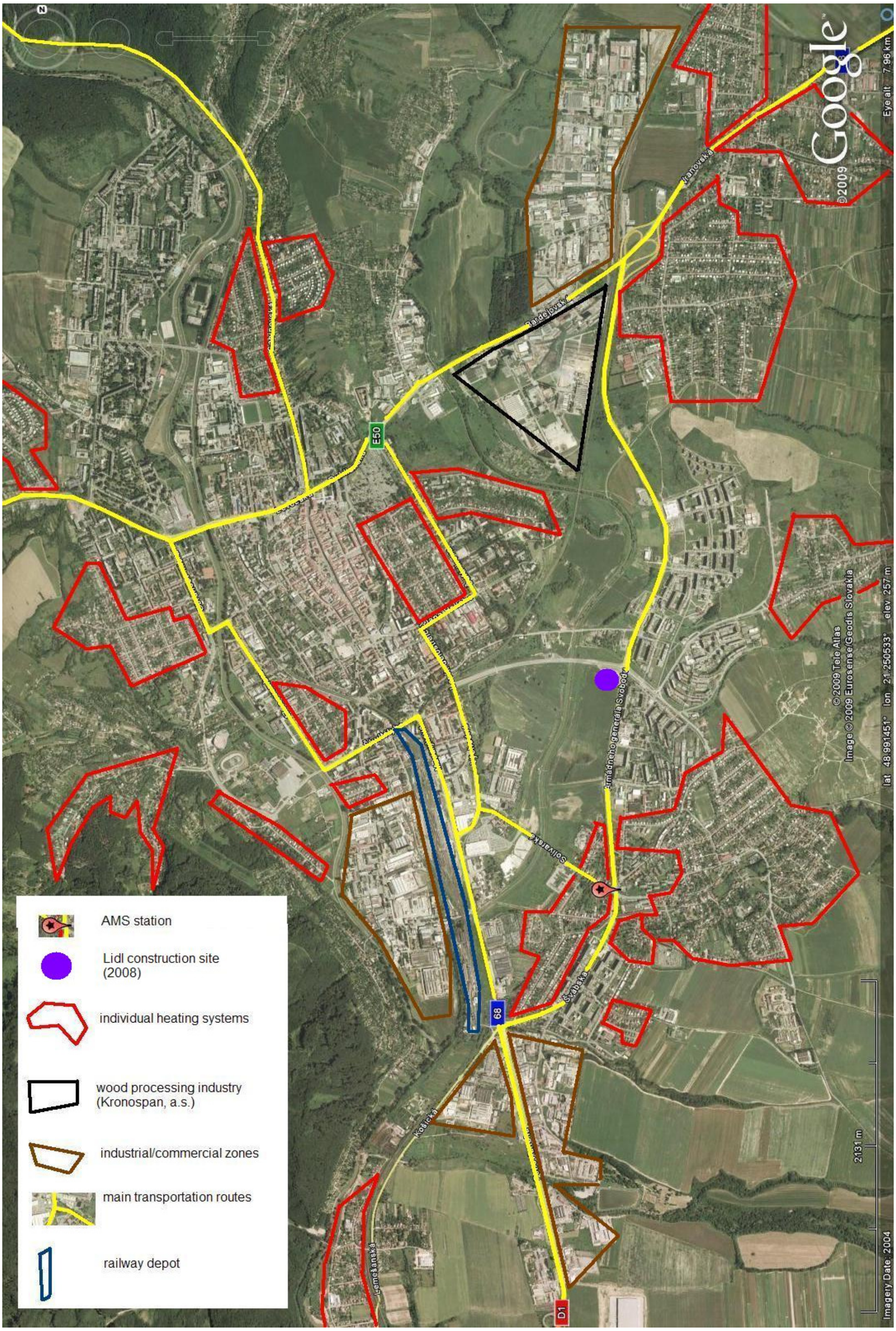


Fig. 2 shows the main potential sources of PM_{10} on territory of the city of Prešov and the municipality of Ľubotice

Figure 2.
Potential PM_{10} sources in the AQMA of Prešov



Source apportionment

The results of source apportionment according to [5] are represented on Fig. 3. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources and traffic had only minor impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify. We attempt to accomplish a qualitative apportionment of the *other* sources using the spatial information on Fig. 2 in combination with wind and concentration statistics summarized in Fig. 5 and other supplementary information described further in the text.

Figure 3
Contribution of different sources to mean annual concentration of PM_{10} in 2005

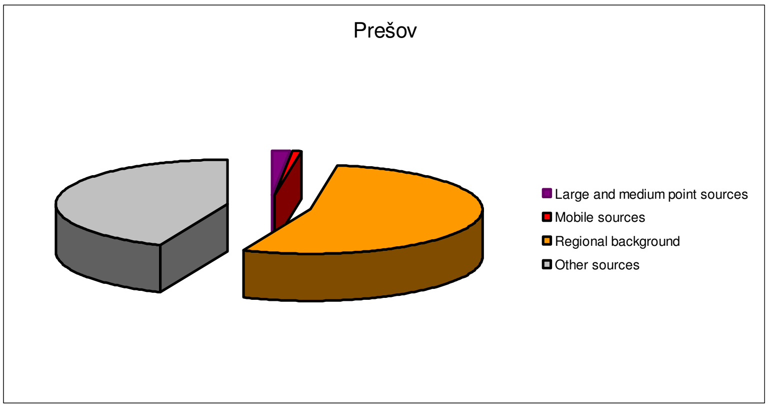
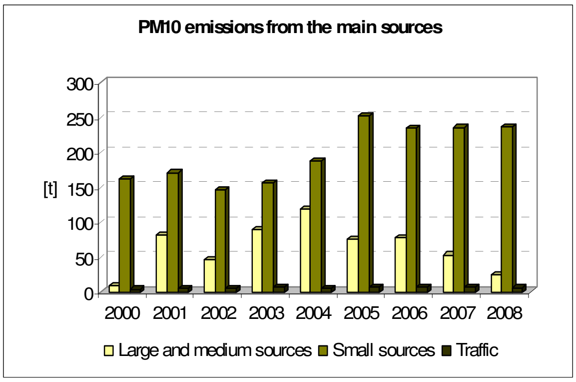
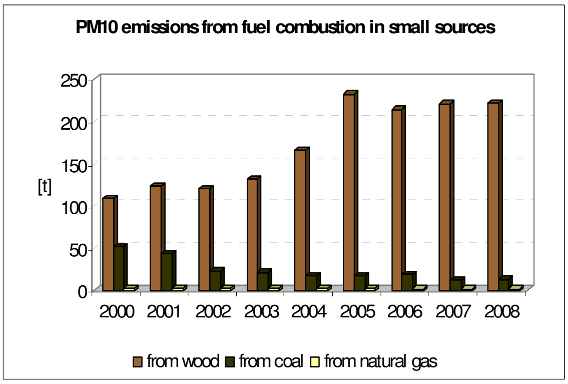


Fig. 4 displays the aggregate emissions on the territory of the city and reflects the findings from Fig. 3 in that the large and medium sources stack emissions play only a minor role in the daily limit exceedances.

Figure 4
Emissions from large, medium and small stationary sources and mobile sources on the territory of the town of Nitra.[10]



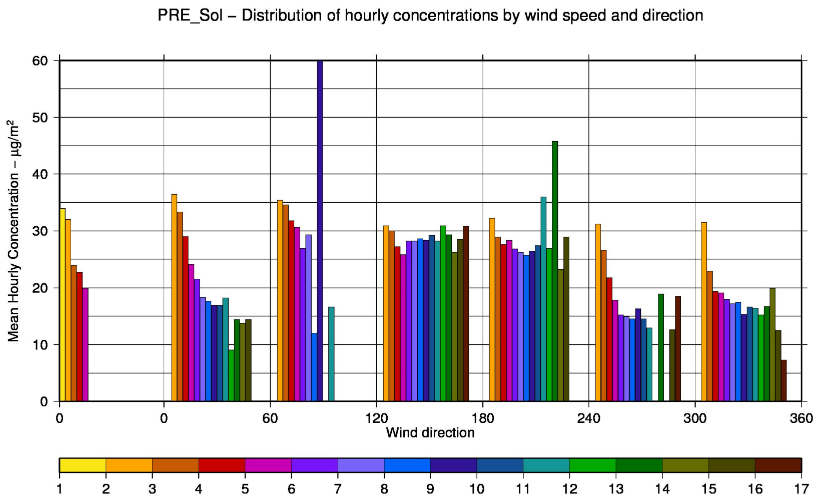


The main industrial source in the territory is Kronospan, a.s. wood processing plant. Its main contribution to the increased PM_{10} concenrations is through the non-stack fugitive emissions from the wood processing and from the resuspension of dust from the plant site.

[10] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

Detailed data on meteorology during LV exceedances in 2005 listed in Appendix B reveal that large part of high exceedances came to Solivarska AMS station from NE, which would support the resuspended emissions from Kronospan. Another large portion of the exceedances came from SE to SW directions, which locally corresponds to fugitive emissions from the industrial and commercial zone, from the family housing areas and from the agricultural arable land. This is also reflected in Fig. 5 showing hourly concentrations.
Fig. 1 shows that there was certain increase in the daily LV exceedances in 2008 – this is most probably connected with the construction of Lidl hypermarket approx. 1.5 km north from the AMS station, which produced fugitive emissions as well as increased traffic of heavy and dirty diesel machinery on the road next to the station.

Figure 5.
Hourly PM_{10} concentrations depending on wind speed and wind directions



Conclusion

It has been demonstrated that transboundary transport of PM_{10} contributes a large part to the concentrations during most of the exceedance situations in the reference year of 2005, and, in accordance with [1], can be subtracted from the measured concentrations. After subtraction, neither of the AMS stations in Prešov exceeded the allowed number of 35 exceedances of daily PM_{10} limit value. Although only the year of 2005 was modeled, there are reasons to believe that the situation will not largely differ for the other years.
However, it is recognized that there are also other sources on the territory of the city, which contribute to the PM_{10} pollution. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the city.
Fig. 1 shows that the PM_{10} exceedances have strongly decreasing trend with the concentrations measured in 2007 in full compliance with the Air Quality Directive [1] (as was explained above, the last year exceedance was only temporary). Implementing further measures described in the air quality plan, there is a high probability that the PM_{10} limit values will not be exceeded in 2011.

Zone: **Prešovský kraj**
AQMA: **Territory of the town of Vranov nad Topľou and municipalities of Hencovce, Kučín, Majerovce a Nižný Hrabovec**

Figure 1
Geographical position and terrain of AQMA (red balloon: AMS station, blue balloon – climatologic station)

Climate relevant to atmosperic dispersion

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 mountains and in the north by the wide zone of the Carpathians. With the long-term (10 years) mean annual wind speed of 1.1 m/s and 27% of calms it belongs to the zones with very adverse climatic conditions with respect to dispersion of pollutants.

AMS station

The station is situated in the town centre which is built up with a mixture of family houses and low condominiums. it is located approximately 2 km north-west from the Bukocel Hencovce wood processing plant. It is characterized as urban background.

PM_{10} concentration data measured in the reference year 2005

Total number of PM_{10} daily limit exceedances: **83**
Exceedances during days with mean wind speed lower than 1.5 m/s: **70**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 2 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 2.
Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in µg/m^3.

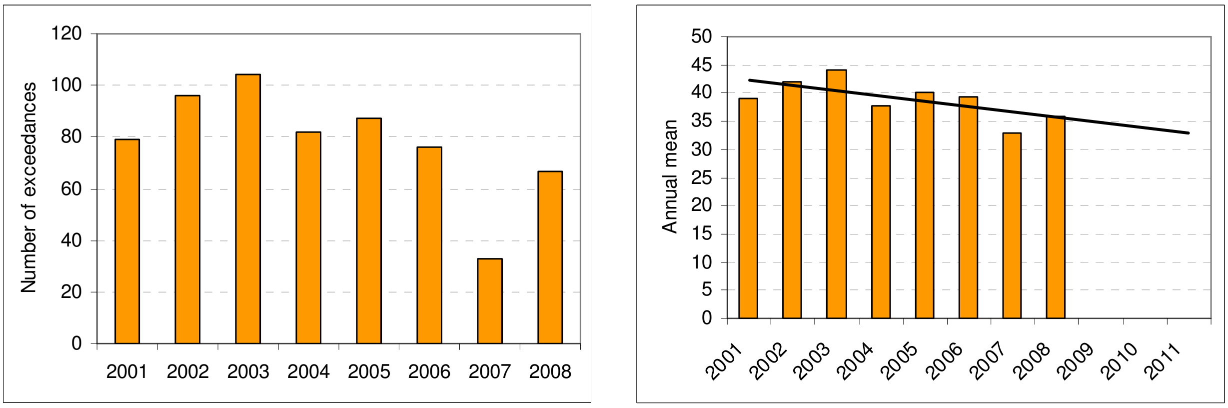
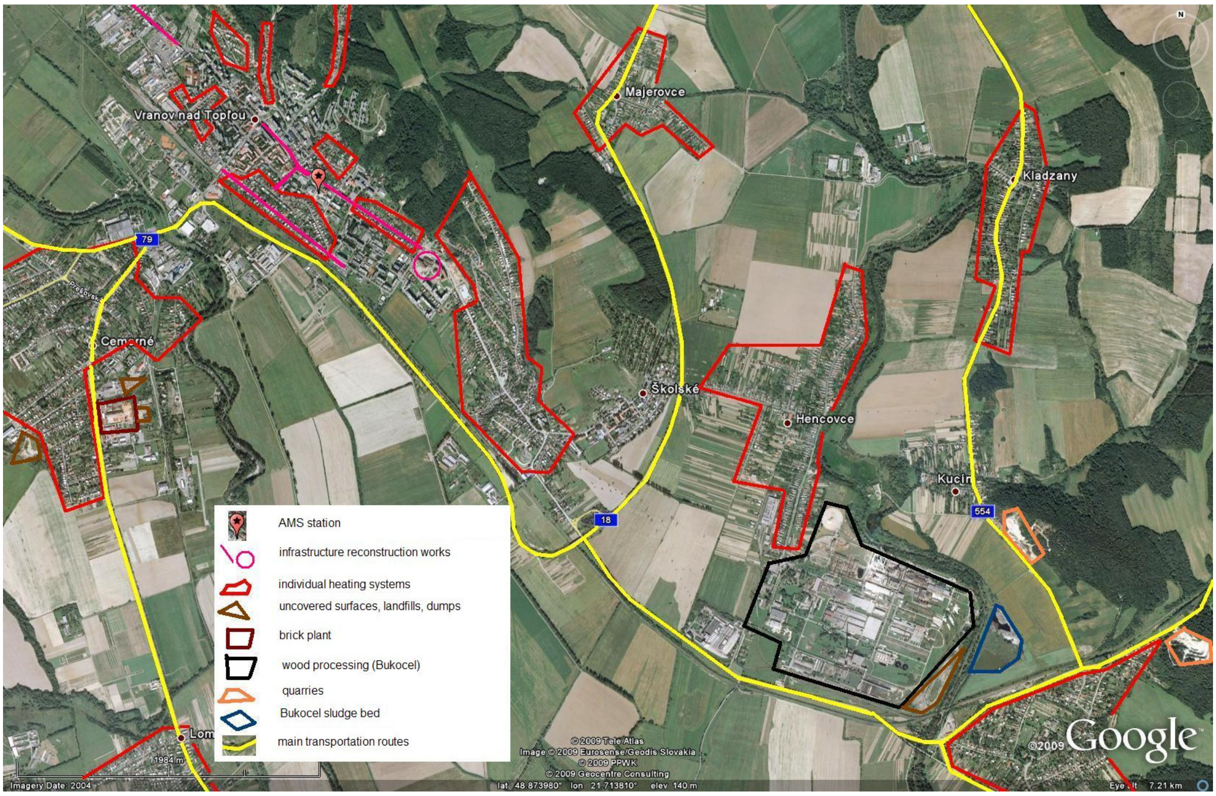


Fig. 3 shows the main potential sources of PM_{10} on the territory of the town of Vranov nad Topľou and municipalities of Hencovce, Kučín, Majerovce a Nižný Hrabovec

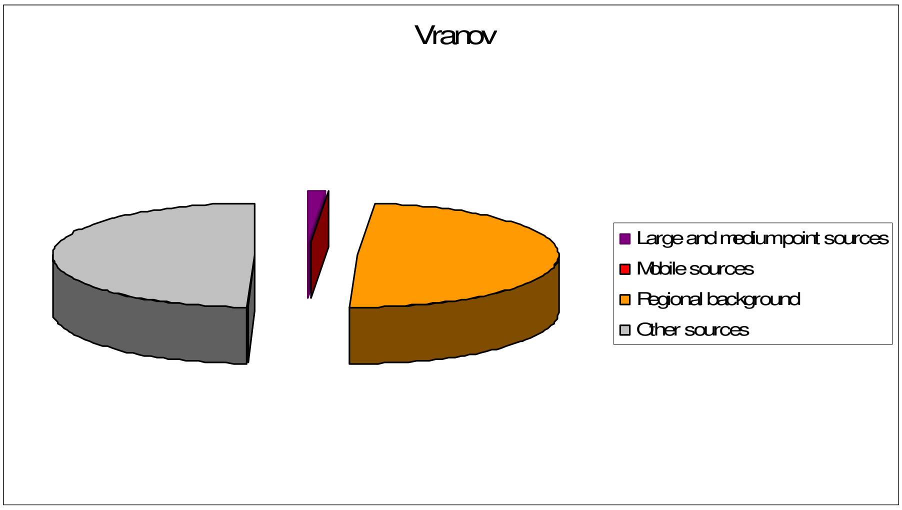
Figure 3
Potential PM_{10} sources in the AQMA of Vranov na Topľou



Source apportionment

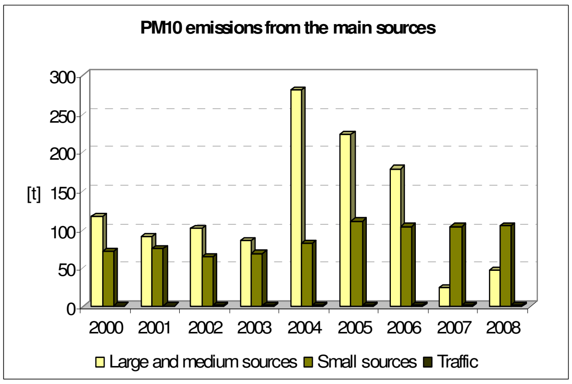
The results of source apportionment according to [5] are represented on Fig. 4. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources and traffic had only minor impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify.

Figure 4.
Contribution of different sources to mean annual concentration of PM_{10} in 2005



These findings correspond to the graph on Fig. 5, showing the aggregated emissions from the main source sectors on the territory of the AQMA. It demonstrates that the emissions from large and medium sources has decreased considerably in the past few years and currently the dominant role is played by small sources, namely, the wood-fuelled local heating, which is included among *other* sources. This is also reflected in the decreasing trend in number of exceedances (Fig. 2). The increase in number of exceedances in 2008 was caused by extensive reconstruction works on practically all the streets surrounding the monitoring stations the infrastructure network reconstruction included excavation of ditches using heavy diesel machinery, and exhaust as well as fugitive emissions from the works had major impact on the increase of PM_{10} concentrations.

Figure 5.
Emissions from large, medium and small stationary sources and mobile sources on the territory of AQMA.[11]



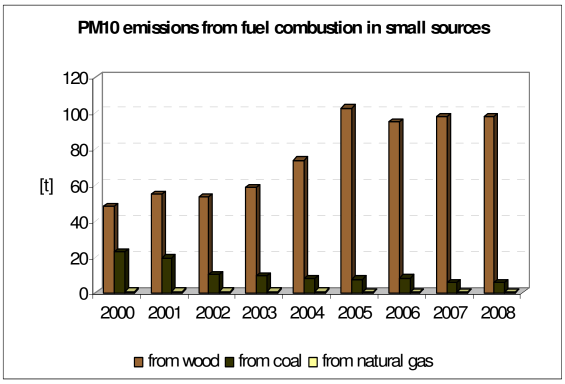
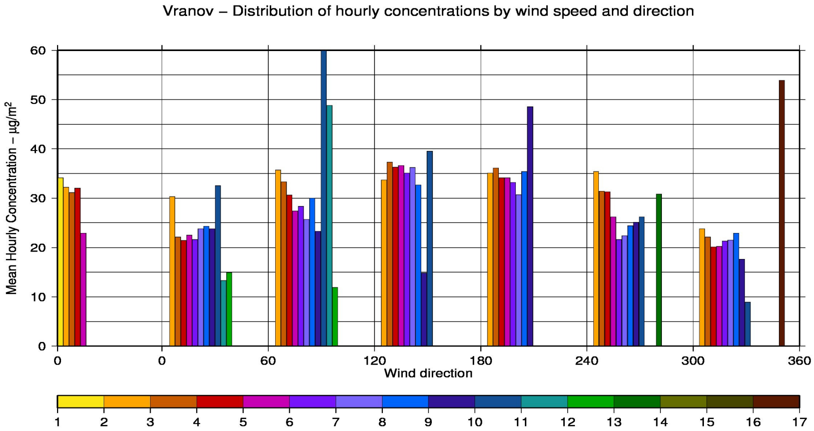


Fig. 6 shows a strong increase with wind speed in hourly concentrations from eastern directions and relatively higher concentrations practically independent on wind speed from SE to SW, which would support the above argument. Other sources which probably contribute to increased PM_{10} concentrations are fugitive emissions from the transportation of material to and from the brick production factory, quarries, dumps and surrounding arable land.

[11] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

Figure 6.
Hourly PM_{10} concentrations depending on wind speed and wind directions



Conclusion

It has been demonstrated that the air quality in AQMA of Vranov is highly influenced by its adverse dispersion conditions associated with its geographical position and adverse climatic conditions with the annual wind speed below 1.5 m/s. It has been demonstrated that 70 out of 83 daily PM_{10} LV exceedances in the reference year of 2005 occurred at days with the wind speed below 1.5 m/s. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the city. Fig. 3 shows that the PM_{10} exceedances have clear decreasing trend – it was shown that the increase in PM_{10} concentrations in 2008 was only temporary. Putting into action further measures described in the air quality plan, there is a high probability that the concentrations fall under the limit value in 2011.

Zone: **Trenčiansky kraj**
AQMA: **The territory of the district of Prievidza**

Figure 1
Geographical position and terrain of AQMA (red balloon: AMS station, blue balloon – climatologic station)

Climate relevant to atmospheric dispersion

The district of Prievidza is situated in the upper valley of the Nitra river, between Strážovské vrchy mountains on the west and Vtáčnik mountains on the east. The most representative meteorological station for the area is located in the town of Prievidza. The long term mean annual wind speed is 2.2 m/s, with 17% of calms. The prevailing wind directions are NE and SW. Although the meteorological station is fairly representative also for Bystričany, the geographical position of Handlová is partially separated by local topography and the winds can be expected to be more blocked and the directions deformed with respect to the meteorological station in Prievidza. Therefore, any conclusions based on the meteorology associated with Handlová need to take this fact into account.

AMS stations

In 2005, there were 3 AMS stations on the territory of the district, two of which are characterized as urban background, one as suburban background.

PM_{10} concentration data measured in the reference year 2005

Prievidza (UB)
Total number of PM_{10} daily limit exceedances: **127**
Number of exceedances after subtraction of transboundary portion: **57**

Handlová (UB)
Total number of PM_{10} daily limit exceedances: **40**
Number of exceedances after subtraction of transboundary portion: **10**

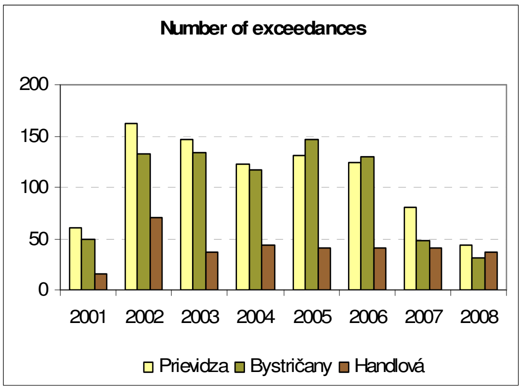
Bystričany (SB)

Number of exceedances before subtraction of transboundary portion: **144**
Number of exceedances after subtraction of transboundary portion: **62**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 2 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 2
Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in $\mu g/m^3$.



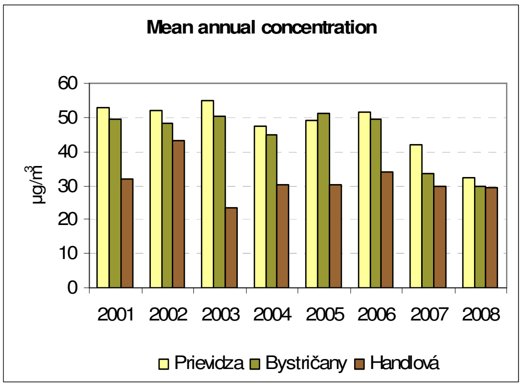


Fig. 3 to 5 show the main potential sources of PM_{10} on the territory of the district of Prievidza

Figure 3.
Potential PM_{10} sources in Prievidza

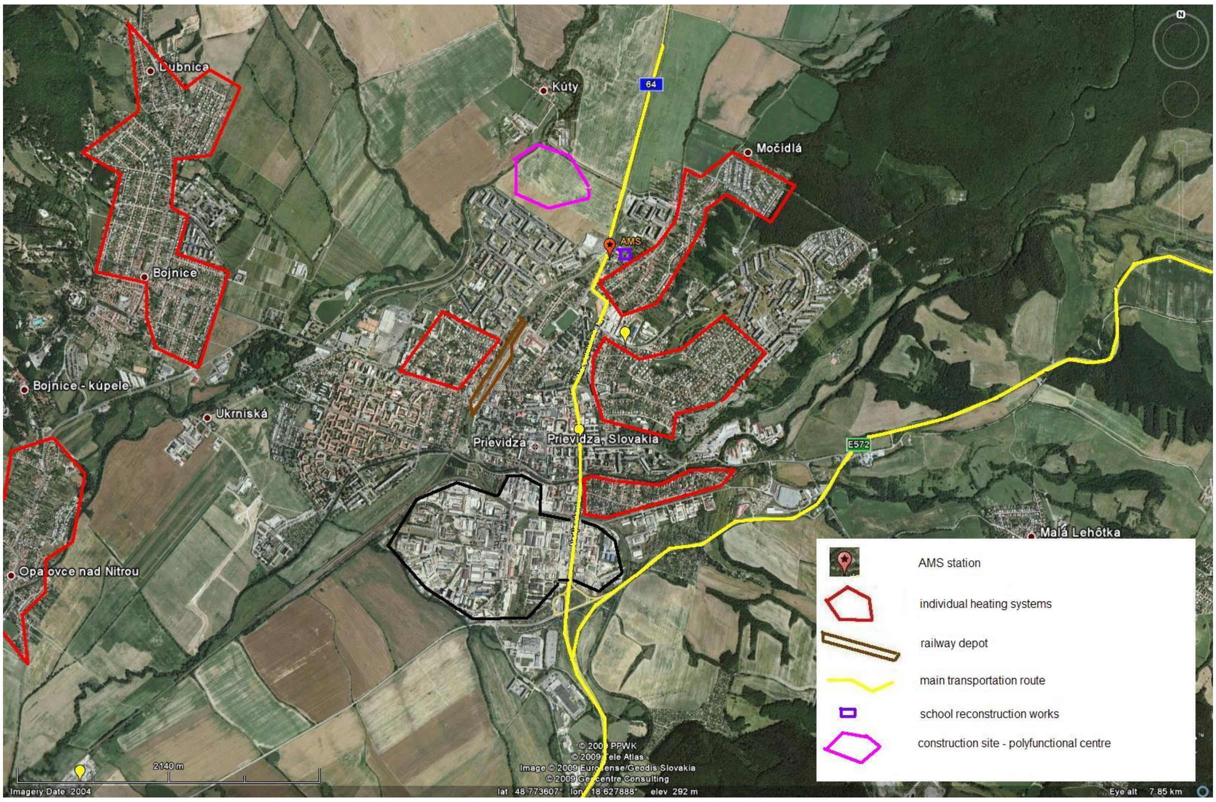


Figure 4.
Potential PM_{10} sources in Bystričany

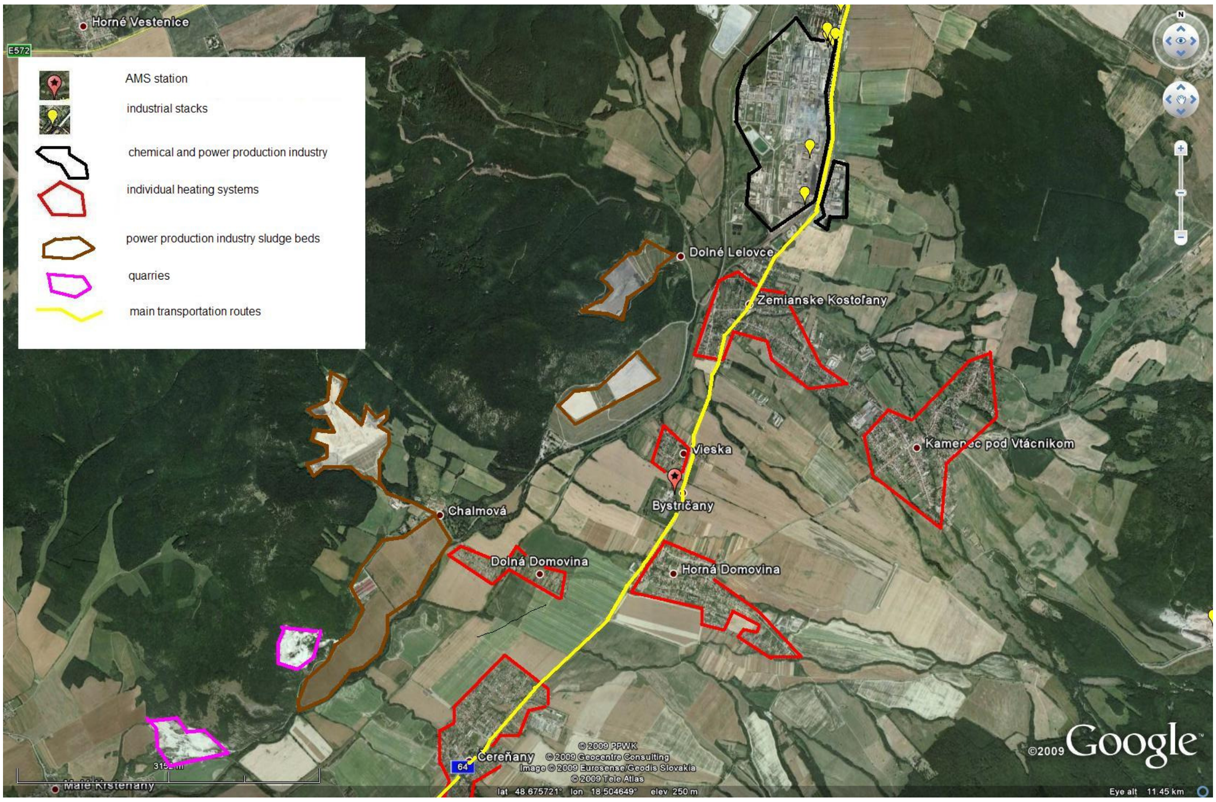
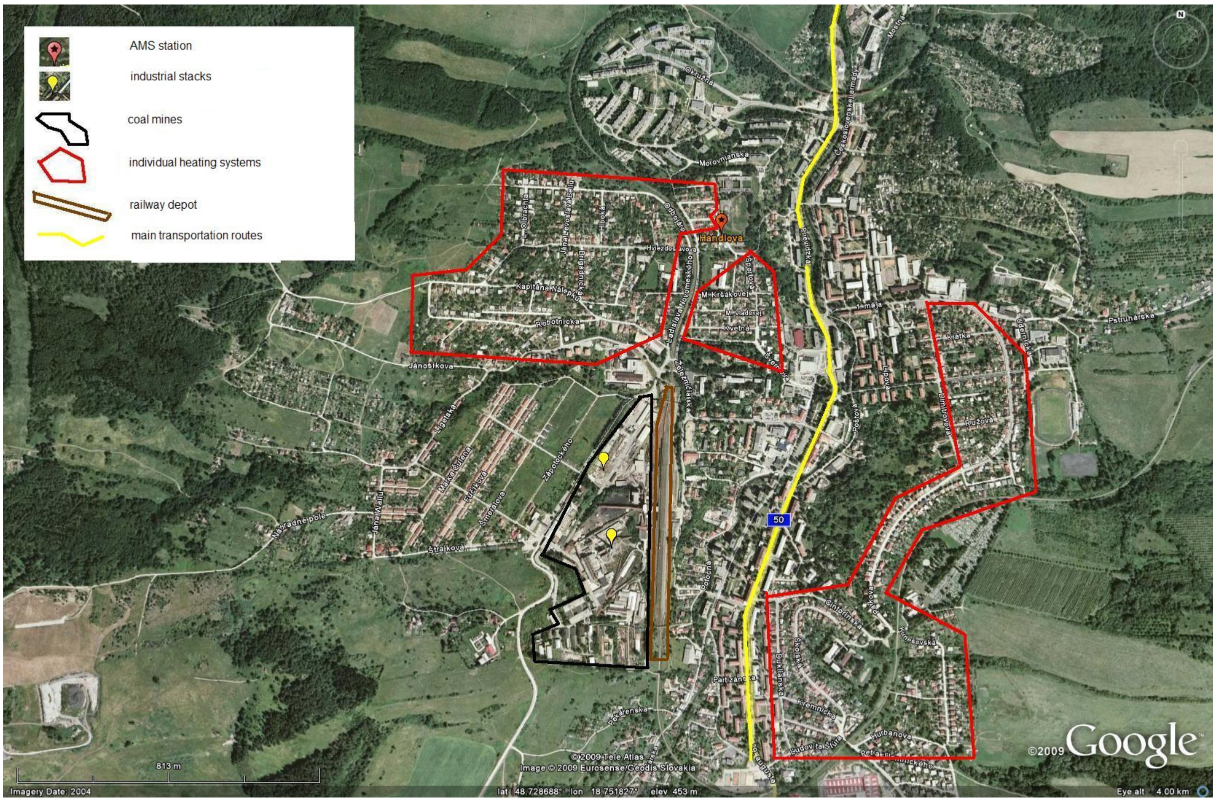


Figure 5.
Potential PM_{10} sources in Handlová



Source apportionment

The results of source apportionment according to [5] are represented on Fig. 6. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005.

In the AQMA of Prievidza district, the largest PM_{10} contributor is regional background, the essential part of which is transboundary portion. The traffic contribution plays only a minor role, as well as large and medium point sources at AMS stations Prievidza and Handlová. AMS station in Bystričany is located downwind from the large industrial sources in Nováky and Zemianske Kostoľany, which has more pronounced impact on PM_{10} concentrations there than in the other two AMS stations. Important contribution comes from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify. They also include the non-stack emissions from large and medium point sources, and an important portion of emissions from the residential heating systems, largely based on wood fuel. It is demonstrated in Fig. 7, where the large and medium point sources emissions show decreasing trend, while the emissions from small sources, including residential heating, increase and then stagnate; actually, starting 2007 they have been higher than the industrial stack emissions. The wood is preferred as fuel especially in rural mountainous regions because it is the least expensive.

Figure 6.
Contribution of different sources to mean annual concentration of PM_{10} in 2005

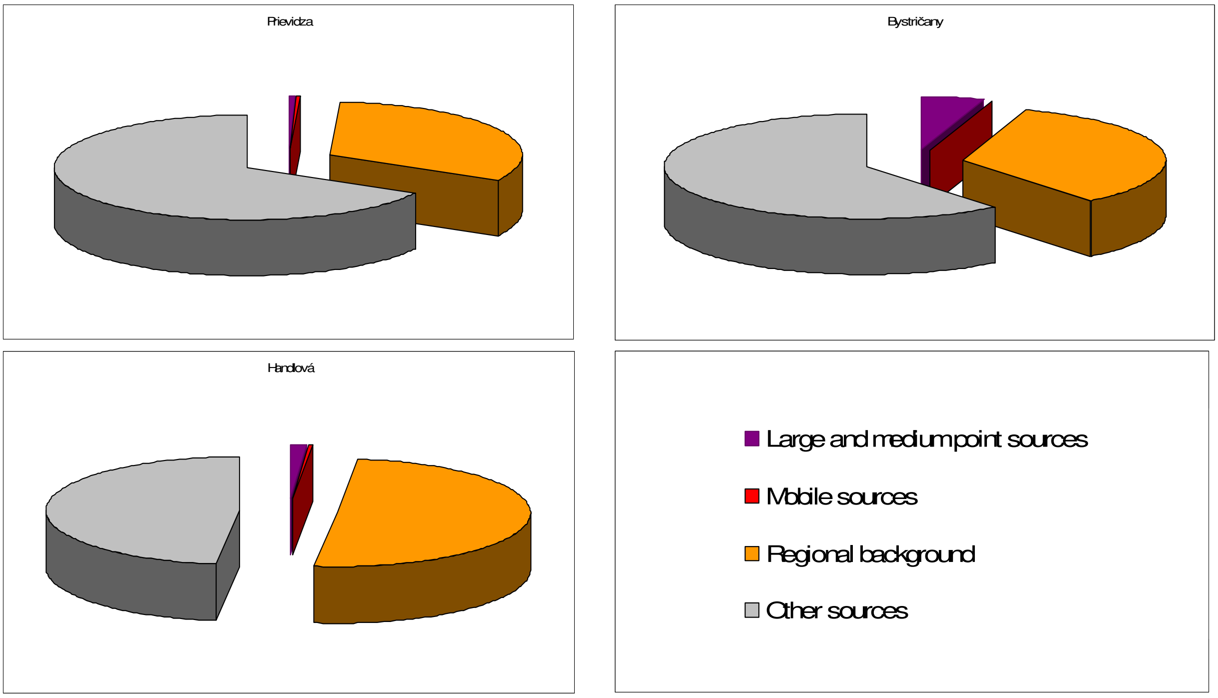
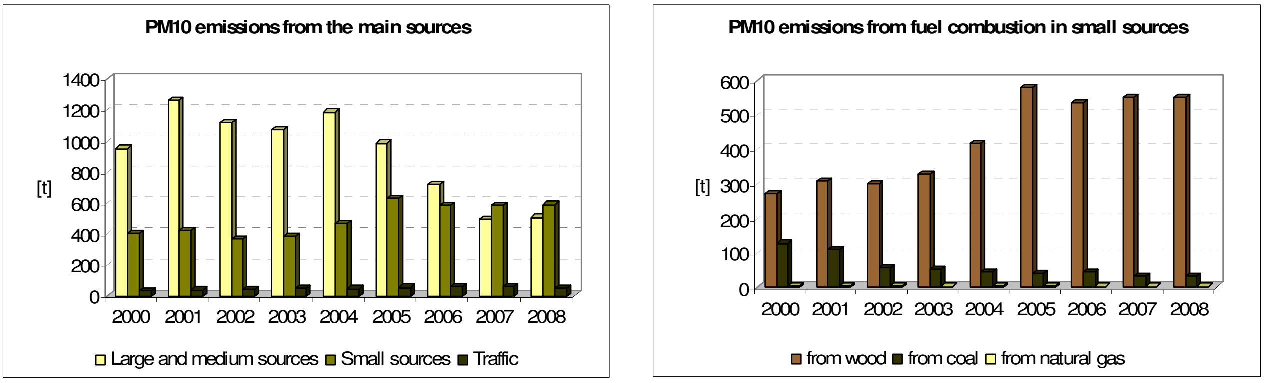


Figure 7.
Emissions from large, medium and small stationary sources and mobile sources on the territory of AQMA.[12]

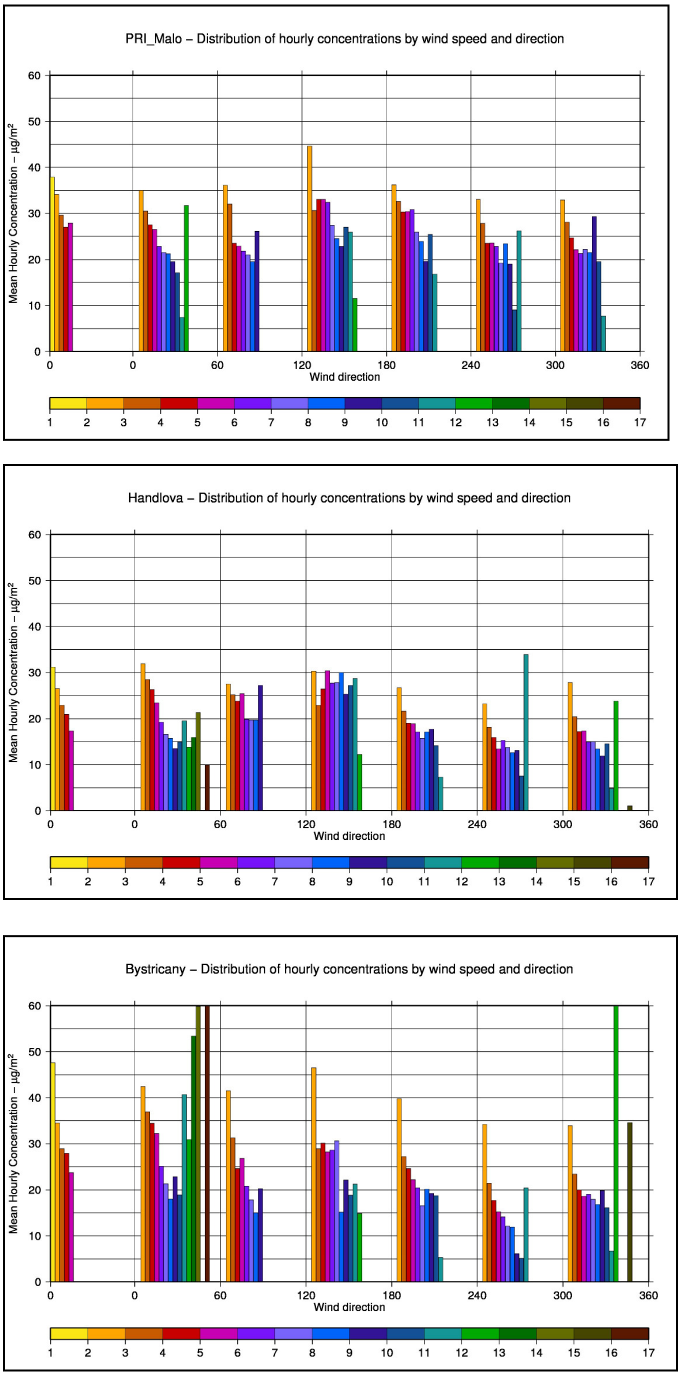


The town of Prievidza is located about 10 km NE from the industrial complex in Nováky, where the main polluters are chemical and power plants. List of exceedance cases (Appendix B) shows that the majority of the exceedances in 2005 occur when the wind blows from SW directions. A considerable part of exceedances occur at very low winds from different directions in winter, which would point to residential heating systems. Fig. 8, depicting hourly concentrations does not show any strong directional preference, but indicates that the highest concentrations occur at low wind speeds, pointing to local sources of PM_{10}.
Most of the exceedances in the past four years in Handlová occur in winter, although not negligible part occurs in spring and autumn months. Some of the exceedances also occur also in summer. Besides local heating in winter and transboudary transport, there is an influence of the Hornonitrianske Bane coal mines which are

[12] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

located SSE from the AMS stations, namely their fugitive emissions. In spring, summer and winter the PM_{10} fugitive emissions from seasonal agricultural works and resuspension of uncovered land play an important role.
AMS station of Bystričany is located near the main road to Prievidza, about 5 km SSW from the power and chemical industry in Novaky. A residential housing in Vieska village is situated in close vicinity N of the station, where there is a high probability of using wood as fuel for heating. There are several sludge processing ponds and facilities N to W from Bystričany. They should not impose any important risks as far as PM_{10} emissions are concerned, because the surface of the ponds should be wetted. The station is surrounded by arable land. Graph in Fig. 8 shows rather high concentrations at high wind speeds from northern sectors, which would imply the influence of the nearby industry, including the dust resuspended from the sites, but can be partially contributed by seasonal agricultural works (part of exceedances occur in spring and autumn months), or dust from large portions of uncovered land adjacent to the sludge ponds in NW. The high concentrations at very low wind speeds can be partially attributed to heating in neighboring residential areas.

Figure 8.
Hourly PM_{10} concentrations depending on wind speed and wind directions



Conclusion

It has been demonstrated that in the AQMA of Prievidza district, the transboundary transport of PM_{10} contributes a large part to the concentrations during most of the exceedance situations in the reference year of 2005, and, in accordance with [1], can be subtracted from the measured concentrations. After subtraction, AMS in Handlová did not exceed the allowed number of 35 daily PM_{10} limit values, while the other two monitoring stations did. However, important measures for abatement of PM_{10} emissions, especially from the industrial sites, has been taken since the reference year, and the exceedances has dropped dramatically, bringing in 2008 AMS stations in Bystričany below the LV and in Handlová almost below the LV even before the subtraction of the transboundary portion.

Although only the year of 2005 was modeled using EMEP model, there are reasons to believe that the situation will not largely differ for the other years and after subtraction of transboundary portion all AMS stations would fall below the LV in 2008.

However, it is recognized that there are also other sources on the territory of the city, which contribute to the PM_{10} pollution, especially the traffic and resuspended dust. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to further improve the air quality in the city.

Taking into account the arguments above, it is strongly believed that in 2011 the whole territory of the AQMA will fully comply with the EU air quality directive [1].

Zone: **Trenčiansky kraj**
AQMA: **Territory of the city of Trenčín**

Climate relevant to atmosperic dispersion

Trenčín is located in the valley of the Váh river, between Biele Karpaty mountains in the NW and Považský Inovec mountains in the SE. It has long-term mean annual wind speed of 2.5 m/s and 19% of calms

AMS station

There is one monitoring station in the AQMA, characterized as urban transport. AMS station started to work during the year 2005, being operational only second half of the year.

PM_{10} concentration data measured in the reference year 2005

Number of exceedances before subtraction of transboundary portion: **51**
Number of exceedances after subtraction of transboundary portion: **11**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 1 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 1

Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in µg/m^3.

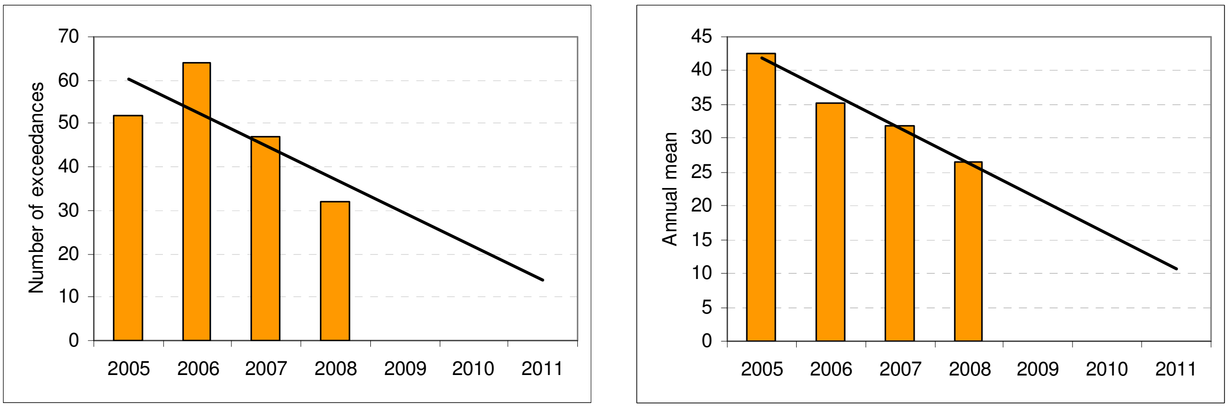
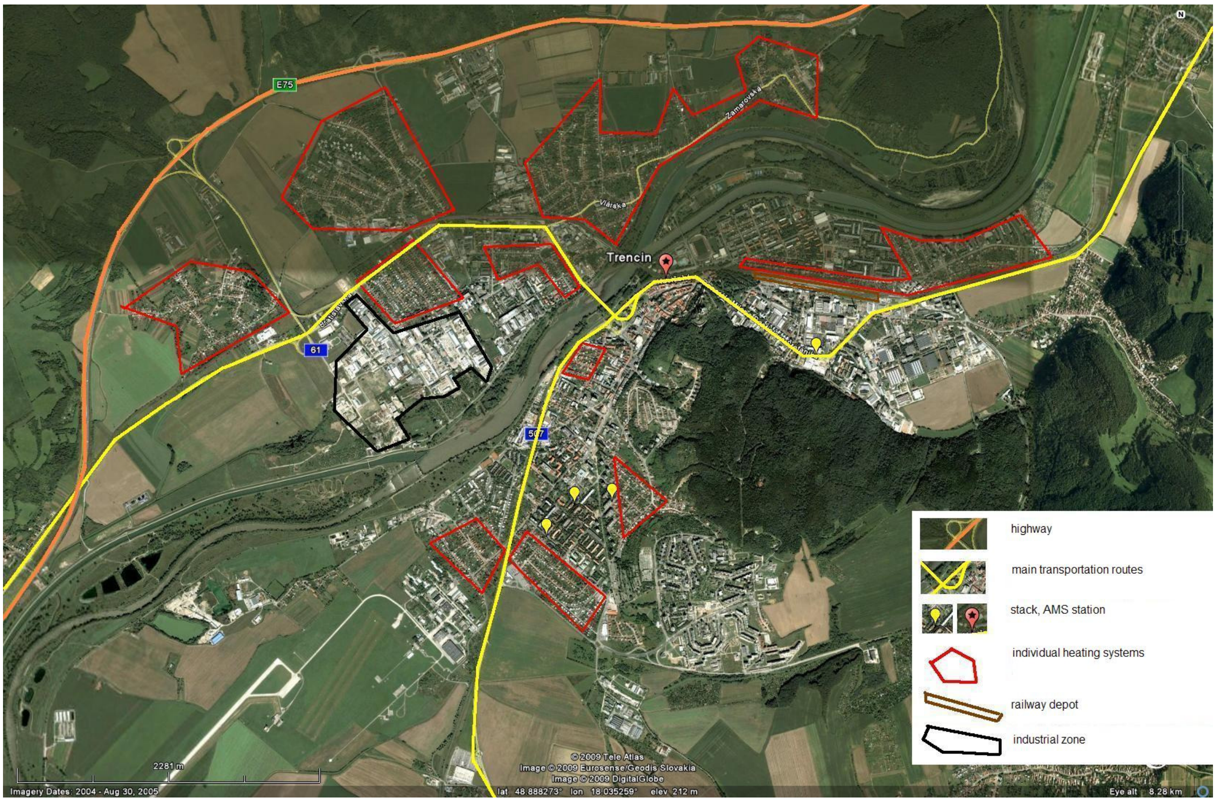


Fig. 2 shows the main potential sources on the territory of the city of Trenčín.

Figure 2.
Potential PM_{10} sources on the territory of the city of Trenčín



Source apportionment

The results of source apportionment according to [5] are represented on Fig. 3. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources and traffic had only minor impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify. We attempt to accomplish a qualitative apportionment of the *other* sources using the spatial information on Fig. 2 in combination with wind and concentration statistics summarized in Fig. 5 and other supplementary information described further in the text.

Figure 3
Contribution of different sources to mean annual concentration of PM_{10} in 2005

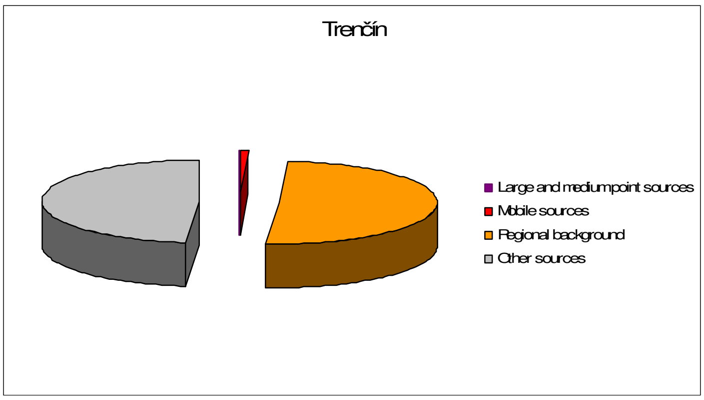
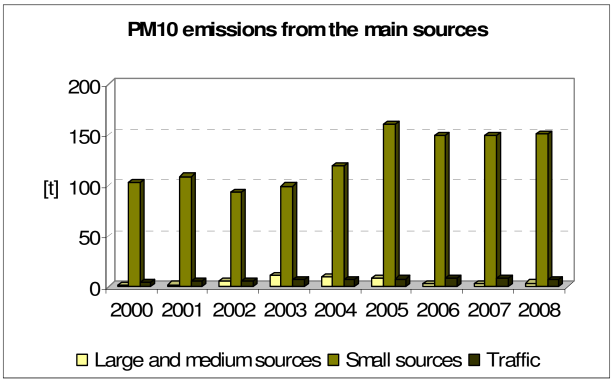
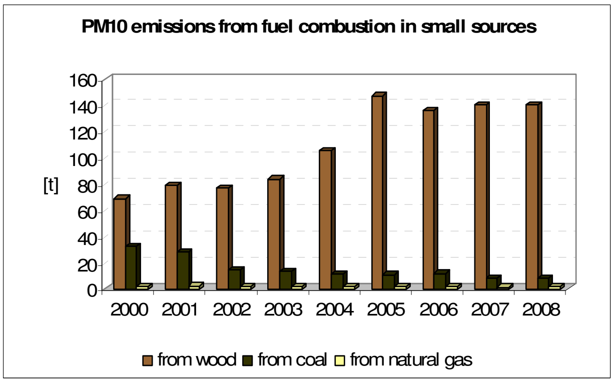


Fig. 4 shows that the aggregate emissions from small sources, namely, residential heating, play a dominant role in PM_{10} emissions. The second graph on Fig. 4 shows that wood is the fuel which is responsible for those emissions.

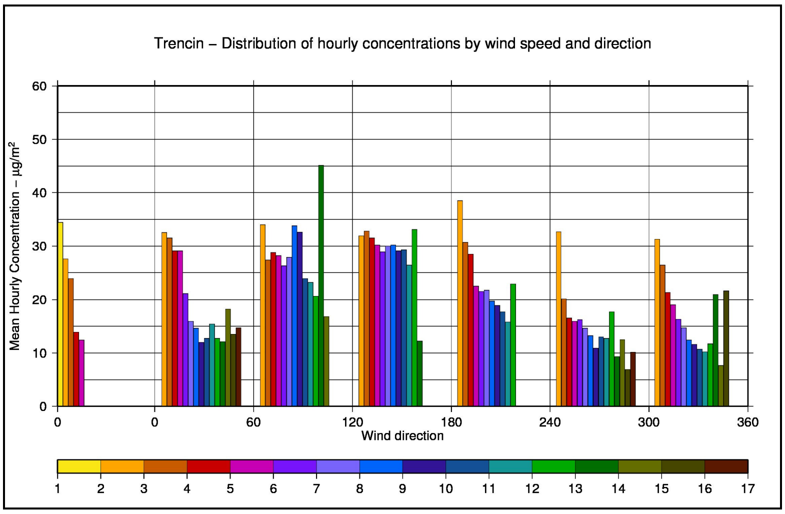
Figure 4.
Emissions from large, medium and small stationary sources and mobile sources on the territory AQMA.[13]





Graph on Fig. 5 indicates that besides low wind situations when hourly concentrations are high independently from wind direction and could be attributed to residential heating and traffic, there is concentration constant with wind speed from SE to S direction – this may be caused by dust resuspension from roads (especially at the end of winder and in spring), as well as erosion of uncovered arable land in spring and autumn months and seasonal agricultural works.

Figure 5.
Hourly PM_{10} concentrations depending on wind speed and wind directions at Trenčín AMS station



Conclusion

It has been demonstrated that the transboundary transport of PM_{10} contributes a large part to the concentrations during most of the exceedance situations in the reference year of 2005, and, in accordance with [1], can be subtracted from the measured concentrations. After subtraction, the AMS station in Trenčín does not exceeded the allowed number of 35 exceedances of daily PM_{10} limit value.

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[13] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

However, it is recognized that there are also other sources on the territory of the city, which contribute to the PM_{10} pollution. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the city.

Fig. 1 shows the PM_{10} exceedances have strongly decreasing trend, with number of daily LV exceedance cases in 2008 below the allowed number of 35. Putting into action further measures described in the air quality plan, there is a high probability that the PM_{10} limit values will not be exceeded in 2011.

Zone: **Trnavský kraj**
AQMA: **Territory of the town of Senica**

Climate relevant to atmosperic dispersion

Senica is situated in the northern part of Záhorská Nížina lowland, near the southern slopes of Biele Karpaty Mountains. It has specific circulation conditions with the long-term (10 years) mean annual wind speed of 2 m/s, with only 1.5% of calms, but with wind speeds lower than 2 m/s occurring 75% of the year. The mean annual wind speeds in the years of 2005, 2006 and 2007 were 1.6, 1.5 and 1.6 m/s respectively.

AMS station

There is one monitoring station in the AQMA. It had been situated at Nam. Slobody until the end of year 2007, and was characterized as urban background. In 2008 it was moved to Štefánikovo Nábrežie, and its character changed to urban traffic. Both sites (past and present) are in lower parts of the city with adverse dispersion conditions.

PM_{10} concentration data measured in the reference year 2005

Number of exceedances before subtraction of transboundary portion: **68**
Number of exceedances at days with the wind speed lower than 1.5 m/s: **40**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 1 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 1.
Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in $\mu g/m^3$.

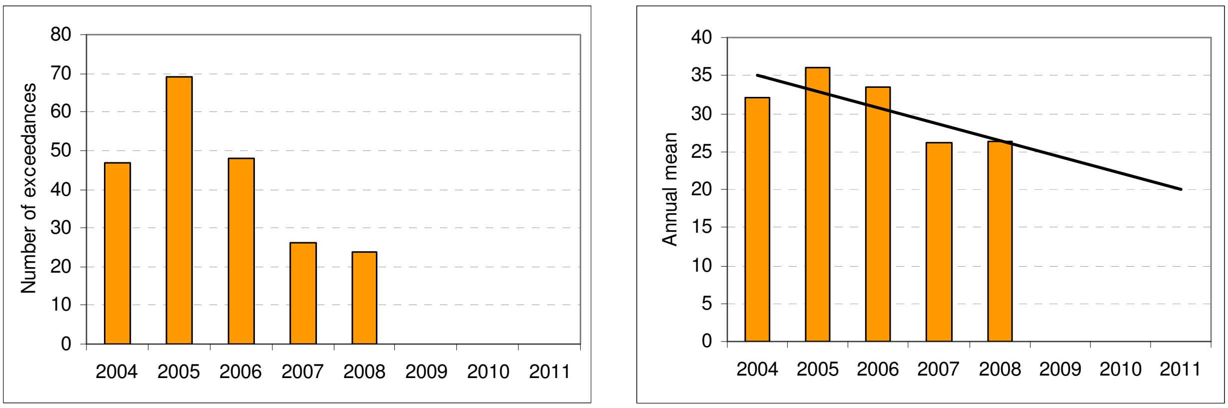
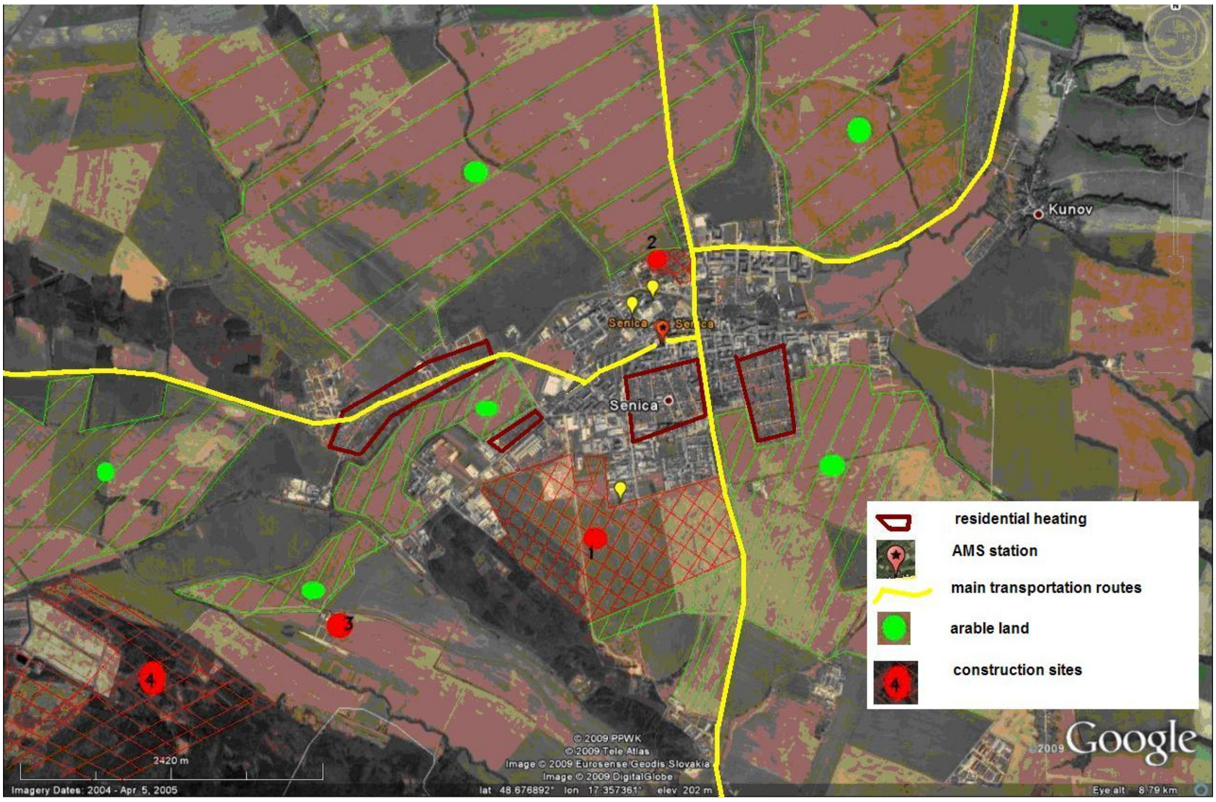


Fig. 2 shows the main potential sources of PM_{10} on the territory of the town of Senica

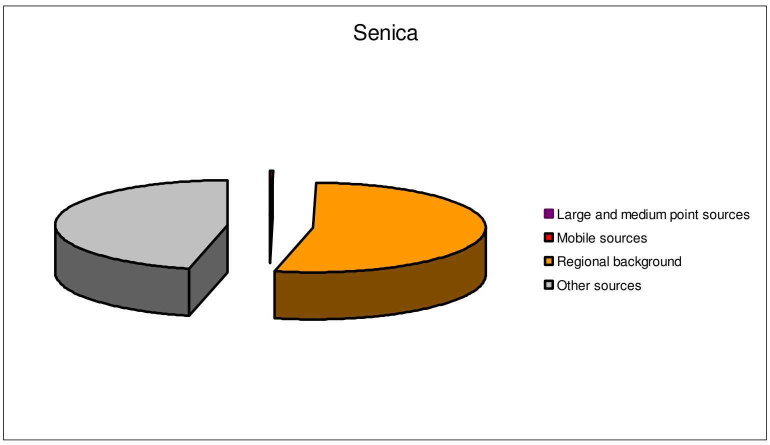
Figure 2.
Potential PM_{10} sources in the AQMA of Senica



Source apportionment

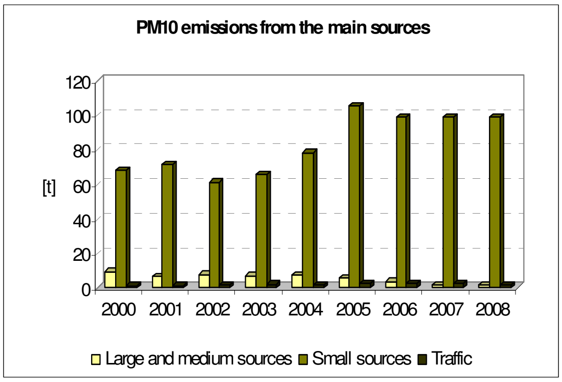
The results of source apportionment according to [5] are represented on Fig. 3. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources and traffic had only minor impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify. We attempt to accomplish a qualitative apportionment of the *other* sources using the spatial information on Fig. 2 in combination with wind and concentration statistics summarized in Fig. 5 and other supplementary information described further in the text.

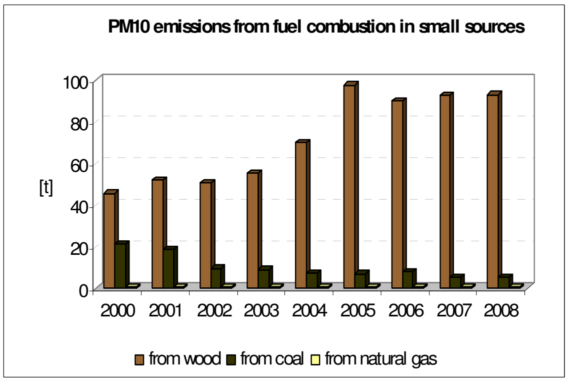
Figure 3
Contribution of different sources to mean annual concentration of PM_{10} in 2005



As shown in Fig. 4, there are no significant emissions from large and medium point sources or traffic in the AQMA of Senica. One of *other* sources responsible for PM_{10} emissions is rather intense construction activity as shown in Fig. 2.

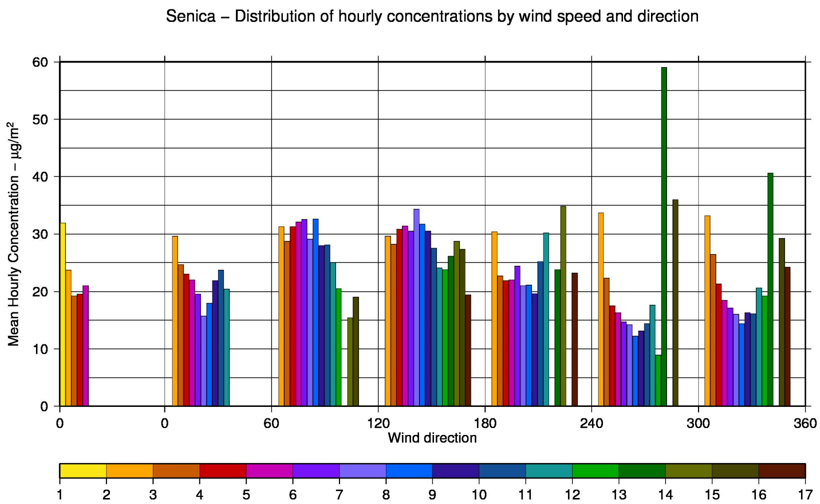
Figure 4.
Emissions from large, medium and small stationary sources and mobile sources on the territory AQMA.[14]





Graph on Fig. 5 shows that there are actually increased concentrations from E to S, independent on wind speed, which would correspond to resuspended PM_{10} from those construction sites. Part of high concentrations can be also attributed to seasonal agricultural works or resuspension of dust from uncovered arable land.

Figure 5.
Hourly PM_{10} concentrations depending on wind speed and wind directions at Senica AMS station



Conclusion

The AQMA of Senica is somehow special in that although its long-term mean annual wind speed does not fall under the 1.5 m/s limit for adverse climatic conditions, as specified in [2], its mean annual wind speed in last several years were close around 1.5 m/s. Furthermore, 40 out of 65 of the PM_{10} daily LV exceedances in the reference year of 2005 occurred at winds below 1.5 m/s. Threrefore, we consider the AQMA of Senica as having adverse climatic conditions with regard to air pollution dispersion.

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[14] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the city.
Fig. 1 shows the PM_{10} exceedances have strongly decreasing trend, with the number of PM_{10} LV exceedances below the limit of 35 in last two years. Putting into action further measures described in the air quality plan, there is a high probability that the PM_{10} limit values will not be exceeded in 2011.

Zone: **Trnavský kraj**
AQMA: **Territory of the city of Trnava**

Climate relevant to atmosperic dispersion

Trnava is situated in the NW part of Podunajská nížina lowland, between the southern edges of Malé Karpaty and Považský Inovec mountains, causing the speed enhancement of the prevailing NW flows. The long-term mean annual wind speed of 4.3 m/s with only 5% of calms makes this region one of the most ventilated regions of Slovakia

AMS station

There is one monitoring station in the AQMA, characterized as urban traffic.

PM_{10} concentration data measured in the reference year 2005

Number of exceedances before subtraction of transboundary portion: **109**
Number of exceedances after subtraction of transboundary portion: **34**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 1 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 1
Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in $\mu g/m^3$.

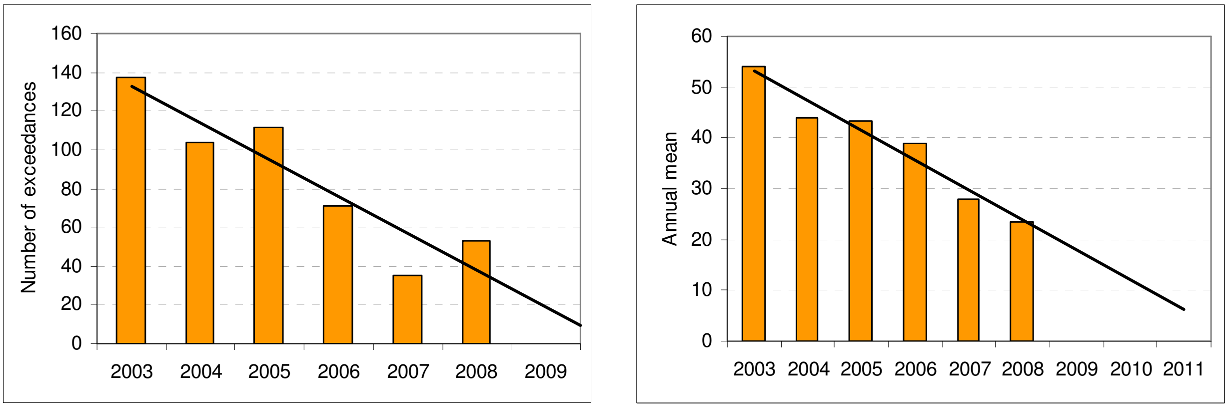


Fig. 2 shows the main potential sources of PM_{10} on the territory of the city of Trnava

Figure 2
Potential PM_{10} sources in the AMQA of Trnava

Source apportionment

The results of source apportionment according to [5] are represented on Fig. 3. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources and traffic had only minor average impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify. We attempt to accomplish a qualitative apportionment of the *other* sources using the spatial information on Fig. 2 in combination with wind and concentration statistics summarized in Fig. 5 and other supplementary information described further in the text.

Figure 3
Contribution of different sources to mean annual concentration of PM_{10} in 2005

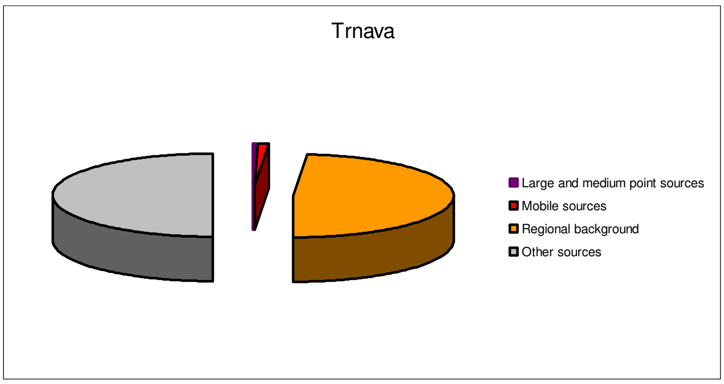
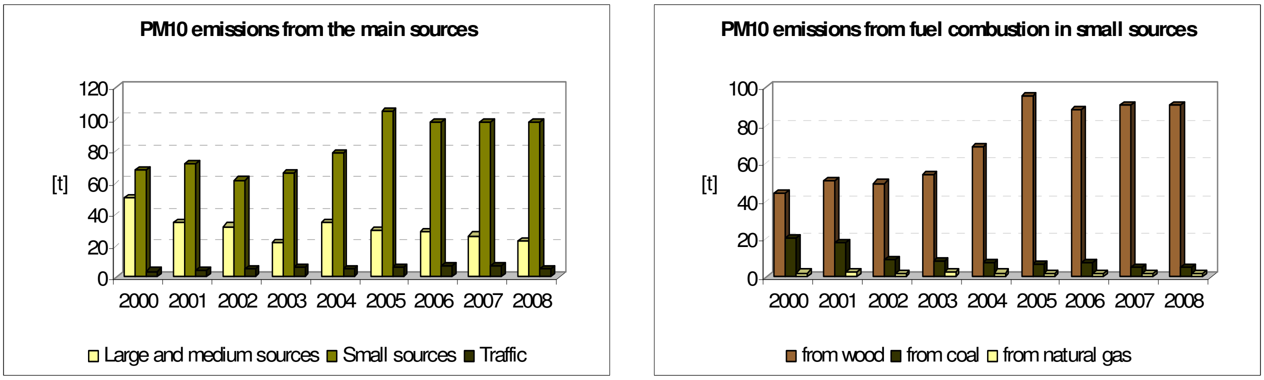


Figure 4.
Emissions from large, medium and small stationary sources and mobile sources on the territory AQMA.[15]

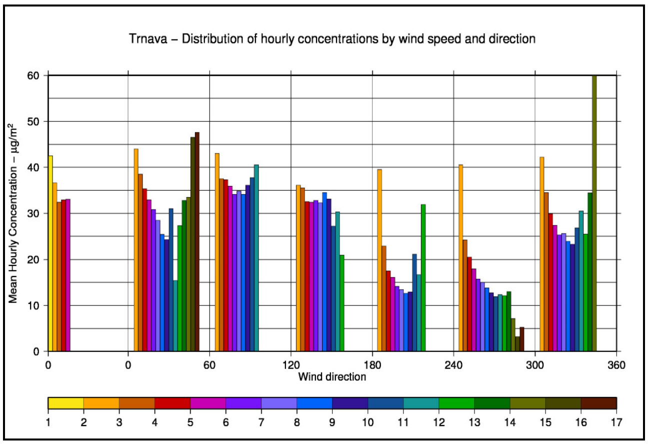


Trnava is one of the most ventilated cities in Slovakia and transboundary transport of PM_{10} forms an important part of not only mean annual PM_{10} concentrations but also daily limit exceedances. As is shown in Fig. 4, the city itself does not have many large and medium sources and most of the aggregate emissions belong to small sources, namely, local heating systems.

AMS station is situated in the city centre near a frequented road, next to the bus terminal and the railway station. The bus terminal probably plays an important role in increased PM_{10} concentrations, especially at low winds. Fig. 5 demonstrates that hourly concentrations from most directions do not depend on the wind speed or they are increasing with increasing wind speed. This points to fugitive and resuspended dust from dirty roads, construction sites and the surrounding arable land.

Fig. 1 shows a slight increase in daily exceedances in the year 2008, which was probably caused by the reconstruction of nearby road and temporary traffic diversion to the city centre, causing traffic jams and increased PM_{10} emisions.

Figure 5.
Hourly PM_{10} concentrations depending on wind speed and wind directions at Trnava AMS station



[15] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

Conclusion

It has been demonstrated that transboundary transport of PM_{10} contributes a large part to the concentrations during most of the exceedance situations in the reference year of 2005, and, in accordance with [1], can be subtracted from the measured concentrations. After subtraction, the AMS station in Trnava does not exceeded the allowed number of 35 exceedances of daily PM_{10} limit value. Although only the year of 2005 was modeled, there are reasons to believe that the situation will not largely differ for the other years.

However, it is recognized that there are also other sources on the territory of the city, which contribute to the PM_{10} pollution. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the city.
Fig. 1 shows the PM_{10} exceedances have strongly decreasing trend and putting into action further measures described in the air quality plan, there is a high probability that the PM_{10} limit values will not be exceeded in 2011.

Zone: **Žilinský kraj**
AQMA: **Territories of the cities of Martin and Vrútky**

Figure 1.
Geographical position and terrain of AQMA (red balloon: AMS station, blue balloon – climatologic station)

Climate relevant to atmosperic dispersion

The town of Martin is situated in the Turčianska basin at the confluence of the rivers Turiec and Váh, surrounded by the Veľká and Malá Fatra mountain ranges. The basin area is located between high mountains and with its long-term (10years) mean annual wind speed of 1.6 m/s and 25% of calms has adverse climatic conditions for pollutant dispersion.

AMS station

The station is located 5 m from the main road in the southern part of the city in a residential housing area, and it is characterized as urban transport.

PM_{10} concentration data measured in the reference year 2005

Total number of PM_{10} daily limit exceedances: **66**
Exceedances during days with mean wind speed lower than 1.5 m/s: **44**
For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 2 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 2.
Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in $\mu g/m^3$.

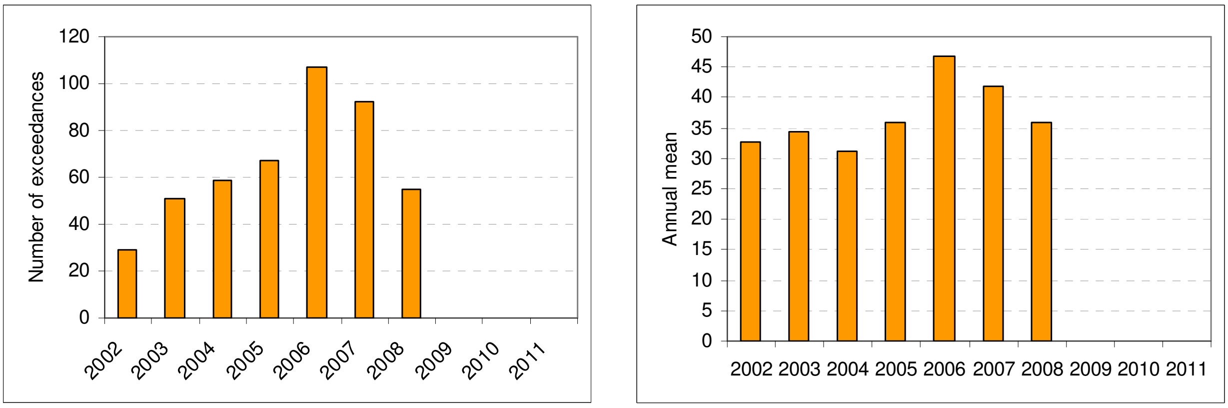
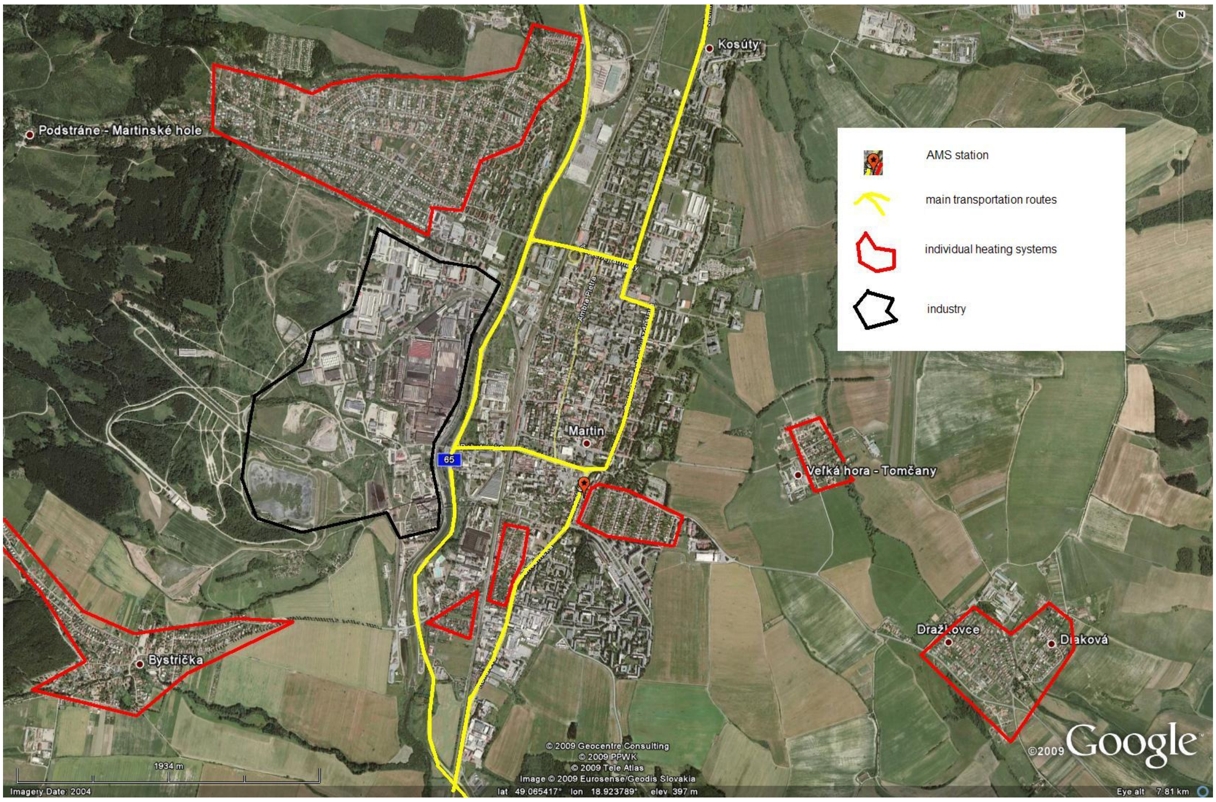


Fig. 3 shows the main potential sources of PM_{10} in the AQMA of Martin

Figure 3
Potential PM_{10} sources in the AQMA of Martin



Source apportionment

The results of source apportionment according to [5] are represented on Fig. 4. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources and traffic had only minor average impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify.

Figure 4
Contribution of different sources to mean annual concentration of PM_{10} in 2005

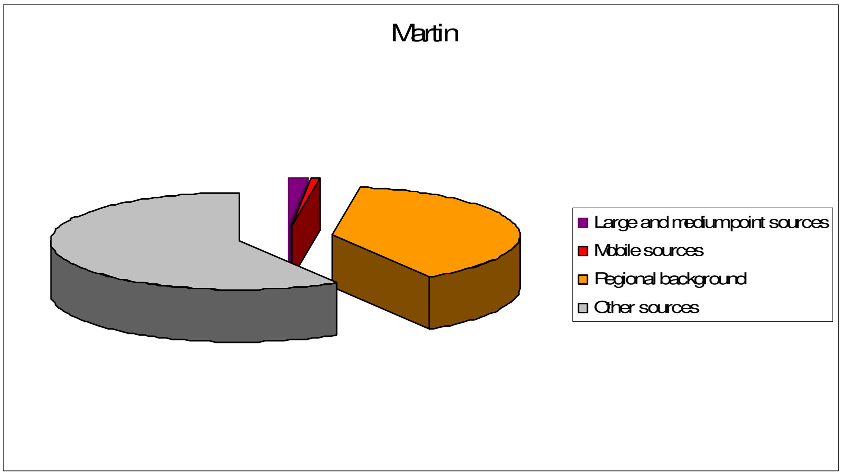
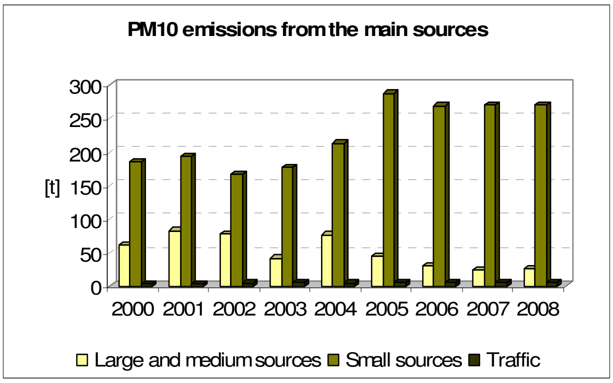
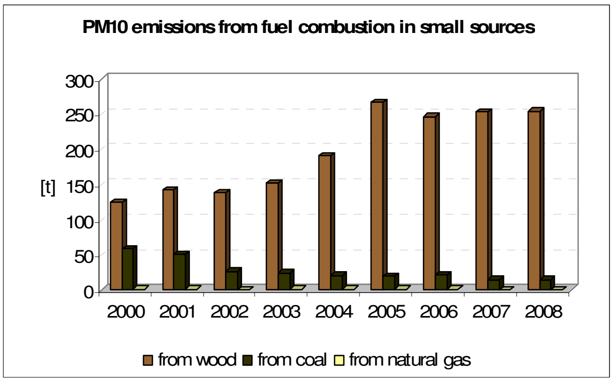


Fig. 5, which is based on aggregated emission data, shows that the emissions come prevailingly from small sources, represented by wood and coal fuelled individual heating systems. Fig. 3 shows that the AMS station is located next to the residential area with family houses, which may be an important PM_{10} source in winter part of the year. However, it has to be pointed out that the emissions from the small sources are disaggregated from the whole district of Martin according to population data, but there are no statistical data available on the number of households in each particular residential area actually using wood for heating.
The monitoring station is located at a roadside, so the emissions from traffic also influence the PM_{10} concentrations – not only exhaust and non-exhaust emissions included explicitly in figures 4 an 5, but also resuspended dust from road dirt and winter sanding.

Figure 5.
Emissions from large, medium and small stationary sources and mobile sources on the territory AQMA.[16]

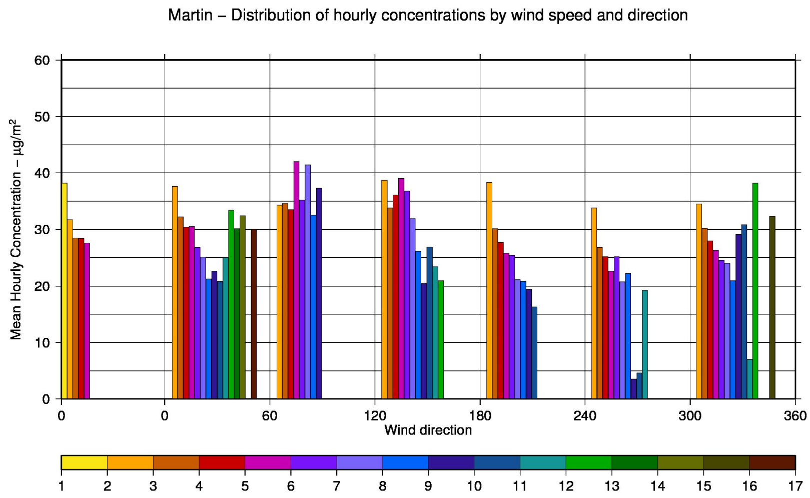




Graph on Fig. 6 shows the concentrations increasing, or not decreasing, with the wind speeds from north to east sectors. Sources which may be responsible for these increased concentrations may be non-stack emissions from industry and arable land.

[16] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

Figure 6
Hourly PM_{10} concentrations depending on wind speed and wind directions at Martin AMS station

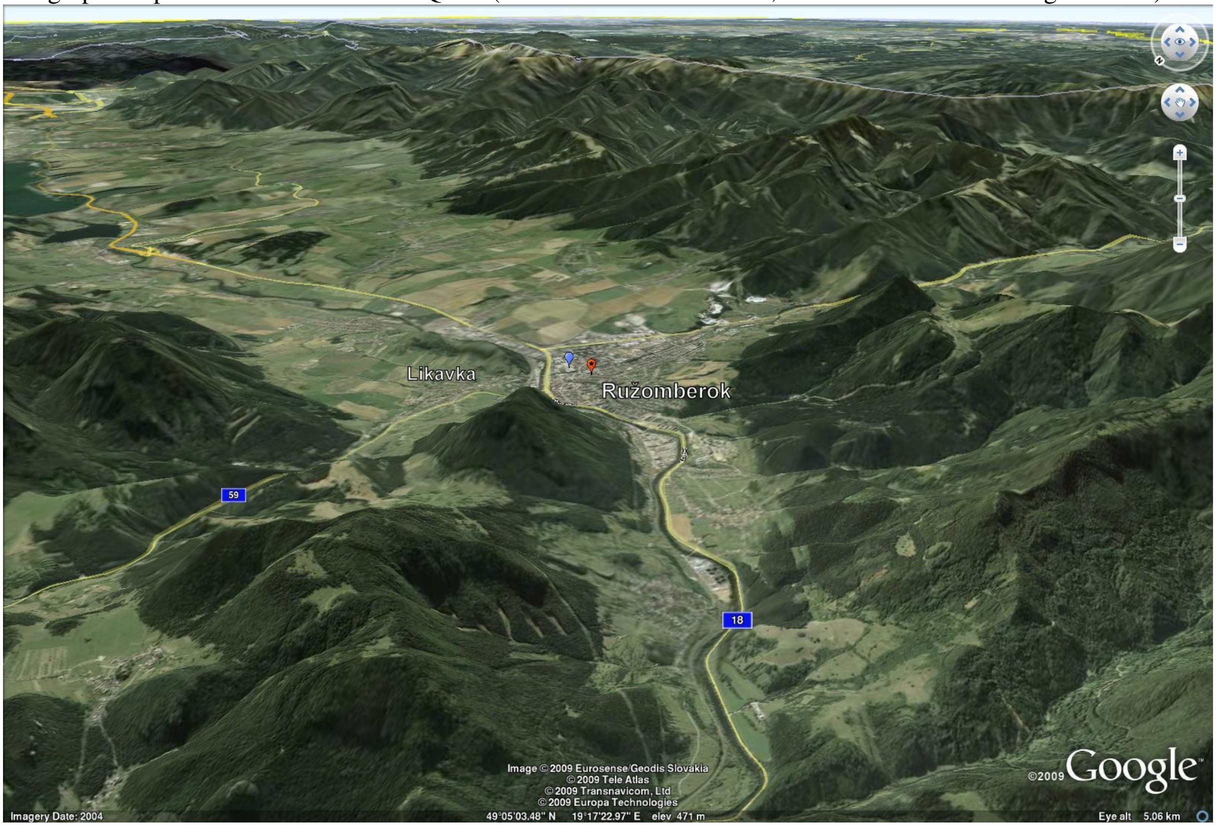


Conclusion

It has been demonstrated that the air quality in Martin is highly influenced by its adverse dispersion conditions associated with its geographical position and adverse climatic conditions with the annual wind speed close to 1.5 m/s. It has been demonstrated that 44 out of 66 daily PM_{10} LV exceedances in the reference year of 2005 occurred at days with the wind speed below 1.5 m/s. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the city. Fig. 3 shows that the PM_{10} exceedances have decreasing trend and putting into action further measures described in the air quality plan, there is a good chance that they fall under the limit value in 2011.

Zone: Žilinský kraj
AQMA: Territory of the city of Ružomberok and the municipality of Likavka

Figure 1.
Geographical position and terrain of AQMA (red balloon: AMS station, blue balloon – climatologic station)



Climate relevant to atmosperic dispersion

The AQMA is situated western part of the Liptovská basin, on the confluence of rivers Váh, Revúca and Likavka. The Veľká Fatra mountains constitute the border in the west, the Chočské mountains in the north and the Low Tatras in the south. Long-term mean annual wind speed of 1.5 m/s and 18% of calms make it a territory with adverse climatic conditions with respect to pollution dispersion.

AMS station

The station is located in the kindergarten close to a low traffic road. It is surrounded by residential housing and characterized as urban background.

PM_{10} concentration data measured in the reference year 2005

Total number of PM_{10} daily limit exceedances: **168**
Exceedances during days with mean wind speed lower than 1.5 m/s: **92**
Exceedances during days with higher wind speeds and transboundary contribution: **43**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 2 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 2.
Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in µg/m^3.

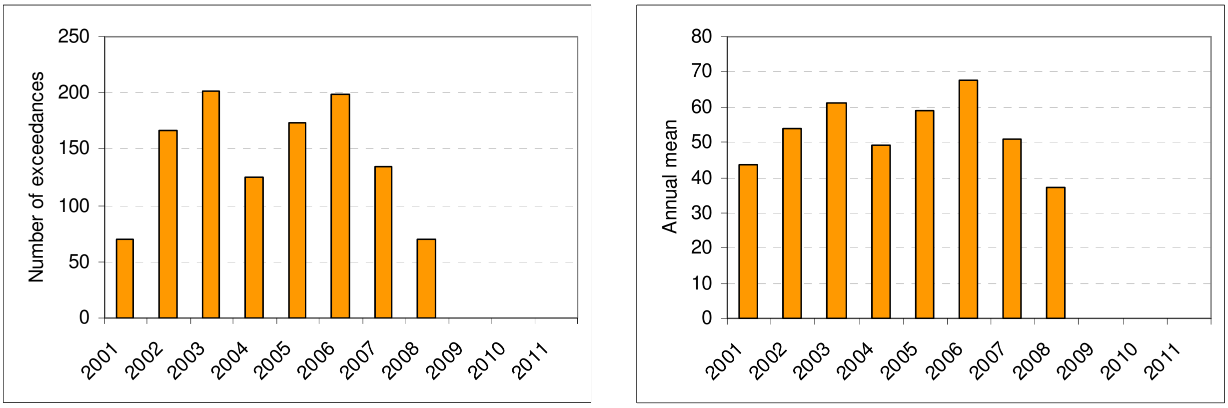
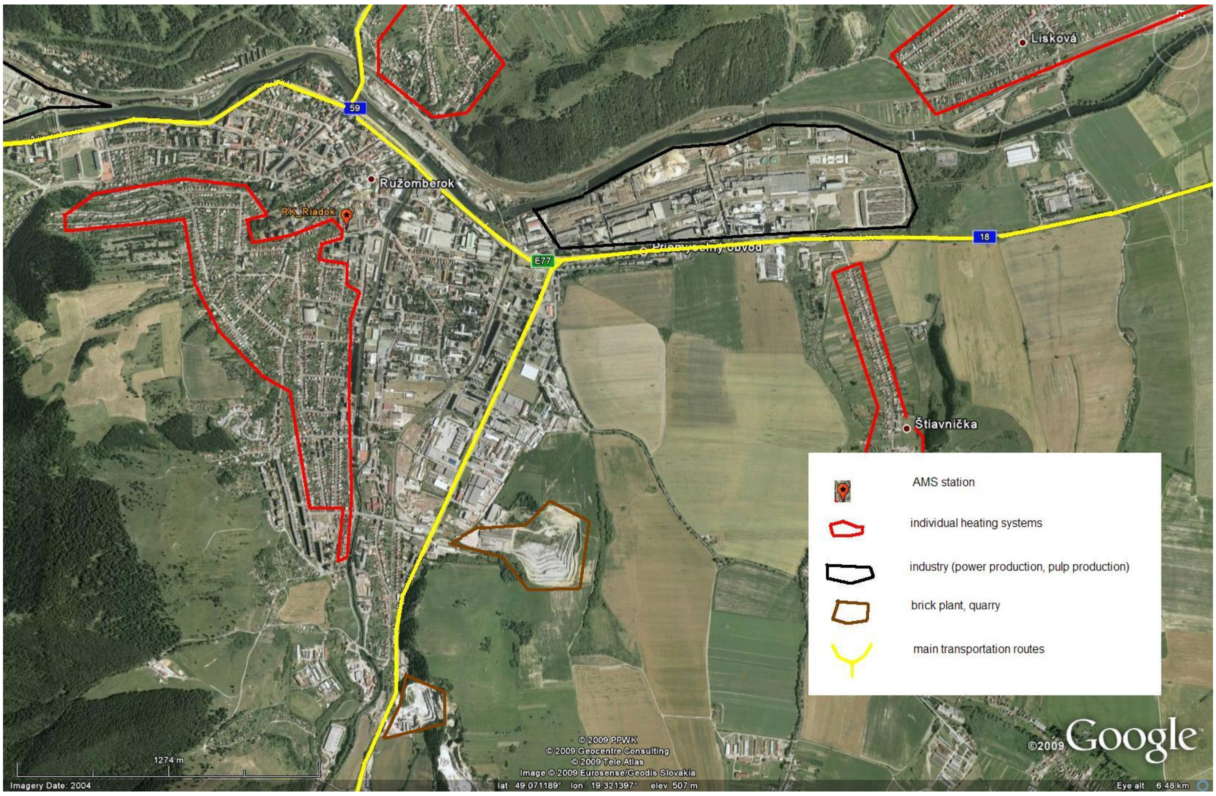


Fig. 3 shows the main potential sources of PM_{10} on the territory of the city of Ružomberok and the municipality of Likavka

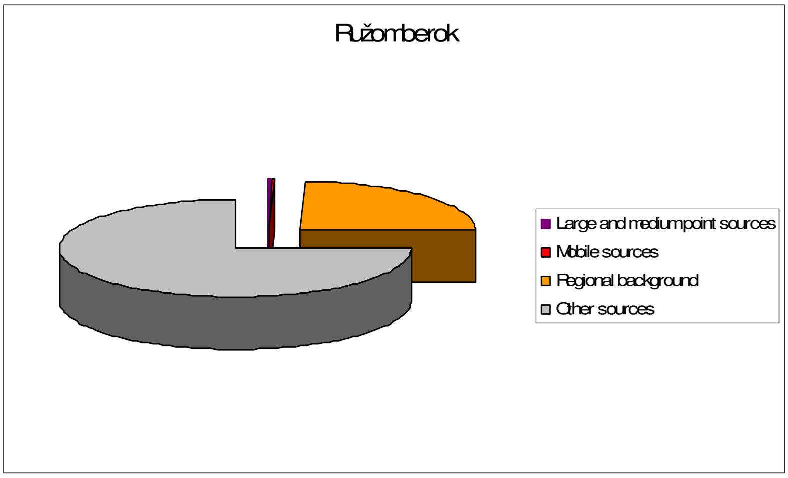
Figure 3.
Potential PM_{10} sources in Ružomberok AQMA



Source apportionment

The results of source apportionment according to [5] are represented on Fig. 4. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources and traffic had only minor average impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify.

Figure 4.
Contribution of different sources to mean annual concentration of PM_{10} in 2005



It corresponds also to graphs in Fig. 5, where small sources dominate the aggregate emissions at the AQMA territory, namely, the emissions of wood burned as fuel in residential heating. Although according to Fig. 4 traffic does not contribute significantly to the average annual concentrations according to the modeling, it may still have significant influence because only direct exhaust and abrasive emissions were modeled. There are 2 important transportation routes meeting in the city east of the AMS stations, which are all loaded with all kinds of transport and other than direct automobile emissions, such as resuspended dirt and winter sanding dust probably contribute to the measured concentrations among *other* sources.

Figure 5.
Emissions from large, medium and small stationary sources and mobile sources on the territory AQMA.[17]

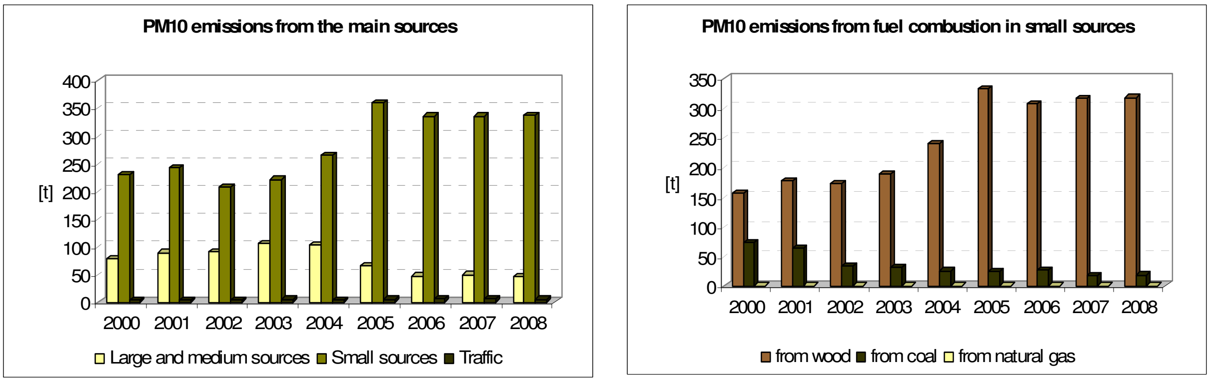


Fig. 6 shows increase in hourly concentrations with higher winds from eastern directions, which would correspond to the traffic junction as well as resuspension of dust from the premises of Mondi, a.s. pulp and paper factory.

Looking at detailed meteorological data at the exceedance cases in 2005 (Appendix A), it reveals that a large part of exceedances occur at higher wind speeds, which allows for the substraction of transboundary portion of the daily PM_{10} concentrations.

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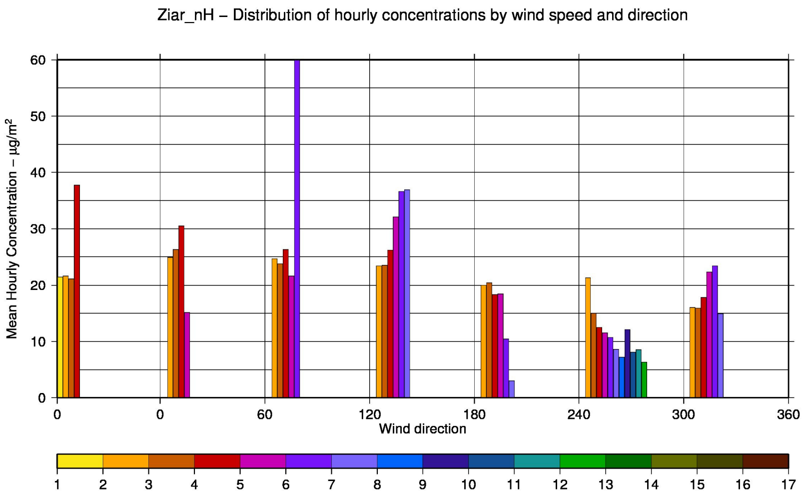
[17] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic.
http://lat.eng.auth.gr/copert/

Figure 6.
Hourly PM_{10} concentrations depending on wind speed and wind directions at Ružomberok AMS station

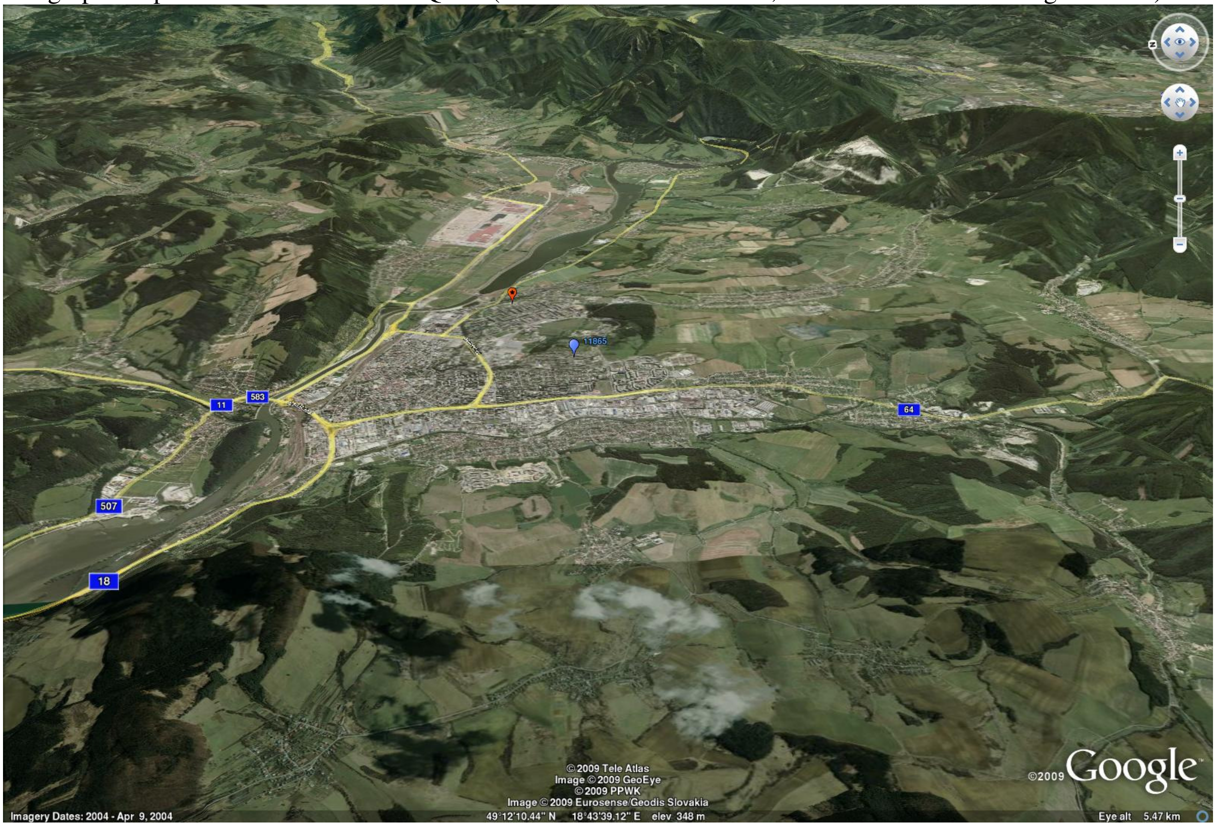


Conclusion

It has been demonstrated that the air quality in the AQMA of Ružomberok is highly influenced by its adverse dispersion conditions associated with its geographical position and adverse climatic conditions with the annual wind speed of 1.5 m/s. It has been demonstrated that 92 out of 168 daily PM_{10} LV exceedances in the reference year of 2005 occurred at days with the wind speed below 1.5 m/s. Based on application of EMEP modeling of transboundary contribution, other 33 cases of exceedances with higher winds have been eliminated. The remaining 43 exceedances are still above the allowed number of 35 in the reference year of 2005.
Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the city. Fig. 3 shows that the PM_{10} exceedances have clear decreasing trend and putting into action further measures described in the air quality plan, there is a good probability that taking into account reasonable portion of transboundary contribution, they fall under the limit value in 2011.

Zone: **Žilinský kraj**
AQMA: **Territory of the city of Žilina**

Figure 1.
Geographical position and terrain of AQMA (red balloon: AMS station, blue balloon – climatologic station)



Climate relevant to atmosperic dispersion
The town itself is spread in the central valley of the Váh river, in the basin of central Považie. From the east the Malá Fatra mountains intervene into the area, from the south the Biele Karpaty Mountains and from the north-west the Javorníky mountains. The winds are blocked by the mountains from most directions, causing the long-term (last 10 years) mean annual wind speed as low as 1.1 m/s, with 51% occurrence of calms.

AMS station
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. It is characterized as urban background.

PM_{10} concentration data measured in the reference year 2005

Total number of PM_{10} daily limit exceedances: **82**
Exceedances during days with mean wind speed lower than 1.5 m/s: **77**

For the detailed information on meteorology during the exceedance days see Appendix A of this document.

Fig. 2 gives the information on the annual means and number of exceedances prior and after the reference year of 2005.

Figure 2.
Development of the PM_{10} concentrations in the last ten years. Left: number of daily LV exceedances, right: mean annual concentration in µg/m^3.

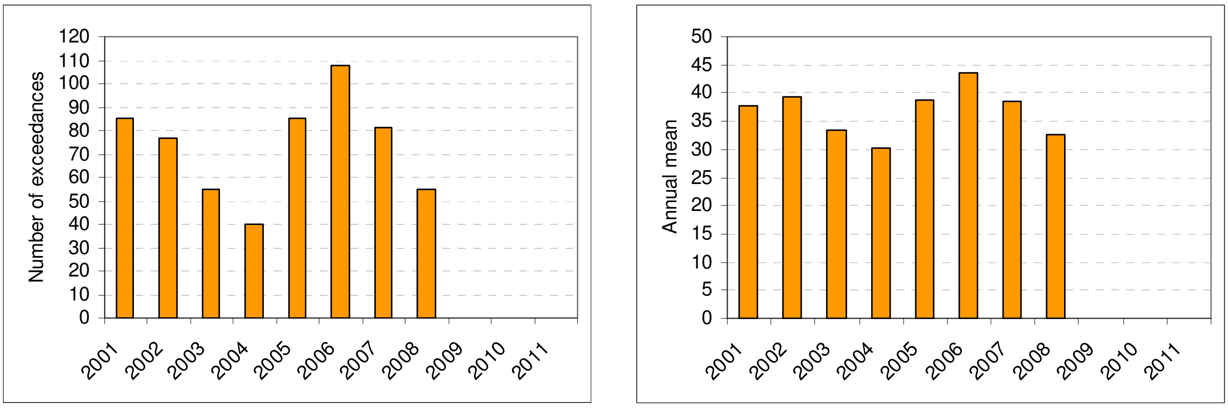
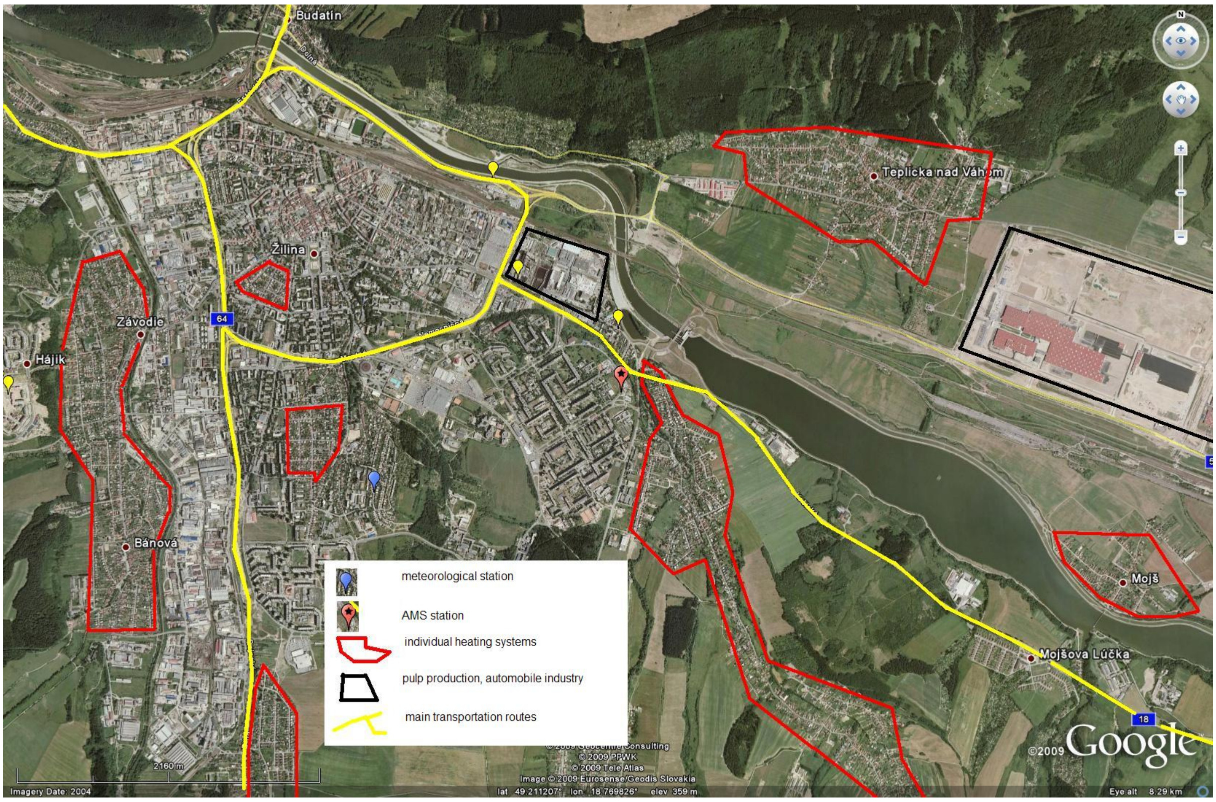


Fig.3 shows the main potential sources of PM_{10} on the territory of the city of Žilina

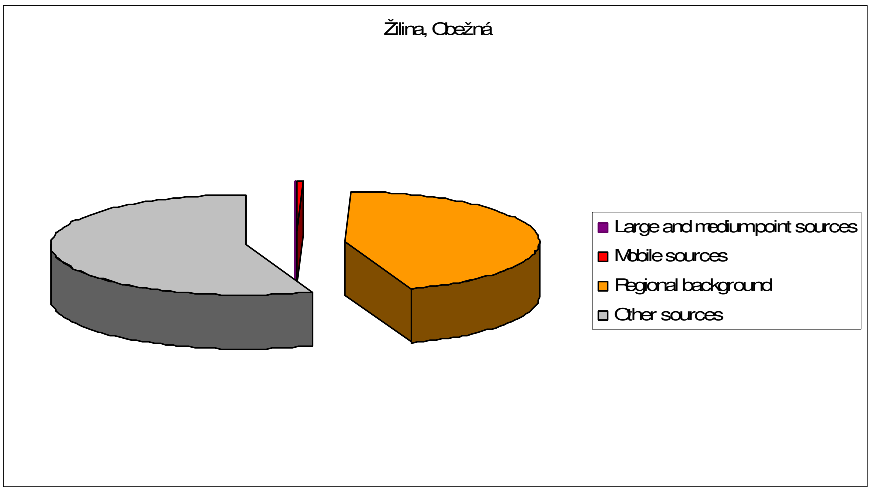
Figure 3
Potential PM_{10} sources in the AQMA of Žilina



Source apportionment

The results of source apportionment according to [5] are represented on Fig. 4. It shows the contribution of large and medium point sources, traffic and regional background to the mean annual PM_{10} concentration in 2005. It shows that the point sources and traffic had only minor impact on the PM_{10} concentrations, most were contributed from regional background, most of which is transboundary, as was shown in Part 1 of this document, and from so-called *other* sources, the existence of which is mostly known, but they are difficult to quantify.

Figure 4.
Contribution of different sources to mean annual concentration of PM_{10} in 2005



These findings correspond to the graph on Fig. 5, showing the aggregated emissions from the main source sectors on the territory of the city, showing that the wood-fuelled local heating, which is included among *other* sources, plays a rather important role in such a low-ventilated area. However, it has to be pointed out that the emissions from the small sources are disaggregated from the whole district of Žilina according to population data, but there are no statistical data available on the number of households in each particular residential area actually using wood for heating.

Figure 5.
Emissions from large, medium and small stationary sources and mobile sources on the territory AQMA.[18]

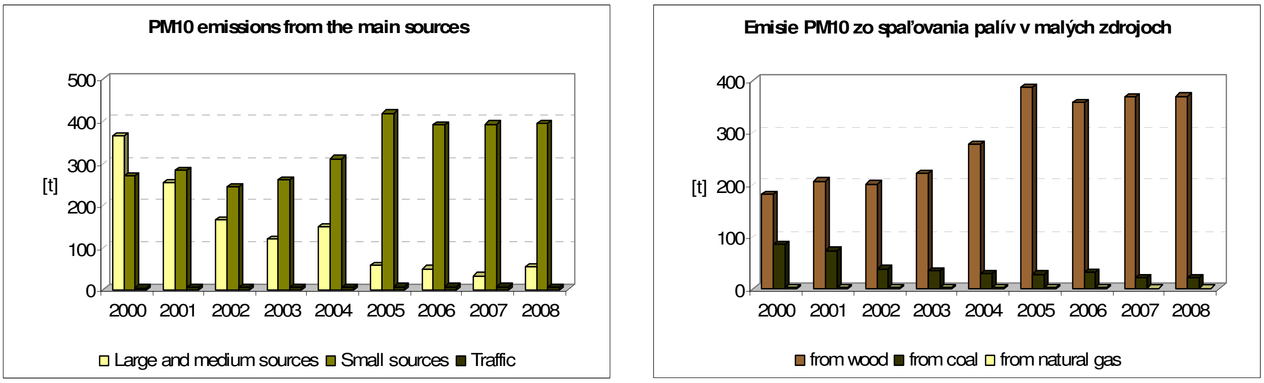
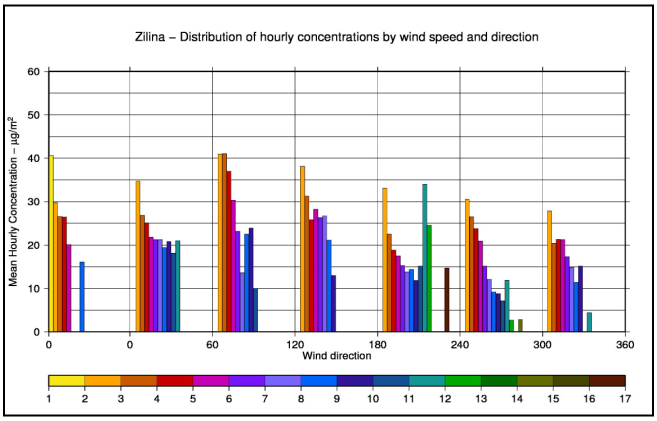


Fig. 9 shows that the highest hourly concentrations occur at low wind speeds at all wind directions, except for the SW, where the concentrations increase with wind speed – these may be caused by the dust resuspension from the arable fields located nearby in that direction, however, these do not usually occur long enough to cause daily PM_{10} limit value exceedance.

[18] PM_{10} emissions were estimated according to the requirement of the Convention on Long-Range Transboundary Air Pollution. TSP emissions from large and medium sources are from NEIS database [7]. Method for PM10 estimation is based on IIASA methodology [14]. Emissions from small sources are based on reported amount of fossil fuels sold at retail. Wood used for fuel was estimated from the difference between the total heat needed for inhabited areas and heat produced by fossil fuels reported by sellers. Respective emission factors reported in literature were applied. COPERT-IV was used for estimation of emissions from road traffic. http://lat.eng.auth.gr/copert/

Figure 6.
Hourly PM_{10} concentrations depending on wind speed and wind directions at Žilina AMS stations



Conclusion

It has been demonstrated that the air quality in Žilina is highly influenced by its adverse dispersion conditions associated with its geographical position and adverse climatic conditions with the annual wind speed below 1.5 m/s. It has been demonstrated that 77 out of 82 daily PM_{10} LV exceedances in the reference year of 2005 occurred at days with the wind speed below 1.5 m/s. Based on quantitative and qualitative analysis of the situation, an air quality plan was elaborated and regularly updated, and appropriate measures has been taken in accordance with the plan in order to improve the air quality in the city. Fig. 3 shows that the PM_{10} exceedances have clear decreasing trend and putting into action further measures described in the air quality plan, there is a good chance that they fall under the limit value in 2011.

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