NATIONAL PM ASSESSMENT REPORT – SLOVAK REPUBLIC

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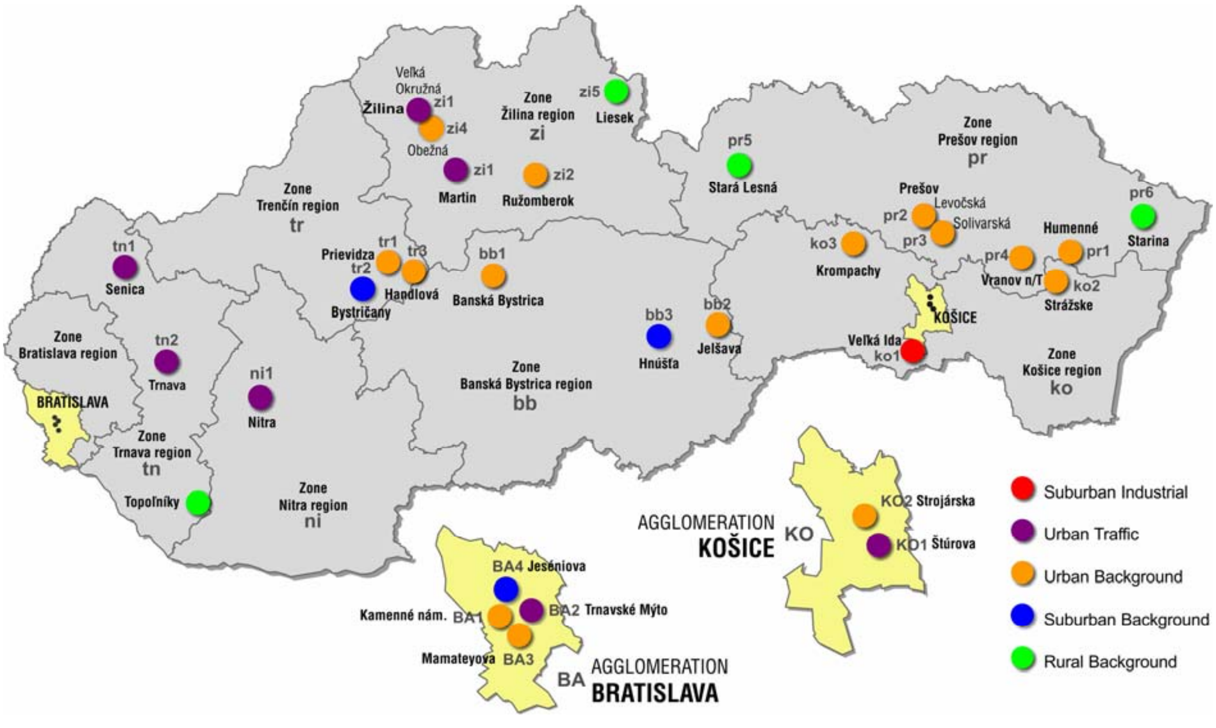
HISTORY OF PM MONITORING

The Slovak Hydrometeorological Institute (SHMU) is state organization, supervised by the Ministry of Environment, authorized for air quality monitoring, assessment and reporting on a national level and thus provide basic input for the development and fulfilment of national reporting obligations, mitigation plans and programs.

The current state of the Slovak national air quality monitoring network is presented in Figure 1. PM_{10} measurements started in 2002 and in 2005 the 28 real-time PM_{10} monitoring stations were in operation in urban/suburban areas. Results from 26 of these stations are presented in this report. PM_{10} inlet systems originate from several renowned European and US producers. At the real-time monitoring stations TEOM instruments were installed using default correction factor 1.3. At 18 TEOMs the FDMS modules were installed last year. Studies from other countries proved that these measurements provide equivalence with the reference method and therefore no correction factor was applied. The rural background PM is monitored at five EMEP sites, but PM_{10} only at three of them Stará Lesná SK04, Liesek SK05 and Starina SK06. At the EMEP stations the sampling period is one week. The EMEP station Topoľníky SK07 in Danube lowlands started the real-time PM_{10} and $PM_{2.5}$ (TEOMs) measurements only recently as well as PM_{10} in weekly interval. The $PM_{2.5}$ was measured in Slovakia in 2005 on three urban traffic station (TEOMs).

Figure 1. National air quality monitoring network in Slovakia (status in 2005)



For improvement of PM data quality, the QA/QC procedures have to be fully implemented at all stations. In the forthcoming year the process of accreditation in air quality monitoring network will start which will result in improvements of maintenance system, calibration processes, demonstration of equivalence to reference method, uncertainty estimates etc. Weighing room and weighing procedures have been already prepared for accreditation. The parallel in-situ measurements (according to EN 12341, resp. EN 14907) with mobile unit have been prepared and are going to start also this year. The quality of $PM_{2.5}$ measurements has to be improved significantly as well which is underlined also by the fact that expected $PM_{2.5}$ limit values will be approved in 2007.

DATA ASSESSMENT

For the time being the available PM_{10} data were assessed and reported only according to the EU AQ obligations. More detailed, scientific assessment of measurements has not been completed yet. However, the present estimates clearly indicate, that PM rural background, especially the share of long-range transboundary transport, play very important role especially for fine particles.

Typical annual PM_{10} averages for Slovakia in 2005

- rural background (EMEP) 15–25 $\mu g.m^{-3}$ (in dependence on altitude)
- urban/suburban background 30–35 $\mu g.m^{-3}$
- urban/suburban all types 30–65 $\mu g.m^{-3}$
- primary anthropogenic particles* 3–10 $\mu g.m^{-3}$ (at some industrial stations even more)

**Model estimation based on national PM emission inventory data (registration of small, medium, large and mobile anthropogenic sources).*

Monthly course of PM_{10} concentrations from all monitoring station is shown in Figure 2. The highest values were registered at the industrial station Velka Ida situated very close to US Steel factory while the lowest values were recorded at rural background stations. Cross correlations of daily concentrations was estimated for 25 real-time stations indicating high correlation exists among all monitoring stations at the whole territory of Slovakia (Table 1) documenting clearly the rural background (transboundary) aspect of PM_{10} pollution level. As expected the lowest correlation was found out for industrial station Velka Ida at which the local PM_{10} sources play decisive role.

Table 1. Correlation matrix of PM_{10} daily concentrations – Slovakia, 2005

AGGLOMERATION / zone			BA			KO		bb			ko			ni	pr				tr			tn		zi			
		Station	1	2	3	1	2	1	2	3	1	2	3	1	1	2	3	4	1	2	3	1	2	1	2	3	4
BA	1	Bratislava, Kam. nám.	1																								
	2	Bratislava, Trnav. mýto	0.86	1																							
	3	Bratislava, Mamateyova.	0.80	0.83	1																						
KO	1	Košice, Štúrova	0.58	0.56	0.52	1																					
	2	Košice, Strojárska	0.53	0.54	0.50	0.93	1																				
bb	1	Ban. Bystrica, Nám.slob.	0.71	0.71	0.63	0.74	0.72	1																			
	2	Jelšava, Jesenského	0.48	0.48	0.43	0.74	0.77	0.73	1																		
	3	Hnúšťa, Hlavná	0.56	0.55	0.56	0.75	0.75	0.75	0.81	1																	
ko	1	Veľká Ida, pri ŽSR	0.19	0.23	0.30	0.15	0.17	0.25	0.10	0.15	1																
	2	Strážske, Mierová	0.50	0.50	0.47	0.85	0.80	0.68	0.63	0.59	0.16	1															
	3	Krompachy, Lorenzova	0.57	0.58	0.56	0.83	0.85	0.77	0.76	0.77	0.23	0.73	1														
ni	1	Nitra, Štefánikova	0.64	0.74	0.71	0.66	0.64	0.71	0.58	0.63	0.22	0.54	0.65	1													
pr	1	Humenné, Nám. slobody	0.50	0.50	0.47	0.83	0.79	0.71	0.67	0.65	0.23	0.94	0.76	0.58	1												
	2	Prešov, Levočská	0.54	0.54	0.55	0.88	0.88	0.70	0.72	0.74	0.20	0.84	0.84	0.63	0.84	1											
	3	Prešov, Solivarská	0.51	0.53	0.57	0.79	0.71	0.62	0.59	0.61	0.20	0.78	0.70	0.62	0.76	0.84	1										
	4	Vranov n/T, M.R.Štefan.	0.52	0.52	0.54	0.83	0.81	0.66	0.64	0.65	0.19	0.87	0.78	0.58	0.85	0.88	0.78	1									
tr	1	Prievidza, J. Hollého	0.64	0.65	0.62	0.72	0.70	0.82	0.64	0.74	0.17	0.66	0.71	0.72	0.68	0.71	0.59	0.66	1								
	2	Bystričany, Roz. SSE	0.54	0.61	0.62	0.55	0.59	0.65	0.55	0.63	0.20	0.52	0.62	0.68	0.52	0.61	0.48	0.54	0.77	1							
	3	Handlová, Morov.cesta	0.66	0.71	0.68	0.65	0.62	0.79	0.62	0.70	0.25	0.59	0.69	0.72	0.64	0.70	0.60	0.71	0.81	0.69	1						
tn	1	Senica, Hviezdoslavova	0.78	0.83	0.82	0.66	0.59	0.74	0.53	0.58	0.27	0.59	0.61	0.84	0.62	0.62	0.65	0.63	0.71	0.62	0.76	1					
	2	Trnava, Kollárova	0.69	0.78	0.75	0.58	0.52	0.66	0.48	0.54	0.23	0.51	0.52	0.78	0.53	0.58	0.62	0.60	0.66	0.58	0.77	0.87	1				
zi	1	Martin, Jesenského	0.51	0.55	0.54	0.63	0.63	0.62	0.52	0.58	0.17	0.47	0.71	0.73	0.51	0.52	0.48	0.49	0.61	0.58	0.52	0.56	0.45	1			
	2	Ružomberok, Riadok	0.61	0.63	0.58	0.67	0.64	0.80	0.59	0.59	0.21	0.61	0.75	0.71	0.65	0.59	0.55	0.58	0.71	0.61	0.63	0.67	0.54	0.81	1		
	3	Žilina, Veľká Okružná	0.72	0.74	0.71	0.66	0.62	0.80	0.63	0.63	0.18	0.59	0.66	0.71	0.61	0.66	0.67	0.66	0.72	0.59	0.78	0.81	0.75	0.53	0.72	1	
	4	Žilina, Obežná	0.70	0.71	0.75	0.71	0.66	0.84	0.67	0.69	0.26	0.69	0.73	0.74	0.70	0.70	0.72	0.67	0.77	0.68	0.75	0.81	0.71	0.66	0.81	0.86	1

Figure 2. Monthly course of PM_{10} concentration in Slovakia (2003-2005 average)

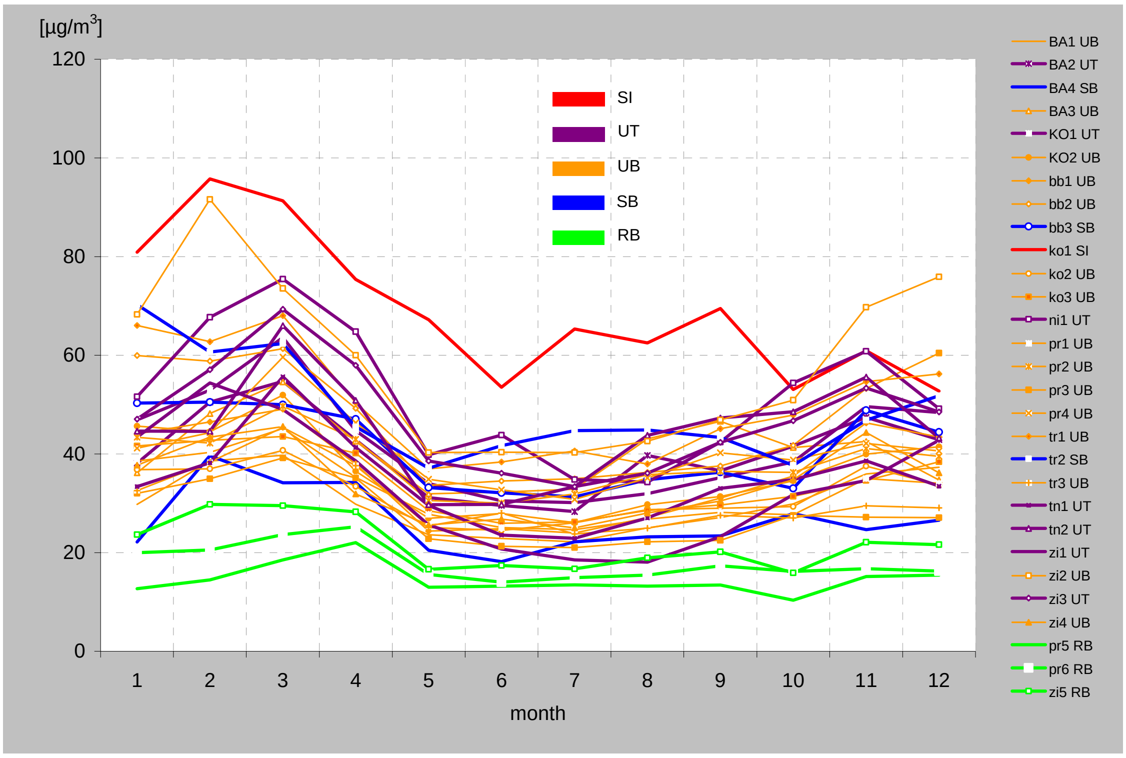
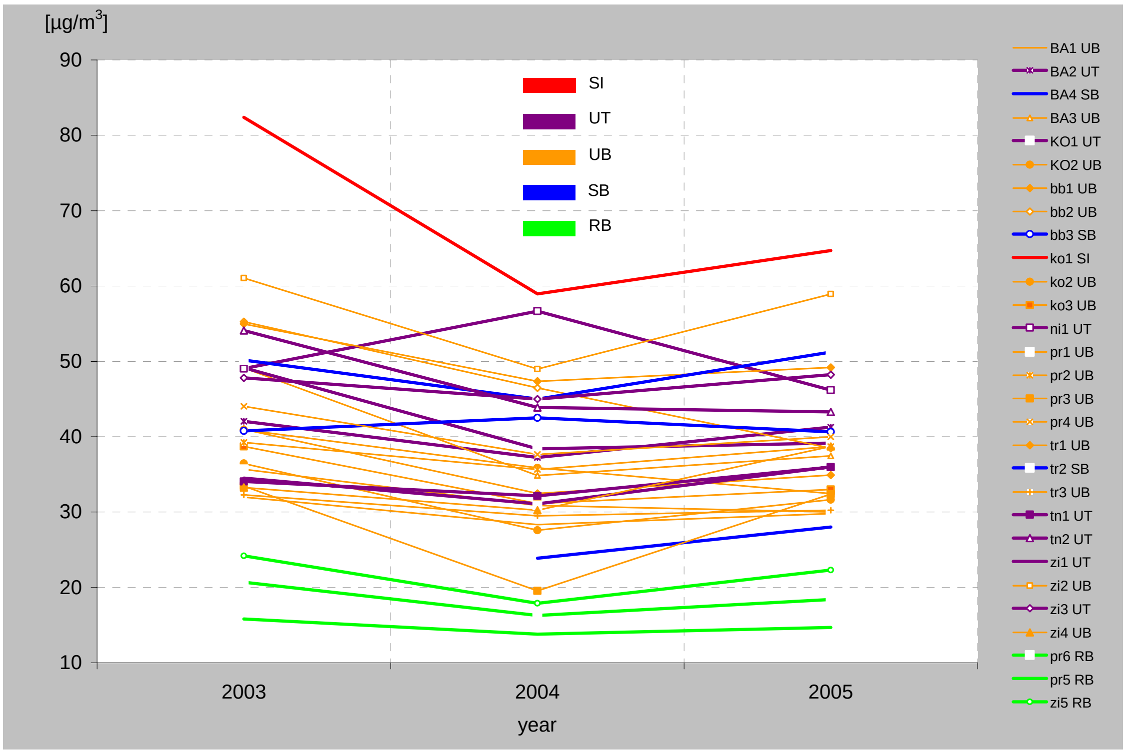


Figure 3. Yearly course of PM_{10} concentration at the Slovak monitoring stations



MODELLING ACTIVITIES

High statistical relationships of PM_{10} concentration among stations enabled to implement 3D interpolation anisotropic model IDWA (Szabó 2004, 2005). An interpolation scheme was proposed, based on an inverse weighting distance between monitoring stations and grid points. The distance used in the interpolation routine is anisotropically re-scaled. The anisotropy ratio respects local conditions. It is determined by a wind rose representative for each grid point. The interpolation scheme contains an empirical altitude dependent function of concentration derived from real rural background measurements (EMEP). Results for the year 2005 are presented in Figures 4 and 5.

Figure 4. Annual average concentration of PM_{10} [µg.m^{-3}] – Slovakia, 2005

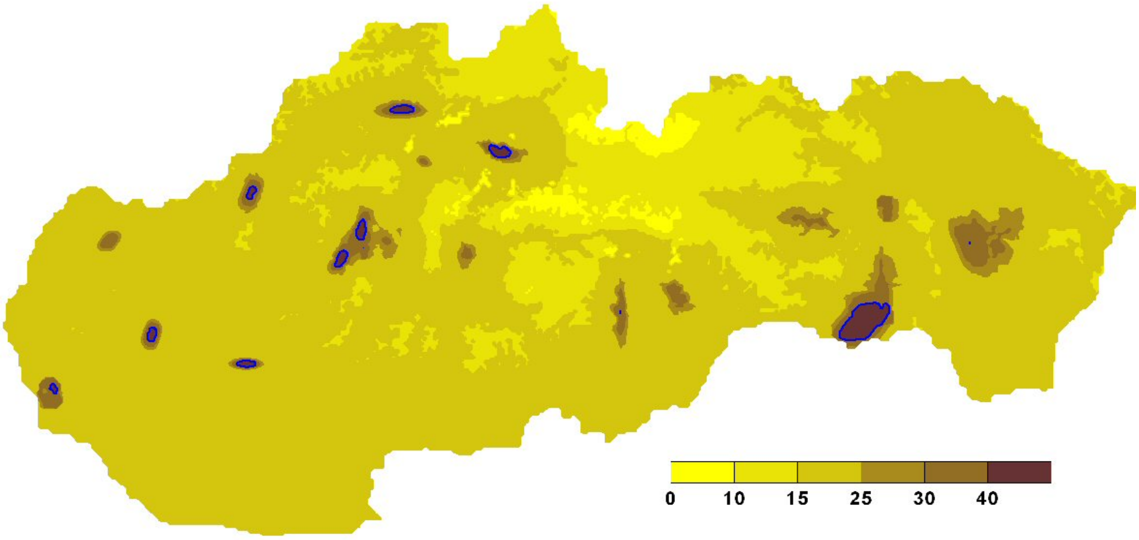
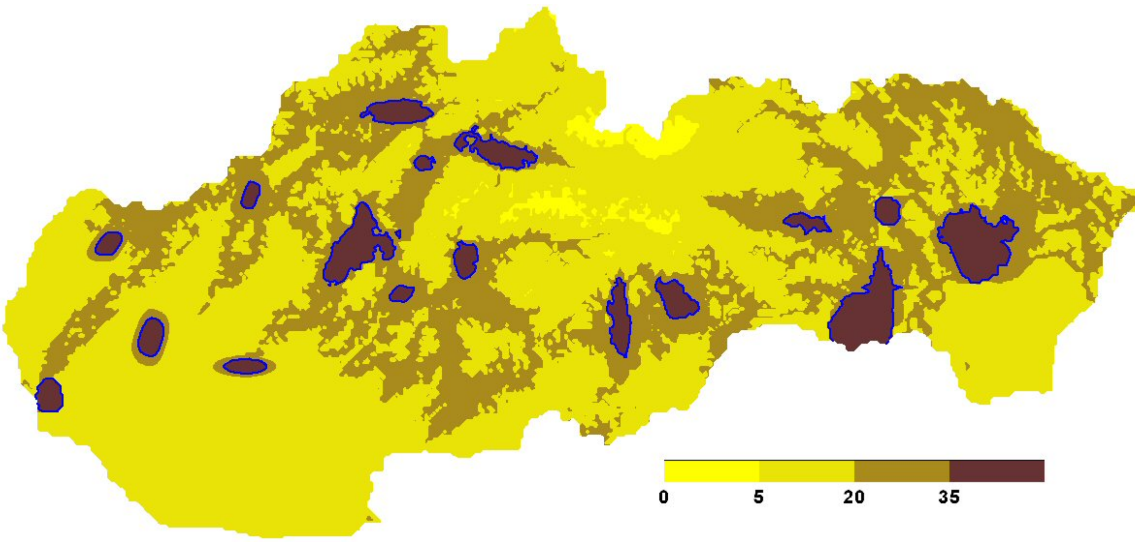


Figure 5. Exceedance (in days) of 24-h concentration of PM_{10} (50 µg.m^{-3}) - Slovakia, 2005



Within the framework of the Holland-Slovak bilateral project "Improving of some pollutant monitoring within the Slovak Republic territory" (PPA03/SK/SK/7/7) the Dutch model LOTOS-EUROS was applied. For the years 1999 and 2003 two model runs were carried out (Szabó, 2006). In both cases two alternatives were taken into account: with and without inclusion of the all Slovak registered emission sources. Sequential 1-hour concentrations of all basic pollutants, including PM_{10}, were computed. The LOTOS outputs are box averages (grid-distance about 30 km), which better reflect the regional background level. Because the fugitive emissions such as wind blown dust and particle water were not taken into account the LOTOS data generally underestimated the monitored data. The year 1999 was close to climatological normal than extremely warm and dry year 2003, when the highest averages were recorded. For 2003 a little higher concentration level was estimated as for 1999 contrary to the national PM emission decrease about 30 % in the period 1999-2003. These facts document the importance of transboundary transport and highlight that PM_{10} problem overcrosses the European scale. The importance role of meteorological factors at PM_{10} pollution indicates also the yearly course of particular matter. There is clear decrease of annual concentrations at almost all stations (28) in 2004, the only exception is traffic station Nitra-Štefánikova, due to of influence new local sources. The share of registered national emissions on the formation of rural background PM_{10} level in Slovakia was estimated less than 20 % on average and share of the transboundary part over 60 % (Szabo, 2006; Ytrri and Aas, 2006).

PM COMPOSITION

There is only little information concerning PM composition in Slovakia. Sulphates and nitrates are regularly monitored at EMEP stations. The share of sulphates in PM at Slovak background stations ranges between 15-25 % and of nitrate 6-11 %, depending on location and year (Table 2). Together with ammonium (the analysis of NH_4 in PM_{10} started in July 2005 on EMEP station SK04) the total contribution in the Slovak PM rural background is over 30 %. Heavy metals in PM_{10} are regularly measured at 26 urban/rural locations, but total HM mass contributions to PM_{10} is below 0.5 %. EC/OC in PM_{10} was measured at EMEP station SK04 during one year campaign 2002/2003 organised by NILU, CNR and National University of Ireland (Yttri et al., 2006). Annual concentration of EC 0.80 $\mu g.m^{-3}$ and OC 4.32 $\mu g.m^{-3}$ was reported for this station. The higher OC concentration observed during summer compared to winter at SK04 site was attributed to the influence of biogenic sources and forest fires (Yttri et al., 2006). Total carbonaceous material in SK04 station accounted for 36 % of PM_{10}. Data from urban area are still missing. Contribution of mineral dust in Slovakia is assumed to be high, especially in lowlands due to agriculture activities, some industrial activities, construction works, etc. Re-suspension and winter sanding may play significant role along roads, mainly in urban areas. However, all fugitive emissions as well as natural emissions have not been assessed in Slovakia until now. Episodes of Saharan dust or dust from other arid regions are sporadically observed, but generally such contribution supposed to be small in Slovakia. The contribution of marine aerosol for Central Europe was estimated about 1 $\mu g.m^{-3}$.

Table 2. Sulphate and nitrate concentrations in PM at some Slovak EMEP stations

EMEP station		SO_4 [$\mu g.m^{-3}$]			NO_3 [$\mu g.m^{-3}$]			SO_4/PM_{10} [%]			NO_3/PM_{10} [%]		
		2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005
Starina	SK06	3.24	3.27	3.27	1.20	1.51	1.59	15.6	20.1	17.8	5.8	9.3	8.6
Stará Lesna	SK04	2.76	3.51	2.55	1.15	1.06	1.15	17.5	25.4	17.3	7.2	7.7	7.8
Liesek	SK05	3.51	3.00	3.42	2.13	2.04	2.39	14.5	16.8	15.3	8.8	11.4	10.7

CONCLUSIONS

1. Slovakia is a small country in Central Europe. The total national anthropogenic (registered) PM emission decreased from 290 kt in 1990 to 51 kt in 2004. Further reduction of this emission is limited. Transboundary transport of PM (of anthropogenic and natural origin) and "non-controlable" national sources of particles play decisive role. Urban background is largely affected by traffic emission (diesel engines), resuspension, construction works and winter sanding. Consumption of coal in Slovakia is relatively very low. Unfortunately supportive scientific studies in Slovakia are still missing.
2. PM concentrations are increasing with increasing aridity, in Europe generally from the West to the East. Therefore some geographical factors should be introduced.
3. PM is typically transboundary problem given by lifetime of particles. Data among all Slovak PM_{10} stations correlate very well. Exceedances of daily limit values can be episodically observed direct on national border, e.g. in winter persistent anticyclones.
4. Knowledge on PM components and their origin in Slovakia is very poor.
5. The share of PM natural sources (primary and secondary) and area fugitive sources including wind blown dust, wild fires and biomass burning in Slovakia has not been estimated yet.
6. Contribution of rural background PM_{10} to urban background level is about 60 % with exception of some industrial and traffic stations.
7. Model computations based only on national primary PM emission inventory data underestimate very significantly the observed concentrations.
8. Further improvement of QA/QC process of PM monitoring and assessment, introduction of regular analysis of PM composition and improvement of modelling tools are needed in Slovakia.
9. The EU and in particular updated WHO guidelines introduced PM_{10} limit values and proposed $PM_{2.5}$ limit values are very strict for Slovakia. To meet these limits in inland Central and Eastern European countries is unreal (transboundary transport, natural sources, etc.). Therefore, the possibilities of national PM mitigation policy in Slovakia are very limited.

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