AIR POLLUTION IN THE SLOVAK REPUBLIC 2023

ANNEX

AIR QUALITY ASSESSMENT IN ZONE PREŠOV REGION

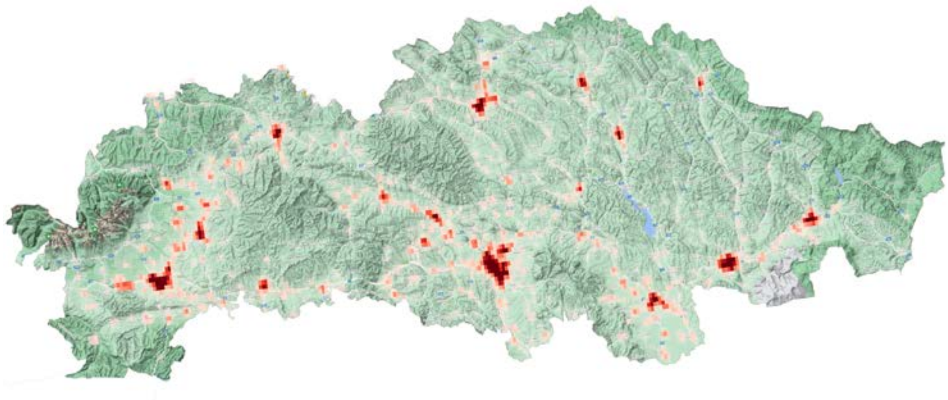
Emissions and Air Quality Division
SLOVAK HYDROMETEOROLOGICAL INSTITUTE

Bratislava, September 2024
Version 1

1 DESCRIPTION OF PREŠOV REGION TERRITORY IN TERMS OF AIR QUALITY

The Prešov region is characterised by mountainous relief, with the highest point Gerlachovský štít (2 655 m a. s. l.) and the lowest point at an altitude of 109 m. This area is built up (dominantly) by the outer Carpathians (Spišská Magura, Podtatranská brázda, Spišsko-šarišské medzihorie, Levočské vrchy, Bachureň, Šarišská vrchovina, Pieniny, Ľubovnianska vrchovina, Čergov, Busov, Ondavská and Laborecká vrchovina, Beskydské predhorie and Bukovské vrchy). The High Tatras, our most important mountain range, belong to the Inner Carpathians. **Fig. 1.1** shows the spatial distribution of population density in the zone. The whole Prešov region is one zone in terms of air quality assessment for SO_2, NO_2, NO_X, PM_{10}, $PM_{2.5}$, benzene, polycyclic aromatic hydrocarbons, and CO in the air.

Fig. 1.1 *Distribution of population density in the zone Prešov region (Source: EUROSTAT, 2018).*



Air pollution sources in the zone Prešov region

The dominant source of air pollution in the zone Prešov region is household heating, especially in smaller villages in the mountainous part of the territory, where the share of firewood use is the highest compared to other areas of the region.

Another source of emissions is road traffic. The busiest parts of roads in the Prešov region are as follows (we report the average number of vehicles per 24 hours according to the National Traffic Census 2022 and 2023[1]):

- **D1 motorway** in the south of the region and connecting the towns of Poprad, Levoča, Prešov, and Košice with a maximum traffic in the Prešov district: 26 620 vehicles (5 838 trucks/buses (hereinafter referred to as T/B) and 20 721 cars (hereafter referred to as C).

Prešov

- **road No. 18**: in the northern part of the city leading from west to east 39 823 vehicles (4 499 T/B, 35 113 C), in front of the city from the north-west 25 513 vehicles (3 310 T/B, 22 097 C) and just behind Prešov on northeast 25 101 vehicles (5 150 T/B, 19 849 C);
- next section of the **road No. 18** from Prešov to the southeast to Vranov nad Topľou and Strážske: before Vranov 12 422 vehicles (1 435 T/B, 10 949 C), between Vranov and Strážske: 9 539 vehicles (1 566 T/B, 7 952 C);
- eastern bypass of Prešov, **road No. 20**: 30 199 vehicles (4 095 T/B, 26 011 C);
- **road No. 68** in the southern part of Prešov: 27 246 vehicles (5 906 T/B, 21 272 C) and from Prešov north-westwards to Sabinov in the direction of Stará Ľubovňa: near Prešov 17 248 vehicles (2 762 T/B, 14 416 C), in Sabinov 15 423 vehicles (1 842 T/B, 13 521 C);
- the southwestern bypass of Prešov, **road No. 68**: 13 298 vehicles (2 939 T/B, 10 331 C);
- **D1 motorway section** from Prešov in the southward direction to Košice: 26 620 vehicles (5 838 T/B, 20 721 C).

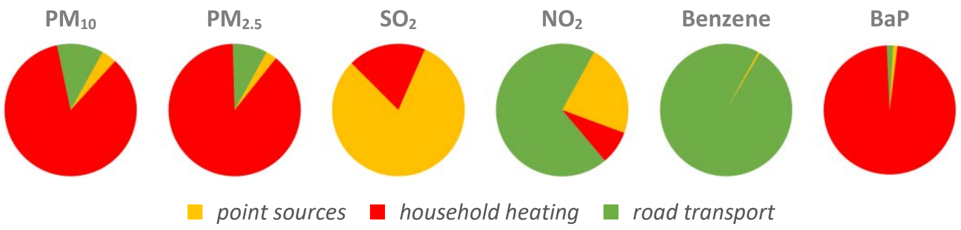
[1] *https://www.ssc.sk/sk/cinnosti/rozvoj-cestnej-siete/dopravne-inzinierstvo/celostatne-scitanie-dopravy-v-roku-2022-a-2023.ssc*

Poprad
- **road No. 66** from Poprad northeast to Kežmarok with the maximum in Poprad: 23 205 vehicles (1 540 T/B, 21 576 C).

The northern part of the region
- in Staráj Ľubovňa **road No. 68** in the northern part of the town: 17 342 vehicles (2 289 T/B, 14 998 C);
- in Bardejov **road No. 77** through the eastern part of the town: 20 716 (2 497 T/B, 18 144 C);
- in Prešov to the north relative to Bardejov **road No. 545**, to the south relative to Bardejov: 14 217 vehicles (1 721 T/B, 12 449 C);
- **road No. 21** from Prešov (after connecting with **road No. 18**) to the northeast to Svidník – a maximum in front of Giraltovce: 11 352 vehicles (2 774 T/B, 8 520 C);
- **road No. 15** Svidník - Stropkov with the maximum in Stropkov: 11 175 vehicles (1 294 T/B, 9 814 C).

The eastern part of the region
- **road No. 18** in Vranov nad Topľou: 20 930 vehicles (2 642 T/B, 18 218 C);
- **road No. 74** from Strážske to the east to Humenné and Snina: 9 371 vehicles (1 512 T/B, 7 828 C);
- **road No. 74** in Humenné: 20 197 vehicles (1 845 T/B, 18 297 C);
- in Humenné **road No. 559** (continuation of **road No. 74A**) going from west to east: 18 159 vehicles (1 545 T/B, 16 547 C);
- in Snina **road No. 74**: 10,630 vehicles (974 T/B, 9,601 CA).

Fig. 1.2 *Share of different types of air pollution sources in total emissions in the Prešov region.*

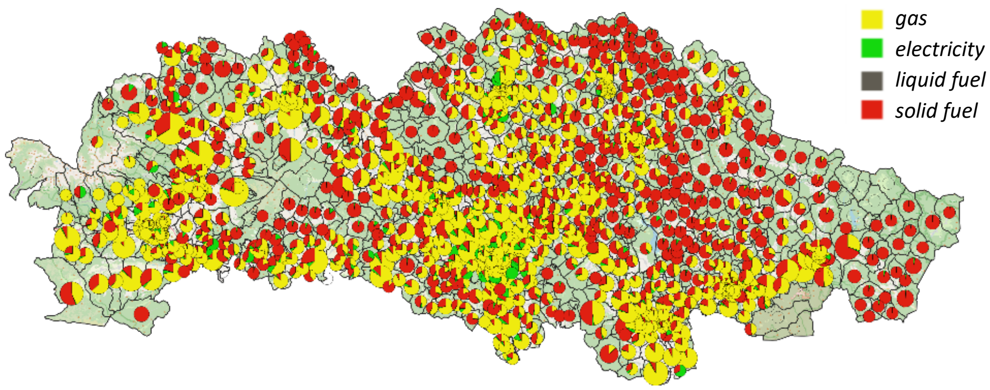


Note: Medium and large air pollution sources registered in the NEIS database are identified for this purpose as "point sources".

Industrial sources of air pollution in the zone Prešov region are less significant in terms of their contribution to the local air pollution by basic pollutants. Depending on meteorological conditions, the contribution of the wood processing industry and heating plants emissions may become significant.

Fig. 1.3 shows the geographic distribution of the heating fuels used in municipalities of the Prešov region. The net proportion of the fuel types shows dominant use of gas for this zone (Population and Housing Census 2021 data), as well as spatial inhomogeneity of the fuels use proportions. Solid heating fuel, particularly wood, is dominantly used in the east and northeast parts of the region (the Upper Zemplín region). The highest proportion of the use of solid heating fuel was determined for the districts of Medzilaborce and Snina, as well as in the regions of Šariš, Spiš and in small municipalities of the central and south-western part of the zone.

Fig. 1.3 *Share of different types of fuel used for heating in the municipalities of the region* [2].



[2] *https://www.scitanie.sk*

2 AIR QUALITY MONITORINGS STATIONS IN ZONE PREŠOV REGION

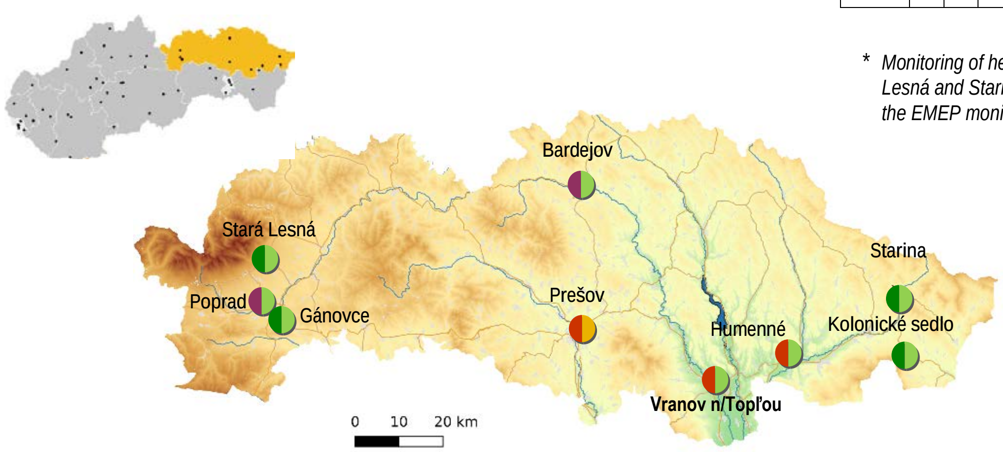
Nine air-quality monitoring stations in the Prešov region comprise four rural background stations (Stará Lesná, Gánovce, Starina and Kolonické sedlo), one traffic station (Prešov, Arm. gen. L. Svobodu, monitored since 2009), and four stations representing the urban and suburban background air quality (Humenné, Poprad, Vranov nad Topľou and Bardejov). Local rural stations also capture a vertical profile of air quality characteristics, due to a large vertical span in the altitudes of the respective monitoring stations. The monitoring stations in Stará Lesná and Starina follow the EMEP monitoring programme (*https://www.emep.int/*). The station at Kolonické sedlo is located near the Astronomical Observatory at an altitude of 454 m above sea level, in the eastern part of the Snina district. It characterises the air quality in a less polluted area.

Tab. 2.1 contains information on air quality monitoring stations in the zone Prešov region:

- international EoI code, characteristics of the station according to the dominant sources of air pollution (traffic, background, industrial), type of area monitored by the station (urban, suburban, rural/regional), and geographical coordinates;
- monitoring programme. Hourly average concentrations of PM_{10}, $PM_{2.5}$, nitrogen oxides, sulphur dioxide, ozone, carbon monoxide, benzene, and mercury are monitored using instruments for continuous monitoring. The SHMÚ laboratory analyses heavy metals and polycyclic aromatic hydrocarbons as part of manual monitoring. The results represent 24-hour average values.

Tab. 2.1 *Air quality monitoring programme in the zone Prešov region.*

Zone Prešov region								Monitoring programme									
								Continuously								Manually	
District	EoI code	Station	Type of		Geographical		Altitude [m]	PM_{10}	$PM_{2.5}$	NO, NO_2	SO_2	O_3	CO	Benzene	Hg	As, Cd, Ni, Pb	BaP
			area	station	longitude	latitude											
Humenné	SK0037A	Humenné, Nám. Slobody	U	B	21°54'50"	48°55'51"	149										
Kežmarok	SK0004R	Stará Lesná, AÚ SAV, EMEP	R	B	20°17'22"	49°09'05"	808									*	
Poprad	SK0041A	Gánovce, Meteo. st.	R	B	20°19'22"	49°02'05"	706										
Poprad	SK0069A	Poprad, Železničná	S	B	20°17'09"	49°03'42"	678										
Prešov	SK0266A	Prešov, Arm. gen. L. Svobodu	U	T	21°16'00"	48°59'33"	252										
Snina	SK0006R	Starina, Vodná nádrž, EMEP	R	B	22°15'36"	49°02'34"	345									*	
Snina	SK0406A	Kolonické sedlo, Hvezdáreň	R	B	22°16'26"	48°56'06"	454										
Vranov n/Topľou	SK0031A	Vranov n/Topľou, M. R. Štefánika	U	B	21°41'15"	48°53'11"	133										
Bardejov	SK0074A	Bardejov, pod Vinbargom	S	B	21°16'38"	48°18'00"	263										
							Total	7	7	7	1	5	1	1	1	2	2



* *Monitoring of heavy metals at the stations Stará Lesná and Starina is carried out according to the EMEP monitoring programme (Tab. 2.2)*

Type of area:
U – urban
S – suburban
R – rural (regional)

Type of station:
T – traffic
B – background
I – industrial

The monitoring stations Stará Lesná and Starina characterise the regional background level of pollution. They are included in the EMEP[3] monitoring programme which, in addition to extended air pollution monitoring, also covers the analysis of atmospheric precipitation.

The air quality monitoring programme at EMEP stations in 2023 is shown in **Tab. 2.2**. Heavy metals are analysed from weekly samples (sampling duration 7 days), other pollutants are analysed from 24-hour samples.

Tab. 2.2 *Monitoring programme at EMEP stations Starina and Stará Lesná.*

	Ozone (O_3)	Sulphur dioxide (SO_2)	Nitrogen oxides (NO_X)	Sulphates (SO_4^{2-})	Nitrates (NO_3^-)	Nitric acid (HNO_3)	Chlorides (Cl)	Ammonia, Ammonium ions (NH_3, NH_4^+)	Alkaline ions (K^+, Na^+, Ca^{2+}, Mg^{2+})	VOC	PM_{10}	EC/OC	Lead (Pb)	Arsenic (As)	Cadmium (Cd)	Nickel (Ni)	Chromium (Cr)	Copper (Cu)	Zinc (Zn)
Starina	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
Stará Lesná	x										x	x	x	x	x	x	x	x	x

Precipitation quality (pH, conductivity, sulphate, nitrate, chloride, ammonium and alkaline ions) is analysed from samples collected at EMEP stations according to the monitoring programme listed in **Tab. 2.3** on either a daily (Starina) or weekly (Stará Lesná) basis. The analyses result in average weekly or monthly values depending on the sampling interval.

The sampling interval for heavy metal analysis is a calendar week at the Starina monitoring station and a calendar month at Stará Lesná. A "wet-only" type rain gauge is used to collect precipitation at Stará Lesná and Starina, which captures only precipitation (it is closed during periods when precipitation does not occur). Wet deposition is assessed on the basis of analyses of the samples thus collected.

Tab. 2.3 *Precipitation measurement programme at EMEP stations Starina and Stará Lesná.*

	pH	Conductivity	Sulphates (SO_4^{2-})	Nitrates (NO_3^-)	Chlorides (Cl^-)	Ammonium ions (NH_4^+)	Alkali ions (K^+, Na^+, Ca^{2+}, Mg^{2+})	Lead (Pb)	Arzenic (As)	Cadmium (Cd)	Nickel (Ni)	Chromium (Cr)	Copper (Cu)	Zinc (Zn)
Starina	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Stará Lesná	x	x	x	x	x	x	x	x	x	x	x	x	x	x

[3] *https://www.emep.int/*

3 ASSESSMENT OF AIR QUALITY IN ZONE PREŠOV REGION

This chapter contains an assessment of air quality in the zone Prešov region based on monitoring, supplemented by mathematical modelling results for PM_{10}, $PM_{2.5}$ and benzo(a)pyrene for the year 2023.

Tab. 3.1 *Assessment of air pollution according to limit values for protection of human health and smog warning system for PM_{10} in the zone Prešov region – 2023.*

	Protection of human health									IT[2]	AT[2]
Pollutant	SO_2		NO_2		PM_{10}		$PM_{2.5}$	CO	Benzene	PM_{10}	PM_{10}
Averaging period	1 h	24 h	1 h	1 year	24 h	1 year	1 year	8 h[1]	1 year	12 h	12 h
Parameter	number of exceedances	number of exceedances	number of exceedances	average	number of exceedances	average	average	average	average	duration of exceedance [h]	duration of exceedance [h]
Limit value [µg·m⁻³]	350	125	200	40	50	40	20	10 000	5	100	150
Maximum number of exceedances	24	3	18		35						
Gánovce, Meteo. st.			0	7							
Humenné, Nám. slobody			0	8	4	19	17			2	0
Prešov, Arm. gen. L. Svobodu			0	34	10	23	16	1 337	0.55	20	0
Vranov n/T, M. R. Štefánika	0	0			4	18	13			10	0
Stará Lesná, AÚ SAV, EMEP			0	4	0	11	8			0	0
Starina, Vodná nádrž, EMEP			0	3							
Kolonické sedlo, Hvezdáreň					0	14	10			0	0
Poprad, Železnicná			0	14	1	16	12			0	0
Bardejov, Pod Vinbargom			0	10	4	17	13			0	0

≥ 90 % of valid measurements

[1] eight-hour maximum concentration

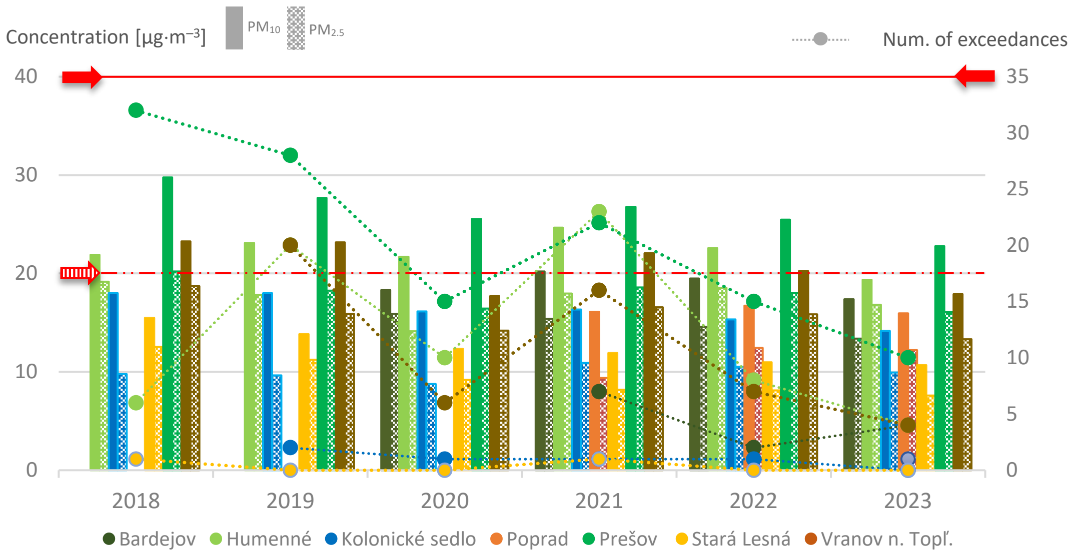
[2] IT, AT – duration of exceedance (in hours) of the information threshold (IT) and alert threshold (AT) for PM_{10}

In accordance with the Decree of the Ministry of Environment of the Slovak Republic No. 250/2023 Coll. on air quality, the required proportion of valid values was observed at the monitoring stations.

3.1 PM10 and PM2.5

Fig. 3.1 shows the average annual concentrations of PM_{10}, $PM_{2.5}$ and the number of days with average daily PM_{10} concentrations above 50 µg·m^{-3} according to the results of measurements at monitoring stations in the Prešov region in 2018 – 2023.

Fig. 3.1 *Average annual concentrations of PM_{10}, $PM_{2.5}$ and the number of exceedances of the daily limit value for PM_{10}.*



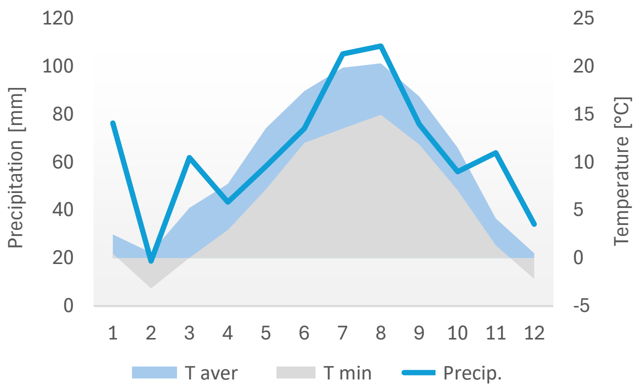
The arrows show the limit values, ***red striped*** *$PM_{2.5}$ (average annual concentration: 20 µg·m^{-3});* ***red on the left*** *PM_{10} (average annual concentration: 40 µg·m^{-3}) and* ***red on the right*** *the number of exceedances (average daily PM_{10} concentration of 50 µg·m^{-3} must not be exceeded more than 35 times in a calendar year).*

The mean annual concentration of PM_{10} did not exceed the limit of 40 µg·m^{-3} at any station in the Prešov region. The daily average concentration limit (50 µg·m^{-3}) was below the annual limit of 35 exceedances at all monitored sites (**Fig. 3.1**). Although the traffic station in Prešov recorded the highest mean annual PM_{10} concentrations (23 µg·m^{-3}) with 10 exceedances of the daily concentration limit, in the long-term observations we identify an improving (decreasing) trend (in 2022: annual average concentration 25 µg·m^{-3} and 15 daily PM_{10} limit exceedances; in 2021: 27 µg·m^{-3} and 22 exceedances). Among the urban and suburban background stations, the highest annual average concentration (19 µg·m^{-3} and 4 exceedances, showing the year-on-year decrease of 4 µg·m^{-3}) was recorded at AMS Humenné. The improving trend was recorded in Humenné (in 2021: annual average concentration 25 µg·m^{-3} and 23 exceedances of the daily limit).

The lowest PM_{10} concentrations were recorded at the rural background station in Stará Lesná, the annual average concentration 11 µg·m^{-3} was here the same as in 2022. This station met both, the new limit set by the EU for PM_{10} (20 µg·m^{-3}), which will enter into force on 1st January 2030, and the WHO recommendation (annual average PM_{10} concentration up to 15 µg·m^{-3}).

Fig. 3.2 presents the monthly precipitation, average and minimum temperature in Prešov. The higher values of PM recorded in the winter months correlate

Fig. 3.2 *Monthly precipitation totals, average and minimum temperatures (data from climatological station in Prešov).*



with the cold season with increased requirements for household heating. The low temperatures were recorded only during several days in February, the situation was however complicated by the long-term occurrence of the high-pressure conditions (anticyclones) accompanied by poor dispersion conditions.

Fig. 3.3 and **Fig. 3.6** present the model of PM_{10} a $PM_{2.5}$ distribution for 2023, calculated using the RIO model adjusted by IDW-R method (details in Chapter 4 of *Air pollution in the Slovak Republic 2023 Report*).

Fig. 3.3 *Average annual PM_{10} concentration (up) and number of exceedances of the PM_{10} daily limit (down) in 2023.*

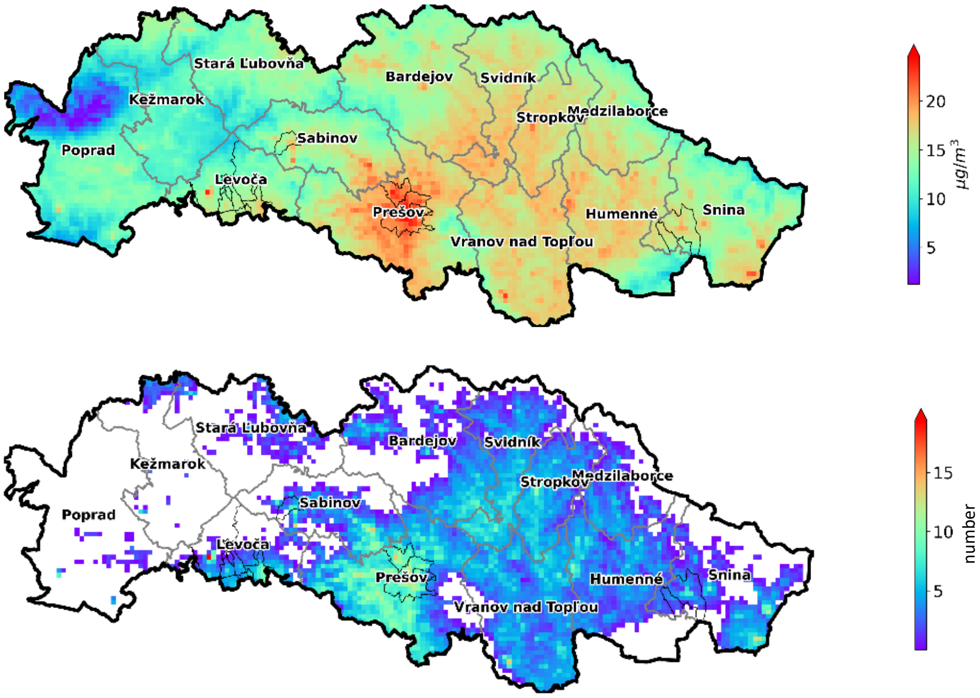
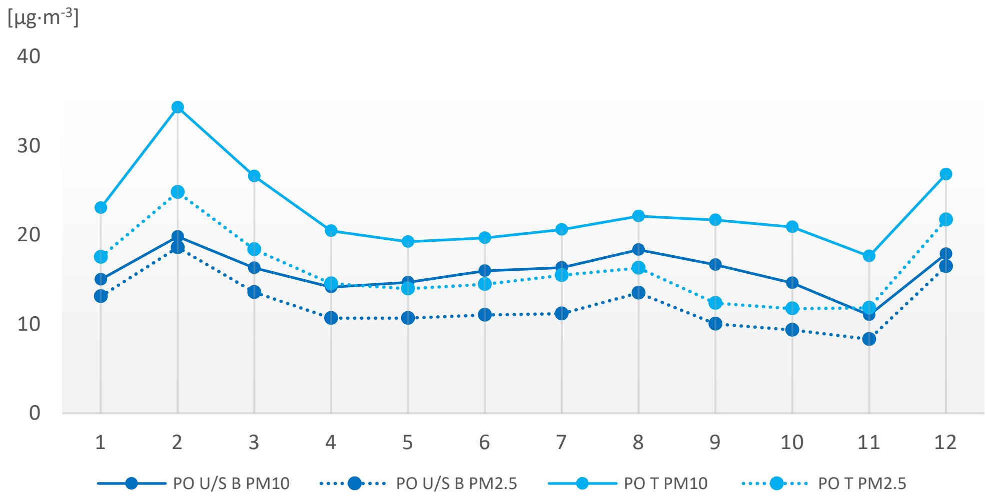


Fig. 3.4 *Average monthly concentrations of PM_{10} and $PM_{2.5}$ in the region by station type.*



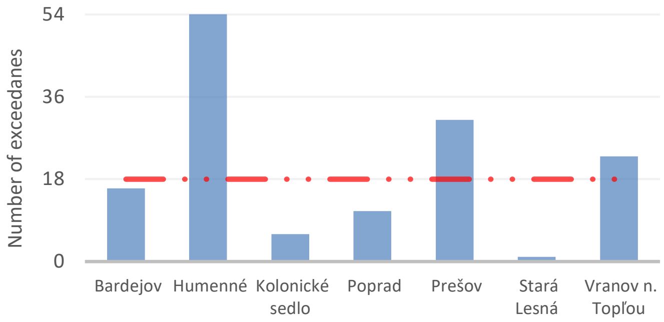
T PM10 *and* ***T PM2.5*** *– average monthly concentration of PM_{10} and $PM_{2.5}$ at the traffic station Prešov;*
U/S B PM10 *and* ***U/S B PM2.5*** *– average monthly concentrations of PM_{10} and $PM_{2.5}$ at urban/suburban background stations Humenné, Vranov n/T, Bardejov and Poprad;*

From **Fig. 3.4** it is evident that during the warm months of the year (except for August), the concentrations of PM_{10} at regional stations (Starina, Stará Lesná, and Kolonické sedlo) and urban background area are very similar, and differences begin to increase in colder months. This is likely because household heating with solid fuels (insufficiently dried wood, possibly in combination with various types of waste materials) in older heating devices is probably responsible for air pollution with PM_{10} particles.

Compared to PM_{10}, fine particles $PM_{2.5}$ have a significantly more negative impact on human health. In **Fig. 3.1**, the average annual concentrations of fine particles are depicted with a dashed line. High values of $PM_{2.5}$ were observed during the cold months of the year, which, like PM_{10}, are probably due to emissions from household heating using solid fuels. The highest average annual concentrations of $PM_{2.5}$ were measured in Humenné (17 $\mu g{\cdot}m^{-3}$ – the year-on-year improvement of 2 $\mu g{\cdot}m^{-3}$) and Prešov (16 $\mu g{\cdot}m^{-3}$ – the year-on-year improvement of 2 $\mu g{\cdot}m^{-3}$). At all stations, including regional background ones, the average annual concentration of $PM_{2.5}$ exceeded the WHO recommendation (5 $\mu g{\cdot}m^{-3}$). Even the average monthly values of fine particulate matter are relatively high, not only in the winter season but also in the summer months when $PM_{2.5}$ concentrations tend to be lowest.

Fig. 3.5 shows $PM_{2.5}$ concentrations against the new EU limit. This limit for the daily mean concentration $PM_{2.5}$ (25 $\mu g{\cdot}m^{-3}$) should not be exceeded more than 18-times per year. Considering the results of 2023, the new EÚ limit was exceeded at the urban background stations in Humenné (55 exceedances) and in Vranov nad Topľou (23 exceedances), and at the traffic station in Prešov (31 exceedances). Interestingly, the number of exceedances in Humenné (urban background station) is almost two-fold higher, than in Prešov (traffic station). The new EU limit was met in 2023 by four stations: Bardejov (suburban background AMS), Poprad (suburban background AMS), Kolonické sedlo (rural background AMS), and Stará Lesná (rural background AMS). The new EU limit for the average annual concentration of $PM_{2.5}$ (10 $\mu g{\cdot}m^{-3}$) was met in 2023 at two stations, Stará Lesná and Kolonické sedlo.

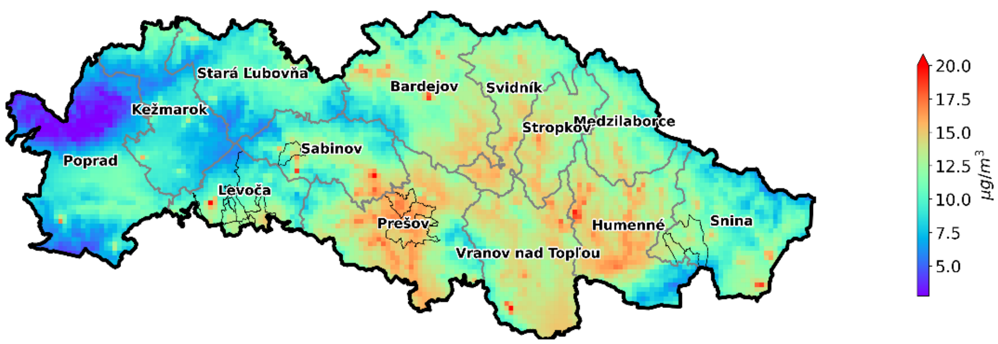
Fig. 3.5 *Number of days with average daily $PM_{2.5}$ concentration > 25 $\mu g{\cdot}m^{-3}$) in 2023 – evaluation in view of the newly introduced EU limit*.*



** According to the new EU limit, which will enter into force on, 1. 1. 2030, daily average concentration of $PM_{2.5}$ should not exceed 25 $\mu g{\cdot}m^{-3}$ more than 18 times per year.*

Fig. 3.6 displays the spatial distribution of the average annual concentration of $PM_{2.5}$ based on the output of the RIO model, IDW-R.

Fig. 3.6 *Average annual $PM_{2.5}$ concentrations.*

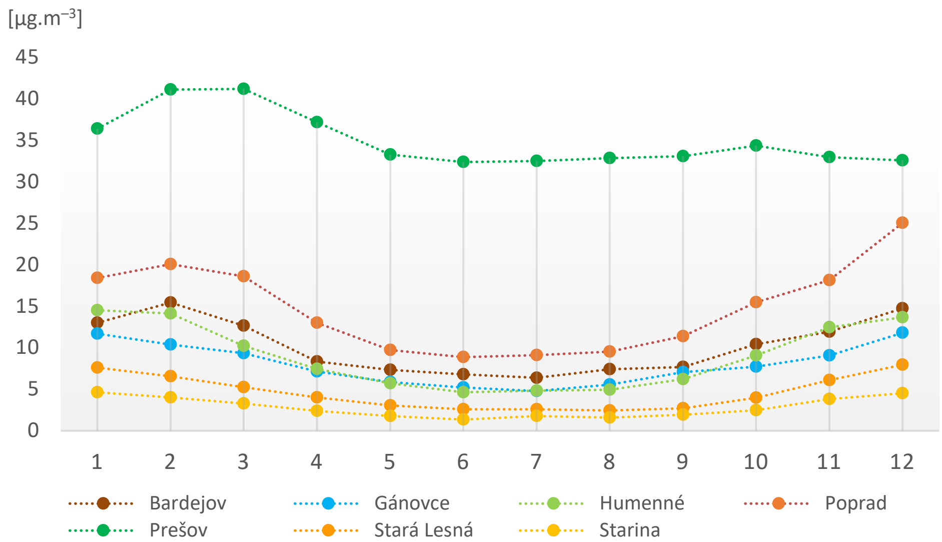


3.2 Nitrogen dioxide

Nitrogen dioxide (NO_2) monitoring is carried out in the zone at seven stations, and the average monthly concentrations for each station are shown in **Fig. 3.7**.

The main source of NO_2 emissions is road traffic, therefore the highest concentrations are recorded at the Prešov, Arm. gen. L. Svobodu traffic station: 32 $\mu g \cdot m^{-3}$ (which represents the year-on-year decrease of 2 $\mu g \cdot m^{-3}$). However, the limit value (40 $\mu g \cdot m^{-3}$) was not exceeded. The measured NO_2 values maintain a relatively constant level throughout the year without seasonal fluctuations (**Fig. 3.7**). The maximum hourly concentration NO_2 at the traffic station in Prešov was 96 $\mu g \cdot m^{-3}$, and at the suburban background station in Poprad 99 $\mu g \cdot m^{-3}$. Overall, air pollution with this pollutant in the Prešov region is relatively low. At five stations, the average NO_2 concentrations in 2023 were lower or equal (higher levels were observed only in Prešov and Poprad) to the WHO recommendation (10 $\mu g \cdot m^{-3}$), two-fold stricter than EU limits (10 $\mu g \cdot m^{-3}$).

Fig. 3.7 *Average monthly NO_2 concentrations in 2023.*



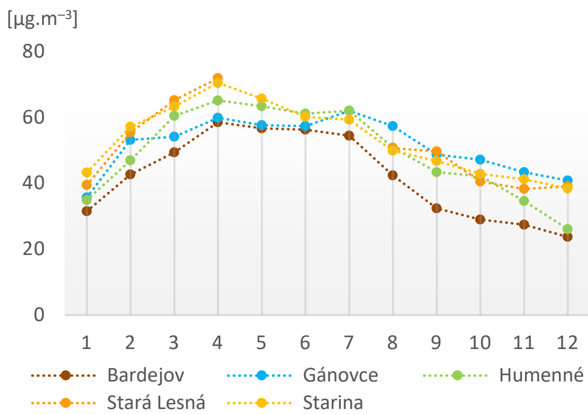
3.3 Ozone

Ozone monitoring in this region is conducted at five monitoring stations, including Stará Lesná and Gánovce in the foothills of the High Tatras, Starina located on the north-eastern border of Slovakia, and two district towns, Bardejov and Humenné.

The highest concentrations of ground-level ozone are typically observed during the warm months with high levels of sunlight (**Fig. 3.8**). O_3 concentrations typically increase with sunrise, peak around midday and gradually decrease in the evening to a minimum that occurs early in the morning. Large differences in ground-level ozone concentrations are also observed between warm and cold seasons.

We did not observe any station exceeding the information or alert threshold in 2023 for ground-level ozone.

Fig. 3.8 *Average monthly O_3 concentrations in 2023.*



3.4 Benzo(a)pyrene

Benzo(a)pyrene is monitored in the Prešov region at two monitoring stations, Starina and Stará Lesná. The target value for benzo(a)pyrene (1 ng·m^{-3}) was not exceeded. However, these are rural background stations and are not directly affected by emissions from household heating by solid fuel, therefore low BaP concentrations can be expected here. (**Tab. 3.2**). Therefore, in this case, the results of mathematical modelling are useful indicators. **Fig. 3.10** shows the spatial distribution of BaP according to the results of the RIO/IDW-R model. Methodology is described in Chapter 4 of the *Air pollution in the Slovak Republic 2023 Report*.

Tab. 3.2 *Average annual concentration of benzo(a)pyrene in 2018–2023.*

	2018	2019	2020	2021	2022	2023
Target value [ng·m^{-3}]	1.0	1.0	1.0	1.0	1.0	1.0
Starina, Vodná nádrž, EMEP	1.2	0.4	0.3	0.4	0.2	0.3
Stará Lesná, EMEP		0.4	0.3	0.4	0.3	0.3

≥ 90 % valid measurements

Fig. 3.9 *Average monthly concentration of benzo(a)pyrene in 2023 at stations Starina and Stará Lesná.*

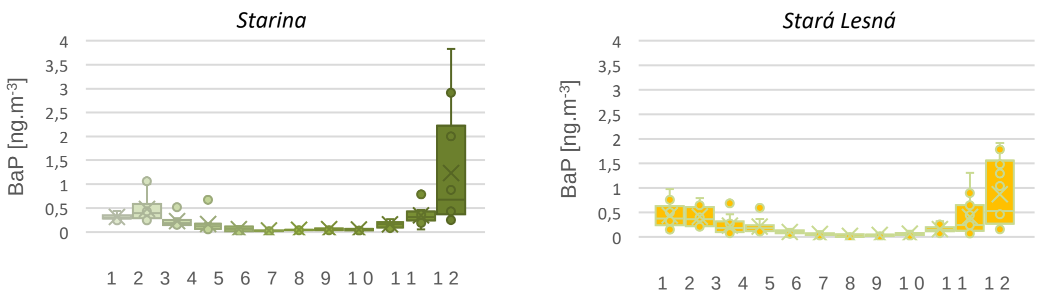
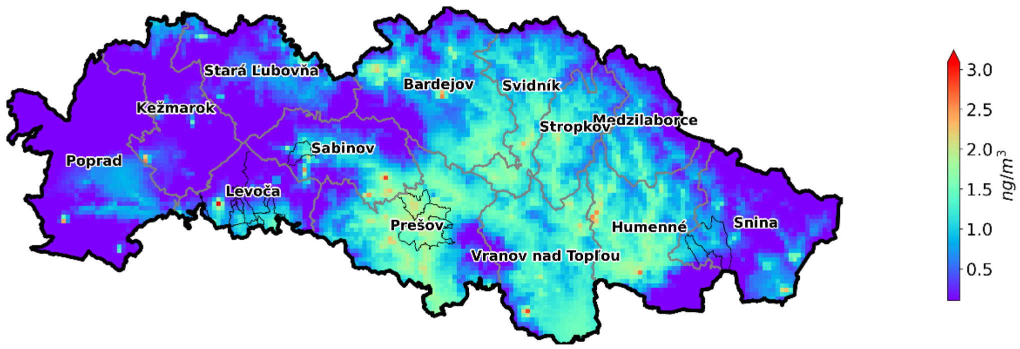


Fig. 3.9 illustrates the monthly average concentrations of benzo(a)pyrene at the rural background stations. Although the target value was not exceeded, the concentrations recorded in the winter period are relatively high, which may be a consequence of the regional traffic, or a local influence. **Fig. 3.10** shows the average annual concentration calculated based on the outputs of the mathematical model. Since the model relies on measured data (and auxiliary fields), the model outputs for the extensive area of the zone Prešov region are subject to considerable uncertainty. Therefore, it is important to focus on relative differences between areas rather than relying on absolute values. According to the model outputs, the highest concentrations are found in the municipalities of the Levoča, Vranov nad Topľou, Prešov, Svidník, Sabinov and Stropkov districts. To obtain a more detailed understanding of the spatial distribution, high-resolution modelling using detailed emission data (i.e., the quantity and type of fuels, types of household heating devices used, etc.) is necessary. The most significant source of benzo(a)pyrene is household heating using solid fuels, especially inadequately dried wood or unsuitable fuels (various types of waste).

Fig. 3.10 *Average annual concentration of benzo(a)pyrene from RIO model output, IDW-R (2023).*



3.5 Chemical composition of precipitation

At the rural background station Starina, the quality of precipitation is monitored on a daily basis. The qualitative composition of basic ions, pH, and conductivity parameters are sampled. The annual average pH value was 5.37, and even monthly averages did not fall below a pH value of 5. Therefore, it can be concluded that there is no excessive acidification of the environment in the zone Prešov region. Detailed monitoring results are provided in Chapter 3.4 of *Air pollution in the Slovak Republic 2023 Report*.

3.6 Risk municipalities

Fig. 3.11 *Risk municipalities in zone Prešov region.*

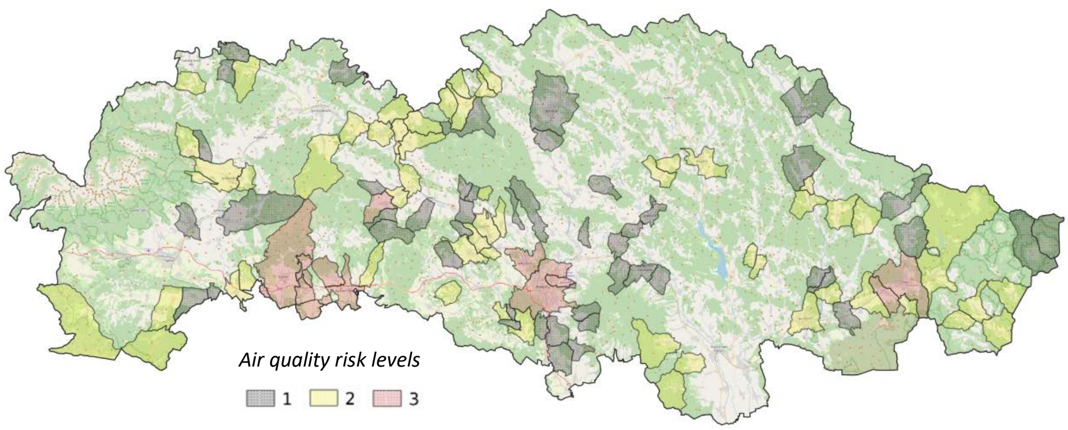


Fig. 3.11 displays municipalities at risk due to deteriorated air quality as determined by the integrated municipal assessment method[4]. Level 3 corresponds to the highest probability of air pollution risk. The methodology involves the level of household heating with solid fuels, the impact of worsened dispersion conditions from both short-term and long-term perspectives, results from the chemical transport model CMAQ, the interpolation model RIO, and high-resolution modelling results using the CALPUFF model in selected domains with an assumed deteriorated air quality.

Municipalities in which the limit value for PM, NO_2, or the target value for BaP was exceeded based on high spatial resolution modelling were automatically assigned a risk level 3, similar to municipalities where the limit or target value exceedance was detected through measurement. The list of municipalities and their risk levels can be found on the SHMÚ website[5].

---

[4] *Štefánik, D., Krajčovičová, J.: Metóda integrovaného posúdenia obcí vzhľadom na riziko nepriaznivej kvality ovzdušia, SHMÚ, 2023, available at https://www.shmu.sk/sk/?page=996*

[5] *https://www.shmu.sk/sk/?page=2768*

Zones and agglomerations that include at least one municipality with a risk level 3 will develop an Air Quality Improvement Program. In this regard, municipalities with a risk level 3 correspond to *air quality management areas*. However, emission reduction measures must be implemented in all municipalities within this designated zone with a risk level 2 or 3, ideally also in municipalities with a risk level 1.

The assessment using the integrated assessment method aims to identify areas where measures to improve air quality are needed. Given the distribution of air pollution sources and considering the microclimatic characteristics of the region, it is likely that pollution levels vary at different locations within the risk area. Spatial distribution of air pollution is provided by high-resolution modelling results, which are gradually updated on the SHMÚ website[6].

3.7 Summary

The results showed year-on-year improvement in mean annual concentration of PM at all monitoring stations in the Prešov region in 2023, except for the stations in Stará Lesná and Poprad, where the concentrations were the same as previous year. The most significant decrease in PM_{10}, $PM_{2.5}$ annual concentrations was recorded in Humenné, Bardejov and Vranov nad Topľou. The most significant decrease in the number of daily limit exceedance (PM_{10}) was recorded in Prešov, an increase was recorded only in Bardejov. The overall trend in the PM concentration in the atmosphere has decreasing character over the past three years. NO_2 concentrations recorded at the station in Prešov are the highest among all monitored sites in Slovakia and display a slightly increasing trend. Other stations within this region recorded relatively low atmospheric NO_2 content over time.

In the zone Prešov region, no exceedances of the limit or target values was observed for any pollutant in the last four assessed years. The highest PM_{10} values were measured in Prešov and Humenné, but in both cases there was a year-on-year improvement in air quality at the monitoring locations. At both sites, a year-on-year decrease of PM_{10} was recorded; however, the duration of an information threshold exceedance was longer, similarly as in Vranov nad Topľou.

Based on the results of mathematical modelling, we can assume that in some areas higher levels of PM and benzo(a)pyrene may occur, especially in the winter months, in locations with a higher proportion of solid fuel used for household heating. This is particularly the case under worsened dispersion conditions.

According to a preliminary assessment of air quality under the new European legislation (which is due to enter into force on 1 January 2030), meeting the new limits for $PM_{2.5}$ would pose a major challenge in the zone Prešov region. To the contrary, the new limits for the annual average of PM_{10} are met at all stations already in 2023, except for AMS Prešov, Arm. gen. L. Svobodu. The annual average concentration limit of $PM_{2.5}$ is met only at rural background stations Stará Lesná, EMEP and Kolonické sedlo. Despite the fact, that the air quality shows an improving trend (except for NO_2 in Prešov), it would be necessary to implement additional measures to meet the new Directive requirements. The air quality indicators in this zone meet the WHO[7] recommended concentrations only in exceptional cases. Annual NO_2 average concentration meets the WHO limits at all stations except for Prešov and Poprad already in 2023. The ambition of the Zero Pollution Action Plan[8] is to reach the air quality according to these recommendations by 2050.

---

[6] *https://www.shmu.sk/sk/?page=2699*

[7] *WHO GLOBAL AIR QUALITY GUIDELINES, 2021. Recommendations on classical air pollutants, str. 4. https://apps.who.int/iris/bitstream/handle/10665/345334/9789240034433-eng.pdf*

[8] *https://www.consilium.europa.eu/en/press/press-releases/2024/02/20/air-quality-council-and-parliament-strike-deal-to-strengthen-standards-in-the-eu/*