AIR POLLUTION IN THE SLOVAK REPUBLIC 2024

ANNEX

AIR QUALITY ASSESSMENT IN ZONE PREŠOV REGION

Emissions and Air Quality Division
SLOVAK HYDROMETEOROLOGICAL INSTITUTE

Bratislava, September 2025
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.

According to the Statistical Office[1] of the Slovak Republic, the average population density in the Prešov Region is 90 inhabitants per km². The region contains areas with the lowest population density in Slovakia. The **highest** population density is in the **Prešov District** with 187 inhabitants per km², while the **Medzilaborce District has the lowest density** in the region with 25 inhabitants per km². For comparison, the Slovak Republic had an average population density of 111 inhabitants per km² on the given date.

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.

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.

Tab. 1.1 *Number of vehicles on the most frequented roads of the Prešov region*

District	Highway/ road	Number of vehicles	Trucks	Passenger cars
Bardejov	č. 21	9 157	993	8 143
Kežmarok	č. 68	13 628	1 623	11 931
Košice	D1	40 805	6 810	33 710
Poprad	D1	27 492	4 533	22 792
	č. 68	16 231	2 330	13 685
Prešov	D1	31 185	5 352	25 585
	č. 18	16 988	1 685	15 231
Prešov	č. 77	11 730	1 392	10 290
St. Ľubovňa	č. 68	12 048	1 289	10 687
Stropkov	č. 77	10 082	1 034	9 043
Svidník	č. 77	11 023	1 247	9 701
Vranov	č. 18	11 561	1 337	10 181

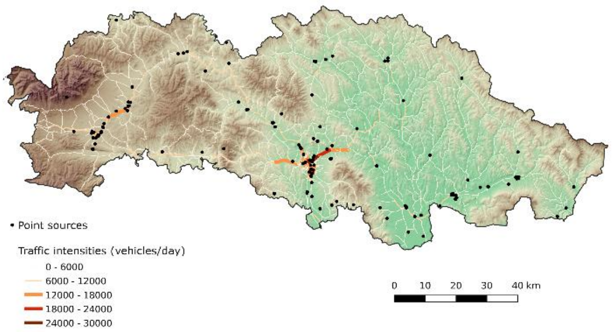


Fig. 1.1 *Road traffic intensity in the Prešov region. Source: CDV*

Another source of emissions is road transport. **Tab. 1.1** contains the traffic intensity on major roads in the region according to the national transport census in 2022 and 2023).

The map in Fig. 1.1 shows the most frequented road sections according to the processing by the Transport Research Center (Centrum dopravního výzkumu, CDV) for the year 2024. The map also includes the locations of point sources[2]

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.

[1] *Available online: ŠÚ SR [cit. 23. 6. 2025],* statdat.statistics.sk

[2] *The term point sources refers to large and medium-sized stationary sources of pollutant emissions, registered in the NEIS database..*

Fig. 1.2 Share of different types of fuel usedfor heating in the municipalities of the region[3].

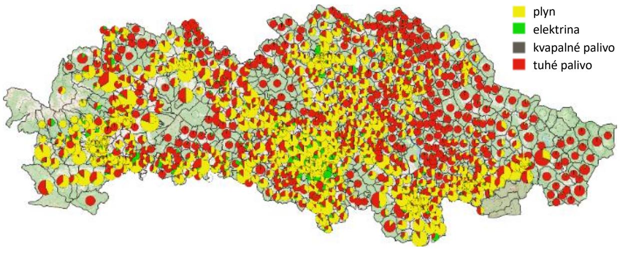


Fig. 1.2 shows the geographic distribution of the heating fuels used in municipalities of the Prešov region. The net proportion of the fuel types shows dominant use of gas for this zone (Population and Housing Census 2021 data), as well as spatial inhomogeneity of the fuels use proportions. Solid heating 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.

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

2 AIR QUALITY MONITORING STATIONS IN ZONE PREŠOV REGION

There are nine air quality monitoring stations in the Prešov Region, of which four stations (**Stará Lesná**, **Gánovce, Starina** and **Kolonické sedlo**) are **rural background** stations. They cover areas distant from the main sources of air pollution and, due to their different altitudes, reflect changes in pollution in the vertical profile. The monitoring stations in Stará Lesná and Starina follow the EMEP monitoring program. The station at Kolonické sedlo is located at the Astronomical Observatory at an altitude of 454 m above sea level, in the eastern part of the Snina district. It characterizes the air quality in a less polluted area. Air quality monitoring here began in 2009. The monitoring station in **Prešov** on Arm. gen. L. Svobodu Street captures the impact of **road transport** in a location with relatively high traffic intensity. The stations in **Humenné, Poprad, Vranov nad Topľou and Bardejov** represent **urban**, respectively. suburban **background pollution**.

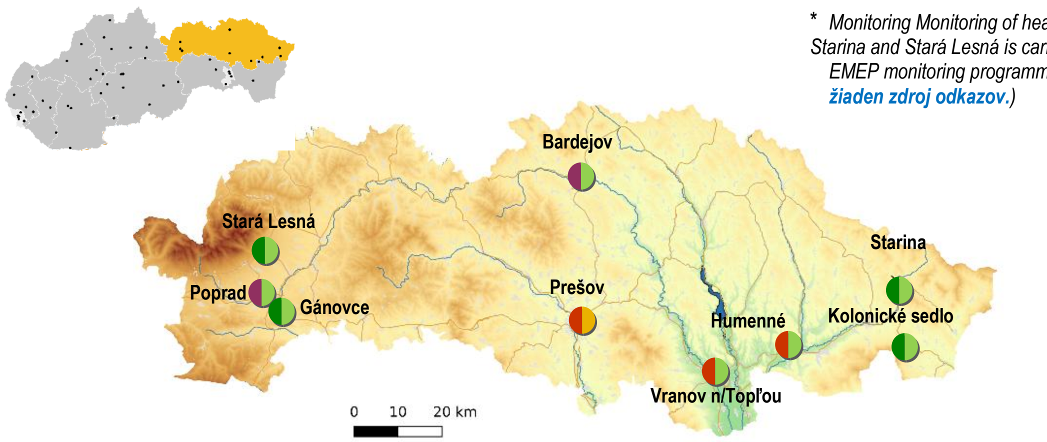
Tab. 2.1 contains information on air quality monitoring stations in the zone Prešov region:

- 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]										
			area	station	longitude	latitude		PM_{10}	$PM_{2,5}$	NO, NO_2	SO_2	O_3	CO	Benzene	Hg	As, Cd, Ni, Pb	BaP
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 Monitoring of heavy metals at the stations Starina and Stará Lesná is carried out according to the EMEP monitoring programme (**Chyba! Nenašiel sa žiaden zdroj odkazov.**)*



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

Typ stanice:
T – traffic
B – background
I – industrial

The monitoring stations Stará Lesná and Starina are included in the EMEP[4] monitoring program. Extended monitoring of heavy metals (**Tab. 2.2**) and sampling of atmospheric precipitation (**Tab. 2.3**) are carried out at the monitoring stations. The air quality monitoring program in Starina and Stará Lesná in 2024 is presented in **Tab. 2.2**.

Tab. 2.2 Monitoring programme of EMEP stanitions Starina and Stará Lesná.

	Sampling interval	SO_2	NO_2	SO_4^{2-}	NO_3^-	HNO_3	Cl^-	NH_3, NH_4^+	Alkaline ións K^+, Na^+, Ca^{2+}, Mg^{2+}	VOC	PM_{10}	EC/ OC	Pb	As	Cd	Ni	Cr	Cu	Zn
Starina	D/W*	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
Stará Lesná	W										x	x	x	x	x	x	x	x	x

Note: D – day is sampling interval for major ions , W- week – other;

A "wet-only" rain gauge is used to collect precipitation, which only captures precipitation - wet

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

	sampling interval / number of days*	pH	Vodivosť	SO_4^{2-}	NO_3^-	Cl^-	NH_4^+	Alkaline ións K^+, Na^+, Ca^{2+}, Mg^{2+}	Pb	As	Cd	Ni	Cr	Cu	Zn
Starina	1/7	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Stará Lesná	7/M	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Note: the first figure applies to the sample for analysis of the main precipitation parameters, the second for heavy metal analyses. M - month

[4] *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 2024.

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 – 2024.*

	Type	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	Area / station	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.	RB			0	6						24	0
Humenné, Nám. slobody	UB			0	8	5	22	17			25	0
Prešov, Arm. gen. L. Svobodu	UT			0	34	15	26	17	1 515	0,6	18	0
Vranov n/T, M. R. Štefánika	UB	0	0			3	20	15			15	0
Stará Lesná, AÚ SAV, EMEP	RB			0	4	3	12	8			26	0
Starina, Vodná nádrž, EMEP	RB			0	3						0	0
Kolonické sedlo, Hvezdáreň	RB					2	15	11			14	0
Poprad, Železničná	SB			0	11	3	17	11			24	4
Bardejov, Pod Vinbargom	SB			0	10	1	18	13			19	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 PM_{10} and $PM_{2,5}$

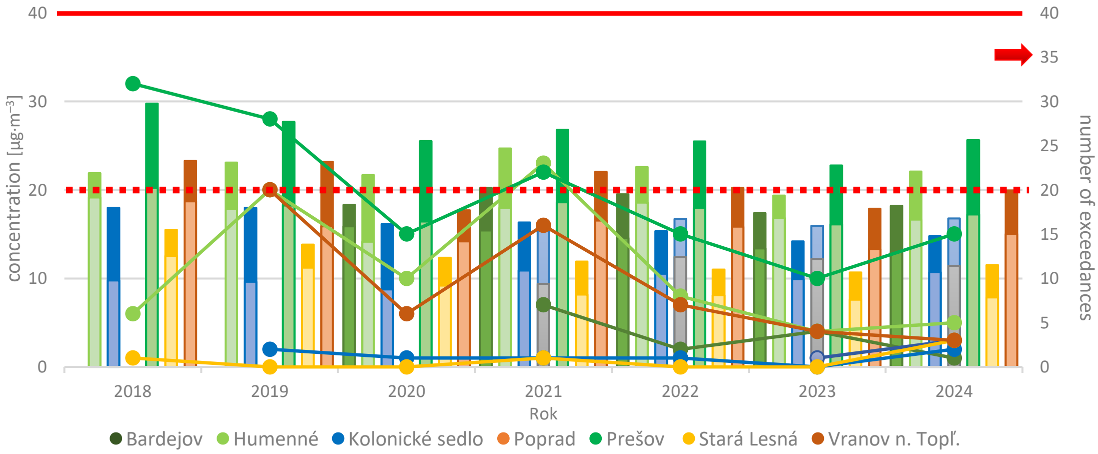
Fig. 1.1 shows the average annual concentrations of PM_{10}, $PM_{2.5}$ and the number of days with average daily PM_{10} concentration above 50 μg·m⁻³ according to the results of measurements at monitoring stations in the Prešov Region zone in the years 2018 – 2024.

The limit value for the average annual concentration of PM_{10}, $PM_{2.5}$, or the limit value for the average daily concentration of PM_{10} **has not been exceeded** at any monitoring station in the zone since 2018. The most days (**Fig. 1.1**) with an average daily concentration of PM_{10} above 50 μg·m⁻³ were recorded at the traffic station in Prešov in 2024, 15 in total and most in February. This station also recorded the highest average annual concentration of PM_{10} in the Prešov Region (26 μg.m⁻³). The average annual concentration of PM2.5 was 17 μg.m⁻³ in both Prešov and Humenné. The values of the average annual concentrations at all stations in the Prešov Region increased by 5-14% compared to 2023, the least in Poprad, the most in Humenné. The main reason is the prolonged adverse dispersion conditions, especially in November 2024, the impact of the desert dust transport episode,

In 2024, adverse dispersion conditions caused increased PM_{10} concentrations, especially in February, March and November. At the turn of March and April, they were further worsened by the transport of Saharan dust, which led to short-term exceedances of the limits at several stations. Compared to the rainy year of 2023, PM_{10} values were higher overall. Less precipitation can be expected in the future and the occurrence of poor dispersion conditions during the heating season is not excluded; meeting the new EU limits will require special measures.

which was manifested by exceptionally high PM_{10} concentrations in the spring. The increased concentrations in 2024 are also related to lower precipitation and worse dispersion conditions than in 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}*

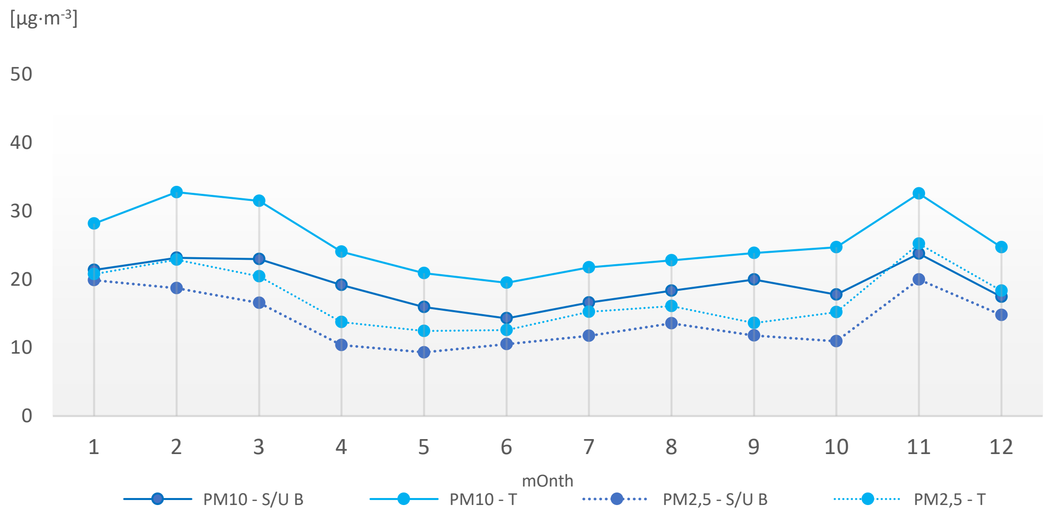


PM_{10} *dark column color,* ***$PM_{2,5}$*** *– light column color;* ***number of exceedances*** *– solid broken lines*
Horizontal lines show limit values (LH), red solid PM10 (average annual concentration: 40 µg·m⁻³);
red striped $PM_{2.5}$ (average annual concentration: 20 µg·m⁻³); red solid arrow – LH number of exceedances
(average daily PM_{10} concentration 50 µg·m⁻³ max. number of exceedances 35/calendar year).

The new EU limit for the average annual concentration of PM_{10} (20 µg.m⁻³) would not be met by the Prešov and Humenné monitoring stations in 2024.

As expected, the PM_{10} and $PM_{2.5}$ concentrations in the zone were lowest at the rural background station in Stará Lesná and, together with the monitoring station at Kolonicke sedlo, would meet not only the new EU limit for the annual average of PM_{10} in 2024, but also the stricter WHO recommendation (annual average of PM_{10} up to 15 µg.m⁻³). These monitoring stations give us a picture of the level of air pollution in nature

Fig. 3.2 Average monthly concentrations of PM_{10} and $PM_{2.5}$ in the Prešov region by station type.



T PM10 *a* ***T PM2.5*** *– average monthly concentration PM_{10} and $PM_{2,5}$ at the Prešov traffic station;* ***U/S PM10*** *a* ***U/S B PM2.5*** *– average of monthly concentrations PM_{10} a $PM_{2,5}$ at urban/suburban background stations: Humenné, Vranov nad Topľou a Poprad.*

As expected, the PM_{10} and $PM_{2.5}$ concentrations in the zone were lowest at the rural background station in Stará Lesná and, together with the monitoring station at Kolonicke sedlo, would meet not only the new EU limit for the annual average of PM_{10} in 2024, but also the stricter WHO recommendation (annual average of PM_{10} up to 15 µg.m^{-3}). These monitoring stations give us a picture of the level of air pollution in nature

Fig. 3.3 *Up: average annual PM_{10} concentration.* ***down:*** *number of exceedances of the daily PM_{10} limit value in 2024.*

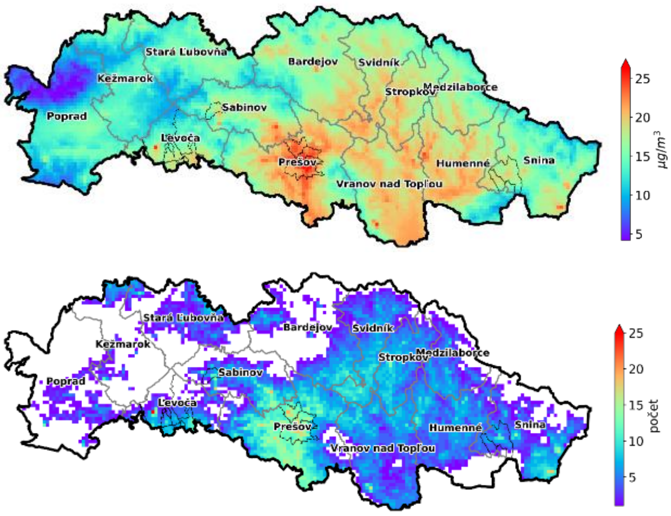


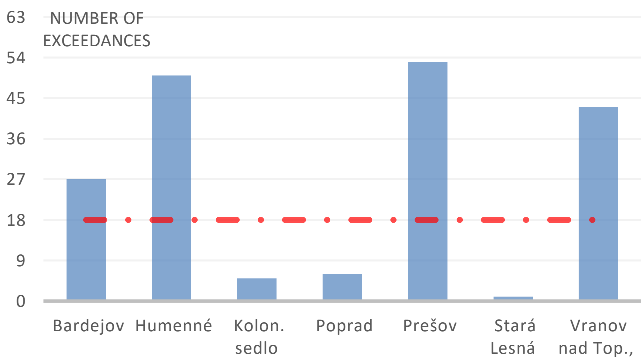
Fig. 3.2 compares the course of monthly averages of PM_{10} and $PM_{2.5}$ at the traffic station in Prešov and urban/suburban background stations. In the Prešov region, similarly to the rest of the Slovak Republic, long-lasting adverse dispersion conditions were manifested at the end of the year, in this case the situation was worse in November. An extreme episode of Saharan dust transport, which occurred at the turn of March and April, brought average daily concentrations above 100 µg.m^{-3} also at the rural monitoring station Kolonicé sedlo.

Compared to PM_{10}, fine particles $PM_{2.5}$ have a significantly more negative impact on human health. In As expected, the PM_{10} and $PM_{2.5}$ concentrations in the zone were lowest at the rural background station in Stará Lesná and, together with the monitoring station at Kolonicke sedlo, would meet not only the new EU limit for the annual average of PM_{10} in 2024, but also the stricter WHO recommendation (annual average of PM_{10} up to 15 µg.m^{-3}). These monitoring stations give us a picture of the level of air pollution in nature

Fig. 3.2, the average monthly concentrations of fine particles are shown by the dashed line. High values of $PM_{2.5}$ were recorded in the cold months of the year, which, as with PM_{10}, is probably caused by emissions from household heating with solid fuels. The highest average annual concentrations of $PM_{2.5}$ were measured in Humenné (17 µg.m^{-3}) and Prešov (16 µg.m^{-3}).

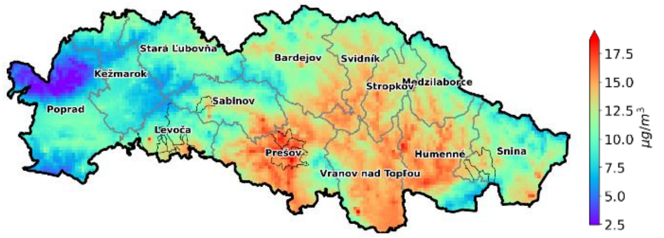
Fig. 3.3 and **Fig. 3.8** show the modeling results for PM_{10} and $PM_{2.5}$ for 2024 using the RIO model subsequently adjusted using the regression IDW-R method; more detailed information is provided in Chapter 4 of the *Air Quality Report in the Slovak Republic for 2024*.

Fig. 3.4 *Number of days with average daily $PM_{2.5}$ concentration > 25 µg.m^{-3} in 2024 – evaluation with respect to the newly introduced EU limit *.*



** Under the new EU limit, which will come into force on 1 January 2030, the average daily concentration of $PM_{2.5}$ must not exceed 25 µg.m^{-3} more than 18 times a year*

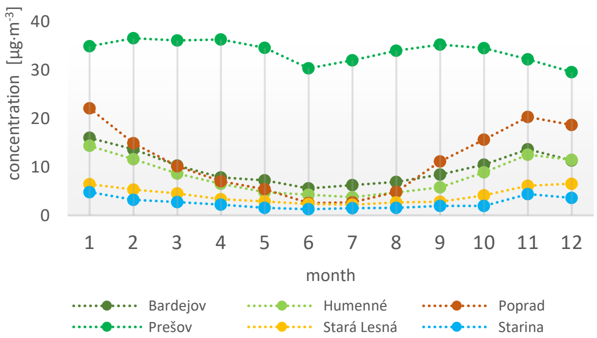
Fig. 3.5 *Annual Average $PM_{2,5}$ concentration. Output of model RIO/IDW-R.*



3.2 Nitrogen dioxide

The main source of NO_2 emissions is road traffic. For this reason, the highest concentrations are recorded at the traffic monitoring station in Prešov, where the highest annual average NO_2 concentration in Slovakia was once again measured: 34 µg·m^{-3}, the same as in 2023. The annual pattern of NO_2 concentrations typically shows a more or less pronounced minimum during the summer months, which is not observed at the traffic station in Prešov (Figure 3.6). Overall, NO_2 air pollution levels in the zone are relatively low, with the exception of Prešov.

Fig. 3.6 *Average monthly NO_2 concentrations in 2024.*



Under the new EU limit values, only the traffic AMS station in Prešov would not comply. At five stations, the average NO_2 concentrations in 2024 were equal to or below the WHO guideline value (10 µg·m^{-3}), which is twice as strict as the new EU limit applicable from 1 January 2030.

Nitrogen dioxide is monitored at seven stations in the zone. Limit values for NO_2 have not been exceeded in the Prešov Region since 2018. Monthly average concentrations for individual stations are presented in***Fig. 3.6***.

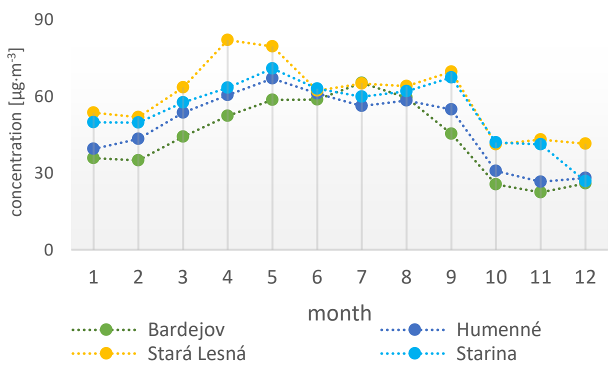
3.3 Ozone

Ozone monitoring in the zone is carried out at four monitoring stations – in Stará Lesná, at Starina (located on the north-eastern border of Slovakia), and in the district towns of Bardejov and Humenné.

The highest concentrations of ground-level ozone typically occur during the warm months, when solar radiation is strong (**Fig. 3.7**). Concentrations increase after sunrise, peak around midday, and gradually decrease in the evening, reaching a minimum in the early morning. Large differences in ground-level ozone concentrations are also observed between the warm and cold seasons.

In 2024, no exceedances of the information or alert thresholds for O_3 were recorded at any of the stations.

Fig. 3.7 *Average monthly O_3 concentrations in 2024.*



3.4 Benzo(a)pyrene

Benzo(a)pyrene is monitored at two stations within the zone – at Starina and Stará Lesná. The target value for benzo(a)pyrene (1 ng·m^{-3}) was not exceeded (**Tab. 3.2**). However, these are rural background stations that are not directly affected by emissions from residential heating with solid fuels; therefore, low BaP concentrations can be expected at these sites.

Tab. 3.2 *Average annual concentrations of benzo(a)pyrene in 2018 – 2024.*

	2018	2019	2020	2021	2022	2023	2024
Target value [ng·m⁻³]	1,0	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	0,2
Stará Lesná, EMEP		0,4	0,3	0,4	0,3	0,3	0,2

≥ 90 % of valid measurements

Fig. 3.8 Concentrations of benzo(a)pyrene in2024

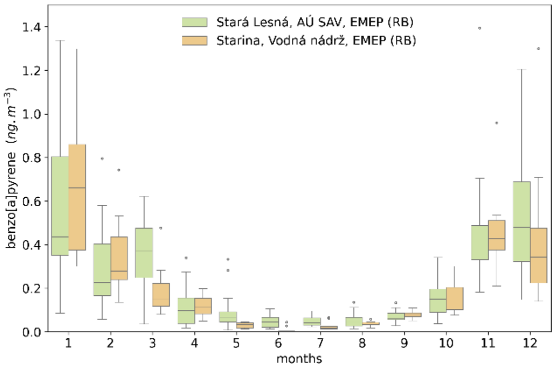
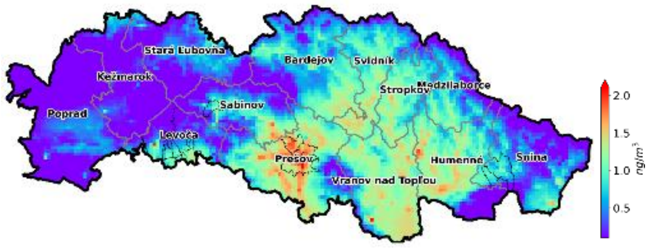


Fig. 3.9 Average annual concentration of BaP according to RIO/IDW- R model output, (2024).



The monthly variation of benzo(a)pyrene concentrations is shown in **Fig. 3.9**. Although the target value was not exceeded, the concentrations are relatively high during the winter period, which may be a result of regional transport or local influence.

As in other cases, mathematical modelling provides a useful tool for assessing BaP air pollution levels in the region. **Fig. 3.9** presents the spatial distribution of BaP based on the results of the RIO/IDW-R model. More detailed information on the applied methodology can be found in Chapter 4 of the 2024 Air Quality Report for the Slovak Republic. The model is based on measured data (and auxiliary fields); however, over the large area of the Prešov Region, the outputs are associated with considerable uncertainty. Therefore, it is more appropriate to focus on relative differences between areas rather than relying on absolute values.

According to the RIO model outputs, the highest concentrations occur in municipalities of the districts of Levoča, Vranov nad Topľou, Prešov, Svidník, Sabinov, and Stropkov. To obtain a more detailed picture of the spatial distribution, high-resolution modelling using detailed emission data is needed (i.e. information on the amount and type of fuels, as well as the types of appliances used for residential heating, etc.).

The most significant source of benzo(a)pyrene is residential heating with solid fuels, particularly insufficiently dried wood or inappropriate fuels (e.g. various types of waste).

3.5 Chemical composition of precipitation

Tab. 3.3 *Annual pH (volume-weighted average) and N, S, Pb deposition, 2024*

Monitoring station	pH	Deposition of SO_4^{2-} [g Sulphur/m²/year]	Deposition of NO_3^- [g Nitrogen/m²/year]	Deposition of Pb [g/ha/year]
Stará Lesná	5,40	0,08	0,11	7,85
Starina	5,25	0,13	0,15	7,34

At the rural background stations Starina and Stará Lesná, precipitation quality is monitored. The qualitative composition of major ions, pH parameters, and conductivity are measured. Annual average of **pH,** as well as **wet deposition of SO_4^{2-}, NO_3^-, and lead**, are presented in **Tab. 3.3**.

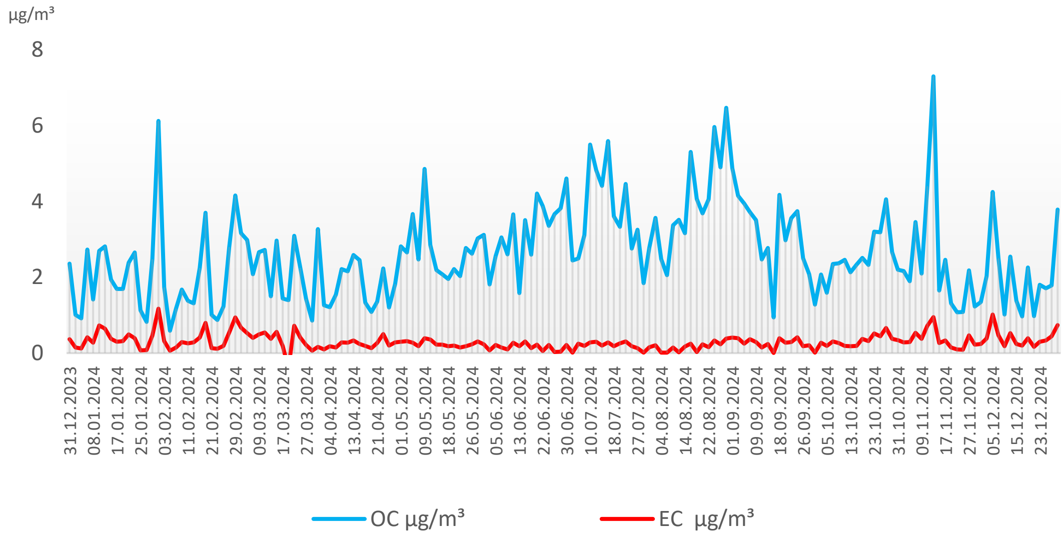
At the Stará Lesná monitoring station, sampling of the $PM_{2.5}$ aerosol fraction for organic and elemental carbon (OC/EC) analysis has been conducted since the end of 2020. These components represent a significant portion of both PM_{10} and $PM_{2.5}$. Samples are collected over a 24-hour period twice a week. Analyses are performed at the Czech Hydrometeorological Institute (ČHMÚ) laboratory in Ostrava.

The term organic carbon encompasses a wide range of compounds, from natural (biogenic) to anthropogenic substances, as well as secondary organic aerosols (SOA) formed through chemical reactions of gaseous precursors in the atmosphere.

Elemental carbon is a component of atmospheric aerosol produced by incomplete combustion of organic materials (e.g., fossil fuels, biomass). It is characterized by a graphitic structure and a strong light-absorbing capacity.

As shown in **Fig. 3.10**, OC significantly dominates over EC in the samples, indicating a high share of organic matter, including secondary organic aerosols (SOA), which are particularly typical for summer periods. EC reflects continuous local combustion sources (e.g., residential heating, traffic emissions); the lower winter peak may indicate a moderate influence of heating.

Fig. 3.10 *Concentrations of organic and elemental carbon at AMS Stará Lesná in 2024*



The Results of measurements confirm the expected seasonality – increased OC in the warmer period – in July and August, and relatively stable low EC – a typical scenario of a clean environment. In the graph, we noted high OC concentrations also in winter – January, November, which are most likely caused by a combination of the impact of household heating and unfavorable dispersion conditions. Detailed results of EMEP monitoring are presented in Chapter 3 in the Regional Monitoring section of report the Air Pollution in the Slovak Republic 2024

OC has different biomass sources:

Summer OC – from biogenic precursors
During summer, a higher share of secondary organic carbon (SOC) is formed through the oxidation of biogenic volatile organic compounds (BVOCs) emitted by plants and trees. These compounds are often allergens for sensitive individuals. EC concentrations are low during this period.

Winter OC – from biomass combustion
In winter, OC concentrations increase mainly due to local residential wood burning. Biomass combustion also produces EC, so winter OC peaks are typically accompanied by elevated EC concentrations.

3.6 Risk municipalities

Fig. 3.11 Risk municipalities in zone Prešov region.

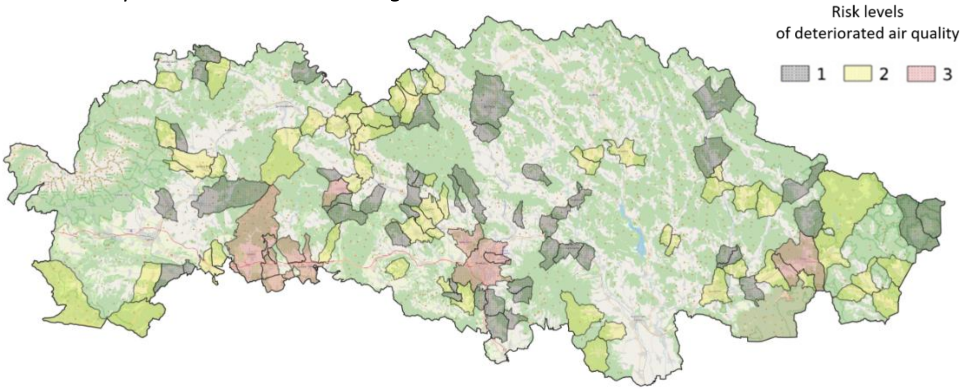


Fig. 3.11 displays municipalities at risk due to deteriorated air quality as determined by the integrated municipal assessment method[5]. Level 3 corresponds to the highest probability of air pollution risk. The methodology involves the level of household heating with solid fuels, the impact of worsened 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 [6].

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 [7].

3.7 Summary

In the Prešov Region zone, no exceedances of any limit or target values have been recorded since 2018. Compared to 2023, annual average PM_{10} concentrations increased at all monitoring stations, while NO_2 concentrations decreased at most stations. NO_2 concentrations in Prešov continue to be the highest among all monitored locations. At the other monitoring stations, the levels of this pollutant remain consistently low.

Based on mathematical modelling results, it can be assumed that higher concentrations of particulate matter and benzo(a)pyrene may occur in some areas, particularly during the winter months, in locations with a higher share of solid fuels used for household heating, especially under unfavourable dispersion conditions.

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[5] *Štefánik, D., Krajčovičová, J.: Metóda integrovaného posúdenia obcí vzhľadom na riziko nepriaznivej kvality ovzdušia, Slovenský hydrometeorologický ústav, 2023, dostupné na https://www.shmu.sk/sk/?page=996*

[6] *https://www.shmu.sk/sk/?page=2873*

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

If compliance were assessed according to the new Ambient Air Quality Directive adopted by the European Parliament in April 2024 (which sets stricter limit values applicable from 1 January 2030), **the main challenge in the Prešov Region zone would be meeting the new $PM_{2,5}$ limit values.**

Annual PM_{10} averages would meet the 2030 target at all stations except for the traffic station in Prešov, as was the case in 2023. Annual $PM_{2.5}$ averages in 2024 would exceed the new EU limit value at all stations except the rural AMS in Stará Lesná. To meet the requirements of the new directive, additional measures will be needed to reduce pollution to the required levels.

If air quality in the zone were assessed according to WHO recommendations[8], pollutant concentrations would meet the recommended levels only in exceptional cases. All stations, except for Prešov and Poprad, would already comply with the annual NO_2 guideline value in 2024. The Zero Pollution Action Plan aims to achieve air quality in line with these recommendations by 2050.

[8] *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*