AIR POLLUTION IN THE SLOVAK REPUBLIC 2022

ANNEX

AIR QUALITY ASSESMENT IN ZONE PREŠOV REGION

Air quality monitoring department
SLOVAK HYDROMETEOROLOGICAL INSTITUTE

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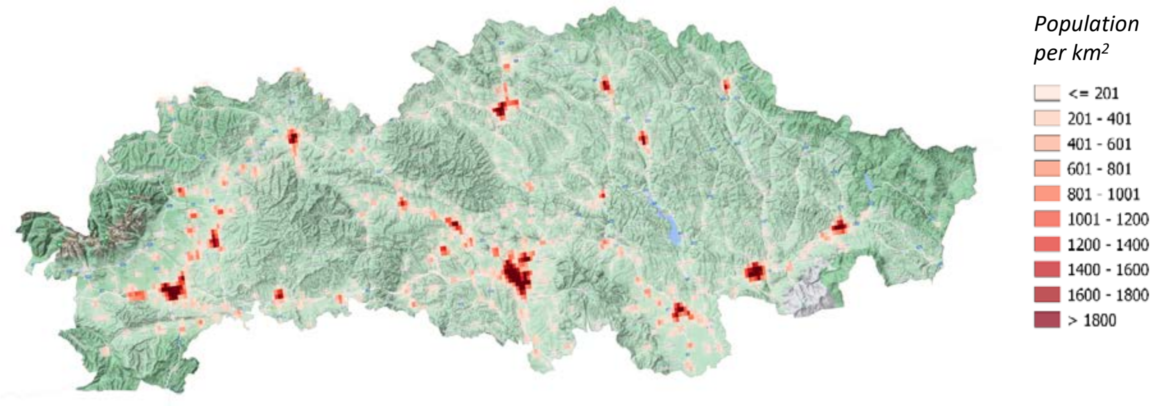
Version 1

1 DESCRIPTION OF PREŠOV REGION TERRITORY IN TERMS OF AIR QUALITY

The Prešov region is characterized by a predominantly mountainous relief, the highest point is Gerlachovský štít - height 2 655 m a.s.l., the lowest point has an altitude of 109 m. Its territory is occupied mainly by the outer Carpathian Mountains (Spišská Magura, Podtatranská brázda, Spišsko-šarišské mezihorie, 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).*



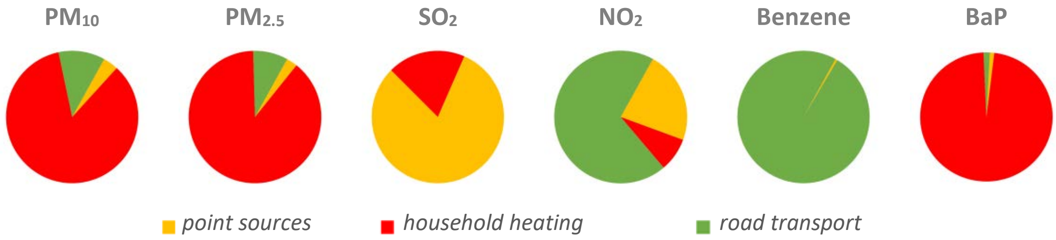
Air pollution sources in zone Prešov region

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 transport. Based on the 2015 national traffic census, we know that an average of 30 731 vehicles (4 025 trucks and 26 528 passenger cars) pass along road No. 18 in the Prešov district every day - the highest in the region. Road No. 3450 is also very busy in this district (23 597 vehicles, of which 3 009 trucks and 20 518 passenger cars). By comparison, the D1 motorway in the region is less busy, with a maximum of 16 560 vehicles (4 002 trucks and 12 527 passenger cars) in the Prešov district. Other roads with heavy traffic - in the Poprad district, road No. 3080 with 21 639 vehicles on average per day (1 573 trucks and 19 997 passenger cars) and road No. 67 with 21 488 vehicles (1 378 trucks and 20 058 passenger cars), in the Humenné district, road No. 74 with 18 790 vehicles (1 481 trucks and 17 213 passenger cars), in the Bardejov district, road No. 77 with 19 833 vehicles (2 315 trucks and 17 441 passenger cars), in Humenné district road No. 74 with 18 790 vehicles (1 481 trucks and 17 213 passenger cars), in Vranov nad Topľou district road No. 18 with 17 371 vehicles (2 958 trucks and 14 340 passenger cars) and in Kežmarok district road No. 67 with 17 095 vehicles (2 306 trucks and 14 733 passenger cars)[1].

[1] *https://www.ssc.sk/sk/cinnosti/rozvoj-cestnej-siete/dopravne-inzinierstvo/celostatne-scitanie-dopravy-v-roku-2015/ zilinsky-kraj.ssc*

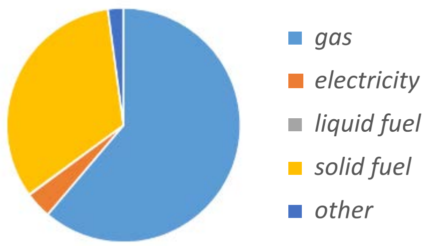
Fig. 1.2 *Share of different types of air pollution sources in total emissions in the Prešov region.*



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 local air pollution by basic pollutants. Depending on meteorological conditions, the influence of the wood processing industry and heating plants can be felt here.

Fig. 1.3 *Share of different types of fuel used for heating in family houses* [2]



According to the Population and Housing Census (PHC) 2021 data, natural gas is mostly used for heating in family houses in the zone, especially in the larger cities. The share of solid fuels is higher than in the Trnava and Nitra regions. Solid fuels are more likely to be used in rural settlement types with good availability of firewood. According to the PHC 2021, the districts of Humenné, Medzilaborce and Snina have the highest share of solid fuels in the zone.

2 AIR QUALITY MONITORINGS 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. These ones monitor areas distant from the main sources of air pollution and reflect the change in the vertical pollution profile due to the different altitudes. 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 characterizes the air quality in a less polluted area. Air quality monitoring started here in 2009. The monitoring station in Prešov, Arm. gen. L. Svobodu captures the impact of road traffic in a location with relatively high traffic intensity. Stations in Humenné, Poprad, Vranov nad Topľou and Bardejov represent urban and suburban background pollution respectively.

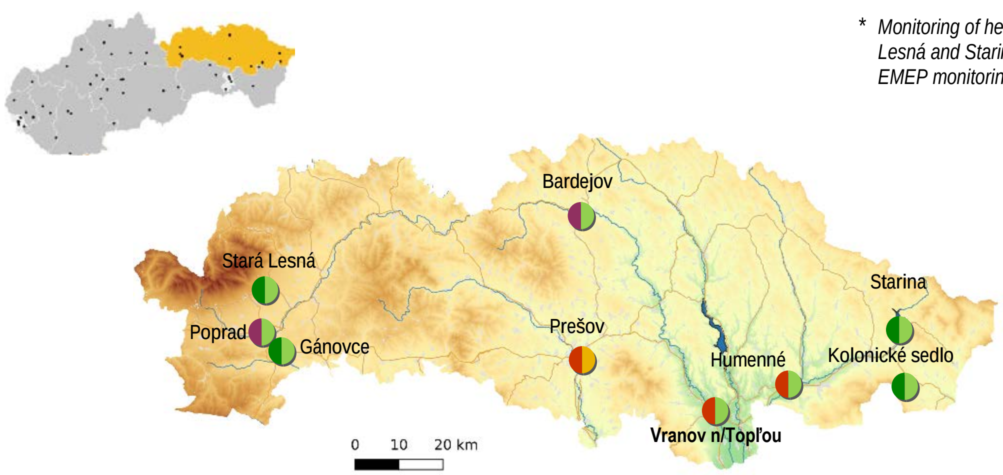
[2] *https://www.scitanie.sk*

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. Automatic continuous monitoring instruments provide hourly average concentrations of PM_{10}, $PM_{2.5}$, nitrogen oxides, sulphur dioxide, ozone, carbon monoxide, benzene and mercury. The SHMÚ test laboratory analyses heavy metals and polycyclic aromatic hydrocarbons as part of manual monitoring. This results in 24-hour average values.

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

Zone Prešov region								Measurement programme									
								Continuously								Manually	
District	Code EoI	Name of station	Type of area	Type of station	Geographical longitude	Geographical latitude	Altitude [m]	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 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 – regional

Type of station:
B – background
T – traffic
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 2022 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 *Measuring 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	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)	Arsenic (As)	Cadmium (Cd)	Nickel (Ni)	Chromium (Cr)	Coper (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 ASSESMENT 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 2022.

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 – 2022.*

	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	8							
Humenné, Nám. slobody			0	9	8	23	19			0	0
Prešov, Arm. gen. L. Svobodu			0	32	15	25	18	1 444	0.82	6	0
Vranov n/T, M. R. Štefánika	0	0			7	20	16			0	0
Stará Lesná, AÚ SAV, EMEP			0	4	0	11	8			0	0
Starina, Vodná nádrž, EMEP			0	3							
Kolonické sedlo, Hvezdáreň					1	15	11			0	0
Poprad, Železnicná			0	15	1	17	12			0	0
Bardejov, Pod Vinbargom			0	10	2	20	15			0	0

≥ 90% of valid measurements

[1] *eight-hour maximum concentration*

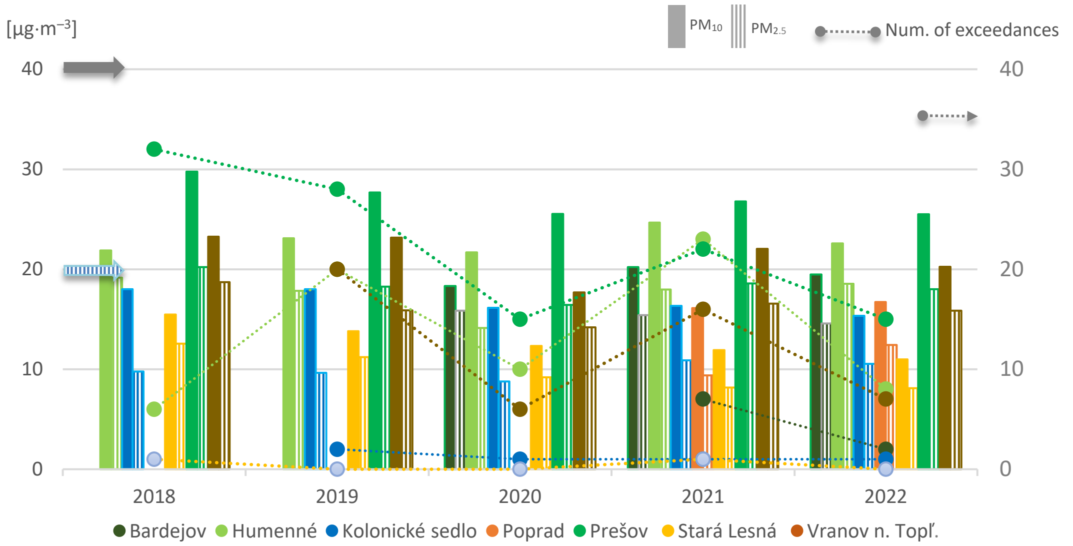
[2] *IT, AT – duration of exceedance (in hours) of the information threshold (IT) and alert threshold (AT) for PM_{10}*

In accordance with the Regulation of MoE SR No. 244/2016 Coll. of Acts on air quality, as amended, the required proportion of valid values at the other stations has been fulfilled.

3.1 PM_{10} and $PM_{2.5}$

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 2022.

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}.



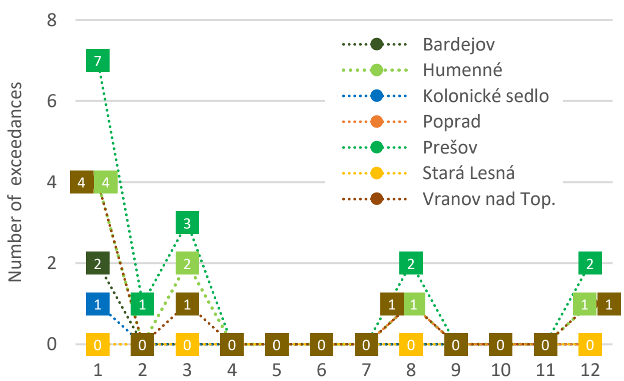
Number of exceedances – show daily average concentrations of PM_{10} higher than 50 µg·m^{-3};

*Arrows show the limit values, **blue striped** $PM_{2.5}$ (average annual concentration: 20 µg·m^{-3}); **solid grey** PM_{10} (average annual concentration: 40 µg·m^{-3}); **grey dotted right** 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).*

PM_{10}

The limit value for the average annual concentration of PM_{10} (40 µg·m^{-3}) in the zone Prešov region was not exceeded. Similarly, the limit value for the number of exceedances per year (35 times) of the average daily limit concentration of PM_{10} (50 µg·m^{-3}) was not reached by any monitoring station (**Fig. 3.1**). The Prešov traffic station recorded the highest average annual PM_{10} concentration of 25 µg·m^{-3} and 15 daily exceedances of the daily limit value. Compared to the year 2021, there was an interannual improvement (year 2021: 27 µg·m^{-3} – average annual concentration and 22 exceeding the daily limit value). Of the urban and suburban background locations, the highest average annual concentration was achieved at the station in Humené 23 µg·m^{-3}. This value is almost at the level of the annual average of the traffic station in Prešov, while in Humenné 8 exceedances of the limit for the average daily concentration of PM_{10} were recorded. However, also at the station in Humenné there was a year-on-year improvement in air quality compared to 2021 (average annual concentration of PM_{10} 25 µg·m^{-3} and 23 exceedances of the daily limit value). **Fig. 3.2** captures the number of exceedances of the average daily limit concentration of PM_{10} for individual months of the year.

Fig. 3.2 Number of PM_{10} daily limit value exceedances per month in 2022.



Almost all of exceedances are concentrated in the cold months with the need for heating. In March, the situation was complicated not only because of the persistent need for heating, and an insignificant episode of Saharan dust transmission in the middle of the second decade and at the end of the month, but also mainly because of unfavourable dispersion conditions during anticyclonic situations. Exceeding the limit in August was probably the result of cross-border transmission. Dust originating from the Caspian Sea, the steppes of Kazakhstan, Uzbekistan and Turkmenistan reached Slovakia (source: *https://www.facebook.com/shmu.sk/posts/8019521158121387*). While the increase in concentrations during March was manifested at monitoring stations throughout the territory of Slovakia, the August long-distance transmission episode mainly affected Eastern Slovakia.

In **Fig. 3.3** and **Fig. 3.5** are the results of modelling for PM_{10} and $PM_{2.5}$, calculated for the year 2022 using the RIO model subsequently adjusted using the regression IDW-R method (more details in Chapter 4 of *Air pollution in the Slovak Republic 2022 Report*).

Fig. 3.3 *Average annual PM_{10} concentration (up) and number of exceedances of the PM_{10} daily limit (down) in 2022.*

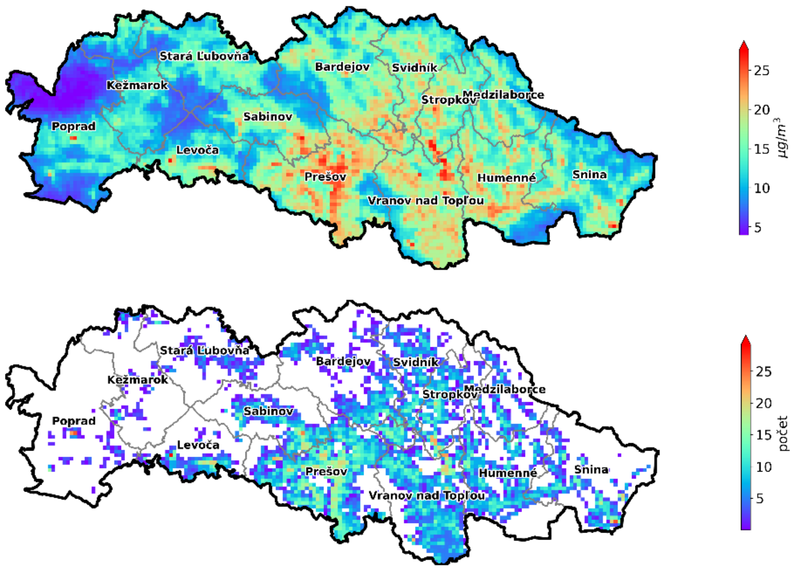
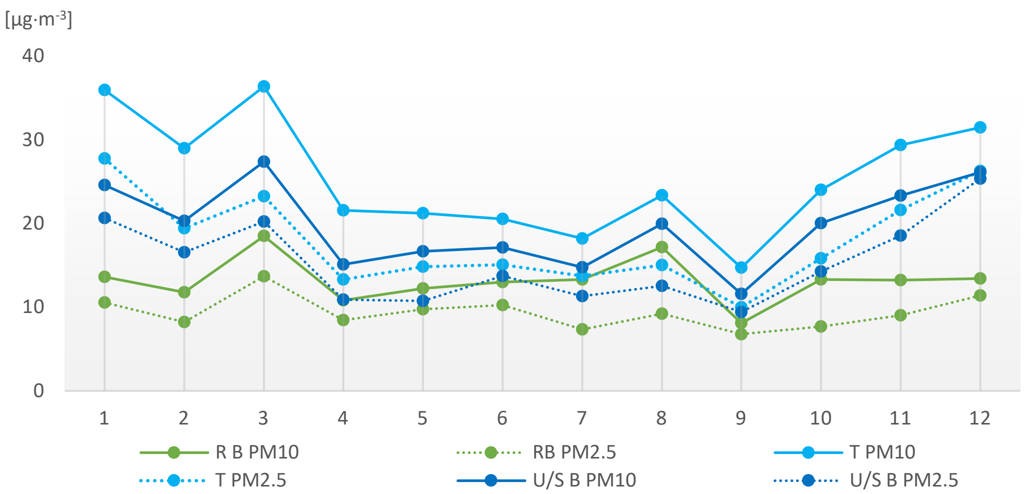


Fig. 3.4 *Average monthly concentrations of PM_{10} and $PM_{2.5}$ in the region by station type.*



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;* ***R B PM10*** *and* ***R B PM2.5*** *– average monthly concentration of PM_{10} a $PM_{2,5}$ at regional background stations Stará Lesná and Kolonické sedlo;*

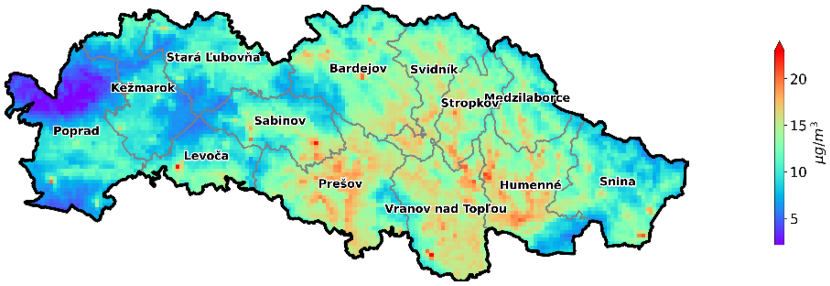
From **Fig. 3.4**, it is evident that during the warm months of the year (except for August), the concentrations of PM_{10} at regional stations (Starina, Stará Lesná, and Kolonické sedlo) and urban background area are very similar, and differences begin to increase in colder months. This is likely because 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. **Fig. 3.2** also supports this evidence.

- **$PM_{2.5}$**

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 (19 $\mu g \cdot m^{-3}$) and Prešov (18 $\mu g \cdot m^{-3}$). 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 are typically the lowest. In 2022, increased $PM_{2.5}$ concentrations in August were caused by the mentioned long-distance transport from the Caspian Sea.

The map in **Fig. 3.5** displays the spatial distribution of the average annual concentration of $PM_{2.5}$ based on the output of the RIO model, IDW-R.

Fig. 3.5 *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. 3.6**.

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. However, the average annual level (32 $\mu g \cdot m^{-3}$) does not exceed the limit value (40 $\mu g \cdot m^{-3}$) even there. The measured NO_2 values maintain a relatively constant level throughout the year without seasonal fluctuations (**Fig. 3.6**). The maximum concentration of NO_2 reached at the Prešov traffic station was 108 $\mu g \cdot m^{-3}$, and at the urban background station in Humenné, it was 75 $\mu g \cdot m^{-3}$. The annual average concentrations at background stations were below 20 $\mu g \cdot m^{-3}$. Overall, air pollution with this pollutant in the Prešov region is relatively low. On five stations, the average NO_2 concentrations in 2022 were lower or equal (higher levels were only observed in Prešov and Poprad) to the WHO recommendation (10 $\mu g \cdot m^{-3}$), which is significantly stricter than EU limits.

Fig. 3.6 *Average monthly NO_2 concentrations.*

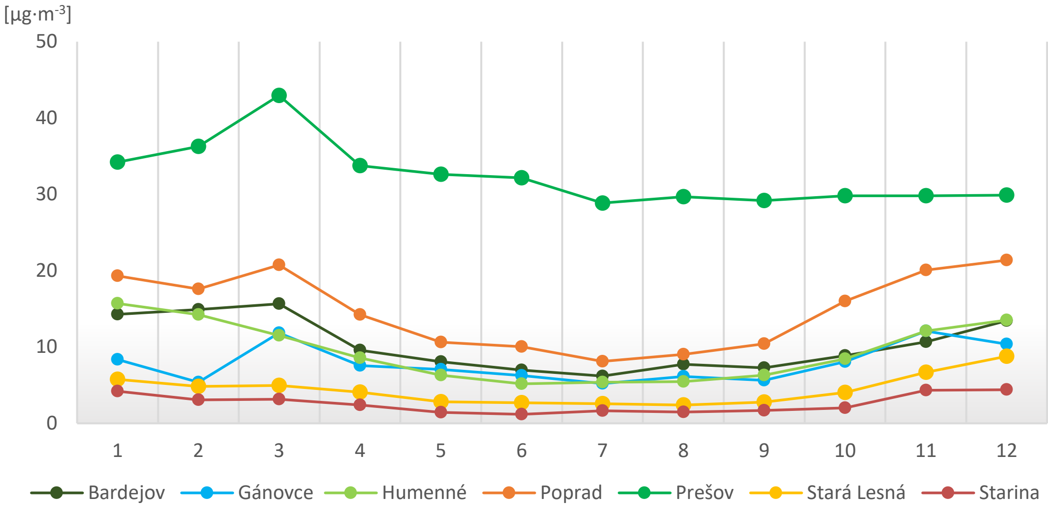
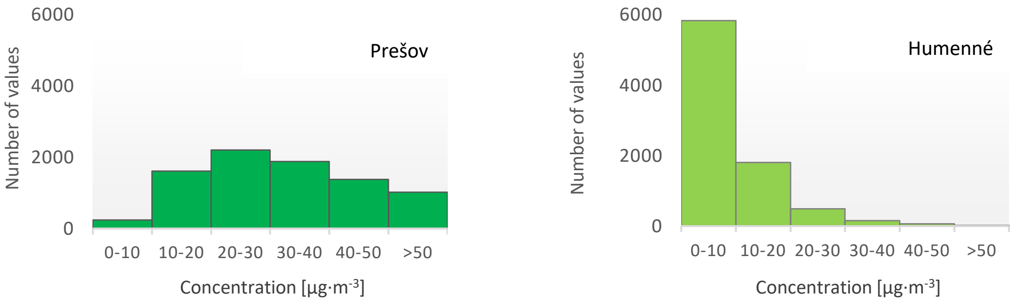


Fig. 3.7 compares the frequency distribution of hourly concentration at the Prešov traffic station and the urban background station in Humenné, which meets the WHO recommendation for the average annual NO_2 concentration (maximum 10 µg·m^{-3}). While the station in Humenné recorded 69% of hourly data within the range of (0 – 10) µg·m^{-3}, the Prešov AMS had only 3% within that range.

Fig. 3.7 *Histogram of hourly NO_2 concentration in Prešov and Humenné.*



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 northeastern 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**). **Fig. 3.9** and **Fig. 3.10** depict the so-called daily course of O_3 concentrations for selected stations (urban background station Bardejov and regional background station Stará Lesná). It shows that concentrations 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.

Fig. 3.8 *Monthly average O_3 concentrations in 2022.*

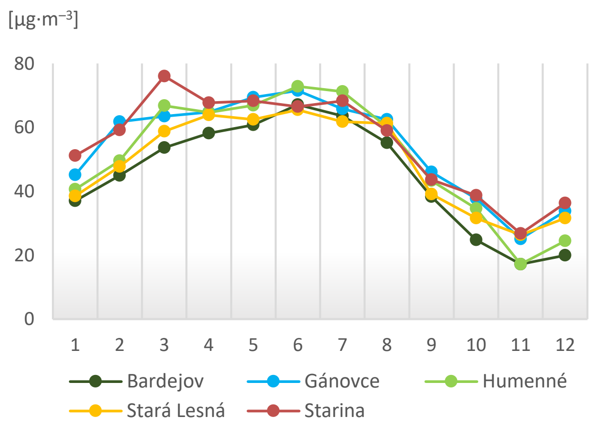


Fig. 3.9 *Daily O_3 concentration in January in 2022.*

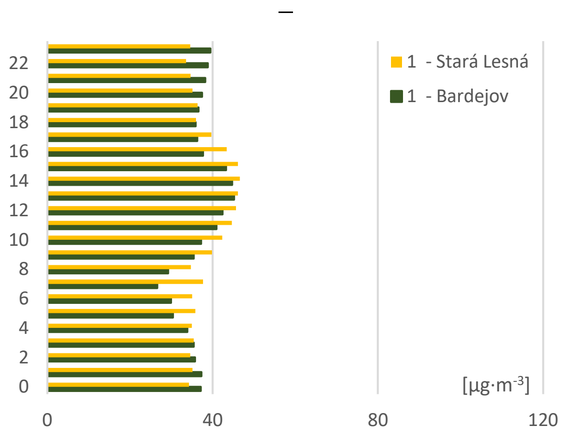
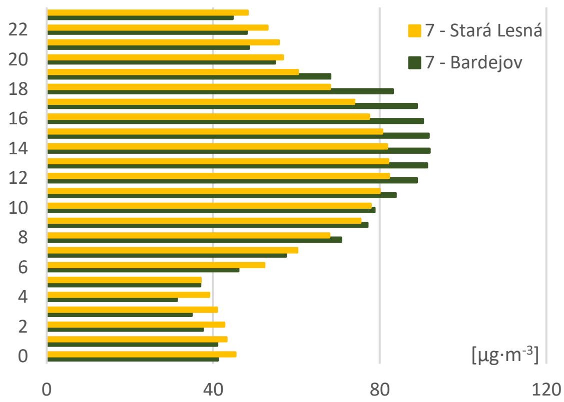


Fig. 3.10 *Daily O_3 concentration in July in 2022.*



We did not observe any station exceeding the information or alert threshold in 2022 for ground-level ozone.

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. Stations on which monitoring is carried out, however; are characterised as rural background, and these are not directly affected by emissions from domestic solid fuel heating (**Tab. 3.2**). Therefore, in this case, the results of mathematical modelling are useful indicators.

Tab. 3.2 *Assessment of air pollution by benzo(a)pyrene.*

	2017	2018	2019	2020	2021	2022
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
Stará Lesná, EMEP			0.4	0.3	0.4	0.3

≥ 90% of valid measurements

Fig. 3.11 illustrates the average daily concentrations of benzo(a)pyrene at rural background stations. Although the target value was not exceeded, the values are relatively high during the winter season, which could be a result of regional transport or local influences. **Fig. 3.12** 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. 3.11 *Results of benzo(a)pyrene measurements in 2022.*

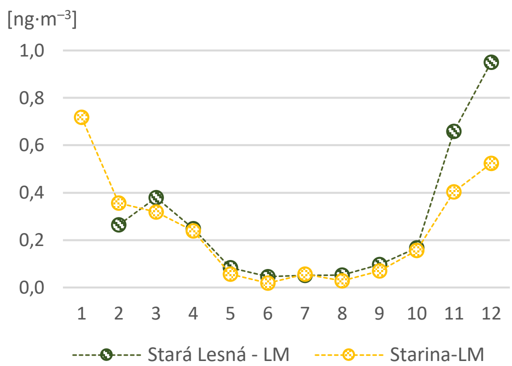
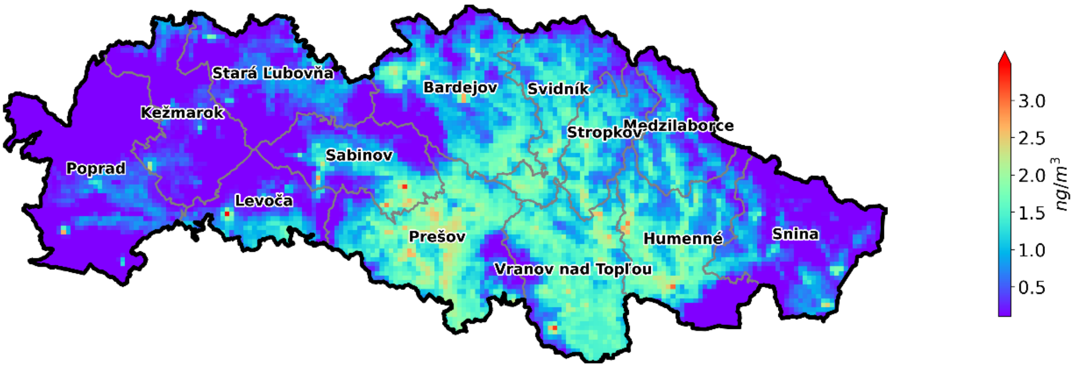


Fig. 3.12 Average annual concentration of benzo(a)pyrene from RIO model output, IDW-R (2022).



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 5.45, 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, Regional Monitoring, in *Air pollution in the Slovak Republic 2022 Report*.

3.6 Risk municipalities

Fig. 3.13 Risk municipalities in zone Prešov region.

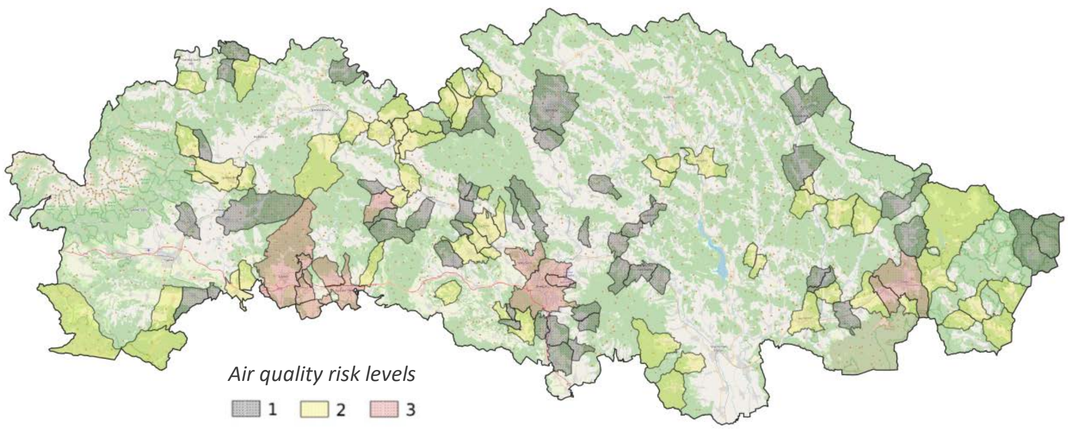


Fig. 3.13 displays municipalities at risk due to deteriorated air quality as determined by the integrated municipal assessment method[4]. Level 3 corresponds to the highest probability of air pollution risk. The methodology involves the level of household heating with solid fuels, the impact of worsened 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.

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

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].

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

In the zone Prešov region, no exceedances of the limit or target values for any pollutant in the last three 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 measured locations.

Based on the results of mathematical modelling, we can assume that in some areas (**Fig. 3.3**, **Fig. 3.5**, **Fig. 3.12**, **Fig. 3.13**) 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.

[5] *https://www.shmu.sk/sk/?page=2768*
[6] *https://www.shmu.sk/sk/?page=2699*