AIR POLLUTION IN THE SLOVAK REPUBLIC 2023

ANNEX

AIR QUALITY ASSESSMENT IN ZONE TRENČÍN REGION

Emissions and Air Quality Division
SLOVAK HYDROMETEOROLOGICAL INSTITUTE

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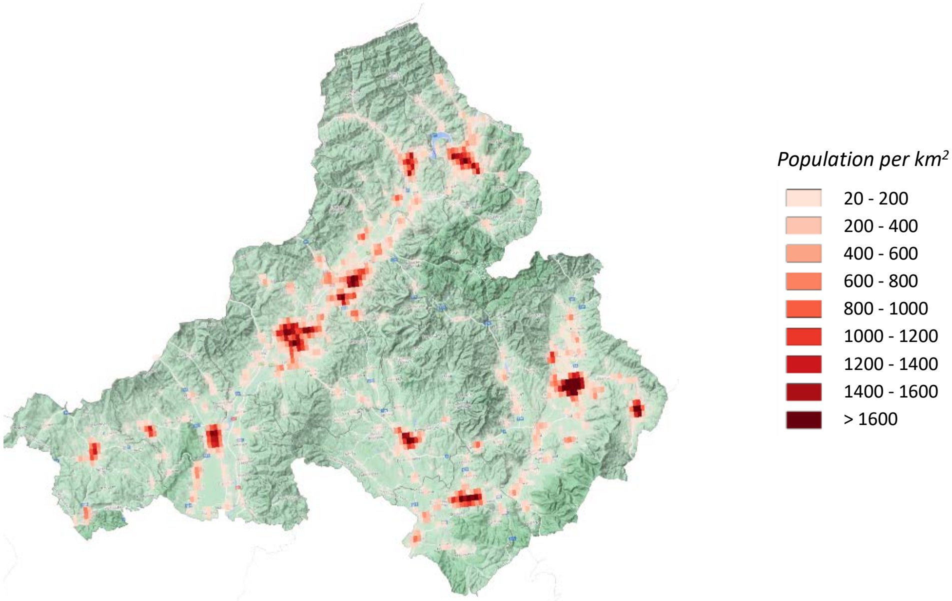
Version 1

1 DESCRIPTION OF TRENČÍN REGION TERRITORY IN TERMS OF AIR QUALITY

With the exception of the basin Horná Nitra, the relief of the Trenčín region is mainly mountainous, including the Myjava Hills and the White Carpathians, partly the Považský Inovec, Javorníky, Vtáčnik and Strážovské vrchy Mountains. The highest point is Vtáčnik with an altitude of 1 346 m a. s. l., the lowest point is 165 m a. s. l. The zone is for the most part well ventilated, lower wind speeds occur in valley of the Váh river. **Fig. 1.1** shows the spatial distribution of population density in the zone.

The whole Trenčín 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 *Population density in the zone Trenčín region (Source: EUROSTAT, 2018).*



Air pollution sources in zone Trenčín region

Household heating is the most significant source of air pollution in the more mountainous part of the zone. Road traffic in the Trenčín region contributes to air pollution depending on its intensity. The busiest road sections with the average number of vehicles per 24 hours according to the National Traffic Census 2022 and 2023[1]:

Western and northern part of the region

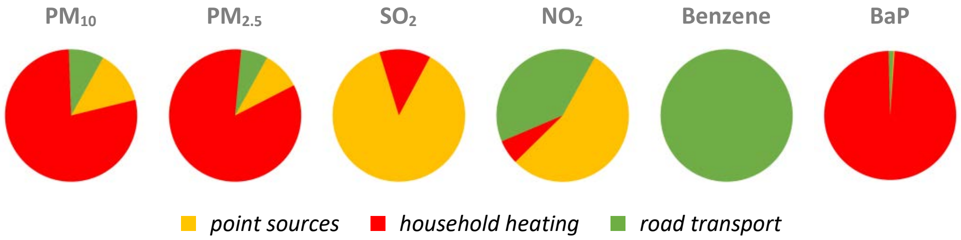
- **D1 motorway** from the south to the north of the region connecting Nové Mesto nad Váhom - Trenčín - Dubnica nad Váhom - Považská Bystrica: 32 222 vehicles (7 325 trucks/buses (hereinafter referred to as T/B) and 18 967 cars (hereinafter referred to as C));
- **road No. 54** in Nové Mesto nad Váhom: 18 405 vehicles (2 992 T/B, 15 289 C) and **road No. 515** in the Nové Mesto nad Váhom district: 17 663 vehicles (3 116 T/B, 14 467 C);
- **road No. 61** in the Trenčín district: 33 470 vehicles (3 240 T/B, 30 081 C), **road No. 61A**: 26 822 vehicles (2 158 T/B, 24 497 C) and **road No. 507**: 16 504 vehicles (1 630 T/B, 14 783 C);
- **road No. 61** in Dubnica nad Váhom (the Ilava district): 20 271 vehicles (1 806 T/B, 18 327 C);
- **road No. 517** in Považská Bystrica: 18 386 vehicles (2 161 T/B, 16 088 C);
- **road No. 49** in Púchov: 14 421 vehicles (1 129 T/B, 13 233 C).

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

South-eastern part of the region

- **road No. 64** in Partizánske in the south of the region: 14 641 vehicles (1 806 T/B, 12 754 C);
- **road No. 64** in Prievidza in the south-eastern part of the region (leading north to Žilina): 19 944 vehicles (2 212 T/B, 17 662 C) and **road No. 1774** in the western part of the city: 21 102 vehicles (1 478 T/B, 19 516 C);
- **road No. 9** connecting Trenčín - Bánovce - Nováky - Prievidza - Handlová: 17 711 vehicles (3 103 T/B, 14 526 C) in the Prievidza district;
- in the south-west of the region in Myjava, **road No. 499** (southern part of the town): 11 061 vehicles (1 722 T/B, 9 256 C) and **road No. 1187** in downtown Myjava: 9 118 vehicles (1 087 T/B, 7 981 C).

Fig. 1.2 *Share of different types of air pollution sources in total emissions in the Trenčín 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 are less significant in the zone Trenčín region in terms of their contribution to local air pollution by basic pollutants, with the exception of cement factories. The influence of heating plants was more pronounced but depending on meteorological conditions they contribute more to the regional background.

Fig. 1.3 *Share of different fuels in heating in the municipalities of the region[2].*

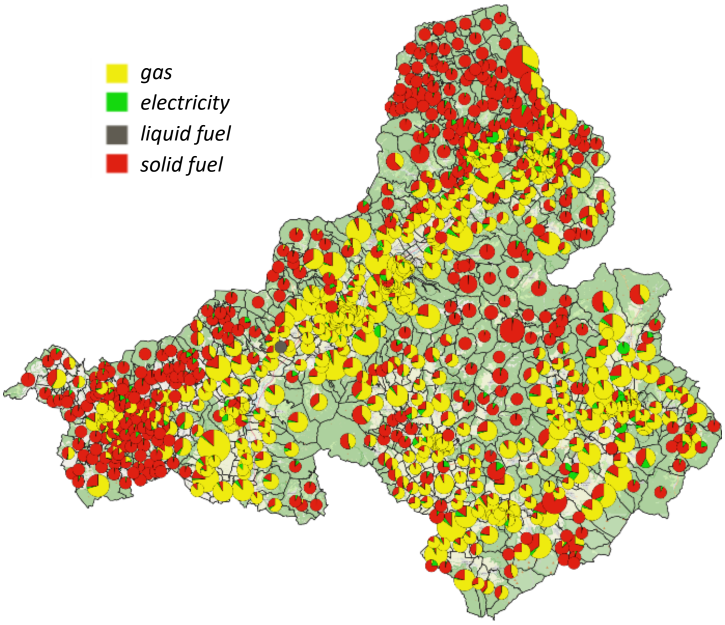


Fig. 1.3 shows the shares of fuel types in the heating of family and block of flats in individual municipalities (or basic settlement units) of the Trenčín region, while it can be seen that the cross-sectional distribution of fuel types is not geographically homogeneous. In the total for the whole zone in 2021, gas heating prevailed. However, in the mountainous areas in the north and west of the region and in the Strážovské hory mountains, heating is almost exclusively by solid fuel.

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

2 AIR QUALITY MONITORING STATIONS IN ZONE TRENČÍN REGION

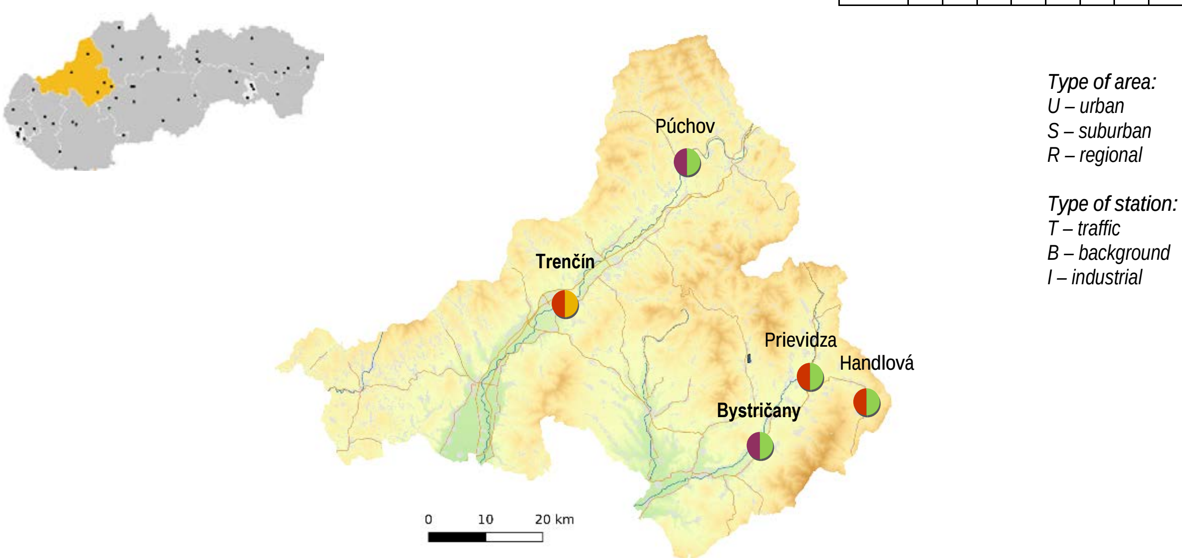
Air quality monitoring in Upper Nitra region started in 1973. Monitoring stations in Prievidza, Handlová and Bystričany were set up at that time mainly to capture the impact of heating plants. As in other similar locations, where monitoring was initially focused on large sources of air pollution, emissions from heating plant have decreased and the monitoring now increasingly reflect other local problems, in particular household heating with solid fuel. There are currently five monitoring stations in the zone. In addition to the three mentioned above, there is a monitoring station in Trenčín and a new station in Púchov, where monitoring started in 2021. AMS Trenčín characterises the impact of road traffic, the intensity of which at the given location is among the moderately burdensome. The AMS Púchov characterizes the background values of pollution levels in the suburban area.

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

- international EoI code, station characteristics according to the dominant sources of air pollution (traffic, background, industrial), type of monitored area (urban, suburban, rural/regional) and geographical coordinates;
- monitoring programme. Continuous monitoring automatic devices provide hourly average concentrations of PM_{10}, $PM_{2.5}$, nitrogen oxides, sulphur dioxide, ozone, carbon monoxide and benzene. The SHMÚ test laboratory analyses heavy metals and polycyclic aromatic hydrocarbons as part of manual monitoring, resulting in 24-hour average concentrations.

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

Zone Trenčín region								Monitoring programme									
								Continuously								Manually	
District	EoI code	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
Prievidza	SK0013A	Bystričany, Rozvodňa SSE	S	B	18°30'51"	48°40'01"	261										
Prievidza	SK0027A	Handlová, Morovianska cesta	U	B	18°45'23"	48°43'59"	448										
Prievidza	SK0050A	Prievidza, Malonecpalská	U	B	18°37'41"	48°46'58"	276										
Trenčín	SK0047A	Trenčín, Hasičská	U	T	18°02'29"	48°53'47"	214										
Púchov	SK0066A	Púchov, 1.mája	S	B	18°19'31"	49°07'08"	262										
							Total	5	5	3	5	1	2	1	0	2	3



3 ASSESSMENT OF AIR QUALITY IN ZONE TRENČÍN REGION

This chapter contains an assessment of air quality in the zone Trenčín 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 Trenčín region – 2023.*

	Protection of human health									IP[2)]	VP[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						
Prievidza, Malonecpalská	0	0	0	19	4	16	12			0	0
Bystričany, Rozvodňa SSE	0	0			5	17	12			0	0
Handlová, Morovianska cesta	0	0			1	15	10			0	0
Púchov, 1. mája	0	0	0	9	6	19	14	1 433		0	0
Trenčín, Hasičská	0	0	0	23	6	19	12	1 144	0.6	0	0

≥ 90% of valid measurements

[1)] *eight-hour maximum concentration*

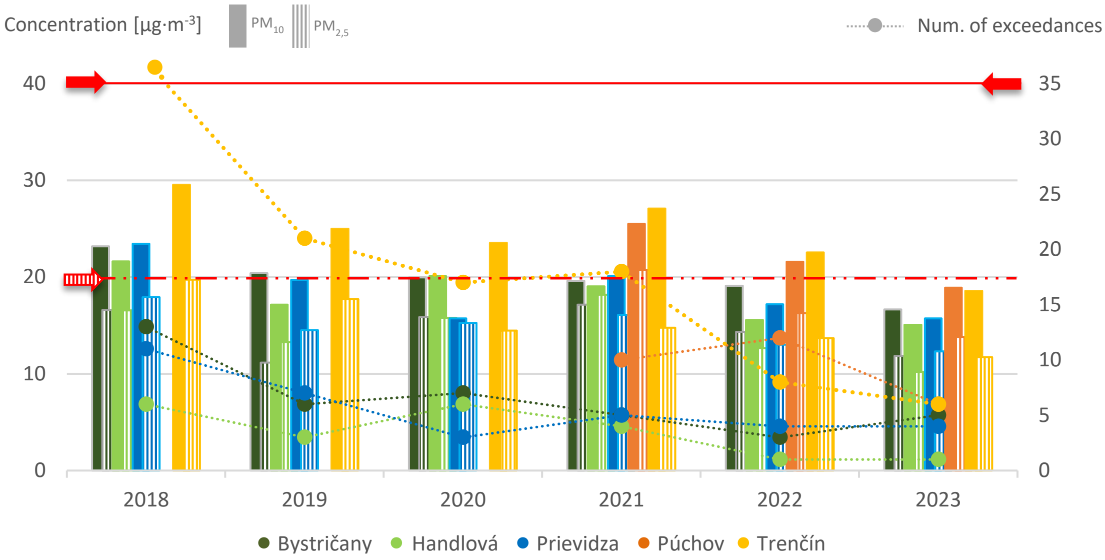
[2)] *IT, AT – duration of exceedance (in hours) of the information threshold (IT) and alert threshold (AT) for PM_{10}*

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 Trenčín 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 average annual PM_{10} concentration did not reach even half of the limit value of 40 µg·m^{-3} at any station in the zone Trenčín region. The limit value for the number of exceedances (35) of the average daily PM_{10} concentration of 50 µg·m^{-3} was also not exceeded by any station – the highest number (6) was recorded by AMS Púchov and Trenčín (**Fig. 3.1**). The Trenčín, Hasičská suburban station measured the highest annual average PM_{10} concentration of 19 µg·m^{-3} (which also means a year-on-year improvement and a decrease of 4 µg·m^{-3}), with 6 daily exceedances (8 the year before), together with the Púchov suburban station (19 µg·m^{-3} and 6 exceedances (10 the year before)). Concentration values at the remaining suburban/urban background stations ranged from 15 to 17 µg·m^{-3}, which represents a year-on-year improvement (concentration reduction) of 1 – 2 µg·m^{-3}.

Fig. 3.2 shows monthly precipitation totals, average and minimum temperatures in different months at the climatological station Beluša, near Púchov. Values of higher PM concentrations in the winter months correlate with periods of low temperatures and the need for household heating. The occurrence of low temperatures continued in February for only a few days, but the situation was complicated by the long-term influence of pressure highs with unfavourable dispersion conditions.

Fig. 3.2 *Monthly precipitation totals, average and minimum temperatures (data from the climatological station Beluša, near Púchov).*

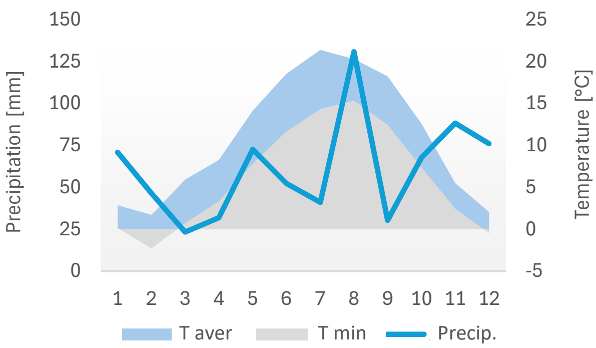
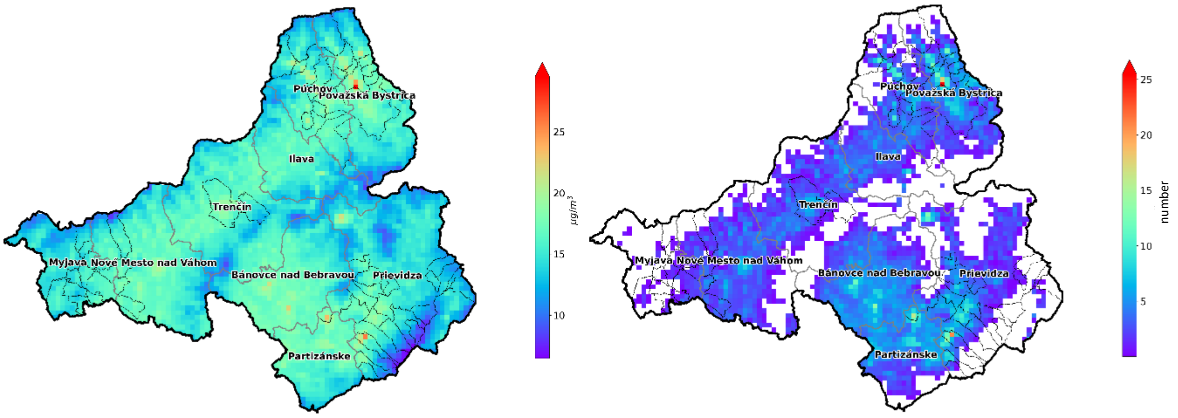


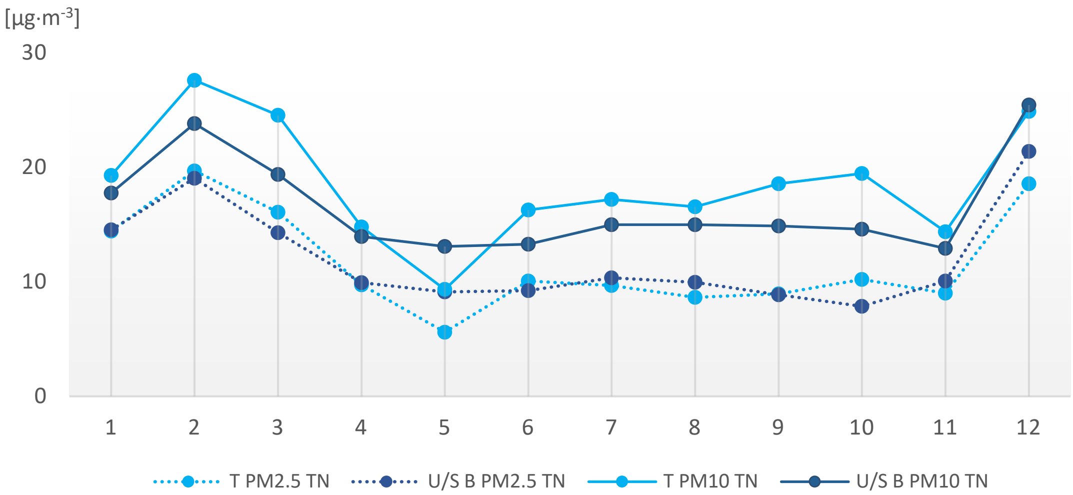
Fig. 3.3 and **Fig. 3.5** show the modelling results for PM_{10} a $PM_{2.5}$ calculated for the year 2023 using the RIO model in combination with IDW-R (the method is described in more detail in Chapter 4 of *Air pollution in the Slovak Republic 2023 Report*).

Fig. 3.3 *Average annual PM_{10} concentration (left) and number of PM_{10} daily limit value exceedances (right) in 2023.*



All urban or suburban background stations in the zone have similar average monthly concentrations of PM_{10} and $PM_{2.5}$, except for AMS in Púchov, which measured higher PM air pollution in 2023 (similar to 2022 and 2021). Therefore, **Fig. 3.4** compares the monthly average PM_{10} and $PM_{2.5}$ of the traffic station in Trenčín, the level in Púchov, and the monthly average of urban and suburban background stations in the zone outside Púchov. An interesting finding was confirmed that the PM_{10} levels at the suburban background station in Púchov in some months (in 2023 in January, April, July, November and December) exceeded the values measured at the traffic station in Trenčín – most significantly in December (29.8 $\mu g \cdot m^{-3}$ in Púchov, 24.9 $\mu g \cdot m^{-3}$ in Trenčín).

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



T PM10 *and* ***T PM2.5*** *– average monthly concentrations of PM_{10} and $PM_{2.5}$ at traffic station Trenčín, Hasičská;* ***U/S B PM10*** *and* ***U/S B PM2.5*** *– average monthly concentrations of PM_{10} and $PM_{2.5}$ at the urban/suburban background stations Bystričany, Rozvodňa SSE; Handlová, Moravianska cesta and Prievidza, Malonecpalská.*

Compared to PM_{10}, fine particles $PM_{2.5}$ have a significantly higher impact on human health. In **Fig. 3.4** their concentrations are shown by the dashed line. In Prievidza, Bystričany and Handlová, the average annual $PM_{2.5}$ concentrations in 2023 were 12 $\mu g \cdot m^{-3}$, 12 $\mu g \cdot m^{-3}$ and 10 $\mu g \cdot m^{-3}$, respectively (the year before 13 $\mu g \cdot m^{-3}$, 14 $\mu g \cdot m^{-3}$ and 13 $\mu g \cdot m^{-3}$ – so there was a significant year-on-year improvement, similar to 2022, in these localities). High $PM_{2.5}$ concentrations were observed in the cold months of the year (almost 19 $\mu g \cdot m^{-3}$ in February and above 20 $\mu g \cdot m^{-3}$ in December). This is probably caused by household heating with solid fuel, as is the case for PM_{10}. At all stations in the zone, the annual mean concentration of $PM_{2.5}$ fine particles was higher than the WHO recommendation (5 $\mu g \cdot m^{-3}$).

Also, their monthly concentrations were above 5 µg·m^{-3}. This is even in summer, when concentrations are lowest.

The map in **Fig. 3.5** shows the spatial distribution of annual average $PM_{2.5}$ concentrations according to the output of the RIO model combined with IDW-R.

Fig. 3.6 shows $PM_{2.5}$ concentrations in relation to the new EU limit and the forward-looking target to be achieved (not exceeded) by EU Member States by 1 January 2030 (approved together with the other new EU limits in April 2024). In this case, the newly established EU limit specifies that the daily average concentration of $PM_{2.5}$ (25 µg·m^{-3}) is not to be exceeded more than 18 times per calendar year. Applying this commitment on 1 January 2030 to the results in 2023, we see that all stations exceeded the new EU limit, most notably AMS Púchov. The suburban trolleybus station in Púchov recorded significantly more exceedances (35) than the traffic station in Trenčín (22).

The new EU limit value of 10 µg·m^{-3} – to be achieved by 1 January 2030 – for the annual average concentration of $PM_{2.5}$ was met in 2023 only by AMS Handlová.

Fig. 3.5 *Average annual $PM_{2.5}$ concentrations (2023).*

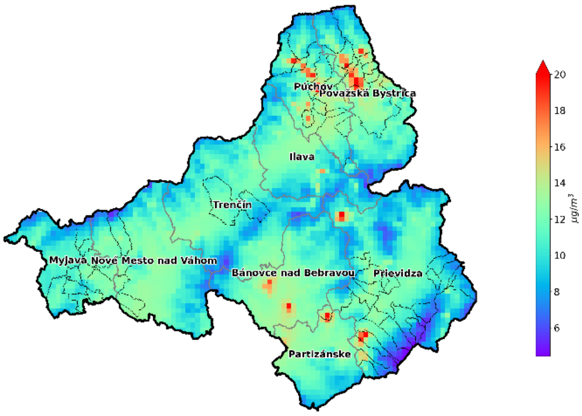
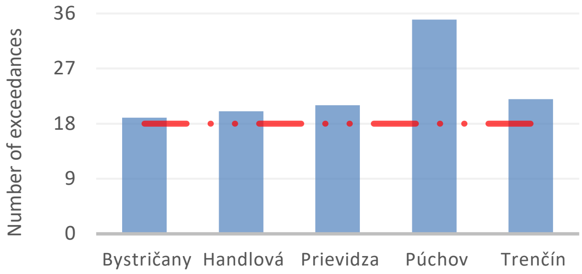


Fig. 3.6 *Number of days with average daily concentration $PM_{2.5}$ > 25 µg·m^{-3} in 2023 – evaluation in view of the newly introduced EU limit*.*



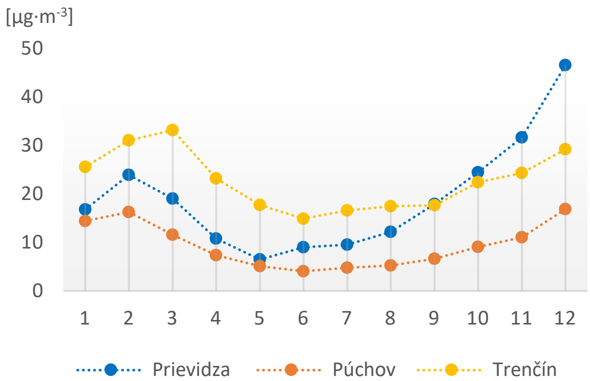
** Under the new EU limit, which will come into force on 1 January 2030, the average daily concentration of $PM_{2.5}$ must not exceed 25 µg·m^{-3} more than 18 times a year.*

3.2 Nitrogen dioxide

Nitrogen dioxide levels in the air are monitored at three stations (Prievidza, Púchov and Trenčín). The average monthly values for each station are shown in **Fig. 3.7**.

The main source of NO_2 emissions is road traffic. The highest concentrations are recorded at the traffic station Trenčín, Hasičská. The average annual level (23 µg·m^{-3}, which represents a year-on-year decrease in concentration by 3 µg·m^{-3}) did not exceed the limit value (40 µg·m^{-3}) here. In Púchov, NO_2 concentrations remained relatively constant throughout the year (in Trenčín and Prievidza higher values were measured in February, March and at the end of the year), with a slight minimum in the summer months. This is due to better dispersion conditions in summer. The average annual concentration at the urban background station in Prievidza, had a value of 19 µg·m^{-3} (year-on-year deterioration by 4 µg·m^{-3}) and in Púchov 9 µg·m^{-3} (year-on-year improvement by 1 µg·m^{-3}). Air pollution with this pollutant was lower here than at other stations in the zone. Overall, NO_2 concentrations in the Trenčín region are at a relatively low level. However, only AMS Púchov met the WHO recommendation (10 µg·m^{-3}) for the annual average NO_2 concentration in 2023, which is significantly stricter than the national and new EU limit (20 µg·m^{-3}, which must be met by 1 January 2030).

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



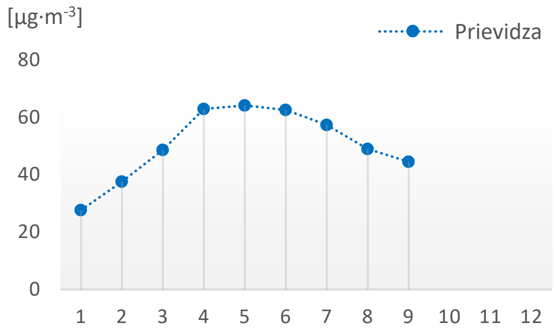
3.3 Ozone

Ozone monitoring is carried out in this zone at the monitoring station in Prievidza.

The highest concentrations of ground-level ozone generally occur in warm months with high sunshine (**Fig. 3.8**). Their values rise with sunrise, peak around noon and gradually decrease in the evening to a minimum that occurs in the morning. Large differences in O_3 concentrations are also observed in the warm and cold seasons.

At the monitoring station in Prievidza, no exceedances of the information or alert threshold for ground level ozone were measured in 2023.

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



3.4 Benzo(a)pyrene

Benzo(a)pyrene (BaP) was measured at two monitoring stations in the Trenčín region in 2023 – in Prievidza on Malonecpalská Street and in Púchov on 1 May Street. The target value (1 ng·m^{-3}) was exceeded by both AMS last year – the average annual concentration reached 1.1 ng·m^{-3} in Prievidza and 1.2 ng·m^{-3} in Púchov, which in the latter case represents a significant reduction compared to the previous year (2.0 ng·m^{-3})(**Tab. 3.2**).

The annual pattern of benzo(a)pyrene concentrations has an even more pronounced maximum in the cold half of the year compared to PM (**Fig. 3.9**). The measured monthly values in February and December are significantly higher in Púchov than in Prievidza. This is probably due to the effect of household heating with solid fuel. Further attention will have to be paid to the locality.

The most significant source of benzo(a)pyrene is household heating with solid fuels (insufficiently dried wood or various types of waste and, in traditionally mining areas, coal). According to the results of the RIO model, the maximum BaP values occur in the Prievidza, Partizánske, Púchov and Bánovce nad Bebravou districts.

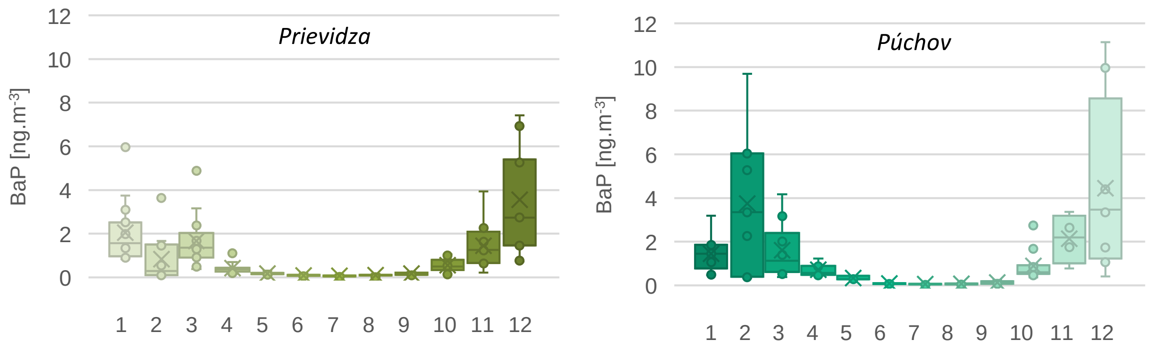
Tab. 3.2 *Average annual concentration of benzo(a)pyrene in 2019 – 2023.*

Target value [ng·m-3]	2019 1.0	2020 1.0	2021 1.0	2022 1.0	2023 1.0
Prievidza, Malonecpalská	1.4	1.2	1.1	*0.9	1.1
Púchov, 1. mája			4.7	2.0	1.2

≥ 90% of valid measurements ** Prievidza – device failure from 24.1. to 21.4.2022.*

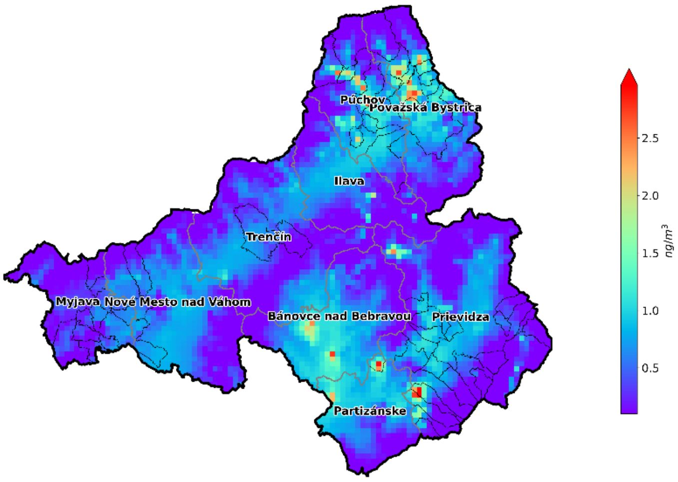
The red colour indicates that the target value has been exceeded in case of sufficient data coverage (≥ 90%) in a given year.

Fig. 3.9 *Average monthly concentrations of benzo(a)pyrene in 2023 at the AMS in Prievidza and Púchov.*



The map in Fig. 3.10 shows the spatial distribution of annual mean BaP concentrations according to the RIO model outputs combined with IDW-R. Due to the orography, it is complicated to obtain a reliable spatial distribution from the interpolation of the measurements (and auxiliary fields). For more detailed information, mathematical modelling with high spatial resolution and detailed information on the spatial and linear distribution of emissions is needed. Therefore, the outputs of the RIO model mainly provide an idea of the relational distribution of annual average BaP concentrations.

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



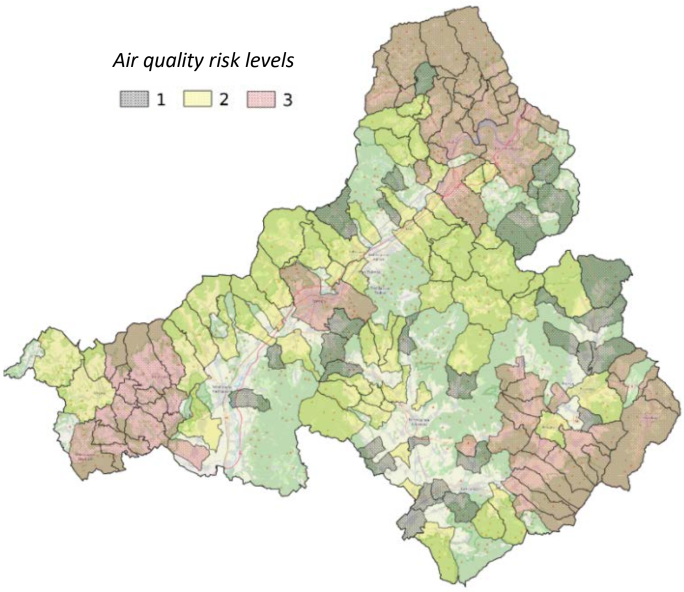
3.5 Risk municipalities

Fig. 3.11 displays municipalities at risk due to deteriorated air quality as determined by the integrated municipal assessment method[3]. Level 3 corresponds to the highest probability of air pollution risk. The methodology includes 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[4].

Zones and agglomerations that include at least one municipality with a risk level 3 will develop an Air Quality Plan. In this regard, municipalities with a risk level 3 correspond to *air quality management areas*. However, measures to reduce emissions 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.

Fig. 3.11 Risk municipalities in zone Trenčín region (2023).



[3] *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*

[4] *https://www.shmu.sk/sk/?page=2773*

The assessment using the integrated assessment method aims to identify areas where action to improve air quality needs to be targeted. 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 updated on the SHMÚ website[5].

3.6 Summary

In 2023, in the zone Trenčín region no exceedance of the limit value for SO_2, NO_2, CO and benzene was measured, nor exceedance of the limit value for the annual average concentration of PM_{10} and $PM_{2.5}$. No monitoring station exceeded the limit value for the number of exceedances of the average daily concentration of PM_{10}. At the measured sites, there was an overall improvement in air quality (the exception is the NO_2 indicator in Prievidza) compared to 2022, most significantly for the PM indicators in Trenčín, Púchov and Handlová. Since 2018, the trend of PM pollution in the zone has a slightly decreasing character, NO_2 concentrations are decreasing in Púchov (measurements since 2021) and Trenčín (since 2016), in Prievidza last year there was an increase observed.

At both stations monitoring air pollution with benzo(a)pyrene – Prievidza and Púchov – the target value was slightly exceeded, while in Púchov the annual concentration was almost halved year-on-year. Based on the results of the mathematical modelling, we can assume that in the zone Trenčín region, high concentrations of PM and benzo(a)pyrene may also occur, especially in winter months, in other areas with unfavourable dispersion conditions and a high share of solid fuels in household heating.

If we were to assess the fulfilment of the requirements resulting from the new Air Quality Directive adopted by the European Parliament in April 2024 (setting stricter limit values applicable from 1 January 2030), the biggest problem in the zone Trenčín region would be the fulfilment of the new limit values for $PM_{2.5}$ and BaP. Annual averages of PM_{10} would meet the 2030 targets for all stations already in 2023, annual averages of $PM_{2.5}$ only for AMS Handlová. Although the level of PM pollution in the region shows a slightly decreasing trend, additional measures will be needed to meet the requirements of the new Directive to help reduce pollution to the required level.

If we assess the air quality according to the WHO recommendations[6], only AMS Handlová and Sereď would meet the recommended concentration values for some pollutants. The ambition of the Zero Pollution Action Plan[7] is to achieve air quality according to these recommendations by 2050.

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

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

[7] *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/*