AIR POLLUTION IN THE SLOVAK REPUBLIC 2024

ANNEX

AIR QUALITY ASSESSMENT IN ZONE TRENČÍN REGION

Emissions and Air Quality Division
SLOVAK HYDROMETEOROLOGICAL INSTITUTE

Bratislava, September 2025
Version 1

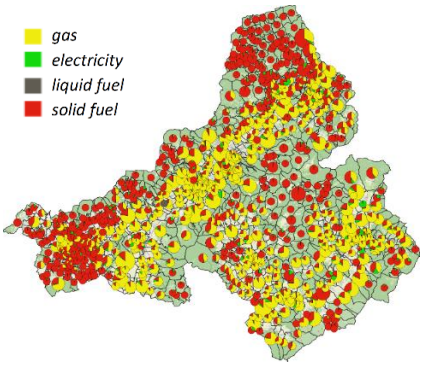
1 DESCRIPTION OF TRENČÍN REGION TERRITORY IN TERMS OF AIR QUALITY

The relief of the Trenčín region is predominantly mountainous, with the exception of the Hornonitriansky Basin, it includes the Myjava Hills and the White Carpathians, partially Považský Inovec, Javorníky, Vtáčnik and Strážovské hills. The highest point is Vtáčnik with an altitude of 1,346 m above sea level, the lowest point is 165 m above sea level. The zone is mostly well ventilated, lower wind speeds occur in the Váh valley.

According to the Statistical Office of the Slovak Republic, the average population density in the Trenčín Region is 126 inhabitants per km² (as assessed as of March 31, 2025).

The **highest population density** is in the **Trenčín District** with 189 inhabitants per km², while the **Bánovce nad Bebravou District** has the **lowest density** in the region with 76 inhabitants per km². For comparison, the Slovak Republic had an average population density of 111 inhabitants per km² on that date. 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 Share of different types of fuel used for heating in the municipalities of the region [1].



Air pollution sources in Trenčín region

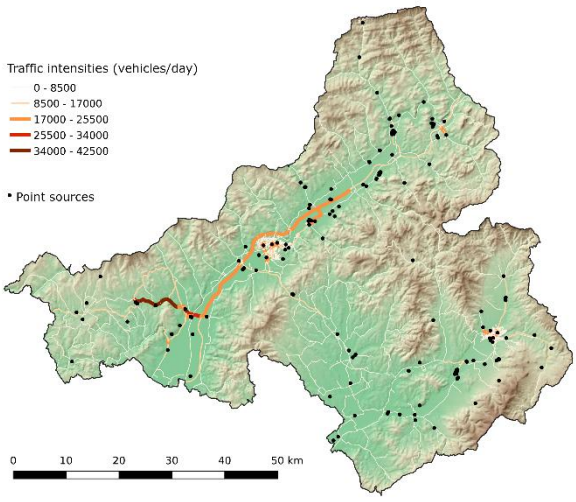
Household heating is the most significant source of air pollution in the mountainous part of the region.

Road transport in the Trenčín Region contributes to air pollution depending on its intensity. The most frequented road sections with the average number of vehicles per 24 hours according to the national transport census 2022 and 2023 are in **Tab. 1.1**. **Fig. 1.1** shows road sections with higher traffic intensity, which were processed by the Transport Research Center (Centrum dopravního výzkumu, CDV) for the year 2024. The map also shows the locations of point sources.

Tab. 1.1 Number of vehicles on the most frequented roads of the Trenčín Region

District	Highway/ road	Number of vehicles	Trucks	Passenger cars
Nové Mesto n. V	**D1**	32 222	7 325	18 967
	54	18 405	2 992	15 289
	515	17 663	3 116	14 467
Trenčín	**61**	33 470	3 240	30 081
Dubnica nad Váhom	**61**	20 271	1 806	18 327
Považská Bystrica	**517**	18 386	2 161	16 088
Púchov	**49**	14 421	1 129	13 233
Partizánske	**64**	14 641	1 806	12 754
Prievidza	**64**	19 944	2 212	17 662
	1774	21 102	1 478	19 516
	9	17 711	3 103	14 526
Myjava	**499**	11 061	1 722	9 256

Fig. 1.2 Road traffic intensity in the Trenčín region. Source: CDV



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

2 AIR QUALITY MONITORING STATIONS IN ZONE TRENČÍN REGION

Air quality in Horná Nitra began to be monitored in 1973. At that time, monitoring stations in **Prievidza, Handlová and Bystričany** were established primarily to monitor the impact of emissions from the thermal power plant at Nováky, but emissions gradually decreased here, and in December 2023 the thermal power plant was finally shut down. Currently, the monitoring stations are mainly focused on the local sources, especially heating of households with solid fuel. There are currently 5 monitoring stations in the zone. In addition to the three mentioned above, these are the monitoring stations in Trenčín and the new station in Púchov, where monitoring began in 2021. The monitoring station in **Trenčín** is focused on the **road traffic**, the intensity of which at a given location is medium. The monitoring station in **Púchov** characterizes **background** pollution values **in the suburban area**.

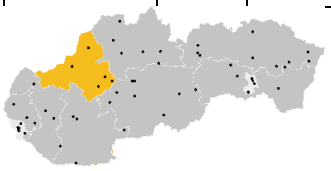
Chyba! Nenašiel sa žiaden zdroj odkazov. contains information on air quality monitoring stations in the zone Trenčín region:

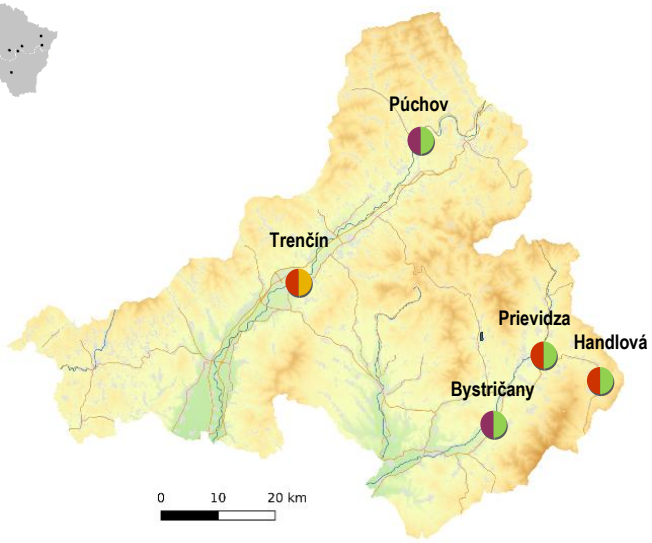
- international EoI code, station characteristics according to the dominant sources of air pollution (traffic, background, industrial), type of monitored area (urban, suburban, rural/regional) and geographical coordinates;
- monitoring programme. Continuous monitoring automatic instruments provide hourly 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, 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	Typ		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											
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

Zone Trenčín region			Monitoring programme																	
					Typ		Geographical			Continuously									Manually	
District	EoI code	Station	area	station	longitude	latitude	altitude [m]	PM_{10}	$PM_{2.5}$	NO, NO_2	SO_2	O_3	CO	Benzene	Hg	As, Cd, Ni, Pb	BaP





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

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

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 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 Trenčín region – 2024.

Pollutant	Type	Protection of human health									IT[2]	AP[2]
		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	Area / station	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	UB	0	0	0	12	7	18	13			25	7
Bystričany, Rozvodňa SSE	SB	0	0			7	18	12			24	9
Handlová, Morovnianska cesta	UB	0	0			6	17	12			23	9
Púchov, 1. mája	SB	0	0	0	9	12	21	17	1 353		40	8
Trenčín, Hasičská	UT	0	0	0	20	15	22	13	2 319	0.5	22	6

≥ 90 % of valid measurements

[1] eight-hour maximum concentration

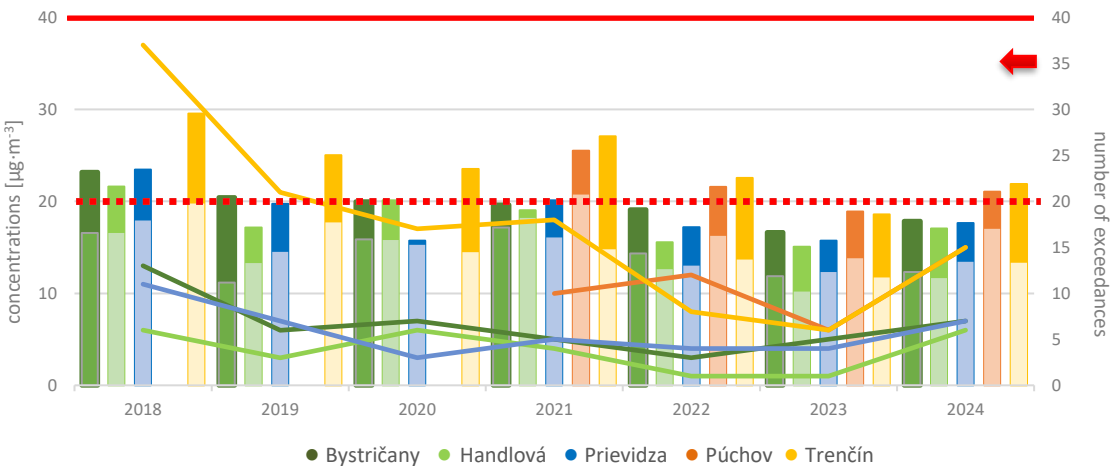
[2] IT, AT – duration of exceedance (in hours) of the information threshold (IT) and alert threshold (AT) for PM_{10}

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. 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 Trnava region in 2018 – 2024.

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}

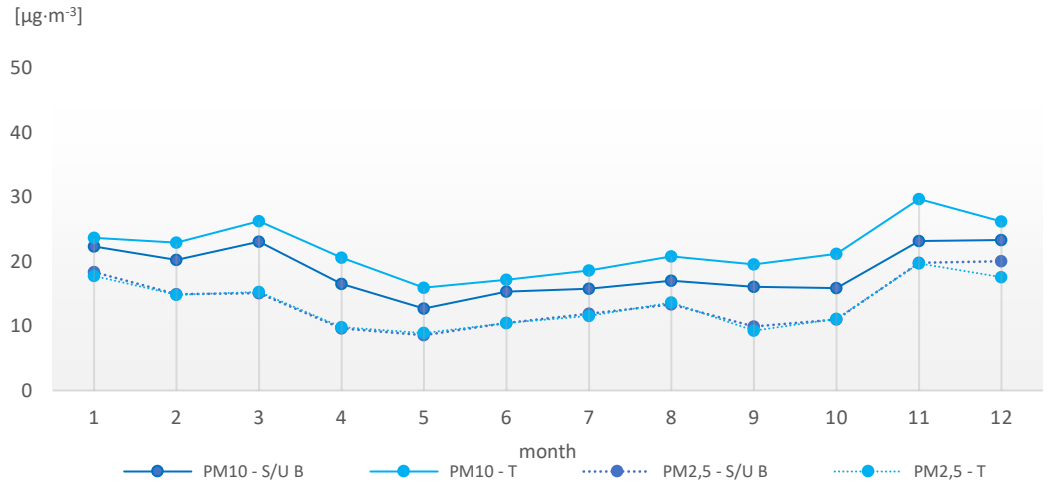


PM_{10} *dark column color,* ***$PM_{2,5}$*** *– light column color;* ***number of exceedances*** *– solid broken lines Horizontal lines show limit values (LH), red solid PM10 (average annual concentration: 40 µg·m^{-3}); red striped $PM_{2.5}$ (average annual concentration: 20 µg·m^{-3}); red solid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

The limit value for the average annual concentration of PM_{10} and $PM_{2.5}$, as well as the limit value for the average daily concentration of PM_{10} in the Trenčín Region zone, **was not exceeded** at any station in 2024. The most days with an average daily concentration of PM_{10} above 50 $\mu g \cdot m^{-3}$ were measured at the Trenčín traffic station (**Fig. 3.1**).

The new EU limit value for the average annual concentration of PM_{10} (20 $\mu g \cdot m^{-3}$), which will need to be achieved in 2030, would not be met by the stations in Trenčín and Púchov.

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

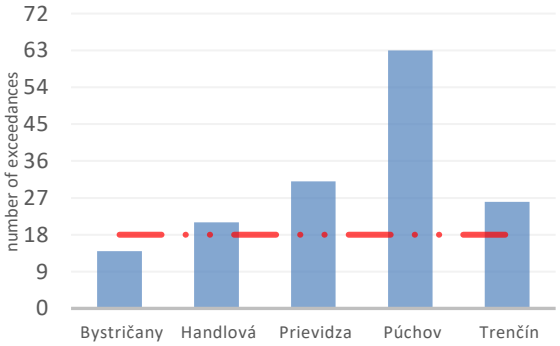


T PM10 *a* ***T PM2.5*** *– monthly average concentrations of PM_{10} and $PM_{2,5}$ at traffic station inTrenčín, Hasičská;* ***U/S B PM10*** *and* ***U/S B PM2.5*** *– average of monthly PM_{10} a $PM_{2,5}$ at urban/ suburban background stations Púchov, 1. mája, Prievidza, Malonecpalská; Bystričany, Rozvodňa SSE and Handlová, Morovnianska cesta.*

Fig. 3.2 shows the monthly averages of PM_{10} and $PM_{2.5}$ concentrations at different types of stations in the zone. PM_{10} concentrations are clearly higher at the traffic station in Trenčín than at the urban background stations. However, according to **Fig. 1.1** also the station in Púchov has comparable PM_{10} levels to Trenčín, which indicates local sources and possible cross-border pollution transfer from Moravia.

$PM_{2.5}$ values at AMS Púchov are significantly higher than at other stations in the zone. This difference is most pronounced in the winter months, which is probably related to intensive solid fuel heating in the area.

Fig. 3.3 *Number of days with average daily $PM_{2.5}$ concentration > 25 $\mu g.m^{-3}$ 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 $\mu g.m^{-3}$ more than 18 times a year*

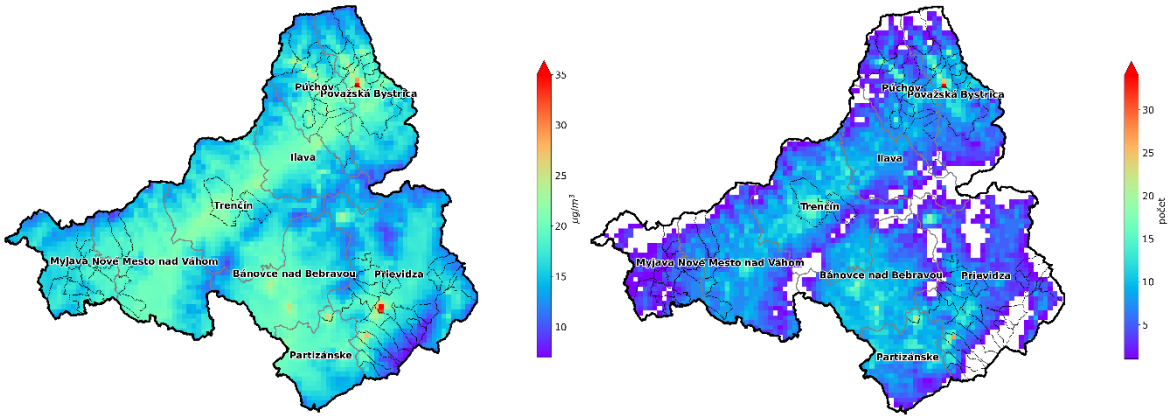
The fine fraction $PM_{2.5}$ has a more significant negative impact on health than PM_{10}. The limit value for the annual average $PM_{2.5}$ (20 $\mu g \cdot m^{-3}$) has not been exceeded in the Trenčín Region since 2017. In 2016, we measured the average annual concentration of $PM_{2.5}$ in Bystričany at the level of 21 $\mu g \cdot m^{-3}$, at a time when the higher limit of 25 $\mu g \cdot m^{-3}$ was still in effect (until 2020). The decrease in $PM_{2.5}$ concentrations in recent years can be attributed, in addition to favorable meteorological conditions, to the gradual decline and in 2023 the termination of the operation of industrial pollution sources in Nováky.

At all stations in the zone, the average annual concentration of fine particles $PM_{2.5}$ was higher than the WHO recommendation (5 $\mu g \cdot m^{-3}$). Also, their monthly concentrations were above 5 $\mu g \cdot m^{-3}$, even in summer, when they are at their lowest.

As illustrated, the new EU limit value for the annual average $PM_{2.5}$ concentration of 10 $\mu g \cdot m^{-3}$ – to be achieved by 1. 1. 2030 – was not met by any station in the zone in 2024.

Fig. 3.4 and **Fig. 3.5** show the modelling results for PM_{10} and $PM_{2.5}$ calculated for 2024 using the RIO model in combination with IDW-R[2]

Fig. 3.4 *Average annual PM_{10} concentration (left) and number of PM_{10} daily limit value exceedances (right) in 2024.*



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

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

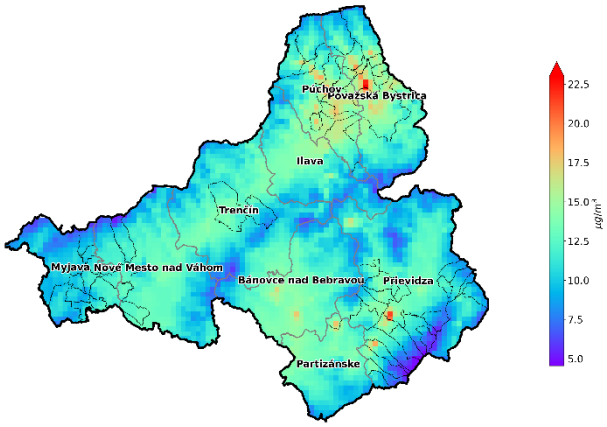
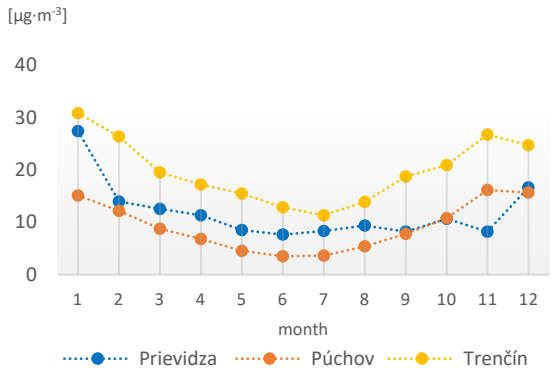


Fig. 3.3 shows the number of exceedances of the daily $PM_{2.5}$ limit value with respect to the new EU limit and the prospective target that EU Member States are to achieve (not exceed) by 1 January 2030 (approved together with other prospective EU limits in April 2024). In this case, the newly introduced EU limit determines that the daily average $PM_{2.5}$ concentration (25 $\mu g \cdot m^{-3}$) should not be exceeded more than 18 times per calendar year. When this commitment as of 1 January 2030 is applied to the results in 2024, we see that all stations in the Trenčín region exceeded the new EU limit except for Bystričany. The suburban background station in Púchov recorded significantly more exceedances (63) than the traffic station in Trenčín (26).

[2] *Metóda je podrobnejšie popísaná v Kapitole 4 Správy o kvalite ovzdušia v SR za rok 2024*

3.2 Nitrogen dioxide

Fig. 3.6 Average monthly NO_2 concentrations.



Nitrogen dioxide is monitored at three monitoring stations: Prievidza, Púchov and Trenčín.

The main source of NO_2 emissions is combustion processes, in urban environments mainly combustion engines in road transport. In the Trenčín region zone, the highest concentrations were measured at the Trenčín, Hasičská traffic station. The limit value for the average annual or hourly concentration of NO_2 was not exceeded at any station in the Trenčín region.

The average monthly values for individual stations are shown in **Fig. 3.6**. NO_2 concentrations are at their minimum in the summer months, similar to PM. This is mainly due to better dispersion conditions in summer. Overall, the measured NO_2 concentrations in the Trenčín Region are relatively low. In 2023 and 2024, only the Púchov AMS met the WHO recommendation (10 µg·m^{-3}) for the average annual NO_2 concentration, which is significantly stricter than the national and new EU limit (valid from 1 January 2030; 20 µg·m^{-3}). The new annual EU limit for NO_2 would be met by all stations in the Trenčín Region in 2024; it should be noted that in Trenčín the annual average NO_2 was at the level of the new EU limit.

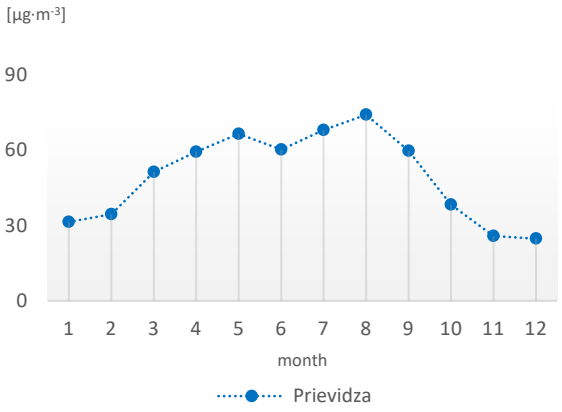
3.3 Ozone

Ozone monitoring takes place in this zone at the monitoring station in Prievidza.

The highest concentrations of ground-level ozone usually occur in warm months with high sunlight intensity (**Fig. 3.7**). Their values rise with sunrise, reach a peak around noon and gradually decrease in the evening to a minimum that occurs in the early morning.

At the monitoring station in Prievidza, we did not record any exceedances of the information or warning threshold for ground-level ozone in 2024.

Fig. 3.7 Average monthly O_3 concentrations.



3.4 Benzo(a)pyrene

In 2024, benzo(a)pyrene was measured in the Trenčín region at two monitoring stations – in Prievidza on Malonecpalská Street and in Púchov on 1. mája Street. The target value (1 ng m^{-3}) was exceeded in 2024 by the station in Púchov, – the average annual concentration in Prievidza reached 0.9 ng·m^{-3} and in Púchov 1.4 ng·m^{-3} (**Tab. 3.2**).

The annual course of benzo(a)pyrene concentrations has an even more pronounced annual course compared to PM, with maxima in the winter months (**Fig. 3.8**). The measured monthly values in Púchov are significantly higher than in Prievidza. This is probably the effect of heating households with solid fuels. The location will need to continue to be given attention.

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
Upper assessment limit	[ng·m^{-3}]	0,6	0,6	0,6	0,6	0,6	0,6	0,6
Lower assessment limit	[ng·m^{-3}]	0,4	0,4	0,4	0,4	0,4	0,4	0,4
Prievidza, Malonecpalská			1,4	1,2	1,1	*0,9	1,1	0,9
Púchov, 1. mája					4,7	2,0	1,2	1,4

≥ 90 % of valid measurements
The exceedance of the target value is marked in red if the station had sufficient (≥90 %) valid measurements in the given year.

Fig. 3.8 Concentrations of benzo(a)pyrene at AMS Prievidza and Púchov in 2024.

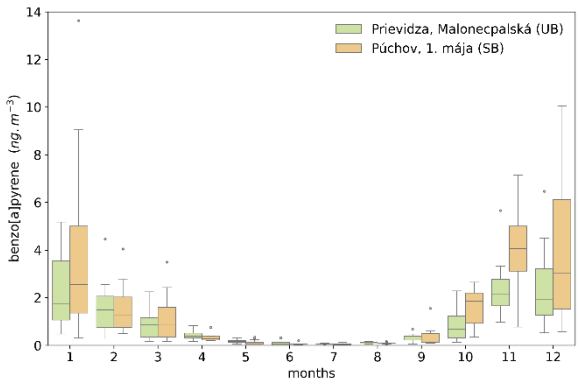
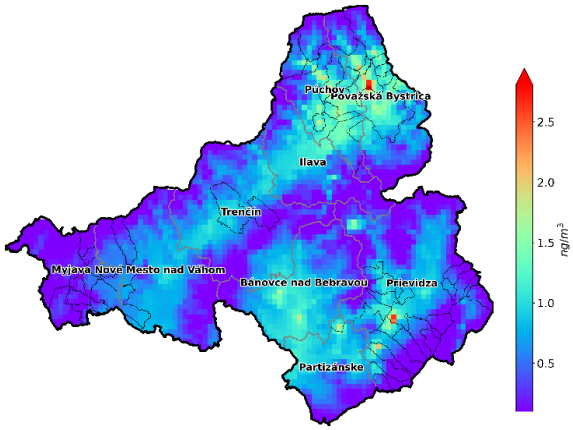


Fig. 3.9 Average annual concentration of BaP. RIO/IDW- R model output, (2024).



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

The map in **Fig. 3.9** shows the spatial distribution of average annual concentrations of benzo(a)pyrene according to the outputs of the RIO model in combination with IDW-R. Due to the complex terrain, it is complicated to obtain a reliable spatial distribution from the interpolation of measurements (and auxiliary fields). For more detailed information, mathematical modeling with high spatial resolution and detailed information on the spatial and temporal distribution of emissions is necessary. The outputs of the RIO model therefore mainly provide an idea of the relative distribution of average annual concentrations of benzo(a)pyrene.

3.5 Risk municipalities

Fig. 3.10 Risk municipalities in zone Trenčín region - 2024.

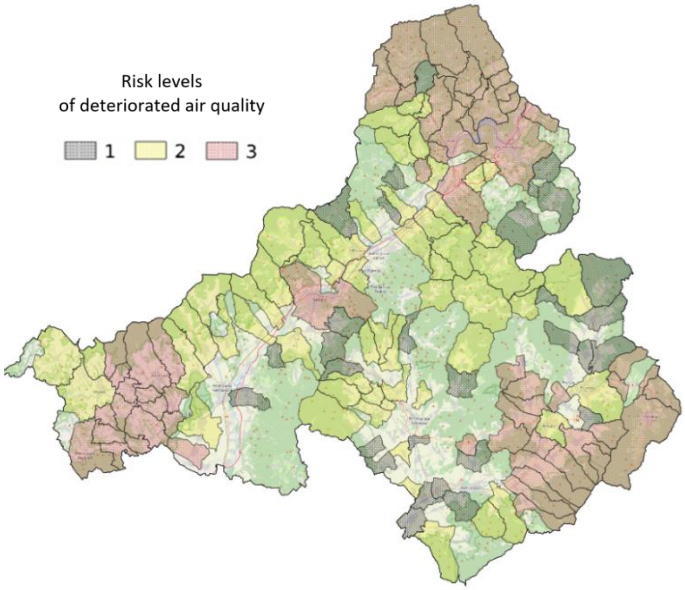


Fig. 3.10 displays municipalities at risk due to deteriorated air quality as determined by the integrated municipal assessment method3. Level 3 corresponds to the highest probability of air pollution risk. The methodology includes the level of household heating with solid fuels, the impact of worsened 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 automati-cally 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 le-vel 3 will develop an Air Quality Plan. In this regard, municipalities with a risk le-vel 3 correspond to *air quality manage-ment areas*. However, measures to re-duce emissions must be implemented in all municipalities within this designa-ted 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 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 2024, no exceedances of the limit values for SO_2, NO_2, CO and benzene were measured in the Trenčín Region zone, nor were the limit values for the average annual concentration of PM_{10} and $PM_{2.5}$ exceeded. No monitoring station exceeded the limit value for the number of exceedances of the average daily concentration of PM_{10}. In the Trenčín Region, similarly to most other locations, there was an increase in the average annual concentrations of PM_{10} and $PM_{2.5}$ and a decrease in NO_2 at all monitoring stations.

The **target value for benzo(a)pyrene was exceeded at the monitoring station in Púchov**. In Prievidza, the average annual concentration fell below the target value in 2024. Based on the results of mathematical modeling, we can assume that in the Trenčín Region zone, high concentrations of PM and benzo(a)pyrene may occur especially in the winter months and in other areas with unfavorable dispersion conditions and a high share of solid fuels for household heating.

[3] *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*

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

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

If we were to assess the compliance with the requirements resulting from the new Air Quality Directive 2024/2881, which sets stricter limit values valid from 1 January 2030, the biggest problem in the Trenčín Region zone would be compliance with the new limit values for $PM_{2.5}$. Three stations would meet the new limit value for the annual average PM_{10} already in 2024, and the annual averages of $PM_{2.5}$ would exceed the new limit value at all stations. In order to meet the requirements of the new directive, it will be necessary to implement additional measures that will help reduce pollution to the required level.