AIR POLLUTION IN THE SLOVAK REPUBLIC 2024

ANNEX

AIR QUALITY ASSESSMENT IN ZONE NITRA REGION

Emissions and Air Quality Division
SLOVAK HYDROMETEOROLOGICAL INSTITUTE

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Version 1

1 DESCRIPTION OF NITRA REGION TERRITORY IN TERMS OF AIR QUALITY

The Nitra region is mostly situated on the Danubian Lowland, partly the Považský Inovec, Tríbeč, Pohronský Inovec and Štiavnické vrchy mountain ranges extend here. The highest point is Panská Javorina (943 m a.s.l.) in the northern part of the zone, the lowest altitude in the Nitra region is around 100 m a.s.l. The area of the region is for the most part well ventilated.

The whole Nitra 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.

According to the Statistical Office of the Slovak Republic, the average population density in the Nitra Region is 105 inhabitants per km² (as assessed as of 31 March 2025).

The **highest population density** is in the **Nitra District** with 189 inhabitants per km², while the **Levice District has the lowest density** in the region with 70 inhabitants per km². For comparison - the Slovak Republic had an average population density of 111 inhabitants per km² on the given date.

The entire Nitra Region is, in terms of air quality assessment, one zone 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 zone Nitra region

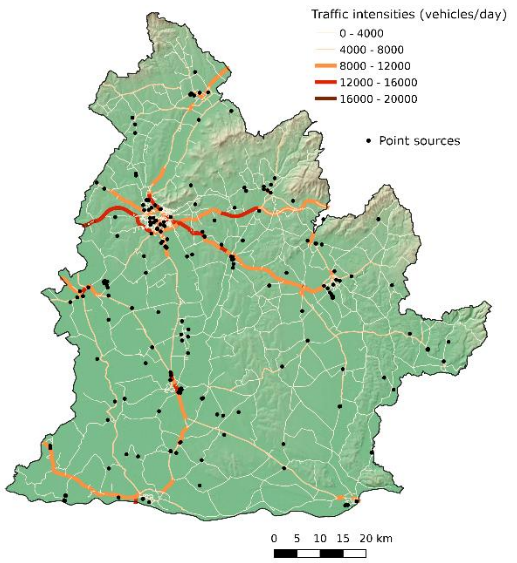
The dominant source of air pollution in the Nitra Region is household heating and, in larger cities, road transport. Mainly natural gas is used for household heating, the share of solid fuels is lower compared to other zones, with the exception of the more mountainous area in the north of the region (according to population census data).

Tab. 1.1 contains the traffic intensity on major roads in the region according to the national transport census in 2022 and 2023). Map on **Fig. 1.1** shows the more frequent road sections, as processed by the Transport Research Centre (Centrum dopravního výzkumu, CDV) for the year 2024.

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

Highway/road	Number of vehicles	Trucks	Passenger cars
R1 Trnava	35 479	7 491	27 941
R1 Nitra	33 116	5 767	27 221
51 Nitra district	24 279	3 309	20 845
51 Levice district	17 229	1 739	15 405
64. Topoľčany district	12 357	1 584	10 703
64 Nitra district	29 816	3 484	26 236
64. Nové Zámky district	16 958	2 683	14 195
64. Komárno district	9 634	1 832	7 753
75 Šaľa district	20 306	2 976	17 187
63 V. Meder – Komárno	19 412	2 746	16 530
č. 564 Levice – Tlmače	14 590	1 567	12 934

Fig. 1.1 *Road traffic intensity in the Trnava region. Source: CDV*[1]

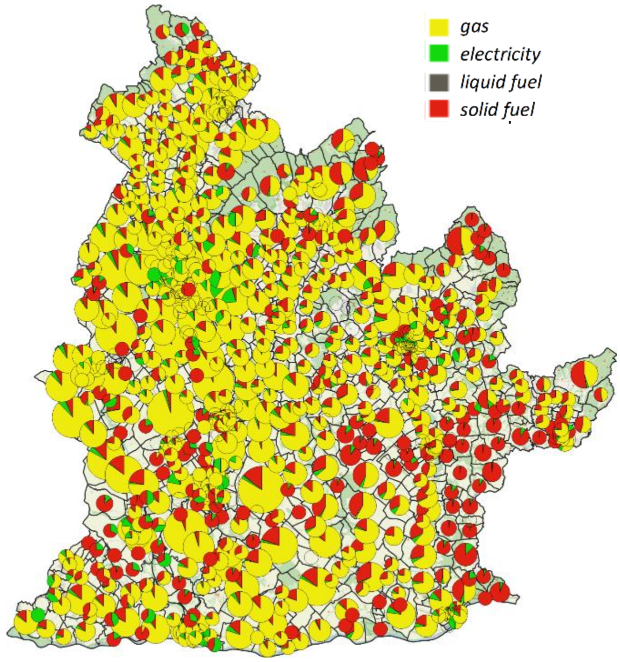


[1] *Zdroj: CDV, spracovanie pre rok 2024*

Industrial sources of air pollution are less significant here in terms of their contribution to local air pollution by basic pollutants; their impact may occur episodically depending on meteorological conditions in the Nitra Region.

Fig. 1.2 shows the shares of fuel types in heating family houses in individual municipalities (or basic settlement units) of the Nitra region. It can be seen that the spatial distribution of fuel types is not geographically homogeneous. In total for the entire zone in 2021, gas heating prevailed in the south-eastern part of the region, while in the area of southern Hont, the southern area of Tekov and Dolna Nitra, heating is almost exclusively with solid fuel.

Fig. 1.2 *Share of different types of fuel used for heating in the municipalities of the region* [2]*.*



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

2 AIR QUALITY MONITORING STATIONS IN ZONE NITRA REGION

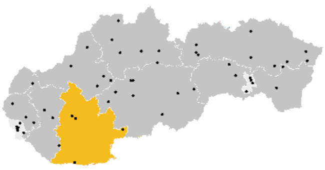
In the Nitra Region, air quality is monitored at 4 stations. The monitoring station Nitra, Štúrova reflects the impact of road traffic approx. 150 meters from the roundabout, the suburban background station is located on the south-eastern edge of the city of Nitra in the district of Nitra, Janíkovce in the school campus. An airport with irregular operations is located approximately 500 m southeast of the monitoring station. The latest additions to the Nitra Region in 2021 were the monitoring stations in Plášťovce and Komárno. The AMS in Komárno is located in a housing estate on Vnútorná Okružná Street, in a location characterizing urban background air pollution. The suburban background AMS in **Plášťovce** - a medium-sized village with mainly family houses, is located in the east of the Nitra Region in the Levice District. Airflow here is influenced by the undulating shape of the terrain, which slopes and opens towards the south, which affects the spread and dispersion of pollutants in the air.

Tab. 2.1 contains information on air quality monitoring stations in the zone Nitra 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 Nitra region.*

Zone Nitra 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	Benzén	Hg	As, Cd, Ni, Pb	BaP
Nitra	SK0269A	Nitra, Štúrova	U	T	18°04'37"	48°18'34"	143										
Nitra	SK0134A	Nitra, Janíkovce	S	B	18°08'27"	48°16'59"	149										
Komárno	SK0064A	Komárno, Vnútorná Okružná	U	B	18°08'19"	47°45'51"	110										
Levice	SK0070A	Plášťovce	S	B	18°58'42"	48°09'35"	149										
							Total	4	4	4	1	3	1	1	0	0	2



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

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

3 ASSESSMENT OF AIR QUALITY IN ZONE NITRA REGION

This chapter contains an assessment of air quality in the zone Nitra 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 Nitra region – 2024.*

Pollutant	Type	Protection of human health									IT[2]	AT[2]
		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						
Nitra, Janíkovce	SB			0	9	6	18	15			22	7
Nitra, Štúrova	UT	0	0	0	24	9	23	13	1 328	0.4	28	9
Komárno, Vnútorná Okružná	UB			0	12	11	20	14			23	5
Plášťovce	SB			0	7	**43**	28	**22**			57	9

≥ 90 % of valid measurements *Červenou farbou je vyznačené prekročenie limitnej hodnoty.*

[1] *eight-hour maximum concentration*

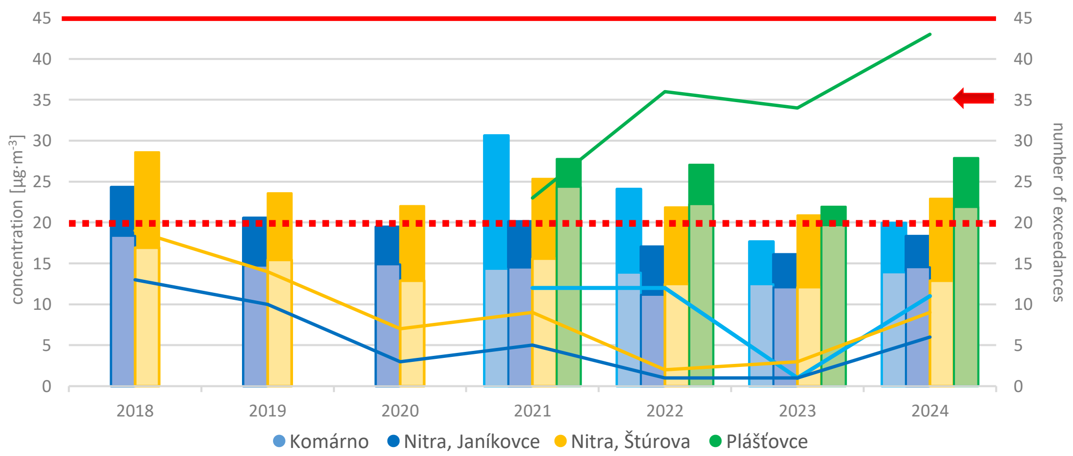
[2] *IT, AT – duration of exceedance (in hours) of the information threshold (IT) and alert threshold (AT) for PM_{10}*

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 Nitra 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 of 40 µg·m^{-3} for the annual average PM_{10} concentration in the Nitra Region zone was not exceeded. The limit value for the number of exceedances (35) of the daily limit value for PM_{10} (50 µg·m^{-3}) was exceeded at the monitoring station in Plášťovce (Fig. 3.1). In 2024, this station also exceeded the limit value for the annual average $PM_{2.5}$ concentration. The situation here, as at most other monitoring stations, was worse than in 2023, when no monitoring station in the Nitra Region exceeded any PM limit values. PM_{10} and $PM_{2.5}$ concentrations in Plášťovce have remained significantly higher than at other stations in the region, as in previous years. The increase in the annual average PM_{10} concentration in 2024 compared to 2023 ranged from about 10% at the traffic station in Nitra (Štúrova Street) to almost 30% at Plášťovce. When comparing the monitoring stations in Nitra, PM_{10} concentrations were higher at AMS Štúrova, whereas $PM_{2.5}$ concentrations were higher at Nitra Janíkovce, reflecting the greater influence of local heating in that area.

In April 2024, the EU adopted Directive 2024/2881 on ambient air quality and cleaner air for Europe. The directive sets new EU limit values for air pollutants and a forward-looking target that Member States are required to meet by 1 January 2030. When comparing the 2024 PM_{10} values with this target (Fig. 3.5), the new EU limit of 20 µg·m^{-3} for the annual average PM_{10} concentration was not exceeded at AMS Nitra, Janíkovce, and Komárno. The remaining two stations exceeded the limit, with AMS Plášťovce exceeding it significantly.

Fig. 3.2 and **Fig. 3.4** show the results of PM_{10} and $PM_{2.5}$ modeling calculated for 2024 using the RIO model subsequently adjusted using the regression IDW-R method (for more details see Chapter 4 of the report Air Polllution in the Slovak Republic for 2024).

In 2024, the highest concentrations of particulate matter (PM) were measured during the heating season in January, November-February and December. In Plášťovce, 10 exceedances of the average daily concentration of 50 µg·m^{-3} were recorded in January and up to 12 in December.

At the turn of March and April, there was a significant episode of Saharan dust transport, which caused the daily limit value to be exceeded for three days at all monitoring stations in the region.

Fig. 3.2 *Average annual PM_{10} concentration (left) and number of PM_{10} daily limit value exceedances (right) in 2024. Output of RIO/IDW-R model.*

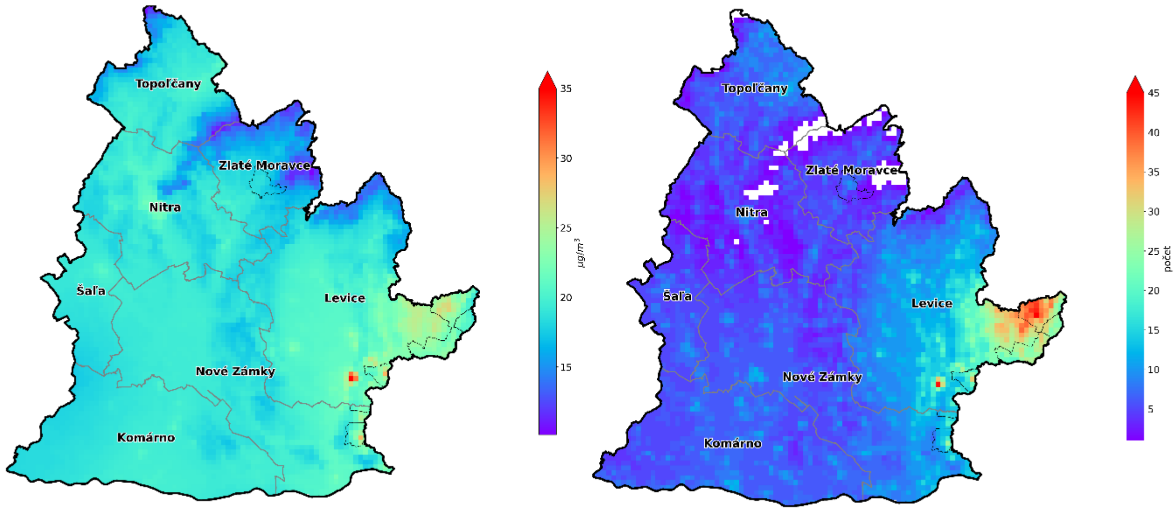
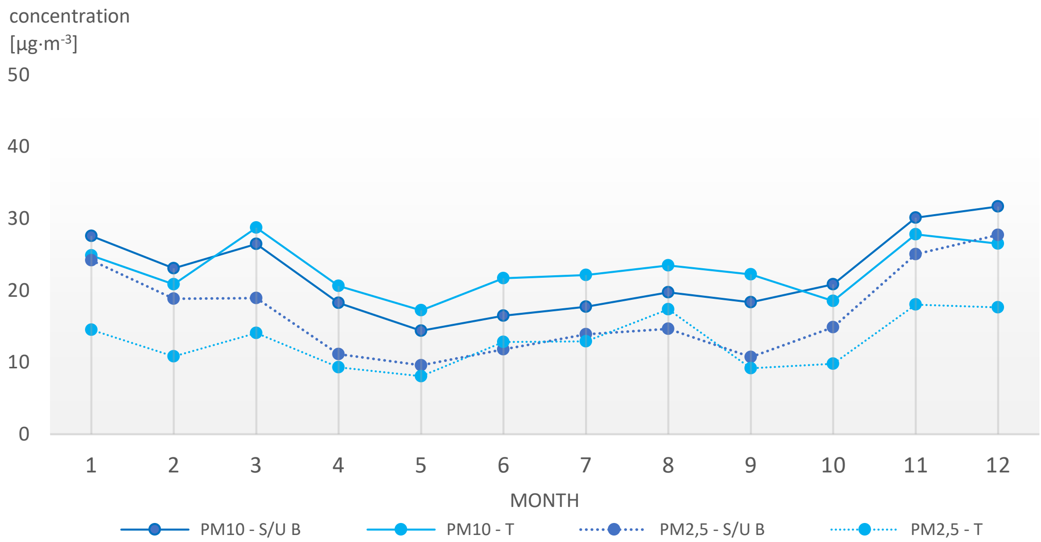
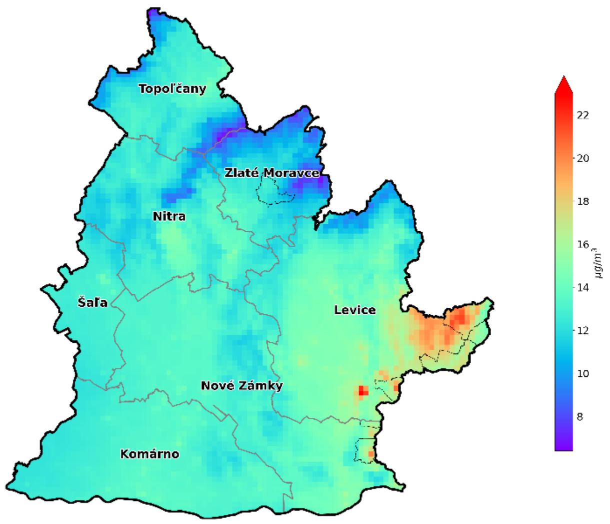


Fig. 3.3 Average monthly concentrations of PM_{10} and $PM_{2.5}$ in the Nitra region by station type.



U/S B PM10 *a* ***U/S B PM2.5*** *– average of monthly concentrations of PM_{10} a $PM_{2,5}$ at urban/suburban stations Nitra, Janíkovce; Komárno a Plášťovce;* ***T PM10*** *a* ***T PM2.5*** *– average monthly concentrations of PM_{10} a $PM_{2,5}$ at traffic station Nitra, Štúrova.*

Fig. 3.4 Average annual concentration of $PM_{2,5}$ in 2024.Output of model RIO/IDW-R.



The graph of monthly average PM_{10} and $PM_{2.5}$ concentrations (

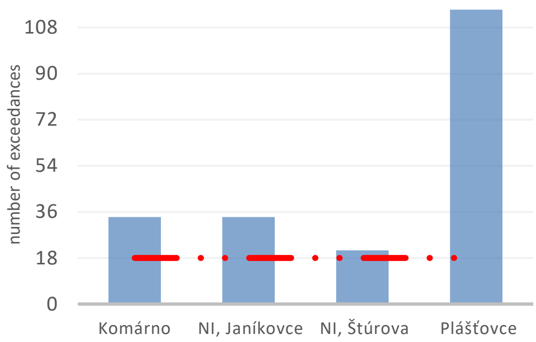
Fig. 3.3) shows high PM_{10} values in March, caused by an episode of Saharan dust transport. Such episodes are typically characterized by pronounced differences between PM_{10} and $PM_{2.5}$ concentrations. In contrast, the influence of residential heating often results in very similar PM_{10} and $PM_{2.5}$ values, as observed at background stations in December.

At all four stations in the zone, the annual average $PM_{2.5}$ concentration exceeded the WHO guideline[3] value (up to 5 µg·m⁻³). This was also the case for all monthly concentrations. Even during the summer months, when $PM_{2.5}$ levels are usually lower, the monthly averages at all AMS stations were more than twice the WHO guideline.

The map in **Fig. 3.4** 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 shows $PM_{2.5}$ concentrations in relation to the forward-looking target and the new EU limit that Member States are required to meet by January 2030. This limit, adopted together with other forward-looking EU limits in April 2024, stipulates that the daily average $PM_{2.5}$ concentration (25 µg·m⁻³) must not be exceeded more than 18 times per calendar year. If we apply this 2030 commitment to the 2024 results, we see that none of the AMS stations in the region would have met the new limit. In Plášťovce (115 exceedances), the number of exceedances was more than six times the new limit; in Komárno (34 exceedances), it was almost twice the limit. The monitoring stations in Nitra (34 and 21 exceedances) also did not comply with the new limit, unlike in 2023.

Fig. 3.5 *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 PM2.5must not exceed 25 µg.m⁻³ more than 18 times a year .*

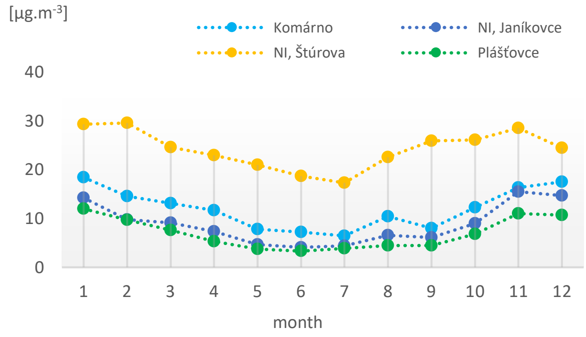
The new EU limit value of 10 µg.m⁻³ for the average annual concentration of $PM_{2.5}$ was not met by any station in the zone in 2024.

3.2 Nitrogen dioxide

[3] *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*

Monitoring of nitrogen dioxide (NO_2) in the zone is carried out at four stations, with monthly average values for each station shown in **Fig. 3.6** NO_2 concentrations are slightly lower in the summer months. In general, NO_2 values in the Nitra region are relatively low.

Fig. 3.6 Average monthly NO_2 concentrations - 2024.



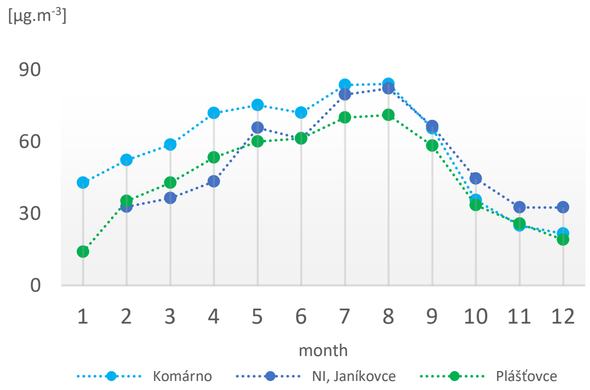
The main source of NO_2 emissions is road traffic. For this reason, the highest concentrations are recorded at the traffic station AMS Nitra, Štúrova, where the annual average NO_2 concentration was 24 $\mu g \cdot m^{-3}$. The current limit value of 40 $\mu g \cdot m^{-3}$ was not exceeded. However, the new EU limit value of 20 $\mu g \cdot m^{-3}$ for the annual average concentration, applicable from 2030, would have been exceeded at this station.

The annual average concentrations measured at the Plášťovce station (7 $\mu g \cdot m^{-3}$) and at Nitra, Janíkovce (9 $\mu g \cdot m^{-3}$) comply with the new EU limit as well as with the WHO guideline value of 10 $\mu g \cdot m^{-3}$, which is significantly stricter than the EU limits.

3.3 Ozone

In the Nitra Region zone, ozone is monitored at the monitoring stations Komárno, Plášťovce and Nitra, Janíkovce.

Fig. 3.7 Average monthly O_3 concentrations - 2024.

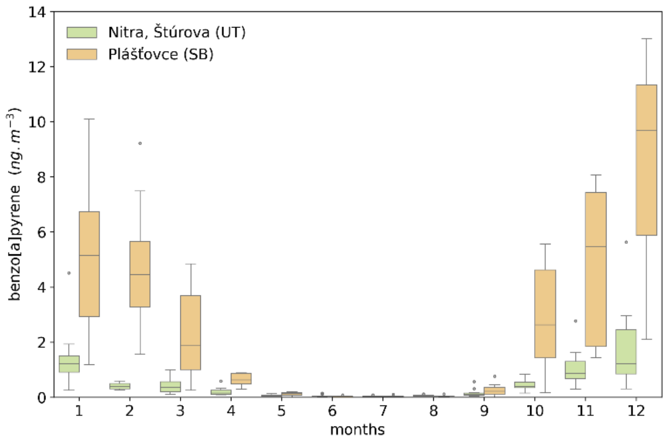


The highest concentrations of ground-level ozone usually occur during periods of high sunlight intensity (**Fig. 3.7**). Their values rise with sunrise, peak around noon and gradually decrease in the evening to a minimum that occurs in the morning. Large differences in ground-level ozone concentrations are recorded in warm and cold periods. In the zone, in 2024, we did not record any exceedance of the information or warning threshold for ground-level ozone, unlike in 2023, when an exceedance was measured in Komárno.

3.4 Benzo(a)pyrene

Benzo(a)pyrene is monitored in the Nitra Region at the traffic station in Nitra on Štúrová Street and in Plášťovce. The annual concentration trend has an even more pronounced maximum in the cold months compared to PM particles **Fig. 3.8**.

Fig. 3.8 Concentrations of benzo(a)pyrene in 2024.



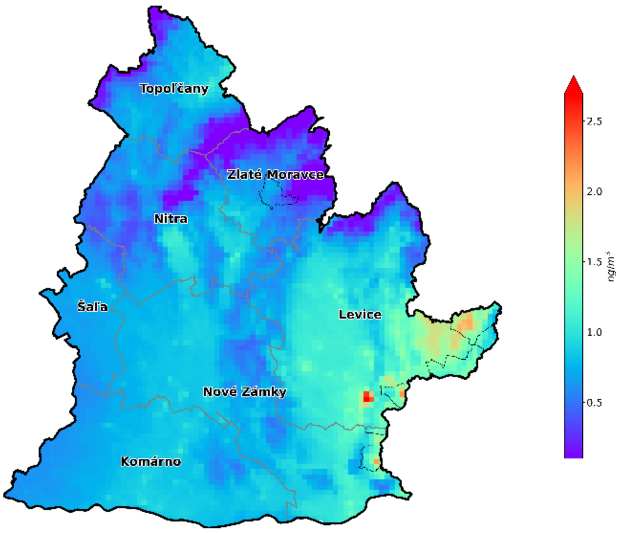
In Plášťovce, the average annual value was 2.2 ng·m^{-3} in 2024. Although the required proportion of valid measurements (90%) was not achieved in Plášťovce, the measurement failure occurred during the heating season in December, so we assume that the average annual concentration with full coverage of the year would only be higher. We consider the target value for BaP to have been exceeded in Plášťovce in 2024 (**Tab. 3.2**).

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

	2018	2019	2020	2021	2022	2023	2024
Cieľová hodnota [ng·m-3]	1,0	1,0	1,0	1,0	1,0	1,0	1,0
Nitra, Štúrova	0,9	0,8	0,6	0,8	0,6	0,5	0,5
Plášťovce				2,2	2,4	2,7	*2,2

≥ 90 % of valid measurements *80 % of valid measurements in 2024

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



The most significant source of benzo(a)pyrene is household heating with solid fuels, especially insufficiently dried wood, or unsuitable fuels (various types of waste). **Fig. 3.9** shows the spatial distribution of the average annual concentration of benzo(a)pyrene according to the outputs of the RIO model in combination with IDW-R. To obtain more detailed outputs, mathematical modeling with high spatial resolution and detailed temporal and spatial distribution of emissions is necessary. In areas with a high share of solid fuels in household heating and unfavorable dispersion conditions in the winter months, air pollution with benzo(a)pyrene represents a potential problem.

3.5 Risk municipalities

Fig. 3.10 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 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 [5].

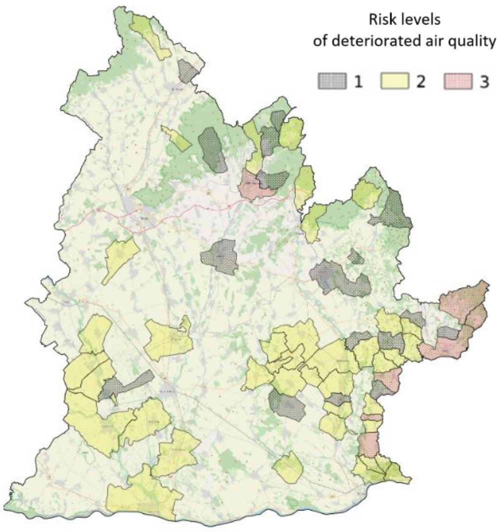
[4] *Štefánik, D., Krajčovičová, J.: Metóda integrovaného posúdenia obcí vzhľadom na riziko nepriaznivej kvality ovzdušia, Slovenský hydrometeorologický ústav, 2023, dostupné na https://www.shmu.sk/sk/?page=996*

[5] *https://www.shmu.sk/sk/?page=2919*

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.

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[6].

Fig. 3.10 *Risk municipalities in zone Nitra region (2024).*



3.6 Summary

In 2024, PM_{10} concentrations at all stations in the Nitra Region increased compared to 2023. NO2 concentrations decreased slightly at all stations, except for the transport station in Nitra on Štúrová Street, where an increase in the average annual NO_2 concentration of approximately 10% was recorded in 2024 compared to 2023.

In 2024, no exceedances of the limit values for SO_2, NO_2, CO and benzene were measured in the Nitra Region zone. The limit value for the average annual concentration of PM_{10} was not exceeded at any monitoring station. **The limit value** for the average daily concentration **of PM_{10} and the average annual concentration of $PM_{2.5}$ was exceeded by the station in Plášťovce**..

The target value for **benzo(a)pyrene was exceeded at the Plášťovce** station in 2024. Although we can assume that in the Nitra region zone, higher concentrations of PM and benzo(a)pyrene will occur mainly in the winter months and in other areas, the nature of the region is predominantly flat and is characterized by mostly good ventilation, which slightly reduces this risk. Areas with unfavorable dispersion conditions and a high share of solid fuels in household heating may be problematic.

If we were to evaluate the fulfillment of the r**equirements (valid from 1/1/2030) resulting from the new directive on air quality 2024/2881**, in the Nitrian Region zone the greatest problem would be the fulfillment of the new limit values for $PM_{2.5}$. **No station** in the Nitra region would meet **the new EU limit for** the annual average **$PM_{2.5}$**. Two stations met the new limit value for the average annual PM_{10} concentration in 2024.

The values of PM particulate pollution in the region depend not only on emissions, but also on meteorological conditions, as was clearly shown in 2024, and on natural sources - such as the long-range transport of desert dust. Although it is unlikely that episodes of desert dust transport would gain as much intensity in subsequent years as the rare year 2024 in this respect.

Episodes with long-lasting adverse dispersion conditions, such as occurred in late 2024, can be expected in the coming years. The situation is often exacerbated by low precipitation - the exception was 2023, which had above-average precipitation and was also more favorable in terms of air quality. To meet the requirements of the new directive, additional measures will need to be taken to reduce pollution to the required level.

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