AIR POLLUTION IN THE SLOVAK REPUBLIC
2022

ANNEX

AIR QUALITY ASSESSMENT IN ZONE TRNAVA REGION

Air quality monitoring department
SLOVAK HYDROMETEOROLOGICAL INSTITUTE

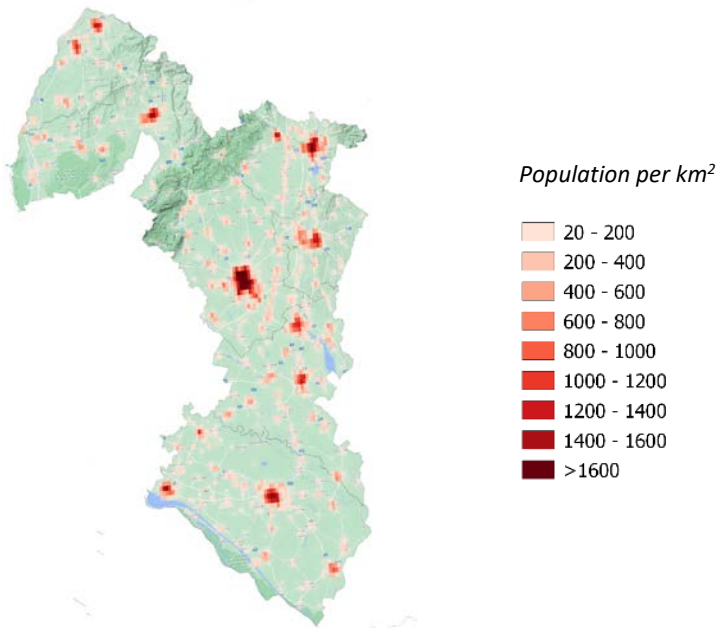
Bratislava, October 2023
Version 1

1 DESCRIPTION OF TRNAVA REGION TERRITORY IN TERMS OF AIR QUALITY

The Trnava region is predominantly lowland and hilly in character. Its two important lowlands – the Danube and Záhorie – are separated by the Little Carpathians, which have a significant influence on the air flow. In the north-western part of the region, an outcrop of the Považský Inovec Mountains extends into the territory of the region. The highest point of the region is Záruby in the Liitle Carpathians with an altitude of 768 m above sea level, but the majority of this zone lies below 200 m above sea level. Larger closed basins do not occur in the Trnava region. **Fig. 1.1** shows the spatial distribution of population density in the zone.

The whole Trnava 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 Trnava region (Source: EUROSTAT, 2018).*



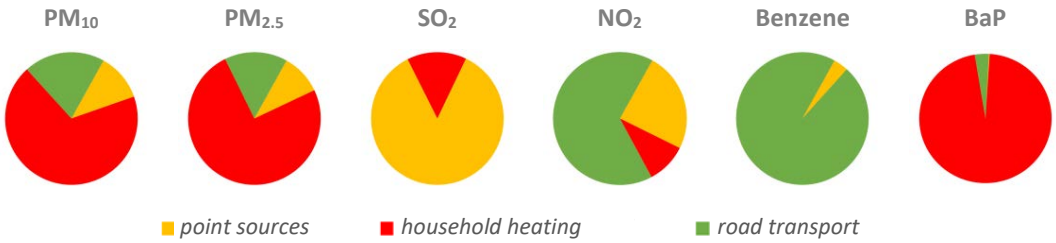
Air pollution sources in zone Trnava region

According to the latest census data, natural gas is mainly used for heating of households in this zone. The share of solid fuels here is among the lowest compared to other zones, while the consumption of firewood is slightly higher in the more mountainous area of the Small Carpathians.

Road transport in the Trnava region contributes to air pollution mainly on these roads – on the section of the D1 highway in front of Trnava in the direction from Bratislava (54 519 vehicles on average daily, 7 615 trucks and 46 881 cars) and the R1 high speed road Trnava – Sereď (39 058 vehicles on average daily, 7 449 trucks and 31 599 cars). Apart from highways and motorways, the highest intensity of road traffic in this region is on the Trnava bypass – road No. 61 (25 111 vehicles on average daily, 2 806 trucks and 22 242 cars), the part of road No. 51 from Trnava to Senica (16 915 vehicles, 2 586 trucks and 14 270 cars), on the road No. 426 Holíč-Skalica (14 422 vehicles, 1 712 trucks and 12 686 cars), on the road No. 499 connecting Piešťany and Vrbové (14 590 vehicles, 1 665 trucks and 12 855 cars), the part of the road No. 63 near Šamorín from the direction of Dunajská Streda – Veľký Meder (12 914 vehicles, 1 991 trucks and 10 849 cars) and on the road No. 513 from Hlohovec westwards (12 507 vehicles daily, 2 450 trucks and 10 004 cars)[1].

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

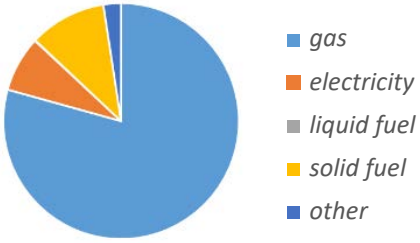
Fig. 1.2 *Share of different types of air pollution sources in total emissions in the Trnava region.*



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 important here in terms of their contribution to local air pollution from basic pollutants.

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 mainly used for heating in family houses in the zone. Solid fuels are more likely to be used in rural settlement types with good availability of firewood.

2 AIR QUALITY MONITORING STATIONS IN ZONE TRNAVA REGION

In the Trnava region, air quality is monitored at 4 stations. In Trnava, on a busy road (Kollárova street), near the train station, we observe the impact of traffic. Another traffic station is located in the north-western part of the region in the district town of Senica. The monitoring station in Sereď is a representative of the urban background and is located in a housing estate of concrete high-rise blocks. There is a rural background station with the lowest altitude in the cadastre of the village Topoľníky, near the Klátov river arm, belonging to the EMEP network in Slovakia. It monitors the impact of long-range air pollution transport on the territory of Slovakia, as well as other monitoring stations included in the EMEP monitoring network (see Chapter 2 of *Air pollution in the Slovak Republic 2022 Report*).

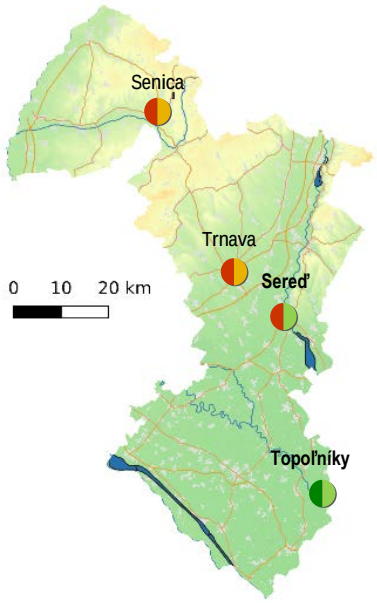
Tab. 2.1 contains information on air quality monitoring stations in the zone Trnava region:

- 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 values of. The exception is the EMEP station Topoľníky, whose monitoring programme is described in **Tab. 2.1**.

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

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

Zone Trnava region								Measurement programme									
								Continuously								Manually	
District	EoI code	Station name	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
Dunajská Streda	SK0007R	Topoľníky, Aszód, EMEP	R	B	17°51'37"	47°57'34"	113									*	
Senica	SK0021A	Senica, Hviezdoslavova	U	T	17°21'47"	48°40'51"	212										
Trnava	SK0045A	Trnava, Kollárova	U	T	17°35'06"	48°22'17"	152										
Sereď	SK0063A	Sereď, Vinárska	U	B	17°44'07"	48°17'01"	130										
							Total	4	4	3	2	1	1	1	1	2	1



* *Monitoring of heavy metals at the station Topoľníky 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 Topoľníky monitoring station characterises the regional background level of pollution. It is 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 the EMEP station Topoľníky in 2022 is presented in **Tab. 2.2**. Heavy metals are analysed from weekly samples (sampling duration is 7 days).

Tab. 2.2 *Measuring program at the EMEP station Topoľníky.*

	Ozone (O_3)	PM_{10}	Lead (Pb)	Arsenic (As)	Cadmium (Cd)	Nickel (Ni)	Chromium (Cr)	Copper (Cu)	Zinc (Zn)
Topoľníky	x	x	x	x	x	x	x	x	x

[3] *https://www.emep.int*

The sampling interval of precipitation (**Tab. 2.3**) for heavy metal analysis is the calendar month. Heavy metals occur at lower concentrations at this site. A wet-only rain gauge is used to collect precipitation, which records only precipitation (the gauge is closed during periods when no precipitation occurs). Wet deposition is assessed by analysing the samples thus collected.

Tab. 2.3 *Precipitation measurement programme at EMEP station Topoľníky.*

	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)	Copper (Cu)	Zinc (Zn)
Topoľníky	x	x	x	x	x	x	x	x	x	x	x	x	x	x

3 ASSESSMENT OF AIR QUALITY IN ZONE TRNAVA REGION

This chapter contains an assessment of air quality in the zone Trnava 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 Trnava 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						
Senica, Hviezdoslavova	0	0			2	19	14			0	0
Trnava, Kollárova			0	28	4	21	13	1 018	0.78	0	0
Topoľníky, Aszód, EMEP	0	0	0	5	3	17	13			13	4
Sereď, Vinárska			0	13	6	19	12			0	0

≥ 90% of valid measurements

[1] *eight-hour maximum concentration*

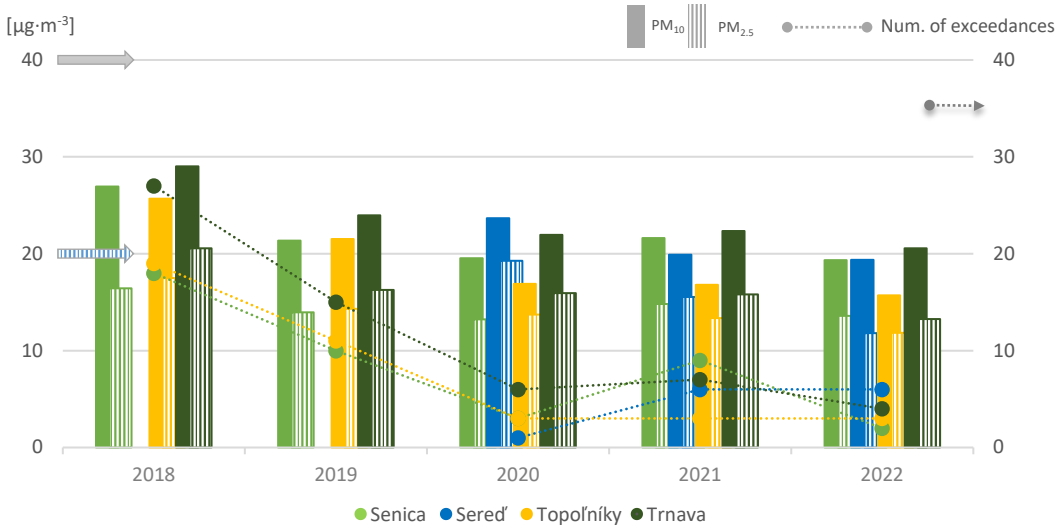
[2] *IT, AT – duration of exceedance (in hours) of the information threshold (IT) and alert threshold (AT) for PM_{10}*

In accordance with Decree No 244/2016 Coll. of the Ministry of the Environment of the Slovak Republic on air quality, as amended, the required proportion of valid values has been 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 $\mu g \cdot m^{-3}$ according to the results of measurements at monitoring stations in the Trnava 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 – daily average concentrations higher than 50 $\mu g \cdot m^{-3}$;

*Arrows show the limit values, **blue striped** $PM_{2.5}$ (average annual concentration: 20 $\mu g \cdot m^{-3}$**); grey solid** PM_{10} (average annual concentration: 40 $\mu g \cdot m^{-3}$); **grey dotted right** number of exceedances (average daily PM_{10} concentration of 50 $\mu g \cdot m^{-3}$ must not be exceeded more than 35 times in a calendar year).*

PM_{10}

The limit value for the annual average concentration of PM_{10} (40 $\mu g \cdot m^{-3}$) in the zone Trnava region was not exceeded. Similarly, the limit value for the number of exceedances (35) of the average daily limit concentration of PM_{10} (50 $\mu g \cdot m^{-3}$) was not exceeded by any station (**Fig. 3.1**).

The annual average PM_{10} concentration at the traffic stations Trnava, Kolárova was 21 $\mu g \cdot m^{-3}$ (22 $\mu g \cdot m^{-3}$ the year before) and Senica, Hviezdoslavova was 19 $\mu g \cdot m^{-3}$ (a significant year-on-year decrease of 3 $\mu g \cdot m^{-3}$). At the urban background station in Sereď, we measured the annual average concentration the same as at the traffic station in Senica (19 $\mu g \cdot m^{-3}$). As expected, PM_{10} concentrations were lowest at the high altitude background station in Topoľníky, but even here we do not meet the WHO recommendations (annual average PM_{10} up to 15 $\mu g \cdot m^{-3}$).

Fig. 3.2 shows the modelling results for PM_{10}, calculated for 2022 using the RIO model subsequently adjusted using the regression IDW method (see Chapter 4 of *Air pollution in Slovak Republic 2022 Report* for more details). Based on the model outputs, we can assume that the highest annual average concentrations may occur mainly in the municipalities of the Trnava, Hlohovec and Piešťany districts.

Fig. 3.1 *Number of PM_{10} daily limit value exceedances per month in 2022.*

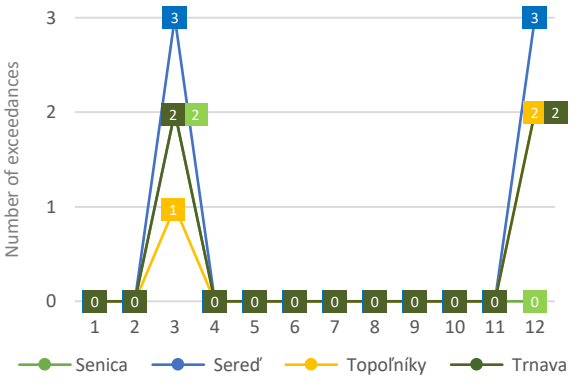


Fig. 3.2 *Average annual PM_{10} concentration (left) and number of exceedances of the PM_{10} daily limit value (right) in 2022.*

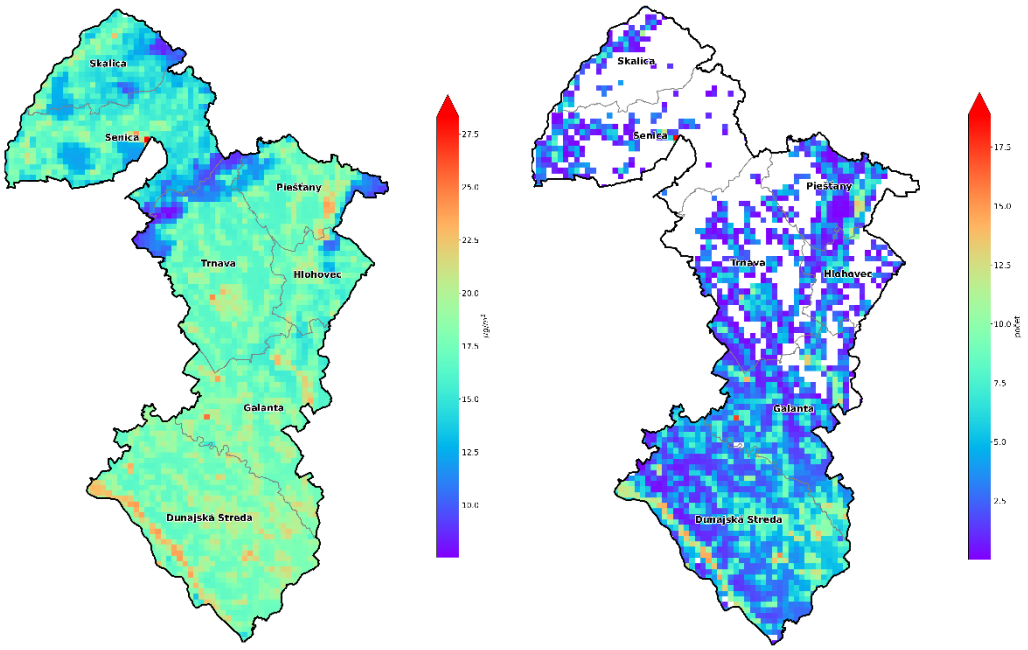
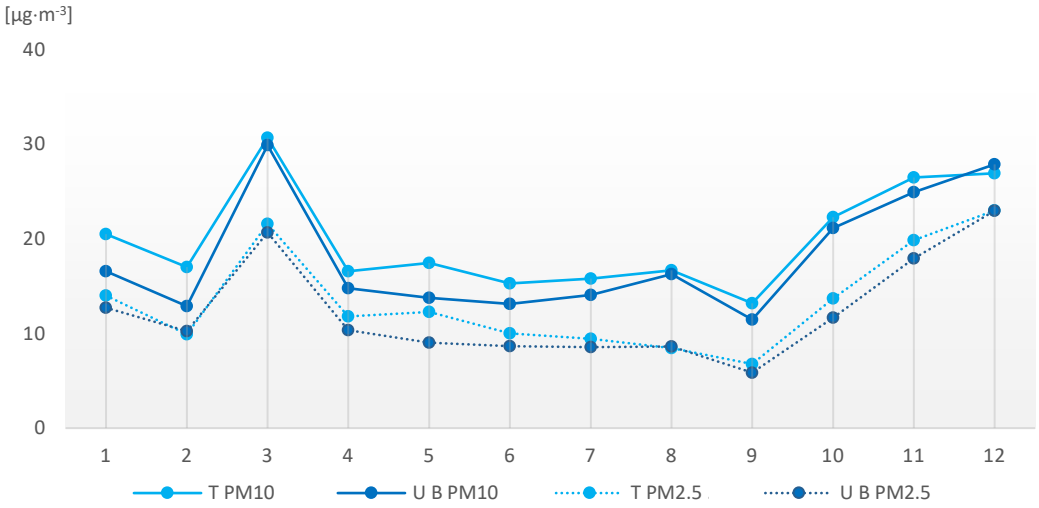


Fig. 3.2 *Average monthly concentrations of PM_{10} and $PM_{2.5}$ in the Trnava region by station type.*



T PM10 *and* ***T PM2.5*** *– average monthly concentrations of PM_{10} and $PM_{2.5}$ at Trnava, Kollárova and Senica, Hviezdoslavova traffic stations;* ***U B PM10*** *and* ***U B PM2.5*** *– monthly concentrations of PM_{10} and $PM_{2.5}$ at the urban background station Sereď, Vinárska.*

Both traffic stations in the zone have similar average monthly concentrations of PM_{10} and $PM_{2.5}$. **Fig. 3.2** compares their average monthly concentrations with the monthly PM_{10} and $PM_{2.5}$ concentrations at the urban background station in Sereď.

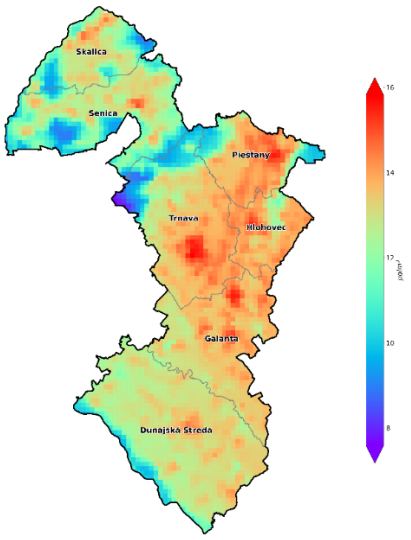
Compared to the other zones, the average monthly PM_{10} concentrations show less seasonal differences between the cooler and warmer months. This is because solid fuel heating, which is a significant source of particulate matter emissions, is not dominant in the zone and dispersion conditions are mostly favourable.

$PM_{2.5}$

Increased concentrations of $PM_{2.5}$ are particularly risky, mainly because of their unfavourable effects on human health. Fig. 3.1 shows $PM_{2.5}$ concentrations depicted by the dashed line. In the zone Trnava region, they (as well as PM_{10}) do not have such a pronounced seasonal pattern as monitoring stations elsewhere in Slovakia. At the rural background station in Topoľníky, where we measure the lowest $PM_{2.5}$ concentrations in the zone, we recorded an annual average concentration higher than the WHO recommendations (5 $\mu g \cdot m^{-3}$). This recommendation was not met in any month of the year, not even in summer, when monthly $PM_{2.5}$ concentrations tend to be lowest.

Map on Fig. 3.3 illustrates the spatial distribution of average annual concentrations of $PM_{2.5}$ according to the output of the RIO model in combination with the IDW-R model.

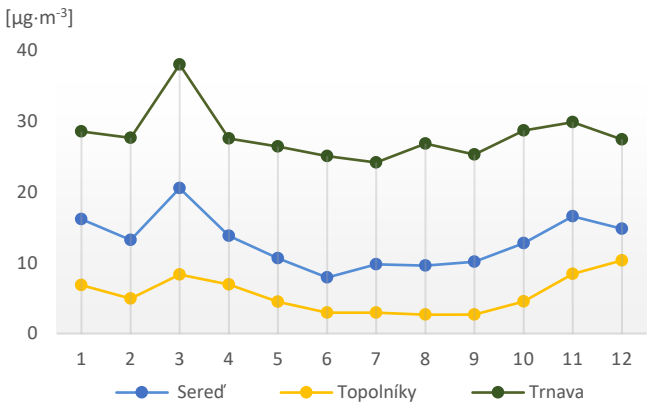
Fig. 3.3 Average annual $PM_{2.5}$ concentrations.



3.2 Nitrogen dioxide

Nitrogen dioxide monitoring is carried out at three stations in the zone, the average monthly values for each station are shown in Fig. 3.4.

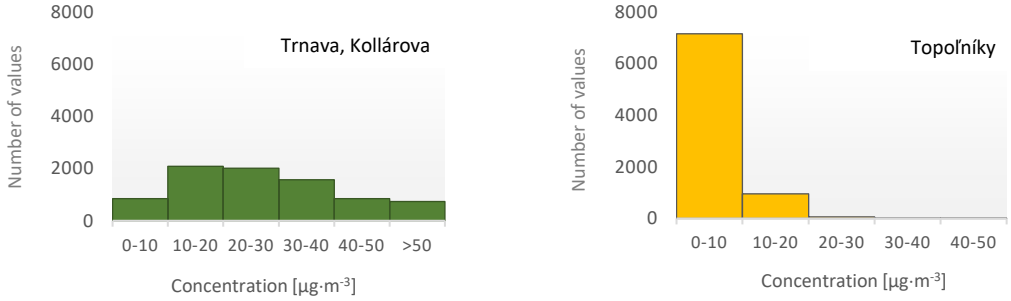
Fig. 3.4 Average monthly NO_2 concentrations.



The main source of NO_2 emissions is road transport. The highest concentrations for this reason are recorded at the traffic station in Trnava. The highest annual average level (28 $\mu g \cdot m^{-3}$) does not exceed the limit for the annual average concentration (40 $\mu g \cdot m^{-3}$). The measured values maintain a relatively constant level throughout the year, with an insignificant minimum in the summer months. The average annual concentrations at the rural background station Topoľníky were 5 $\mu g \cdot m^{-3}$. Overall, NO_2 concentrations in the Trnava region are at relatively low levels. Nevertheless, the only station that met the WHO recommendations (up to 10 $\mu g \cdot m^{-3}$) is Topoľníky. The maximum hourly NO_2 concentration reached at the Trnava traffic station was 153 $\mu g \cdot m^{-3}$ (22 March 2022 at 18:00). The maximum measured NO_2 concentration at the Topolníky background station was 46 $\mu g \cdot m^{-3}$ (22 March 2022 at 23:00). Both extremes are likely due to unfavourable dispersion conditions during the anticyclonic situation.

Fig. 3.5 shows the different frequency distribution of hourly NO_2 concentrations at two types of stations – the traffic station in Trnava and the regional (rural) background station in Topoľníky. While in Trnava we measured 739 values (9%) higher than 50 $\mu g \cdot m^{-3}$, in Topoľníky none and only three values above 40 $\mu g \cdot m^{-3}$.

Fig. 3.5 *Histogram of hourly NO_2 concentrations in Trnava and Topoľníky.*



3.3 Ozone

Ozone monitoring is carried out in this zone at rural background station Topoľníky.

The highest concentrations of ground-level ozone generally occur in warm months with high sunshine (**Fig. 3.6**). **Fig. 3.7** and **Fig. 3.8** show the so-called daily course of O_3 concentration. It depicts 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 in the warm and cold seasons.

Fig. 3.6 *Average monthly concentrations O_3 in 2022.*

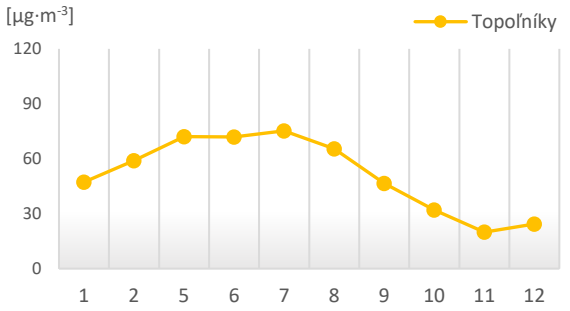


Fig. 3.7 *Daily O_3 concentration in January 2022.*

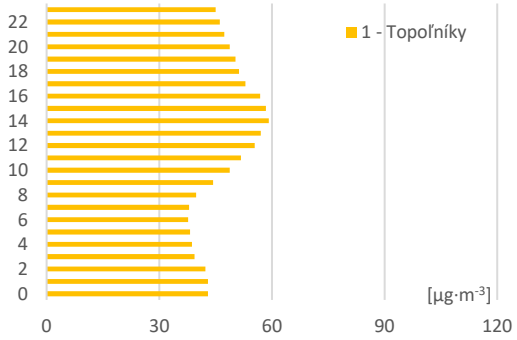
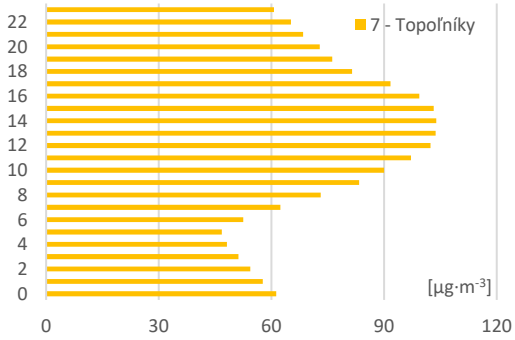


Fig. 3.8 *Daily O_3 concentration in July 2022.*



3.4 Benzo(a)pyrene

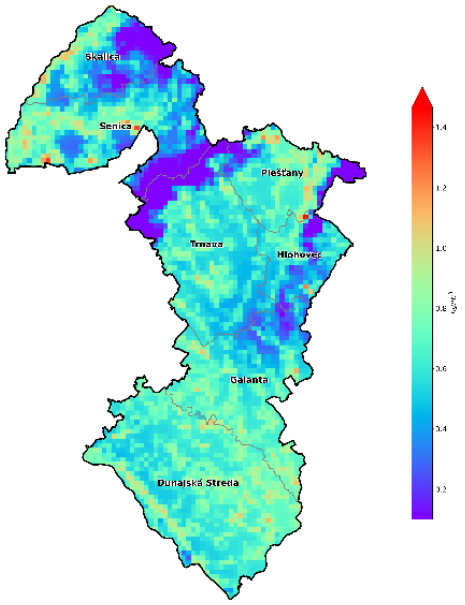
Benzo(a)pyrene is monitored in this zone at the monitoring station in Trnava. Target value for the annual average concentration (1 ng·m^{-3}) has not been exceeded here since the start of the measurement. Although in 2022 the measurements had a shortfall especially during October, the values observed in previous years indicate that the BaP target value for the annual average concentration (1 ng·m^{-3}) would probably not be exceeded here even in 2022.

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
Trnava, Kollárova		0.9	0.7	0.5	0.6	*0.5

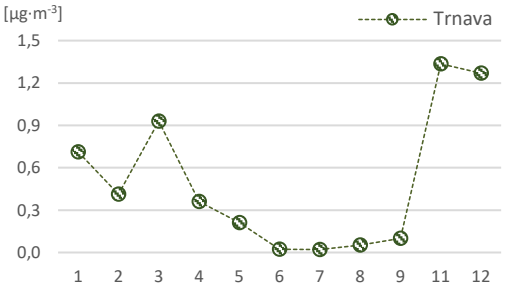
≥ 90% of valid measurements ** disturbance from 19. 9. 2022 to 4. 11. 2022*

Fig. 3.9 *Average annual concentration of B(a)P from RIO model output, IDW-R (2022).*



Higher levels of benzo(a)pyrene were measured in the colder months of the year (Fig. 3.10). On the basis of the mathematical modelling outputs (Fig. 3.9), we can assume that the annual target value for benzo(a)pyrene is probably mostly not exceeded in the Trnava region zone, the risk areas are described in Chapter 3.6.

Fig. 3.10 *Average monthly concentration of benzo(a)pyrene in 2022.*



3.5 Chemical composition of precipitation

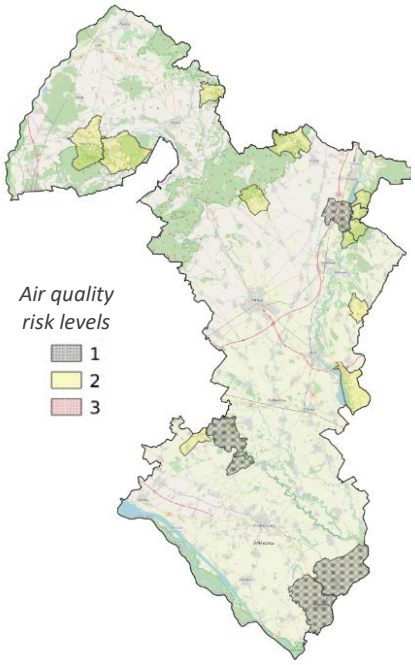
At the rural background station Topoľníky, the quality of precipitation is monitored on a weekly basis. The qualitative composition of basic ions, pH parameters and conductivity are monitored. The annual average pH value was 5.60 and the monthly averages did not fall below pH 5. Sulphate and nitrate concentrations were at low levels throughout the year. It can therefore be concluded that there is no excessive acidification of the environment in the in the zone Trnava region. Detailed monitoring results are presented in Chapter 3.4 Regional monitoring section of *Air pollution in the Slovak Republic 2022 Report.*

3.6 Risk municipalities

Fig. 3.11 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

Fig. 3.11 *Risk municipalities in zone Trnava region.*



[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

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 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].

3.7 Summary

In 2022, in the zone Trnava region no exceedance of the limit value for SO_2, NO_2, CO and benzene, nor exceedance of the limit value for the annual average concentration of PM_{10} and $PM_{2.5}$ was measured.

The number of days with average daily PM_{10} concentrations above 50 $\mu g \cdot m^{-3}$ was below the permissible limit. The target value for the annual average concentration of benzo(a)pyrene was not exceeded.

In the Trnava region, no exceedance of the limit or target value for any pollutant has been measured in the last three assessment years, therefore no air quality management area has been defined in this zone on the basis of monitoring. According to available data, the number of villages at risk of poor air quality due to household heating with solid fuel is relatively low in the Trnava region. There are no municipalities with risk level 3 according to the current methodology in this zone. However, the energy crisis may also be reflected in an increase in the consumption of firewood, which in areas with poorer ventilation may result in a deterioration of air quality. The zone is one of the less problematic in terms of air quality.

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