AIR POLLUTION IN THE SLOVAK REPUBLIC 2021

ANNEX

AIR QUALITY ASSESSMENT IN ZONE TRNAVA REGION

Air quality monitoring department
SLOVAK HYDROMETEOROLOGICAL INSTITUTE

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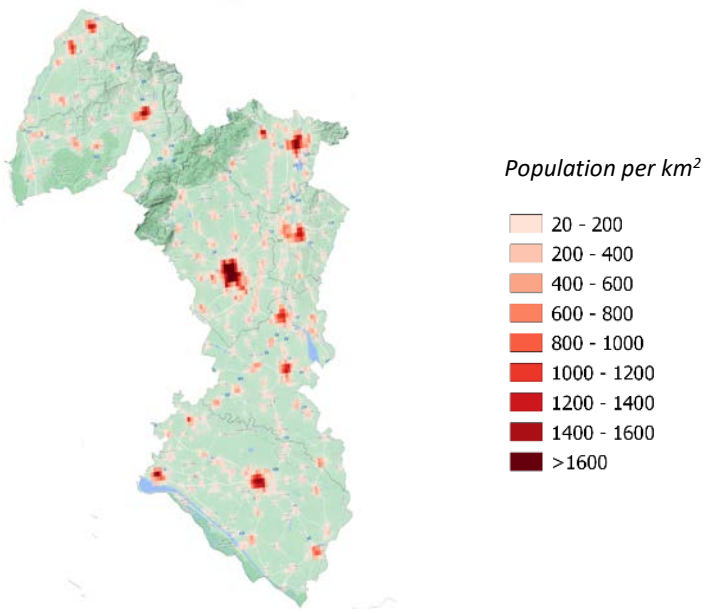
Version 2

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 Small 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 Small 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 valley do not occur in the Trnava region. **Fig. 1.1** shows the spatial distribution of population density in the zone.

The whole zone 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).*



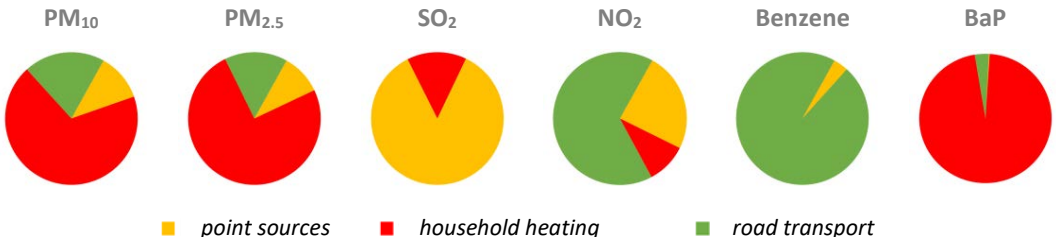
Air pollution sources in zone Trnava region

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 a 46 881 cars) and the R1 high speed road Trnava – Sereď (39 058 vehicles on average daily, 7 449 trucks a 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*

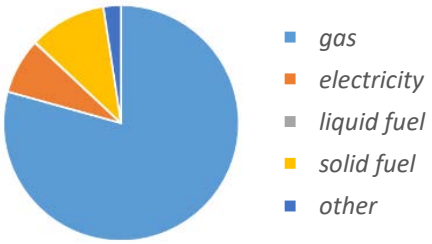
Fig. 1.2 *Share of different types of air pollution sources in total emissions in the Trnava region.*



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 the county town 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. In the cadastral area of Topoľníky, near the Klátovské river arm, there is the lowest rural background station 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.

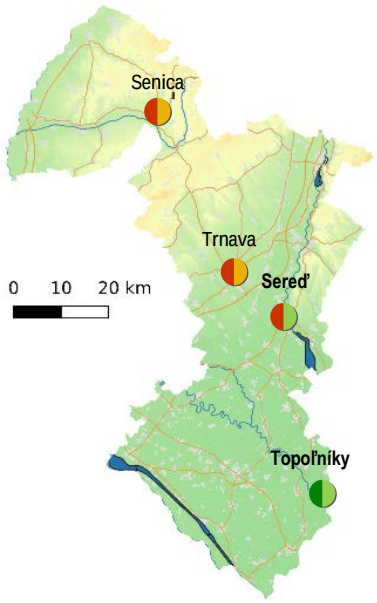
Tab. 2.1 contains information on air quality monitoring stations in the zone Trnava region:

- 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. 2.2**.

[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	Code EoI	Name of station	Type of area	Type of station	Geographical longitude	Geographical latitude	Altitude [m]	PM_{10}	$PM_{2.5}$	NO, NO_2	SO_2	O_3	CO	Benzene	Hg	As, Cd, Ni, Pb	BaP
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 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 2021 is presented in **Tab. 2.2**. Heavy metals are analysed from weekly samples (sampling duration is 7 days).

Tab. 2.2 *Measuring program EMEP station Topoľníky.*

	PM_{10}	EC/OC	Lead (Pb)	Arsenic (As)	Cadmium (Cd)	Nickel (Ni)	Chromium (Cr)	Copper (Cu)	Zinc (Zn)
Topoľníky	x		x	x	x	x	x	x	X

The sampling interval of precipitation (**Tab. 2.3**) 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 captures only wet deposition (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 2021.

Tab. 3.1 *Assessment of air pollution according to limit values for protection of human health and numbers of alert threshold exceedances in the zone Trnava region – 2021.*

	Protection of human health									AT [2]	
Pollutant	SO_2		NO_2		PM_{10}		$PM_{2.5}$	CO	Benzene	SO_2	NO_2
Averaging period	1 h	24 h	1 h	1 year	24 h	1 year	1 year	8 h [1]	1 year	3 h in a row	3 h in a row
Parameter	number of exceedances	number of exceedances	number of exceedances	average	number of exceedances	average	average	average	average	number of exceedances	number of exceedances
Limit value [µg·m^{-3}]	350	125	200	40	50	40	20	10 000	5	500	400
Maximum number of exceedances	24	3	18		35						
Senica, Hviezdoslavova	0	0			9	22	15			0	
Trnava, Kollárova			0	28	7	22	16	1 140	0.74		0
Topoľníky, Aszód, EMEP	0	0	0	6	3	17	13			0	0
Sereď, Vinárska			0	14	6	20	15				0

≥ 90% of valid measurements

Exceedance of the limit value is marked in red.

[1] *eight-hour maximum concentration*

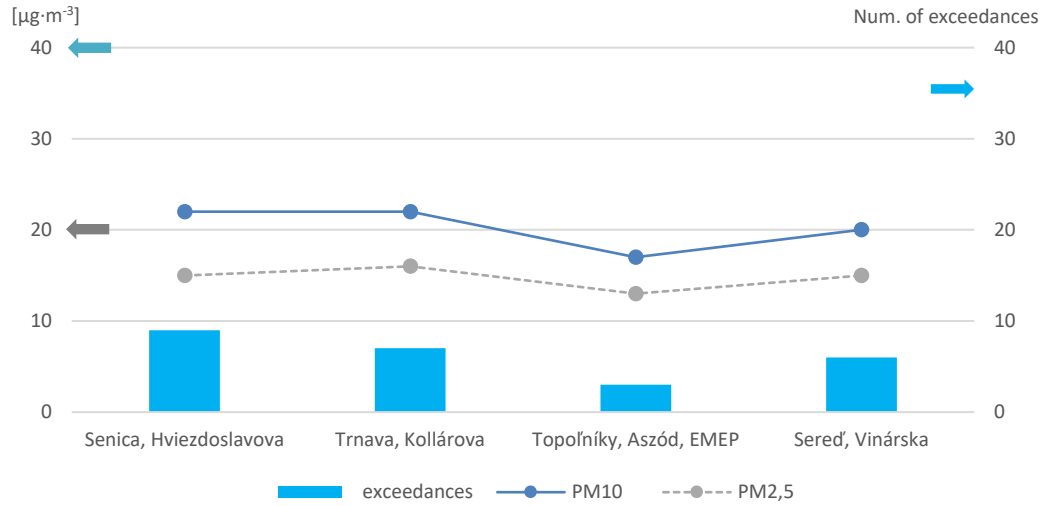
[2] *limit values for alert thresholds*

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

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

Fig. 3.1 shows the average annual concentrations of PM_{10}, $PM_{2.5}$ and the number of days with average daily PM_{10} concentrations above 50 $\mu g \cdot m^{-3}$ according to the results of measurements at monitoring stations in the Trnava region in 2021.

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, ***grey arrow*** *$PM_{2.5}$ (average annual concentration: 20 $\mu g \cdot m^{-3}$);* ***blue left arrow*** *PM_{10} (average annual concentration: 40 $\mu g \cdot m^{-3}$);* ***blue right arrow*** *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. 3.2**). The annual average PM_{10} concentration at the traffic stations Trnava, Kolárova and Senica, Hviezdoslavova was 22 $\mu g \cdot m^{-3}$. At the urban background station Sereď, we measured an annual average concentration only slightly lower than at urban traffic stations. At the rural background station in Topoľníky, PM_{10} concentrations were the lowest as expected, but even here we do not meet the WHO recommendations (annual average PM_{10} up to 15 $\mu g \cdot m^{-3}$).

Fig. 3.3 shows the modelling results for PM_{10}, calculated for 2021 using the RIO model subsequently adjusted using the regression IDW method (see Chapter 4 of *Air pollution in the Slovak Republic 2021 Report* for more details). For better illustration, only areas for which the annual mean concentrations were higher than the WHO recommended annual limits (which are much stricter compared to the EU limits) are shown. 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. 3.2 *Number of PM_{10} daily limit value exceedances per month in 2021.*

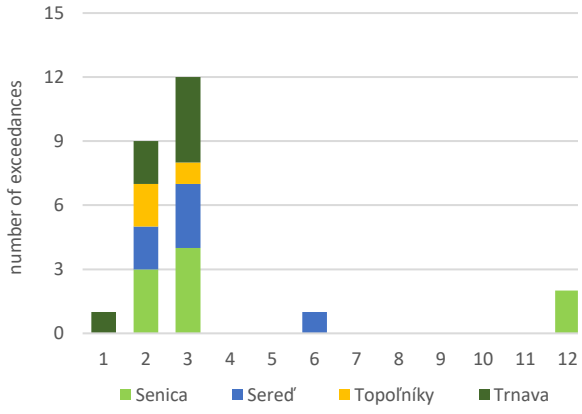


Fig. 3.3 *Average annual PM_{10} concentration (left) and number of exceedances of the PM_{10} daily limit value (right) in 2021. Only values above 15 $\mu g \cdot m^{-3}$ and non-zero number of exceedances are shown.*

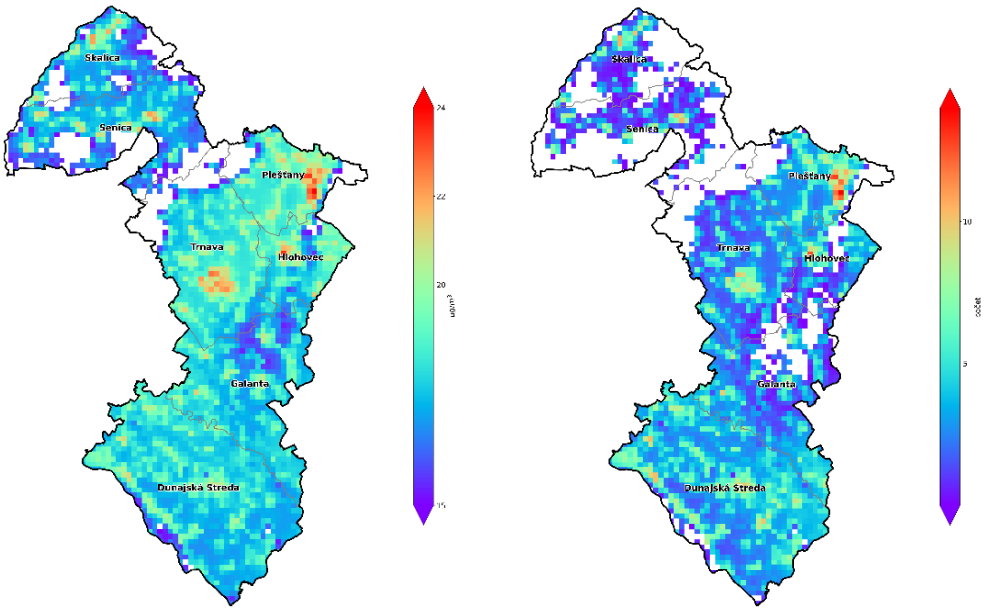
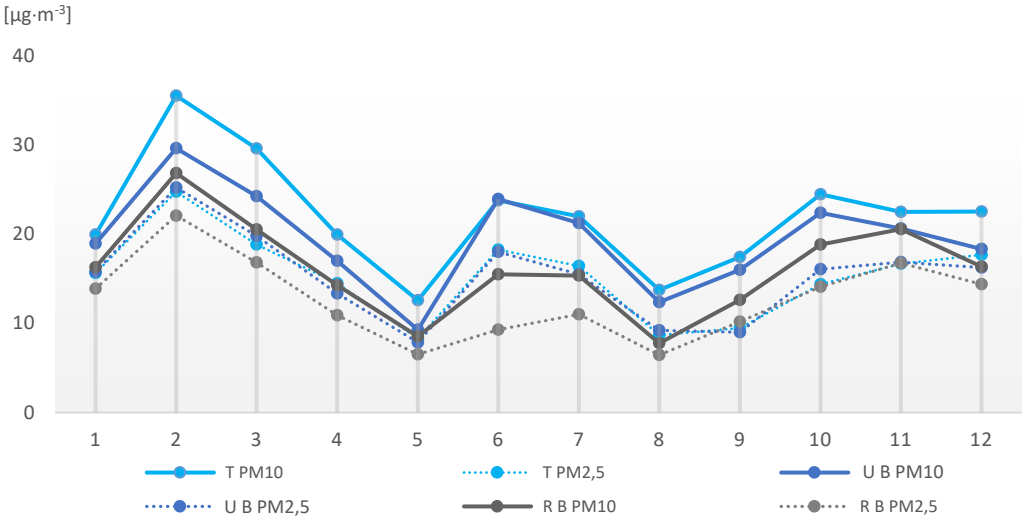


Fig. 3.4 *Average monthly concentrations of PM_{10} and $PM_{2.5}$ in the Trnava region by station type.*



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

Both traffic stations in the zone have similar average monthly concentrations PM_{10} as well $PM_{2.5}$. Fig. 3.4 compares the average of their monthly concentrations with the monthly concentration PM_{10} and $PM_{2.5}$ at the urban traffic station in Sereď and the rural background station in Topoľníky. It is interesting that in June, July and August the values PM_{10} in Sereď are at the level of traffic stations.

Compared to the other zones, the average monthly concentrations PM_{10} show (Fig. 3.4) smaller seasonal differences between cooler and warmer months. This is because solid fuel heating, which is a significant source of particulate emissions, is not dominant in the zone and dispersion conditions are mostly favourable.

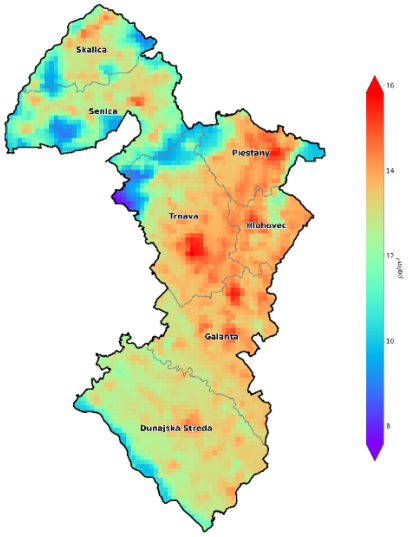
In June, we recorded unusually high concentrations of particulate matter in the Trnava region for the summer period and also exceeded the daily limit value. This was caused by a combination of several factors – the presence of an anticyclone on the territory of the zone and an episode of long-distance transport of dust from arid areas. All these factors contributed to the increased concentration of pollution in the atmosphere. **Fig. 3.2** shows the number of exceedances of the average daily limit concentration of PM_{10} for each month of the year. In the Trnava region, the number of exceedances at all four stations combined for the whole year was 25. This is a number that in some zones is exceeded by only one station.

$PM_{2.5}$

Increased concentrations of $PM_{2.5}$ are particularly risky, mainly because of their unfavourable effects on human health. **Fig. 3.4** shows $PM_{2.5}$ concentrations shown by the dashed line. In the zone Trnava region, they (as well as PM_{10}) do not show such a pronounced seasonal pattern as monitoring stations elsewhere in Slovakia. Even 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. 3.5** shows 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. 3.5 *Average annual $PM_{2.5}$ concentrations.*



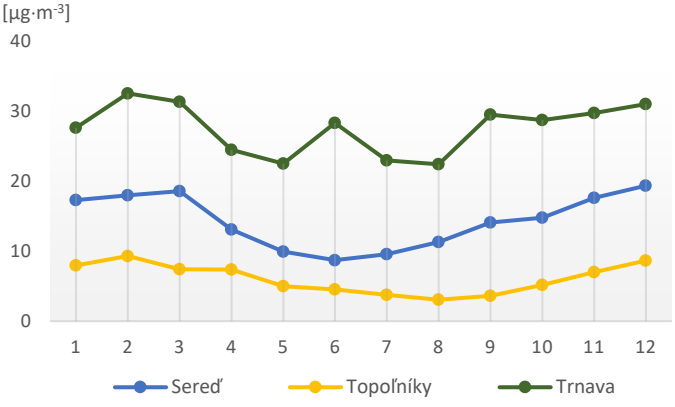
Only values above 5 $\mu g \cdot m^{-3}$ are shown, which is the threshold recommended by the WHO.

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. 3.6**.

The main source of NO_2 emissions is road transport. The highest concentrations for this reason are recorded at the traffic station 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. Interesting is the local maximum in June, measured at the traffic station in Trnava, but also at other traffic stations in the western part of Slovakia (Malacky, Bratislava Trnavské Mýto), probably caused by the deterioration of dispersion conditions in an anticyclonic situation. Average annual concentrations at the rural background station were 6 $\mu g \cdot m^{-3}$. Overall NO_2 concentrations in the Trnava region are at a relatively low level. Nevertheless, the only station that met the WHO recommendations (10 $\mu g \cdot m^{-3}$) is Topoľníky.

Fig. 3.6 *Average monthly NO_2 concentrations.*



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. 3.7). Fig. 3.8 and Fig. 3.9 show the so-called daily course of O_3 concentration. It shows that concentrations increase with sunrise, peak around midday and gradually decrease in the evening to a minimum that occurs early in the morning. Large differences in ground-level ozone concentrations are also observed in the warm and cold seasons.

Fig. 3.7 *Monthly average O_3 concentrations.*

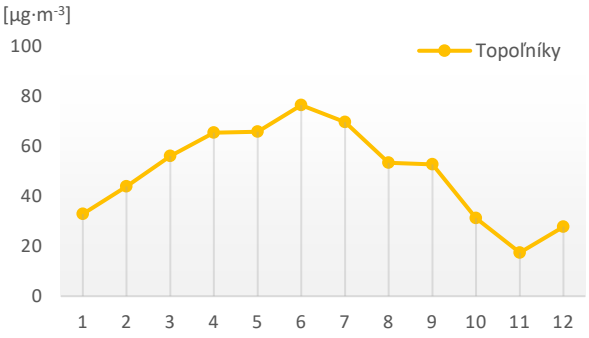


Fig. 3.8 *Daily O_3 concentration in January 2021.*

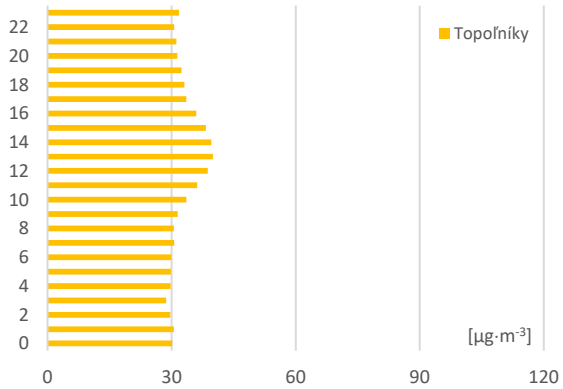
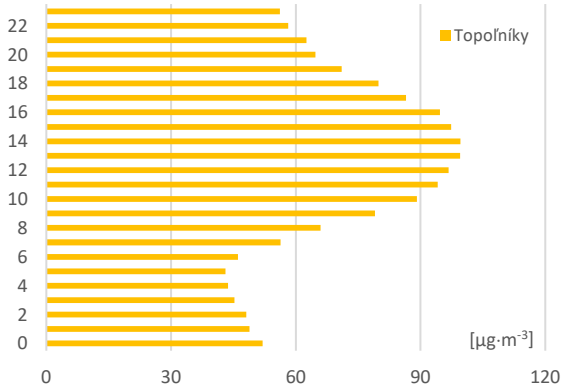


Fig. 3.9 *Daily O_3 concentration in July 2021.*



3.4 Benzo(a)pyrene

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

	2017	2018	2019	2020	2021
Target value [ng·m^{-3}]	1.0	1.0	1.0	1.0	1.0
Trnava, Kollárova		0.9	0.7	0.5	0.6

≥ 90% of valid measurements

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. Higher levels of benzo(a)pyrene were measured in the colder months of the year (Fig. 3.10). Based on the outputs of the mathematical modelling (Fig. 3.11) it can be assumed that the annual target value for benzo(a)pyrene is probably largely not exceeded in the Trnava Region zone, the risk areas are described in chapter 3.6.

Fig. 3.10 *Results of benzo(a)pyrene measurements in 2021.*

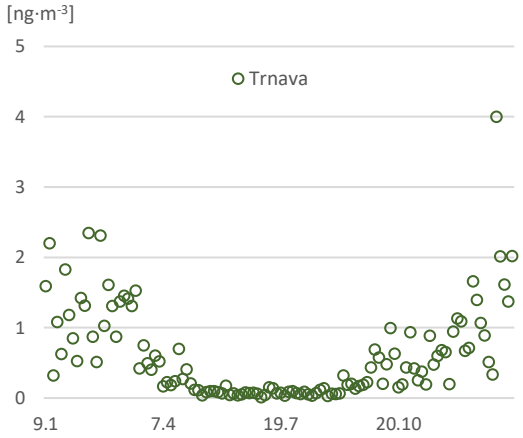
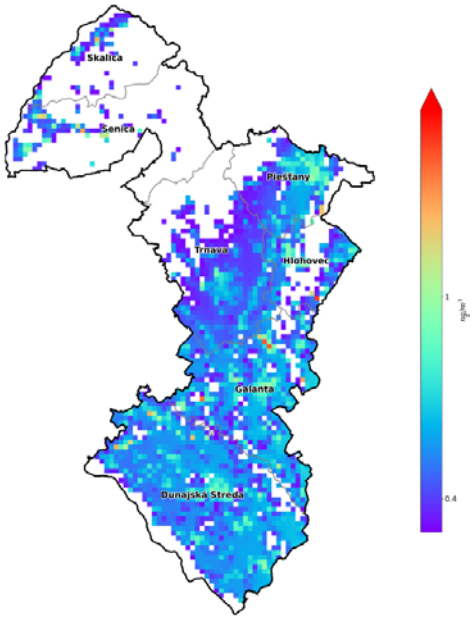


Fig. 3.11 *Average annual concentration of benzo(a)pyrene from RIO model output, IDW-R (2021).*



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 2021 Report*.

3.6 Risk areas

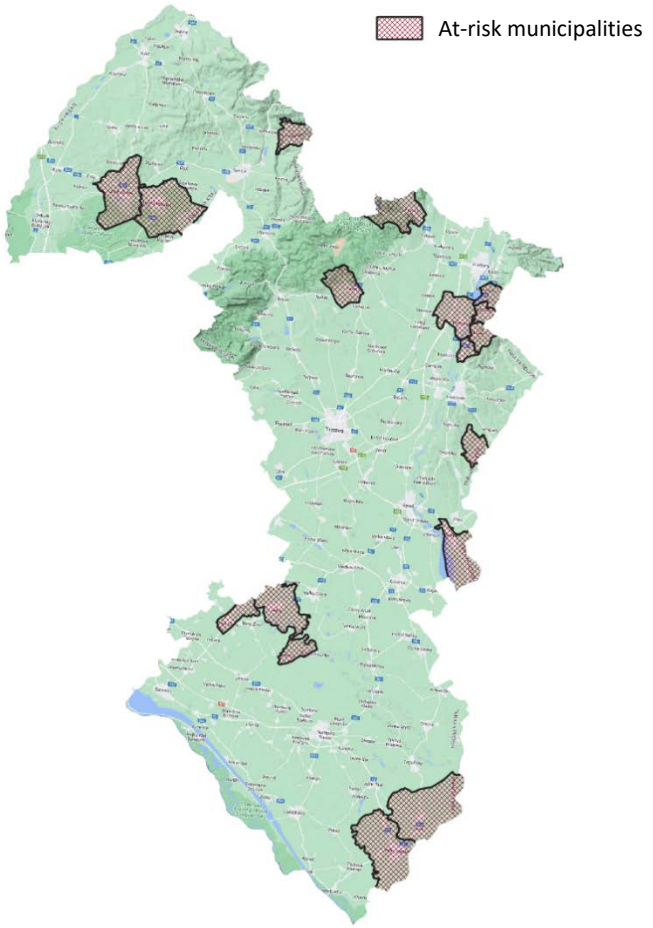
Fig. 3.12 shows the areas at risk of air quality deterioration due to pollutants (PM and benzo(a)pyrene) from domestic heating based on the modelling results. The modelling results were obtained by using the methodology of *D. Štefánik: Identification of at-risk municipalities with air quality threatened by local heating and adverse dispersion conditions* (updated in 2022)[3].

This methodology is based on data from Population and Housing Census (PHC) 2021 (usage of solid fuels for household heating), and it also takes into account high PM concentrations obtained from mathematical modelling and adverse dispersion conditions. There are no available input data with high spatial resolution covering the whole country for mathematical modelling. Therefore, we assume that the area is at risk is if it has a high proportion of solid fuel heating even though this was not indicated by mathematical modelling.

According to data from the PHC 2021, the number of households using solid fuel for heating in the Slovak Republic has increased by 45%. However, these figures have not yet captured the impact of the energy crisis.

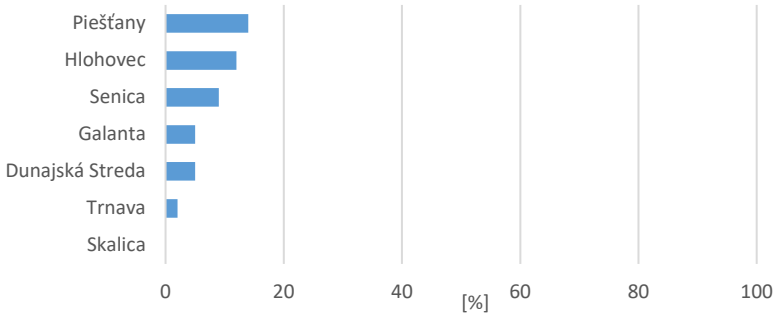
[3] *https://www.shmu.sk/File/oko/studie_analyzy/Popis_metody_na_urcenie_rizikovych_oblasti_aktualizacia.pdf*

Fig. 3.12 *Risk areas in the Trnava region.*



According to the updated methodology, the zone contains 17 at-risk municipalities; there are none in the Skalica district. The percentage of at-risk municipalities in individual districts is shown in **Fig. 3.13**.

Fig. 3.13 *Percentage proportion of at-risk municipalities in the districts of Trnava region.*



The Trnava Region has a smaller proportion of municipalities at risk and is relatively less vulnerable in this respect. which is due to the fact that the area is largely lowland in nature, is relatively well ventilated, and the consumption of firewood and coal for heating households is lower. ***More detailed data is available on the interactive map*** [4].

More detailed data on the type and consumption of fuels and the type of heating equipment at the level of municipalities and their parts is a necessary input for high-resolution modelling. Its outputs would help to quantify the source apportionment and the contribution of the regional background.

[4] *https://ruraj-git.github.io/folium_html/*

3.7 Summary

In 2021, 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. However, the energy crisis may also be reflected in an increase in the consumption of firewood, which may result in a deterioration of air quality in areas with poorer ventilation. The zone is one of the less problematic in terms of air quality.