AIR POLLUTION IN THE SLOVAK REPUBLIC 2021

ANNEX

AIR QUALITY ASSESSMENT IN ZONE NITRA REGION

Air quality monitoring department
SLOVAK HYDROMETEOROLOGICAL INSTITUTE

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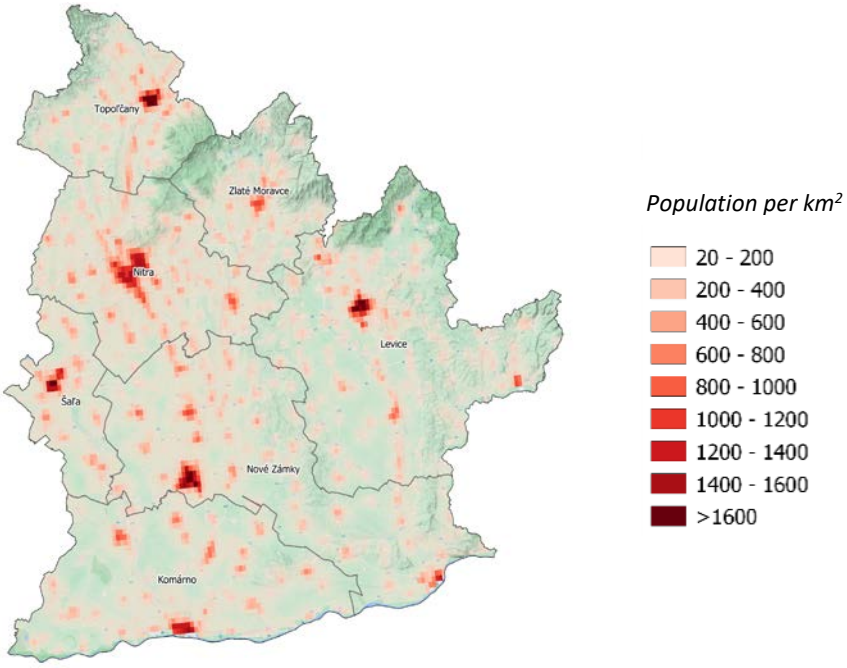
Version 2

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. **Fig. 1.1** shows the spatial distribution of population density in the zone.

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.

Fig. 1.1 *Population density in the zone Nitra region (Source: EUROSTAT, 2018).*



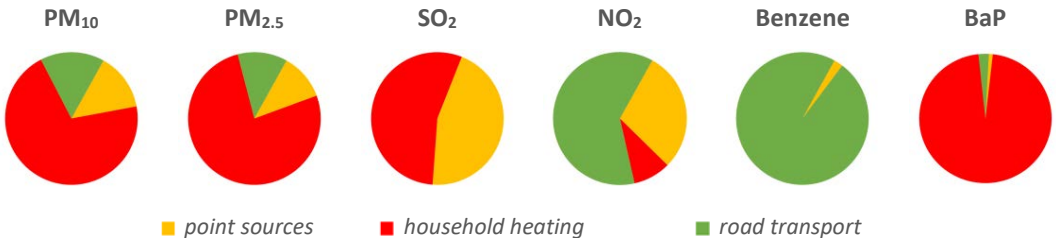
Air pollution sources in zone Nitra region

The dominant source of air pollution in the Nitra region is road transport. Natural gas is mainly used for household heating, the share of solid fuels is lower compared to other zones, except for the more mountainous area in the north of the region (according to census data).

Characteristics of road transport: the most frequent is the R1 high speed road on the part in front of Nitra from Trnava with an average daily number of 28 785 vehicles (5 582 trucks and 23 154 cars), the part of the road No. 64 in Nitra (23 436 vehicles, 3 503 trucks and 19 798 cars), the part of the road No. 63 connecting Veľký Meder and Komárno (21 847 vehicles, including 2 171 trucks and 19 573 cars), the part of road No. 75 from Šaľa to Nové Zámky (20 019 vehicles, 2 848 trucks and 17 045 cars), road No. 51 through Levice (17 367 vehicles, 2 162 trucks and 15 146 cars) and the R1 high speed road near Zlaté Moravce (17 998 vehicles, including 4 119 trucks and 13 802 cars)[1].

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

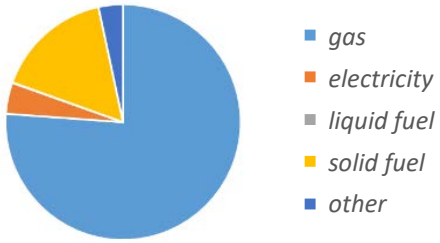
Fig. 1.2 *Share of different types of air pollution sources in total emissions in the Nitra region.*



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. Depending on meteorological conditions, the influence of the chemical industry can be seen in the Nitra region.

Fig. 1.3 *Share of different types of fuels 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. The share of solid fuels is slightly higher than in the Bratislava and Trnava regions. Solid fuels are more likely to be used in rural settlements with good availability of firewood.

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 about 100 metres from the roundabout. The suburban background station is located on the south-eastern outskirts in the Nitra Janíkovce in the school grounds and represents an area of rural character. An airport with irregular traffic is located to the south-east approximately 500 m from this monitoring station.

In 2021, a monitoring station in Komárno and Plášťovce became operational in the Nitra region. The new station in Komárno complemented the air quality measurements in the southern part of the Danubian Lowland. The AMS is located in the housing estate on Vnútorná Okružná street, in a location characterised by urban background air pollution.

Plášťovce is a medium-sized municipality with a predominantly detached houses. The municipality lies in the eastern part of the Nitra region in the Levice district. The air flow is influenced by the rolling terrain, which slopes and opens towards the south affecting the spread and dispersion of air pollutants. The station monitors background levels of pollution in a suburban area.

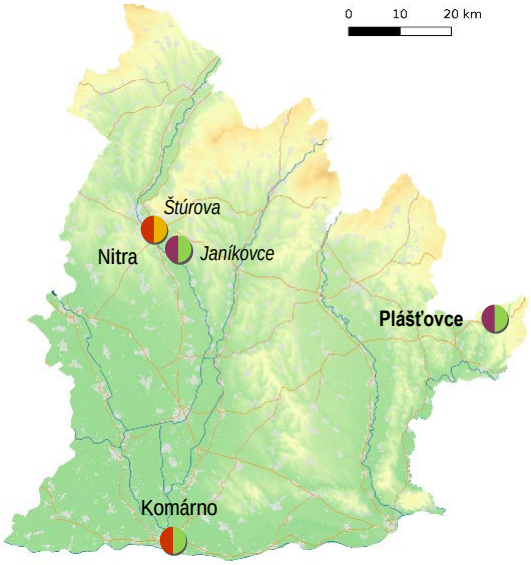
[2] *https://www.scitanie.sk*

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 devices provide hourly average concentrations of PM_{10}, $PM_{2.5}$, nitrogen oxides, sulphur dioxide, ozone, carbon monoxide and benzene. The SHMÚ test laboratory analyses heavy metals and polycyclic aromatic hydrocarbons as part of manual monitoring, resulting in 24-hour average concentrations.

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

Zone Nitra 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
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 – regional

Type of station:
B – background
T – traffic
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 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 Nitra 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						
Nitra, Janíkovce			0	9	5	20	14				0
Nitra, Štúrova	0	0	0	27	9	25	16	1 611	0.63	0	0
Komárno, Vnútorná Okružná*			0	13	12	30	14				0
Plášťovce*			0	6	23	28	**24				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*

** AMS began measuring during 2021*

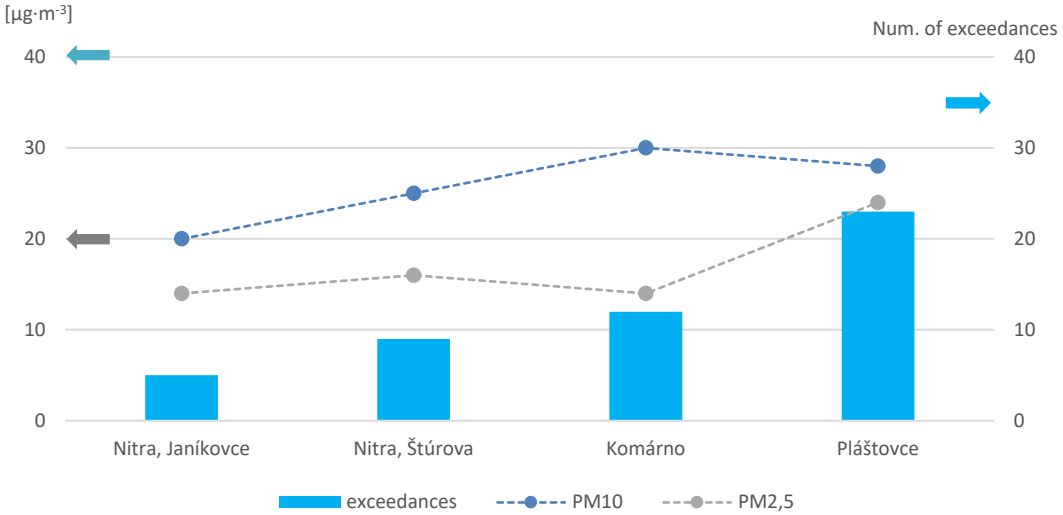
*** measurements started during 2021, there are not enough valid measurements to assess the exceedance of limit values on a yearly basis*

Except for the new monitoring stations (installed during the calendar year - Komárno 29. 5. 2021, Plášťovce 18. 6. 2021), 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 Nitra 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}.*



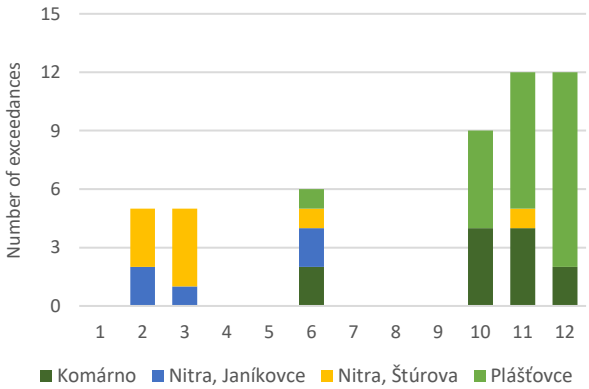
Number of exceedances - daily average concentrations higher than 50 $\mu g \cdot m^{-3}$; the Plášťovce station started measuring PM_{10} on 18 June 2021 and the Komárno station on 29 May 2021, therefore the number of exceedances and the annual average value for these two stations do not reflect air pollution for the whole year.

*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 Nitra region was not exceeded. 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 traffic station Nitra, Štúrova recorded the highest annual average concentration of PM_{10} 25 $\mu g \cdot m^{-3}$, but a relatively low number of daily exceedances (9). Of the urban and suburban background stations, the highest annual mean concentrations were measured at the Nitra, Janíkovce station (20 $\mu g \cdot m^{-3}$). The station Plášťovce started measuring only during 2021. **Fig. 3.2** shows the number of exceedances of the average daily limit concentration of PM_{10} for each month of the year. Almost all of the exceedances are concentrated in the cold months when heating is needed. The exception is the June episode, when in the third decade, under unfavourable dispersion conditions, long-distance transport of dust from arid areas occurred, which was evinced at all stations in the zone.

Fig. 3.2 *Number of PM_{10} daily limit value exceedances per month in 2021.*



In **Fig. 3.3** and **Fig. 3.5** the results of the modelling for PM_{10} and $PM_{2.5}$ are calculated for the year 2021 using the RIO model modified subsequently using the regression

IDW-R 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 more stringent annual limits recommended by WHO are shown.

Fig. 3.3 *Average annual PM_{10} concentration (left) and number of exceedances of the PM_{10} daily threshold (right) in 2021. Only values above 15 µg·m^{-3} and non-zero number of exceedances are shown.*

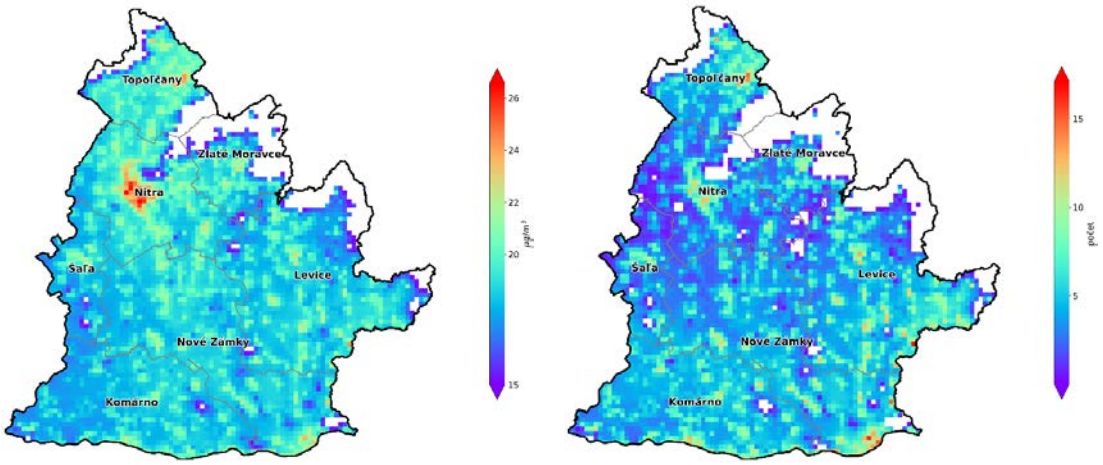
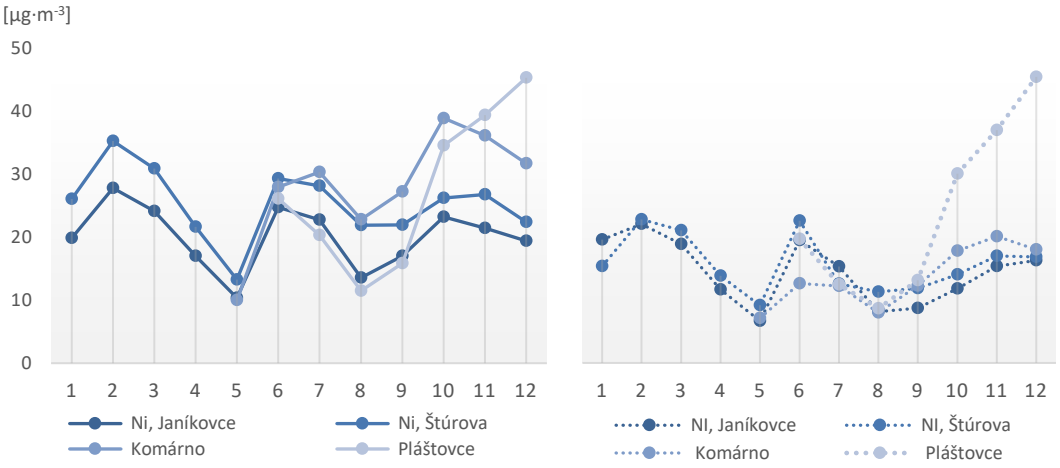


Fig. 3.4 *Average monthly concentrations of PM_{10} and $PM_{2.5}$ in the Nitra region by station type.*



NI, Janíkovce - average monthly concentration of PM_{10} and $PM_{2.5}$ at the urban background station Nitra, Janíkovce; NI, Štúrova - average monthly concentration of PM_{10} and $PM_{2.5}$ at the urban traffic station Nitra, Štúrova; Komárno - average monthly concentration of PM_{10} and $PM_{2.5}$ at the urban background station; Plášťovce - average monthly concentration of PM_{10} and $PM_{2.5}$ at the suburban background station. Komárno and Plášťovce stations started measuring during 2021.

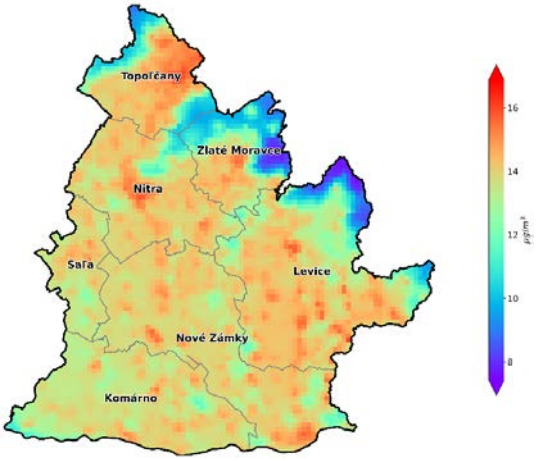
In the plot of monthly mean PM_{10} and $PM_{2.5}$ concentrations (**Fig. 3.4**), we see a similar pattern for all stations, influenced by episodes of long-distance transport of Saharan dust in February and the aforementioned episode of transmission from arid regions in June. The new stations (the urban background station in Komárno and the suburban background station in Plášťovce) generally have higher PM_{10} values than the two stations in Nitra. The effect of household heating with solid fuel, which is reflected in an increase in concentrations in the cold part of the year, was most pronounced at the new station in Plášťovce. The same characteristic small difference between PM_{10} and $PM_{2.5}$ as seen in the case of Plášťovce is typical for combustion processes (e.g. domestic heating). It is interesting to note the very similar pattern of monthly average $PM_{2.5}$ concentrations at the other stations.

$PM_{2.5}$

Increased concentrations of $PM_{2.5}$ fine particles in the air are dangerous, mainly because of their unfavourable effects on human health. The annual average $PM_{2.5}$ concentration at both stations in Nitra (Štúrova and Janíkovce) reached similar values (16 $\mu g \cdot m^{-3}$ and 14 $\mu g \cdot m^{-3}$) (**Tab. 3.1**); neither the station in Komárno nor the station in Plášťovce had year-round measurements yet in 2021. High concentrations of these particles were observed in the cold months of the year (**Fig. 3.4**, right) at the new station Plášťovce. This is probably due to the heating of households with solid fuel, as mentioned above. At all stations, the mean annual concentration was higher than the WHO recommendation (up to 5 $\mu g \cdot m^{-3}$), and this recommendation was not met in any month of the year, including summer, when $PM_{2.5}$ concentrations tend to be lowest.

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

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



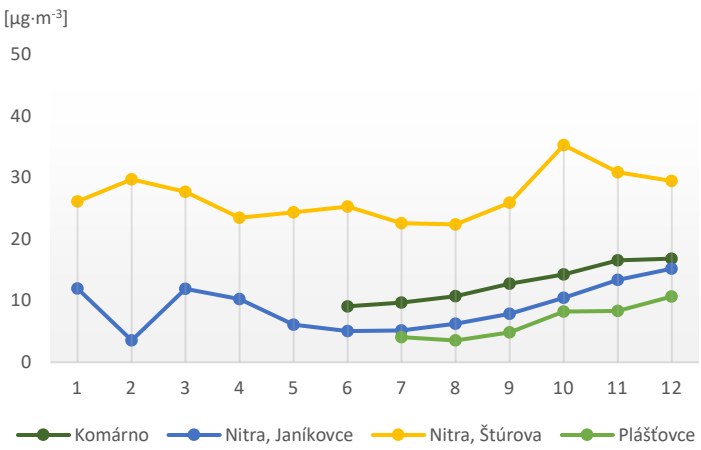
Average annual concentration of $PM_{2.5}$ in 2021. Only values above 5 $\mu g \cdot m^{-3}$ are shown, which is the threshold recommended by the WHO.

3.2 Nitrogen dioxide

Nitrogen dioxide monitoring is carried out at four 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 Nitra, Štúrova, but even here the annual average value (27 $\mu g \cdot m^{-3}$) did not exceed the limit value (40 $\mu g \cdot m^{-3}$). NO_2 concentrations in the zone maintain a relatively constant level throughout the year without seasonal fluctuations, as illustrated in **Fig. 3.6**. The concentrations measured at the station Nitra, Janíkovce comply with the WHO recommendations (10 $\mu g \cdot m^{-3}$), which are generally considerably stricter than the EU limits. At the Nitra, Štúrova station the situation is the opposite, at the new monitoring stations in Komárno and Plášťovce in 2021 there were not enough measurements to assess.

Fig. 3.6 *Average monthly NO_2 concentrations.*



3.3 Ozone

Ozone monitoring is carried out in this zone at three monitoring stations Komárno, Plášťovce and Nitra, Janíkovce.

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.

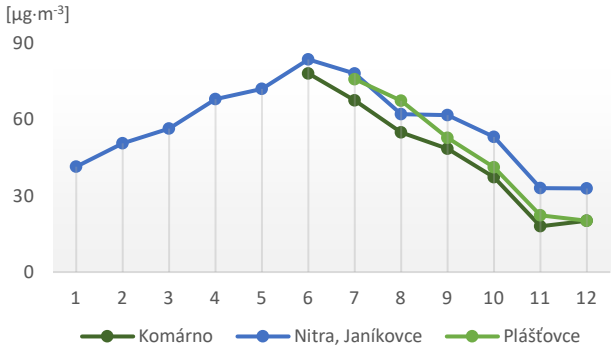


Fig. 3.8 Daily O_3 concentration in January 2021.

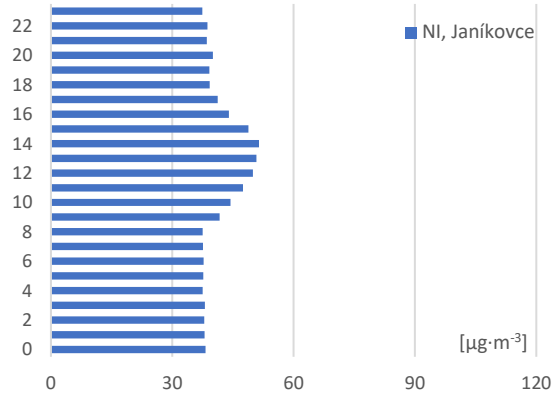
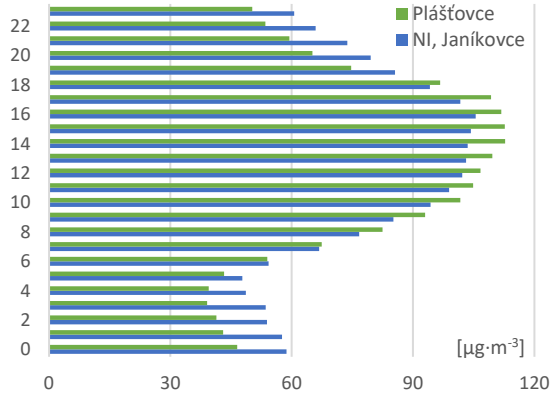


Fig. 3.9 Daily O_3 concentration in July 2021.



No exceedances of the ground-level ozone information or alert threshold were observed at any station in the zone in 2021.

3.4 Benzo(a)pyrene

Benzo(a)pyrene is monitored at two monitoring stations in the Nitra region - in Nitra, Štúrova and in Plášťovce. The annual pattern of concentrations has an even more noticeable maximum in the cold half of the year compared to PM particles (Fig. 3.10).

The target value for benzo(a)pyrene (1 ng·m^{-3}) was not exceeded in Nitra in 2021 according to the measurements (Tab. 3.2), the station in Plášťovce does not yet have year-round measurements, but the values recorded at the end of the year are several times higher than in Nitra.

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. 3.11 shows the spatial distribution of the annual average benzo(a)pyrene concentration according to the outputs of the RIO model combined with IDW-R. To obtain more detailed outputs, mathematical modelling with high spatial resolution and detailed temporal and spatial distribution of emissions is required. In areas with a high share of solid fuels in domestic heating and unfavourable dispersion conditions in winter months, benzo(a)pyrene air pollution is a potential problem.

Tab. 3.2 *Assessment of air pollution by benzo(a)pyrene – annual mean concentrations.*

	2017	2018	2019	2020	2021
Target value [ng·m^{-3}]	1.0	1.0	1.0	1.0	1.0
Nitra, Štúrova	1.3	0.9	0.8	0.6	0.8
Plášťovce *					*2.2

≥ *90% of valid measurements*

** Measurements started during the year, there are not enough valid measurements for a full year assessment.*

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

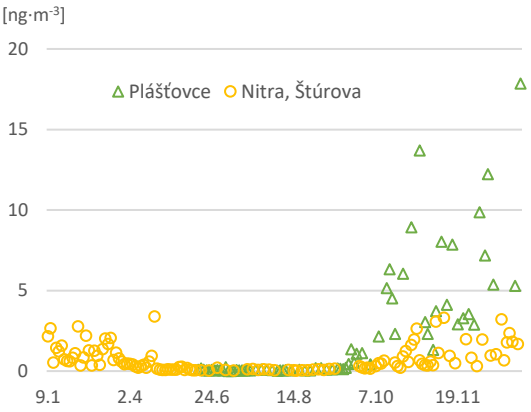
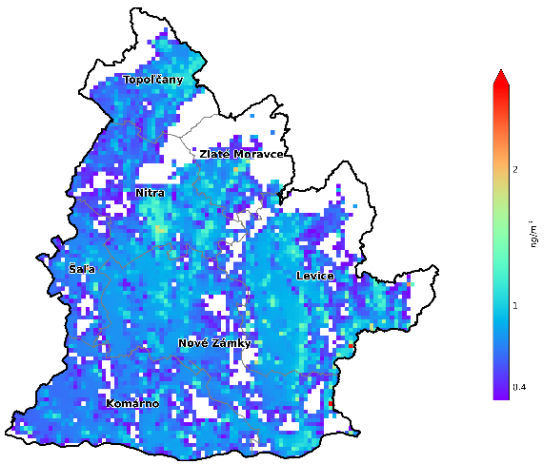


Fig. 3.11 *Average annual concentration of benzo(a)pyrene from RIO model output, IDW-R (2021).*



3.5 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].

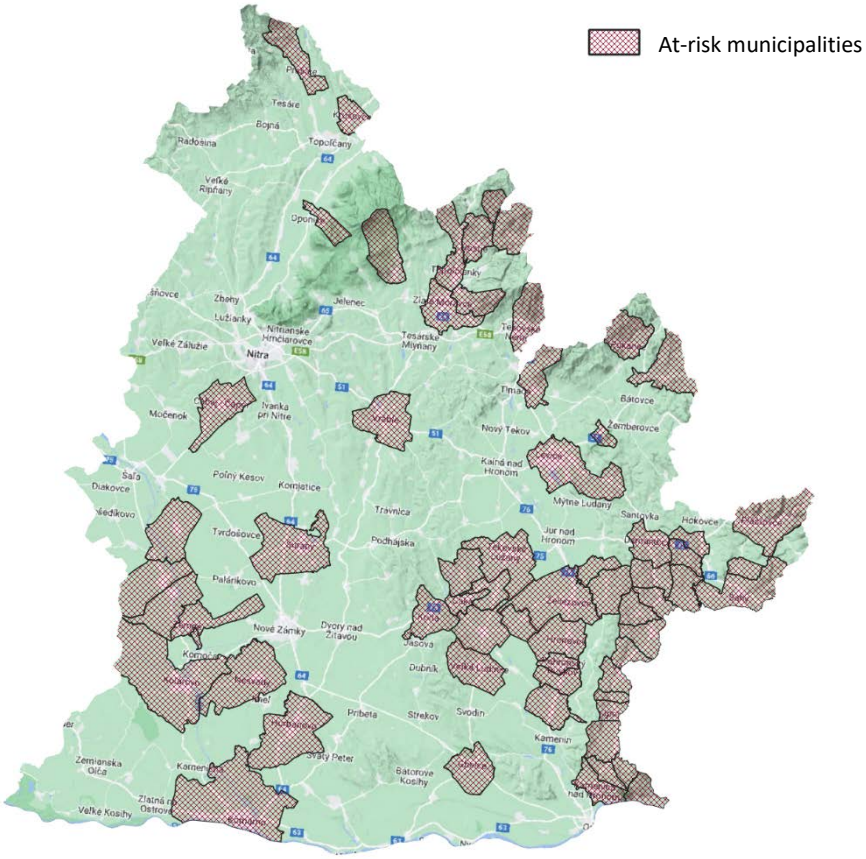
This methodology is based on data from Population and Housing Census (PHC) 2021 (usage of solid fuels for household heating), and it also takes into account high PM concentrations obtained from mathematical modelling and adverse dispersion conditions. There are no available input data with high spatial 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 the updated methodology, the zone contains 60 at-risk municipalities. 30% of the population in the Nitra region lives in municipalities potentially at risk of air quality deterioration due to household heating and adverse dispersion conditions, making the region relatively less at risk. This is due to the fact that the Nitra region is predominantly well ventilated and the share of solid fuels in household heating is lower.

The highest number of at-risk municipalities is in the south-eastern part of the region in the district of Levice with the more mountainous areas. ***More detailed data is available on the interactive map***[4].

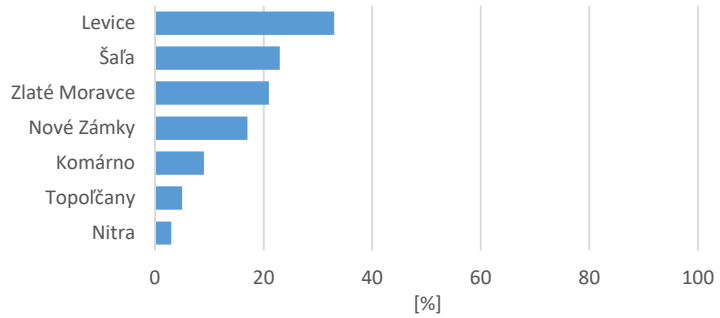
[3] *https://www.shmu.sk/File/oko/studie_analyzy/Popis_metody_na_urcenie_rizikovych_oblasti_aktualizacia.pdf*
[4] *https://ruraj-git.github.io/folium_html/*

Fig. 3.12 *At-risk areas in the Nitra region.*



The percentage of at-risk municipalities in each district is shown in **Fig. 3.13**. Based on PHC in 2021, the number of homes using solid fuel for heating increased by 45% compared to data from PHC 2011. However, these data have not yet reflected the impact of the energy crisis.

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



3.6 Summary

In 2021, in the Nitra region no exceedance of the limit value for SO_2, NO_2, CO and benzene was measured, nor exceedance of the limit value for the annual average concentration of PM_{10}. The limit value for the average daily concentration of PM_{10} and $PM_{2.5}$ was not exceeded at any monitoring station. The highest number of PM_{10} exceedances (23) was recorded at the Plášťovce station, which, however, started measuring during 2021 only.

The target value for benzo(a)pyrene was not exceeded at the monitoring station Nitra, Štúrova. However, it is possible that the Plášťovce site will exceed it in the year-round measurement. In the Nitra region, no air quality management areas have been defined on the basis of monitoring.

Although it can be assumed that higher concentrations of PM and benzo(a)pyrene will occur in the Nitra region also in other areas especially in the winter months, the nature of the region is predominantly flat and characterised by mostly good ventilation. Areas with unfavourable dispersion conditions and a high share of solid fuels in domestic heating may be problematic.