# AIR POLLUTION IN THE SLOVAK REPUBLIC 2021

# ANNEX

## AIR QUALITY ASSESSMENT IN ZONE TRENČÍN REGION




Air quality monitoring department
SLOVAK HYDROMETEOROLOGICAL INSTITUTE



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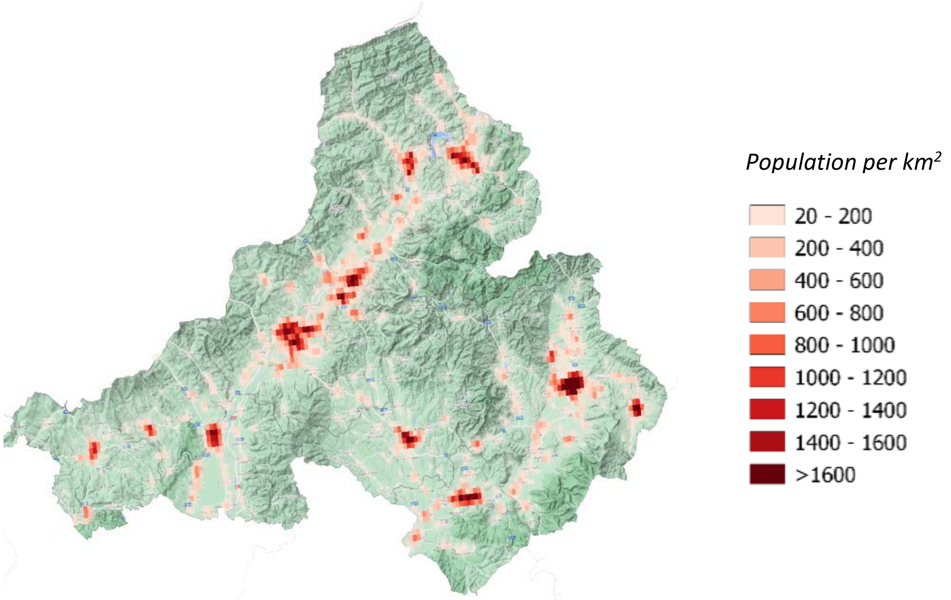
Version 2

# 1 DESCRIPTION OF TRENČÍN REGION TERRITORY IN TERMS OF AIR QUALITY

With the exception of the basin Horná Nitra, the relief of the Trenčín Region is mainly mountainous, including the Myjava Hills and the White Carpathians, partly the Považský Inovec, Javorníky, Vtáčnik and Strážov Hills. The highest point is Vtáčnik with an altitude of 1 346 m a. s. l., the lowest point is 165 m a. s. l. The zone is for the most part well ventilated, lower wind speeds occur in valley of the Váh river. **Fig. 1.1** shows the spatial distribution of population density in the zone.

The whole Trenčín region is one zone in terms of air quality assessment for $SO_2$, $NO_2$, $NO_X$, $PM_{10}$, $PM_{2.5}$, benzene, polycyclic aromatic hydrocarbons and CO in the air.

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

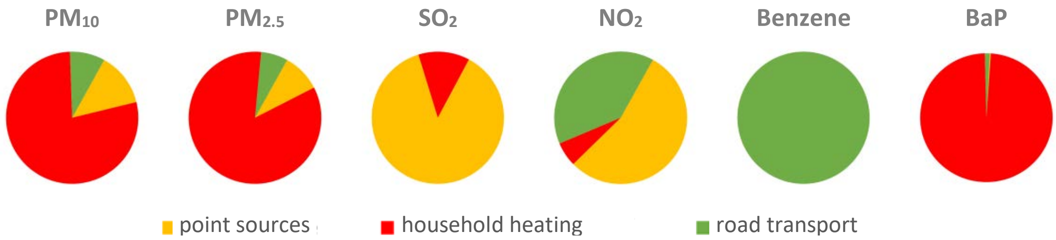



***Air pollution sources in zone Trenčín region***

Household heating is the most significant source of air pollution in the more mountainous part of the zone. Characteristics of road traffic: in terms of the density of car traffic in the zone, the predominant roads are the road No. 61 in the Trenčín district with 32 705 vehicles (3 349 trucks and 29 128 cars), the D1 motorway with a density of 21 000 – 28 000 vehicles (in the Trenčín district, on the busiest section 5 666 trucks and 22 392 cars), the road No. 64 in the Prievidza district with 18 014 vehicles (2 457 trucks and 15 452 cars), the road No. 54 in the district of Nové Mesto nad Váhom with 17 261 vehicles (2 293 trucks and 14 861 passenger cars), road No. 507 in the district of Trenčín with 18 979 vehicles (2 193 trucks and 16 743 passenger cars), road No. 517 in the district of Považská Bystrica with 18 026 vehicles (2 440 trucks and 15 453 passenger cars) and road No. 1774 in the district of Prievidza with 18 329 vehicles (1 245 trucks and 16 998 passenger cars)[1].

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

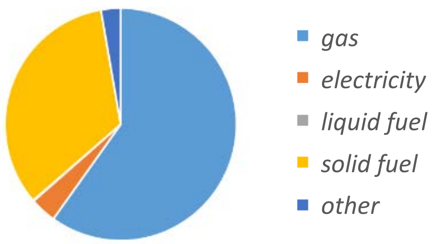
*Fig. 1.2* *Share of different types of air pollution sources in total emissions in the Trenčín region.*




*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 significant in the zone in terms of their contribution to local air pollution by basic pollutants, with the exception of cement factories. The influence of the heating plant was more pronounced, but depending on meteorological conditions it contributes more to the regional background.

*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 mostly used for heating in family houses in the zone, especially in the larger cities. The share of solid fuels is higher than in the Trnava and Nitra regions. Fuel wood is used to a greater extent in the mountainous northern part of the region.

## 2 AIR QUALITY MONITORING STATIONS IN ZONE TRENČÍN REGION

Air quality monitoring in Upper Nitra region started in 1973. Monitoring stations in Prievidza, Handlová and Bystričany were set up at that time mainly to capture the impact of thermal power plants. As in other similar locations, where monitoring was initially focused on large sources of air pollution, emissions from thermal power station have decreased and the monitoring now increasingly reflect other local problems, in particular household heating with solid fuel. There are currently 5 monitoring stations in the zone. In addition to the three mentioned above, there is a monitoring station in Trenčín and a new station in Púchov, where monitoring started in 2021. AMS Trenčín characterises the impact of road traffic, the intensity of which in the given location belongs to the moderate. The AMS Púchov characterizes the background values of pollution levels in the suburban area.

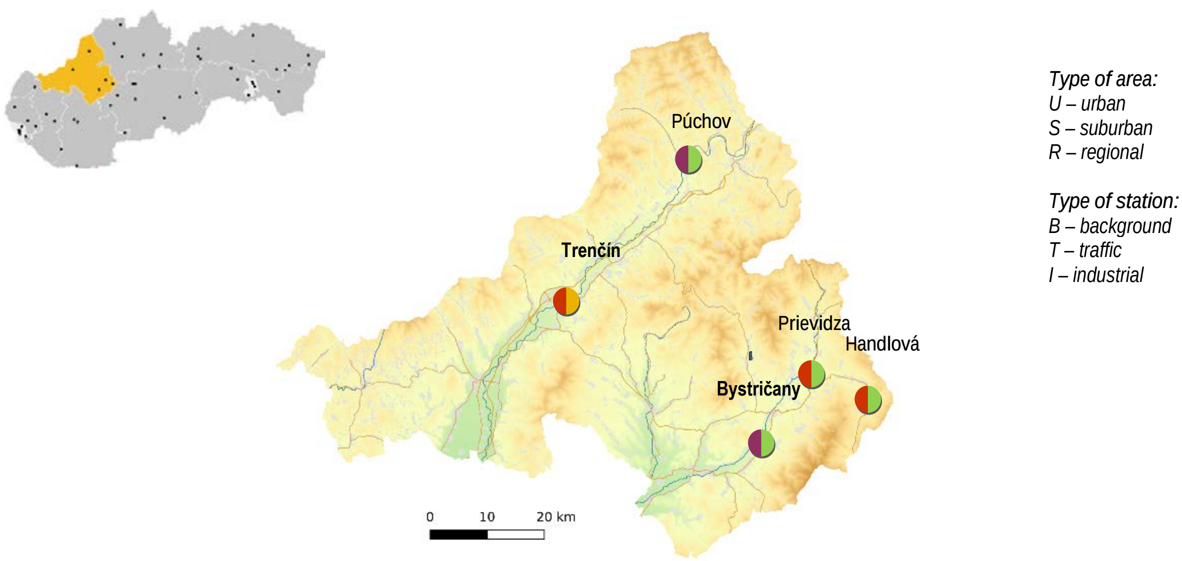
[2] *https://www.scitanie.sk*

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

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

*__Tab. 2.1__ Air quality monitoring programme in the zone Trenčín region.*

| **Zone Trenčín region** | | | | | | | | Measurement programme | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Continuously | | | | | | | | Manually | |
| District | EoI code | 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 |
| Prievidza | SK0013A | Bystričany, Rozvodňa SSE | S | B | 18°30'51" | 48°40'01" | 261 | | | | | | | | | | |
| Prievidza | SK0027A | Handlová, Morovnianska cesta | U | B | 18°45'23" | 48°43'59" | 448 | | | | | | | | | | |
| Prievidza | SK0050A | Prievidza, Malonecpalská | U | B | 18°37'41" | 48°46'58" | 276 | | | | | | | | | | |
| Trenčín | SK0047A | Trenčín, Hasičská | U | T | 18°02'29" | 48°53'47" | 214 | | | | | | | | | | |
| Púchov | SK0066A | Púchov, 1. mája | S | B | 18°19'31" | 49°07'08" | 262 | | | | | | | | | | |
| | | | | | | | Total | 5 | 5 | 5 | 2 | 3 | 3 | 2 | 0 | 2 | 3 |



# 3 ASSESSMENT OF AIR QUALITY IN ZONE TRENČÍN REGION

This chapter contains an assessment of air quality in the zone Trenčín region based on monitoring, supplemented by mathematical modelling results for $PM_{10}$, $PM_{2.5}$ and benzo(a)pyrene for the year 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 Trenčín 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 | | | | | | |
| Prievidza, Malonecpalská | 0 | 0 | 0 | 15 | 5 | 20 | 16 | | | 0 | 0 |
| Bystričany, Rozvodňa SSE | 0 | 0 | | | 5 | 20 | 17 | | | 0 | |
| Handlová, Morovnianska cesta | 0 | 0 | | | 4 | 19 | 18 | | | 0 | |
| Púchov, 1. mája * | 0 | 0 | 0 | 13 | 2 | 26 | **22 | 1 201 | | 0 | 0 |
| Trenčín, Hasičská | 0 | 0 | 0 | 23 | 18 | 27 | 15 | 1 236 | 0.90 | 0 | 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*

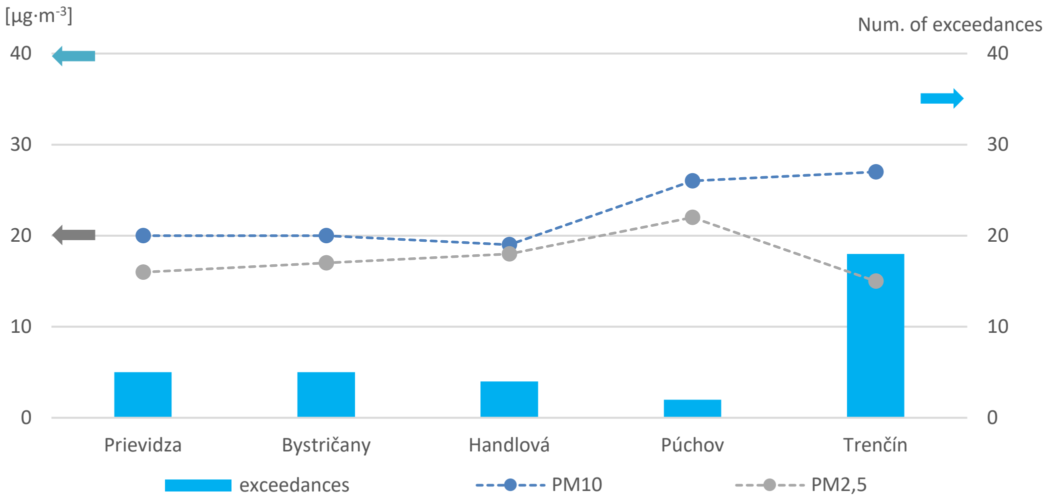
*** measurements started during 2021, there are not enough valid measurements to assess the exceedance of limit values on a yearly basis*

*With the exception of the new monitoring station in Púchov (installed during the calendar year; started measuring on 22. 9. 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 µg·m$^{-3}$ according to the results of measurements at monitoring stations in the Trenčín 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 $PM_{10}$.*



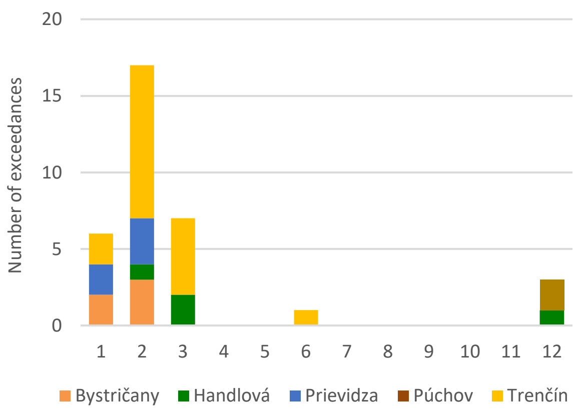

*Number of exceedances - daily average concentrations higher than 50 µg·m$^{-3}$; the Púchov station started measuring $PM_{10}$ in September 2021, therefore the number of exceedances and the annual average value for these two stations do not reflect air pollution for the whole year. $PM_{10}$ and $PM_{2.5}$ limit values are exceeded mainly in the winter months when this measuring station was not in operation (January, February).*

*The arrows show the limit values, **grey arrow** $PM_{2.5}$ (average annual concentration: 20 µg·m$^{-3}$); **blue left arrow** $PM_{10}$ (average annual concentration: 40 µg·m$^{-3}$); **blue right arrow** number of exceedances (average daily $PM_{10}$ concentration of 50 µg·m$^{-3}$ must not be exceeded more than 35 times in a calendar year).*

### $PM_{10}$

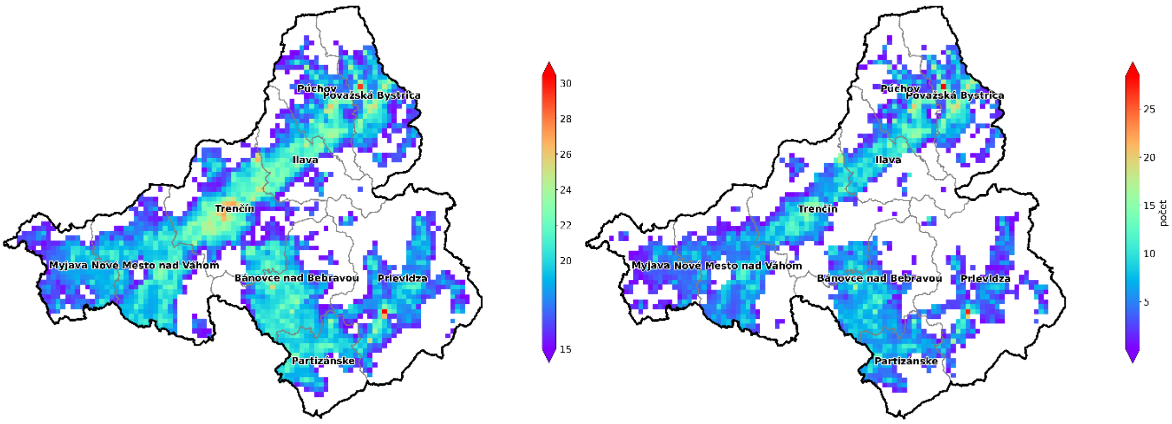
The limit value for the annual average concentration of $PM_{10}$ (40 µg·m$^{-3}$) in the Trenčín region was not exceeded. Similarly, the limit value for the number of exceedances (35) of the average daily concentration of $PM_{10}$ was not exceeded by any station (**Fig. 3.1**). The station in Trenčín, Hasičská measured the highest annual average $PM_{10}$ concentration of 27 µg·m$^{-3}$ with the number of daily exceedances of 18. The station in Púchov started to measure only in September 2021. The values of concentrations at urban and suburban background stations were around 20 µg·m$^{-3}$. In **Fig. 3.2** we can see that almost all exceedances are concentrated in cold months with the need for heating. The exception is June with an episode of long-range dust transmission from dry areas. Interesting are the relatively high values measured at the new monitoring station in Púchov in December.

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



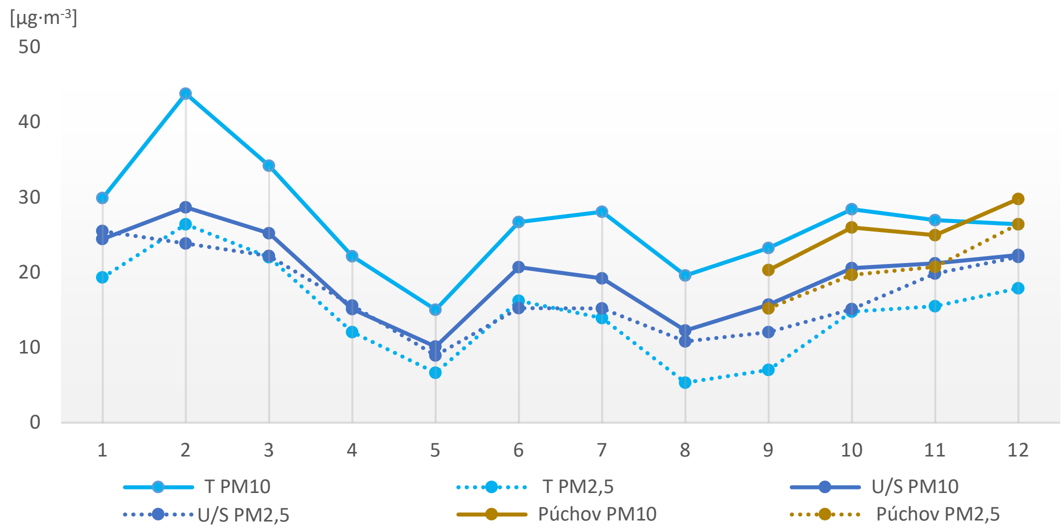
In **Fig. 3.3** and **Fig. 3.5** the results of the modelling for $PM_{10}$ and $PM_{2.5}$ are calculated for the year 2021 using the RIO model modified subsequently using the regression IDW-R method (see Chapter 4 of *Air pollution in the Slovak Republic 2021 Report* for more details). For better illustration, 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.*




All urban and suburban background stations in the zone have similar average monthly concentrations of $PM_{10}$ and $PM_{2.5}$, except for the AMS in Púchov, which has measured significantly higher particulate air pollution since it became operational in September 2021. Therefore, **Fig. 3.4** compares the monthly average $PM_{10}$ and $PM_{2.5}$ of the traffic station in Trenčín, the level in Púchov, and the monthly average of the urban and suburban background stations in the zone outside Púchov. It is interesting to note that both $PM_{10}$ and $PM_{2.5}$ values at the suburban background station in Púchov are close to the values measured at the traffic station in Trenčín. In December, even the average monthly concentration of $PM_{10}$ in Púchov exceeded the value measured in Trenčín.

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



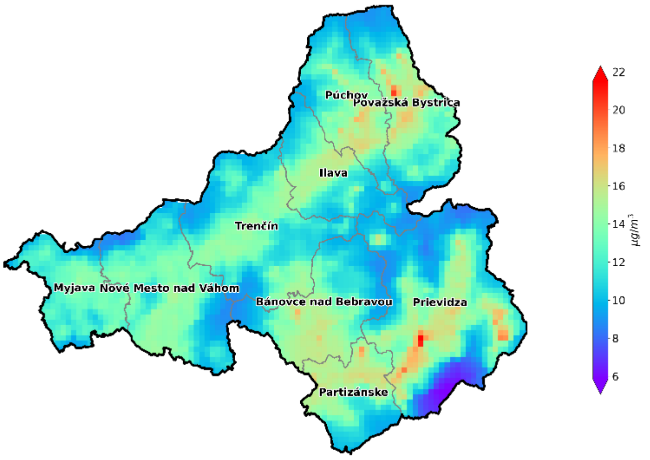

***T PM10*** *and* ***T PM2,5*** *– average monthly concentration of $PM_{10}$ and $PM_{2.5}$ at the traffic station Trenčín, Hasičská;* ***U/S B PM10*** *and* ***U/S B PM2,5*** *– average monthly concentrations of $PM_{10}$ and $PM_{2.5}$ at the urban/suburban background stations Bystričany, SSE substation; Handlová, Moravianska cesta and Prievidza, Malonecpalská;* ***Púchov PM10*** *and* ***Púchov PM2,5*** *– average monthly concentration of $PM_{10}$ and $PM_{2.5}$ at the Púchov suburban background station.*

## ■ $PM_{2.5}$

Compared to $PM_{10}$, fine particles ($PM_{2.5}$) have a significantly more negative impact on human health. In **Fig. 3.4** their concentrations are shown by the dashed line. In Prievidza, Bystričany and Handlová, $PM_{2.5}$ average annual concentration were as follows: 16 μg·m$^{-3}$, 17 μg·m$^{-3}$ and 18 μg·m$^{-3}$. High concentrations of $PM_{2.5}$ were observed in the cold months of the year. This is probably caused by heating of households with solid fuel, as is the case for $PM_{10}$. At all stations in the zone, the annual average concentration of $PM_{2.5}$ was higher than the WHO recommendation (5 μg·m$^{-3}$). Also, their monthly concentrations were above 5 μg·m$^{-3}$. This also occurred in summer when they tend to be lowest.

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

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



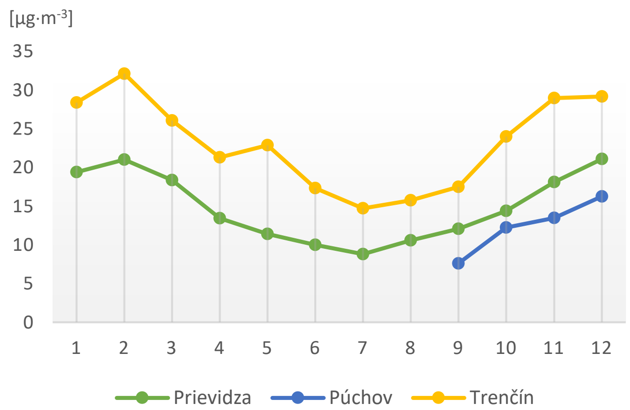

*Average annual concentration of $PM_{2.5}$ in 2021. Only values above 5 μg·m$^{-3}$ are shown, which is the threshold recommended by the WHO.*

## 3.2 Nitrogen dioxide

Nitrogen dioxide levels in the air are monitored at three stations. 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 are recorded at the Trenčín, Hasičská traffic station. The annual average level (23 μg·m$^{-3}$) did not exceed the limit value (40 μg·m$^{-3}$) here. The $NO_2$ concentrations maintain a relatively constant level throughout the year, with an insignificant minimum in the summer months. This is due to better dispersion conditions in summer. The average annual concentration at the urban background station in Prievidza, had a value of 15 μg·m$^{-3}$. In Púchov, $NO_2$ started to be measured in September 2021. The air pollution with this pollutant reached lower values here than at other stations in the zone. Overall, $NO_2$ concentrations in the Trenčín region are at a relatively low level. However, the annual average concentrations do not meet the WHO recommendations (10 μg·m$^{-3}$), which are significantly stricter than the EU limits.

***Fig. 3.6*** *Average monthly $NO_2$ concentrations.*



## 3.3 Ozone

Ozone monitoring is carried out in this zone at the monitoring station in Prievidza.

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.*

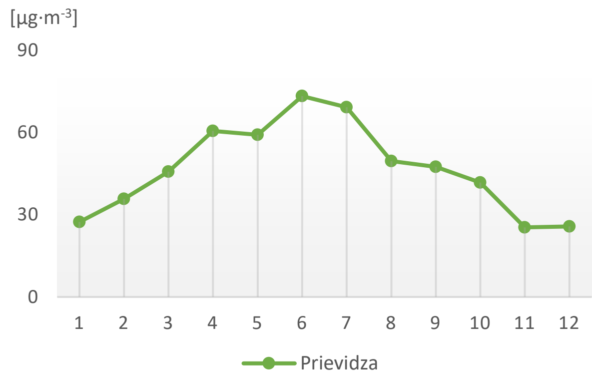



***Fig. 3.8*** *Daily $O_3$ concentration in January 2021.*

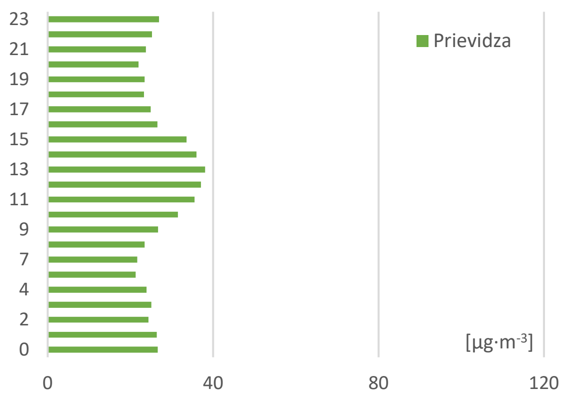
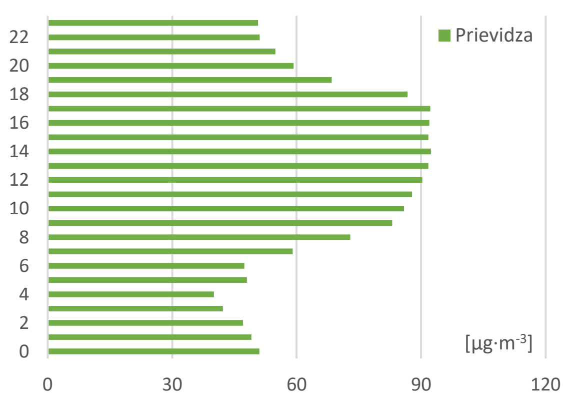



***Fig. 3.9*** *Daily $O_3$ concentration in July 2021.*




At the monitoring station in Prievidza, no exceedances of the information or alert threshold for ground-level ozone were measured in 2021.

## 3.4 Benzo(a)pyrene

Benzo(a)pyrene is monitored at three monitoring stations in the Trenčín Region - in Prievidza, Malonecpalská, in Trenčín, Hasičská and in Púchov, 1 May. The annual pattern of concentrations has an even more pronounced maximum in the cold half of the year compared to the PM (**Fig. 3.10**). The target value for benzo(a)pyrene (1 $ng \cdot m^{-3}$) is only slightly exceeded in Prievidza (**Tab. 3.2**). In Púchov the measurement was carried out only for a short part of the year (from mid-October). However, the measured values are higher than at other stations in the zone. This is probably due to the influence of household heating with solid fuel. The site will need further attention.

The map in **Fig. 3.11** shows the spatial distribution of annual mean benzo(a)pyrene concentrations according to the RIO model outputs combined with IDW-R. Due to the orography of the landscape, it is complicated to obtain a reliable spatial distribution from interpolation of measurements (and auxiliary spatial data). For more detailed information, mathematical modelling with high spatial resolution and detailed information on the spatial and temporal distribution of emissions is needed. Therefore, the RIO model outputs mainly provide an idea of the relative distribution of annual average benzo(a)pyrene concentrations.

***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 |
| Prievidza, Malonecpalská | | | 1.4 | 1.2 | 1.1 |
| Trenčín, Hasičská | | | | 0.8 | **1.1 |
| Púchov, 1.mája | | | | | *4.7 |

*≥ 90% of valid measurements*

*The red colour indicates that the target value has been exceeded in case of sufficient data coverage (≥ 90%) in a given year.*

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

*** In Trenčín, measurements of benzo(a)pyrene were interrupted due to technical reasons during the summer and sporadically also in the next part of the year, therefore there are not enough valid measurements for a full year assessment.*

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

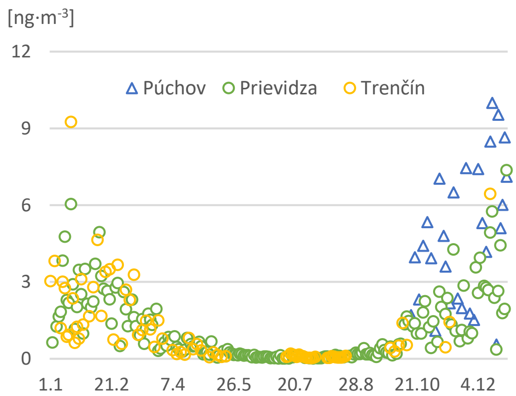
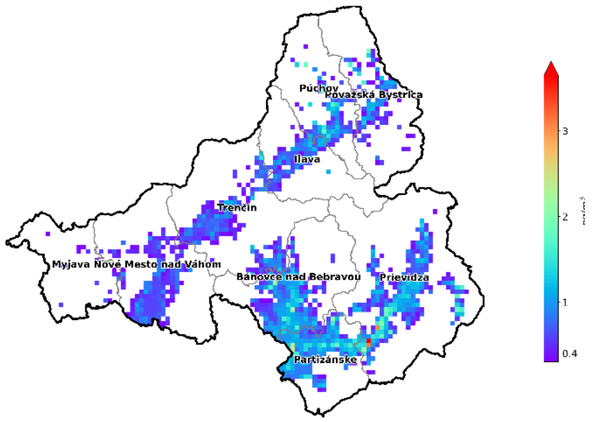



***Fig. 3.11*** *Average annual concentration of benzo(a)pyrene from RIO, IDW-R models output (2021).*




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

## 3.5 Risk areas

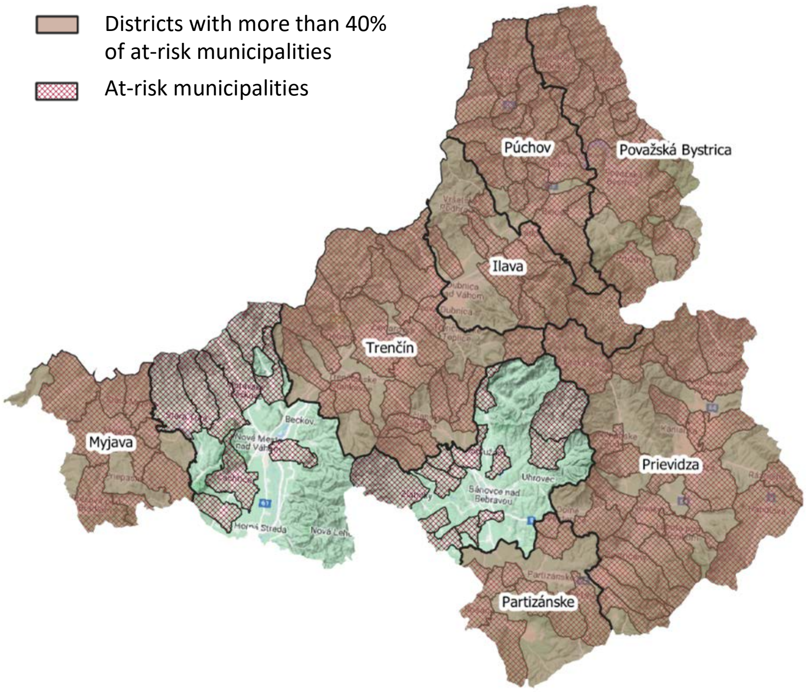
**Fig. 3.12** shows the areas at risk of air quality deterioration due to pollutants (PM and benzo(a)pyrene) from domestic heating based on the modelling results. The modelling results were obtained by using the methodology of *D. Štefánik: Identification of at-risk municipalities with air quality threatened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

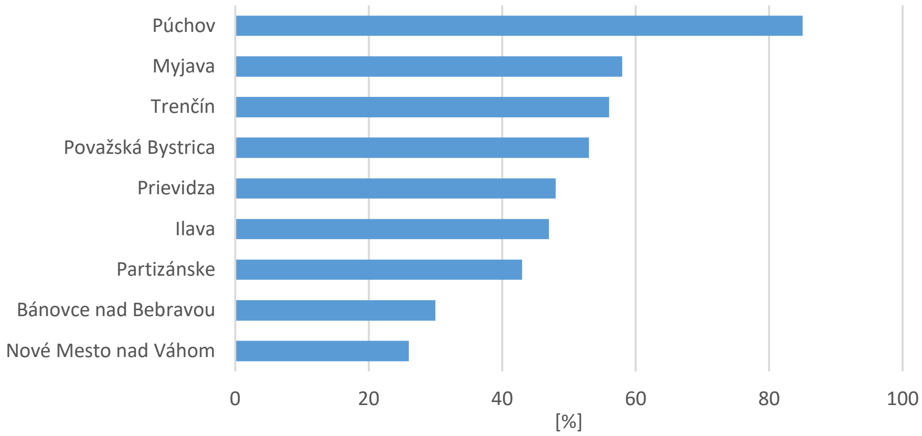
[3] *https://www.shmu.sk/File/oko/studie_analyzy/Popis_metody_na_urcenie_rizikovych_oblasti_aktualizacia.pdf*

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




The percentage of at-risk municipalities in each district is shown in **Fig. 3.13**. If a district has more than 40% of the municipalities at risk, the whole district is defined as at risk. In the Trenčín Region, these are the following districts: Púchov, Myjava, Trenčín, Považská Bystrica, Prievidza, Ilava, Partizánske.

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




The highest proportion of at-risk municipalities in the Trenčín region is in the districts of Púchov, Myjava and Trenčín, especially the mountain basins with good availability of firewood are problematic. More than 70% of the at-risk municipalities in the Trenčín region have less than 2 000 inhabitants, which confirms the assumption that the problem is significantly greater in areas with a rural type of settlement. ***More detailed data are available on the interactive map***[4].

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

### 3.6 Summary

In 2021, in the zone Trenčín 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 $PM_{10}$ and $PM_{2.5}$. No monitoring station exceeded the limit value for the average daily concentration of $PM_{10}$.

The target value for benzo(a)pyrene was exceeded at the monitoring station in Prievidza, Malonecpalská, the territory of the city of Prievidza was therefore defined as an air quality management area for benzo(a)pyrene on the basis of the measurements. A new monitoring station in Púchov at the end of 2021 measured high daily concentrations of benzo(a)pyrene. However, we will have to wait until measurements covering the whole year are available to make an assessment. However, it is also likely to be a problem area.

Based on the results of the mathematical modelling, we can assume that in the zone, high concentrations of PM and benzo(a)pyrene may also occur, especially in the winter months, in other areas with adverse dispersion conditions and a high share of solid fuels in household heating.