# AIR POLLUTION IN THE SLOVAK REPUBLIC 2022

# ANNEX

## AIR QUALITY ASSESSMENT IN ZONE TRENČÍN REGION




Air quality monitoring department
SLOVAK HYDROMETEOROLOGICAL INSTITUTE



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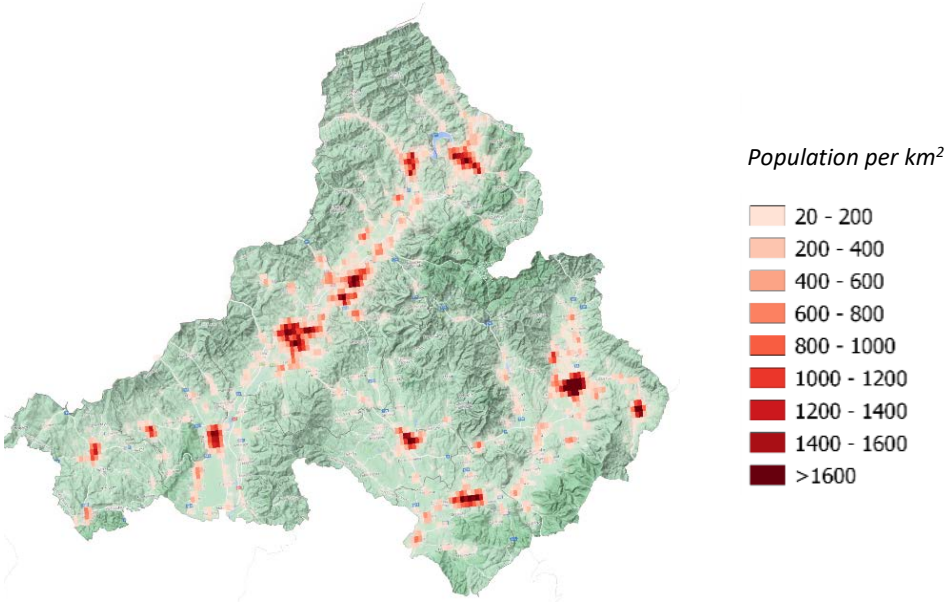
Version 1

# 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).*

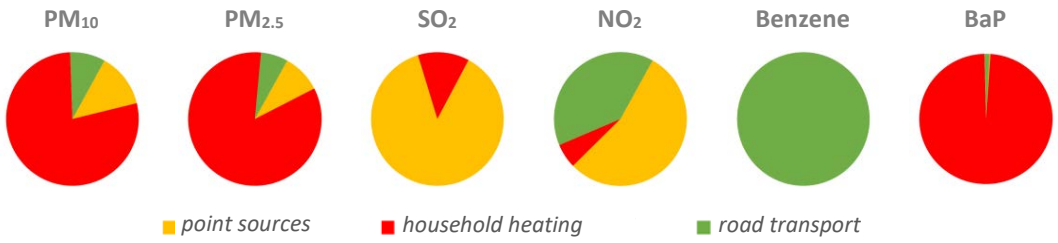



***Air pollution sources in zone Trenčín region***

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*

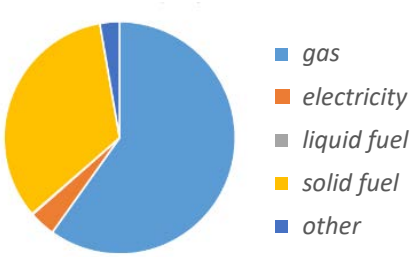
*Fig. 1.2* *Share of different types of air pollution sources in total emissions in the Trenčín region.*




*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 towns. The share of solid fuels is slightly 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 five 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.

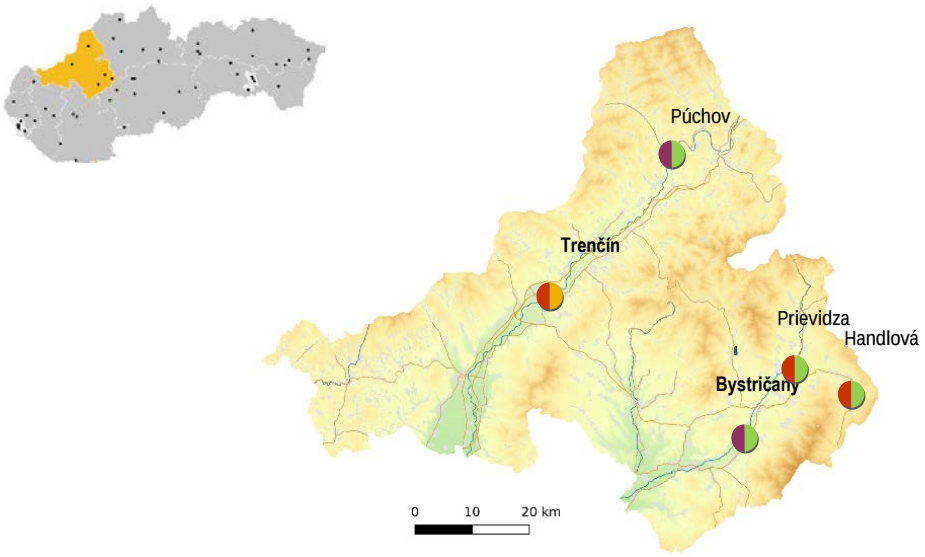
[2] *https://www.scitanie.sk*

**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 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 Trenčín region.*

| **Zone Trenčín region** | | | | | | | | Measurement programme | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Continuously | | | | | | | | Manually | |
| District | EoI code | Station name | Type of | | Geographical | | Altitude [m] | $PM_{10}$ | $PM_{2.5}$ | NO, $NO_2$ | $SO_2$ | $O_3$ | CO | Benzene | Hg | As, Cd, Ni, Pb | BaP |
| | | | area | station | longitude | latitude | | | | | | | | | | | |
| 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 | 3 | 5 | 1 | 2 | 1 | 0 | 2 | 3 |




*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 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 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 Trenčín 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 | | | | | | |
| Prievidza, Malonecpalská | 0 | 0 | 0 | 15 | 4 | 17 | 13 | | | 0 | 0 |
| Bystričany, Rozvodňa SSE | 0 | 0 | | | 3 | 19 | 14 | | | 0 | 0 |
| Handlová, Morovnianska cesta | 0 | 0 | | | 1 | 16 | 13 | | | 6 | 0 |
| Púchov, 1. mája | 0 | 0 | 0 | 10 | 10 | 22 | 16 | 1 647 | | 13 | 0 |
| Trenčín, Hasičská | 0 | 0 | 0 | 26 | 8 | 23 | 14 | 1 417 | 0.78 | 0 | 0 |

*≥ 90% of valid measurements*

[1] *eight-hour maximum concentration*

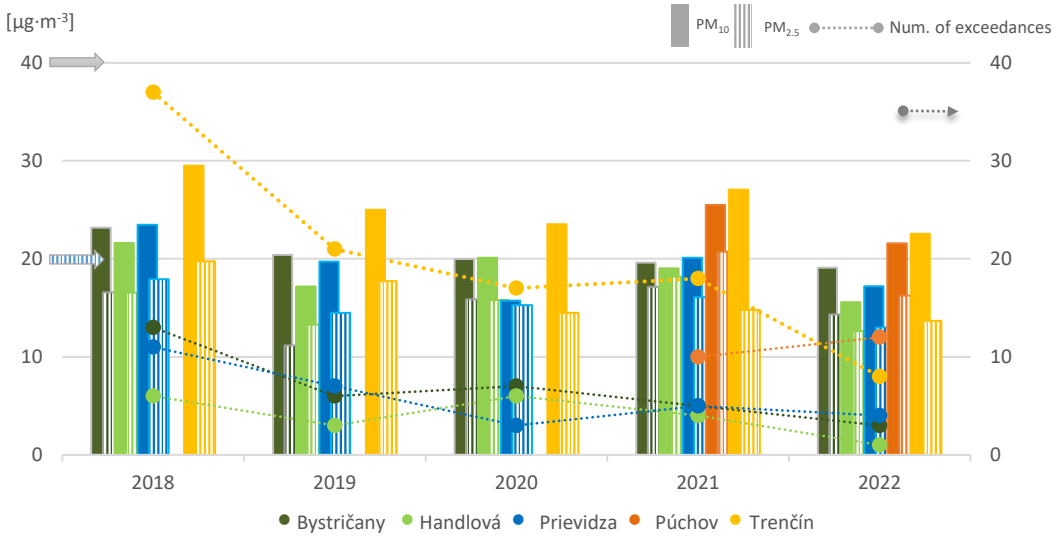
[2] *IT, AT – duration of exceedance (in hours) of the information threshold (IT) and alert threshold (AT) for $PM_{10}$*

*In accordance with the Decree of the Ministry of Environment of the Slovak Republic No. 244/2016 Coll. on air quality as amended, the required proportion of valid values was observed at the monitoring stations.*

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

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



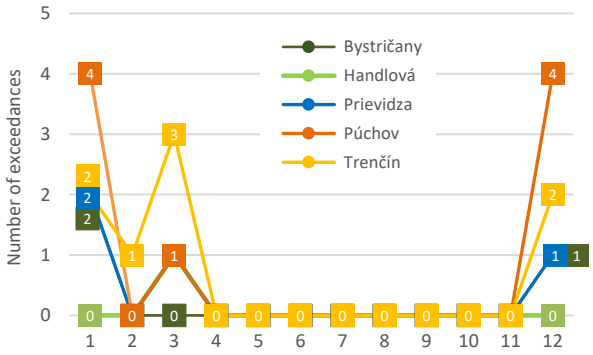

*Number of exceedances – daily average concentrations greater than 50 $\mu g \cdot m^{-3}$.*

*Arrows show limit values, **blue striped** $PM_{2.5}$ (annual average concentration: 20 $\mu g \cdot m^{-3}$); **grey solid** $PM_{10}$ (annual average concentration: 40 $\mu g \cdot m^{-3}$); **grey dotted** right number of exceedances (daily average $PM_{10}$ 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 mean concentration of $PM_{10}$ (40 $\mu g \cdot m^{-3}$) 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**).

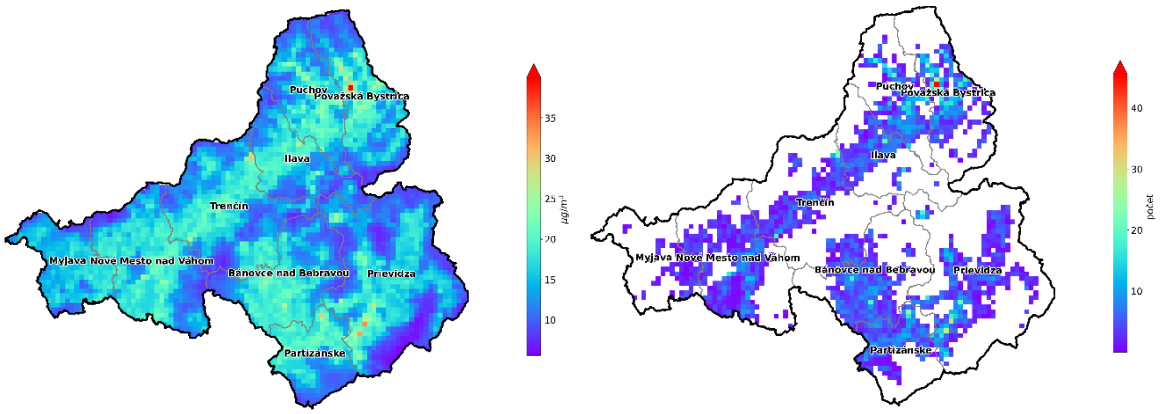
***Fig. 3.2*** *Number of $PM_{10}$ daily limit value exceedances per month in 2022.*




The traffic station Trenčín, Hasičská recorded the highest annual average $PM_{10}$ concentration of 23 $\mu g \cdot m^{-3}$ (representing a year-on-year decrease of 4 $\mu g \cdot m^{-3}$) with 8 daily exceedances, the suburban out-of-band station in Púchov 22 $\mu g \cdot m^{-3}$ with 10 daily exceedances. Concentration values at the remaining urban and suburban background stations ranged from 16 to 19 $\mu g \cdot m^{-3}$, which represents a year-on-year improvement (concentration reduction) of 1 – 3 $\mu g \cdot m^{-3}$). In **Fig. 3.2** we can see that all exceedances are concentrated in the cold months when heating is required. The relatively high values measured at the monitoring station in Púchov, which started operating in 2021, were confirmed in 2022. The station recorded the highest number of exceedances (4) of the daily limit value on a monthly basis, in January and December.

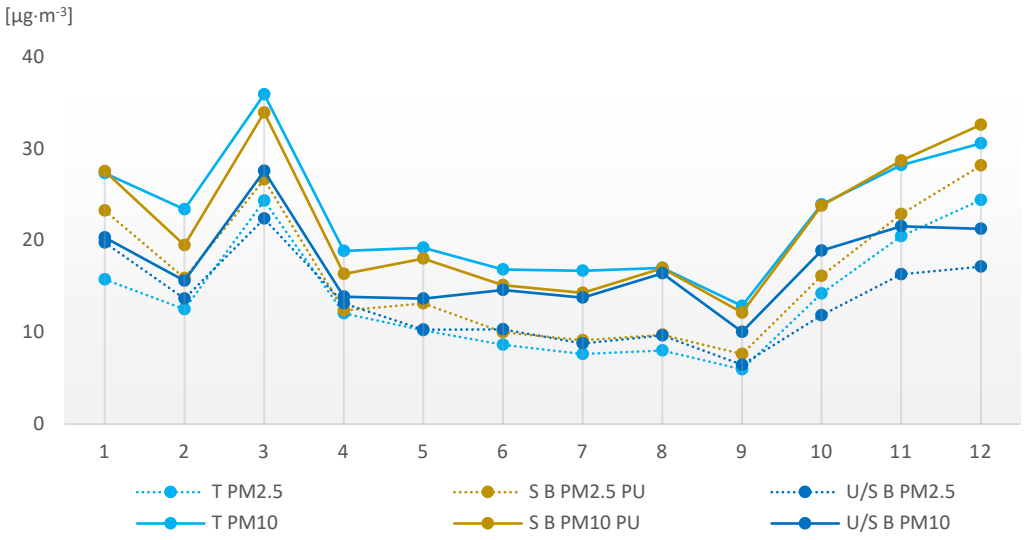
**Fig. 3.3** and **Fig. 3.5** show the modelling results for $PM_{10}$ and $PM_{2.5}$ calculated for the year 2022 using the RIO model in combination with IDW-R (the method is described in more detail in Chapter 4 of *Air pollution in the Slovak Republic 2022 Report*).

***Fig. 3.3*** *Average annual $PM_{10}$ concentration (left) and number of $PM_{10}$ daily limit value exceedances (right) in 2022.*




All urban or suburban background stations in the zone have similar average monthly concentrations of $PM_{10}$ and $PM_{2.5}$, except for AMS in Púchov, which measured higher particulate matter air pollution in 2022 (similar to 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 urban and suburban background stations in the zone outside Púchov. An interesting finding was confirmed that the $PM_{10}$ levels at the suburban background station in Púchov are close to those measured at the traffic station in Trenčín. In December, even the average monthly $PM_{10}$ concentration in Púchov (32.7 µg·m$^{-3}$) significantly exceeded the value measured in Trenčín (30.5 µg·m$^{-3}$).

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



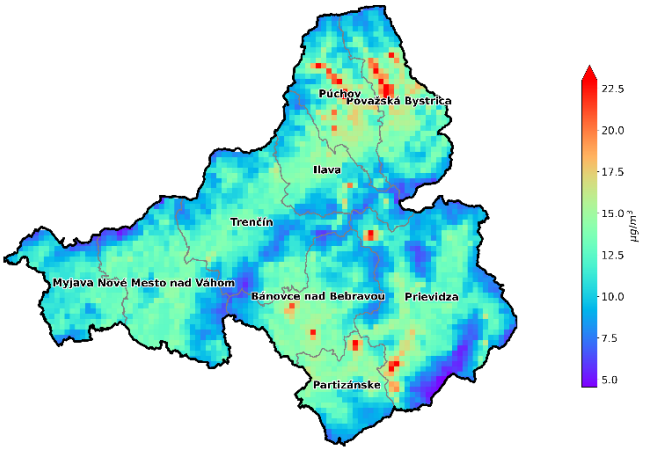

***T PM10*** *and* ***T PM2.5*** *– average monthly concentration of $PM_{10}$ and $PM_{2.5}$ at the traffic station Trenčín, Hasičská;* ***S B PM10 PU*** *and* ***S B PM2.5 PU*** *– average monthly concentration of $PM_{10}$ and $PM_{2.5}$ at the suburban traffic station Púchov.* ***U/S B PM10*** *and*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

### $PM_{2.5}$

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, the annual mean $PM_{2.5}$ concentrations were 13 µg·m$^{-3}$, 14 µg·m$^{-3}$ and 13 µg·m$^{-3}$, respectively (16 µg·m$^{-3}$, 17 µg·m$^{-3}$ and 18 µg·m$^{-3}$ the year before, so there was a significant year-on-year improvement in these locations). High concentrations of $PM_{2.5}$ were observed in the cold months of the year. This is probably caused by household heating with solid fuels, as is the case for $PM_{10}$. At all stations in the zone, the mean annual concentration of fine particles $PM_{2.5}$ was higher than the WHO recommendation (5 µg·m$^{-3}$). Also, their monthly concentrations were above 5 µg·m$^{-3}$. This is even in summer, when they tend to be lowest.

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

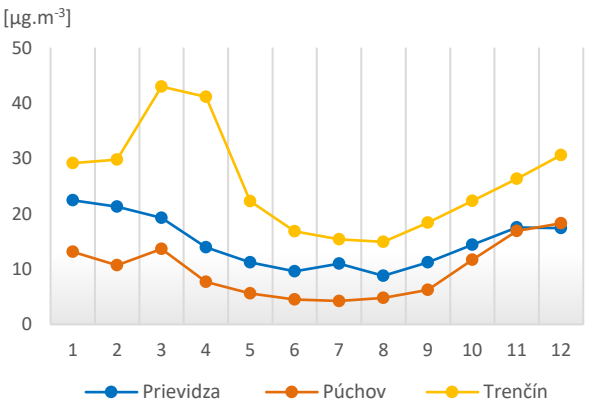
*Fig. 3.5* *Average annual $PM_{2.5}$ concentrations.*




## 3.2 Nitrogen dioxide

Nitrogen dioxide levels in the air are monitored at three stations (Prievidza, Púchov and Trenčín). The average monthly values for each station are shown in Fig. 3.6.

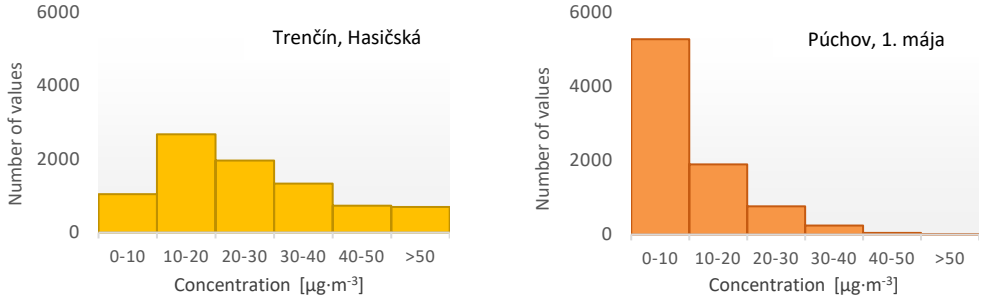
*Fig. 3.6* *Average monthly $NO_2$ concentrations in 2022.*




The main source of $NO_2$ emissions is road transport. The highest concentrations were recorded at the Trenčín, Hasičská traffic station. The annual average level (26 µg·m$^{-3}$, which represents an annual increase in concentration of 3 µg·m$^{-3}$) did not exceed the limit value (40 µg·m$^{-3}$) here. In Prievidza and Púchov, $NO_2$ concentrations remain relatively constant throughout the year (in Trenčín higher values were measured in March and April), with a slight 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 10 µg·m$^{-3}$. The air pollution with this pollutant was lower 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. 3.7 shows the different frequency distribution of hourly $NO_2$ concentrations at two types of stations – the traffic station in Trenčín and the suburban background station in Púchov. While in Trenčín we measured 698 values higher than 50 µg·m$^{-3}$, in Púchov only one.

*Fig. 3.7* *Histogram of hourly $NO_2$ concentrations at Trenčín and Púchov stations.*




## 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. 3.8**). **Fig. 3.9** and **Fig. 3.10** 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. 3.8* *Average monthly concentrations $O_3$ in 2022.*

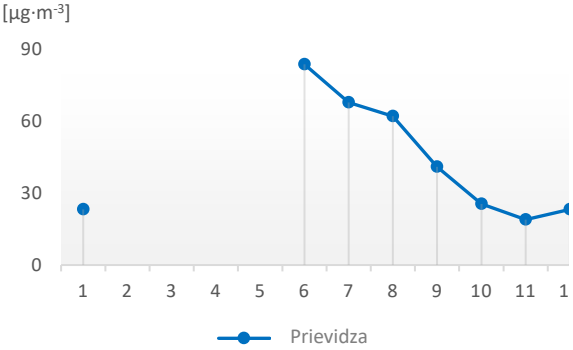



*Fig. 3.9* *Daily $O_3$ concentration in July 2022.*

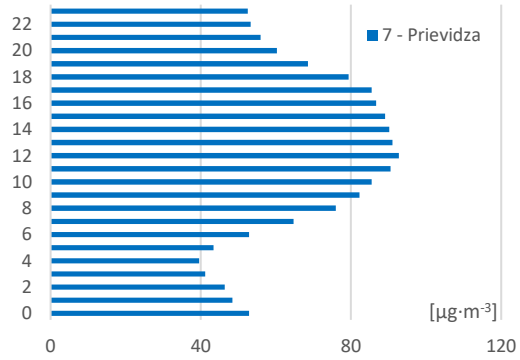
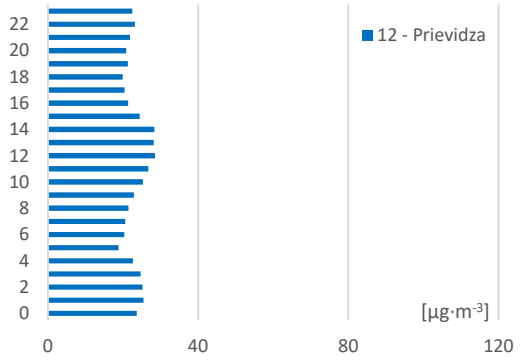



*Fig. 3.10* *Daily $O_3$ concentration in December 2022.*




At the monitoring station in Prievidza, no exceedances of the information or alert threshold for ground-level ozone were measured in 2022.

## 3.4 Benzo(a)pyrene

In 2022, benzo(a)pyrene was monitored at two monitoring stations in the Trenčín region – in Prievidza, Malonecpalská and Púchov, 1 mája. The sampler in Trenčín on Hasičská street had a malfunction. The annual pattern of concentrations has an even more pronounced maximum in the cold half of the year compared to PM (**Fig. 3.11**). The target value for benzo(a)pyrene (1 ng·m$^{-3}$) is exceeded in Prievidza every year, although only slightly (**Tab. 3.2**). In 2022, the sampler at the AMS in Prievidza on Malonecpalská street had a malfunction from 24 January to 21 April and it is very likely that, with sufficient measurements, the target value would have been exceeded in 2022 as well, as the failure of the measurements affected the period when concentrations are usually highest. The measured values at Púchov are higher than at the other stations in the zone. This is probably due to the effect of household heating with solid fuel. The site will require further attention.

The map in **Fig. 3.12** shows the spatial distribution of annual mean benzo(a)pyrene concentrations according to the RIO model outputs combined with IDW-R. Due to the zone orography, 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 | 2022 |
|---|---|---|---|---|---|---|---|
| Target value | [ng·m⁻³] | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Upper assessment threshold | [ng·m⁻³] | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Lower assessment threshold | [ng·m⁻³] | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Prievidza, Malonecpalská | | | | 1.4 | 1.2 | 1.1 | *0.9 |
| Trenčín, Hasičská | | | | | 0.8 | 1.1 | |
| Púchov, 1. mája | | | | | | 4.7 | 2.0 |

*≥ 90% of valid measurements* ** Prievidza – device failure from 24.1. to 21.4.2022.*

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

***Fig. 3.11*** *Average monthly concentration of benzo(a)pyrene in 2022.*

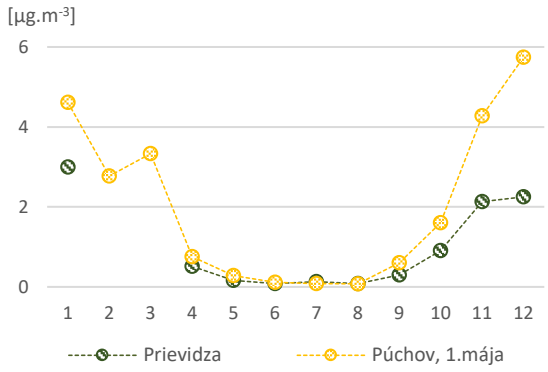
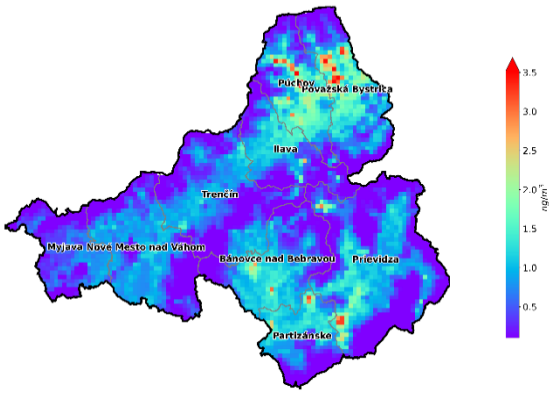



***Fig. 3.12*** *Average annual concentration of benzo(a)pyrene from RIO, IDW-R models output (2022).*



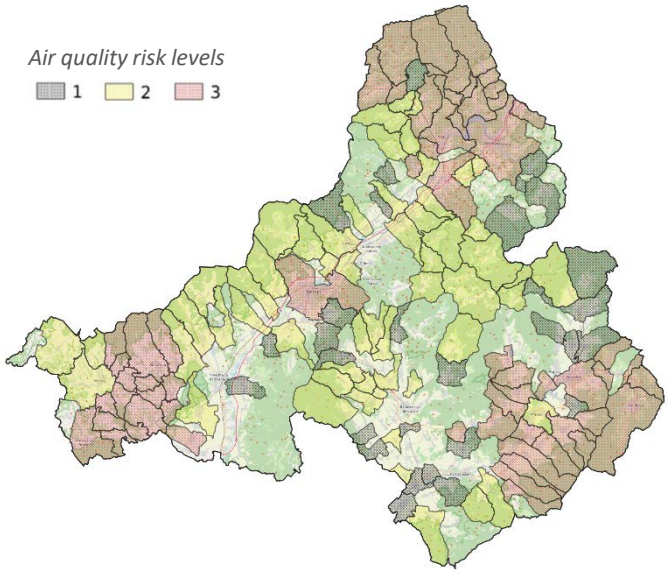

The most significant source of benzo(a)pyrene is domestic heating with solid fuels (by insufficiently dried wood or various types of waste and, in traditionally mining areas, by coal). According to the results of the RIO model, the maximum BaP values occur in the Prievidza, Partizánske, Púchov and Bánovce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

## 3.5 Risk municipalities

**Fig. 3.13** displays municipalities at risk due to deteriorated air quality as determined by the integrated municipal assessment method[3]. 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.

[3] *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*

*Fig. 3.13* *Risk municipalities in zone Trenčín region.*




Municipalities in which the limit value for PM, $NO_2$, or the target value for BaP was exceeded based on high spatial resolution modelling were automatically assigned a risk level 3, similar to municipalities where the limit or target value exceedance was detected through measurement. The list of municipalities and their risk levels can be found on the SHMÚ website[4].

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[5].

## 3.6 Summary

In 2022, no exceedances of the limit values for $SO_2$, $NO_2$, CO and benzene, nor exceedances of the limit values for the annual average concentration of $PM_{10}$ and $PM_{2.5}$ were measured in the Trenčín region. No monitoring station surpassed 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 Púchov, 1. mája.

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

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