AIR POLLUTION IN THE SLOVAK REPUBLIC 2022

ANNEX

AIR QUALITY ASSESSMENT IN ZONE BANSKÁ BYSTRICA REGION

Air quality monitoring department
SLOVAK HYDROMETEOROLOGICAL INSTITUTE

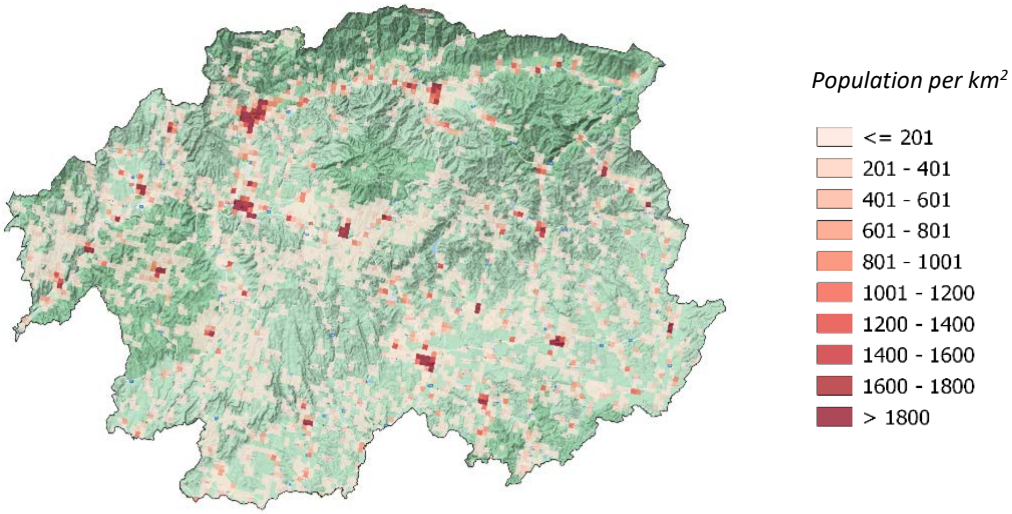
Bratislava, October 2023
Version 1

1 DESCRIPTION OF BANSKÁ BYSTRICA REGION TERRITORY IN TERMS OF AIR QUALITY

The terrain of the Banská Bystrica region is predominantly mountainous. The mountain basins in the area are characterized by low wind speeds and frequent temperature inversions, especially in winter. In the north of the district there are the higher mountains of the Low Tatras and outcrops of the Veľká Fatra. A relatively large part is occupied by the medium-high mountains - the Slovenské Rudohorie, Štiavnické vrchy a Krupinská planina in the central part of the district. The south of the district is characterized by lower altitudes - Juhoslovenská kotlina and Cerová vrchovina are located here. The highest point is Ďumbier with an altitude of 2 046 m a.s.l., the lowest point is 124 m a.s.l. **Fig. 1.1** shows the spatial distribution of population density in the zone.

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

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

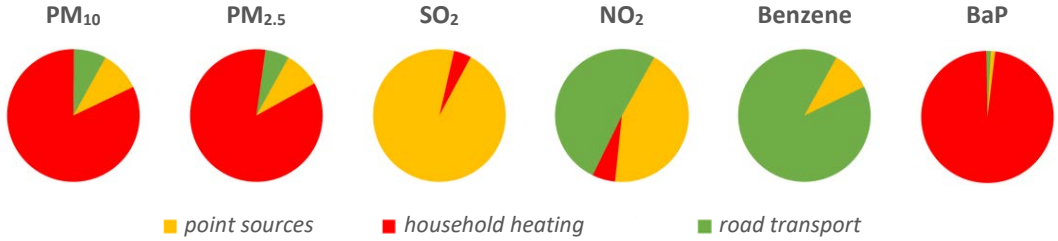


Air pollution sources in zone Banská Bystrica region

The dominant source of air pollution in the Banská Bystrica region is household heating, especially in the northern part, where the share of firewood use is the highest compared to other areas. Road transport is also important locally. It reaches the highest intensity in the district of Banská Bystrica - on the R1 highway (an average of 40 011 vehicles pass through it daily, of which 4 644 trucks and 35 174 passenger cars) and on road No. 66 (34 559 vehicles, of which 2 740 trucks and 31 719 passenger cars). Road No. 50 is significant in terms of traffic congestion in the district of Zvolen, Žiar nad Hronom and Detva - in Zvolen with a level of 29 988 vehicles (19% trucks), in Žiar nad Hronom 16 707 vehicles (23% trucks) and in Detva with 14 357 vehicles (11% trucks) - and route No. 66 in the districts of Zvolen (14 715 vehicles, of which 2 534 trucks and 12 135 cars) and Brezno (12 289 vehicles, of which 1 659 trucks and 10 559 cars). In the district of Lučenec, roads are No. 585, No. 50 and No. 75 are important, while the heaviest traffic is on the first of them (13 815 vehicles, of which 1 387 trucks and 12 370 passenger cars) [1].

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

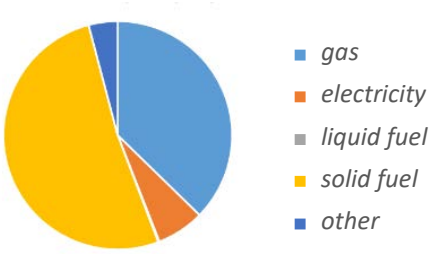
Fig. 1.2 *Share of different types of air pollution sources in total emissions in the Banská Bystrica region.*



Note: Medium and large air pollution sources registered in the NEIS database are identified for this purpose as "point sources".

Non-ferrous metallurgy and other industrial sources have a less significant contribution to local air pollution with the basic pollutants in Banská Bystrica region. Under suitable meteorological conditions, the impact of heating plants will also appear in this zone. A significant source of PM and BaP in this region is household heating, road transport is a source of NO_2 and benzene.

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, both solid fuels and natural gas are used for heating in family houses in the zone. According to the SODB, the Banská Bystrica region has the second highest share of solid fuels for household heating. Solid fuels are probably used more in rural type of settlements with good availability of firewood. The districts of Detva, Krupina and Zvolen have the highest share of solid fuels in the zone.

2 AIR QUALITY MONITORING STATIONS IN ZONE BANSKÁ BYSTRICA REGION

In the Banská Bystrica region, air quality has been monitored at eight locations. In the city of Banská Bystrica, there are two stations, a transport station on Štefánikova street and a city background station on Zelená street in a sloping terrain with residential-type buildings. Urban background stations, which mainly monitor the effect of household heating in a rural environment, are represented in the south-eastern part of the region in the cities of Jelšava and Hnúšťa. In 2021, a station was added in Lučenec to monitor the impact of traffic. The north-western part of the region is covered by stations in Zvolen and Žiar nad Hronom and Žarnovica, which monitor the urban or suburban (Žarnovica) background.

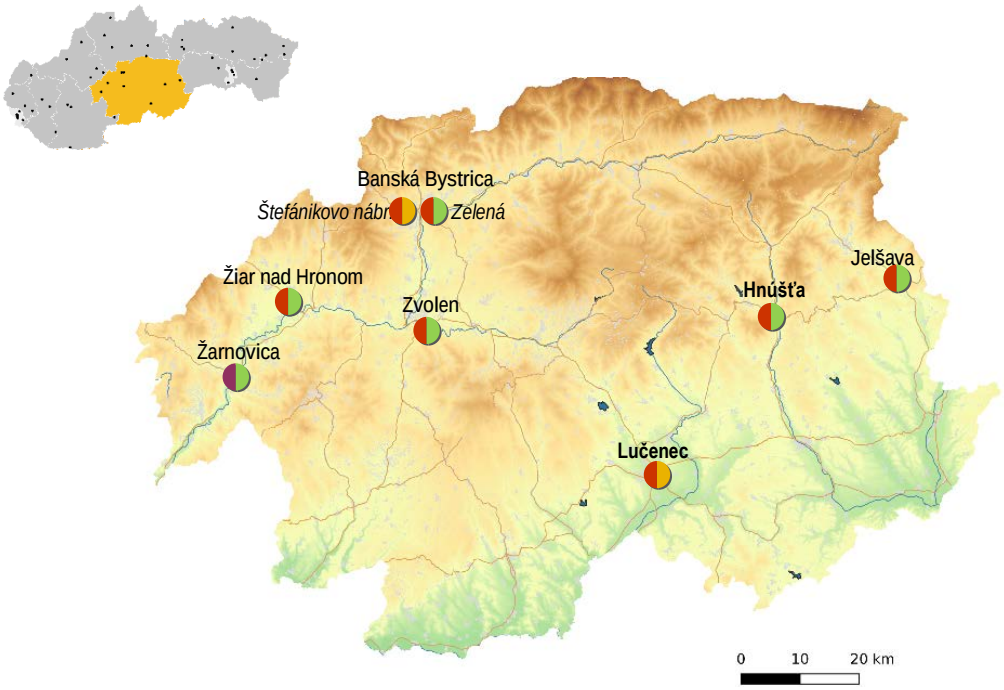
[2] *https://www.scitanie.sk*

Tab. 2.1 contains information about air quality monitoring stations in the zone Banská Bystrica region:

- international EoI code, characteristics of the station according to dominant sources of air pollution (traffic, background, industrial), type of area that the station monitors (urban, suburban, rural/ regional) and geographical coordinates;
- monitoring programme. Automatic continuous monitoring 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. The results of measurement are average 24-hour values.

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

Zone Banská Bystrica region								Measurement programme									
								Continuously								Manually	
District	EoI code	Station name	Type of		Co-ordinates		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											
Banská Bystrica	SK0214A	Banská Bystrica, Štefánikovo nábrežie	U	T	19°09'18"	48°44'06"	346										
Banská Bystrica	SK0263A	Banská Bystrica, Zelená	U	B	19°06'55"	48°44'01"	425										
Revúca	SK0025A	Jelšava, Jesenského	U	B	20°14'26"	48°37'52"	289										
Rimavská Sobota	SK0022A	Hnúšťa, Hlavná	U	B	19°57'06"	48°35'02"	320										
Lučenec	SK0072A	Lučenec, Gemerská cesta	U	T	19°40'33"	48°20'12"	183										
Zvolen	SK0262A	Zvolen, J. Alexyho	U	B	19°09'25"	48°33'30"	321										
Žarnovica	SK0065A	Žarnovica, Dolná	S	B	18°43'10"	48°28'58"	222										
Žiar n/Hronom	SK0268A	Žiar n/Hronom, Jilemnického	U	B	18°50'34"	48°35'59"	296										
							Total	8	8	5	1	3	2	2	0	2	4



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 BANSKÁ BYSTRICA REGION

This chapter contains an assessment of air quality in the zone Banská Bystrica 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 Banská Bystrica 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						
Banská Bystrica, Štefánik. nábr.	0	0	0	24	20	26	16	1 644	0.94	33	0
Banská Bystrica, Zelená			0	8	0	16	12			0	0
Jelšava, Jesenského			0	8	53	30	22			85	0
Hnúšťa, Hlavná					5	21	14			0	0
Lučenec, Gemerská cesta			0	15	19	24	17	1 494	0.74	0	0
Zvolen, J. Alexyho					1	19	14			0	0
Žarnovica, Dolná			0	11	21	25	20			14	0
Žiar n/H, Jilemnického					0	16	12			0	0

≥ 90% of valid measurements *Exceedance of the limit value is marked in red.*

[1] *eight-hour maximum concentration*

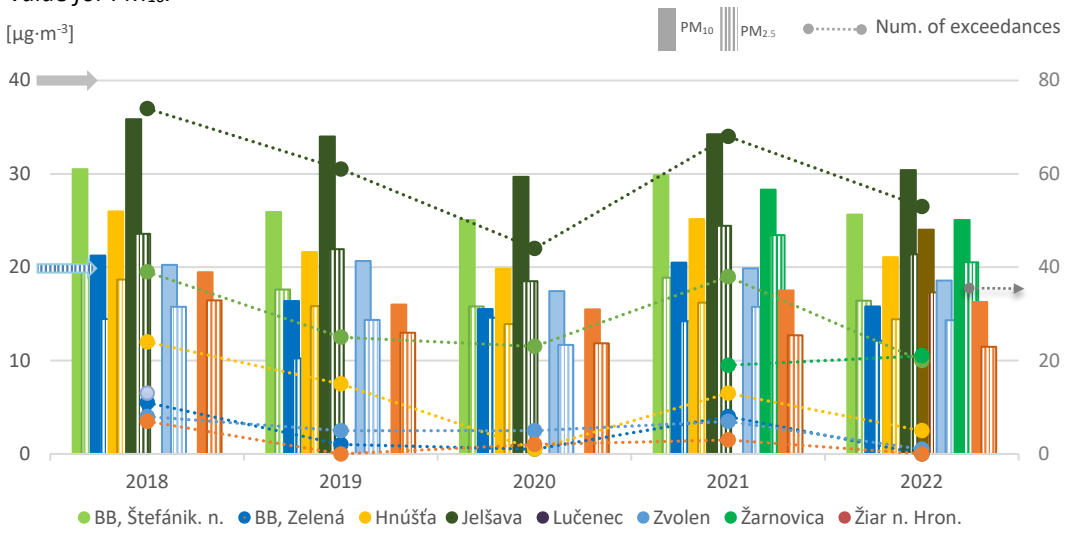
[2] *IT, AT – duration of exceedance (in hours) of the information threshold (IT) and alert threshold (AT) for PM_{10}*

In accordance with the 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 Banská Bystrica region in 2022.

Fig. 3.1 *Annual mean concentrations of PM_{10}, $PM_{2.5}$ and the number of exceedances of the daily limit value for PM_{10}.*



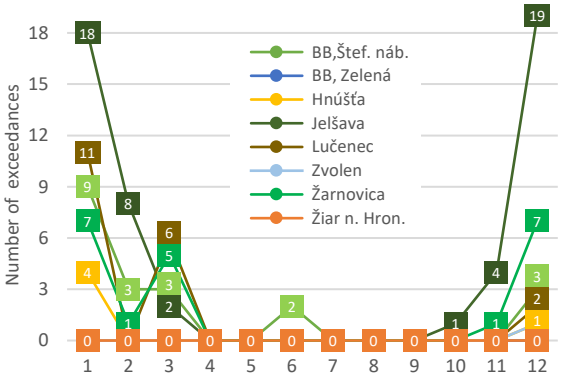
Number of exceedances - daily average concentrations higher than 50 $\mu g \cdot m^{-3}$.

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

PM_{10}

Only Jelšava exceeded the limit value (max 35 exceedances of 50 $\mu g \cdot m^{-3}$) for the average daily concentration of PM_{10} in 2022 (53 exceedances) (**Fig. 3.2**). The situation was slightly better than in 2021, in which Jelšava had 68 exceedances. The traffic station in Banská Bystrica recorded an exceedance of the limit value for the average daily concentration of PM_{10} in 2021 when it was affected by construction activity near the station. In 2022, it did not exceed this limit value again, similarly to other monitoring stations in the zone. The limit value for the annual average PM_{10} concentration (40 $\mu g \cdot m^{-3}$) in the zone Banská Bystrica region was not exceeded.

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



Although the long-term series of measurements[3] show that the situation has improved compared to 15 years ago in the vicinity of the transport station in Banská Bystrica, the problem remains in areas with a significant impact of household heating and with adverse dispersion conditions. This is evidenced by measurements of PM_{10} in Jelšava and, to a lesser extent, in Žarnovica.

The new limit value for the annual average concentration of PM_{10} (20 $\mu g \cdot m^{-3}$) proposed in the new EU Directive[4] would be exceeded by the traffic stations in Banská Bystrica and Lučenec, the urban background stations in Jelšava and Hnúšťa and the suburban background station in Žarnovica.

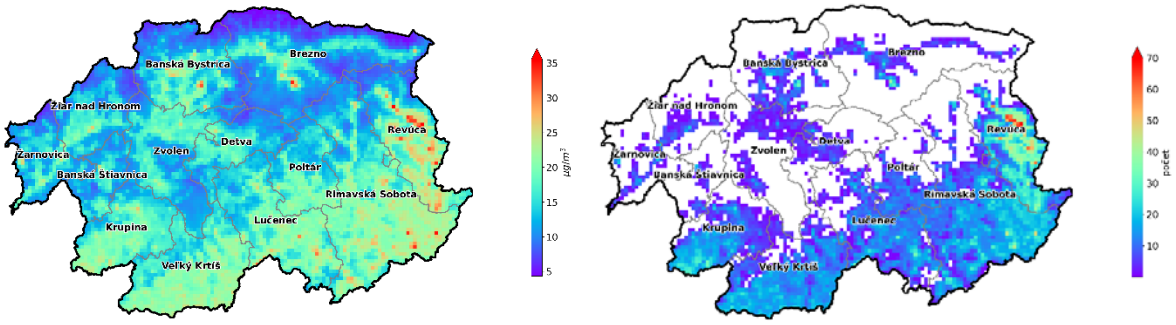
[3] *https://www.shmu.sk/sk/?page=2767*

[4] *https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/747087/EPRS_BRI(2023)747087_EN.pdf*

High concentrations of PM_{10} occurred mainly in January, March and December (**Fig. 3.3**), which corresponds to the number of exceedances (**Fig. 3.2**). It is also evident that in the warmer months of the year PM_{10} concentrations in Jelšava are only slightly above the average of other stations which confirms the assumption that the source of PM_{10} and $PM_{2.5}$ emissions here is mainly local heating - i.e. inappropriate way of solid fuel combustion in old boilers. The situation here is aggravated by frequent adverse dispersion conditions.

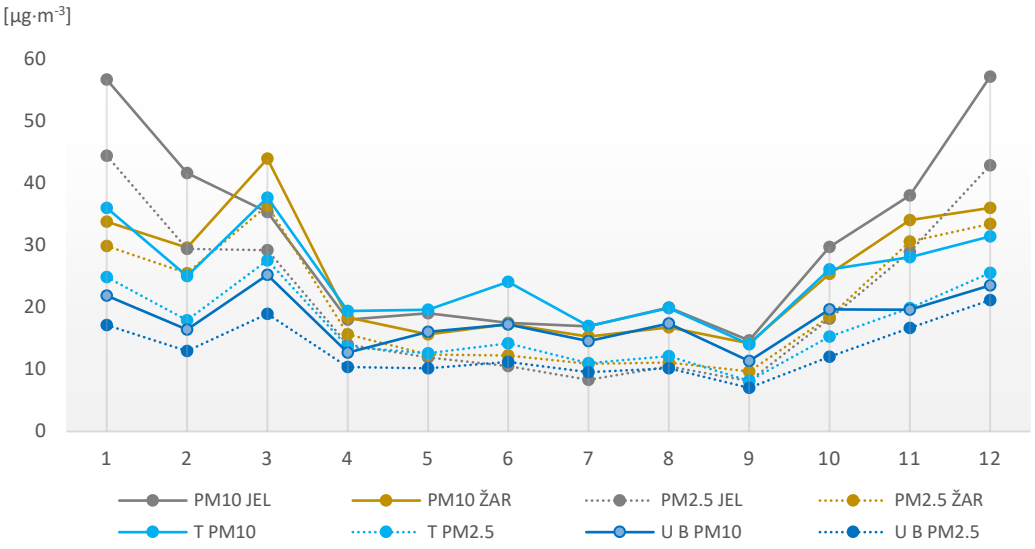
Fig. 3.3 and **Fig. 3.5** show the modelling results for PM_{10} and $PM_{2.5}$, calculated for the year 2022 using the RIO model subsequently adjusted using the regression IDW-R method (see Chapter 4 of *Air pollution in the Slovak Republic 2022 Report* for more details).

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



Both traffic stations in the region (in Banská Bystrica at Štefánikovo nábrežie and in Lučenec) have similar average monthly concentrations of PM_{10} and $PM_{2.5}$, but different patterns are observed in Žarnovica, Jelšava and other stations. Therefore **Fig. 3.4** shows the comparison of the monthly average PM_{10} and $PM_{2.5}$ of the traffic stations in the region, the level at the suburban background station in Žarnovica, the urban background station in Jelšava and the monthly average of the remaining urban background stations in the region.

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



T PM10 *and* ***T PM2.5*** *- average of monthly concentrations of PM_{10} and $PM_{2.5}$ at the traffic stations Banská Bystrica, Štefánikovo. nábr. and Lučenec;* ***U B PM10*** *and* ***U B PM2.5*** *- average of monthly concentrations of PM_{10} and $PM_{2.5}$ at the urban background Banská Bystrica, Zelená; Hnúšt'a; Zvolen and Žiar n/Hronom;* ***PM10 JEL*** *and* ***PM2. 5 JEL*** *- average monthly concentration of PM_{10} and $PM_{2.5}$ at the urban background station Jelšava;* ***PM10 ŽAR*** *and* ***PM2.5 ŽAR*** *- average monthly concentration of PM_{10} and $PM_{2.5}$ at the suburban background station Žarnovica.*

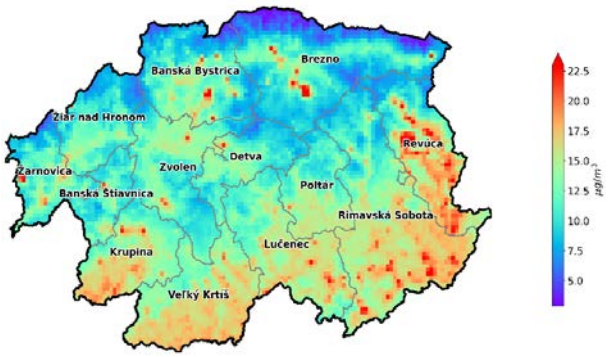
$PM_{2.5}$

Compared to PM_{10}, fine $PM_{2.5}$ particles have a significantly higher negative impact on human health. In Fig. 1.1 and Fig. 3.4, annual mean concentrations of $PM_{2.5}$ are shown by a dashed line. In Jelšava, the average annual concentration of $PM_{2.5}$ (22 µg·m^{-3}) exceeded the limit value (20 µg·m^{-3}) and, as with PM_{10}, very high concentrations of $PM_{2.5}$ were measured in the cold period of the year and in March, which, in addition to persistent heating demands, also had recurring adverse dispersion conditions during the anticyclonic situations that occurred in the two-thirds of March 2022.

The new limit value for the annual average concentration of $PM_{2.5}$ (10 µg·m^{-3}) proposed in the new forthcoming EU Directive would be exceeded by all monitoring stations in the zone.

As mentioned above for PM_{10}, air quality monitoring has also been carried out for the pollutant $PM_{2.5}$. The map in Fig. 3.5 is the output of the RIO model combined with IDW-R.

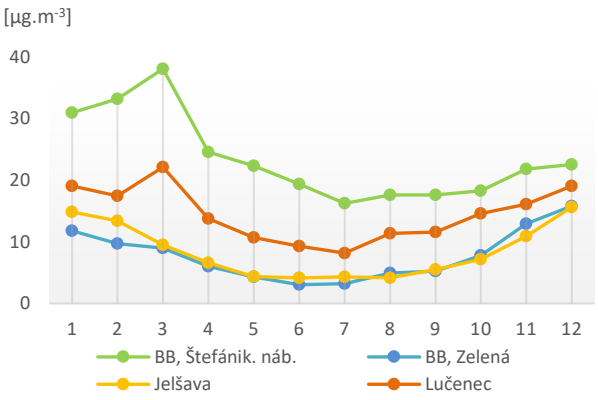
Fig. 3.5 *Average annual $PM_{2.5}$ concentration.*



3.2 Nitrogen dioxide

The limit value for the annual average or hourly concentration was not exceeded at any station, the highest annual average concentration did not even reach 2/3 of the limit value. The average monthly concentrations for individual stations are shown in Fig. 3.6. The March maxima, which occurred at the traffic stations in Banská Bystrica and Lučenec, were probably caused by unfavourable dispersion conditions brought by several anticyclones that passed over our territory.

Fig. 3.6 *Monthly average NO_2 concentrations.*

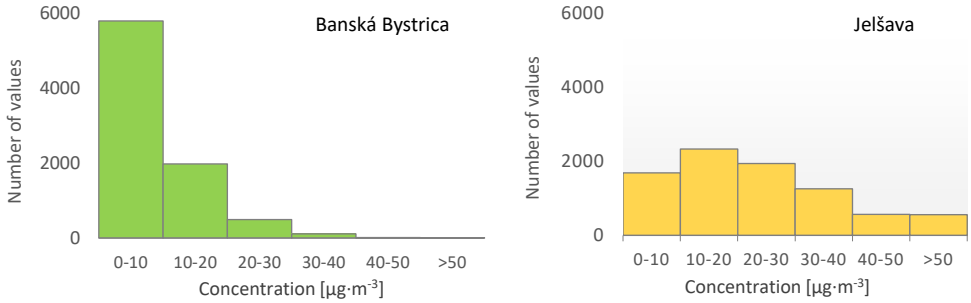


Comparison of the histograms in Fig. 3.7 from the traffic station in Banská Bystrica and the suburban background station in Jelšava indicates that the main source of nitrogen oxides is road traffic, the intensity of which is significantly higher in Banská Bystrica.

Average annual NO_2 concentrations at urban background stations in the Banská Bystrica region exceeded 10 µg·m^{-3} at all monitoring stations except Jelšava and Banská Bystrica, Zelená. This NO_2 level (10 µg·m^{-3}) represents the WHO recommended limit value (2021 recommendation). In general, the WHO recommendations are significantly more stringent than the EU limits. The new limit value for the annual average NO_2 concentration (20 µg-m^{-3}) proposed in the new forthcoming EU Directive would be exceeded by the traffic station in Banská Bystrica.

Fig. 3.7 compares the frequency distribution of hourly concentrations at the traffic station in Banská Bystrica, Štefánikovo nábr. and the urban background station in Jelšava, which meets the WHO recommendation for an annual average NO_2 concentration (max. 10 µg·m^{-3}). While the Jelšava station recorded 69% of hourly data in the band up to 10 µg·m^{-3}, the AMS in Banská Bystrica recorded only 19%.

Fig. 3.7 *Histogram of hourly NO_2 concentrations at AMS Banská Bystrica, Štefánikovo nábr. and Jelšava.*



3.3 Ozone

Ozone monitoring is carried out at three monitoring stations - in the regional town of Banská Bystrica, Zelená, Jelšava and Lučenec.

The highest concentrations of ground-level ozone generally occur in warm months with high sunshine intensity (**Fig. 3.8**). **Fig. 3.9** and **Fig. 3.10** show the so-called daily course of O_3 concentration at stations (urban background stations Jelšava and Banská Bystrica, Zelená). It shows the increase of their levels with sunrise, the peak they reach around noon and the gradual decrease in the evening to the minimum occurring in the morning. Large differences in ground-level ozone concentrations are also observed in the warm and cold seasons.

Fig. 3.8 *Monthly average O_3 concentrations.*

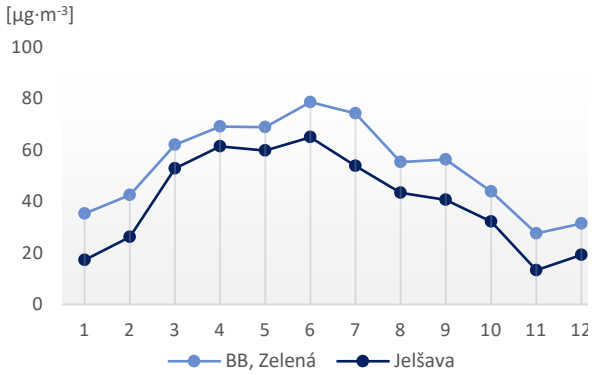


Fig. 3.9 *Daily O_3 concentration in January 2022.*

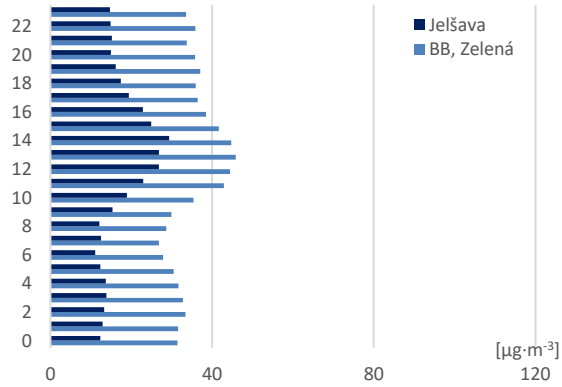
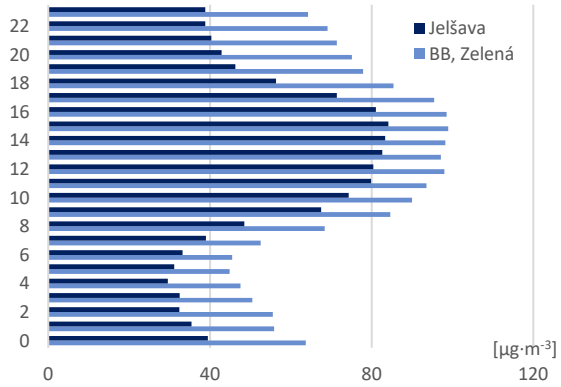


Fig. 3.10 *Daily O_3 concentration in July 2022.*



3.4 Benzo(a)pyrene

Benzo(a)pyrene is monitored in the Banská Bystrica region at one urban and two suburban background stations (in Banská Bystrica, Zelená, Jelšava and from 2021 also in Žarnovica) and one traffic station (in Banská Bystrica, Štefánikovo nábrežie).

In 2022, the target value was exceeded at all monitored sites with the exception of the station Banská Bystrica, Zelená (**Tab. 3.2**). Values measured in Žarnovica in winter months are similarly high as in Jelšava (**Fig. 3.11**). The average annual concentration at these sites is almost double the value measured at the

traffic station in Banská Bystrica. The highest concentrations were measured in January (16.5 ng·m^{-3} in Jelšava on 2 January 2022 and 14 ng·m^{-3} in Žarnovica on 24 January 2022).

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

	2017	2018	2019	2020	2021	2022
Target value [ng·m^{-3}]	1.0	1.0	1.0	1.0	1.0	1.0
Banská Bystrica, Štefánikovo nábrežie	2.9	2.1	1.7	1.6	1.7	1.4
Banská Bystrica, Zelená			1.1	1.2	1.3	0.9
Jelšava, Jesenského		3.9	4.0	3.0	2.8	2.7
Žarnovica, Dolná					2.2	2.7

≥ 90% of valid measurements

Exceeding the target value is marked in red if there were enough (≥ 90%) valid measurements at the station in the given year.

The most significant source of benzo(a)pyrene is the heating of households with solid fuel, especially insufficiently dried wood, or unsuitable fuel (various types of waste). Modern heating devices achieve relatively low emissions with proper maintenance and operation. However, in areas such as Jelšava, modern boilers are probably only used to a small extent, which is a reflection of the significant representation of low-income households. **Fig. 3.12** shows the average annual concentration according to the outputs of mathematical modelling. In areas with extremely adverse dispersion conditions, such as Jelšava, this substance with carcinogenic properties represents a significant problem.

Fig. 3.11 *Monthly average benzo(a)pyrene concentrations in 2022.*

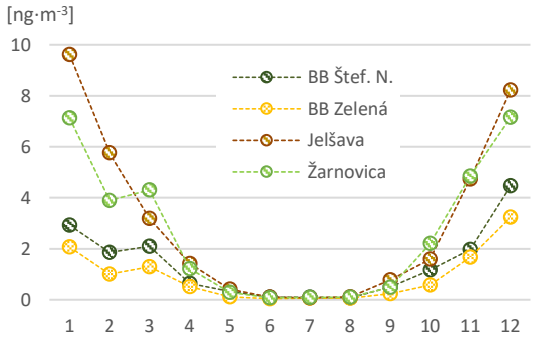
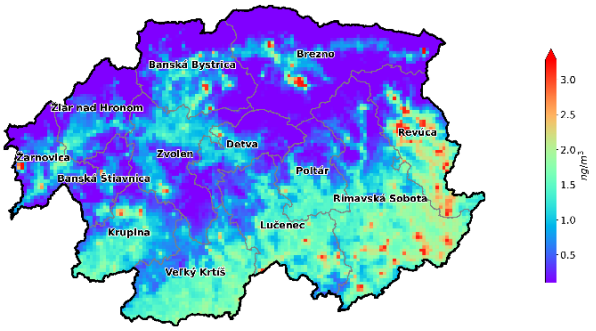


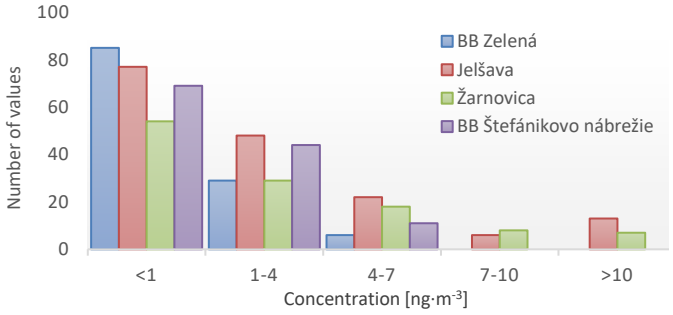
Fig. 3.12 *Average annual concentration of benzo(a)pyrene from RIO model output, IDW-R (2022).*



In the traditionally problematic Jelšava, samples for the analysis of polycyclic aromatic hydrocarbons were taken every second day and at the other stations every third day.

Fig. 3.14 shows that the highest concentrations (values above 7 ng·m^{-3}) were measured only in Jelšava and Žarnovica.

Fig. 3.13 *Histogram of average daily concentrations of benzo(a)pyrene in Banská Bystrica, Štefánikovo nábr. and Zelená street, Jelšava and Žarnovica in 2022.*



3.5 Risk municipalities

Fig. 3.14 shows municipalities at risk of poor air quality, identified by the integrated municipal assessment method with regard to the risk of adverse air quality[5]. Risk level 3 corresponds to the highest probability of being at risk from air pollution.

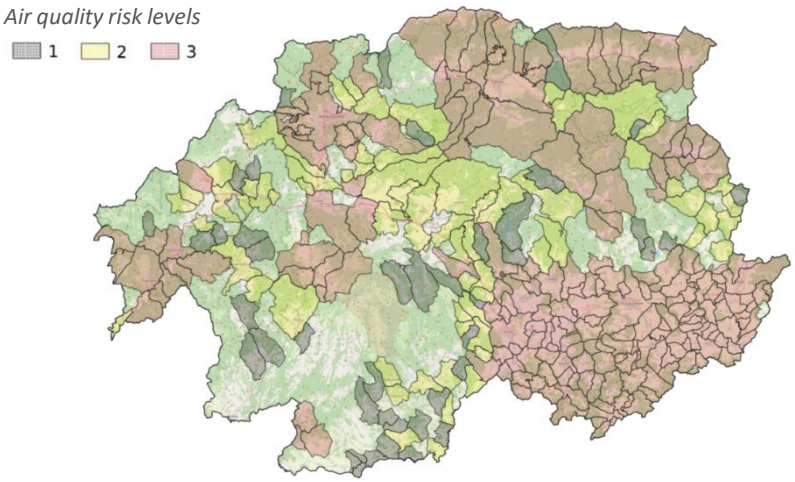
The methodology includes the rate of household heating with solid fuels, the impact of impaired dispersion conditions in the short and long term, the results of the CMAQ chemical-transport model, the RIO inter-field model and the results of high-resolution CALPUFF modelling on selected domains with a presumption of impaired air quality.

Municipalities where the limit value for PM, NO_2 or the target value for BaP was exceeded according to modelling with high spatial resolution were automatically assigned risk level 3, similarly to municipalities where the limit or target value was exceeded according to measurement. A list of municipalities and their risk levels is available on the SHMÚ website.[6]

Zones and agglomerations containing at least one municipality with risk level 3 are required to prepare Air Quality Plan. Based on this, municipalities at risk level 3 correspond to Air Quality Management Areas (ORKO). However, measures to reduce emissions must be implemented in all municipalities with risk level 2 or 3 included in the zone, ideally also in municipalities with a risk level of 1.

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 the microclimatic characteristics of the area, it is likely that the level of pollution in the risk area will vary from one location to another. An idea of the spatial distribution of air pollution is provided by the results of high-resolution modelling, which are progressively added to the website[7].

Fig. 3.14 *Risk municipalities in zone Banská Bystrica region.*



[5] *D. Štefánik, J. Krajčovičová: Metóda integrovaného posúdenia obcí vzhľadom na riziko nepriaznivej kvality ovzdušia. SHMÚ, 2023. https://www.shmu.sk/File/oko/studie_analyzy/Metodika_final_v2a.pdf*

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

[7] *https://www.shmu.sk/sk/?page=2699*

3.6 Summary

In 2022, in the zone Banská Bystrica region, no exceedances of the limit values for SO_2, NO_2, CO and benzene were measured, nor exceedances of the limit value for the annual average concentration of PM_{10}.

The limit value for the average daily concentration of PM_{10} was exceeded at the monitoring station Jelšava, Jesenského. The limit value for the annual average concentration of $PM_{2.5}$ was also exceeded at the monitoring station in Jelšava.

The target value for the annual average concentration of benzo(a)pyrene was exceeded at the monitoring station in Jelšava, Žarnovica and at the monitoring station in Banská Bystrica, Štefánikovo nábrežie. The annual average concentration of benzo(a)pyrene at the monitoring station in Banská Bystrica on Zelená street remained just below the target value, in contrast to 2021.

Based on the results of the mathematical modelling, we can assume that in the Banská Bystrica region, high concentrations of PM and benzo(a)pyrene may also occur, especially in the winter months, in other areas that have been defined as at risk, especially in mountain valleys with adverse dispersion conditions and a high share of solid fuels used for domestic heating.