AIR POLLUTION IN THE SLOVAK REPUBLIC

2023

ANNEX

AIR QUALITY ASSESSMENT IN AGGLOMERATION KOŠICE AND ZONE KOŠICE REGION

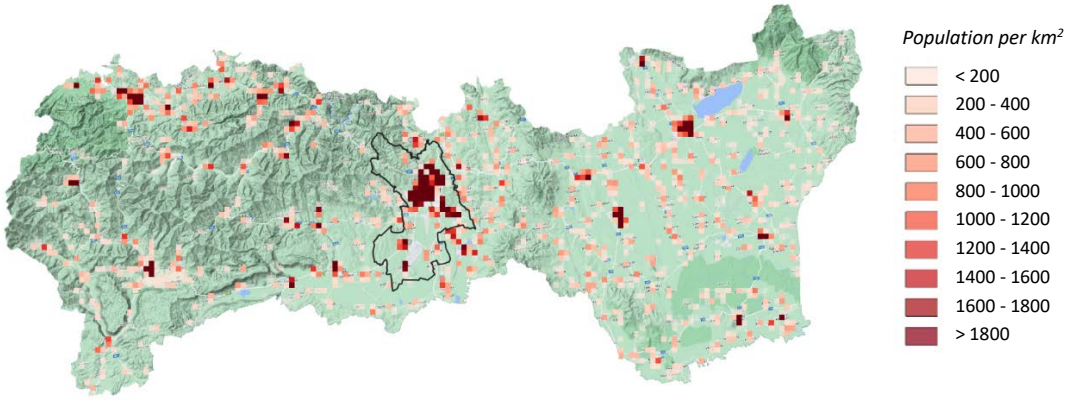
Emissions and Air Quality Division
SLOVAK HYDROMETEOROLOGICAL INSTITUTE

Bratislava, September 2024
Version 1

1 DESCRIPTION OF TERRITORY OF AGGLOMERATION KOŠICE AND ZONE KOŠICE REGION IN TERMS OF AIR QUALITY

For the purposes of air quality assessment, the territory of Slovakia is divided into zones and agglomerations (*https://www.shmu.sk/sk/?page=1&id=oko_info_az*). The territory of the Košice region includes the agglomeration Košice (the territory of Košice and the municipalities of Bočiar, Haniska, Sokoľany and Veľká Ida) and the zone Košice region (Košice region without Košice agglomeration. **Fig. 1.1** shows the spatial distribution of population density in the region Košice. The borders of the agglomeration Košice are marked with a dark line in the picture.

Fig. 1.1 *The population density in the Košice region (Source: EUROSTAT, 2018).*



1.1 AGGLOMERATION KOŠICE (the territory of Košice and the municipalities Bočiar, Haniska, Sokoľany and Veľká Ida)

Košice is located in the Hornád valley in the Košice basin, and according to the orographic classification, belongs to the Inner Carpathians. From the southwest, it extends into the Slovak Karst region, to the north lies the Slovak Ore Mountains, and to the east of the city are the Slanské vrchy Mountains. Wind conditions in Košice are characterised by a prevailing flow from the north, the area is relatively well-ventilated.

Air pollution sources in agglomeration Košice

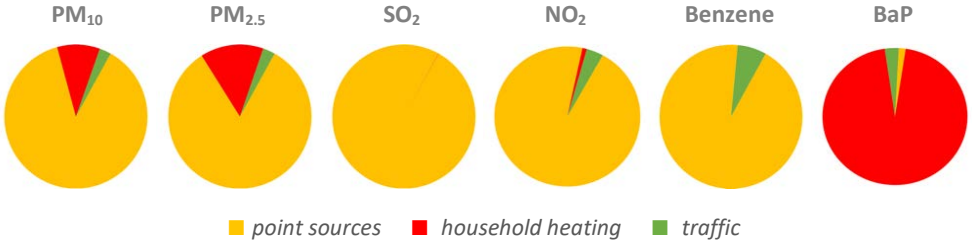
Among the main pollution sources, a dominant industrial contribution represents an industrial complex focused on the metallurgy of iron, steel, and coke production in Košice-Šaca district. Other industrial sources include cement production plants. Air quality in the villages of Veľká Ida, Haniska, Sokoľany, and Bočiar, and to a lesser extent in Košice, is affected by pollution from the metallurgic complex in Košice-Šaca. The northerly winds help to decrease the local population's exposition.

Road traffic in Košice contributes significantly to the local air quality. The busiest parts of the roads in the eastern Slovak agglomeration with the average number of vehicles per 24 hours based on the latest National Traffic Census in 2022 and 2023[1]:

- **road No. 20 -** the eastern bypass (Košice III): 38 939 vehicles (6 178 trucks/busses (hereinafter referred to as T/B) a 32 684 cars (hereinafter referred to as C));
- **road No. 16 -** the southern city part (Košice IV): 52 733 vehicles (9 400 T/B, 43 159 C);
- **road No. 19 -** the north-eastern city part (Košice III): 18 151 vehicles (2 137 T/B, 15 960 C);
- **road No. 552 -** the south-eastern city part (Košice IV): 18 273 vehicles (2 706 T/B, 15 512 C);
- **road No. 17 -** the south of Košice: 21 993 vehicles (4 264 T/B, 17 608 C).

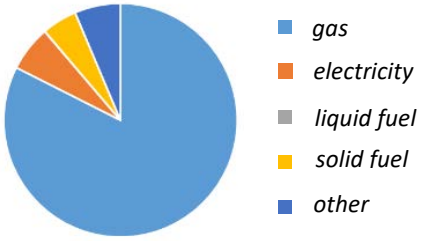
[1] *https://www.ssc.sk/sk/cinnosti/rozvoj-cestnej-siete/dopravne-inzinierstvo/celostatne-scitanie-dopravy-v-roku-2022-a-2023.ssc*

Fig. 1.2 *Share of different types of air pollution sources in total emissions in the Košice agglomeration.*



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

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, the dominant fuel used for heating in households is natural gas. Solid fuels are more commonly used in rural type of settlements.

1.2 ZONE KOŠICE REGION (without Košice agglomeration)

The relief of the eastern part of the Košice region is mainly flat thanks to the Eastern Slovak Plain, which is separated from the Košice Basin by the Slanské Hills. On the border with the Prešov region stretch Vihorlat Mountains, from west to east stretches the Hornád Basin. In the western, more mountainous part region, the Volovské vrchy Mountains are separated from the Slovak Karst by the Rožňava Basin. Hornád Basin in the northern part of the territory extends into the southern part of the Prešov region. The highest point of the Košice region is Stolica Hill (1 476 m a. s. l.) in the Stolice Hills, the lowest point is 94 m a. s. l.

Sources of air pollution in the zone Košice region

The busiest parts of roads in the zone with the average number of vehicles per 24 hours according to the latest National Traffic Census in 2022 and 2023:

North-west

- **road No. 533** in Spišská Nová Ves: 15 077 vehicles (1 562 T/B, 13 398 C).

East

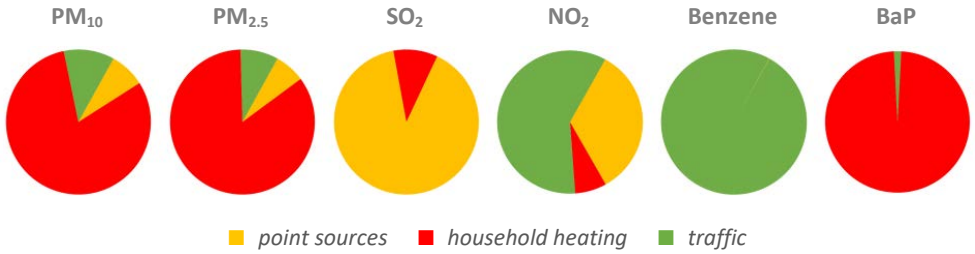
- **road No. 19** from Košice eastwards to Sečovce, Michalovce and Sobrance: in front of Sečovce 13 653 vehicles (2 467 T/B, 11 154 C), at the entry to Michalovce 20 536 vehicles (2 444 T/B, 18 007 C) and in Sobrance 7 976 vehicles (1 045 T/B, 6 903 C);
- **road No. 18** from Michalovce northwards to Strážske: 9 269 vehicles near the Strážske (1 566 T/B, 7 661 C);
- **road No. 79** in Trebišov: 9 988 vehicles (1 604 T/B, 8 335 C).

South

- **road No. 16** along the southern major traffic corridor of Slovakia from Rožňava to Moldava nad Bodvou and Košice: near Rožňava 10 980 vehicles (1 890 T/B, 9 045 C), in the district of Košice-okolie 13 192 vehicles (1 773 T/B, 11 352 C);
- **road No. 526** in Rožňava: 11 910 vehicles (866 T/B, 10 973 C), in Moldava 10 239 vehicles (839 T/B, 9 362 C).

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

Fig. 1.4 *Share of different types of air pollution sources in total emissions in the zone Košice region.*



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

Fig. 1.5 *Share of different types of fuels in heating in the municipalities of the region[3].*

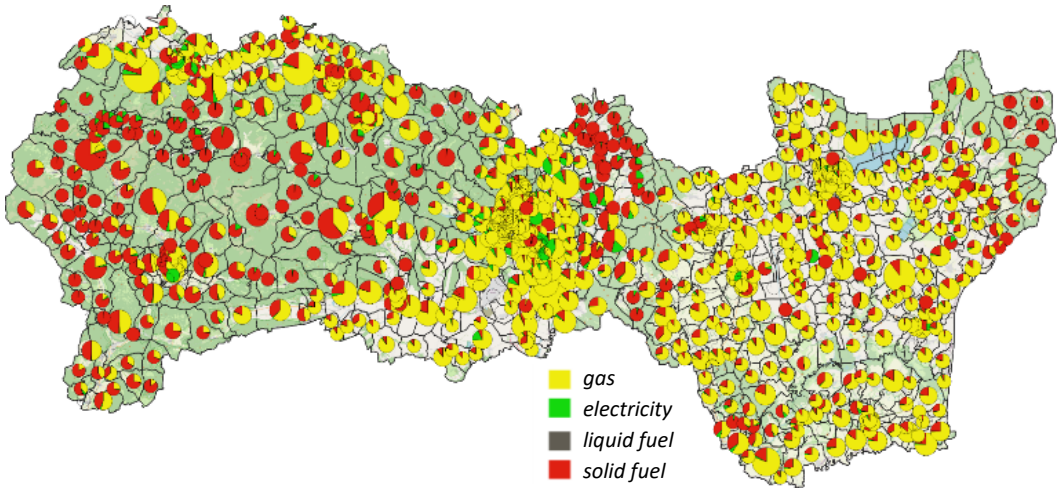


Fig. 1.5 shows the shares of fuel types in the heating of houses and block of flats in each municipality (or basic settlement units) of the Košice region, showing that the spatial distribution of types of fuels is not geographically homogeneous. In the western part, in the north of the Košice basin and in the extreme north-east, solid fuels predominate, in Košice and its surroundings and in the eastern part gas is largely used for heating.

2 AIR QUALITY MONITORING STATIONS IN AGGLOMERATION KOŠICE AND ZONE KOŠICE REGION

Tab. 2.1 and **Tab. 2.2** contain information on air quality monitoring stations in the agglomeration Košice and the zone Košice region:

- international EoI code, station characteristics based on dominant sources of air pollution (traffic, background, industrial), the type of area monitored by each station (urban, suburban, rural/regional), and geographical coordinates;
- The monitoring programme. Automatic continuous monitoring devices provide average hourly concentrations of PM_{10}, $PM_{2.5}$, nitrogen oxides, sulphur dioxide, ozone, carbon monoxide and benzene. The SHMÚ testing laboratory conducts manual monitoring, analysing heavy metals and polycyclic aromatic hydrocarbons, resulting in 24-hour values.

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

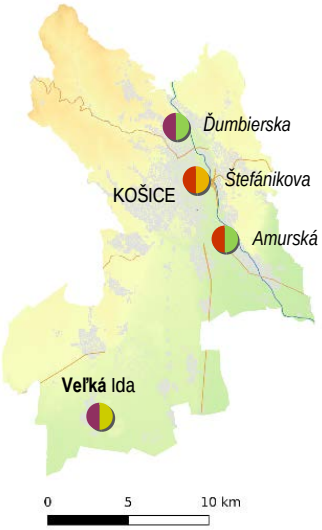
2.1 AGGLOMERATION KOŠICE

Air quality monitoring in Košice began in 1971. Currently, air quality is being monitored at four stations in the area. The Košice, Štefánikova station reflects the influence of road traffic, while the monitoring stations Košice, Amurská, and Košice, Ďumbierska characterise urban and suburban background pollution. The monitoring station in Veľká Ida* is located near the railway station in an open grassy area on the south-eastern edge of the municipality. To the northeast of the station, there is a metallurgical complex producing iron, steel, and coke (U. S. Steel site), and to the southeast of the station is mostly grassed waste dump.

** Note: For the purpose of air quality assessment and its division into zones and agglomerations, the municipalities of Veľká Ida, Bočiar, Haniska, and Sokoľany are considered part of the Košice agglomeration.*

Tab. 2.1 *Air quality monitoring programme in the agglomeration Košice.*

Agglomeration Košice								Monitoring programme									
								Continuously								Manually	
District	Eol Code	Station	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											
Košice I	SK0264A	Košice, Amurská	U	B	21°17'08"	48°41'25"	201										
Košice I	SK0267A	Košice, Štefánikova	U	T	21°15'32"	48°43'35"	209										
Košice I	SK0016A	Košice, Ďumbierska	S	B	21°14'42"	48°45'12"	240										
Košice okolie	SK0018A	Veľká Ida, Letná	S	I	21°10'31"	48°35'32"	209										
							Total	3	3	1	1	1	2	1	0	1	1



Type of area:
U – urban
S – suburban
R – regional

Type of station:
T – traffic
B – background
I – industrial

2.2 ZONE KOŠICE REGION

Air quality monitoring in the zone Košice region is complicated due to the diversity of terrain and the size of the area. There are four monitoring stations in the region, two of the sites have relatively long-term history of measurements. The beginnings of air quality monitoring in Krompachy and Strážske date back to the 1980s. The goal was to capture the impact of industrial activities. Over the years, the impact of industrial sources has declined, and the station in Krompachy is categorised as urban traffic, and in Strážske as urban background. In 2020, a suburban monitoring station was added in Trebišov.

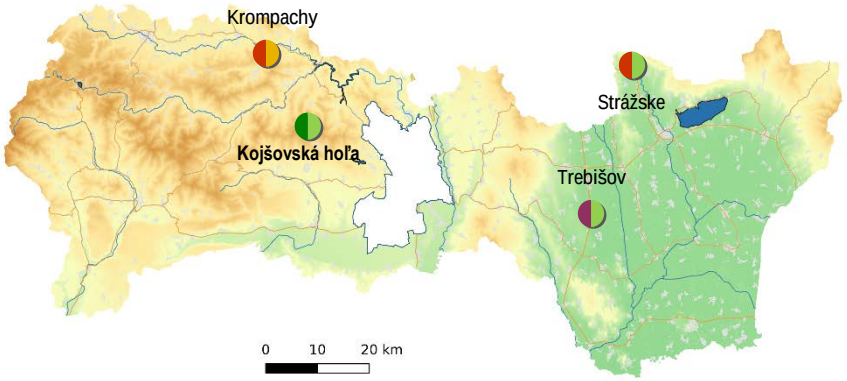
The station at Kojšovská hora is located at a radar site at an altitude of 1 232 m a. s. l., in the eastern part of the Snina district. It characterises the air quality in a less polluted area. Air quality monitoring started here in 2009.

Tab. 2.2 *Monitoring programme of air quality in the zone Košice region.*

Zone Košice region								Monitoring programme									
								Continuously								Manually	
District	Eol Code	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
Gelnica	SK0042A	Kojšovská hoľa	R	B	20°59'14"	48°46'58"	1232										
Michalovce	SK0030A	Strážske, Mierová	U	B	21°50'15"	48°52'27"	133										
Spišská Nová Ves	SK0265A	Krompachy, SNP	U	T	20°52'26"	48°54'56"	372										
Trebišov	SK0073A	Trebišov, T. G. Masaryka	S	B	21°42'45"	48°37'42"	107										
							Total	3	3	3	1	2	1	1	0	0	1

Type of area:
U – urban
S – suburban
R – rural (regional)

Type of station:
T – traffic
B – background
I – industrial



3 ASSESSMENT OF THE AIR QUALITY IN AGGLOMERATION KOŠICE AND ZONE KOŠICE REGION

This chapter focuses on a detailed analysis of air quality assessment based on the monitoring results in the agglomeration Košice and the zone Košice region in 2023. Recall that the Košice agglomeration encompasses the city of Košice as well as the municipalities of Veľká Ida, Haniska, Sokoľany and Bočiar. The reason for expanding the assessment of air quality to cover this extended area is the fact that the metallurgical complex producing iron, steel, and coke, located to the south of Košice near these four municipalities, to some extent influences the entire Košice agglomeration. The zone Košice region covers the territory of the Košice NUTS-3 region, excluding the agglomeration Košice.

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 Košice agglomeration and in the zone Košice – 2023.*

		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 rok	24 h	1 rok	1 rok	8 h[1]	1 rok	12 h	12 h
	Parameter	number of exceedances	number of exceedances	number of exceedances	average	number of exceedances	average	average	average	average	Duration of the exceedance [h]	Duration of the exceedance [h]
	Limit [µg·m^{-3}]	350	125	200	40	50	40	20	10 000	5	100	150
	Maximum count of exceedances	24	3	18		35						
KOŠICE	Košice, Štefánikova	0	0	0	22	13	24	16	1 437	0.88	28	0
	Košice, Amurská					5	20	15			0	0
	Veľká Ida, Letná					36	30	20	2 962		15	0
Košice region	Kojšovská hoľa			0	2							
	Trebišov, T. G. Masaryka			0	10	4	19	14			0	0
	Strážske, Mierová					3	19	14			0	0
	Krompachy, SNP	0	0	0	14	17	22	17	1 706	1.07	20	0

≥ 90% 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}*

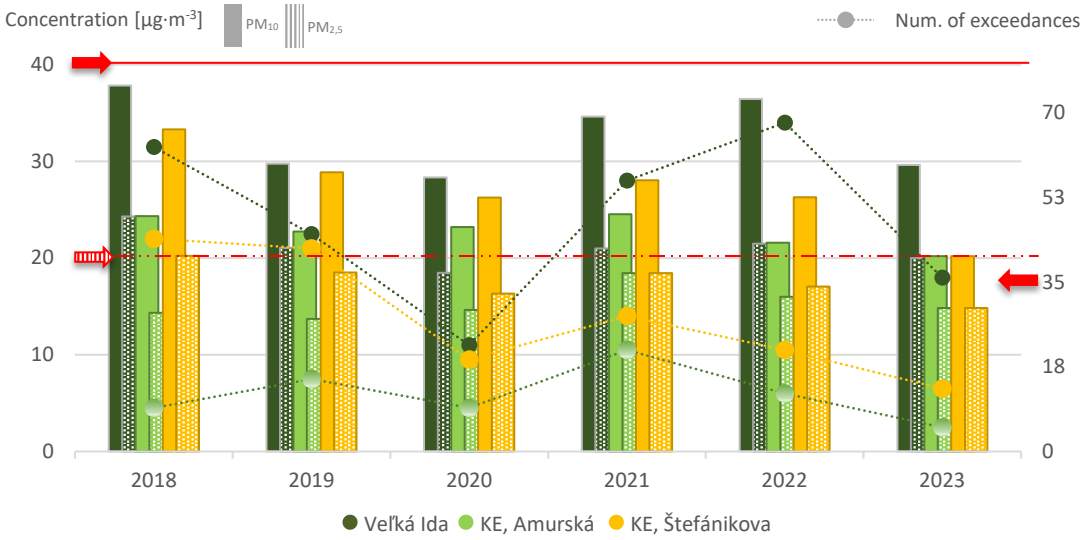
In accordance with the Decree of the Ministry of Environment of the Slovak Republic No. 250/2023 Coll. on air quality, the required proportion of valid values was observed at the monitoring stations in the agglomeration Košice and in the zone Bratislava region.

3.1 AGGLOMERATION KOŠICE

3.1.1 PM_{10} and $PM_{2.5}$

Fig. 3.1 illustrates the average annual concentrations of PM_{10}, $PM_{2.5}$ and the number of days with an average daily PM_{10} concentration exceeding 50 µg·m^{-3} over the period 2018 – 2023.

Fig. 3.1 *Average annual concentration of PM_{10}, $PM_{2.5}$ and the number of PM_{10} daily limit exceedances.*

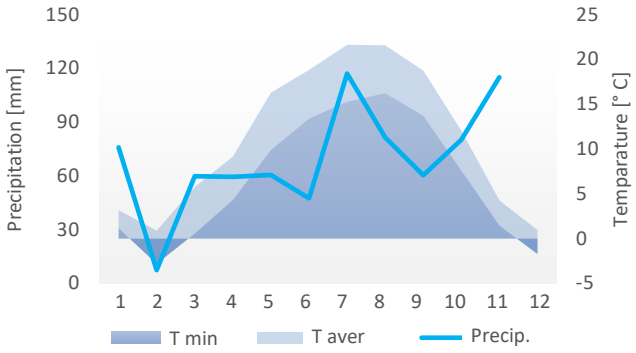


*The arrows show the limit values, **red striped** $PM_{2.5}$ (annual average concentration: 20 µg·m^{-3}); **red on the left** PM_{10} (annual average concentration: 40 µg·m^{-3}) and **red on the right** the number of exceedances (daily average PM_{10} concentration of 50 µg·m^{-3} must not be exceeded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

In 2023, the exceedance of the daily average concentration of PM_{10} (50 µg·m^{-3}) was recorded in 36 days at the station in Veľká Ida. The daily average concentration was exceeded here mostly in spring, summer, and early autumn months (20 times over April – September), outside of the heating season. The most exceedances per month were recorded in May (7) and April (5). These months were slightly dryer than normally (**Fig. 3.2**) especially in the first half of May no precipitation was recorded at this site[4], and with intense the northerly winds. This situation might have contributed or caused an increased resuspension of the particles from nearby industrial dump and other industrial areas, that could potentially explain higher number of exceedances in Veľká Ida.

The number of exceedances at other stations in Košice decreased compared to the past two years (**Fig. 3.1**). The annual average concentration threshold for PM_{10} (40 µg·m^{-3}) and $PM_{2.5}$ (20 µg·m^{-3}) was not exceeded at any station in agglomeration Košice in 2023.

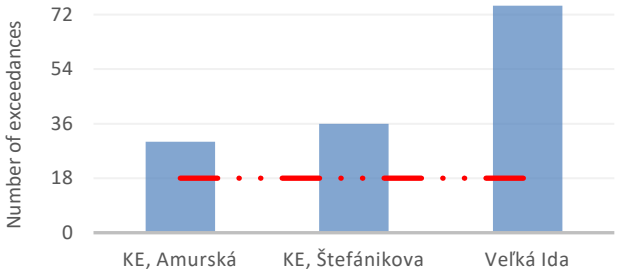
Fig. 3.2 *Monthly precipitation totals, average and minimum temperatures (data from the climatological station Košice-airport).*



[4] *https://www.shmu.sk/sk/?page=1784&id=&identif=11968&rok=2023&obdobie=1981-2010*

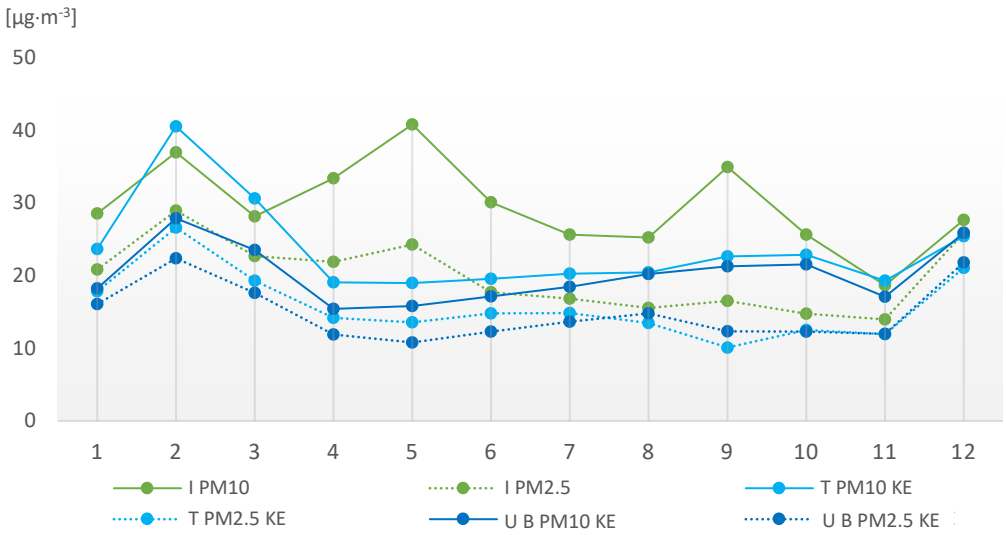
As a part of the Green Deal, the European Union elaborated the Zero Pollution Action Plan[5], that describes a vision for the year 2050. It aims to reduce by that year air pollution to levels that are no longer considered harmful to human health or ecosystems. As a part of this Action Plan new limit values and new target values for most of the pollutants were introduced. The major challenge for Slovakia will be to meet the new limit values for $PM_{2,5}$ (25 µg·m^{-3}) with the limit for exceedance count per year 18, that is to be reached by 1. 1. 2030. **Fig. 3.3** illustrates how many exceedances of the new daily limit for $PM_{2.5}$ would we have in 2023. In the agglomeration Košice, the new limit value would have been significantly exceeded at all monitoring stations, at the station in Veľká Ida it would have reached 75 exceedances in 2023.

Fig. 3.3 *Number of days with average daily $PM_{2.5}$ concentration > 25 µg·m^{-3} in 2023 – evaluation in view of the newly introduced EU limit*.*



** The average daily concentration of $PM_{2.5}$ > 25 µg·m^{-3} must not be exceeded more than 18 times a year. This newly introduced EU limit is to be achieved by 1 January 2030.*

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



T PM10 *and* ***T PM2.5*** *– average monthly concentration of PM_{10} and $PM_{2.5}$ at the traffic station Košice, Štefánikova;* ***U B PM10*** *and* ***U B PM2.5*** *– average monthly concentration of PM_{10} and $PM_{2.5}$ at the urban background station: Košice, Amurská;* ***I PM10 and I PM2.5*** *– average monthly concentrations of PM_{10} and $PM_{2.5}$ at the industrial station: Veľká Ida, Letná.*

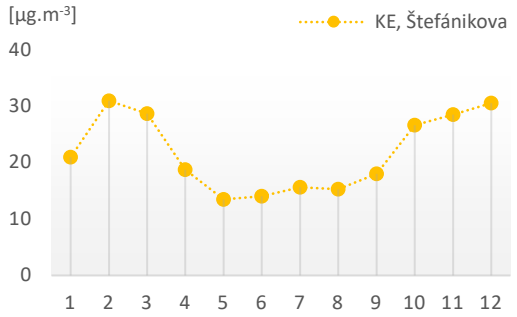
The highest concentrations of $PM_{2.5}$ and PM_{10} (**Fig. 3.4**) were measured at the traffic station Košice, Štefánikova in February and at industrial station Veľká Ida in May and September. However, in other months outside the heating season, PM_{10} concentrations were also high compared to the other stations. We assume that the cause was resuspension from an uncovered and unsecured waste dump located north of the monitoring station.

[5] *https://www.consilium.europa.eu/en/press/press-releases/2024/02/20/air-quality-council-and-parliament-strike-deal-to-strengthen-standards-in-the-eu/*

3.1.2 Nitrogen dioxide

Nitrogen dioxide is being monitored at the traffic station at Štefánikova street in Košice. The monthly average concentrations of NO_2 returned the highest values in winter with a maximum in February (31 µg·m^{-3}; **Fig. 3.5**), which was also the coldest month of the year with poor dispersion conditions (**Fig. 3.2**). During the summer months, NO_2 concentrations were significantly lower. The annual mean concentration of NO_2 was 22 µg·m^{-3}, which does not exceed the limit of 40 µg·m^{-3}.

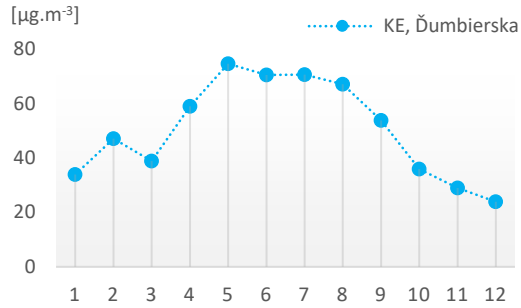
Fig. 3.5 *Average monthly concentration of NO_2.*



3.1.3 Ozone

Ozone is being monitored at the suburban background station in Košice, on Ďumbierska Street. The highest concentrations of ground-level ozone generally occur in the warmer months (**Fig. 3.6**). The diurnal regime of O_3 concentrations is typical of a gradual increase in the morning with a peak at about noon, followed by a gradual decrease towards the evening reaching a minimum at night. Large differences in the O_3 concentrations are also observed between the warm and cool seasons.

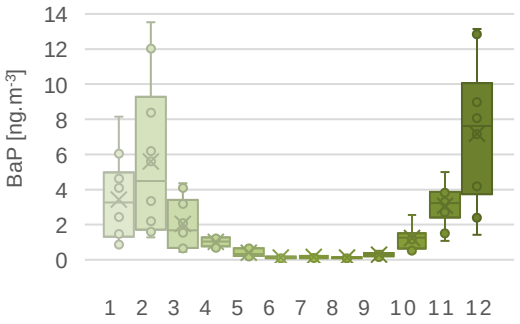
Fig. 3.6 *Average monthly concentration of O_3.*



3.1.4 Benzo(a)pyrene

Benzo(a)pyrene (BaP) is being monitored in Košice agglomeration at a suburban industrial monitoring station in Veľká Ida. Concentrations below 1 ng·m^{-3} account only for 16% of the measurements, 31% of measurements returned concentrations above 5 ng·m^{-3}. Extremely high concentration of BaP was recorded in January (40.8 ng·m^{-3}) and August (36 ng·m^{-3}). Except for February and April, each month recorded concentrations above 10 ng·m^{-3}. The target value for BaP was exceeded more than 4 times (4.9 ng·m^{-3}). This site is strongly influenced by the emissions from the nearby metallurgic industry. This is documented by high and relatively constant monthly average concentrations of BaP throughout the year (**Fig. 3.7**), contrary to the other monitoring sites, where the dominant contributor to the BaP concentrations is household heating, which records a significant decrease of BaP in months outside the heating season.

Fig. 3.7 *Average monthly benzo(a)pyrene concentration at Veľká Ida in 2023.*



Tab. 3.2 *Average annual concentration of benzo(a)pyrene in 2018 – 2023.*

	2018	2019	2020	2021	2022	2023
Target value [ng·m^{-3}]	1.0	1.0	1.0	1.0	1.0	1.0
Veľká Ida, Letná	5.8	4.5	4.6	6.1	5.4	4.9

≥ 90% valid measurements

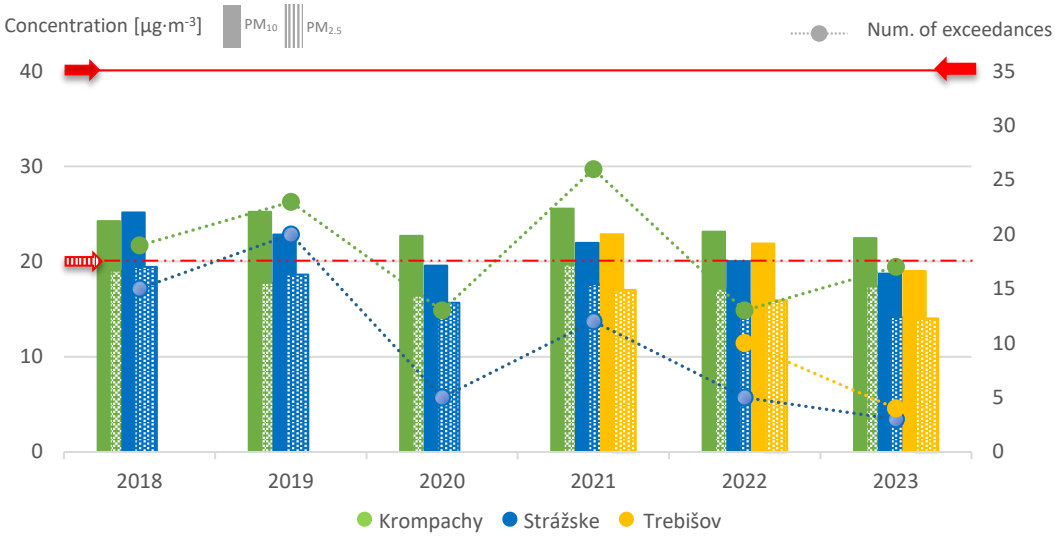
Concentrations marked in red indicate exceeding the target value.

3.2 ZONE KOŠICE REGION

3.2.1 PM_{10} and $PM_{2.5}$

Fig. 3.8 displays the average annual concentrations of PM_{10}, $PM_{2.5}$, and the number of days with an average daily PM_{10} concentration exceeding 50 $\mu g \cdot m^{-3}$ based on measurement results at monitoring stations in the zone Košice region in 2018 – 2023.

Fig. 3.8 *Average annual concentration of PM_{10}, $PM_{2.5}$ and the number of PM_{10} daily limit exceedances.*



*The arrows show the limit values, **red striped** $PM_{2.5}$ (annual average concentration: 20 $\mu g \cdot m^{-3}$); **red on the left** PM_{10} (annual average concentration: 40 $\mu g \cdot m^{-3}$) and **red on the right** the 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).*

The limit value for the annual average concentration of PM_{10} (40 $\mu g \cdot m^{-3}$) in the zone Košice region was not exceeded. Similarly, none of the stations exceeded the limit value for the number of exceedances per year (35 times) of the average daily PM_{10} concentration (50 $\mu g \cdot m^{-3}$) (**Fig. 3.8**). The average annual concentration was slightly lower at all stations compared to 2022. The traffic station in Krompachy recorded the highest concentration of PM_{10} (22 $\mu g \cdot m^{-3}$). The number of daily limit exceedances in Krompachy (17) was higher compared to 2022, however, other stations recorded a decrease in the number of daily exceedances relative to the previous year, a particular improvement occurred in Trebišov (4 exceedances in 2023, compared to 10 in 2022).

Fig. 3.9 displays an overview of the meteorological conditions in this zone recorded at the climatologic station in Michalovce. The lowest average monthly temperatures were recorded in February and December, just in these months we measured the highest average monthly PM_{10} and $PM_{2.5}$ concentrations of (**Fig. 3.10**). At the traffic monitoring station in Kromapchy, and suburban background stations in Strážske and Trebišov the recorded values were very similar. The reason for this observation may be the similar character of the emission sources. On the significant impact of household heating at the traffic station in Krompachy is indicated by a significant increase in $PM_{2.5}$ concentrations in cold February and December, as it is household heating is the most significant source of $PM_{2.5}$.

Fig. 3.9 *Monthly precipitation totals, the average and the minimum air temperature (data of the climatological station in Michalovce).*

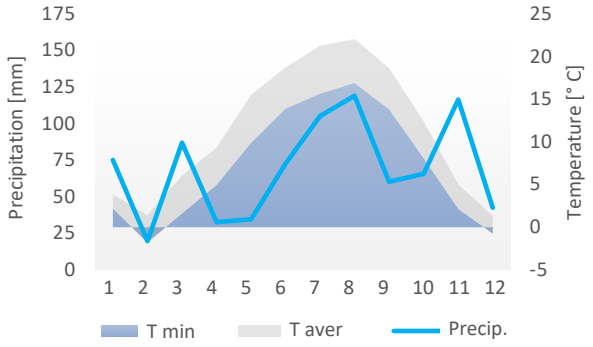
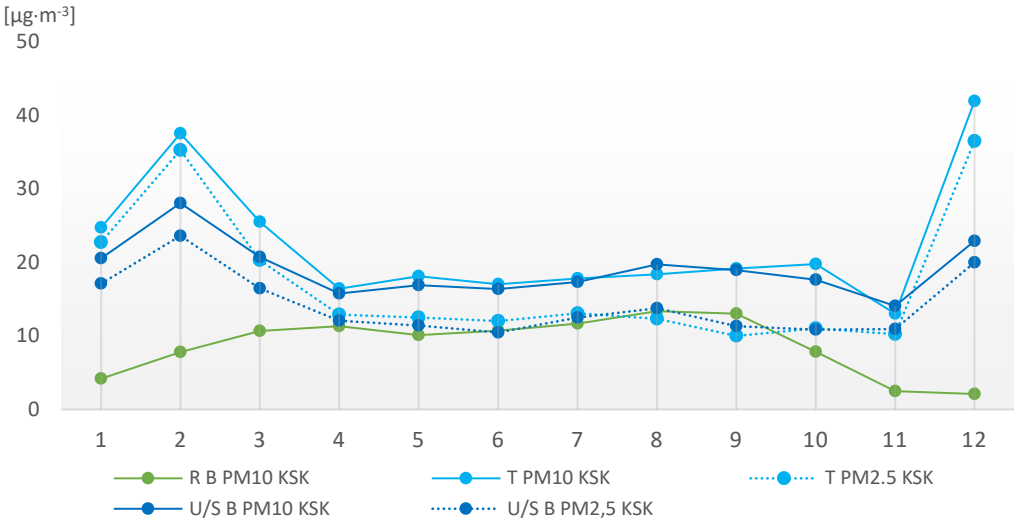


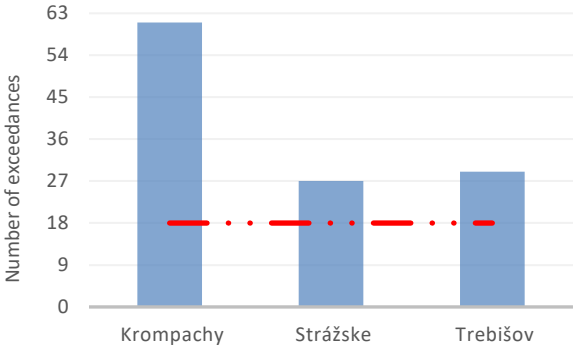
Fig. 3.10 *Average monthly concentrations of PM_{10} and $PM_{2.5}$ according to the station type.*



R B PM10 *– average monthly concentration of PM_{10} at the rural background station in Kojšovská Hoľa;* ***T PM10*** *and* ***T PM2.5*** *– average monthly concentration of PM_{10} and $PM_{2.5}$ at the traffic station Krompachy;* ***U/S B PM10*** *and* ***U/S B PM2.5*** *– average monthly concentration of PM_{10} and $PM_{2.5}$ at the urban background station: Strážske and Trebišov.*

According to the vision of the European Zero Pollution Action Plan[6], the goal for the foreseeable future is to decrease air pollution to levels that are not considered harmful to human health or ecosystems. The new limit value of 25 µg·m^{-3}, is not to be exceeded more than 18 times per year as displayed in **Fig. 3.11**, relative to data of 2023. This Illustrates, that as of 2023 in the zone Košice region, the new limits would have not been met (e.g. at AMS Krompachy 61 exceedances). Similarly, the $PM_{2.5}$ concentrations at all monitoring stations do significantly exceed the WHO[7] recommendation of 5 µg·m^{-3} in all months of the year including the summer months typical of very low values.

Fig. 3.11 *Number of days with average daily $PM_{2.5}$ concentration > 25 µg·m^{-3} in 2023 – evaluation in view of the newly introduced EU limit*.*



** The average daily concentration of $PM_{2.5}$ > 25 µg·m^{-3} must not be exceeded more than 18 times a year. This newly introduced EU limit is to be achieved by 1 January 2030.*

3.2.2 Nitrogen dioxide

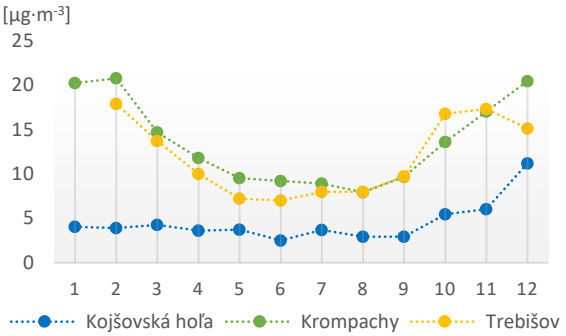
Nitrogen dioxide is being monitored at three stations. The monthly average concentrations are shown in **Fig. 3.12**. The mean annual concentration does not exceed the limit value of 40 µg·m^{-3} at any station. The main source of NO_2 emissions is traffic. The highest concentrations are being recorded at the traffic station in Krompachy (14 µg·m^{-3}). However, compared with commonly observed values at traffic stations (in general terms), the value of 14 µg·m^{-3} is rather low, suggesting that the impact of traffic is not as significant at this station.

[6] *https://www.consilium.europa.eu/en/press/press-releases/2024/02/20/air-quality-council-and-parliament-strike-deal-to-strengthen-standards-in-the-eu/*

[7] *WHO GLOBAL AIR QUALITY GUIDELINES, 2021. Recommendations on classical air pollutants, p. 4. https://apps.who.int/iris/bitstream/handle/10665/345334/9789240034433-eng.pdf*

In the zone Košice region, the mean annual concentration of NO_2 met the WHO recommendation of 10 µg·m^{-3} at the station Trebišov (10 µg·m^{-3}) and at the rural station Kojšovská hoľa (2 µg·m^{-3}).

Fig. 3.12 *Average monthly concentration of NO_2.*

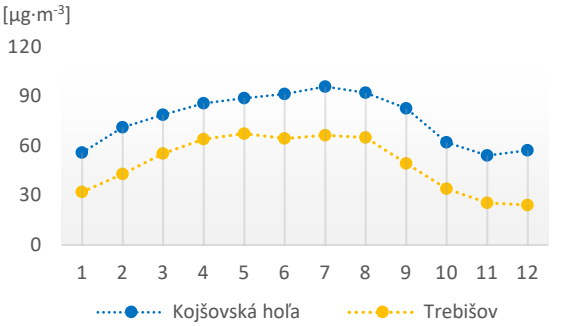


3.2.3 Ozone

The ground-level ozone is being monitored at two stations – Trebišov and Kojšovská hoľa, that is located at a higher altitude. The high altitude is obviously probably a reason for higher ozone concentrations at Kojšovská hoľa station, which may result from transmission from higher atmospheric layers.

The highest O_3 concentrations generally occur in warm months with high sunshine intensity (**Fig. 3.13**). In 2023, was the peak concentration recorded in July. The diurnal change in O_3 concentration is pronounced with a peak at noon and a minimum before sunrise. The annual oscillation reflects the differences between the warm and cold seasons.

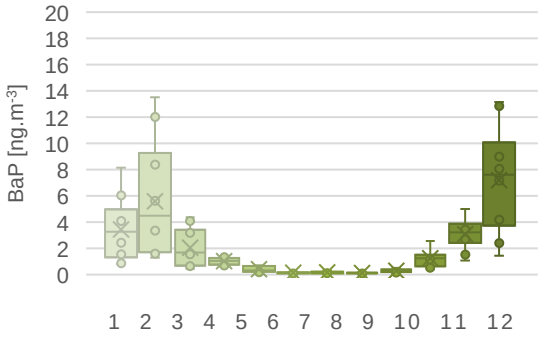
Fig. 3.13 *Average monthly concentration of O_3.*



3.2.4 Benzo(a)pyrene

Benzo(a)pyrene (BaP) is being monitored in the zone at one station – Krompachy, SNP. The target value for BaP (1 ng·m^{-3}) is being significantly exceeded over the past six years (**Tab. 3.3**). The concentrations of BaP in Krompachy return maximum values during the winter months coincident with the heating season (**Fig. 3.14**), and during the periods outside the heating season are the BaP concentrations very low. This observation is in good contrast with what was recorded in Veľká Ida of Košice agglomeration (**Fig. 3.7**). This can serve as evidence, that the dominant source of BaP in Krompachy is household heating.

Fig. 3.14 *Average monthly concentration of BaP in Krompachy.*



Tab. 3.3 *Average annual concentration of benzo(a)pyrene in 2019 – 2023.*

	2019	2020	2021	2022	2023
Target value [ng·m^{-3}]	1.0	1.0	1.0	1.0	1.0
Krompachy, SNP	2.7	2.1	2.2	2.2	2.1

≥ 90% valid measurements

Numbers in red indicate the exceedance of the target value.

4 AIR QUALITY MODELLING

Fig. 4.1 presents the modelling results for PM_{10} calculated using models RIO and IDW-R (method details and description are in Chapter 4 of *Air Pollution in the Slovak Republic 2023 Report*).

Based on the results of mathematical modelling with the interpolation model RIO and IDW-R, we can assume that the highest concentrations of PM_{10} are found in the southern part of the agglomeration Košice (in the municipalities of Veľká Ida, Sokoľany, Haniska, Bočiar) and are influenced by emissions from the metallurgical complex. In the zone Košice region, the highest PM_{10} values are likely to occur mainly in Abov region and the districts of Rožňava, Spišská Nová Ves, and Geľnica (**Fig. 4.1**) The modelling of exceedance of the daily limit for PM_{10} returned the highest count of exceedance at the same sites (**Fig. 4.2**).

Fig. 4.1 *Average annual concentration of PM_{10} in 2023.*

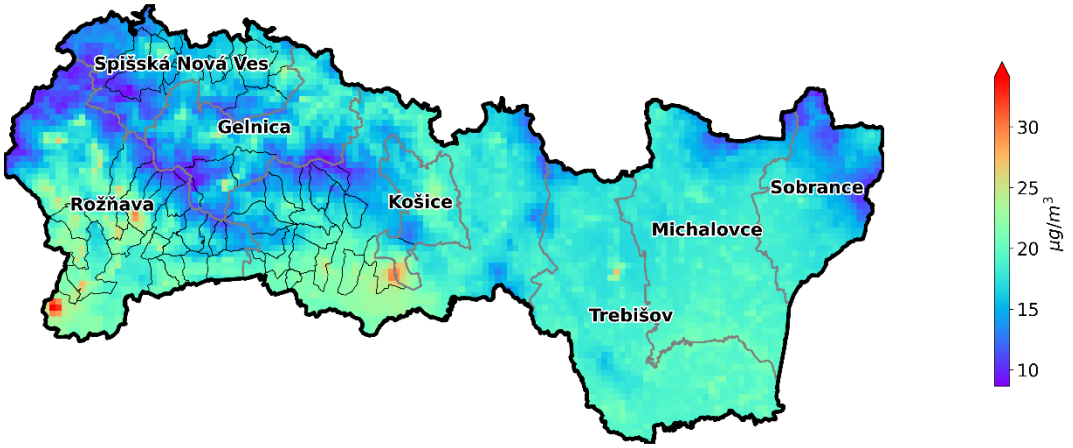
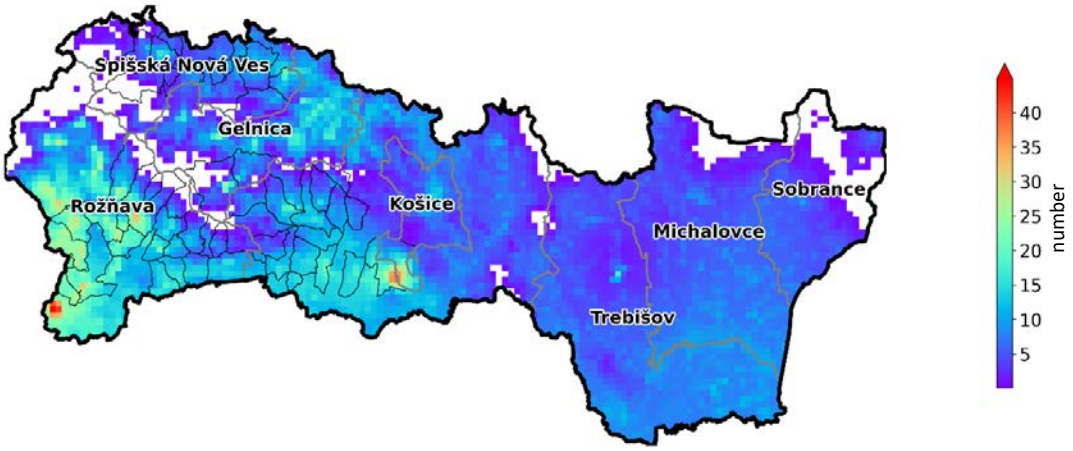


Fig. 4.2 *Number of exceedances of the PM_{10} daily limit value in 2023. Only areas for which the number of exceedances was non-zero are shown.*



The map in **Fig. 4.3** displays the spatial distribution of average annual $PM_{2.5}$ concentrations based on the output from the RIO model in combination with the IDW-R model. According to the model outputs, the average annual $PM_{2.5}$ concentration across the entire zone was higher than the limit value recommended by the WHO (WHO limit values are stricter than EU limits).

The spatial distribution of average annual $PM_{2.5}$ concentrations according to the RIO model, IDW-R, exhibits a similar pattern to that of PM_{10}. Maximum values are likely to be found not only in the Košice agglomeration but also in Abov region, in the Rožňava district, and in Spišská Nová Ves.

Fig. 4.3 *Average annual $PM_{2.5}$ concentration in 2023 according to the output of the RIO model, IDW-R.*

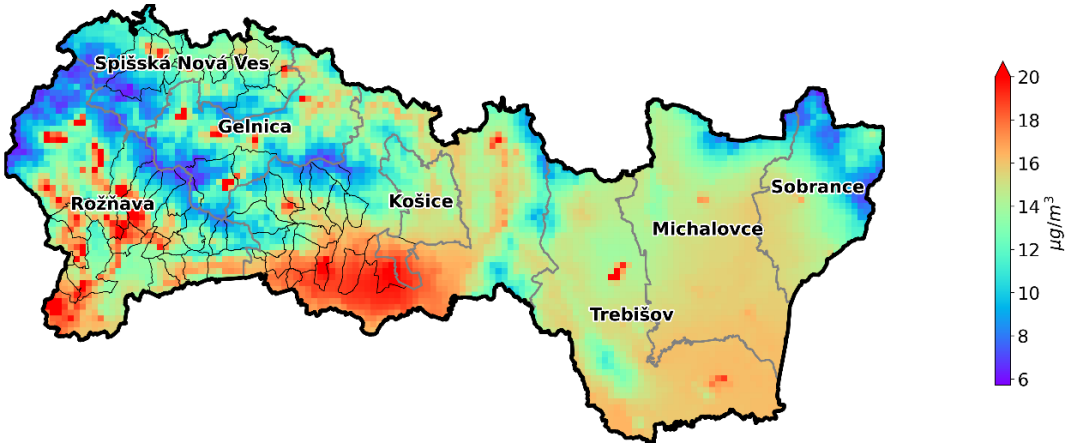
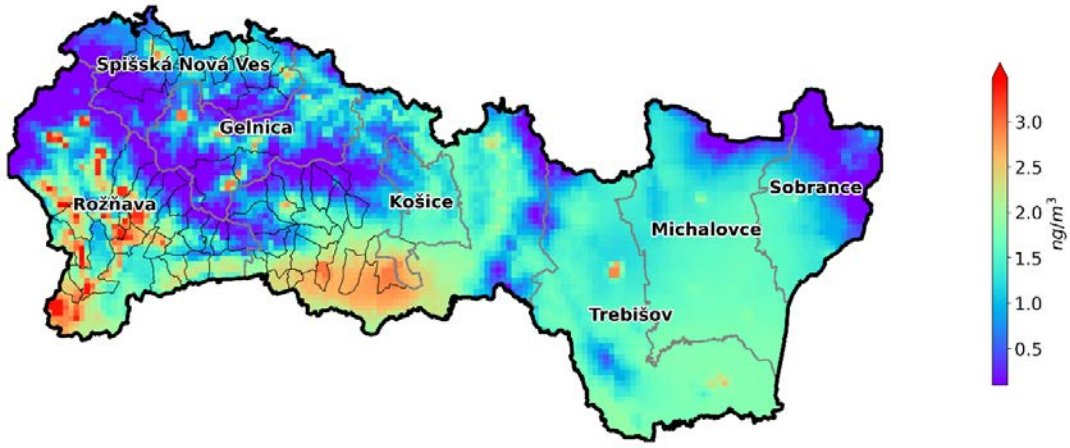


Fig. 4.4 displays the spatial distribution of average annual benzo(a)pyrene concentrations based on the output from the RIO model, IDW-R. Since the model relies on measured data (and auxiliary fields), the outputs over the extensive territory of the Košice region are subject to considerable uncertainty.

The model may tend to overestimate benzo(a)pyrene concentrations, particularly in the vicinity of Košice and the Eastern Slovak Lowland. This is primarily influenced by the high average annual concentration measured in Veľká Ida, which is one of the two stations in the Košice region where benzo(a)pyrene is monitored.

To gain a more detailed understanding of the spatial distribution, modelling with high resolution using detailed emission data (such as information on the quantity and type of fuels, the type of household heating equipment used, etc.) is necessary. The most significant source of benzo(a)pyrene in the Košice agglomeration is coke production, while household heating is a smaller contributor. The situation is reversed in the zone Košice region, where household heating with solid fuels, especially inadequately dried wood or inappropriate fuels (various types of waste), is the most significant source.

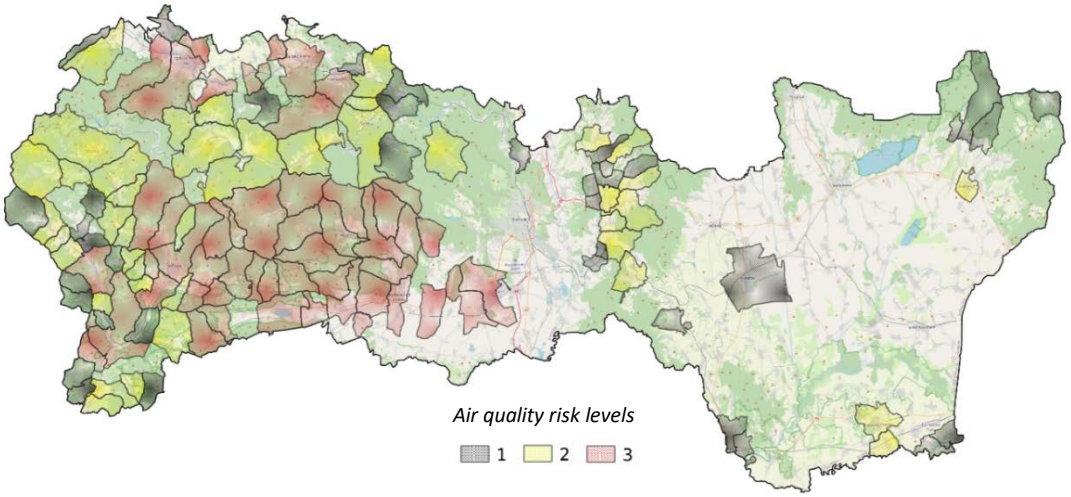
Fig. 4.4 *Average annual concentration of benzo(a)pyrene in 2023 according to the output of the RIO model, IDW-R.*



4.1 Risk municipalities

Fig. 4.5 displays the municipalities at risk of deteriorated air quality as determined by the integrated municipal assessment method for municipalities[8]. Level 3 corresponds to the highest likelihood of air pollution risk. This methodology considers the extent of household heating with solid fuels, the impact of poor dispersion conditions in both the short and long term, results from the chemical transport model CMAQ, the interpolation model RIO, and the outcomes of high-resolution modelling using the CALPUFF model in selected domains with an assumption of worsened air quality.

Fig. 4.5 *Risk municipalities in zone Košice region and agglomeration Košice.*



The municipalities in which the limit value for PM, NO_2, or the target value for BaP was exceeded according to high-resolution modelling were automatically assigned a risk level 3, similar to municipalities where the limit or target value exceedance was detected by measurements. The list of municipalities and their risk levels can be found on the SHMÚ website[9].

Zones and agglomerations that contain at least one municipality with a risk level 3 will develop an Air Quality Improvement Program. In this regard, municipalities with a risk level 3 correspond to air quality management areas. However, emission reduction measures must be implemented in such designated zones in all municipalities with a risk levels 2 or 3, ideally also in municipalities with a risk level 1.

The assessment using the integrated assessment method aims to identify areas where measures to improve air quality are necessary. Given the distribution of air pollution sources and considering the microclimatic characteristics of the region, the level of pollution is likely to vary at different locations within the risk area. The results of high-resolution modelling, which provide insights into the spatial distribution of air pollution, are gradually being supplemented on the website[10].

[8] *Štefánik, D., Krajčovičová, J.: Metóda integrovaného posúdenia obcí vzhľadom na riziko nepriaznivej kvality ovzdušia, SHMÚ, 2023, available at https://www.shmu.sk/sk/?page=996*

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

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

5 SUMMARY

The air quality monitoring of 2023 documented, that in the Košice agglomeration (the territory of Košice city and the municipalities of Veľká Ida, Haniska, Bočiar, and Sokoľany) were recorded exceedances of the limit value for daily average concentration of PM_{10} and exceedance of the target value for BaP at the monitoring station Veľká Ida, Letná. No exceedance of the limit value for annual average of PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO, and benzene was recorded, nor exceedance of the target value for O_3. In the zone Košice region (excluding Košice agglomeration) no exceedance of the limit values was measured for SO_2, NO_2, CO, and benzene in 2023, nor an exceedances of the limit value for the annual average concentrations of PM_{10} and $PM_{2.5}$. The number of days with average daily PM_{10} concentrations above 50 $\mu g \cdot m^{-3}$ was below the limit.

The long-term trends of air pollution by particulate matter PM and NO_2 are decreasing at all monitoring stations of the zone and the agglomeration, except for the AMS Veľká Ida, Letná.

Based on the outputs of the RIO, IDW-R model, we can conclude an increased risk of the occurrence of higher concentrations of $PM_{2.5}$ a BaP in municipalities of the districts Rožňava, Spišská Nová Ves, and Gelnica as well as in the southern part of Košice agglomeration. If we were to assess the fulfilment of the requirements resulting from the new Air Quality Directive adopted by the European Parliament in April 2024, which sets stricter limit values (which will come into force from 1 January 2030), the biggest problem in the zone Košice region and in the Košice agglomeration would be not to exceed the new limit values for $PM_{2.5}$ and BaP. All stations in the region do not currently meet several of the stricter requirements of the new Air Quality Directive. Although pollution levels here are showing a downward trend, effective additional measures will be needed to meet the requirements of the new Directive to help reduce pollution to the required level.

If we were to assess air quality according to the WHO recommendations[11] , no station in the zone and agglomeration would meet the concentration values for the pollutants. The ambition of the Zero Pollution Action Plan[12] is to achieve air quality according to these recommendations by 2050.

In terms of air quality, the most significant problem of the Košice region is the high level of pollution by BaP in the southern part of the Košice agglomeration, strongly influenced by emissions from the metallurgical complex. This area is one of the areas most burdened by poor air quality in Slovakia.

[11] *WHO GLOBAL AIR QUALITY GUIDELINES, 2021. Recommendations on classical air pollutants, str. 4. https://apps.who.int/iris/bitstream/handle/10665/345334/9789240034433-eng.pdf*

[12] *https://www.consilium.europa.eu/en/press/press-releases/2024/02/20/air-quality-council-and-parliament-strike-deal-tostrengthen-standards-in-the-eu/*