AIR POLLUTION IN THE SLOVAK REPUBLIC 2024

ANNEX

AIR QUALITY ASSESSMENT IN AGGLOMERATION KOŠICE AND ZONE KOŠICE REGION

Emissions and Air Quality Division
SLOVAK HYDROMETEOROLOGICAL INSTITUTE

Bratislava, September 2025
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 [1]. 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. According to data from the Statistical Office of the Slovak Republic, the average population density in Košice region[2] is 115 inhabitans per km^2.

The highest population density is in the Košice III District, with 1,630 inhabitants per km^2, while the Sobrance District had the lowest population density in the region, with 41 inhabitants per km^2. For comparison, the average population density of the Slovak Republic on the given date was 111 inhabitants per km^2.

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

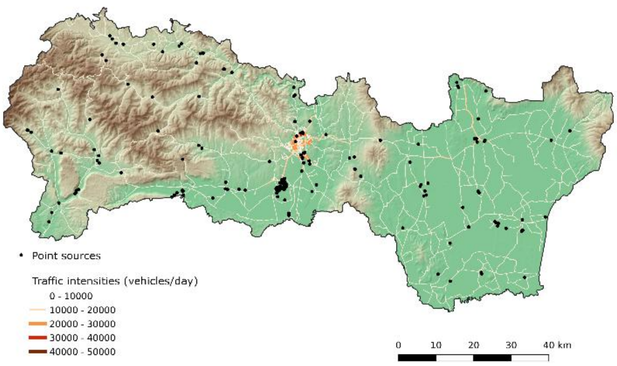
In the Košice agglomeration, the Košice-Šaca district, there is an industrial complex focused on iron and steel metallurgy and coke production, which is the dominant industrial source of air pollution. Other industrial sources include cement plants. The air quality in the municipalities of Veľká Ida, Haniska, Sokoľany and Bočiar and to a lesser extent also in Košice is influenced by pollution sources from the nearby industrial complex. A relatively favorable circumstance here is the prevailing wind flow from the north. Air quality here is also affected by heating households with solid fuel

Tab. 1.1 contains the traffic intensity on major roads in agglomeration according to the national transport census in 2022 and 2023)[3]. **Fig. 1.1** shows road sections with higher traffic intensity, which were processed by the Transport Research Center (Centrum dopravního výzkumu, CDV) for the year 2024. The map also shows the locations of point sources.

Tab. 1.1 *Number of vehicles on the most frequented roads of the agglomeration*

Highway/road	Number of vehicles	Trucks	Passenger cars
20 – eastern bypass (KE III)	38 939	6 178	32 684
16 – south part of Košice (KE IV)	52 733	9 400	43 159
19 (KE III)	18 151	2 137	15 960
552 (KE IV)	18 273	2 706	15 512
17 – south of Košice	21 993	4 264	17 608

Fig. 1.1 *Road traffic intensity in the Košice region. Source: CDV*



[1] *https://www.shmu.sk/sk/?page=1&id=oko_info_az*
[2] *dostupné na https://statdat.statistics.sk/*
[3] *https://www.ssc.sk/sk/cinnosti/rozvoj-cestnej-siete/dopravne-inzinierstvo/celostatne-scitanie-dopravy-v-roku-2022-a-2023.ssc*

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

Tab. 1.2 contains the traffic intensity on major roads in the region according to the national transport census in 2022 and 2023).

Tab. 1.2 Number of vehicles on the most frequented roads of the zone Košice

Highway/road	Number of vehicles	Trucks	Passenger cars
Road no. 533 in Spišská Nová Ves	15 077	1 562	13 398
Road no. 19 in front of Sečovce	13 653	2 467	11 154
Road no. 19 at the entrance to Michalovce	20 536	2 444	18 007
Road no. 19 in Sobrance	7 976	1 045	6 903
Road no. 18 pri Strážskom	9 269	1 566	7 661
Road no. 79 in Trebišov	9 988	1 604	8 335
Road no. 16 near Rožňava	10 980	1 890	9 045
Road no. 16 in district Košice-okolie	13 192	1 773	11 352
Road no. 526 in Rožňava	11 910	866	10 973
Road no. 526 in Moldava	10 239	839	9 362

Fig. 1.2 Share of different types of fuels in heating in the municipalities of the region [4]

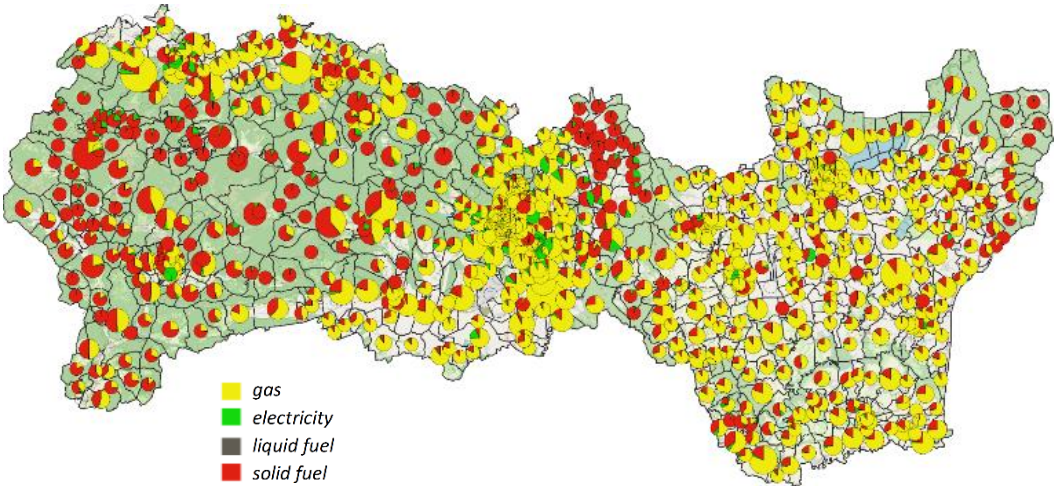


Fig. 1.2 shows the shares of fuel types in the heating of houses and block of flats in each municipality (or basic settlement units) of the Košice region, showing that the spatial distribution of types of fuels is not geographically homogeneous. In the western part, in the north of the Košice basin and in the extreme north-east, solid fuels predominate, in Košice and its surroundings and in the eastern part gas is largely used for heating.

[4] https://www.scitanie.sk

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

2.1 AGGLOMERATION KOŠICE

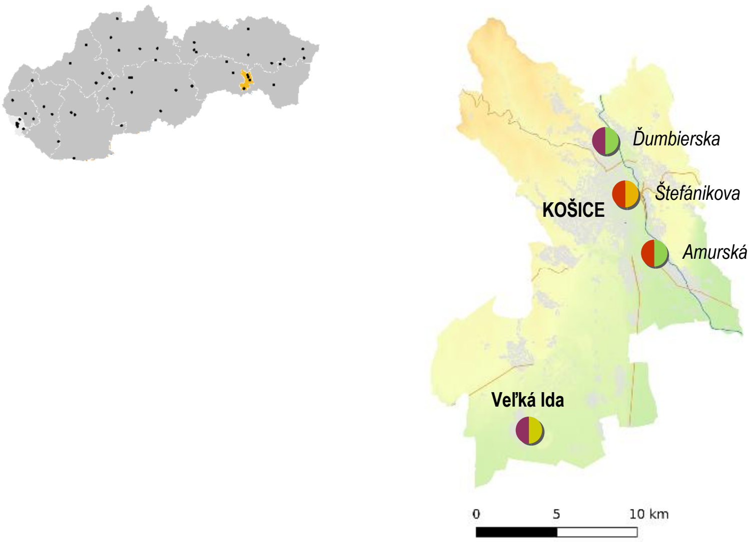
(the territory of Košice and the municipalities Bočiar, Haniska, Sokoľany and Veľká Ida)

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	EoI code	Station	Type		Geographical		Altitude [m]										
			area	station	longitude	latitude		PM_{10}	$PM_{2,5}$	NO, NO_2	SO_2	O_3	CO	Benzene	Hg	As, Cd, Ni, Pb	BaP
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 – rural (regional)

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

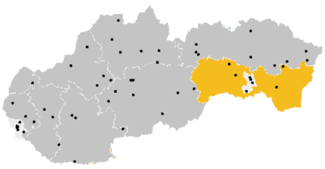
2.2 ZONE KOŠICE REGION
(without Košice agglomeration)

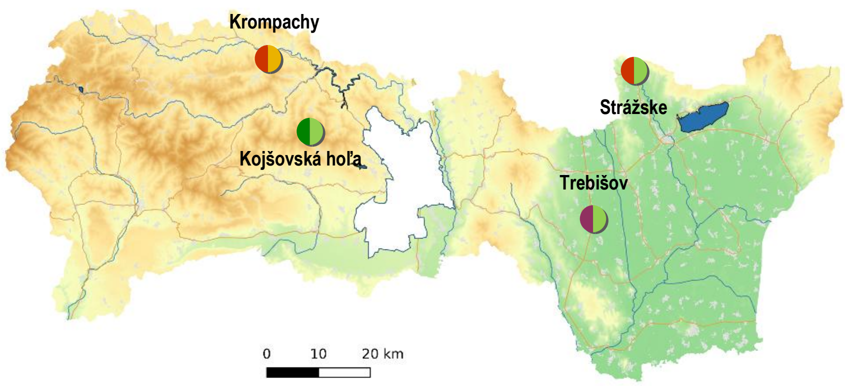
Air quality monitoring in the zone Košice region is complicated due to the diversity of terrain and the size of the area. There are four monitoring stations in the region, two of the sites have relatively long-term history of measurements. The beginnings of air quality monitoring in Krompachy and Strážske 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 (without aglomeration Košice)								Monitoring programme									
								Continuously								Manually	
District	EoI code	Station	Type		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											
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 2024. 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 – 2024.*

AGGLOMERATION Zone		Type	Protection of human health									IT[2)]	AT[2)]
	Pollutant		SO_2		NO_2		PM_{10}		$PM_{2,5}$	CO	Benzén	PM_{10}	PM_{10}
	Averaging period	Area / station	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						
KOŠICE	Košice, Štefánikova	UT	0	0	0	21	21	26	16	1 997	1,0	21	0
	Košice, Amurská	UB					12	23	16			16	0
	Veľká Ida, Letná	SI					**46**	33	20	2 223		0	0
Košice region	Kojšovská hoľa	RB			0	2						55	0
	Trebišov, T. G. Masaryka	SB			0	11	10	22	15			19	0
	Strážske, Mierová	UB					3	21	15			15	0
	Krompachy, SNP	UT	0	0	0	12	13	23	18	1 505	0,9	16	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$_{10}$*

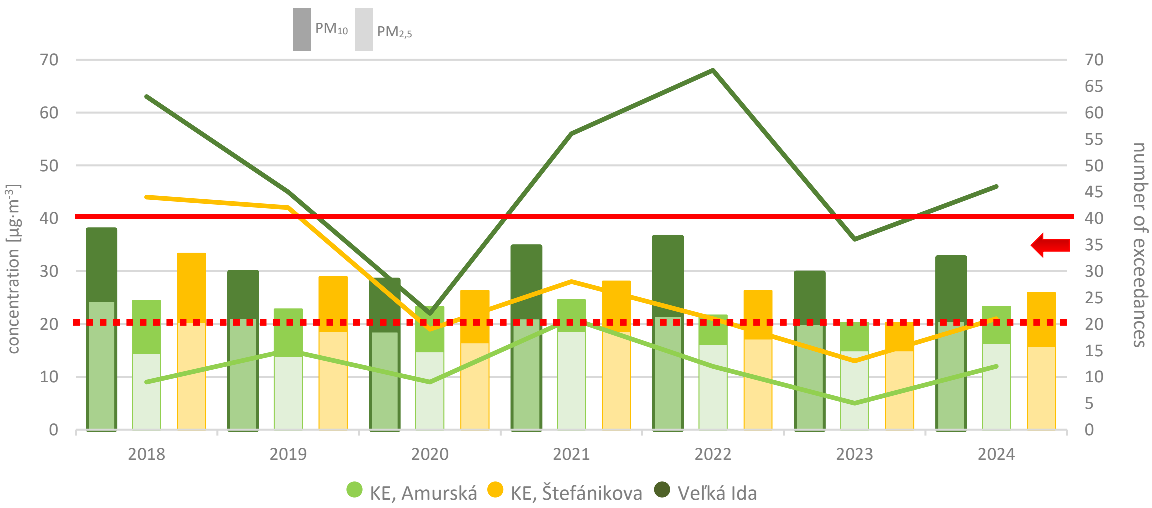
In accordance with the Decree of the Ministry of Environment of the Slovak Republic No. 250/2023 Coll. on air quality, the required proportion of valid values was observed at the monitoring stations.

3.1 AGGLOMERATION KOŠICE

3.1.1 PM_{10} and $PM_{2,5}$

Fig. 3.1 shows the average annual concentrations of PM_{10}, $PM_{2.5}$ and the number of days with average daily PM_{10} concentrations above 50 µg·m^{-3} according to the results of measurements at monitoring stations in the agglomeration Košice in 2018 – 2024.

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}

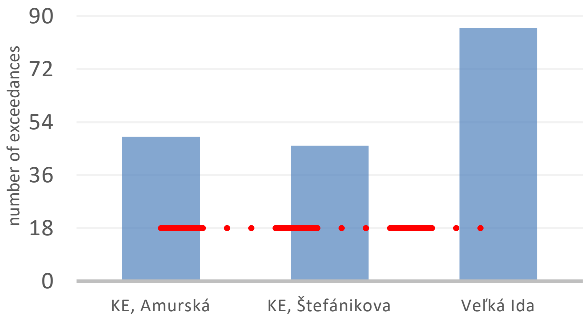


*PM_{10} dark column color, $PM_{2,5}$ – light column color; **number of exceedances** – solid broken lines*
Horizontal lines show limit values (LH), red solid PM10 (average annual concentration: 40 µg·m^{-3});
red striped $PM_{2.5}$ (average annual concentration: 20 µg·m^{-3}); red solid arrow – LH number of exceedances
(average daily PM_{10} concentration 50 µg·m^{-3} max. number of exceedances 35/calendar year).

The limit value for the average annual concentration of PM_{10} (40 µg.m^{-3}) and $PM_{2.5}$ (20 µg.m^{-3}) in the agglomeration was not exceeded. The limit value for the number of exceedances (35) of the average daily concentration of PM_{10} (50 µg.m^{-3}) was exceeded in Veľká Ida (46). A significant decrease in the number of exceedances of the daily limit for PM_{10} can be observed at the AMS Košice, Štefánikova (**Fig. 3.1**).

Sixteen exceedances of the daily PM_{10} concentration limit were recorded in Veľká Ida again outside the heating season, which is unusual compared to other locations. If we exclude the exceedances caused by the transport of desert dust in March-April, the remaining cases occurred in the months of July to October, with the highest number – seven exceedances – recorded in September. These summer and autumn episodes are probably related to emissions from industrial sources in the vicinity. This assumption is also confirmed by the significant difference in PM_{10} and $PM_{2.5}$ concentrations at the Veľká Ida AMS in September and October, but also in other months of the year (**Fig. 3.3**). The coarser fraction of PM_{10} is more likely to be associated with mechanical dustiness (e.g. from industry, transport or construction activities), while the finer fraction of $PM_{2.5}$ comes mainly from

Fig. 3.2 Number of days with average daily $PM_{2.5}$ concentration > 25 µg.m^{-3} in 2024 – evaluation with respect to the newly introduced EU limit.*

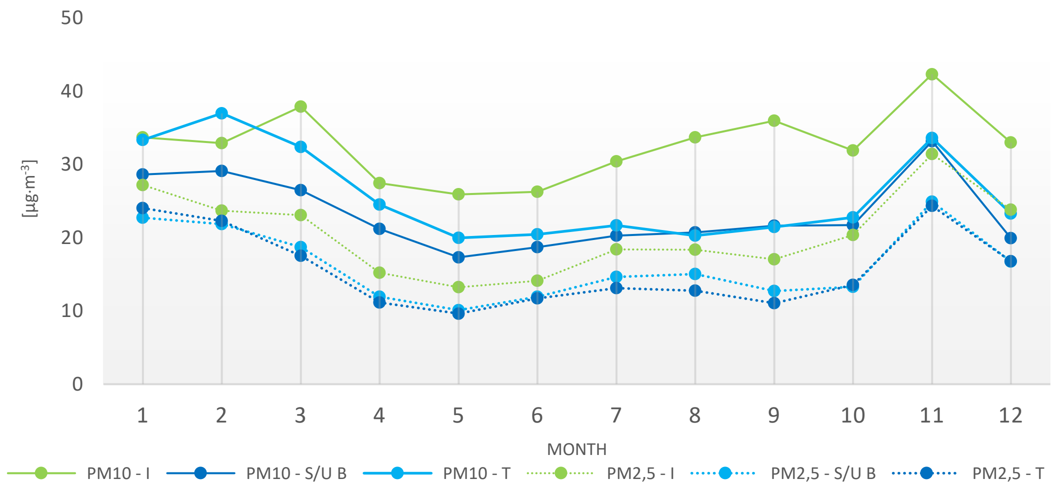


** Under the new EU limit, which will come into force on 1 January 2030, the average daily concentration of $PM_{2.5}$ must not exceed 25 µg.m^{-3} more than 18 times a year.*

combustion processes. It follows from the above that targeted measures to reduce dust from industrial sources could significantly contribute to reducing the number of daily limit exceedances - and it would not have to be exceeded at this station.

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 $\mu g \cdot m^{-3}$) with the limit for exceedance count per year 18, that is to be reached by 1. 1. 2030. **Fig. 3.2** shows how many exceedances of the new EU daily limit for $PM_{2.5}$ we would reach in 2024. In the Košice agglomeration, all monitoring stations would significantly exceed the new EU limit value. At the station in Veľká Ida, there would be up to 86 exceedances, which significantly exceeds the permitted number. Other AMS in the agglomeration are also significantly far from meeting this requirement.

Fig. 3.3 *Average monthly concentrations of PM_{10} and $PM_{2,5}$ in agglomeration Košice by station type.*



__T PM10__ a __T PM2.5__ – average monthly concentration of PM_{10} and $PM_{2,5}$ at traffic station Košice, Štefánikova; __U B PM10__ a __U B PM2.5__ – average monthly concentration of PM_{10} and $PM_{2,5}$ at urban background station Košice, Amurská; __I PM10__ a __I PM2.5__ – average monthly concentration of PM_{10} and $PM_{2,5}$ at industrial station Veľká Ida, Letná;

Sixteen exceedances of the daily PM_{10} concentration limit were recorded in Veľká Ida again outside the heating season, which is unusual compared to other locations. If we exclude the exceedances caused by the transport of desert dust in March-April, the remaining cases occurred in the months of July to October, with the highest number – seven exceedances – recorded in September. These summer and autumn episodes are probably related to emissions from industrial sources in the vicinity. This assumption is also confirmed by the significant difference in PM_{10} and $PM_{2.5}$ concentrations at the Veľká Ida AMS in September and October, but also in other months of the year (**Fig. 3.3**). The coarser fraction of PM_{10} is more likely to be associated with mechanical dustiness (e.g. from industry, transport or construction activities), while the finer fraction of $PM_{2.5}$ comes mainly from combustion processes. It follows from the above that targeted measures to reduce dust from industrial sources could significantly contribute to reducing the number of daily limit exceedances - and it would not have to be exceeded at this station.

As a part of the Green Deal, the European Union elaborated the Zero Pollution Action Plan, that describes a vision for the year 2050. It aims to reduce by that year air pollution to levels that are no

[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/*

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. 3.2 shows how many exceedances of the new EU daily limit for $PM_{2.5}$ we would reach in 2024. In the Košice agglomeration, all monitoring stations would significantly exceed the new EU limit value. At the station in Veľká Ida, there would be up to 86 exceedances, which significantly exceeds the permitted number. Other AMS in the agglomeration are also significantly far from meeting this requirement.

Fig. 3.4 Average monthly NO_2 concentrations in 2024.

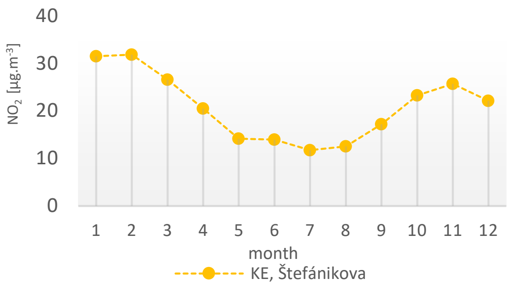


Fig. 3.5 Average monthly O_3 concentrations in 2024.

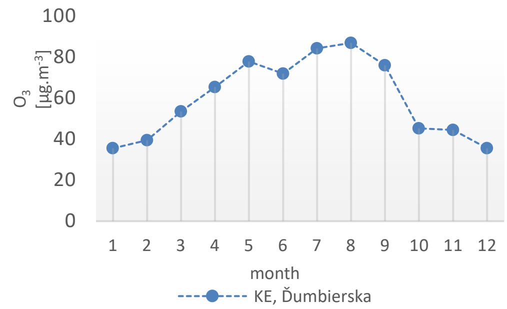


Fig. 3.3 shows the seasonal course of PM_{10} and $PM_{2.5}$ concentrations, especially in the traffic and urban background AMS, which corresponds to the typical influence of the heating season. The increased values in November are related to the onset of the heating season, which was supported by the cold course of the month.

AMS **Veľká Ida** reaches the highest concentrations of PM_{10} throughout the year. High values even outside winter indicate the dominant influence of industrial sources. The largest difference between PM_{10} and $PM_{2.5}$ is visible at the Veľká Ida station during the warmer months, which confirms the contribution of the coarse fraction from mechanical dust. We assume that one of the causes of these increased concentrations is the resuspension of dust from an uncovered and unsecured landfill located north of the monitoring station.

3.1.2 Nitrogen dioxide

The graph **Fig. 3.4** shows the monthly average concentrations of NO_2, the highest concentrations were recorded in the winter period – maximum in January and February, which is related to the deteriorated dispersion conditions. In the summer months, the concentrations were significantly lower, in these months there is also a lower traffic intensity (holidays, vacations) and more favorable dispersion conditions occur. The average annual concentration (21 µ·gm^{-3}) does not exceed the limit value (40 µg·m^{-3}). However, the station would not meet the new EU limit value for the annual average.

3.1.3 Ozone

Ozone monitoring is carried out at the suburban background station in Košice on Ďumbierská Street. The highest concentrations of ground-level ozone usually occur in warm months (**Fig. 3.5**), in 2024 it was in August, due to exceptionally warm weather. The graph shows a typical seasonal course of O3 concentrations with significant differences in concentrations in warm and cold periods.

3.1.4 Benzo(a)pyrene

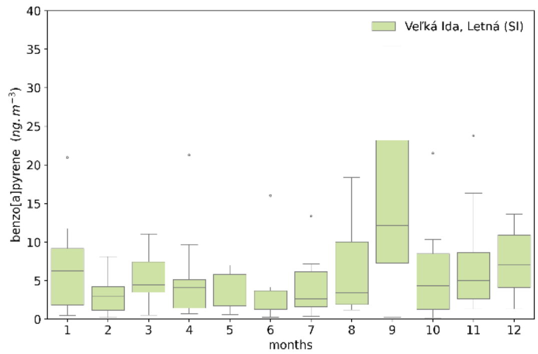
B(a)P (benzo(a)pyrene) is monitored in the Košice agglomeration at a suburban industrial station in Veľká Ida, on Letná Street. The target value for B(a)P was exceeded more than sixfold at this station (6.2 ng·m^{-3}). The location is significantly affected by emissions from a metallurgical plant, which confirms the relatively balanced monthly course of concentrations throughout the year (**Fig. 3.6**). Another source of B(a)P is household heating, which is less significant compared to coke production.

Unlike other monitored locations, where the main source of pollution is household heating and B(a)P concentrations decrease significantly in the summer months, this decrease is not significant in Veľká Ida. Daily mean concentrations below 1 ng·m^{-3} occurred in only 16% of measurements, while 41% of samples exceeded 5 ng·m^{-3} and 20% of samples even exceeded 10 ng·m^{-3}.

The maximum concentration of benzo(a)pyrene was recorded in September (35.4 ng·m^{-3}), which represents an extreme value and indicates an episodic occurrence of high pollution, probably due to industrial activity and unfavorable dispersion conditions.

Tab. 3.2 *Average annual concentration of benzo(a)pyrene in 2018–2024.*

Fig. 3.6 *Concentrations of B(a)P at station Veľká Ida in 2024.*



	2018	2019	2020	2021	2022	2023	2024
Target value [ng·m^{-3}]	1,0	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	6,2

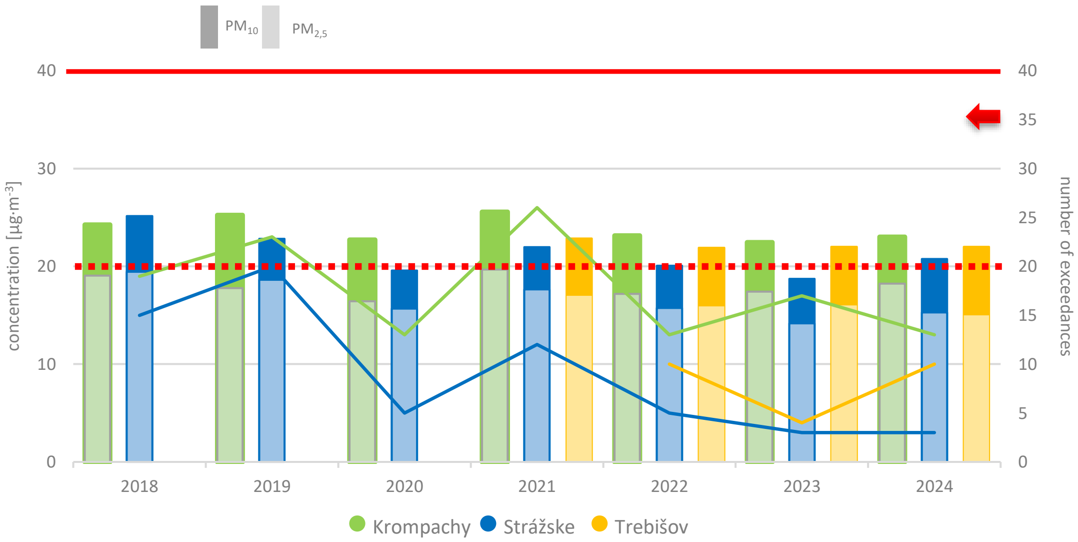
≥ 90 % % valid measurements *Concentrations marked in red indicate exceeding the target value.*

3.2 ZONE KOŠICE REGION

3.2.1 PM_{10} and $PM_{2,5}$

Fig. 3.7 shows the average annual concentrations of PM_{10}, $PM_{2.5}$ and the number of days with average daily PM_{10} concentration above 50 µg·m^{-3} according to the results of measurements at monitoring stations in the Košice region in 2018–2024.

Fig. 3.7 *Average annual concentrations of PM_{10}, $PM_{2.5}$ and the number of exceedances of the daily limit value for PM_{10}.*



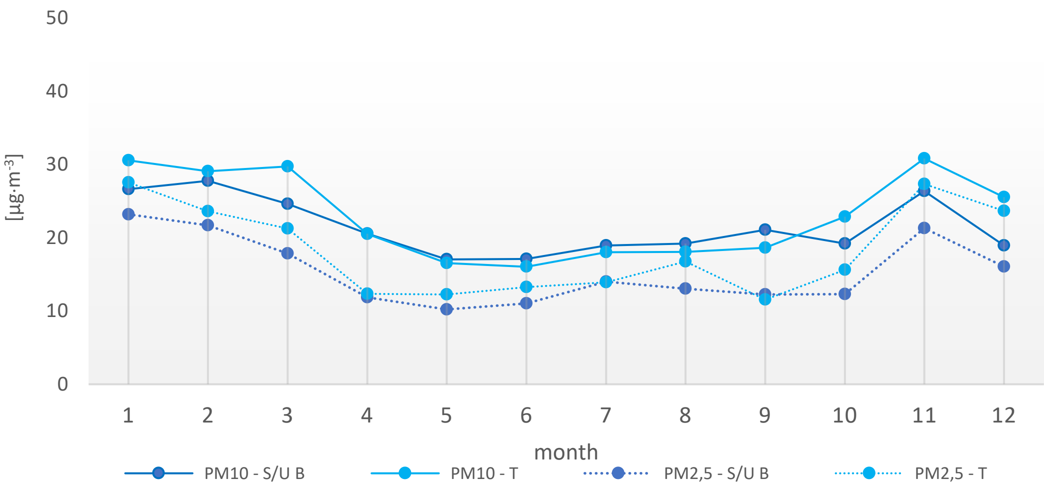
PM_{10} *dark column color,* ***$PM_{2,5}$*** *– light column color;* ***number of exceedances*** *– solid broken lines*
Horizontal lines show limit values (LH), red solid PM10 (average annual concentration: 40 µg·m^{-3});
red striped $PM_{2.5}$ (average annual concentration: 20 µg·m^{-3}); red solid arrow – LH number of exceedances
(average daily PM_{10} concentration 50 µg·m^{-3} max. number of exceedances 35/calendar year).

The limit value for the average annual concentration of PM_{10} (40 µg·m^{-3}) and $PM_{2.5}$ (20 µg·m^{-3}) in the Košice region zone was not exceeded. Similarly, the limit value for the number of exceedances per year (35 times) of the average daily concentration of PM_{10} (50 µg·m^{-3}) was not exceeded by any station (**Fig. 3.7**). In Strážske, the number of exceedances of the daily limit of PM_{10} has a significantly decreasing trend and in recent years (2023–2024) has been at the level of WHO recommendations. In Trebišov, monitoring was launched in 2021, the concentrations of particulate matter of both PM size fractions are at the level of the traffic AMS in Krompachy.

The monthly PM_{10} concentrations shown in **Fig. 3.8** show the most pronounced seasonal trend at the traffic monitoring AMS in Krompachy, where values are significantly higher in the winter months (January–March and November–December) than in the summer. This trend is related to the combined effect of traffic, local heating and adverse dispersion conditions typical of the winter period.

In contrast, *urban and suburban background* AMS in Strážske and Trebišov (S/U B) show a milder seasonal pattern, with less pronounced differences between winter and summer. The difference between PM_{10} and $PM_{2.5}$ is greatest in the winter months at the beginning of the year in Krompachy, which indicates a significant share of the coarser particle fraction, typical of road traffic (resuspension) and mechanical processes.

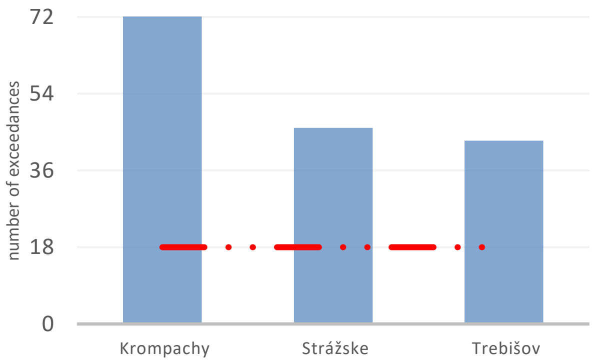
Fig. 3.8 *Average monthly concentrations of PM_{10} and $PM_{2,5}$ in zone Košice region by station type.*



***T PM10** a **T PM2.5** – average monthly concentrations of PM_{10} and $PM_{2,5}$ at traffic station Krompachy; **U/S B PM10** a **U/S B PM2.5** – average of monthly concentrations PM_{10} and $PM_{2,5}$ at urban/suburban background stations Strážske a Trebišov.*

As mentioned in Chapter 3.1.1, the European Union has developed a Zero Pollution Action Plan[6], that sets a vision for 2050. Its aim is to reduce air pollution to a level that is no longer considered harmful to health and natural ecosystems by this year. The plan for $PM_{2.5}$ introduces a daily limit value of 25 µg·m^{-3}, which must not be exceeded more than 18 times per year (this is to be achieved by 1. 1. 2030). **Fig. 3.9** illustrates how many exceedances of the new EU daily limit for $PM_{2.5}$ we would reach in 2024. In the Košice region zone, no monitoring station would meet the new EU limit value. At the Krompachy monitoring station, there would be up to 74 exceedances, and at the other AMS the numbers of exceedances were also significantly above the limit value of 18 exceedances.

Fig. 3.9 *Number of days with average daily $PM_{2.5}$ concentration > 25 µg·m^{-3} in 2024 – evaluation with respect to the newly introduced EU limit*.*



** Under the new EU limit, which will come into force on 1 January 2030, the average daily concentration of $PM_{2.5}$ must not exceed 25 µg.m^{-3} more than 18 times a year.*

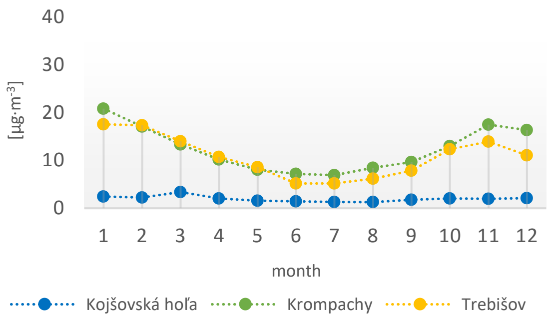
3.2.2 Nitrogen dioxide

Nitrogen dioxide concentrations are monitored at three stations, with average monthly values shown in **Fig. 3.10**. The main source of NO_2 emissions is road transport, as reflected by the highest concentrations at the transport station in Krompachy, with annual average of 12 µg·m^{-3}. However, this is a relatively low value compared to other transport locations, indicating that the impact of transport at this location is not significant. NO_2 concentrations in both Krompachy and Trebišov meet not only the current but also the proposed stricter EU limit values, which are part of the revision of the Air Quality Directive, with

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/*

a large margin. At the background station Kojšovská hoľa, NO_2 concentrations are significantly lower and stable throughout the year. In the Košice Region, in 2024, the average annual NO_2 concentrations were in line with the WHO recommendation (10 µg.m^{-3}) at the Kojšovská hoľa (2 µg.m^{-3}).

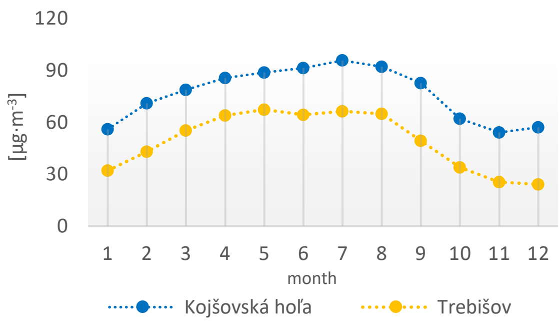
Fig. 3.10 Average monthly NO_2 concentrations in 2024.



3.2.3 Ozone

Ground-level ozone is measured at Trebišov and Kojšovská hoľa. The station at Kojšovská hoľa is located at a higher altitude, which is reflected in significantly higher ozone concentrations throughout the year. This phenomenon is probably related to the transfer of ozone from higher layers of the atmosphere. Both stations show a typical seasonal pattern with the highest concentrations in the summer months (May – August), (**Fig. 3.11**) which is related to the higher intensity of solar radiation required for the formation of ground-level ozone. The lowest values are observed in the winter (December – February), when solar radiation is weaker and atmospheric conditions are less favorable for the formation of ozone.

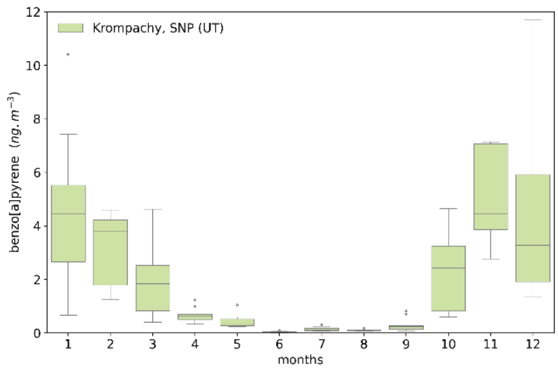
Fig. 3.11 Average monthly O_3 concentrations in 2024.



3.2.4 Benzo(a)pyrene

Benzo(a)pyrene (BaP) is monitored in the Košice region at one station – Krompachy, SNP (UT). The target value for BaP (1 ng·m^{-3}) is significantly exceeded in this location every year (**Tab. 3.3**). As shown in **Fig. 3.12**, BaP concentrations in Krompachy have a significant seasonal trend with a maximum in the winter months. Outside the heating season, the values are very low to negligible, which is a significant contrast to the Veľká Ida location (**Fig. 3.6**), where the values are also increased during the summer. The dominant source of benzo(a)pyrene in Krompachy is probably household heating, which significantly contributes to air pollution with this carcinogenic substance in the winter.

Fig. 3.12 Concentrations of B(a)P at Krompachy in 2024.



Tab. 3.3 Average annual concentration of benzo(a)pyrene in 2018 – 2024.

	2018	2019	2020	2021	2022	2023	2024
Target value [ng·m-3]	1,0	1,0	1,0	1,0	1,0	1,0	1,0
Krompachy, SNP		2,7	2,1	2,2	2,2	2,1	1,8

≥ 90 % valid measurements *Concentrations marked in red indicate exceeding the target value.*

4 AIR QUALITY MODELLING

In **Fig. 4.1** , the results of PM_{10} modeling calculated using the RIO model in combination with IDW-R (a more detailed description of the method is in Chapter 4 of the report *Air Pollution in the Slovak Republic 2024*).

Based on the results of mathematical modeling using the RIO, IDW-R interpolation model, we can assume that the highest PM_{10} concentrations occur in the southern part of the Košice agglomeration (in the municipalities of Veľká Ida, Sokoľany, Haniska, Bočiar) and are influenced by emissions from the metallurgical complex. In the Košice region zone, the highest PM_{10} values will probably be especially in Abov and in the districts of Rožňava, Spišská Nová Ves and Gelnica (**Fig. 4.1**). Based on the modeling, we would also assume that the highest exceedances of the daily limit for PM_{10} in the same locations (**Fig. 4.2**).

Fig. 4.1 Annual average PM_{10} concentration. Output of model RIO/IDW-R.

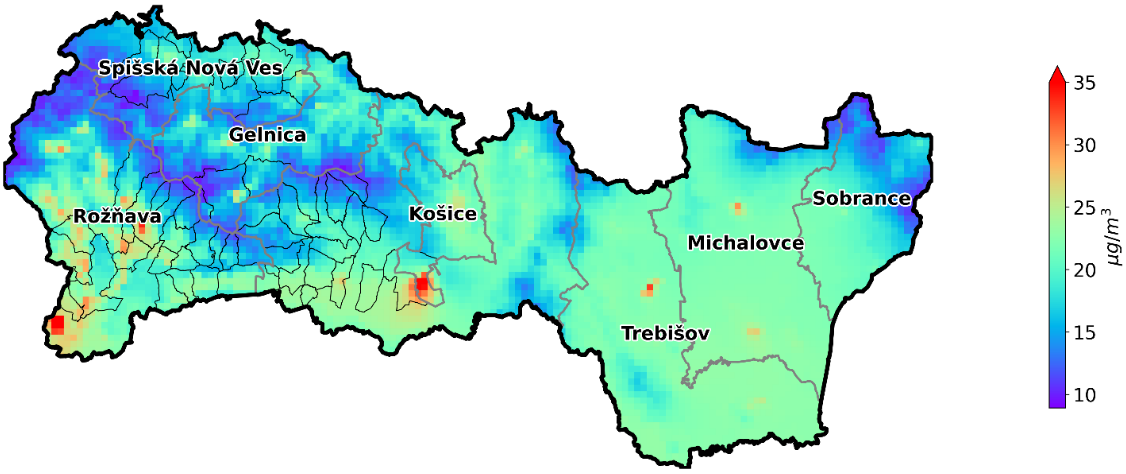
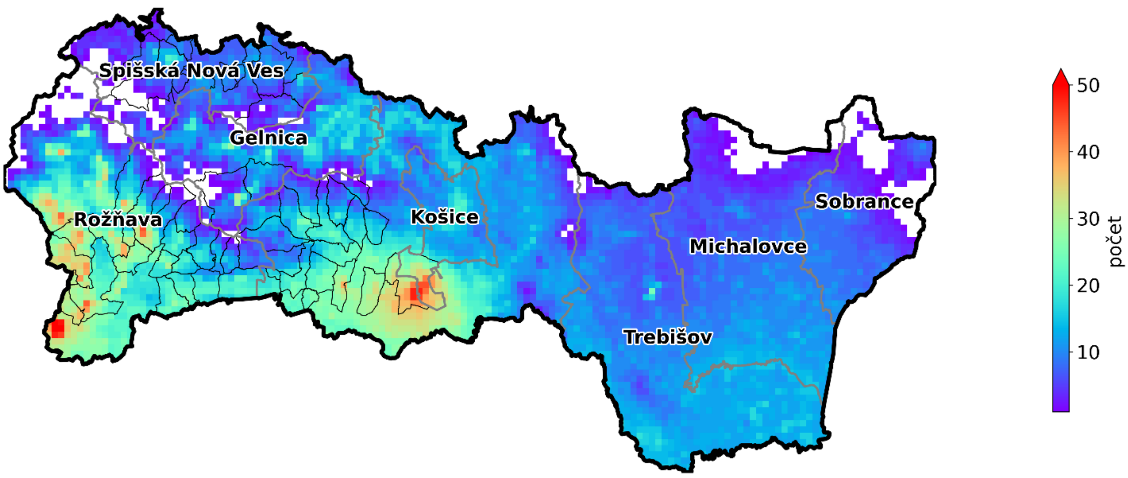


Fig. 4.2 Number of exceedances of the PM_{10} daily limit value in 2024. Only areas for which the number of exceedances was non-zero are shown.



The map in **Fig. 4.4** shows the spatial distribution of average annual $PM_{2.5}$ concentrations according to the output of the RIO model in combination with the IDW-R model. According to the model outputs, the average annual $PM_{2.5}$ concentration in the entire area of the zone, except for uninhabited mountainous areas, was higher than the limit value recommended by WHO (WHO limit values are stricter than EU limits).

The spatial distribution of average annual $PM_{2.5}$ concentrations according to the RIO, IDW-R model has a similar character to that for PM_{10}. In addition to the Košice agglomeration, the maximum values occur in Abov, in the Rožňava district and Spišská Nová Ves.

Fig. 4.3 *Annual average $PM_{2,5}$ concentration in 2024. Output of model RIO/IDW-R.*

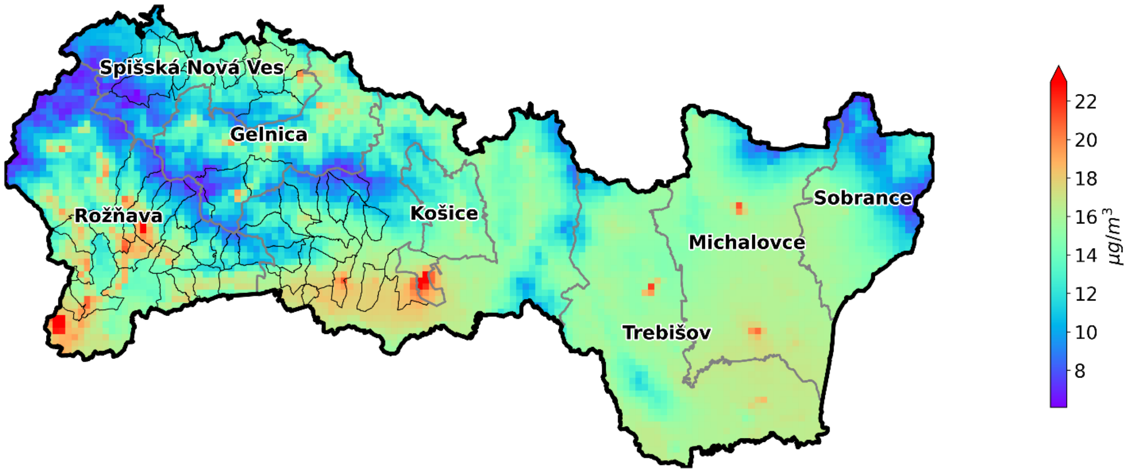
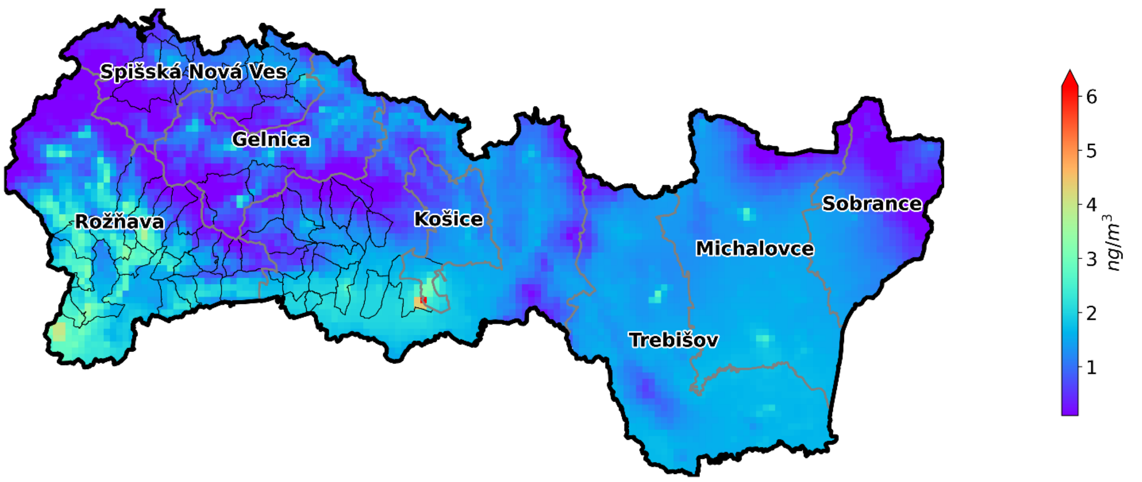


Fig. 4.4 captures the spatial distribution of the average annual concentration of benzo(a)pyrene according to the output of the RIO, IDW-R model. Since the model is based on measured data (and proxy fields), the outputs are burdened with considerable uncertainty over the vast territory of the Košice region.

The model may overestimate the concentrations of benzo(a)pyrene, especially in the vicinity of Košice and the East Slovak Lowland. It is strongly influenced by the high average annual concentration measured in Veľká Ida. Together with Krompach, this is one of the two stations in the Košice region zone where benzo(a)pyrene is monitored.

To obtain a more detailed idea of the spatial distribution, high-resolution modeling is necessary using detailed emission data (i.e. data on the amount and type of fuels, the type of equipment used for heating households, etc.). The most significant source of benzo(a)pyrene in the Košice agglomeration is coke production, and to a lesser extent household heating. The situation is the opposite in the Košice region, where the most significant source is household heating with solid fuel, especially insufficiently dried wood or unsuitable fuel (various types of waste).

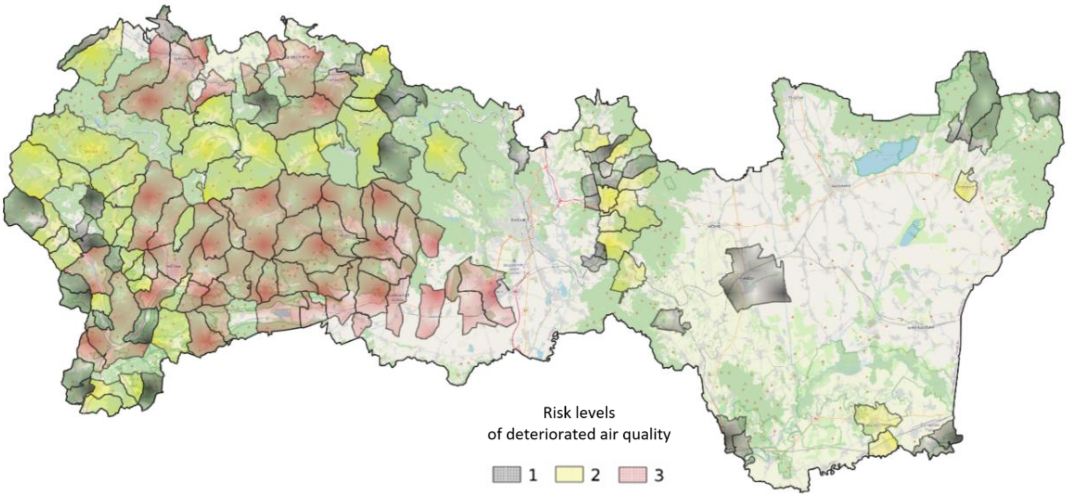
Fig. 4.4 *Annual average benzo(a)pyrene concentration in 2024. Output of model RIO/IDW-R.*



4.1 Risk municilalities

Fig. 4.5 displays the municipalities at risk of deteriorated air quality as determined by the integrated municipal assessment method for municipalities[7]. 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. 2024.



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[8].

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 [9].

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[7] *Štefánik, D., Krajčovičová, J.: Metóda integrovaného posúdenia obcí vzhľadom na riziko nepriaznivej kvality ovzdušia, Slovenský hydrometeorologický ústav, 2023, dostupné na https://www.shmu.sk/sk/?page=996*

[8] *https://www.shmu.sk/sk/?page=2873*

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

5 SUMMARY

The monitoring results from 2024 show that in the Košice agglomeration[10] the limit value for the average **daily** concentration of **PM_{10} was exceeded** at the monitoring station **Veľká Ida** – Letná. This year too, several exceedances were recorded in the warm months, which points to an ongoing problem. *Targeted measures aimed at reducing dust from industrial sources could significantly contribute to reducing the number of these exceedances.*

The **target value for benzo(a)pyrene (BaP) was exceeded** at the monitoring stations **Krompachy** and **Veľká Ida**, Letná, at this AMS the target value was exceeded more than 6-fold. At none of the stations was the limit value for the annual average concentration of PM_{10}, $PM_{2,5}$, SO_2, NO_2, CO, benzene or the target value for ozone (O_3) recorded.

In the **Košice Region zone, no exceedance of the limit values** for SO_2, NO_2, CO and benzene was recorded in 2024, nor was the exceedance of the limit values for the average annual concentration of PM_{10} and $PM_{2.5}$.

Long-term trends in pollution by PM particles (**Fig. 3.1**) and NO_2 have a decreasing character at all monitoring stations of the zone and agglomeration with the exception of AMS Veľká Ida, Letná.

Based on the outputs from the RIO, IDW-R model, we can conclude that in the Košice Region zone there is a risk of higher concentrations of PM2.5 and BaP in municipalities in the southwest of the region in the districts of Rožňava, Spišská Nová Ves and Gelnica and in the Košice agglomeration in its southern part.

If we were to assess the fulfillment of the requirements resulting from the new Air Quality Directive 2024/2881, which sets stricter limit values (will enter into force on 1 January 2030), in the Košice Region zone and the Košice agglomeration, the biggest problem would be not to exceed the new limit values for $PM_{2.5}$ and BaP. All stations in the region currently do not meet several of the stricter requirements of the new air quality directive.

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

In the terms of air quality, a major problem is the high level of BaP pollution in the southern part of the Košice agglomeration - the municipality of Veľká Ida, which is significantly affected by emissions from the metallurgical complex. This area is among the areas in Slovakia most affected by adverse air quality.

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[10] *Territory of Košíc a municipalities Bočiar, Haniska, Sokoľany a Veľká Ida*

[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-to-strengthen-standards-in-the-eu/*