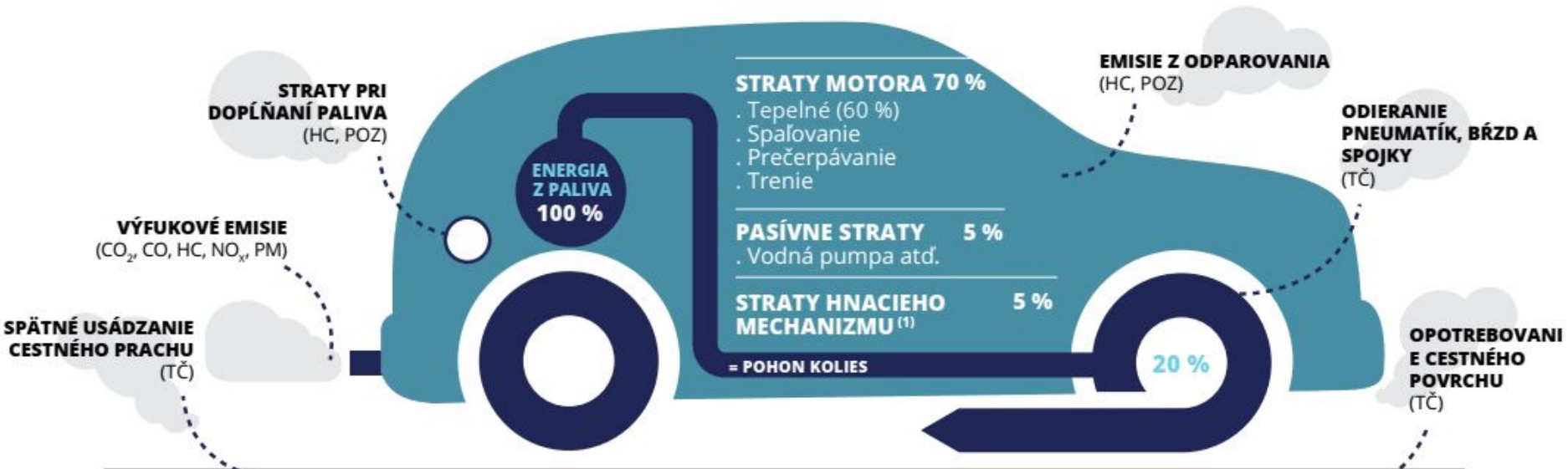
Final conference | 24th of November 2020

AIR TRITIA – čisté ovzdušie v srdci Európy
„Cestná doprava – modelovanie a meranie kvality ovzdušia“

AIR TRITIA | UNIZA| **Dušan Jandačka**, Daniela Ďurčanská, Marek Drličiak

EMISIE Z AUTOMOBILOVEJ DOPRAVY



(1) Hnací mechanizmus motorového vozidla je skupina súčastí, ktoré vytvárajú silu na pohon kolies. Patrí medzi ne prevodovka, osi a kolesá.

HC – uhľovodík; **POZ –** prchavé organické zlúčeniny; **TČ –** tuhé častice; **CO –** oxid uhoľnatý; **CO_2 –** oxid uhličitý; **NO_x –** oxidy dusíka;

DOPRAVNÝ MODEL

Modelované územie

Žilinský samosprávny kraj
- Žilina
- Martin

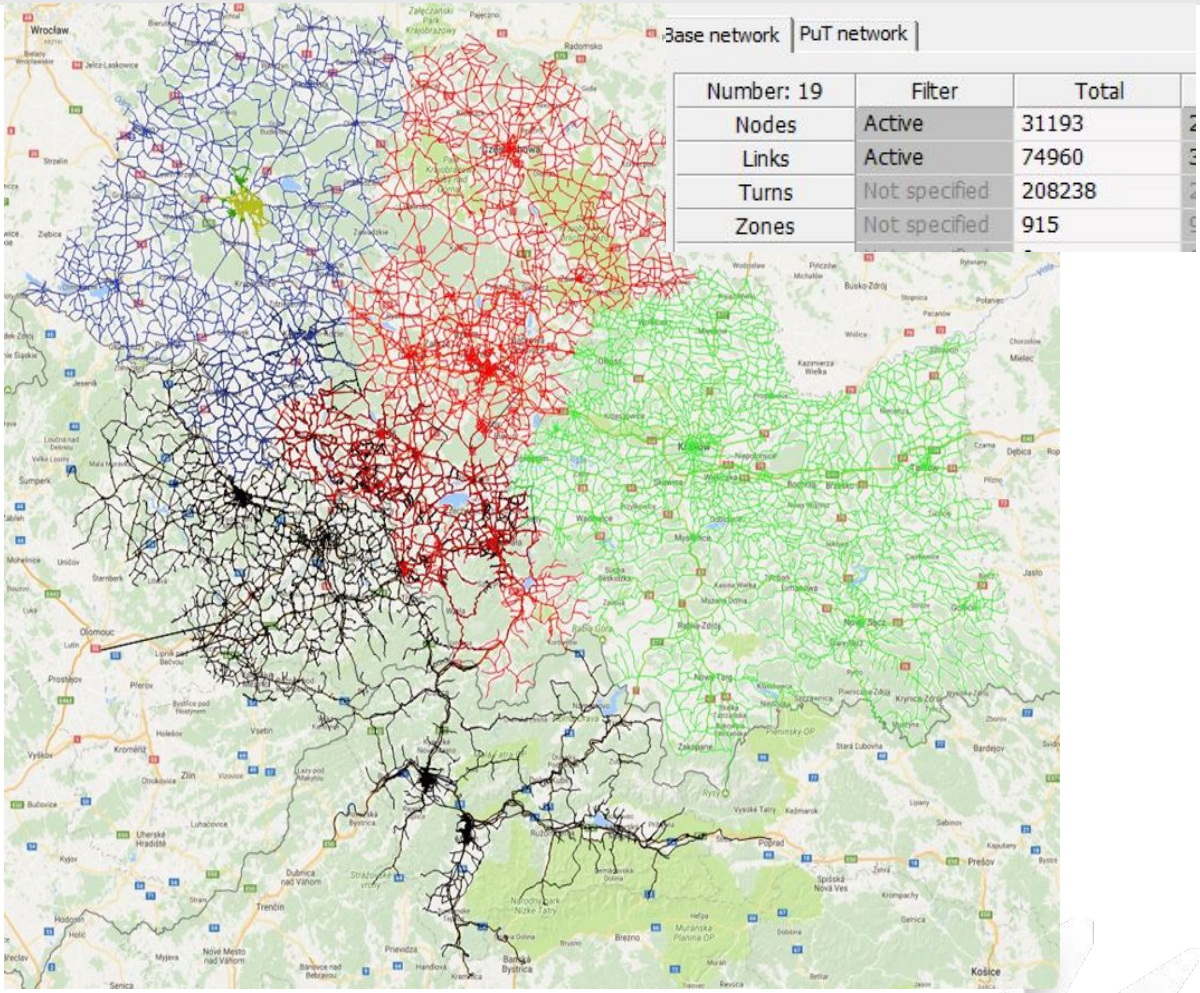
Moravskoslezský kraj
- Ostrava
- Opava

Sliezske vojvodstvo
- Rybnik

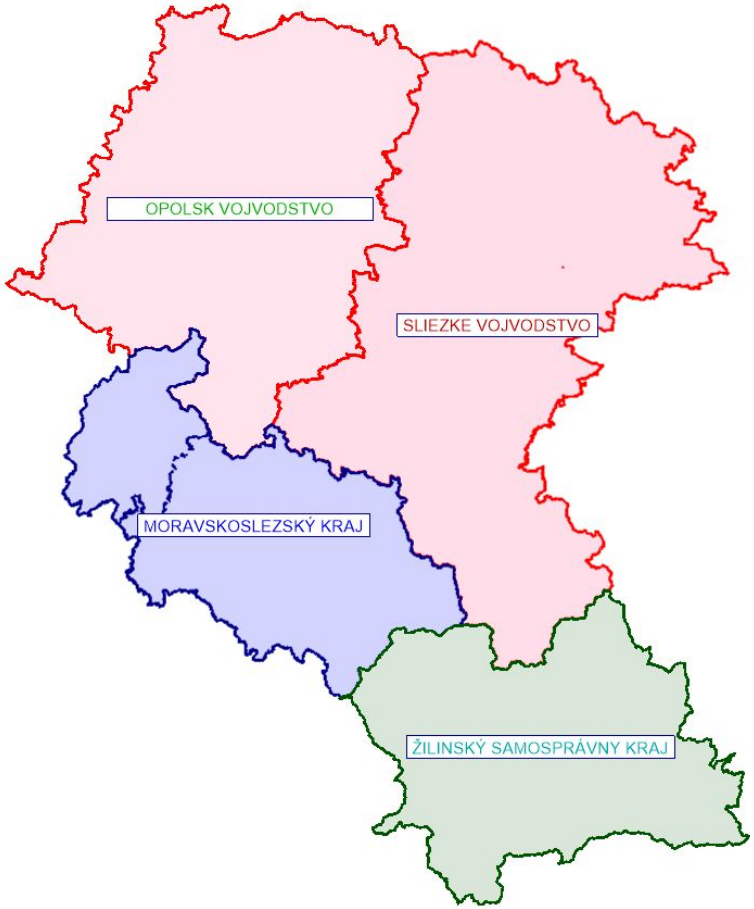
Opolské vojvodstvo
- Opole

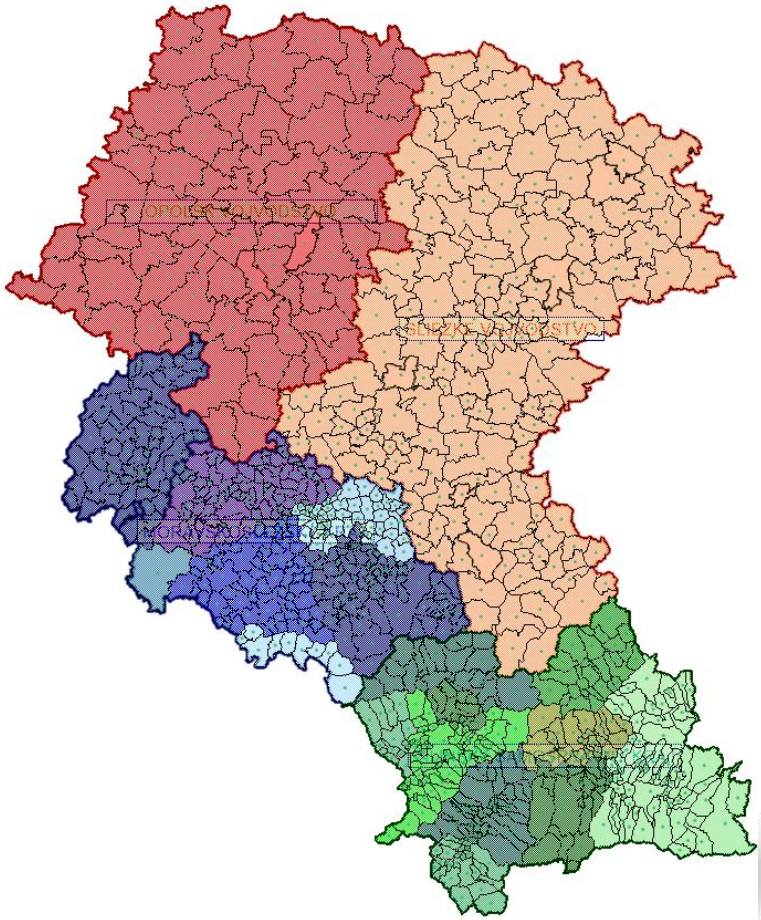
Štatistiky modelu

- počet dopravných uzlov: 31 193,
- počet ciest (links): 74 960,
- počet zón: 915.

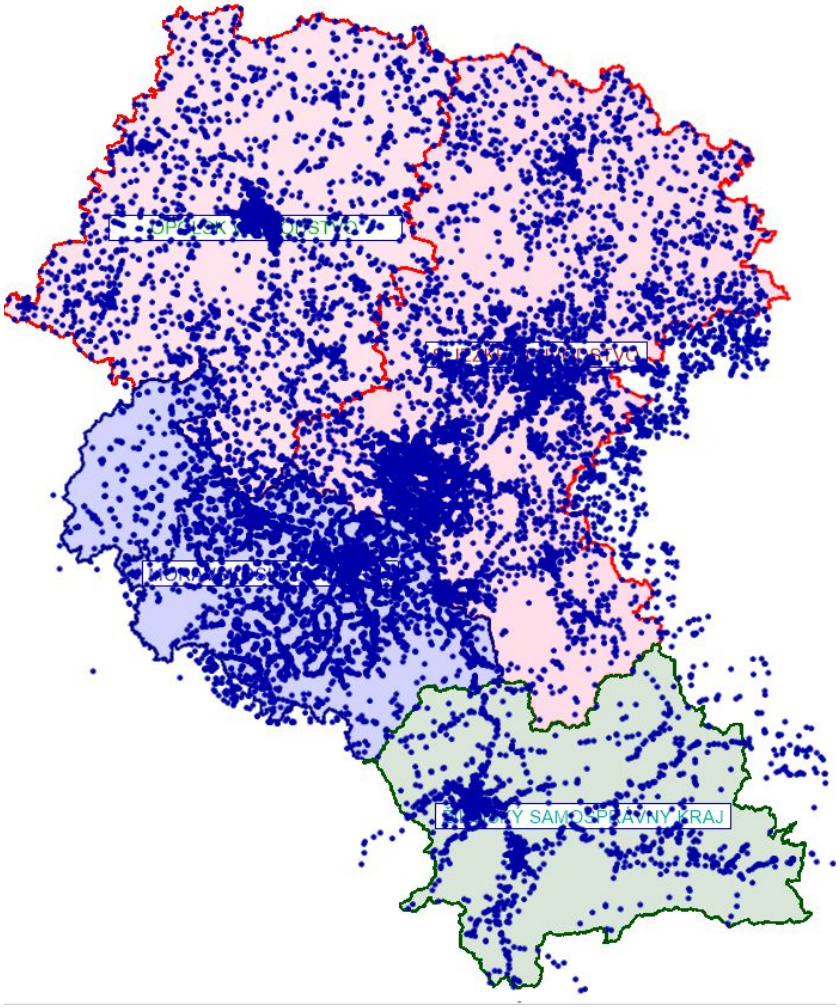


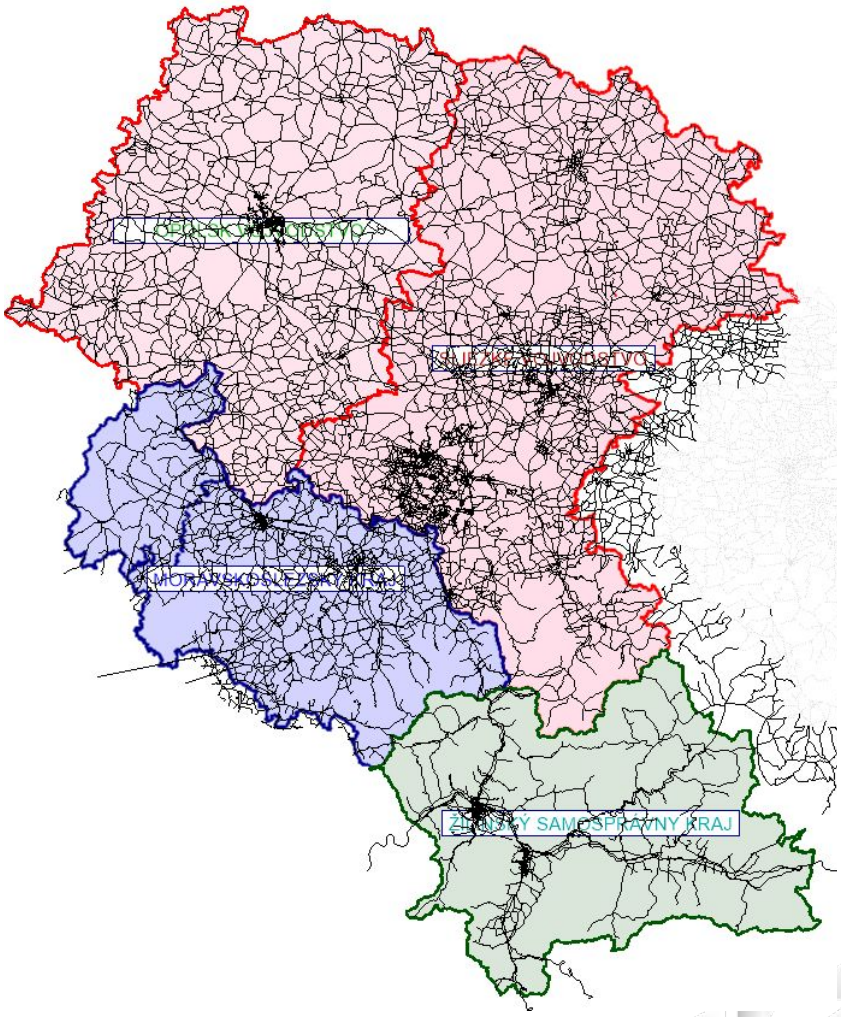
ZONÁLNE ČLENENIE





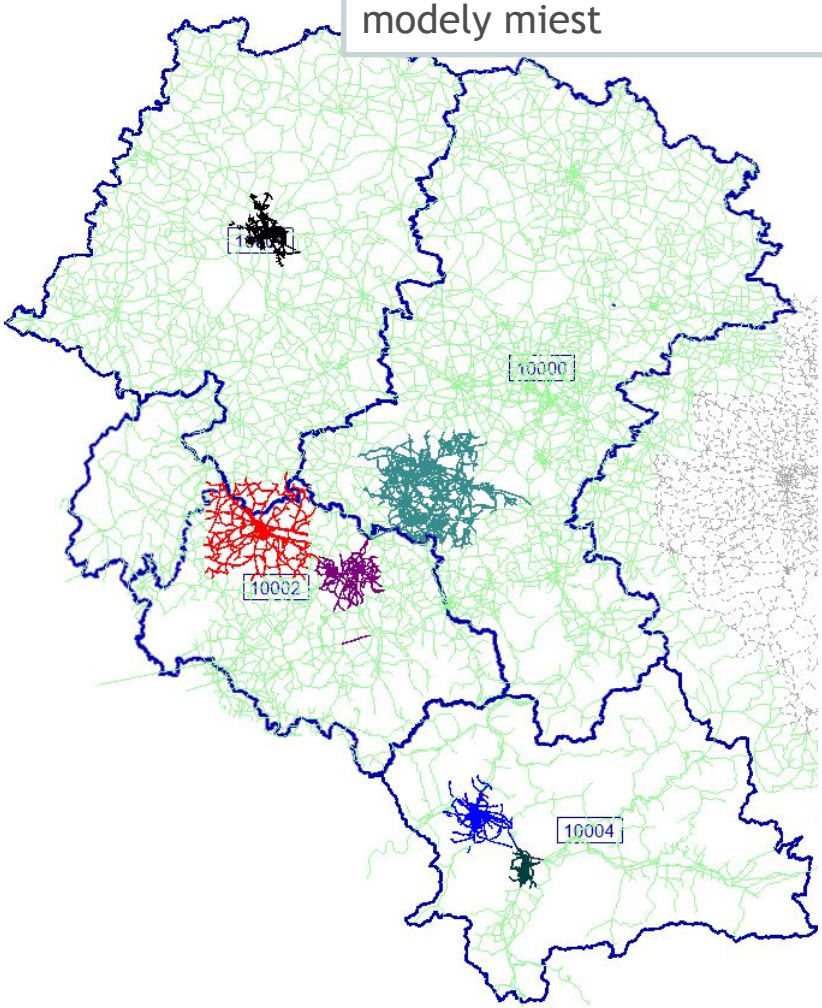
DOPRAVNÉ UZLY A CESTNÁ SIEŤ



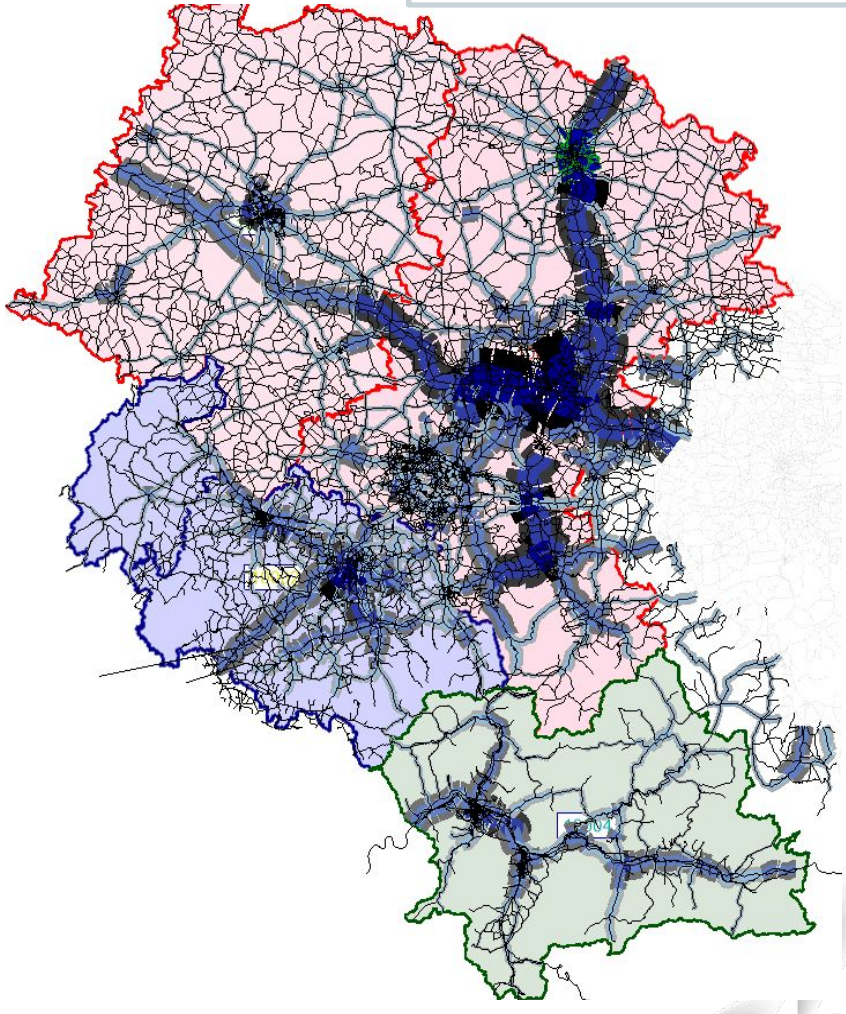


DOPRAVNÉ UZLY A CESTNÁ SIEŤ

Importované dopravné modely miest



Zaťažená cestná sieť



VZDUŠIA V
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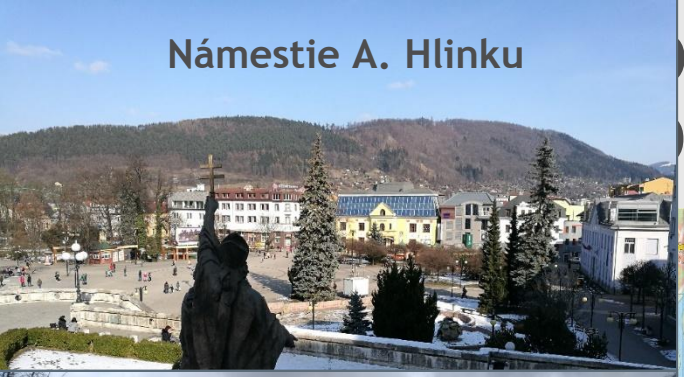
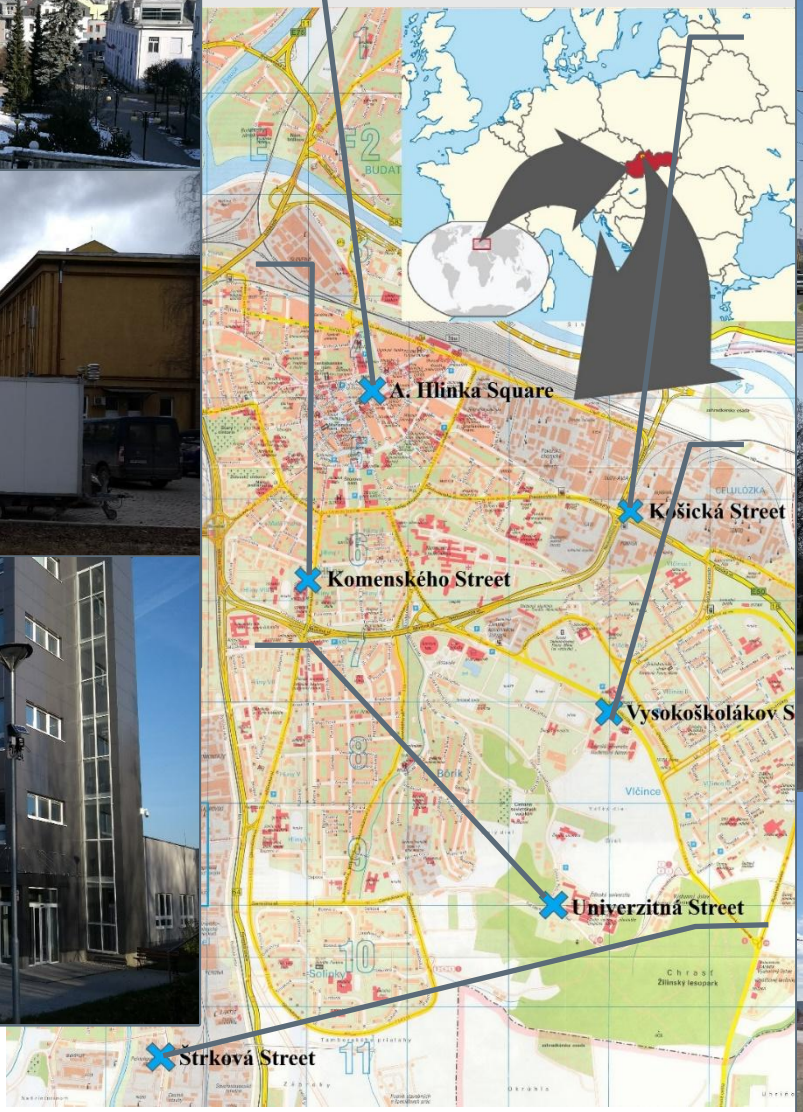
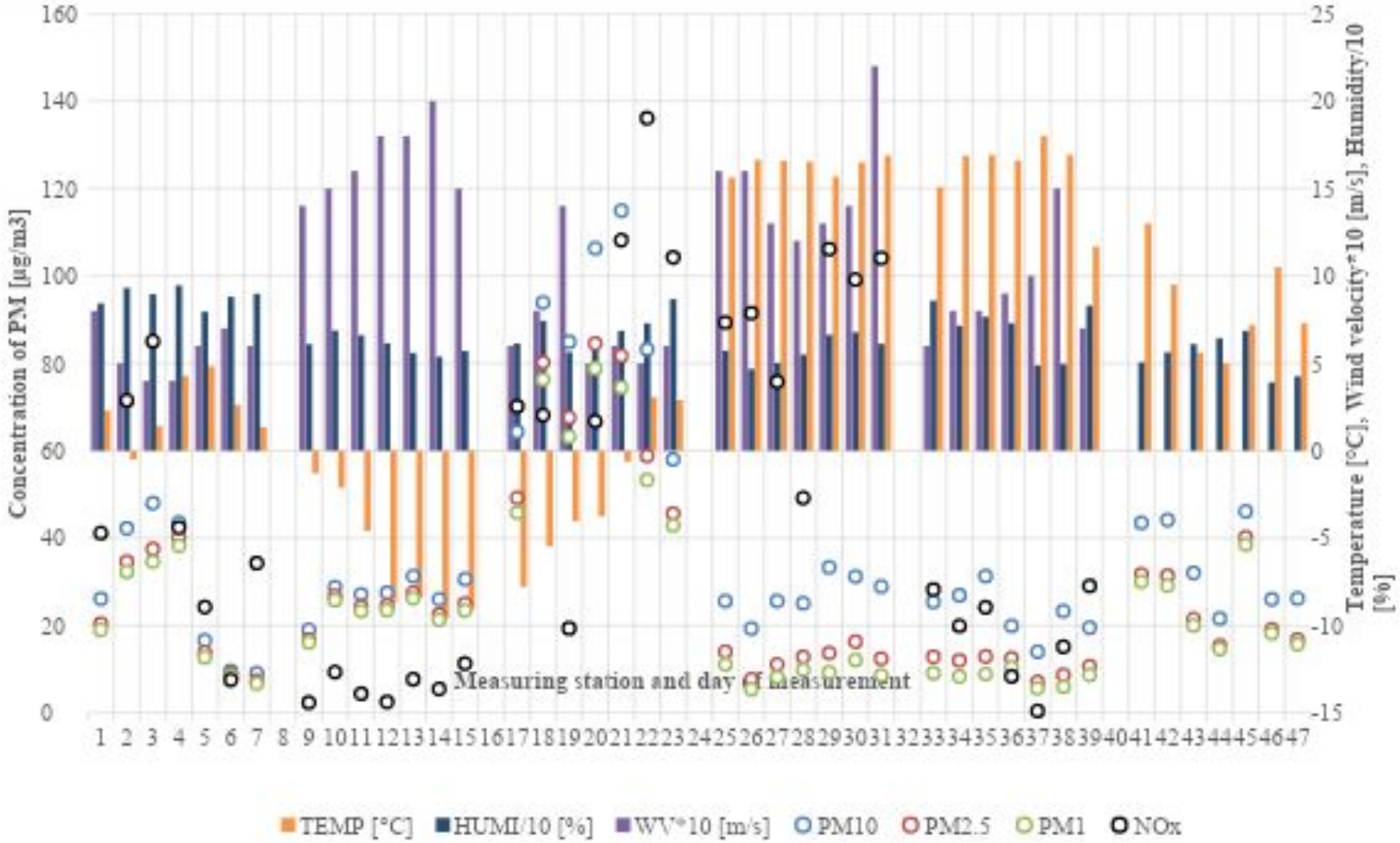




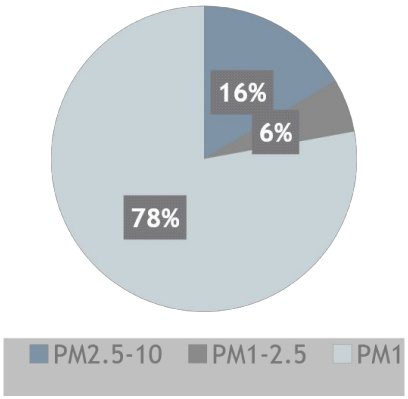
TAKING COOP

PRIESTOROVÁ A ČASOVÁ VARIÁCIA KONCENTRÁCIÍ ZNEČISŤUJÚCICH LÁTOK

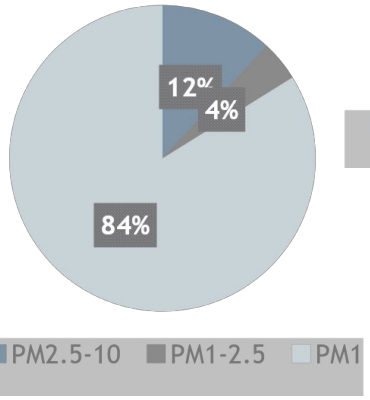


TUHÉ ČASTICE - DISTRIBÚCIA

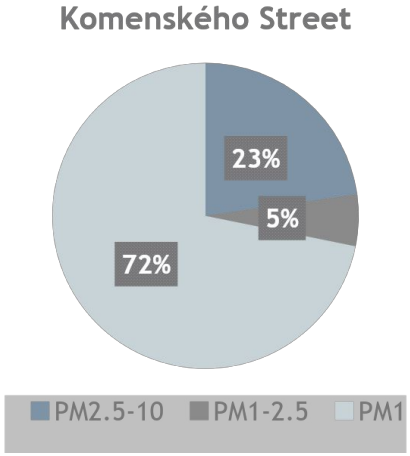
Univerzitná Street



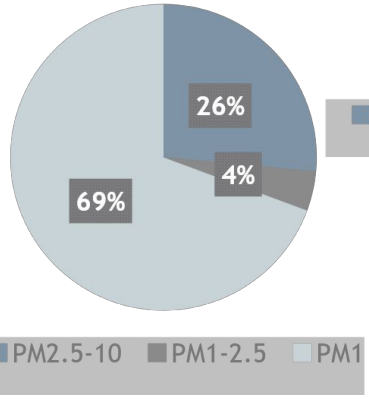
A. Hlinku Square



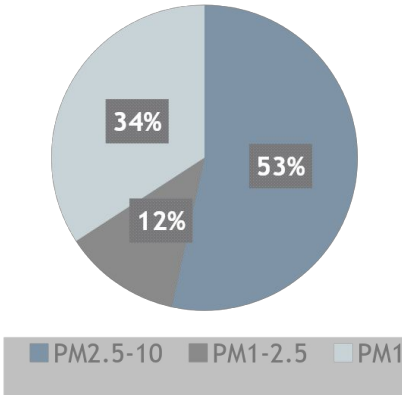
Komenského Street



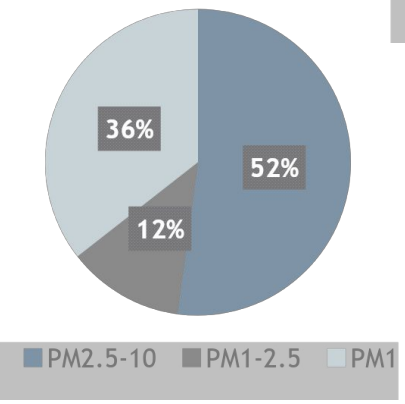
Vyskoškolákov Street



Košická Street

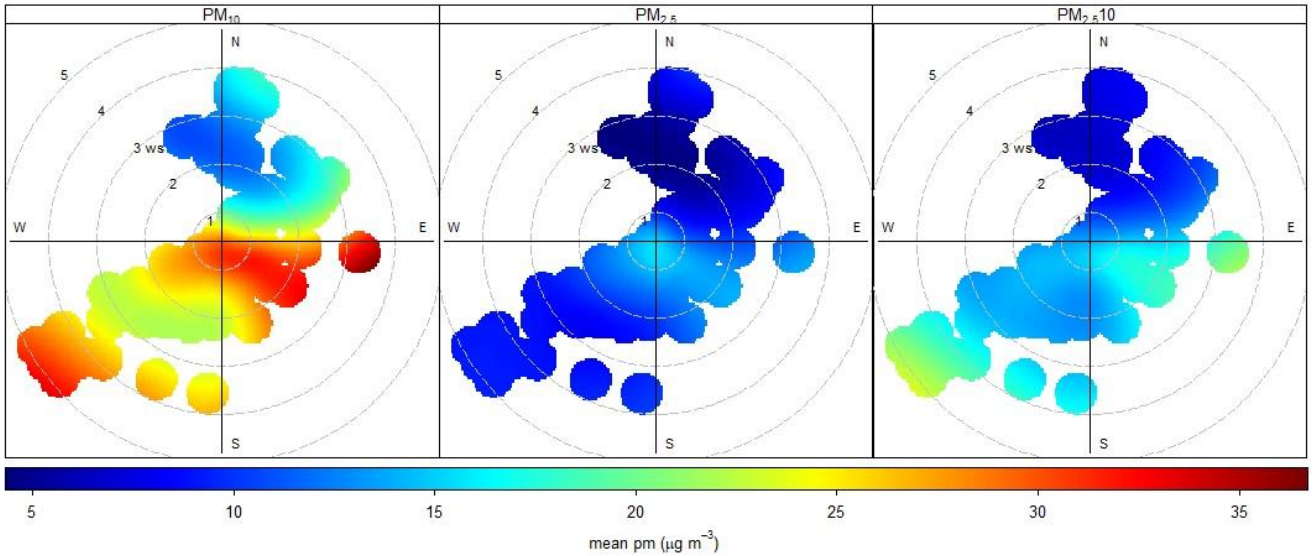


Štrková Street



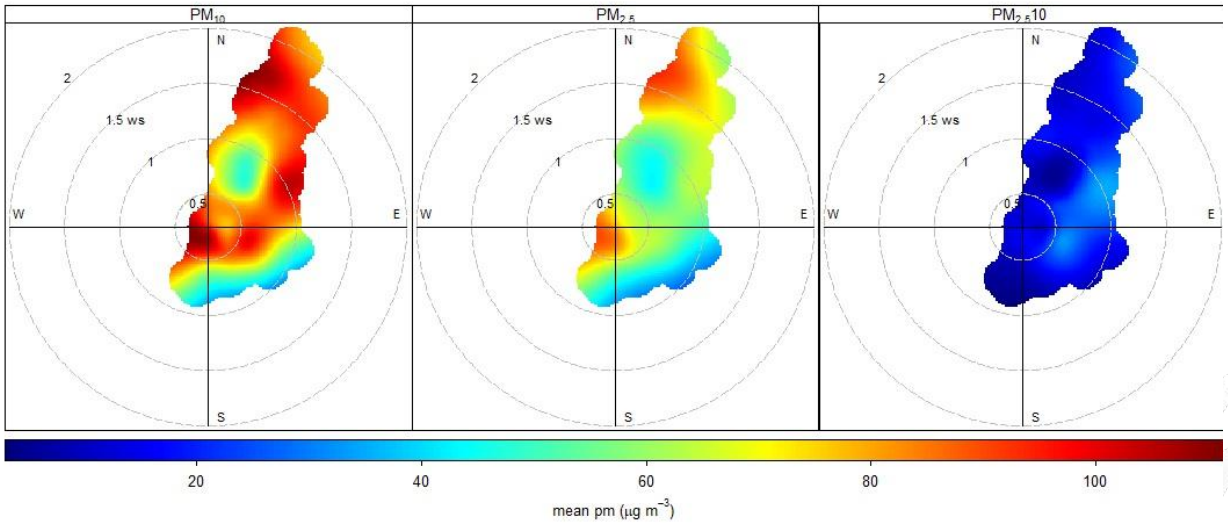
Measuring station	Average value and standard deviation of PM concentrations [µg/m^3]					
	$PM_{2.5-10}$	Std. Dev. $PM_{2.5-10}$	$PM_{1-2.5}$	Std. Dev. $PM_{1-2.5}$	PM_1	Std. Dev. PM_1
Univerzitná Street	4.6	3.3	1.6	0.8	21.7	12.2
A. Hlinka Square	3.2	1.1	1.1	0.3	22.8	3.1
Komenského Street	19.7	6.8	4.7	1.4	62.1	13.9
Košická Street	14.4	2.7	3.3	0.7	9.2	2.0
Štrková Street	11.9	4.0	2.8	0.9	8.1	1.6
Vysokoškolákov Street	9.1	2.6	1.4	0.5	23.7	8.3

TUHÉ ČASTICE – PRIESTOROVÉ ŠÍRENIE



Polárny graf – Košická ulica

Polárny graf – Komenského ulica



TUHÉ ČASTICE – CHEMICKÉ ZLOŽNIE

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$PM_{2.5-10}$

Table 1. Average concentration of elements in the particulate matter (PM) fraction ($PM_{2.5}$ and $PM_{2.5-10}$) at different measuring stations, with more than 60% in the $PM_{2.5-10}$.

MS *	PM	Average Concentration ± Standard Deviation [ng/m³] of the Element in the PM Fraction							
		Mg	Al	Si	Ca	Cr	Cu	Fe	Ba
uvp	$PM_{2.5}$	12.4	10.2	6.1	50.1	4.2×10^{-1}	4.4	87.1	9.1×10^{-1}
		±8.5	±9.1	±10.0	±35.7	$\pm 2.0 \times 10^{-1}$	±2.5	±23.4	$\pm 5.9 \times 10^{-1}$
	$PM_{2.5-10}$	128.4	131.1	242.0	701.9	12.8×10^{-1}	9.1	353.6	54.9×10^{-1}
		±121.5	±131.9	±196.8	±688.3	$\pm 8.2 \times 10^{-1}$	±7.5	±327.0	$\pm 60.5 \times 10^{-1}$
hlin	$PM_{2.5}$	15.0	25.7	16.8	58.4	7.8×10^{-1}	2.2	50.9	LQ*
		±7.8	±13.0	±18.4	±35.8	$\pm 7.6 \times 10^{-1}$	±1.3	±23.2	LQ*
	$PM_{2.5-10}$	47.6	64.7	93.1	337.3	7.4×10^{-4}	0.2	59.0	7.2×10^{-1}
		±13.4	±28.3	±40.3	±158.8	$\pm 18.2 \times 10^{-4}$	±0.5	±39.0	$\pm 5.0 \times 10^{-1}$
zsk	$PM_{2.5}$	114.0	99.2	122.1	1137.7	10.4×10^{-1}	7.2	247.1	36.8×10^{-1}
		±87.7	±69.9	±148.4	±1587.6	$\pm 6.9 \times 10^{-1}$	±4.2	±171.4	$\pm 27.4 \times 10^{-1}$
	$PM_{2.5-10}$	203.9	167.8	234.5	1479.0	13.5×10^{-1}	15.3	517.0	110.3×10^{-1}
		±130.4	±76.8	±167.2	±864.1	$\pm 6.0 \times 10^{-1}$	±7.2	±136.8	$\pm 39.2 \times 10^{-1}$
tep	$PM_{2.5}$	88.0	141.6	274.2	283.8	14.2×10^{-1}	9.4	336.6	65.2×10^{-1}
		±42.4	±97.4	±190.5	±162.9	$\pm 5.8 \times 10^{-1}$	±2.8	±141.8	$\pm 19.8 \times 10^{-1}$
	$PM_{2.5-10}$	299.0	392.0	607.3	1390.4	55.4×10^{-1}	36.0	1324.6	252.7×10^{-1}
		±98.3	±142.9	±182.8	±390.9	$\pm 20.5 \times 10^{-1}$	±10.2	±395.8	$\pm 77.8 \times 10^{-1}$
strk	$PM_{2.5}$	70.4	92.6	204.0	315.9	9.5×10^{-1}	2.8	232.2	36.8×10^{-1}
		±34.0	±45.2	±97.0	±219.5	$\pm 6.8 \times 10^{-1}$	±1.4	±150.4	$\pm 13.7 \times 10^{-1}$
	$PM_{2.5-10}$	158.0	211.9	375.8	758.1	12.0×10^{-1}	4.2	456.0	39.1×10^{-1}
		±93.6	±118.3	±210.1	±406.4	$\pm 7.4 \times 10^{-1}$	±2.5	±278.1	$\pm 32.5 \times 10^{-1}$
vys	$PM_{2.5}$	16.0	25.9	10.6	57.0	2.3×10^{-1}	1.6	66.2	8.1×10^{-1}
		±4.6	±9.1	±10.9	±31.3	$\pm 0.9 \times 10^{-1}$	±0.5	±23.2	$\pm 2.6 \times 10^{-1}$
	$PM_{2.5-10}$	79.2	121.8	92.0	566.5	4.4×10^{-1}	3.3	196.4	33.7×10^{-1}
		±29.2	±46.6	±85.3	±195.3	$\pm 3.3 \times 10^{-1}$	±1.0	±64.2	$\pm 9.2 \times 10^{-1}$

* MS—monitoring station, LQ—below detection limit.

$PM_{2.5}$

Table 2. Average concentration of elements in the particulate matter (PM) fraction ($PM_{2.5}$ and $PM_{2.5-10}$) at different measuring stations, with more than 60% in the $PM_{2.5}$.

MS *	PM	Average Concentration ± Standard Deviation [ng/m³] of the Element in the PM Fraction						
		K	S	Cd	Sb	Pb	Ni	Zn
uvp	$PM_{2.5}$	216.7	546.3	29.4×10^{-2}	15.2×10^{-1}	65.1×10^{-1}	11.8×10^{-1}	43.3
		±135.2	±374.1	$\pm 20.4 \times 10^{-2}$	$\pm 10.2 \times 10^{-1}$	$\pm 33.5 \times 10^{-1}$	$\pm 1.0 \times 10^{-1}$	±29.1
	$PM_{2.5-10}$	61.6	312.4	4.4×10^{-2}	8.5×10^{-1}	9.1×10^{-1}	7.7×10^{-1}	9.1
		±58.0	±333.2	$\pm 8.5 \times 10^{-2}$	$\pm 7.6 \times 10^{-1}$	$\pm 14.6 \times 10^{-1}$	$\pm 6.9 \times 10^{-1}$	±10.5
hlin	$PM_{2.5}$	224.8	1695.4	23.2×10^{-2}	6.9×10^{-1}	80.1×10^{-1}	18.6×10^{-1}	40.7
		±28.6	±843.1	$\pm 9.9 \times 10^{-2}$	$\pm 3.0 \times 10^{-1}$	$\pm 41.3 \times 10^{-1}$	$\pm 5.3 \times 10^{-1}$	±10.2
	$PM_{2.5-10}$	3.5	9.7	1.3×10^{-2}	0.4×10^{-1}	3.4×10^{-1}	1.2×10^{-1}	8.6
		±5.9	±23.8	$\pm 3.1 \times 10^{-2}$	$\pm 1.1 \times 10^{-1}$	$\pm 8.4 \times 10^{-1}$	$\pm 1.9 \times 10^{-1}$	±19.5
zsk	$PM_{2.5}$	564.2	2442.8	63.5×10^{-2}	22.0×10^{-1}	185.6×10^{-1}	18.3×10^{-1}	89.3
		±186.9	±1234.5	$\pm 27.8 \times 10^{-2}$	$\pm 12.9 \times 10^{-1}$	$\pm 89.4 \times 10^{-1}$	$\pm 4.5 \times 10^{-1}$	±31.3
	$PM_{2.5-10}$	18.5	265.2	6.7×10^{-2}	8.7×10^{-1}	12.5×10^{-1}	3.1×10^{-1}	7.6
		±28.4	±263.1	$\pm 8.1 \times 10^{-2}$	$\pm 3.4 \times 10^{-1}$	$\pm 14.2 \times 10^{-1}$	$\pm 4.0 \times 10^{-1}$	±6.6
tep	$PM_{2.5}$	107.3	495.9	18.8×10^{-2}	26.6×10^{-1}	55.8×10^{-1}	13.2×10^{-1}	29.2
		±29.8	±425.4	$\pm 6.3 \times 10^{-2}$	$\pm 8.5 \times 10^{-1}$	$\pm 15.4 \times 10^{-1}$	$\pm 2.0 \times 10^{-1}$	±6.2
	$PM_{2.5-10}$	123.0	224.5	3.4×10^{-2}	78.3×10^{-1}	21.6×10^{-1}	11.3×10^{-1}	21.5
		±52.5	±143.4	$\pm 2.1 \times 10^{-2}$	$\pm 29.6 \times 10^{-1}$	$\pm 9.4 \times 10^{-1}$	$\pm 6.8 \times 10^{-1}$	±6.1
strk	$PM_{2.5}$	98.8	457.2	14.6×10^{-2}	11.6×10^{-1}	57.7×10^{-1}	15.8×10^{-1}	22.2
		±24.0	±181.2	$\pm 4.5 \times 10^{-2}$	$\pm 7.0 \times 10^{-1}$	$\pm 22.5 \times 10^{-1}$	$\pm 4.4 \times 10^{-1}$	±6.9
	$PM_{2.5-10}$	110.3	164.9	2.9×10^{-2}	6.1×10^{-1}	22.7×10^{-1}	7.2×10^{-1}	13.6
		±55.6	±107.0	$\pm 2.2 \times 10^{-2}$	$\pm 3.9 \times 10^{-1}$	$\pm 27.3 \times 10^{-1}$	$\pm 5.8 \times 10^{-1}$	±13.7
vys	$PM_{2.5}$	81.5	880.1	19.1×10^{-2}	4.0×10^{-1}	31.0×10^{-1}	0.9×10^{-1}	12.7
		±26.7	±462.3	$\pm 7.8 \times 10^{-2}$	$\pm 1.6 \times 10^{-1}$	$\pm 18.6 \times 10^{-1}$	$\pm 1.3 \times 10^{-1}$	±5.2
	$PM_{2.5-10}$	34.2	77.1	0.4×10^{-2}	1.8×10^{-1}	1.1×10^{-1}	0.9×10^{-1}	2.0
		±29.4	±71.4	$\pm 0.6 \times 10^{-2}$	$\pm 1.0 \times 10^{-1}$	$\pm 0.9 \times 10^{-1}$	$\pm 1.1 \times 10^{-1}$	±1.6

* MS—monitoring station.

TUHÉ ČASTICE – VYUŽITIE CHEMICKÉHO ZLOŽENIA

Využité viacrozmerné štatistické metódy pre identifikáciu zdroja znečistenia ovzdušia tuhými časticami

Analýza hlavných komponentov - PCA

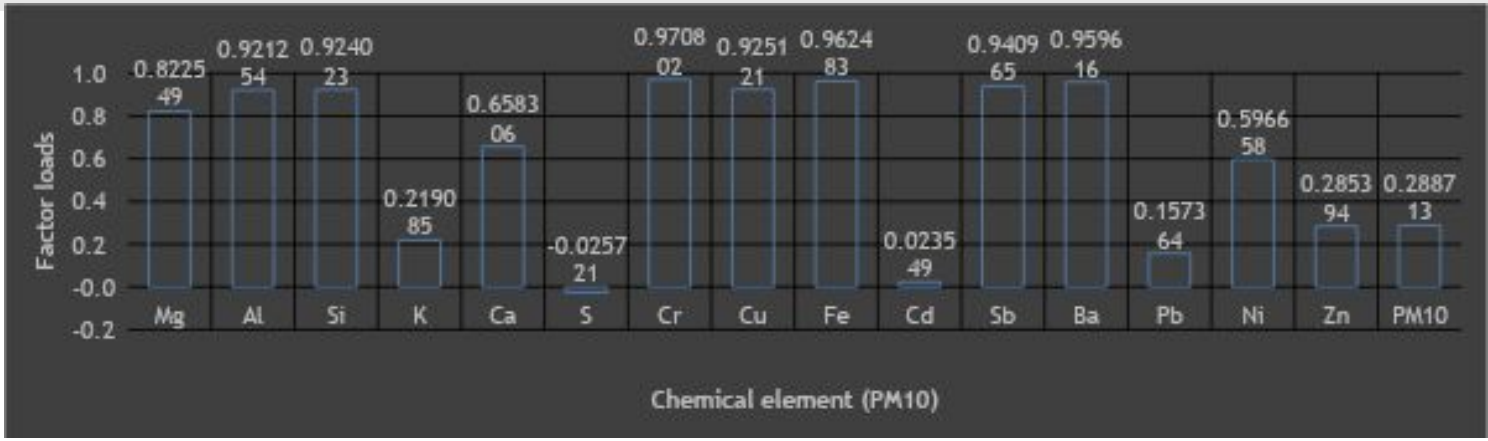
$$y_1 = \sum_{j=1}^{m} v_{1j} x_j,$$

Faktorová analýza - FA

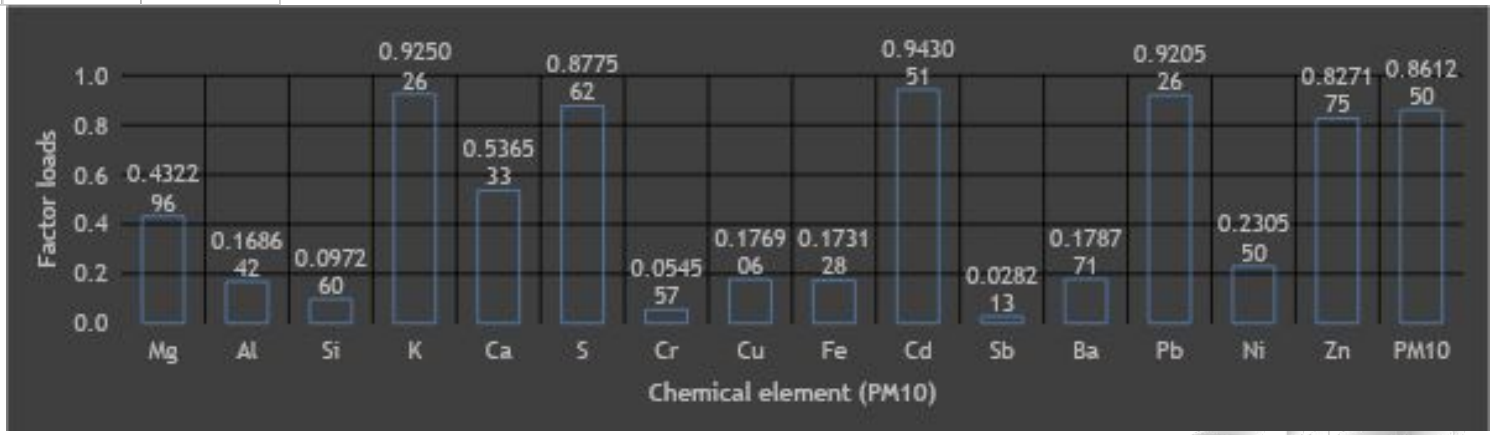
$$X_j = \sum_{k=1}^{m} \lambda_{jk} F_k + E_j, j,$$

Kombináciou týchto dvoch metód sa dosiahne minimálny počet latentných premenných s maximom pôvodných informácií (PCA) a potom použije minimálny počet latentných premenných (faktory) pre FA a vkladá do nich pôvodné znaky (kovy).

TUHÉ ČASTICE – VÝSLEDKY FA



Faktor	vl. Číslo	% celk. Rozptylu	Kumulativ. Vlast. Číslo	Kumulativ. %
1	9.491232	59.32020	9.49123	59.32020
2	3.898265	24.36415	13.38950	83.68435



TUHÉ ČASTICE - ZDROJE

MS	Factor	% of the total variance	Significant chemical elements for the factor	Source of PM_{10}
uvp	F1	71.8	Mg, Al, Si, K, Ca, Ba, Zn	Road dust resuspension
	F2	12.4	S	Combustion – local, central heating
	F3	9.2	Cr, Cu, Fe, Cd,	Traffic related abrasion
hlin	F1	50.8	S, Cd, Sb, Pb	Combustion – local, central heating
	F2	21.9	Al, Si, K, Ba	Traffic, pavement related abrasion
	F3	14	Mg, Ca, Zn	Road dust resuspnsion
	F4	7.9	Cu, Fe, Ni	Industry
zsk	F1	60.3	Al, Si, Cr, Cu, Fe, Sb, Ba	Traffic related abrasion
	F2	25.1	K, S, Cd, Pb	Combustion – local, central heating
	F3	9.9	Mg, Ca, Zn	Road dust resuspension, exhaust processes
tep	F1	66	Mg, Al, Si, K, Ca, Cr, Cu, Fe, Sb, Ba	Road dust resuspension, traffic related abrasion
	F2	16.8	Cd, Pb	Industry
	F3	9.3	S	Combustion – central heating
strk	F1	66.2	Cr, Cu, Fe, Sb, Pb, Ni, Zn	Industry, traffic related abrasion
	F2	15	Mg, Al, Si, K, Ca, Ba	Road dust resuspension
	F3	7.8	S	Combustion
vys	F1	52	Al, K, Cr, Fe, Ni,	Traffic related abrasion
	F2	28	Cd, Sb, Pb, Zn	Combustion - local
	F3	12.8	Mg, Ca, Cu, Ba, S	Traffic related emissions
all	F1	59.3	Mg, Al, Si, Cr, Cu, Fe, Sb, Ba	Traffic related emissions
	F2	24.4	K, S, Cd, Pb, Zn	Combustion – local, central

ĎAKUJEM ZA POZORNOSŤ