Content of Trace Elements and Polycyclic Aromatic Hydrocarbons in Particulate Matter and their Vertical Distribution in Street-Canyon

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Abstrakt

V příspěvku jsou prezentovány dílčí výsledky z prescreeningového sledování koncentrace pevných částic o velikosti 2.5 mm (PM2.5) v ovzduší lokality zatížené dopravou. Pozornost byla zaměřena především na jejich vertikální distribuci, koncentraci a chemické složení (vybrané prvky a polycyklické aromatické uhlovodíky). Z výsledků měření je možné konstatovat, že nebyl zjištěn statisticky významný rozdíl v obsahu sledovaných pevných částic ani v jejich chemickém složení v závislosti na jejich vertikálním rozložení. Závislost byla zjištěna pouze na vlhkosti a teplotě a to jen u některých kovů. Výsledky jsou orientační a prezentovaná problematika je předmětem dalšího výzkumu.

Keywords

Particulate matters, polycyclic aromatic hydrocarbons, vertical distribution, transport, pollution, metals, humidity, temperature.

Introduction

The traffic-related emissions of particulate matters (PM) have probable negative impacts on human health, especially in cities with the high traffic intensity. The chronic exposition to their impact causes shortening of the expected life length due to heart and lung diseases. Recent studies refer also on possible development of lung cancer. The used LECKEL Medium Volume Sampler system can be fitted with a PM_{10}, $PM_{2.5}$ or $PM_{1.0}$ inlet for size selection, as well as a TSP inlet for total suspended particles. The sampler operates as a single filter system and confirms to EU Directive 1999/30/EC and CEN standard EN 12341 for sampling of particulate matter for heavy metals analysis. The attention is paid to the share of individual fractions of particles and their chemical composition. The Obtained information serves mainly for the finding of the actual emission situation and provides the main input information for the assessment of inhabitants exposition near roads. The measured data will be used for mathematical modelling of particles transport in the environment.

1. Methodology

The street named “Kotlarska” (in Brno, Czech Republic) was selected as the sampling site. It is a relatively narrow street canyon (H/W = 1.16) with high vehicle flows (about 20 000 vehicles / 24 hours). Three samplers LECKEL MVS6, standard flow rate 2.3 Nm^3/hour, (under the standard conditions: temperature = 273 K and pressure = 1013 mbar) (where the temperature = 273 K and the pressure = 1013 mbar are the standard conditions), were carried out using nitrocellulose filters (Millipore, type: porosity 1.2 µm, diameter 47 mm) and located on the balconies (in 3 different hight levels) (3 height levels). The sampling period was generally 24 hours. All filters were treated in the same way. Each filter was weighted after 48 hours conditioning with microbalance Mettler-Toledo MX5/A. The temperature and humidity were measured in one-minute intervals on the 6-th floor during all sampling periods and their

averages were calculated from acquired data. The filters were digested with mixture: 2 ml H_2O_2 + 3 ml HNO_3 + 1 ml HCl by means of microwave digestion device with quartz glass vessels (working pressure 75 bar) Multiwave (Anton Paar), equipped with a combined pressure-temperature sensor accessory for reaction control. Determination of elements was carried out by inductively coupled plasma quadrupole mass spectrometry ICP-QMS (ELAN DRC plus, Perkin-Elmer).
The same sampling equipment was used for sampling of organic pollutants in TSP. Quartz fibre filters (Milipore) were applied under the same sampling conditions. Samples were extracted with dichloromethane in Büchi System B-811 automatic extractor. 16 US EPA polycyclic aromatic hydrocarbons (PAHs) were determined using of a GC-MSD. Recoveries varied from 72 to 98 %.

2. Results

The results of the analyses of the $PM_{2,5}$ and the contained metals in the air at standard conditions are summarised in the Table 1. The contents of individual metals per a unit of $PM_{2.5}$ are in the Table 2. Table 3 contains measured concentrations of selected PAHs adsorbed on TSP in air. The $PM_{2.5}$ vertical dependency for three day of measurements is shown on Fig. 1. As Because a the statistically significant dependence of $PM_{2.5}$ vertical distribution was not found, the influences of other conditions (relative humidity and air temperature) on the particles concentrations have been searched. As an example, the regression between relative humidity and $PM_{2.5}$ concentration is shown on Fig. 2. Fig. 3 shows vertical distribution of PAHs adsorbed on TSP in four sampling days.

Table 1: Concentrations of $PM_{2,5}$ and metals in air

Sampling Date	Balcony – Floor No.	Temp.	Humi-dity	$PM_{2.5}$	Cr	Mn	Co	Ni	Cu	Zn	Rb	Sr	Zr	Mo	Cd	Sn	Sb	Ba	Pb
		°C	%	µg.Nm^{-3}	ng.Nm^{-3}														
3.5.2004	2	18,9	53,1	17,8	1,05	18,1	0,0496	1,00	6,79	58,9	0,323	0,526	0,221	0,518	0,252	1,92	1,67	3,07	13,5
	4			19,4	1,25	20,8	0,0575	1,16	6,16	67,0	0,357	0,548	0,243	0,573	0,291	2,16	1,74	3,24	15,0
	6			18,4	1,24	21,0	0,0510	1,46	5,88	66,2	0,354	0,559	0,329	0,535	0,282	2,11	1,71	4,26	15,4
10.5.2004	2	13,1	69,2	25,9	15,3	65,2	0,167	1,91	23,9	277	0,535	0,593	0,964	2,16	1,01	2,74	5,46	7,78	59,7
	4			28,5	16,8	70,3	0,159	1,80	20,4	288	0,464	0,418	0,801	2,03	1,09	2,74	4,79	6,97	61,7
	6			25,1	16,6	68,1	0,150	2,08	19,0	284	0,469	0,432	0,694	1,92	1,10	2,50	4,36	6,46	61,7
17.5.2004	2	15,1	59,2	21,6	3,33	6,85	0,0497	3,34	14,0	27,0	0,237	0,444	0,680	1,22	0,346	1,44	3,54	5,20	7,49
	4			21,2	4,05	6,72	<LOQ	3,37	12,2	26,2	0,199	0,873	0,731	1,14	0,357	1,36	3,36	4,73	7,44
	6			20,8	3,73	6,31	<LOQ	3,43	10,4	25,5	0,199	0,433	0,535	1,00	0,347	1,21	3,04	3,99	7,30

Table 2: Contents of metals in $PM_{2,5}$

Sampling Date	Balcony – Floor No.	Cr	Mn	Co	Ni	Cu	Zn	Rb	Sr	Zr	Mo	Cd	Sn	Sb	Ba	Pb
		ng.mg^{-1} of $PM_{2.5}$														
3.5.2004	2	58,9	1 010	2,78	55,9	381	3 310	18,1	29,5	12,4	29,1	14,2	108	93,9	172	755
	4	64,2	1 070	2,96	59,7	317	3 450	18,4	28,2	12,5	29,5	15,0	111	89,3	167	772
	6	67,4	1 140	2,77	79,4	319	3 600	19,3	30,4	17,9	29,1	15,3	115	92,7	232	835
10.5.2004	2	592	2 520	6,46	73,9	922	10 700	20,7	22,9	37,2	83,3	39,0	106	211	301	2 310
	4	588	2 460	5,57	63,3	716	10 100	16,3	14,6	28,1	71,2	38,2	96,0	168	244	2 160
	6	662	2 720	5,97	83,1	757	11 300	18,7	17,2	27,7	76,6	44,0	100	174	258	2 460
17.5.2004	2	154	317	2,30	155	646	1 250	11,0	20,6	31,5	56,5	16,0	66,5	164	241	347

	4	191	316	<LOQ	159	574	1 240	9,39	41,1	34,4	53,8	16,8	63,9	158	223	350
	6	180	304	<LOQ	165	500	1 230	9,58	20,8	25,7	47,9	16,7	58,3	146	192	351

Table 3: Concentrations of PAHs adsorbed on TSP in air

Sampling Date	Balcony – Floor No.	Nap	Acy	Ace	Flen	Phen	Anth	Flu	Py	BaA	Chry	BbF	BkF	BaP	IPy	DBA	BPe	PAHs
		ng.Nm^{-3}																
28.4.2004	2	0,132	0,018	<LOQ	0,044	0,544	0,026	1,022	0,742	0,165	0,540	0,434	0,492	0,375	0,437	0,033	0,735	5,739
	4	0,147	0,049	0,034	0,136	0,727	0,090	1,277	0,892	0,173	0,682	0,441	0,576	0,362	0,456	0,030	0,810	6,882
	6	0,139	0,022	<LOQ	0,040	0,541	<LOQ	0,977	0,655	0,139	0,527	0,428	0,596	0,373	0,391	<LOQ	0,647	5,475
29.4.2004	2	0,155	0,030	<LOQ	0,044	0,262	0,018	0,321	0,314	0,081	0,129	0,092	0,162	0,070	0,089	<LOQ	<LOQ	1,767
	4	0,159	<LOQ	<LOQ	0,051	0,319	0,036	0,330	0,337	0,054	0,163	0,080	0,138	0,145	0,087	<LOQ	0,210	2,109
	6	0,140	<LOQ	<LOQ	0,033	0,236	0,040	0,364	0,294	0,063	0,228	0,147	0,247	0,177	0,096	<LOQ	0,276	2,341
24.5.2004	2	0,204	0,055	<LOQ	0,044	0,540	0,066	0,638	0,766	0,186	0,511	0,171	0,416	0,299	0,233	<LOQ	0,690	4,819
	4	0,212	0,033	<LOQ	0,062	0,460	0,084	0,580	0,584	0,128	0,442	0,193	0,369	0,234	0,201	<LOQ	0,522	4,104
	6	0,124	0,026	<LOQ	0,040	0,346	0,029	0,408	0,426	0,149	0,379	0,244	0,346	0,204	0,226	<LOQ	0,459	3,406
25.5.2004	2	0,276	0,036	0,018	0,051	0,504	0,069	0,649	0,733	0,239	0,628	0,290	0,660	0,421	0,461	<LOQ	0,943	5,978
	4	0,152	0,025	<LOQ	0,040	0,323	0,036	0,479	0,450	0,152	0,559	0,268	0,399	0,323	0,214	<LOQ	0,646	4,066
	6	0,188	0,029	0,022	0,054	0,406	0,043	0,543	0,569	0,148	0,435	0,239	0,420	0,406	0,340	<LOQ	0,848	4,690

Abbreviation for 16 PAHs (EPA) in Table 3

Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene
Nap	Acy	Ace	Flen	Phen	Anth	Flu	Py	BaA

Chrysene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(123-cd)pyrene	Dibenz(ah)anthracene	Benzo(ghi)perylene
Chry	BbF	BkF	BaP	IPy	DBA	BPe

Fig. 1: Vertical Distribution of $PM_{2.5}$

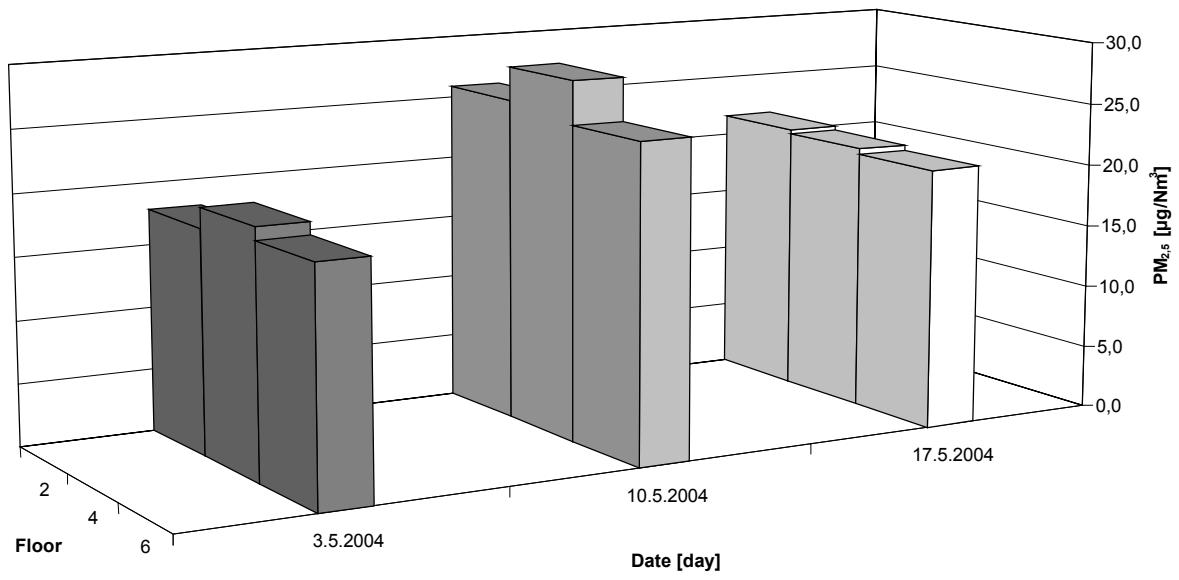


Fig. 2: Regression Curve for $PM_{2.5}$ vs. Relative Humidity

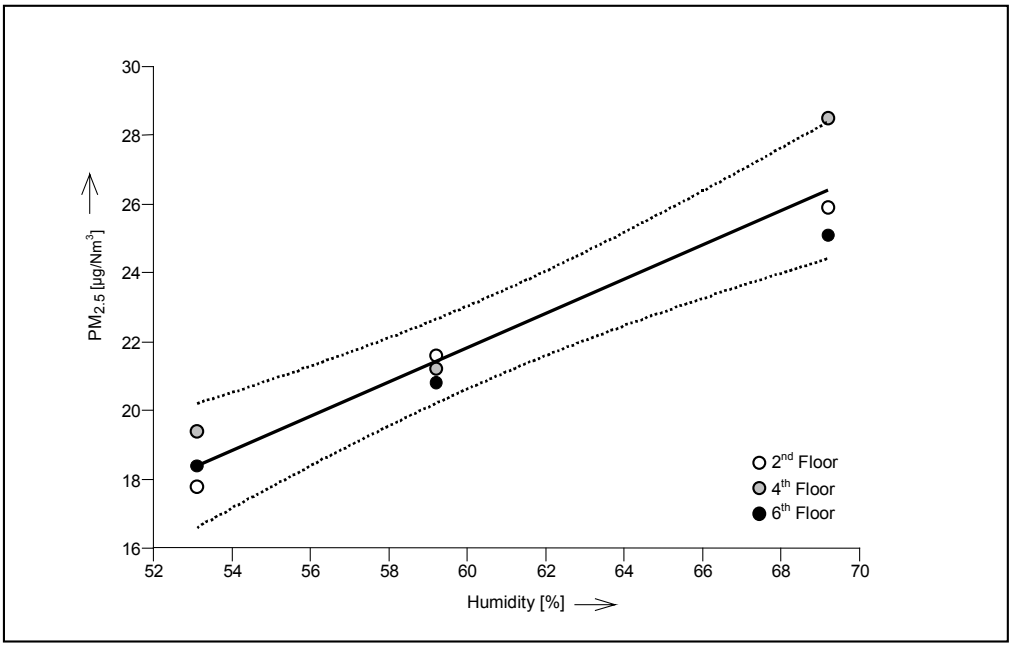
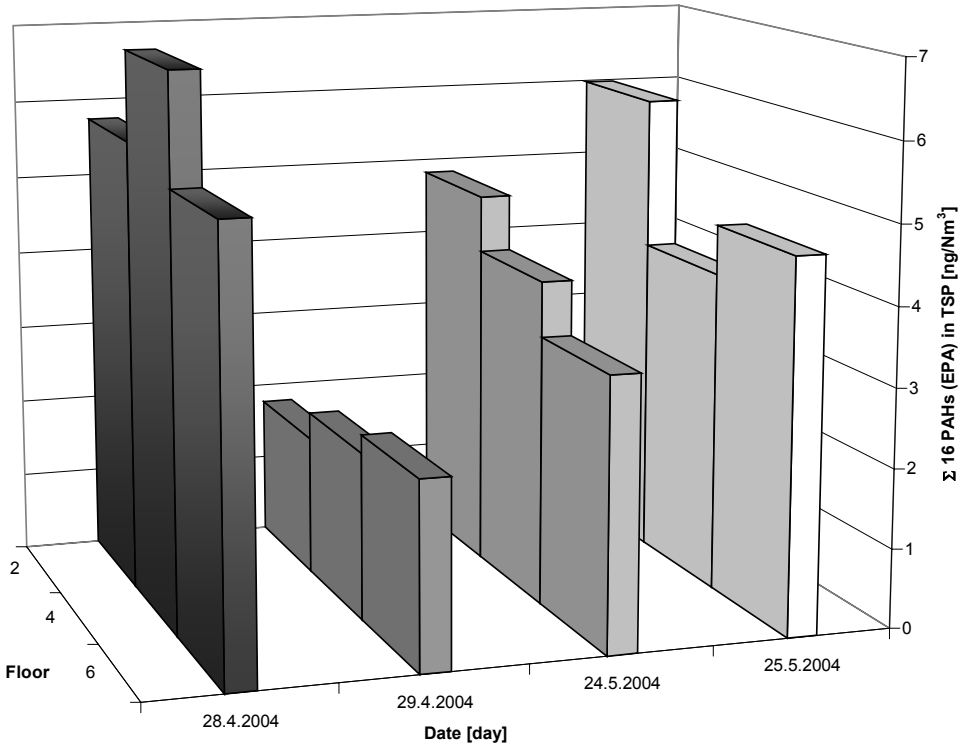


Fig. 3: Vertical Distribution of PAHs Adsorbed on TSP in Air



3. Conclusion

From the preliminary monitoring, the dependence between the $PM_{2.5}$ content and monitored organic and inorganic pollutants, related to the vertical distribution of samplers, was not found. Reason of these results could be wide profile of chosen street-canyon and relatively good level of ventilation through the side streets. Effects of these factors will be studied in following phases of the project.
The statistically significant influence of the relative air humidity on the PM concentration was proved. The air temperature and relative humidity had the statistically significant influence on the metals contents (content of metals). The Cr, Mn, Co, Zn, Cd, Sn a Pb contents increased with the increasing temperature and humidity and the Ni content decreased in reverse. The Mo content increased only with the increasing humidity. The Cu, Ba, Zr and Sb contents decreased with the increasing temperature. The statistically significant dependence of Sr content was not proved neither on humidity nor temperature. The presented results have pre-screening character. This study is still continuing with the aim at more detailed analyses of pollutants contents and shorter times for the determination of the PM vertical distribution.

Acknowledgement

The study was supported by Czech Ministry of Education, Youth and Sport (Programme Kontakt, project “Analysis of Air Particulate Matter for the Assessment of the Influence of Traffic on Environment and Health”) and COST 633 “Particulate Matter: Properties Related to Health Effects” as a research project.

References

ADAMEC, V. et al. (2004): *Research of Environmental Burden from Transport*. CDV, Brno. 202 p. (in Czech).

RECENZNÝ POSUDOK

Meno recenzenta:

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A. Názov príspevku:

Content of Trace Elements and Polycyclic Aromatic Hydrocarbons in Particulate Matter and their Vertical Distribution in Street-Canyon

B .

1. **2. Splnenie obsahových požiadaviek pre konferenciu**	áno	nie

C. Konkrétne pripomienky

a) technické

Bez pripomienok.

b) formálne

Príspevok upraviť podľa farebne označených pripomienok v texte.

D. Záver posudku

Odporúčam prijať.

Dátum: 8.10.2004

Jozef Mačala, v.r.

…….

podpis recenzenta

Pokyny pre recenzentov :

Časť C. Tvrdenia formulovať stručne, jednoznačne, a presne (podľa potreby s udaním strany a riadku). Dodržať rozdelenie na časť a) a b).

Časť D. Napísať jednu z troch variant : 1. Odporúčam prijať, 2. Neodporúčam prijať z dôvodov , 3. Odporúčam prijať po prepracovaní na základe pripomienok z časti D. Pripomienky musia byť konkrétne: treba doplniť …, treba vynechať …, treba opraviť … . Ak na pripomienky nestačí priestor v časti D, možno použiť i opačnú stranu tohoto listu s podpisom recenzenta.